

PREPARED FOR

HAMPTON ROADS TRANSPORTATION PLANNING ORGANIZATION



# HAMPTON ROADS HIGH SPEED PASSENGER RAIL VISION PLAN



November 2014

PREPARED BY

**TEMS**

TRANSPORTATION ECONOMICS & MANAGEMENT SYSTEMS, INC.



## **REPORT DOCUMENTATION**

### **TITLE**

Hampton Roads High Speed Passenger Rail Vision Plan

### **PROJECT CONSULTANT**

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### **ACKNOWLEDGEMENT**

Prepared in cooperation with the U.S. Department of Transportation (USDOT), the Federal Highway Administration (FHWA), the Virginia Department of Rail and Public Transportation (DRPT), and the Virginia Department of Transportation (VDOT). The contents of this report reflect the views of the Hampton Roads Transportation Planning Organization (HRTPO). The HRTPO is responsible for the facts and accuracy of the data presented herein. The contents do not necessarily reflect the official views of policies of the FHWA, VDOT or DRPT. This report does not constitute a standard, specification, or regulation.

These opinions, findings and conclusion are preliminary in nature and do not represent final statements of fact or final projections of high speed and intercity passenger rail service to Hampton Roads. It is anticipated that upon completion of a NEPA Service Development Plan and/or TIER I Environmental Impact Statement, these initial study results will be refined to a level that supports the Hampton Roads Vision Plan for High Speed and Intercity Passenger Rail services from Washington D.C. to the Hampton Roads metropolitan area.

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### **DISCLAIMER**

This report presents alternative high speed and intercity passenger rail proposals that are un-negotiated, un-funded and at a feasibility level of analysis. It is understood that in following detailed environmental and engineering studies, the details of integrating the proposed passenger rail operations with Norfolk Southern and CSX freight operations will be subject to review, verification, and approval by both Norfolk Southern and CSX. Findings are not and should not be construed to be a commitment on the part of either Norfolk Southern or CSX to operate additional service.

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## 1. INTRODUCTION

*This section provides a description of the background and purpose of the Norfolk-Richmond corridor Phase 2A Data Collection and the Phase 2B Alternatives Analysis studies, the scope of the work, and the organization of the Vision Plan.*

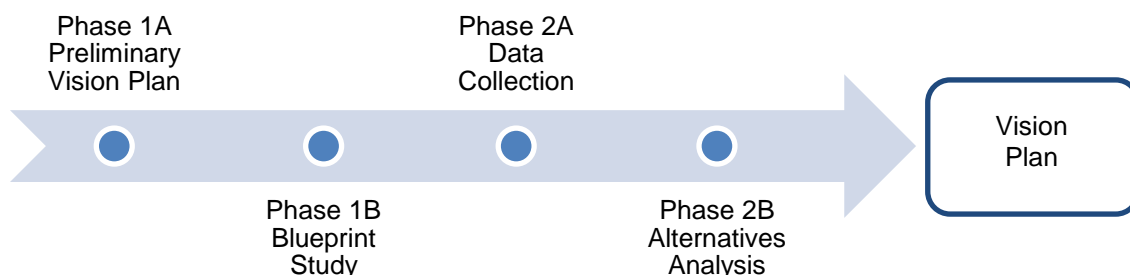
### 1.1 PURPOSE OF STUDY

The Virginia Department of Rail and Public Transportation (DRPT) developed the Richmond/Hampton Roads Passenger Rail Project Tier I Draft Environmental Impact Statement (EIS) in accordance with the National Environmental Policy Act (NEPA) to develop conventional passenger rail service to the I-64/CSX corridor and the US Route 460/Norfolk Southern corridor. The state's draft NEPA document was released for public review and comment in December 2009. In February 2010, based on the evaluation and public comments received, the Commonwealth Transportation Board selected Alternative 1 as the preferred alternative for enhanced passenger rail service between Richmond and Newport News and higher speed passenger rail service between Petersburg and Norfolk. DRPT has completed the Tier I Final EIS document, which was circulated for public comment in August 2012. The Record of Decision (ROD) was approved by the Federal Railroad Administration (FRA) on December 7, 2012.

The Final Tier 1 EIS proposes 6 trains per day at 90 mph from Norfolk to Richmond and Washington D.C., and 3 trains per day from Newport News to Richmond and Washington D.C. To support and further develop the Commonwealth's efforts, the Hampton Roads Transportation Planning Organization (HRTPO) Board approved a resolution in October 2009 that endorses the designation of a "high speed rail" corridor with ultimate speeds of more than 110 mph along the Norfolk Southern/Route 460 (Norfolk-Richmond) corridor and that enhances the intercity passenger rail service along the CSX/I-64 corridor (Newport News-Richmond).

TEMS was commissioned to develop a Vision Plan for passenger rail service for the Hampton Roads region that implements the HRTPO objectives established by the Board. An initial phase (Phase 1) of work was completed by TEMS in July 2010. Recent and current work on Phase 2A Data Collection and on Phase 2B Alternatives Analysis work is designed to build a database and an evaluation framework for identifying the potential for high speed rail in the Norfolk-Richmond corridor, and for higher speed rail in the Newport News-Richmond corridor. See Exhibit 1-1. The current report describes the data collection process and the evaluation of routes and technology options needed to complete the Hampton Roads-Richmond Corridor Vision Plan. The Vision Plan includes the analysis needed to support the preparation of a Service Development Plan (SDP) and Service NEPA that are the key documents needed by U.S. Department of Transportation (USDOT) FRA to support further planning work on high speed rail for the Norfolk-Washington D.C. corridor.

**Exhibit 1-1 Overview of Study Development Process**



## 1.2 DEVELOPMENT STEPS – NORFOLK-RICHMOND CORRIDOR

Exhibit 1-2 shows the four step process envisaged by DRPT and HRTPO for developing passenger rail service. Development Steps 1 and 2 (79-90 mph) come under the DRPT's focus on conventional passenger rail service, while Steps 3 and 4 reflect the HRTPO's "higher and high speed" rail focus of the HRTPO. In terms of Step 1 and Step 2, DRPT has made good progress in starting an Amtrak 79-mph service to Norfolk. The service was started in December 2012 and provides a daily direct connection from Norfolk to Petersburg, Richmond-Staples Mill, Washington D.C., and connections to the Northeast corridor. Development Step 3 and Step 4 are the focus of the HRTPO planning process to develop high speed rail for the Norfolk-Richmond corridor.

**Exhibit 1-2: Proposed System Development Steps for the Norfolk-Richmond Corridor**

Steps	Route	Max Speed	No. of Trains	Infrastructure	Station
Step 1	Route 460/ Norfolk Southern**	79 mph	1-3*	Shared Track NS	Staples Mill Only Norfolk
Step 2 (FEIS Opt 1)	Route 460/ Norfolk Southern**	79-90 mph	4-6	Shared Track V Line	Main Street Bowers Hill
Step 3	Norfolk-Richmond along Route 460	110 mph	8-12	Dedicated Track V Line	Main Street Bowers Hill
Step 4	Norfolk-Richmond along Route 460	150 mph	12-18	Dedicated Electric Track V Line	Main Street Bowers Hill

\* Two additional trains are planned in the near future by DRPT.

\*\* Norfolk Southern (NS) does not permit passenger train maximum authorized speed in excess of 79 mph on any NS track. Where the V-line (former Virginian Railway) has existing freight services, maximum authorized speed for passenger trains will be 79 mph. Along the Algren – Kenyon portion of the V-line (over which NS freight rail service has been formally abandoned); passenger rail planners may consider speeds above 79 mph. Any use, implied, explicit, or otherwise, of NS right-of-way will be subject to the concurrence of NS, and to NS' Passenger Rail Policy which governs the speed of passenger trains utilizing it or encroaching upon it.

## 1.3 SCOPE OF THE STUDY

Phases 2A and 2B of this study provide the basic data needed to plan for "high and higher speed" passenger rail service in the Hampton Roads-Richmond corridor, as well as the analysis of route and technology options that should be considered for the Vision Plan.

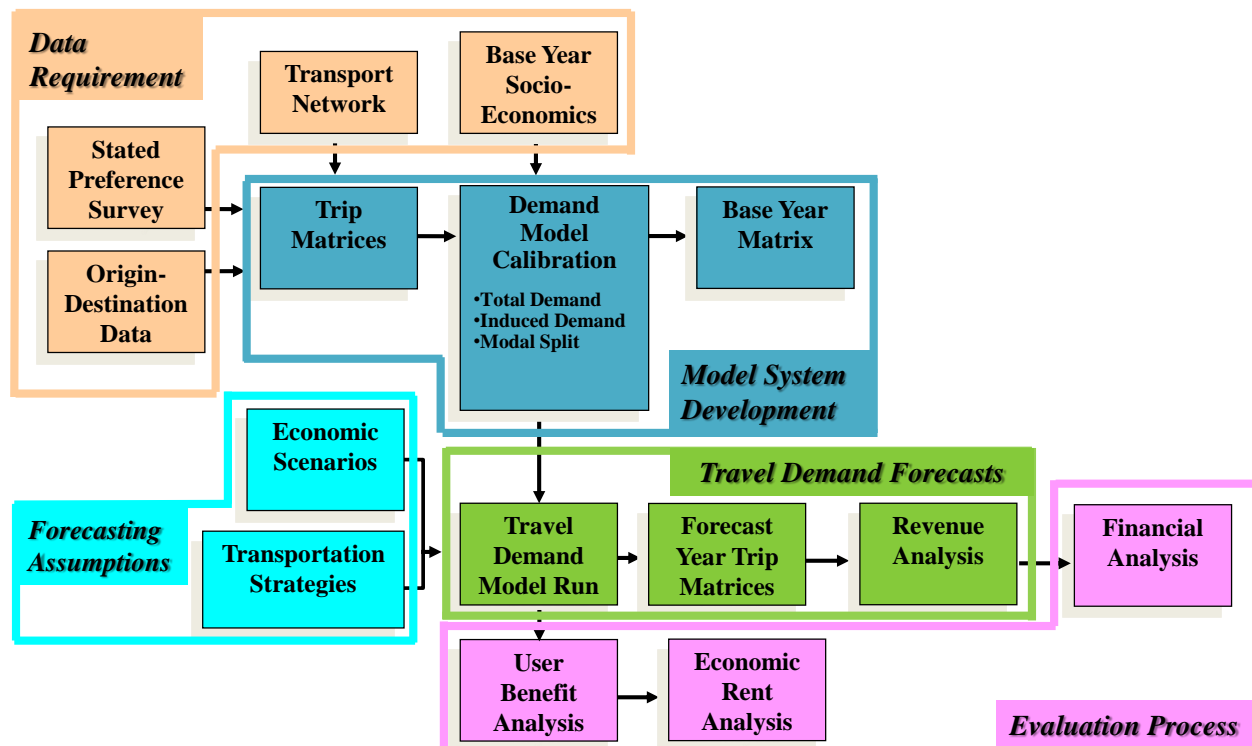
The Phase 2A report and study focused on the initial and the most vital stage of high speed passenger rail analysis: Data Collection. For high speed rail planning purposes, databases are required in four key areas:

- Market Database – Hampton Roads to Boston and Charlotte
- Technology Database – National US and International Benchmarks
- Engineering Database – Hampton Roads to Washington, D.C.
- Environmental Database – Hampton Roads to Richmond

A key driver of high speed rail studies is the Market Database. A key factor is to understand the full competitive environment for auto, air, rail and intercity bus travel between Hampton Roads and the

Northeast and Southeast corridors. Given the potential competition between the Norfolk-Richmond and Newport News-Richmond rail lines, both corridors are included in the data collection for the Market Database. As such, a thorough understanding of the responsiveness of the region's population and its opportunity to use the proposed high speed rail system provides the critical element in the ability to evaluate and potentially justify the systems. As seen in Exhibit 1-3, the final outcome of demand forecasting analysis is dependent on the socioeconomic, transportation networks, stated preference survey, and the origin destination database.

**Exhibit 1-3: Market Database Requirements for COMPASS™ Model Ridership and Revenue Analysis**



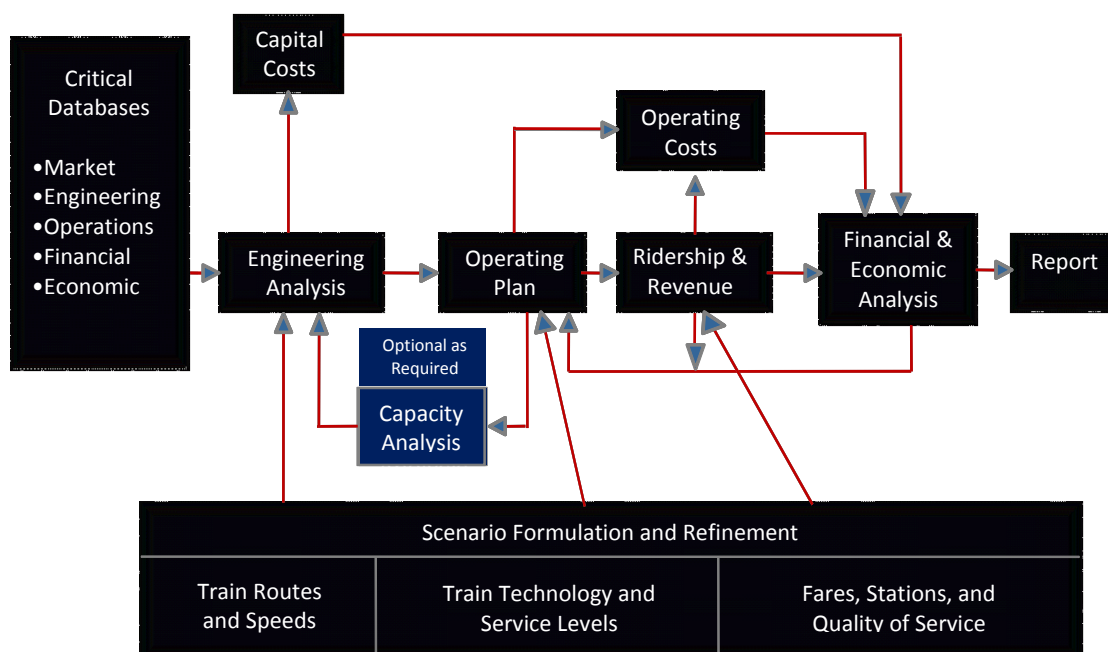
For a comprehensive travel demand model to be developed, data must be collected on the latest socioeconomic data, traffic volumes (air, bus, auto, and rail) by purpose and updated network data (e.g., gas prices) to test likely ridership response to service improvements over time. To develop ridership and revenue demand estimates, using the COMPASS™ demand modeling system, data is needed on the quality of the service frequencies, travel times, fares, fuel prices, congestion and other trip attributes. Demand Forecasts are made by entering: long term forecasts of the economy (economic scenarios including energy prices) and future rail, and other mode strategies for infrastructure improvements, into the model in order to develop forecasts of high speed rail potential.

The second step in the process, once the existing and future market for rail travel is assessed, is an Interactive Analysis to identify (based on FRA evaluation criteria) the optimum high speed rail system for the market. Exhibit 1-4 shows the interaction of the databases and the Interactive Analysis process needed to develop the critical FRA performance metrics required to show the value of the project<sup>1</sup>.

<sup>1</sup> Value of the project will be assessed by financial and economic analysis; this measures the cost benefit ratio and operating ratio.



Exhibit 1-4: Interactive Analysis Process



With respect to the quality of service offered by a high speed rail system, a detailed Interactive Analysis is needed to optimize the potential alignment and the technologies being proposed for the “higher and high speed” rail systems. To effectively model the market, the technology analysis assesses the potential technologies that will be used for both the Norfolk-Richmond and Newport News-Richmond corridors. As a result, the study investigates the interaction between alignments and technologies in order to identify optimum trade-offs between capital investments in track, signals, other infrastructure improvements, and train operating speed. The engineering assessment must include aerial and/or ground inspections of significant portions of track and potential alignments, and of potential station and maintenance base locations for each option. For the purpose of this study, TEMS *TRACKMAN*<sup>™</sup> is used to catalog the base track infrastructure and improvements, and provides a database<sup>2</sup> that will allow the full range of technology and train service options to be assessed. Once the track data has been collected, the *LOCOMOTION*<sup>™</sup> train performance program provides the next step in assessing the performance of various train technologies on the track at different levels of investment. The *LOCOMOTION*<sup>™</sup> program requires that different train operating characteristics (train acceleration, curving and tilt capabilities, etc.) be developed during the technology assessment.

The Technology Database will therefore need to include all the different technologies to be appraised including the existing 79-mph conventional rail, as well as the 110-mph technology associated with “higher” train speed performance and the 150 mph plus technologies associated with true high speed rail operation. The Interactive Analysis can then assess the infrastructure requirements and costs (on an itemized segment basis) necessary to achieve high levels of performance for the train technology options being evaluated.

<sup>2</sup> The Engineering Database includes data on existing and potential rights-of-way and alignments. The data to be assembled in *TRACKMAN*<sup>™</sup> includes rights-of-way, FRA speeds, curves, speeds, grades, rail and highway crossings, signaling facilities, and potential restrictions such as bridges and track limitations. The database is upgraded by improvements to the track and signaling systems e.g., removing curves or introducing an advanced Positive Train Control (PTC) signaling system, which enforces speed limits and prevents trains from running past red signals. This allows higher train speeds and higher quality service in the corridor.

In terms of an Environmental evaluation, a Service NEPA<sup>3</sup> at the landscape level<sup>4</sup> of documentation is needed for Step 3 and Step 4. (The current Tier I EIS only covers Steps 1 and 2 phases of system development.) This includes the environmental data collection at the landscape level for the envelope of the Study Area from Richmond to Hampton Roads. This Vision Plan describes an environmental database that was prepared to support a Service NEPA Environmental Assessment. The Service NEPA is a preliminary environmental scan that leads to a decision whether a Tier 1 EIS<sup>5</sup>, an Environmental Assessment (EA)<sup>6</sup>, a Finding of No Significant Impact (FONSI), or a Categorical Exclusion is appropriate. This Tier 1 work may be followed by a Tier 2 EA<sup>7</sup> or EIS site specific analysis. Depending on the impact findings, either the EIS is prepared and followed by a ROD in case of Tiered analysis, or an FRA approval is required for a Categorical Exclusion. The process for Environmental Database collection and determining the final outcome are shown in Exhibit 1-5.

Lack of capacity and poor geometry on the Richmond to Washington D.C. segment have been reported in recent months. DRPT<sup>8</sup> and CSX have both indicated that the combination of freight services, Amtrak, VRE and planned SEHSR service will more than reach the capacity of a triple tracked line between Richmond and Washington. This is especially a concern if the two bottleneck areas in Ashland and Fredericksburg are not addressed and remain only double tracked. Even the DRPT planned Richmond to Washington D.C. services may face significant delays and require added schedule pad due to the lack of capacity.<sup>9</sup>

As a result, it is clear that development of a new greenfield alignment from Richmond to Washington D.C., and a capacity improvement plan that goes beyond DRPT's current plan, are absolute prerequisites to a potential implementation of High Speed Rail for Hampton Roads. Without an improved alignment north of Richmond, High Speed service to Hampton Roads cannot be effective. The scope of this study has not allowed a full exploration of these issues, so we can only re-state the assumptions that have been employed since 2010 in developing the operational and cost analysis. An environmental study will be required to completely confirm and validate these assumptions.

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<sup>3</sup> Service NEPA as defined in the guidance of FRA is an essential first step for corridors providing an overview of the level of improvements that are needed to implement significantly expanded conventional or high speed rail services. This document provides an environmental database that will be used in preparation of Service NEPA Environmental Assessment for the Petersburg to Norfolk Corridor. The Service NEPA EA typically addresses the broader environmental questions relating to the type of service being proposed, Communities being served, types of operations (speed, electric, or diesel powered), ridership projections and major infrastructure components, improvement alternative being proposed and measures taken to minimize harm to the corridor. <http://www.fra.dot.gov/Page/P0262>

<sup>4</sup> Landscape level in this report refers to preliminary overview of the process i.e., inspection of an area by aerial and on site photographs without any detailed inspection.

<sup>5</sup> TIER 1 would be typical to large expansive projects like for example, EISs that FRA has prepared with the California High Speed Rail Authority for the state's proposed high speed rail project. <http://www.fra.dot.gov/Page/P0262>

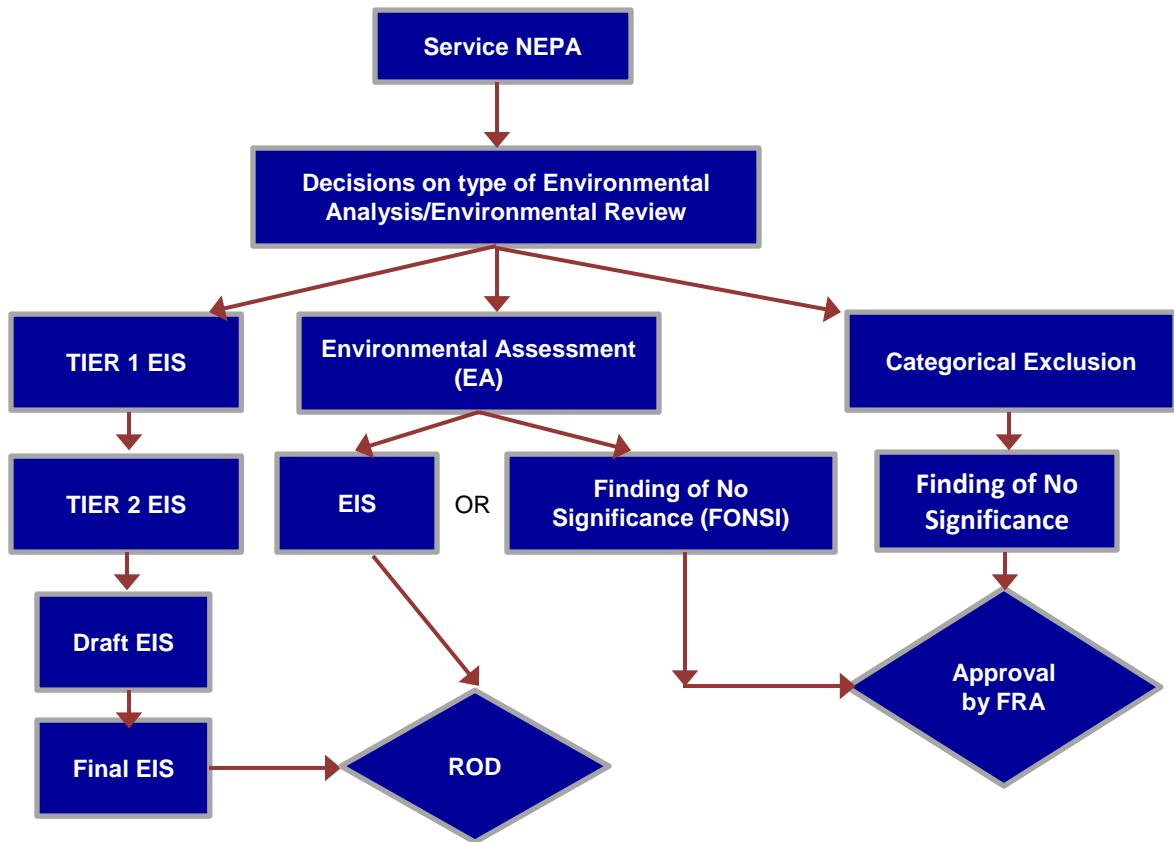
<sup>6</sup> An EA would be appropriate only for a more limited corridor development program where no significant environmental impacts are anticipated. <http://www.fra.dot.gov/Page/P0262>

<sup>7</sup> TIER 2 or EA would be typically for corridor programs with smaller scope and narrower range of reasonable alternatives. <http://www.fra.dot.gov/Page/P0262>

<sup>8</sup> DRPT/HRTPO meeting on October 23, 2013

<sup>9</sup> For example even though DRPT has suggested a 90 minute Richmond to Washington D.C. travel time might be possible, neither the SEHSR nor DRPT Hampton Roads planned service schedules are actually based on this time. Rather SEHSR and DRPT's planning both assumes a 2-hour timetable which is probably a more realistic assessment of the actual capability of CSX's alignment, even after DRPT's proposed capacity improvements have been made. See FAQ # 5 of <http://www.sehsr.org/faq.html> Also, the 2 hour Richmond to Washington D.C. schedule and not 90-minutes has been assumed in planning Hampton Roads service, see Table 6 of the Richmond/Hampton Roads Passenger Rail Study, Alternatives Analysis and Tier 1 Environmental Impact Statement, DRPT, November 2005 see: <http://rich2hrrail.info/downloads/FinalAltDvpReport011706.pdf>

Exhibit 1-5 FRA Environmental Process<sup>10</sup>



At this point in time, an environmental study region has been defined and preliminary environmental data has been collected. The detailed environmental work needed to precisely locate prospective alignments within the study area has yet to be completed. These will be more fully developed, with appropriate levels of community input during a future EIS if and when directed by the HRTPO

In the Phase 2B Alternatives Analysis, the market, engineering, technology and environmental data of Phase 2A was used to define the route and technology options to be evaluated.

To meet this need for the Norfolk to Richmond segment, a number of possible conceptual northern and southern options (north and south of US 460 between Suffolk and Petersburg) were defined, along with a Norfolk Southern (NS)\* route that would parallel the very straight NS track (route) from Suffolk to Petersburg. The suggested three options (See Exhibits 1-6 and 1-7) are:

- A Northern Greenfield (Option 2A)
- A Southern Greenfield (Option 1A)
- A Richmond Direct (Option 3)

<sup>10</sup> Prepared by TEMS, based on HSIPR NEPA Guidance and Table <http://www.fra.dot.gov/Page/P0262>

\* Any use, implied, explicit, or otherwise, of NS right-of-way will be subject to the concurrence of NS, and to NS' Passenger Rail Policy which governs the speed of passenger trains utilizing it or encroaching upon it.

Exhibit 1-6: Option 2A, Northern Greenfield Route and Option 2B, Norfolk Southern Variant

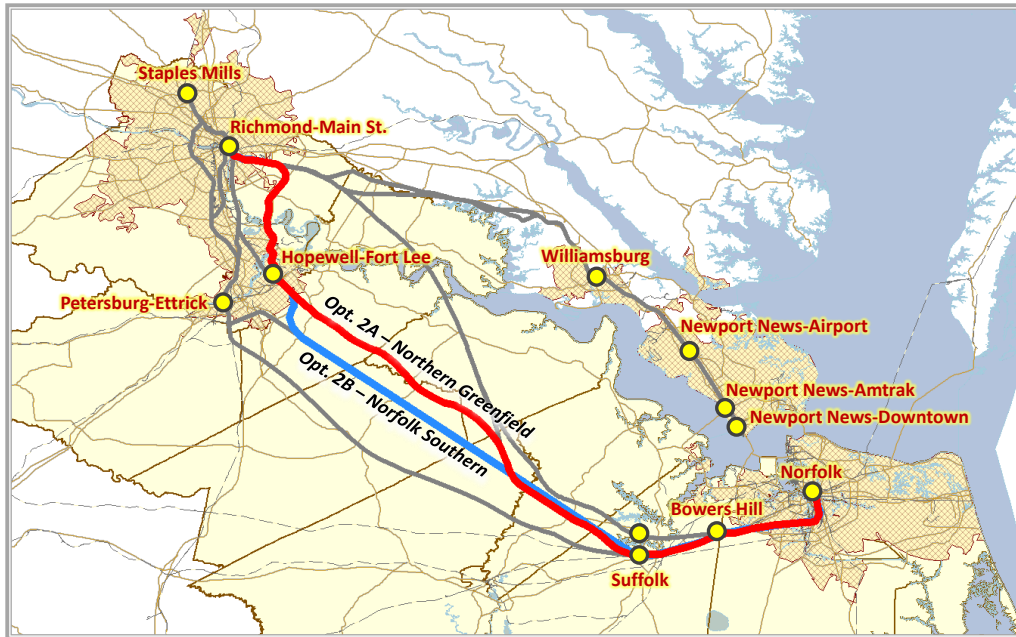
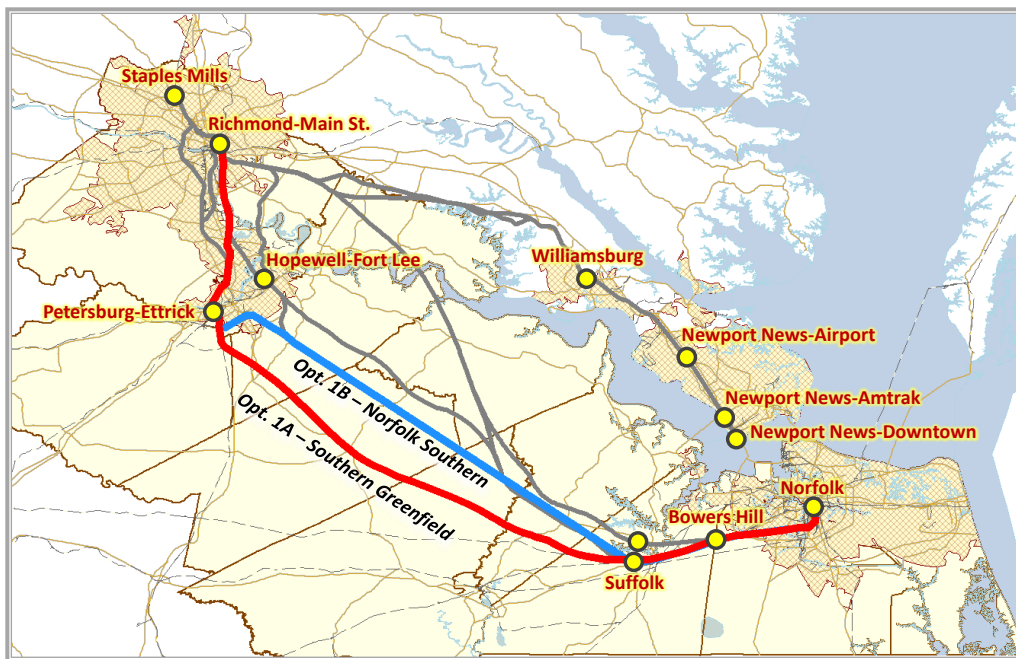


Exhibit 1-7: Option 1A, Southern Greenfield Route and Option 1B, Norfolk Southern Variant

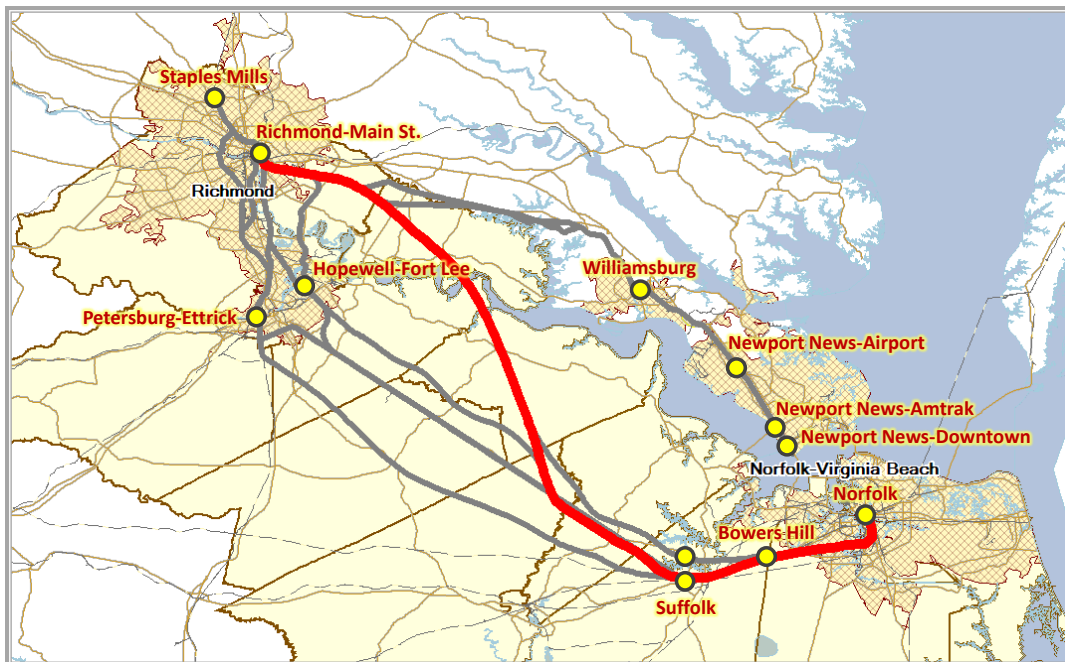


\* Any use, implied, explicit, or otherwise, of NS right-of-way will be subject to the concurrence of NS, and to NS' Passenger Rail Policy which governs the speed of passenger trains utilizing it or encroaching upon it.



Environmental and engineering assumptions were developed in detail from Richmond to Hampton Roads, but all High Speed options also require a new greenfield alignment from Richmond to the Washington D.C. area. This was developed at a conceptual level in the 2010 study and has been used in the current study as a placeholder. Accordingly the previous 2010 study assumptions were carried forward into the current study. The specific assumptions made are fully described on pages B-9 and B-14 of “Progress Report B” of the 2010 Study. Subsequently, in development of the (Phase 2B) Alternatives Analysis, it became apparent that in addition to the Northern and Southern greenfield routes initially identified, a further more easterly route might be considered that gave a direct route to Richmond from Suffolk. This route was called “Richmond Direct”.

**Exhibit 1-8: Route Option 3, Richmond Direct**



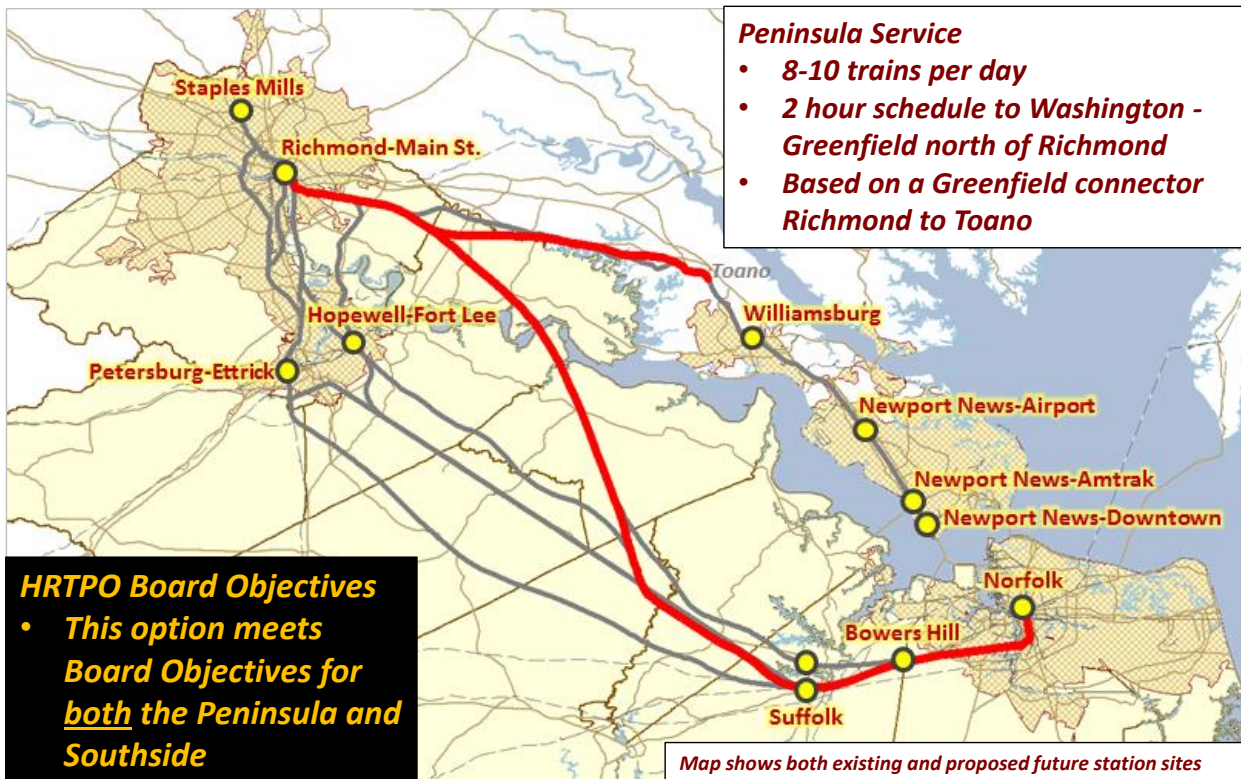
In addition to the Richmond Direct route, it quickly became apparent that it would be difficult to access Petersburg and Richmond from the south or west. As a result, a number of routes were developed that accessed Richmond from the east using suburban bypasses through Hopewell and the Richmond/Petersburg I-295 bypass. See Exhibit 1-8. This created a number of route sub options.

As a result, the Interactive Analysis suggested four main routes be assessed for developing Norfolk to Richmond connectivity; North and South Greenfield routes, Norfolk Southern\* route, and a Richmond Direct Greenfield route. Beyond this however, it soon became apparent particularly that Option 3: Richmond Direct offered a synergistic opportunity to develop a Peninsula connection, so diesel trains from the Peninsula and electric trains from the Southside could share a common entryway into downtown Richmond.

This resulted in development of a new concept for adding a High Speed connection linking the Richmond Direct corridor across open countryside over to Toano. (Beyond Toano, the Peninsula through Williamsburg and down to Newport News is more heavily developed, making it harder to find feasible greenfield alignments.) It was assumed beyond Toano that diesel trains to Newport

News could enter the existing CSX tracks and that 8-10 trains per day in each direction would be operated. This was called Option 4: Richmond Direct Improved, as shown in Exhibit 1-9. Unlike Options 1-3 that only developed Norfolk service, Option 4 develops service to both the Peninsula and Southside. Option 4 is thus in compliance with HRTPO Board Resolution #2009-05 that service to both the Peninsula and Southside be developed in a balanced way.

**Exhibit 1-9: Route Option 4, Richmond Direct Improved**



In terms of technology, the developments in rail technology have been very rapid; and while 150 mph technology was the best commercial speed possible twenty years ago, the latest technology allows speeds up to 220-240 mph. In rural areas, Greenfield routes can be developed with only very limited curvature and are thus ideal for the highest speed trains. Since the latest 220-mph trains are similar in cost to the 150 mph trains, it was decided to assess 220-mph trains on the new Greenfield routes, and at reduced speed on track shared with freight. This 220-mph service using electric trains has been developed for the Southside.

For higher speed trains, the diesel trains capable of 110 mph can be geared to operating at 130 mph; so a new option for consideration is that of operating diesel trains at 130 mph on Greenfield routes. This 130-mph service using diesel trains has been developed for the Peninsula. In urban areas where the track is more curvy or shared with freight trains, high speed trains are limited to 79-90 mph. At the current time, Norfolk Southern allows a maximum speed of 79-mph on their right-of-way; CSX is willing to share tracks with passenger trains up to 90-mph. As a result, the planned passenger services are likely to operate in urban areas at 79-90 mph, with increased speeds of up to 130-220 mph outside the built up urban areas on Greenfield routes.

## 1.4 REPORT ORGANIZATION

This report is organized in the following way:

- **Chapter 1 – Introduction:** Chapter 1 discusses the purpose of the Norfolk-Richmond corridor Phase 2A Data Collection study, the Phase 2B Alternatives Analysis, the scope of the study, and the organization of the report.
- **Chapter 2 – Development of the Route and Technology Options:** This chapter describes the development of route options for analysis, including route options for accessing Richmond via Hopewell versus Petersburg or Direct approaches. Because of the identified synergy with the Peninsula a “Richmond Direct Improved” Option 4 has been developed that provides an enhanced diesel service to the Peninsula, and High Speed electric train service to the Southside.
- **Chapter 3 – Route Analysis:** This chapter identifies the speed restrictions including major speed curves, grades, major rail and highway crossings, and other potential speed restrictions and environmental issues associated with the preliminary infrastructure analysis of the existing and proposed route options. This section of the report also discusses the proposed improvements and preliminary infrastructure costs for each of the proposed route options. A detailed assessment of five Norfolk-Richmond alternatives is included, as well as a single representative route for the Newport News-Richmond segment that was necessary to complete the analysis of Option 4. An important purpose of this Chapter is to serve as a scoping document by defining a range of reasonable routes for a possible future EIS. While the current study has identified a number of potentially feasible route options, at this time, it appears that a Richmond Direct alternative offers the best approach to development of the High Speed system due to its strong synergy with the Peninsula. This finding however, still needs to be confirmed by a full environmental study.
- **Chapter 4 – Engineering Analysis:** This chapter discusses track infrastructure and train technologies, and describes unit capital costs for estimating infrastructure, equipment, and maintenance facility capital costs for each route and technology option.
- **Chapter 5 – Operating Plan and Costs:** This chapter discusses the development of the operating plan, station stopping patterns, frequencies, train times and train schedules for each route and technology option. Operating costs were also calculated for each year the system is planned to be operational using operating cost drivers such as passenger volumes, train miles, and operating hours.
- **Chapter 6 – Market Analysis:** This chapter is divided into subsections of introduction of the chapter, zone system, socioeconomic data, transportation network data, origin-destination data, stated preference survey process, results and analysis. This chapter describes the steps of developing the market data which includes developing a zone system, socioeconomic database of the Study Area, how the transportation networks were developed, how the origin and destination databases were obtained and validated, methodology used to conducting stated preference survey and analysis of the results.
- **Chapter 7 – Financial and Economic Analysis:** For each route option, a detailed financial analysis was developed, including key financial measures such as Operating Surplus and

Operating Ratio. A detailed Economic Analysis was also carried out for each route option using criteria set out by the 1997 FRA Commercial Feasibility Study and including key economic measures such as NPV Surplus and Benefit/Cost Ratio at 3% and 7% discount rates.

- **Chapter 8 – Preferred Option Development:** This chapter will assess the impact of integrating the Norfolk and Newport News – Richmond options assessed in Chapter 7, with the Southeast High-Speed Rail and further develop the potential synergies between the two services.
- **Chapter 9 – Conclusions:** This chapter outlines the key findings of the study, and the next steps that should be taken to move the project forward.
- **Appendices:**
  - Appendix A – Zone System and Socioeconomic Data
  - Appendix B – *COMPASS*™ Model
  - Appendix C – *TRACKMAN*™ Files
  - Appendix D – Environmental Scan Updated
  - Appendix E – Phase 2(A) Engineering Field Survey: Petersburg to Norfolk
  - Appendix F – Transportation Use of Utility Corridors Reference
  - Appendix G – 1993 Peninsula Route Assessment by D. W. Dodson
  - Appendix H – Public Comments



## 2. DEVELOPMENT OF THE ROUTE AND TECHNOLOGY OPTIONS

*For implementation of high speed rail service in the Hampton Roads to Washington corridor, a Tier 1 Alternatives Analysis and Environmental Study will be needed to determine the most appropriate and effective greenfield alignment option. This Vision Plan and Environmental Scan are needed to serve as an essential but preliminary Scoping Study for developing the options and estimating the level of effort that will be needed to complete a full environmental analysis. In recent years, inclusion of an Environmental Scan as part of the route and technology evaluation has increasingly become a standard component of rail corridor feasibility studies. This is especially true for high speed studies like this one, which propose to develop extensive segments of new Greenfield alignment. This chapter first covers the requirement for developing the environmental database and definition of the National Environmental Policy Act (NEPA); second, the list of databases such as geographic boundaries, cultural resources, ecology, hazardous material sites, and air quality in the proposed environmental study area; third, the Route Options; and finally, the Train Technology Options.*

### 2.1 PURPOSE OF THE ENVIRONMENTAL ANALYSIS

In developing route options for the study, an initial overview of environmental issues is considered a critical element of National Environmental Policy Act (NEPA) compliance for the development of high speed passenger rail service. Under the Federal Railroad Administration's (FRA) HSIPR program guidance, FRA implements the environmental review process as required by the National Environmental Policy Act (NEPA) together with related laws and regulations, (including Section 106 of the National Historic Preservation Act and 49 U.S.C. 303, which protects public parks, recreation areas, wildlife and waterfowl refuges, and historic sites). The statutory requirement as stated in the *HSIPR NEPA Guidance*<sup>1</sup> is that "NEPA requires that appropriate environmental documentation be available to public officials and citizens *before* decisions are made and actions are taken. *The available information should be relevant to the decision to be made at any particular stage of project development*" (italics added for emphasis) including the decision as to whether or not to launch a detailed environmental study in the first place.

To apply for funding for a high speed rail system, FRA has defined the creation of a Service Development Plan (SDP) as well as a Service NEPA as essential first steps. *It is important to note that neither the "Service NEPA" nor SDP are actually NEPA legal documents; they are only support for an FRA funding application.* A "Service NEPA" has been defined by the FRA as a *landscape level of environmental review that defines from day one the most critical environmental issues before any substantial investments in the corridor are made.* The reason for developing a Service NEPA is to ensure that there are no *obvious* fatal flaws associated with the proposals being submitted to the FRA, and that due diligence and reasonable consideration have been given to the environmental issues associated with the project.

The *HSIPR NEPA Guidance* states that "Several different approaches are available to accomplish Service NEPA," including for advanced projects, "Tiered NEPA (Tier 1 environmental impact statement (EIS) or environmental assessment (EA) followed by Tier 2 EISs, EAs or categorical exclusion determinations (CE)) or non-Tiered NEPA (one EIS or EA covering both service issues and individual project components)"<sup>1</sup>. A large expansive project such as a high speed rail corridor development would typically be addressed in a Tier 1/2 EIS process requiring several rounds of environmental review, such as the multiple EIS's that have been prepared by the California High-Speed Rail Authority, and the Georgia and North Carolina Departments of Transportation. However, it is clear that SDP's and Service NEPA's can only be developed to a level of detail reflecting the stage of development of each project. As projects advance, more detail is needed to support the progressively increasing funding amounts required. Clearly

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<sup>1</sup> Compliance With The National Environmental Policy Act In Implementing the High Speed Rail Intercity Passenger Rail Program, August 2009.  
<https://www.fra.dot.gov/Elib/Document/2319>

a Service NEPA associated with a construction application will have more detail than one associated with an application for EIS Tier 1 funds.

This chapter and Appendices D and E, present a high level Environmental Scan that is intended to give insight into the issues that may be associated with a decision to proceed with further development of the High Speed rail system. An initial “Service NEPA” at this stage should consist of a mapping analysis of environmental factors within the corridors where proposed alignments are likely to be located. A preliminary conceptual analysis is sufficient to show that there are no obvious fatal flaws along the routes that might be developed. Where environmental issues do arise, there should be an understanding of potential mitigation or avoidance strategies. This level of environmental planning ensures that the routes proposed for a Tier 1 EIS are in fact “Reasonable Routes” and that they are likely able to be developed into fully engineered alternatives. Clearly, detailed development of such routes will be part of the Tier 1/2 EIS. Any representative alignments used as the basis of the analysis are highly conceptual and preliminary. The primary reason for considering environmental issues along the corridors is to identify (and avoid) *obvious* fatal flaws, and to develop an order-of-magnitude assessment of potential impacts.

It is expected that this Environmental Scan can serve as a very useful tool for agency outreach to engage discussion, and gain FRA concurrence on the list of reasonable routes that may need to be screened in a potential future Tier I EIS. For doing this, it is essential to identify both the number of alternatives that need to be assessed, and to assess the level of detail at which they will likely need to be evaluated to support a screening determination. This is essential so that the Service NEPA can support the funding application and also aid in planning the actual Tier 1 EIS, including estimating of the level of effort that will likely be needed to complete it. This document therefore, serves as the “bridge” between preliminary Feasibility-level planning and the formal NEPA environmental documentation which is still to come if development of the High Speed rail system is going to be further pursued.

## 2.2 LIST OF DATA COLLECTION AND MAPPING SOURCES

This section identifies the potential list of factors that impact on the community and environment to include transportation, air quality, noise and vibration, energy, land use, socioeconomic factors, community impacts, environmental justice, parklands, farmlands, aesthetics, utilities, contaminated sites, cultural resources, geologic resources, hydrologic and water resources, wetlands, and biological resources (habitats and species). Potential environmental constraints will be reported in the next phase of the study based on the proposed alternatives. A more detailed environmental analysis will be needed once preferred alternatives are assessed in the Tier 1/EA analysis. Exhibit 2-1 provides an overview of the list of data collection elements that will be discussed in the following report sections and in Appendix D, which provides an update to the environmental scan level data presented in the “*Hampton Roads Passenger Rail Study Data Collection – Phase 2A Norfolk – Hampton Roads Corridor*” report submitted by TEMS in March 2013. The following sources provided significant input to the development of this chapter and Appendix D:

- NEPA Guidance: Compliance with the National Environmental Policy Act in Implementing the High-Speed Intercity Passenger Rail Program.
- Service NEPA Environmental Assessment Chicago-Detroit/Pontiac Rail Corridor Improvements From Chicago, Illinois to Pontiac, Michigan by Michigan DOT.
- Richmond to Hampton Roads Passenger Rail Study, Tier I Environmental Impact Statement, Virginia DRPT.
- Passenger Rail Investment and Improvement Act of 2008 (PRIIA).

Exhibit 2-1: List of Elements and Data Sources

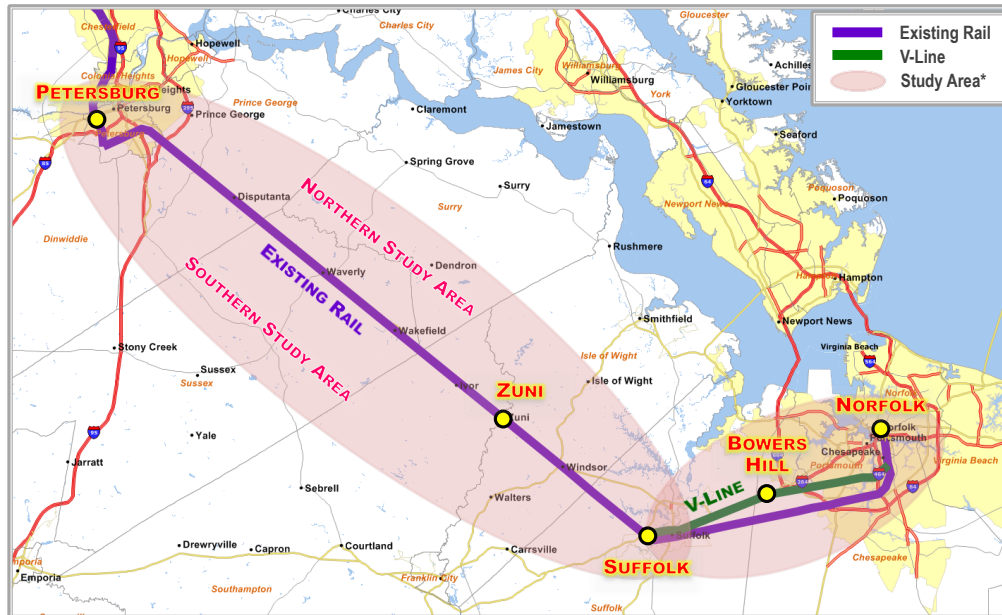
Data Element	Source
<b>Geographic Boundaries:</b> State, County, Census tract, Census Block Group, City, MPO, MSA, Congressional Districts, Community Facilities	US Census Bureau: 2009 TIGER/ Line Shapefiles and Virginia Department GIS, National Transportation Atlas Database (NTAD)
<b>Cultural Resources:</b> Parks, Wildlife Refuge, Heritage preserves, Archaeology resources, Historical resources, Federal lands, etc.	Virginia Department of Conservation and Recreation (DCR), United States Department of Agriculture Forest Service National Park Service U.S. Department of the Interior U.S. Fish and Wild life Service VA DCR: Natural Heritage site Virginia Department of Forestry
<b>Ecology:</b> Wetlands, Hydric Soils, Streams, Waters of US, State waters, Federally protected species, State protected Species, Critical stream habitats, Migratory bird habitat, floodplain encroachment/impacts, coastal zone encroachments	Virginia Department of Game and Inland Fisheries, National Wetlands Inventory, US Fish & Wildlife Service, Virginia Department of Conservation and Recreation: Land Conservation Data Explorer, VA Natural Landscape Assessment (VaNLA)
<b>Hazardous Materials</b>	Virginia Department of Environmental Quality, US EPA
<b>Air Quality</b>	Environmental Protection Agency
<b>OTHER (Satellite Imagery, Street Views, Land Parcel Data, etc.)</b>	Google Earth, Bing Maps, Henrico Co. Parcel Viewer, Richmond Parcel Mapper.
<b>Noise and Vibration,</b>	<i>High-Speed Ground Transportation Noise and Vibration Impact Assessment</i> , U.S. Department of Transportation, Federal Railroad Administration, Washington, DC, December 1998 standards, and Richmond to Hampton Roads Passenger Rail Study, Tier I Environmental Impact Statement, Virginia DRPT.
<b>Utilities,</b>	Aerial photographs and mapping available from several internet sites (Google Earth, Bing Maps) site specific photographs, and Richmond to Hampton Roads Passenger Rail Study, Tier I Environmental Impact Statement, and Virginia DRPT.
<b>Environmental Justice,</b>	U.S. Census
<b>Geology and Soil,</b>	U.S. Geological Survey (USGS) maps, Virginia Department of Conservation and Recreation: Land Conservation Data Explorer.
<b>Transportation,</b>	U.S. Census, National Transportation Atlas Database (NTAD)
<b>Land Status, land Use, and Zoning,</b>	U.S. Census, Henrico County Parcel Viewer, Richmond Parcel Mapper (Zoning-City of Richmond)

<b>Socioeconomic Conditions, and</b>	U.S. Census
<b>Public Health and Safety:</b> Railroads grade crossings, Pedestrians and Rail operations	Federal Highway Railroad (FRA) and Federal Highway Administration (FHWA)

## 2.3 ENVIRONMENTAL STUDY AREA

The Environmental Study Area is defined by the potential region or area within which potential rail alignments might lie and for which environmental data must be collected. For the preliminary step of data collection in Phase 2(A), an environmental study area from Norfolk to Petersburg was defined and landscape environmental data such as cultural resources, ecology, hazardous materials, air quality, noise and vibration, utilities were collected at a landscape level.

**Exhibit 2-2: Original Environmental Study Area\* - Phase 2(A) Study**

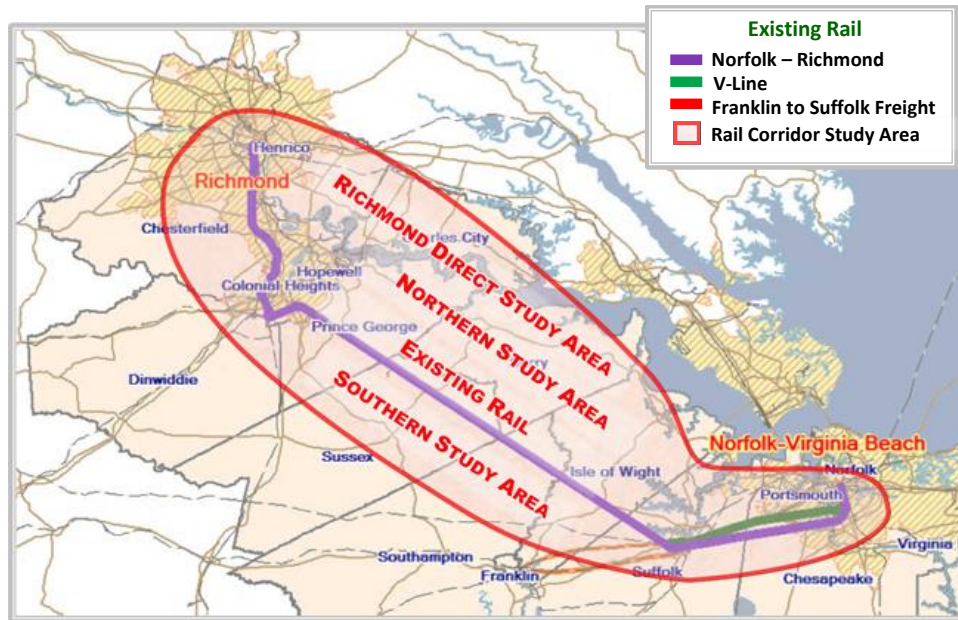


In the Phase 2(B) study, the environmental study area had to be expanded to allow for development of the “Richmond Direct (Option 3)” route as described in Chapter 1. The environmental study area was extended from Hampton Roads to Richmond, VA and data collection and the resulting tabulations in *Appendix D: Environmental Scan (Updated)* were updated. Exhibit 2-3 shows the expanded environmental study area that was used in the original Phase 2(B) study<sup>2</sup>. For assessing the feasibility of High Speed rail service from Norfolk to Richmond, multiple route options were developed at the feasibility level within this study area. The results given in Appendix D are based on this area.

<sup>2</sup> U.S. Census and 2009 TIGER/Line shapefiles provide information on state, county, city, and MPO boundaries for the State of Virginia and these sources were used in specifying boundaries for the Norfolk to Richmond Environmental Study Area. The counties and independent cities considered in the Norfolk to Richmond Study Area are as follows: Henrico Co., Chesterfield Co., Richmond City, Charles City Co., Colonial Heights (city), Hopewell (city), Petersburg (city), Prince George Co., Dinwiddie Co., Surry Co., Sussex Co., Isle of Wight Co., Southampton Co., Franklin (city), Suffolk (city), Portsmouth (city), Norfolk (city), Chesapeake (city), and Virginia Beach (city). This study area was taken as the base for preparing all environmental database maps for the Phase 2B Study.



Exhibit 2-3: Norfolk to Richmond Environmental Study Area (Original Phase 2B)



Subsequently HRTPO Supplemented Phase 2(B) to fully assess “Richmond Direct Improved (Option 4).” This was originally developed only as a sensitivity option in the original Phase 2(B) study, but HRTPO asked for a higher level of certainty on the Capital Costs in the draft report, adding Option 4 for providing enhanced passenger rail to the Peninsula<sup>3</sup>. The previously approved Phase 2(B) report and the Supplemental work for the Peninsula were combined together to complete the Hampton Roads High Speed Passenger Rail Vision Plan Alternatives Analysis.

It should be noted that a number of potentially viable routes have been identified for each segment, but only one representative Peninsula route has been developed here. Additional alternatives are suggested for scoping the Tier I EIS. As a result, we do not claim that the representative route is optimal<sup>4</sup> or that it will ultimately be selected by the environmental analysis. If other routes turned out to be better than the one suggested, then the current study assumptions would be conservative. This is appropriate for the current stage of project development, and is sufficient for confirming the capital costs.

<sup>3</sup> It should be noted that the original Phase 2(B) capital costs had \$0 for the Peninsula (due to the initially restricted Scope of Work) and that Washington D.C. to Richmond costs were scaled from the earlier 2010 Vision Plan, brought to current dollars. Those 2010 costs had been benchmarked on the basis of similar greenfield routes but without the benefit of route specific analysis. To bring the Peninsula capital costs up to a Feasibility level required a fundamental reexamination and refinement of the assumptions that had been made by the 2010 study.

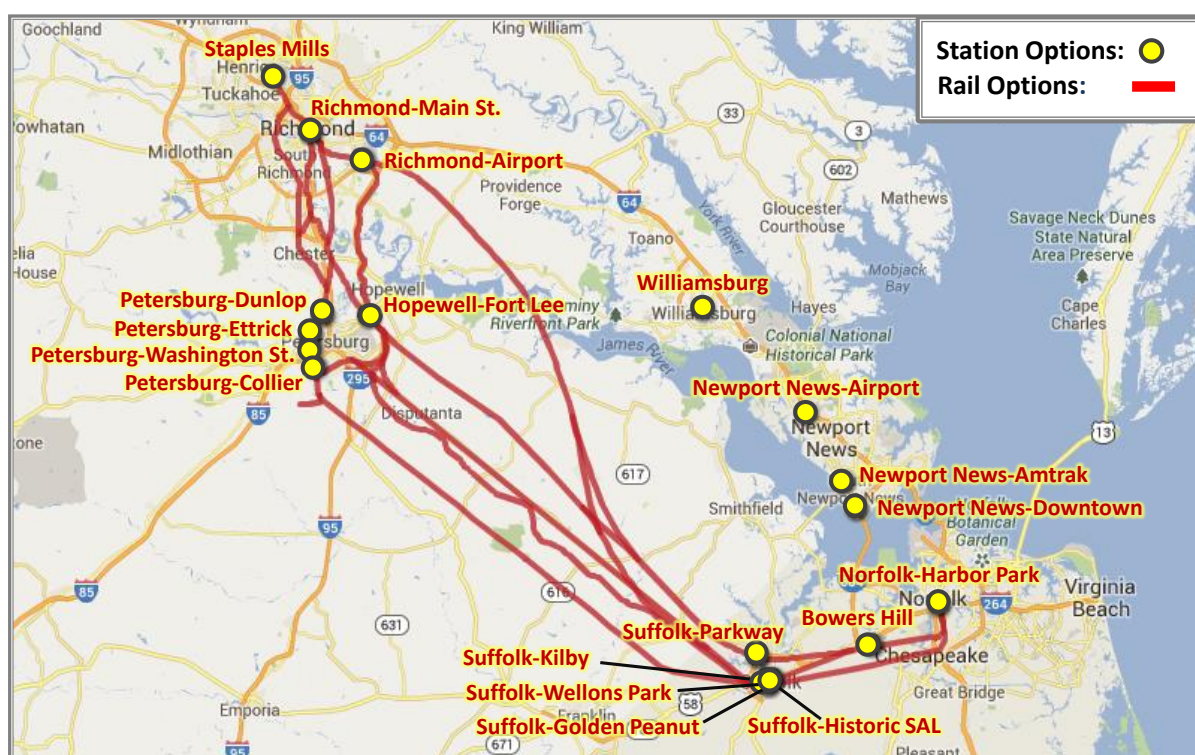
<sup>4</sup> Such a determination would require much more detailed environmental study and the development of a full alternatives analysis, which would be performed during the Tier I EIS evaluation.

## 2.4 ROUTE OPTIONS

### 2.4.1 Potential Route Options from Norfolk to Richmond

The route options from Norfolk to Richmond are derived from the Phase 2(B) assessment. From Norfolk Harbor Park station to the proposed Portsmouth suburban station at Bowers Hill, all options share a common routing over the Norfolk Southern “V”-Line. Alignment options west of Bowers Hill include the possibility of adding track to the existing NS\* rail corridor, as well as potential Northern, Southern, and Richmond Direct greenfield options<sup>5,6</sup>. Exhibit 2-5 shows all the route and station options that were initially considered for the Norfolk to Richmond segment. Some options were screened early on, while the surviving options were defined to a greater level of detail.

**Exhibit 2-5: Potential Rail Routes\* in the Norfolk to Richmond Corridor**



*\*Alignments will not be determined until the Tier II Environmental Process is complete.*

\*Any use, implied, explicit, or otherwise, of NS right-of-way will be subject to the concurrence of NS, and to NS' Passenger Rail Policy which governs the speed of passenger rail trains utilizing it or encroaching upon it.

<sup>5</sup> A Greenfield is a brand-new proposed rail line where no rail line ever has existed. This contrasts with upgrades to an existing rail corridor, or the restoration of an abandoned rail corridor, since the locations of existing or abandoned alignments are known for sure. We have identified potential corridors for conceptual Greenfield options both north and south of the existing NS rail line, but have not located the alignments precisely.

<sup>6</sup> This follows the approach of the US 460 highway study, which in addition to assessing the possibility for improving the existing US 460 highway, also developed one greenfield option north, and one greenfield option south of the existing highway. This level of environmental assessment was considered adequate for locating a new highway and resulted in a Record of Decision, so it was thought that it should be appropriate for locating the rail line as well. However, one additional option (Richmond Direct) has been refined and developed based on feedback received through the stakeholder involvement process.

From Petersburg to Richmond, Southeast High-Speed Rail (SEHSR) currently plans to add one additional track following the CSX existing “S-Line” rail corridor into Richmond. The current Amtrak “A Line” routing from Petersburg directly to Staples Mill was not considered for this study, since it bypasses downtown Richmond. Adding Norfolk trains to the already planned service using the “S-Line” may necessitate adding a second additional track to at least parts of that alignment. Since this option has already been well-studied in the SEHSR process, it was not assessed in detail here; but, the current SEHSR plan does allow room for an additional track to be added. Based on stakeholder advice, it is believed that the incremental environmental impacts of doing this would be minimal beyond those impacts that have already been identified for the basic SEHSR improvements. If it were decided to carry this option forward in a Tier 1 NEPA evaluation it would be necessary to coordinate the impacts of adding a Norfolk service with the SEHSR environmental process. However, following SEHSR into Richmond would limit speeds to 90 mph all the way from Petersburg to Richmond; and as such, would not allow true high speed service.

Possible rail use of the proposed new US 460 highway corridor, also shown in Exhibit 2-5, was considered. Unfortunately, the curves along the proposed new US 460 are too sharp for passenger trains to effectively use the alignment. Conversely, the grades are too steep for freight trains, particularly at certain highway interchanges where the freeway is planned to overpass local roads. The geometric requirements for adding a freight track could not be accommodated without redesigning those interchanges to reduce grades, by taking local roads over the freeway. As a result, the alternative of using the US 460 highway alignment for either freight or passenger rail was not considered further.

The focus of the current study has been to identify options that could allow for truly high speed (125 mph or greater) service except in densely built up urban areas, where the need to share existing rights of way<sup>7</sup> is likely to constrain speed. Three main route options have been developed utilizing a combination of greenfield and existing rail rights of way: via Petersburg, Hopewell and Richmond Direct.

For the Petersburg and Hopewell options, variants have also been developed based on the existing NS rail corridor. Normally, geometric issues would prevent a true high speed service operating along an existing rail alignment, but in this highly unusual situation the existing alignment is arrow-straight from Suffolk to the outskirts of Petersburg. This suggests at least the possibility of developing a high speed service within or close to this right-of-way, in concurrence with NS policy, so a preliminary assessment has been performed.

**Southern Option 1 via Petersburg:** As shown in Exhibit 2-6, two route variants were developed from Norfolk to Richmond via Petersburg. Option 1A, a ***Southern Greenfield***, was developed that could use a portion of the abandoned “Virginian” right-of-way from Suffolk west to the vicinity of Walters, VA, where it would turn northwesterly on new alignment to Petersburg<sup>8</sup>. Option 1B is based on the existing Norfolk Southern rail alignment from Suffolk to Petersburg (Collier). For linking the NS Option 1B over to Petersburg, at Poe there is a need to grade separate both the NS Main Line rail crossing as well as I-295. Implementing this grade separation would likely require either a tunnel or a high level bridge. Continuing from Poe to Collier, residential and commercial development encroaches tightly on the Petersburg Belt line right-of-way; so significant property taking might be needed to widen the corridor. North of Petersburg to Richmond, a high speed option was developed to improve geometry compared to the existing CSX rail corridor. An East Shore Greenfield would leave the CSX corridor north of Dunlop, parallel I-95 for a short distance

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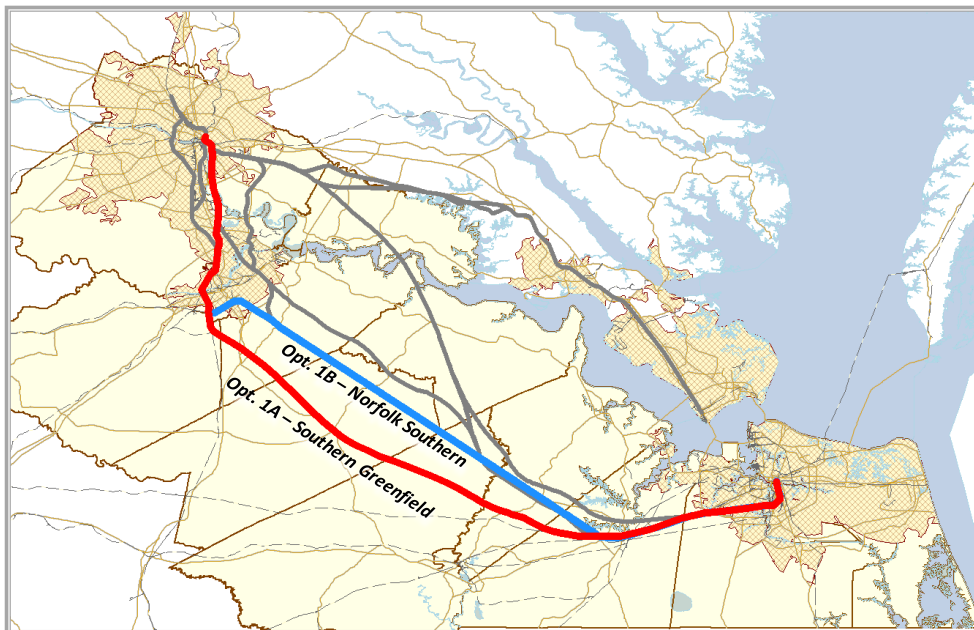
<sup>7</sup> This is characteristic of California’s “Blended” approach <http://www.caltrain.com/projectsplans/CaltrainModernization/BlendedSystem.html> which has also been typical of the way European high speed systems have been developed, by following existing rail alignments into urban areas.

<sup>8</sup> However, the Country Club of Petersburg and Richard Bland College were seen to both lie across the path of a direct rail alignment. This particular conflict could be eliminated by shifting the option farther south to Burgess. It must be emphasized however, that this Southern routing has not been precisely located. The current analysis only suggests that it may be possible to avoid some obvious obstacles south of the existing rail alignment. It does not suggest any precise location for the alignment.



and then cross to the east shore of the James River in the vicinity of Osborne Landing. From there, it would traverse relatively undeveloped farmland on the east shore of the James River, skirting but not directly impacting the Richmond National Battlefield Park, and then rejoin the CSX existing rail alignment (Peninsula Subdivision) in the vicinity of the Fulton Gas Works. From here, the alignment would fly over the CSX tracks to the north side, and approach Richmond Main Street station from the east, rather than from the south. Conceptually, the SEHSR could also choose to share the East Shore Greenfield in lieu of developing the currently planned “S”-Line approach via Centralia.

**Exhibit 2-6: Petersburg Rail Options 1A and 1B**



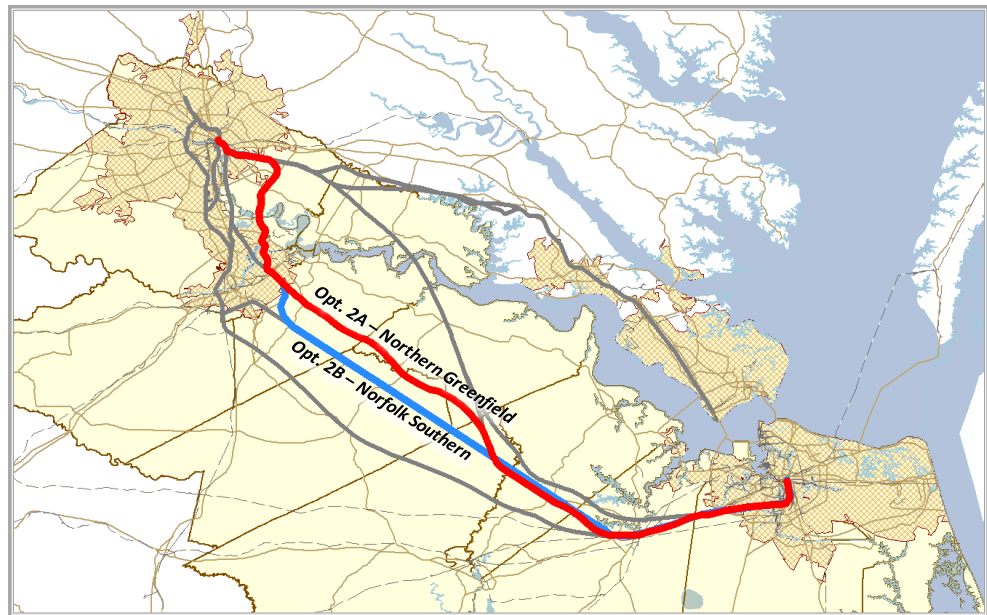
- **Northern Option 2 via Hopewell:** As shown in Exhibit 2-7 two route variants were developed from Norfolk to Richmond via Hopewell. Option 2A, a **Northern Greenfield**, was developed that would enter the I-295 median south of Fort Lee.<sup>9</sup> Option 2B is based on the existing Norfolk Southern\* rail alignment from Suffolk to Petersburg (Poe). Option 2B would connect to I-295 where the railroad alignment passes under I-295 on the east side of Petersburg.

From Fort Lee north, it appears that the most practical approach would be to follow I-295 north to where it crosses the CSX Peninsula Subdivision line just east of Richmond Airport. The option would then parallel the CSX Peninsula Subdivision on the north side into downtown Richmond. The alignment would also approach Richmond Main Street station from the east, rather than from the south. Conceptually, the SEHSR could also share this alternative by constructing a connecting greenfield from Burgess to the junction of I-95 and I-295, then following the I-295 median north.

<sup>9</sup> Since most of the Norfolk ridership will be headed north towards Richmond and Washington D.C., a northerly alignment would tend to be shorter and more direct. From Suffolk to Zuni, a new rail alignment could either parallel the existing NS rail line or follow an existing electric utility right-of-way. Beyond Zuni the proposed alignment would cross to the north side of the existing rail alignment and head towards Prince George, VA. The Northern Greenfield would line up with I-295 and follow the highway past Fort Lee. A challenge to the development of any northerly option is how to get through the heavily built-up urban area which covers the whole area from Petersburg to Hopewell on the west shore of James River. However, the I-295 median could provide a possible alternative passageway through the area.

\*Any use, implied, explicit, or otherwise, of NS right-of-way will be subject to the concurrence of NS, and to NS' Passenger Rail Policy which governs the speed of passenger rail trains utilizing it or encroaching upon it.

**Exhibit 2-7:  
Hopewell Rail  
Options 2A and  
2B**



As a result, it can be seen that the Southern Greenfield is logically paired with the East Shore Greenfield in Option 1; while the Northern Greenfield is paired with I-295 in Option 2. The Norfolk Southern\* variant<sup>10</sup> could pair with either the East Shore Greenfield (via Petersburg) or I-295 (via Hopewell) north to Richmond.

The possibility of constructing a hybrid option “1/2” by pairing the Northern Greenfield with the East Shore Greenfield was considered. Making this connection would require construction of a high speed rail alignment directly across the Fort Lee grounds, which are used for active military training. It is not clear that crossing Fort Lee is even feasible, and a preliminary review of this option does not show any clear environmental or operational advantages to doing this. Adding this option into the study would only appear to make sense if some fatal flaw were found in the I-295 opportunity. Given the difficulties associated with crossing the Fort Lee grounds, it is likely that this hybrid option of linking the Northern Greenfield to the East Shore Greenfield will be screened early in the Tier 1 NEPA evaluation.

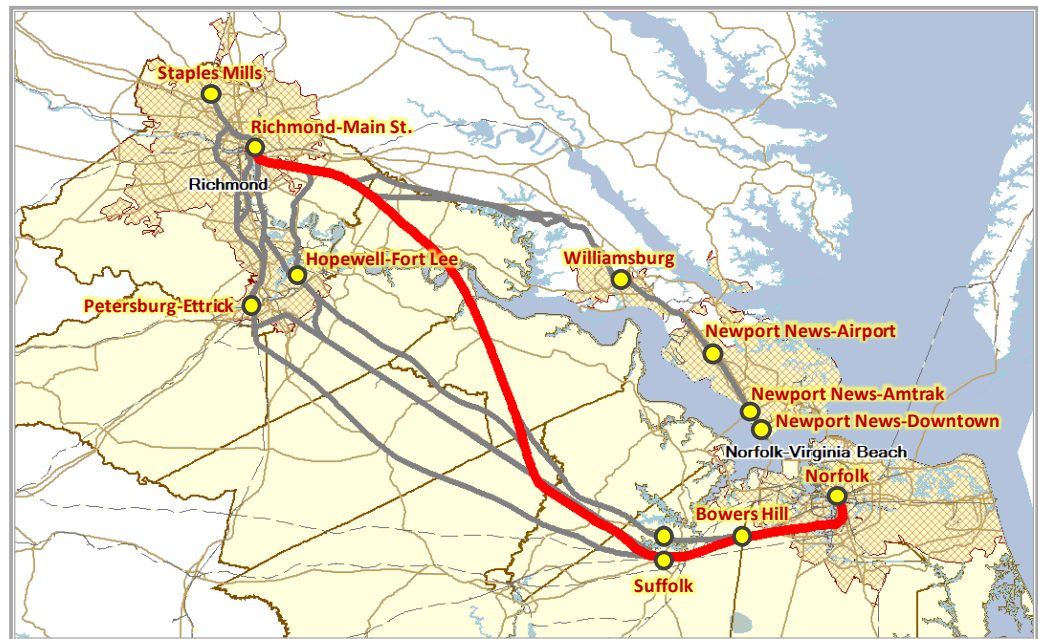
- **Option 3 – Richmond Direct:** shown in Exhibit 2-8 foregoes the benefit of serving intermediate markets at Petersburg and Hopewell, but it also avoids the high costs and environmental issues associated with developing urban infrastructure and sharing either the SEHSR (CSX rail) or I-295 (highway) alignments through Petersburg or Hopewell. The **Richmond Direct** option instead relies on the planned SEHSR service to serve Petersburg. Bypassing this area with its potentially high development cost could potentially offer the fastest, most direct and most cost effective way to connect south Hampton Roads to Richmond and the large cities of the Northeast Corridor.

<sup>10</sup> From Suffolk to Petersburg, a Norfolk Southern variant of Options 1 and 2 was considered. The key element of this analysis was a sensitivity analysis of the adoption of various corridor widths or “footprints” for adding passenger tracks to the existing rail corridor. This suggested the technical possibility of squeezing up to four tracks within a 100’ wide right-of-way, with a 30’ minimum separation between active freight and passenger tracks, or a 120’ wide right-of-way with a 50’ minimum separation. A key finding was that footprints wider than 120’ would result in excessive property taking and significant wetland impacts. These would produce an uncompetitive environmental profile as compared to available greenfield options. As a result it is not likely that any “wide footprint” options will survive preliminary screening in a NEPA evaluation. However, the analysis also suggests that a “tight footprint” option up to 120 feet wide for the NS existing rail corridor could produce an environmental profile that is competitive to greenfield alternatives, so this option was retained.

\*Any use, implied, explicit, or otherwise, of NS right-of-way will be subject to the concurrence of NS, and to NS’ Passenger Rail Policy which governs the speed of passenger rail trains utilizing it or encroaching upon it.

Doing this also maximizes potential synergies with development of Peninsula service to Newport News, which could utilize the high speed alignment for access to downtown Richmond.

**Exhibit 2-8:**  
**Option 3 -**  
**Richmond**  
**Direct**



From Suffolk to Zuni, the representative alignment would follow the same route as the Northern Greenfield: a new rail alignment could either parallel the existing NS rail line or follow an existing electric utility right-of-way<sup>11</sup>. Beyond Zuni the alignment would cross to the north side of the existing rail alignment and head straight towards Richmond. Crossing the James River in the vicinity of Charles City, the alignment would gently curve west to line up with the CSX Peninsula subdivision east of Richmond Airport. From here, crossing under I-295 and paralleling the CSX Peninsula Subdivision on the north side into downtown Richmond, the alignment would approach Richmond Main Street station from the east, rather than from the south.

The possibility of adding intermediate station stops to serve local communities between Suffolk and Richmond has also been noted. The High Speed service is planning to run enough trains so some trains could stop in Surry County<sup>12</sup> (pop 7,828) and Charles City County<sup>13</sup> (pop 7,256) without harming the overall service objective for the system. Surry County in particular has requested consideration of an added stop. The Surry County Comprehensive Plan identifies only three economic centers: Claremont, Surry and Dendron; of these, the county land use plan suggests that Dendron<sup>14</sup> should become the focus of future Surry County economic development

<sup>11</sup> As part of the Richmond Direct or Northern Greenfield options, a possible alternative around the north side of Suffolk was also considered. Heading west from the proposed Bowers Hill rail station, instead of following the CSX Portsmouth Subdivision into downtown Suffolk, a "Suffolk Bypass" would head straight west across the Dismal Swamp, skirt the Suffolk Regional Landfill and follow US-13 around the northern outskirts of Suffolk. This is attractive because it could potentially allow an electric train to accelerate directly to 220-mph upon leaving the Bowers Hill station. However, because of extensive wetland impacts and to avoid significant property taking, it is likely that a significant portion of this alignment would need to be constructed on elevated structure. Stakeholders did not consider it to be fatally flawed, but an alternative utilizing the CSX Portsmouth Subdivision through downtown Suffolk will likely be much more cost effective. It is expected that the Suffolk Bypass will likely be screened early on in a Tier I NEPA evaluation because of right-of-way issues, wetland impacts and the high cost of the elevated structures that will likely be required.

<sup>12</sup> See: [http://en.wikipedia.org/wiki/Surry\\_County,\\_Virginia](http://en.wikipedia.org/wiki/Surry_County,_Virginia)

<sup>13</sup> See: [http://en.wikipedia.org/wiki/Charles\\_City\\_County,\\_Virginia](http://en.wikipedia.org/wiki/Charles_City_County,_Virginia)

<sup>14</sup> See: <http://www.surrycountyva.gov/uploads/docs/COMPREHENSIVE%20PLAN%20PART%20B.pdf>, p. 64. The town of Dendron is in close proximity to U.S. Route 460 and the Norfolk Southern Rail Line. Dendron will be connected to the Surry County waste water treatment plant in the near future. With the development of a water system, the necessary utilities to permit urban growth will be in place, and Surry County can compete for the economic growth that will be stimulated by the multi-modal transportation development on the county's southern border.



efforts. In Charles City County, the proposed Richmond Direct alignment passes within a mile of the county seat, making Charles City a logical stopping place north of the James River.

Given the current low population of these two counties, stops at Dendron or Charles City have not been shown on the station map in Exhibits 2-5 or 2-8. Presently, adding these stations would not materially impact the ridership forecast, financial or economic projections for the High Speed rail system. If stops were added however, the high speed rail system could contribute significantly to the economic growth of these two counties. Over time as economic growth induces more ridership, these stations might start contributing more significantly to the ridership, financial and economic case for developing the High Speed rail system. The prospects for adding these stations should be assessed more thoroughly in the proposed Tier I EIS.

Please note that these options are more fully developed in Chapter 3. In addition, Appendices D and E contain additional detailed information that is specific to the Richmond-Norfolk route options as background for scoping the proposed environmental study.

#### 2.4.2 Potential Route Options from Newport News to Richmond

The initial Phase 2(B) assessment assumed only Amtrak service with one added daily round trip to Newport News. But it soon became apparent that development of the Richmond Direct option could offer a synergistic opportunity to add a Peninsula connection, so diesel trains from the Peninsula and electric trains from the Southside could share a common entryway into downtown Richmond<sup>15</sup>. This was originally explored only as a sensitivity analysis, Option 4 – Richmond Direct Improved. See Exhibit 2-9.

**Exhibit 2-9:  
Option 4 -  
Richmond Direct  
Improved**



<sup>15</sup> The potential for track sharing depends on which Norfolk option is selected during the environmental process. If the Richmond Direct Option 3 were selected then there is significant sharing potential. If the Northern Greenfield Option 2 via Hopewell were selected, then the final approach inside the I-295 beltway could be shared. However, selecting the Southern Greenfield Option 1 via Petersburg would practically eliminate the potential for Peninsula track sharing, since this alternative enters Richmond from the south rather than from the east. However, all of these options could still share the line from Richmond to Washington, D.C.

This resulted in development of a new concept for linking the Richmond Direct corridor using a new greenfield connection across open countryside to Toano.<sup>16</sup> However, the original 2(B) report was not specific about how a greenfield connection could be made because the option was assessed only as a sensitivity, so the Capital cost was assessed based only on benchmarking.

This report has looked at the development of rail service for the Peninsula, including greenfield alignment issues in more detail. A preliminary environmental scan has been performed and feasibility-level engineering costs have been developed for one representative route from Roxbury to Toano. Specific assumptions for this route will be detailed in Chapter 3. This section provides a high level overview of possible options for developing rail service on the Peninsula. This could be useful in helping define a possible scope for a Tier I EIS that includes greenfield options as well as existing rail alignments.

Exhibit 2-10 presents a concept for developing the Newport News to Richmond corridor in conjunction with Richmond Direct High Speed service to Norfolk:

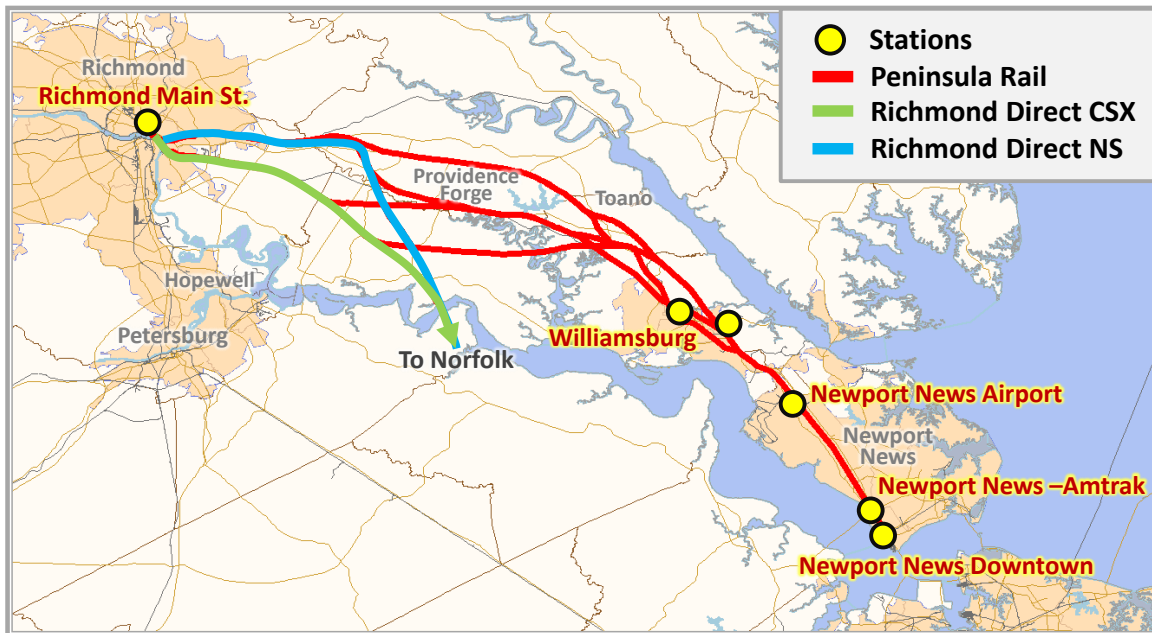
- The Green line on Exhibit 2-10 corresponds to the Richmond Direct alignment that was proposed as part of the original Phase 2(B) work. This alignment crosses the James River on a high-level bridge just south of Charles City, then arcs northwesterly to line up with the CSX tracks entering Richmond south of the airport. Although it would parallel the CSX corridor from the vicinity of I-295, this Richmond Direct option would not share the existing CSX tracks, rather a new double-tracked electrified greenfield would be built on the north side of the existing rail alignment.
- As a new alternative, the Blue line on Exhibit 2-10 corresponds to a “shifted” Richmond Direct alignment, farther east than was envisioned by the original Phase 2(B) study, which would line up with the NS tracks entering Richmond north of the airport. Since the NS entrance into Richmond is only a lightly used branch line, this option assumes that the rail line and right-of-way would be purchased from Norfolk Southern so improved tracks could be constructed on the existing track bed.<sup>17</sup> This is likely to be less costly than greenfield construction and results in an effective Acca Yard bypass. However, it increases the length of the alignment to Norfolk by 5 miles.
- The Red lines in Exhibit 2-10 all correspond to various Peninsula alternatives that might be considered by a future environmental study. These alignments all connect to either the Green or Blue Richmond Direct options for sharing access into downtown Richmond with the Norfolk High Speed trains.

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<sup>16</sup> A connector could be developed as an adjunct to the proposed Richmond Direct alignment, since the countryside between Richmond and Toano is still relatively open. From Williamsburg to Newport News, development density is much higher. This limits available options east of Toano to existing corridors: CSX, I-64, or utility rights of way.

<sup>17</sup> Freight service could still run in the mid-afternoon, evening and night hours since passenger train speeds over this portion of the alignment will be restricted due to geometric concerns. Strict temporal separation would not be necessary because the passenger trains will be able to share tracks with freight trains at under 125-mph, under the proposed FRA Alternative Tier I equipment regulations.

Exhibit 2-10: Potential Rail Routes\* in the Newport News to Richmond Corridor



\*Alignments will not be determined until the Tier II Environmental Process is complete.

For understanding the characteristics of these possible alignments, Exhibit 2-11 shows the Peninsula route options by Right-of-Way type. The selected representative route via Roxbury and Toano is highlighted in Exhibit 2-12.

Exhibit 2-11: Potential Peninsula Route Alignments by Right-of-Way Type

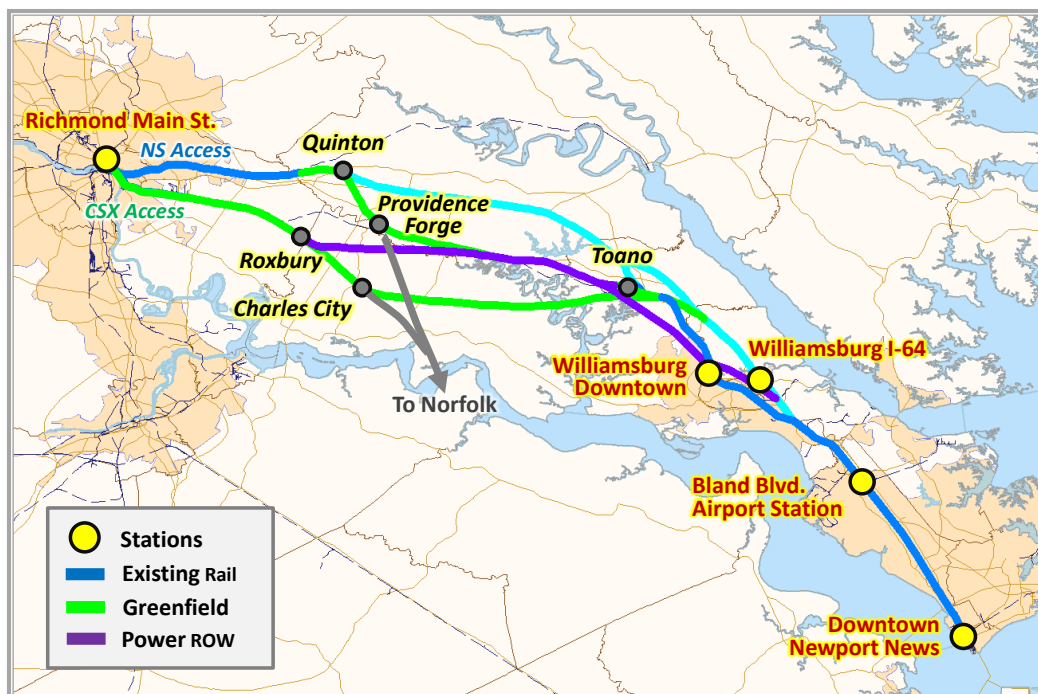
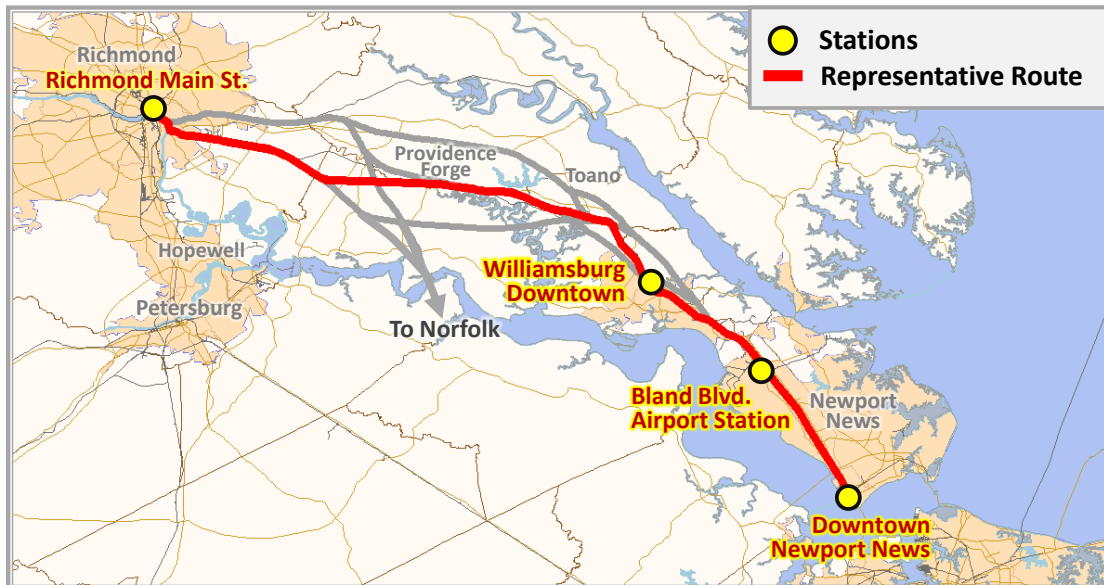


Exhibit 2-12: Peninsula Representative Route via Toano and Roxbury



First, the representative route will be described: Starting in downtown Newport News<sup>18</sup>, the existing CSX rail alignment would be used past the stations at Bland Boulevard and Williamsburg, to Toano. Top speed would be limited to 90-mph in this stretch. From Toano a dedicated alignment would follow a power line right-of-way to Roxbury. Diesel trains could achieve 130-mph on this section, which would be fully grade-separated. From Roxbury the route would join the Richmond Direct 220-mph line shared with Norfolk service, entering Richmond on a new greenfield alignment paralleling CSX past the airport.

It was noted that an existing utility corridor extends all the way from Roxbury through downtown Williamsburg to Busch Gardens (see Exhibit 2-11.) For development of the representative route it was decided to utilize this existing utility corridor<sup>19</sup> from Roxbury to Toano, because it is very straight and minimizes the need for property takes (other than some utility pole relocations, as needed.)

For development of alternatives for the environmental study, it should be noted that just east of Busch Gardens, the CSX alignment comes very close to the I-64 highway allowing a transition to the highway alignment if desired. This was originally proposed by Dodson<sup>20</sup> in his 1993 study of Peninsula rail options. Dodson proposed only to use I-64 to bypass the curvy stretch of track through downtown Williamsburg, from Busch Gardens to Toano. At Toano, Dodson's 1993 alignment returned to the CSX rail alignment, rather than continuing on I-64 all the way to Richmond.

However, VDOT plans to add lanes to I-64<sup>21</sup> which may conflict with potential rail use of the corridor. Initial plans are only to add lanes from Jefferson Avenue (exit 255) to Lee Hall (exit 247), but these may eventually extend as far as Lightfoot, west of Williamsburg.

<sup>18</sup> For the purpose of this study, it is assumed that Peninsula rail service will start at a new downtown Newport News station, stop at Bland Boulevard and continue on to Williamsburg. This is consistent with current official HRTPO planning documents, see: <http://www.hrtptip.org/PDFs/T9097.pdf> as well as previous DRPT plans for development of Peninsula rail service. The FRA Record of Decision <http://www.fra.dot.gov/ELib/Document/2710> for the current DRPT Tier I FEIS is based on current Amtrak stations on the Peninsula, but leaves final station selection up to the municipalities, saying that: *Specific station sites will be determined in the future by the municipalities, and appropriate levels of environmental documentation will be undertaken at that time.*

<sup>19</sup> An alternative greenfield from Toano to Charles City crosses the Chickahominy River farther south where the river is still navigable, and would likely need a high level bridge crossing. Property takes are also a concern for the Charles City alignment. Farther north along the utility corridor to Roxbury, there is a need to span wetlands but not navigable river.

<sup>20</sup> Richmond - Hampton Roads Passenger Rail Project Tier I Final Environmental Impact Statement (EIS), DRPT, August 2012, see <http://www.fra.dot.gov/ELib/Details/L03722> and Preliminary Engineering Feasibility Study, D. W. Dodson, August 1993, see Appendix G.

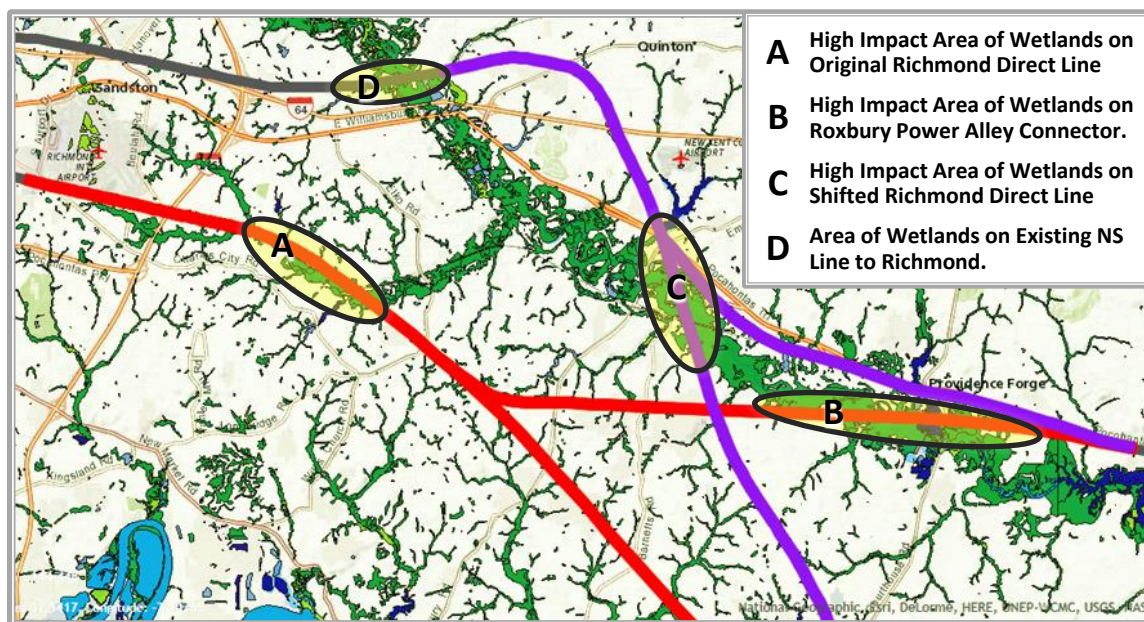
<sup>21</sup> See: <http://wydaily.com/2014/05/01/vdot-hosts-public-hearing-on-i-64-widening/>



- From Busch Gardens to Toano, the I-64 median is approximately 85' wide, which if highway lanes were added may not leave enough room to also fit rail tracks into this segment of the corridor.
- Further west from Toano to the I-295 Junction at Quinton, the I-64 median widens to 250-300' most of the way, although it narrows to 125' as I-64 approaches I-295. Because of this wide median, rail development may be easier along west end of I-64 between Toano and the I-295 Junction, than it will be along the central portion from Busch Gardens to Toano.<sup>22</sup>
- For connecting an I-64 option to downtown Richmond, it should be noted that I-64 joins the Norfolk Southern (NS) alignment east of Richmond. As a result it makes more sense to use the NS entry into Richmond rather than CSX in conjunction with an I-64 option.

So as not to preclude future consideration of an I-64 option, the possibility for shifting the Richmond Direct alignment eastward and northward to enter Richmond via NS rather than CSX has also been considered. This has both advantages as well as disadvantages; a full environmental analysis will likely be needed to discriminate the differences.

**Exhibit 2-13: Wetland Crossings associated with Peninsula Alternatives**



As shown in Exhibit 2-13:

- The original Richmond Direct alignment parallel to CSX (red line in Exhibit 2-13) crosses an area of wetlands in area A. This will need to be mitigated by bridging the wetlands and by using environmentally sensitive construction<sup>23</sup>. Adding a Peninsula connection from Toano to Roxbury introduces a second area of wetlands, area B, which will also need to be mitigated by bridging.

<sup>22</sup> Detailed discussion with VDOT is needed to find out whether any portion of I-64 may have room to accommodate a rail alignment. This should be done as part of the environmental process. To stand any chance of preserving a possible I-64 footprint for a rail alignment between Busch Gardens and Toano, early consultation with VDOT is needed. Unless a right-of-way reservation is preserved, highway development will likely consume the needed right-of-way between these points.

<sup>23</sup> See *Low Impact Development* at <http://water.epa.gov/polwaste/green/>



- The shifted Richmond Direct alignment utilizing NS (purple line in Exhibit 2-13) crosses an area of wetlands in area C. This will need to be mitigated by bridging the wetlands. By linking from Toano to Providence Forge or using I-64 median, the Peninsula connection remains north of the wetlands.<sup>24</sup> The shifted Richmond Direct alignment also has a second wetland crossing at area D. However, this second crossing has already been compromised by the existing railroad fill so it likely would require at the most, retaining walls to widen the footprint with minimal wetland impact.<sup>25</sup>

In summary, it is recommended to maintain flexibility at the current time since the optimal location for the Richmond Direct alignment may also be dependent on the environmental issues associated with developing a Peninsula greenfield connection. The two should be jointly optimized. While shifting the Richmond Direct alignment east and north may reduce wetland impacts, it may also increase the need for direct property takes. In addition, shifting the alignment north and east would add five miles to its length, which will cause an undesirable perpetual increase in operating cost and transit time. The ability to use any part of the I-64 highway or Norfolk Southern rail alignment is not known at this time. These issues are too complex to be resolved at the current level of study and so will need a full environmental analysis to be sure of locating the optimal alignment.

#### 2.4.3 Hypothetical Route Options from Richmond to Washington D.C.

For updating the capital costs, it has been necessary to estimate costs for one representative route from Richmond to Washington D.C., since a greenfield alignment north of Richmond forms an essential component of the Hampton Roads corridor. A high quality alignment north of Richmond is needed to support High Speed rail service to the Southside and Enhanced Passenger Rail on the Peninsula, as called for by HRTPO Board Resolution #2009-05. The current study scope did not enable the development or environmental review of any actual alignments north of Richmond. However, a very preliminary mapping analysis had already been conducted for establishing costs for the 2010 study along with a review of published reports. For satisfying our due diligence obligation is regard to representation of financial and economic results for the overall corridor, this earlier analysis was brought up to date.

A preliminary assessment suggests that a broad range of options may exist for linking Richmond north to Fredericksburg, through mostly rural lands. North of Fredericksburg the options are much more limited. In concept, many different combinations of greenfield, electric utility right-of-ways, highway and existing rail alignments, may be assembled for developing route alternatives between Richmond and Washington D.C. A comprehensive assessment will require a full environmental study. However, to preserve the potential for developing greenfields, such a study should be undertaken with some urgency. Even if actual construction may be some years away, it is important to establish the needed right-of-way reservations by including them in local master plans *before* development further encroaches open land areas. Moving expeditiously to preserve rights of way will minimize the cost escalation that California's rail system reported.<sup>26</sup>

<sup>24</sup> This link to Providence Forge will likely have more property taking impacts than the representative alignment that follows power line right-of-way to Roxbury, but less wetlands impacts.

<sup>25</sup> However, we cannot be sure of this without a detailed engineering analysis. If it is not possible to share the existing NS right-of-way but rather need to develop a new dedicated alignment parallel to the existing rail line, the added width of the right-of-way on this wetland crossing will likely undermine much of the environmental benefit. This will have to be assessed by a future study.

<sup>26</sup> See: [http://www.hsr.ca.gov/docs/about/business\\_plans/BPlan\\_2012Ch3\\_Cap\\_Cost.pdf](http://www.hsr.ca.gov/docs/about/business_plans/BPlan_2012Ch3_Cap_Cost.pdf) "The initial program planning predated much of California's real estate boom in the mid-2000s. Large expanses of vacant or under-utilized property, over which the system would have operated at-grade, have since become bustling communities, suburbs, and roadways. California added nearly 5 million people between 2000 and 2010, with much of this growth along the project route. In many areas, the alignment has had to be relocated, elevated on bridges, or placed in tunnels to avoid severe community impacts and to navigate through densely populated urban areas. In addition, more detailed investigations during Preliminary Engineering have identified challenging geologic and geotechnical conditions, floodplains, and differences in terrain that required realignment of the route or more expensive design approaches."

## 2.5 TRAIN TECHNOLOGY OPTIONS

The key element for developing an operating plan is the technology selection from a range of alternative technologies available. In the case of the slower speed alternatives (79-110 mph), the most effective option is using existing railroad rights-of-way and where the volume of freight rail traffic is limited, to share tracks with freight traffic. As speeds and frequency of passenger rail service increase, the ability to share tracks with freight becomes more limited, although if wide enough the right-of-way may still be shared. For very high speeds the ability to even use existing railroad rights-of-way is typically lost. Of course, sharing track or using freight rail right-of-way may still occur (at lower speeds) in urban areas to gain access to downtown stations, but away from the urban area true high speed service is likely to require a greenfield route – since high speed rail operations need long stretches of straight track and very gentle curves to achieve high speed. Even sharing Interstate highway right-of-way may not be possible since they frequently have curves that are too tight for the faster trains. In general, faster systems have fewer stops. A compromise may be needed to ensure all key communities are served, but this results in a trade-off between end-to-end speed and connecting communities. Each station stop takes three to seven minutes (including deceleration, stop time and acceleration back to speed) so multiple stops soon dramatically increase end-to-end running times.

A key study assumption that determines transit time is a passenger car's "tilt" or "non-tilt" design. The track in curves is typically banked (super-elevated) up to six degrees (6° or 6"), which results in designation of a balance speed for each curve (at which speed a vehicle occupant would feel no sideways force in the curve). However, up to four degrees (4° or 4") of imbalance (cant deficiency) is acceptable for passenger comfort. Beyond this, onboard hydraulic systems (active tilt) or car suspension designs (passive tilt) can permit even higher speeds, by lowering the centrifugal forces felt inside cars.

True high speed trains typically do not include tilting mechanisms, because the allowable cant deficiency reduces to only 2.5 degrees (2.5° or 2.5") at 220 mph<sup>27</sup>. This limitation on cant deficiency at the wheel-rail interface eliminates the benefit of tilt for true high speed rail. It should be noted that the geometric standards for interstate highway alignments generally allow speeds of 125-150 mph, which are in the effective range for tilting trains, but the curves are usually too sharp to support true high speed trains (186 mph+). As a result, high speed trains need very gentle curves, which are typically only obtained through development of new "greenfield" alignments. Tilting capability may still be beneficial to high-speed trains however, on shared segments of existing line on urban approaches, or for extended operations beyond the limits of the high speed territory.

Another key issue for determining the suitability of train technology is compliance with FRA safety requirements. The FRA Tier I safety requirements allow speeds up to 125 mph. More stringent Tier II requirements are applied to passenger trains operating with speeds 125-150 mph. The FRA Railroad Safety Advisory Committee (RSAC) recently announced "Alternative Tier I" compliance standards<sup>28</sup> that could make it easier to adapt European train designs to meet United States requirements.

**Conventional Rail – 79 mph or less:** Conventional trains, as shown in Exhibit 2-16, typically operate at up to 79 mph on existing freight tracks. 79 mph represents the highest speed at which trains can legally operate in the United States without having a supplementary cab signaling system on board the locomotive. The key characteristics of these trains are that they:

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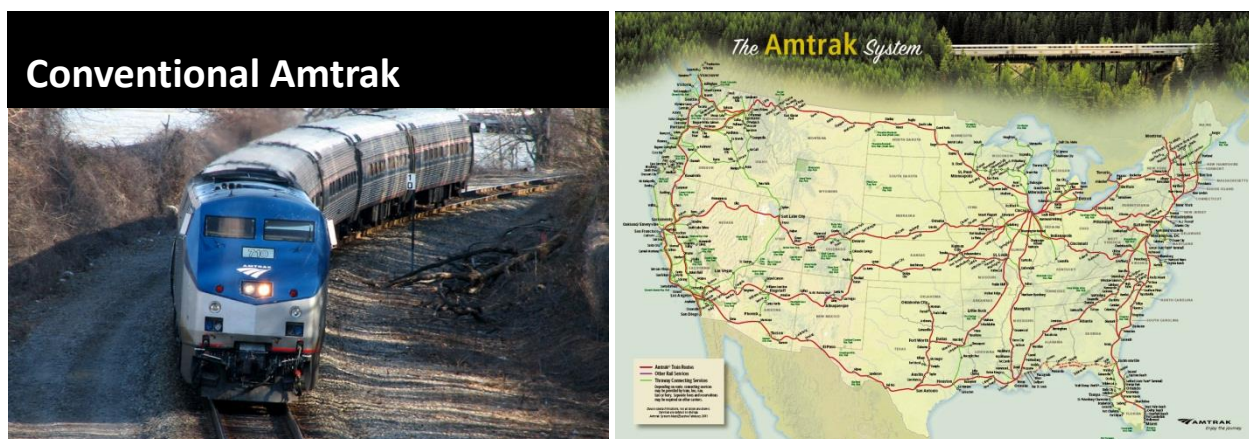
<sup>27</sup> See: <http://www.scribd.com/doc/24548877/High-Speed-Railway-Lines-en>

<sup>28</sup> Railway Track and Structures, <http://www.rtands.com/index.php/track-maintenance/off-track-maintenance/rsac-recommends-passenger-rail-crashworthiness-standards-to-accommodate-hsr.html>

- Are designed for economical operation at conventional speeds
- Can be diesel or electric powered
- Are non-tilting for simplified maintenance

Conventional rail is used for example by Amtrak in corridors across the country outside the Northeast corridor. Such trains do operate at up to 110 mph in developing corridors in Illinois and Michigan, but they need an extra locomotive in order to attain satisfactory acceleration or braking performance. The high center of gravity of the P-42 locomotive limits its safe speed around curves, as compared to higher speed trainsets, which are designed to have a lower center of gravity.

**Exhibit 2-16: Conventional Rail – Representative Trains and Corridor Service**



**Higher Speed Rail - 110-130 mph:** A 110 to 130-mph service can often be incrementally developed from an existing conventional rail system by improving track conditions, adding a supplementary Positive Train Control safety system, and improving grade crossing protection. Tilt capability, built into the equipment can be used to allow trains to go around curves faster, and has proven to be very effective for improving service on existing track, often enabling a 20-30 percent reduction in running times. Trains operating at 110 mph, such as those proposed for the Midwest, Ohio Hub and New York State systems (See Exhibit 2-17), have generally been found to be affordable, produce auto-competitive travel times, and are able to generate sufficient revenues to cover their operating costs.

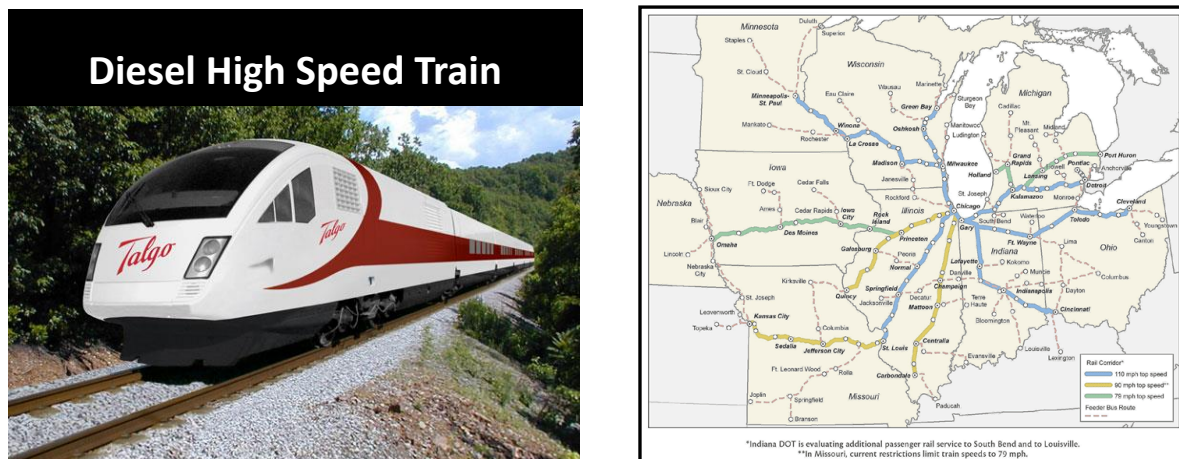
Higher speed trains:

- Are designed for operation above 110 mph on existing rail lines and diesel trains can attain sustained speed of 130 mph on dedicated grade separated rights of way.
- Can be diesel or electric powered.
- Are usually tilting unless the track is very straight.

In the United States, 110-mph service has been seen to provide a low cost infrastructure option by using existing railroad rights-of-way, and quad-gating crossings, which are relatively low cost options. However, it may contradict some existing freight railroad passenger principles unless additional improvements are made. For example, while Norfolk Southern's passenger principles do not prohibit the operation of higher speed tilting trains, they do prohibit speeds above 79 mph on Norfolk Southern-owned rights of way. CSX policies have generally prohibited operations above 90 mph. To reach 110-mph speeds or higher an alternative arrangement, such as the purchasing of a parallel strip of right way, or

right-of-way easement and separate ownership of the track may be needed to comply with the requirements of the freight railroads.

Exhibit 2-17: High Speed Rail Shared Use (Diesel) – Representative Trains and Corridor Service



**High Speed Rail - 130-220 mph:** The costs of grade separation for 125 mph can easily double the capital cost of a project, as the number of public and private crossings can be as many as two per mile. This is why true high speed rail is typically twice the cost per mile of higher speed rail. Once full grade separation has been accomplished however, speeds can be pushed up to 220 mph by electrification and the use of Electric train systems. This will tend to improve further the economic return on capital investment.

Representative trains include the Amtrak Acela Electric locomotive hauled train as well as the proposed California trainset shown in Exhibit 2-18. While initially the Acela speed was limited to 150 mph, it is now being tested at speeds of 160 mph. However, this concept has been superseded by the joint equipment procurement by Amtrak and the California High-Speed Rail Authority, as well as Amtrak's cancellation of its own intended Acela fleet expansion for the Northeast Corridor. Instead, California and Amtrak intend to collaborate on the purchase of a common fleet of high speed electric trains<sup>29</sup>. It should be noted that in the last twenty years electric high speed train technology has evolved rapidly from 150 mph maximum speed to 220 mph maximum speed. This revolution in train capabilities has been due to rapid advances in the design of the propulsion system of modern electric trains. It is assumed that new electric trains based on the new standards will be able to operate up to 220 mph on dedicated alignment and still be able to comingle with freight trains on the same tracks as needed, at speeds under 125 mph. Both Amtrak and California have produced feasibility and business plans showing the advantage of moving to 220-mph technology.

<sup>29</sup> See: <http://www.amtrak.com/ccurl/620/710/Amtrak-CHSRA-Joint-RFI-HSR-Train-Sets-ATK-13-012.pdf>



Exhibit 2-18: High Speed Rail Shared Use (Electric) – Representative Trains and Corridor Service



Electric HSR – 150 mph



Electric Greenfield HST – 220 mph



### 2.5.1 OTHER ROLLING STOCK AND OPERATIONAL ASSUMPTIONS

Consistent with the assumptions customarily made in feasibility-level planning and Tier I EIS studies, the following general assumptions are proposed regarding operating requirements for the rolling stock:

- Trains will be reversible for easy push-pull operations (able to operate in either direction without turning the equipment at the terminal stations);
- Trains will be accessible from low-level station platforms for passenger access and egress, which is required to ensure compatibility with freight operations;
- Trains will have expandable capacity for seasonal fluctuations and will allow for coupling two or more trains together to double or triple capacity as required;



- Train configuration will include galley space, accommodating roll-on/roll-off cart service for on-board food service. Optionally, the trains may include a bistro area where food service can be provided during the entire trip;
- On-board space is required for stowage of small, but significant, quantities of mail and express packages, and also to provide for an optional checked baggage service for pre-arranged tour groups;
- Each end of the train will be equipped with a standard North American coupler that will allow for easy recovery of a disabled train by conventional locomotives;
- Trains will not require mid-route servicing, with the exception of food top-off. Refueling, potable water top-off, interior cleaning, required train inspections and other requirements will be conducted at night, at the layover facilities located at or near the terminal stations. Trains would be stored overnight on the station tracks, or they would be moved to a separate train layover facility. Ideally, overnight layover facilities should be located close to the passenger stations and in the outbound direction so a train can continue, without reversing direction, after its final station stop; and
- Trains must meet all applicable regulatory requirements including:
  - FRA safety requirements for crash-worthiness,
  - Requirements for accessibility for disabled persons,
  - Material standards for rail components for high speed operations, and
  - Environmental regulations for waste disposal and power unit emissions.

## 2.5.2 SOUTHSIDE ROUTE AND TECHNOLOGY OPTIONS

The three main route options described above (including the two variant options that utilize the Norfolk Southern alignment), have been assessed at two maximum train speeds: 130 mph and 220 mph, consistent with the capabilities of modern diesel and electric train technologies. As a result, the following Exhibit (2-19) shows the five routes and two technology/speed combinations have been assessed for the Norfolk-Richmond segment in this study, leading to a total of ten options:

**Exhibit 2-19: Study Options Assessed for the Southside**

OPTION	VARIANT	SPEED
Southern Option 1 – via Petersburg	Southern Option 1A - Greenfield	130 / 220 mph
	Southern Option 1B - Norfolk Southern	130 / 220 mph
Northern Option 2 – via Hopewell	Northern Option 2A - Greenfield	130 / 220 mph
	Northern Option 2B - Norfolk Southern	130 / 220 mph
Option 3 – Richmond Direct	----	130 / 220 mph

To avoid biasing the analysis, the same capabilities have been assumed for all segments of alignment, so train speeds are limited by only equipment capabilities and track geometric restrictions. For comparative purposes, all alignments are assumed to be double tracked and fully grade separated. As a result, a top speed of 130 mph was assumed for diesel trains in all options, and 220 mph for electric trains.

In terms of the “B” options that involve segments of Norfolk Southern right-of-way between Suffolk and Petersburg, these have been assessed on an equitable basis based on geometry, since the existing rail alignment is arrow-straight between Suffolk and Poe, on the outskirts of Petersburg.

In the short term these Norfolk Southern options may be easier to develop on an incremental or phased basis, assuming that the agreement of the freight railroad can be gained to install the incremental improvements. However, care must be taken in pursuing incremental development of the existing rail corridor west of Suffolk to ensure that the speed capability is in fact, ultimately extendable to support the ultimate 220 mph build-out of the system, if it were decided to pursue such incremental options.

### **2.5.3 PENINSULA TECHNOLOGY OPTION**

Due to the lack of electrification east of Toano, only one train technology type has been considered for the Peninsula: the modern 130-mph tilting diesel train. While this train can reach up to 130-mph on dedicated High Speed tracks, it would be limited to 90-mph on CSX east of Toano as well as north of Aquia Creek on the shared right-of-way to Washington D.C.

In a future study the option of a dual mode train may also be considered. A dual mode diesel/electric train may save 15 minutes on the timetable between Newport News and Washington D.C. by being able to run 220-mph west of Toano<sup>30</sup>, and an additional 20-30 minutes saved by not needing to change the locomotive in Washington D.C. Currently a Newport News diesel train could run as far north as Philadelphia, PA under diesel power but it could not continue into New York City without either changing to an electric locomotive or having dual-mode capability. It should be noted that not needing to change locomotives in Washington D.C. will also significantly enhance the capacity of the lower level Union Station platform tracks. As an enhancement to the current Peninsula option, this should be considered in the next phase of study.

### **2.5.4 TECHNOLOGY OPTIONS SUMMARY**

In terms of development of the passenger rail service to Hampton Roads, as described in Chapter 1, the original Phase 2(B) report developed a series of “steps” describing a phased build out option for the system. As described in Chapter 1, Exhibit 1-2, the first two “steps” represented short term actions based on conventional Amtrak train technology. Step 3 was based on High Speed Diesel, and Step 4 on High Speed Electric train technology. So as not to duplicate the work that DRPT was doing, the original Phase 2(B) study focused only on Steps 3 and 4, the High Speed rail options.

As a result of this earlier work it became clear that given the high cost associated with developing greenfield routes from Norfolk to Richmond to Washington D.C, electrification to run at 220-mph (instead of just 130-mph) was a good choice. For the southside, a 220-mph electric service produced better Cost Benefit results than did the 130-mph diesel options. The southside option producing the best financial and economic results was Option 3 – Richmond Direct, electrified at 220-mph which formed the starting point for the Peninsula supplemental analysis.

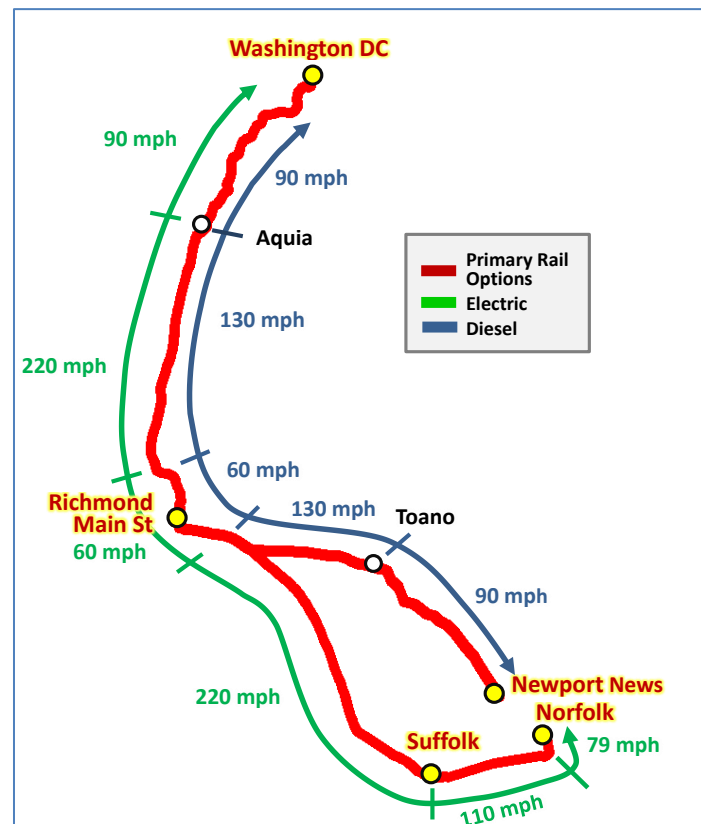
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<sup>30</sup> Or Roxbury, if electrification is not extended onto the Roxbury-Toano greenfield segment.

As a result, the current preferred Option 4 – Richmond Direct Improved is comprised of two distinct components, as shown in Exhibit 2-20:

- **A 220-mph High Speed electric train for the Southside, assuming electrification extends all the way to Harbor Park in downtown Norfolk:** However, speeds on the shared CSX alignment north of Aquia would be limited to 90-mph. On a short stretch through downtown Richmond, speeds would be limited to 60-mph or less. It is assumed that the “V-Line” right-of-way would be purchased from Norfolk Southern\* so it can be upgraded to 110-mph, the highest speed allowed by FRA without grade separation of all highway crossings. From South Norfolk to Norfolk Harbor Park, speeds would be limited to 79-mph on shared right-of-way, consistent with Norfolk Southern’s policy.
- **A 130-mph High Speed diesel train for the Peninsula, assuming diesels can run “under the wire” at 130-mph:** However, speeds on the shared CSX alignment north of Aquia would be limited to 90-mph. On a short stretch through downtown Richmond, speeds would be limited to 60-mph or less. Beyond Toano on shared CSX track to Newport News, diesel trains would share the existing rail corridor at 90-mph, consistent with CSX policy.

Exhibit 2-20: Southside Electric and Peninsula Diesel Components of Hypothetical Combined System



\*Any use, implied, explicit, or otherwise, of NS right-of-way will be subject to the concurrence of NS, and to NS’ Passenger Rail Policy which governs the speed of passenger rail trains utilizing it or encroaching upon it.

### 3. ROUTE ANALYSIS

*Route options have been developed at a conceptual level based on a mapping analysis of the routes. Particularly for new greenfield alignments, environmental considerations not only determine where an alignment might go, but also directly drive the capital costs in terms of unavoidable consequences and mitigation costs. Particular attention has been paid to crossings of highways and other rail lines, required property takings, river bridges and wetland crossings since these are key capital cost drivers. This route analysis focuses primarily on the factors that directly impact capital cost and develop the key environmental and engineering findings, upon which the preliminary capital cost development for each option will be based.*

#### 3.1 DEVELOPMENT OF ROUTE OPTIONS

The focus of this study is on further developing the two Hampton Roads to Richmond segments of the Hampton Roads High Speed rail corridor, both from Richmond to Norfolk as well as to Newport News. Chapter 2 first proposed three conceptual Options 1-3 for linking Norfolk to Richmond on a new high speed alignment. These options were fully developed at the Feasibility Level by the original Phase 2(B) study.<sup>1</sup> Subsequently the scope of the study was supplemented to allow development of one option for Peninsula rail service (Option 4, as an add-on to the Richmond Direct high speed alignment.) For completing the capital cost estimate to include the critical Richmond to Washington D.C. link, the assumptions of the original 2010 feasibility study were carried forward. This allows the financial and economic analysis to reflect the full utility of connecting NEC traffic, since even today, ridership to Washington D.C. and points north is a critical component of Amtrak ridership, and even the existing passenger rail service could not be sustained without it. With High Speed rail in the future, improving the link north to Washington D.C. will become an even more critical component of the overall plan for implementing High Speed rail service to Hampton Roads.

##### 3.1.1 NORFOLK TO RICHMOND ROUTE OPTIONS

Chapter 2 of the original Phase 2(B) study proposed three conceptual options for linking Norfolk to Richmond on a new high speed alignment. These are routes via: Petersburg, Hopewell, or Richmond Direct. The Petersburg and Hopewell options have two variants: where the “A” variant is a new greenfield alignment, and the “B” variant would utilize the existing Norfolk Southern rail corridor from Suffolk to Petersburg.

This makes five route options in total (see Exhibit 3-1), which are called 1A, 1B, 2A, 2B and 3, respectively. However, the 1B and 2B options share the Norfolk Southern segment from Suffolk to Petersburg. This option for developing a dedicated track along the Norfolk Southern Suffolk to Petersburg line will be developed only once, for both options. Because of this overlap, *four* route segments will be developed in this chapter:

**1A- Southern Greenfield via Petersburg** would link Kilby to Burgess, south of CSX’s Collier Yard in Petersburg. From Burgess the alignment would follow the SEHSR through Petersburg to Woods Edge Road. There, the alignment would leave the CSX rail corridor, parallel I-95 for a short distance, cross the James River and enter a possible “East Shore Greenfield” through open land to Richmond.

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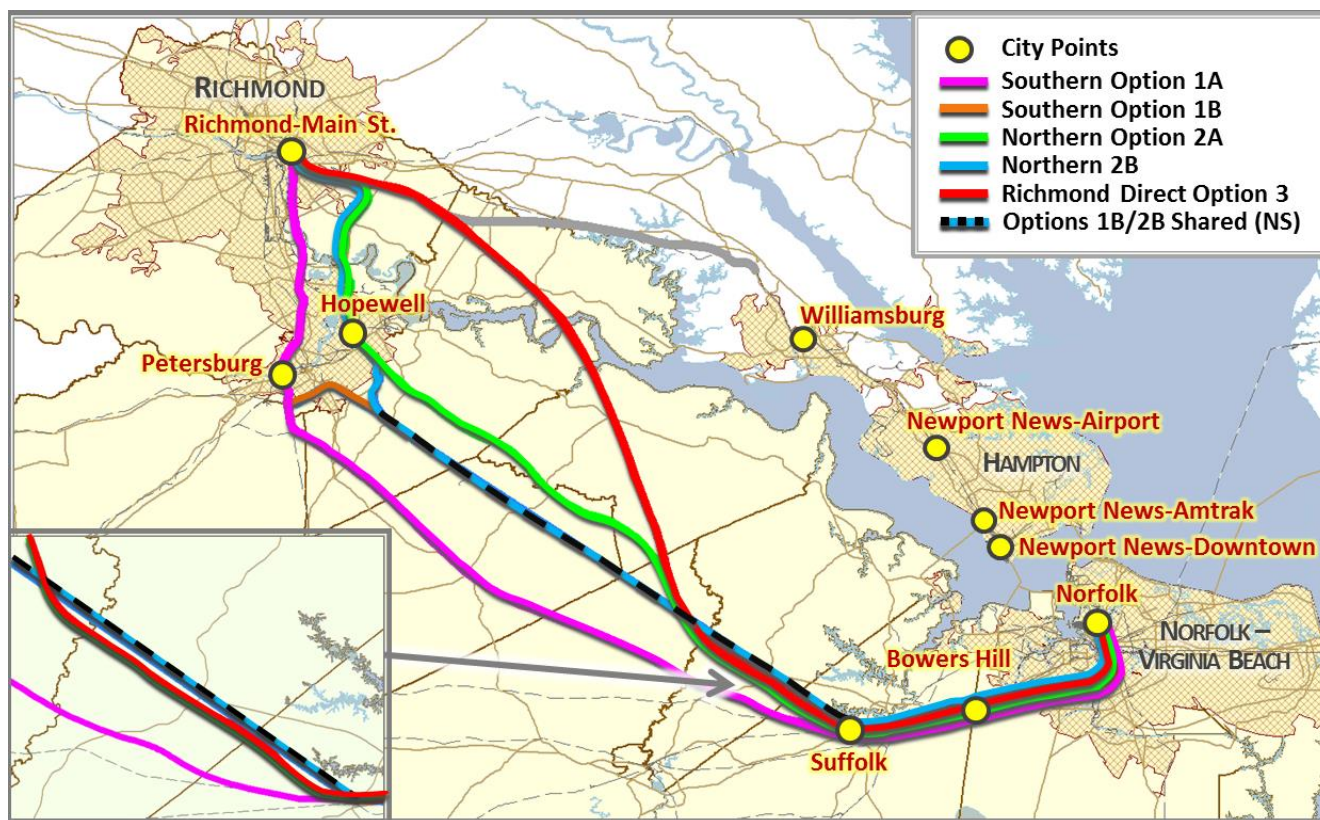
<sup>1</sup> However, it should also be noted as a result of CSX discussions that occurred during the course of the Phase 2(B) supplement, a small adjustment to the original plan for developing a High Speed rail alignment through Suffolk has been made. As a result of this refinement, passenger trains can now be fully separated from freight trains through Suffolk. However, the plan will be subject to re-review and possible revision during the course of the environmental studies that are needed to further progress the system towards implementation.

**2A – Northern Greenfield via Hopewell** would link Kilby to Hopewell, then follow I-295 north to Richmond. The alignment would leave I-295 where it crosses the CSX Peninsula Subdivision, and parallel the CSX rail line into Richmond Main Street Station

**3–Richmond Direct Greenfield** would head directly to Richmond on the shortest practicable routing through open land. It would cross the James River near Charles City and line up with the CSX Peninsula Subdivision just east of the I-295 crossing. From here it would parallel the CSX rail line into Richmond.

**1B and 2B (Common Segment from Suffolk to Petersburg) – Dedicated Tracks Along the Existing Rail Corridor** would develop dedicated infrastructure closely following the Norfolk Southern mainline to Poe, on the eastern outskirts of Petersburg. From Poe, the corridor would either follow the Belt Line to Collier and connect to the planned Southeast High-Speed Rail (SEHSR) through Petersburg; or else it would follow the I-295 highway median north via Hopewell to Richmond.

Exhibit 3-1: Norfolk-Richmond Route Options Assessed for the Engineering Analysis



All options share a common segment using the existing “V-Line” rail alignment from Norfolk Harbor Park to a rail junction called “Kilby” on the west end of the City of Suffolk. Beyond Kilby, the new Greenfield options 1A, 2A and 3 have been developed, to offer an alternative to options 1B and 2B that would develop a dedicated track paralleling the Norfolk Southern rail right-of-way, and also to address the issue of how to connect the high speed alignment north to Richmond.

\*Any use, implied, explicit, or otherwise, of NS right-of-way will be subject to the concurrence of NS, and to NS’ Passenger Rail Policy which governs the speed of passenger rail trains utilizing it or encroaching upon it.



These high speed rail options include two segments in urban areas, where the tracks would be shared with freight trains at reduced speeds. These are:

- Norfolk Harbor Park to Kilby on NS and CSX
- Collier to Dunlop (Woods Edge Road) on CSX (enhanced SEHSR plan)

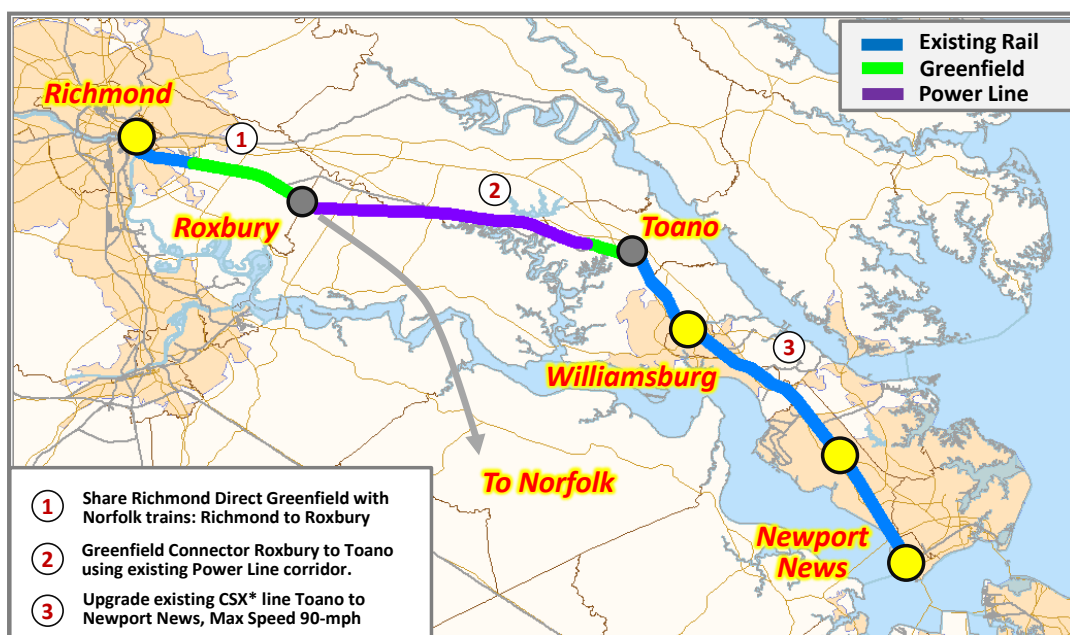
These two segments are based on existing rail alignments and have been subject to previous Environmental studies, so the assumptions for these segments can be spelled out in some detail. However, some of the earlier engineering assumptions may need to be adjusted for supporting the higher service intensities that are associated with high speed rail operation, particularly the need for adding double dedicated tracks. Any implementation based on existing rail lines might be phased to develop infrastructure improvements incrementally, provided the initial planning accommodates the ultimate capacity need. Such infrastructure could be added over time as the service develops.

### 3.1.2 NEWPORT NEWS TO RICHMOND ROUTE OPTIONS

From Newport News to Richmond, Chapter 2 discussed the development of several conceptual route options, including some that may involve the use of I-64 highway or Norfolk Southern rights of way and/or shifting the Richmond Direct alignment towards the east and north.

However, for the purpose of the Phase 2(B) supplement the goal was to develop an incremental way to exploit the synergies that became apparent as a result of developing the Richmond Direct alignment to Norfolk. By adding a relatively short connecting link to Toano, Peninsula trains could share the Richmond Direct line into Richmond as well as the whole route north to Washington D.C. As such, an option that follows an existing utility line corridor from Roxbury over to Toano (shown in Exhibit 3-2) was chosen for development as a representative route. The other options still remain on the table for consideration during the detailed Tier I Environmental studies that are yet to come.

**Exhibit 3-2: Newport News-Richmond Route Assessed for the Engineering Analysis**



As can be seen in Exhibit 3-2, the Peninsula representative route includes three segments.

- **Richmond Direct Segment 1: Richmond to Roxbury:** This first segment is a part of the Richmond Direct alignment to Norfolk, so infrastructure assumptions along that segment are developed as part of the Norfolk route option. Peninsula diesel trains could use this track (130-mph on diesel power, not using the overhead electrification) for no additional capital cost.
- **Toano Connector Segment 2: Roxbury to Toano:** This segment would be a greenfield connector following an electric utility right-of-way over to Toano. Although new dedicated track will be constructed the segment will not need to be electrified. This will be developed as part of the Peninsula route option.
- **Shared CSX Peninsula Segment 3: Toano to Newport News:** This segment from Toano to Newport News would follow the existing CSX rail line and be limited to a 90-mph top speed. This will be developed as part of the Peninsula route option.

As a result Segment #1 is developed as part of the Norfolk service. Only segments #2 and #3 are solely associated with developing Enhanced Passenger Rail on the Peninsula.

### 3.1.4 FREIGHT RAILROAD PRINCIPLES

Any shared use of freight rail corridors or tracks must respect the need for continued safe and economical rail freight operations. At a minimum, it is intended that the freight railroads must be able to operate their trains as effectively as they could if passenger service did not exist. Beyond this, it is desirable to actually create benefits for freight rail service if possible while developing the infrastructure needed to support passenger services. This has been done in Virginia, for example through development of the NS Heartland Corridor and CSX National Gateway. These projects were justified based on their economic and job creation benefits. Freight railroads must retain their ability not only to handle current traffic, but also to expand their own franchises for future traffic growth.

As such, both CSX and Norfolk Southern have established “Letters of Principle” to provide guidance to passenger rail planners. The purpose of the principles is to protect the safety of railroad employees and communities, service to freight customers, and the right-of-way and land needed to fulfill the railroads’ freight transportation mission. However, Norfolk Southern acknowledges that each passenger proposal is unique, so NS’ application of the principles to particular proposals will often be unique as well.

With regard to high speed rail (HSR) service and corridors, Norfolk Southern’s principles point out that the following special considerations are necessary:

- Norfolk Southern will work with planners to insulate high speed rail corridors from interference with and from NS freight corridors.
- On Norfolk Southern, passenger trains operating in excess of 79 mph require their own dedicated tracks, although CSX will share tracks up to 90 mph. On Norfolk Southern, Trains operating in excess of 90 mph require their own private right-of-way.
- Where higher -speed trains share tracks with conventional freight trains, those high speed trains will not be able to exceed 79 mph. Where shared track is concerned higher speed trains must meet the same safety standards as conventional freight trains.

CSX's principles<sup>2</sup> require that:

- Access to host railroad track and property must be negotiated between the parties on a voluntary basis.
- Designing for safety is paramount and separate tracks will be needed to segregate freight and conventional passenger rail from high speed rail at sustained speeds in excess of 90 mph.
- Service to rail freight customers must be reliable and protected and cannot be compromised; adequate capacity must be maintained and, in some cases, built to address future freight growth.
- New infrastructure design must fully protect the host railroad's ability to serve its existing customers, both passenger and freight, and locate future new freight customers on its lines.
- Host railroads must be adequately compensated, especially in regard to the significantly higher maintenance cost associated with enhanced track infrastructure that will be required for high speed rail.
- Host freight railroads need to be fully protected against any and all liability that would not have resulted but for the added presence of high speed passenger rail service.

Norfolk Southern requested that this draft report make clear (See Appendix H) that all high speed (above 90 mph) portions of the route would be constructed off of Norfolk Southern right-of-way, so any high speed route should assume at least a 50-foot separation between high-speed and Norfolk Southern freight tracks. As a result, in this study where speeds greater than 90-mph have been proposed, it has been assumed that a public entity would purchase a strip of land parallel to the existing rail right-of-way.

At present the passenger proposals laid out here are still un-negotiated, un-funded and at a feasibility level. The required capacity analysis for shared track segments has yet to be done. As a result, the work is not yet at a detailed enough level to satisfy the needs of the freight railroads. It is understood that in following detailed engineering and environmental studies, the details of integrating the proposed passenger operations with freight operations will be subject to close negotiations with the railroads. This will include detailed engineering and operation studies. The final capital plan and capital costs for shared segments will eventually need to be worked out in negotiations with the freight railroads.

In the meantime, this report contains preliminary data which is subject to review, verification and approval by both CSX and Norfolk Southern Railroad. As of the date of this report, this review process has not taken place. Findings are not to be construed as a commitment on the part of either CSX or Norfolk Southern to operate additional service.

### **3.2 SEGMENT BY SEGMENT ANALYSIS – NORFOLK TO RICHMOND**

The following subsections will address environmental and engineering conditions existing along each route segment from Norfolk to Richmond. A Norfolk Harbor Park to Suffolk segment using the "V"-Line is common to all alternatives.<sup>3</sup> After that, individual segments are assembled to develop the full route for each of the developed Options 1A, 1B, 2A, 2B and 3.

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<sup>2</sup> See: <http://pt.slideshare.net/HRPartnership/passenger-trains-for-va-peninsula-csx-7-17-09>

<sup>3</sup> A potential alternative rail routing between South Norfolk and Suffolk could follow the existing Norfolk Southern main line. Existing Amtrak service uses this line, but studies dating back at least as far as 2002 have argued that the "V-Line" offers a better opportunity to develop a dedicated passenger rail alignment. Using the "V-Line" avoids a major rail freight yard at Portlock, and also avoids the need for adding tracks to Norfolk Southern's main line across the Dismal Swamp. DRPT's Hampton Roads Tier I EIS assumed that the "V-Line" would be used, and this recently was granted an FRA Record of Decision. However, even while the "V-Line" does presents an obvious opportunity to develop a dedicated

### 3.2.1 NORFOLK HARBOR PARK TO SUFFOLK - EXISTING RAIL SEGMENT

This segment of existing urban rail corridor is common to all options. Although the proposed “V”-Line alignment is fairly straight, it does include some speed restrictions as well as proposed station stops at Bowers Hill and Suffolk that will limit train speeds. It is proposed that the “V”-line and Portsmouth Subdivision right-of-way be purchased from NS and CSX from South Norfolk through Suffolk, subject to an easement for continued freight operations. From the Harbor Park station through South Norfolk to the lift bridge over the south branch of the Elizabeth River, a 79 mph design standard will suffice and produces the best compatibility with shared freight operations. From the Elizabeth River lift bridge to Kilby (west of Suffolk), it is suggested that the alignment be developed to 110 mph standards which is still compatible with shared freight operations and allows grade crossings. This speed option can be considered based on the proposed purchase of this right-of-way to be developed into a dedicated passenger alignment.

For speeds up to 110 mph, special highway grade crossing treatments (quad gates) are needed, but grade separations are not required. This does not preclude consideration of grade separations for this segment, but since they are not required by regulation, each grade separation should be individually reviewed and justified on its own merits.

Since the existing Amtrak service could also use the Suffolk to Norfolk improvement, any upgrades made for developing the “V”-line from Suffolk to Norfolk would have independent utility. Improvements to this segment could therefore proceed incrementally in advance of development of the full High Speed rail project and would in fact help lay the groundwork for bringing High Speed rail into Norfolk.

#### NORFOLK HARBOR PARK TO SOUTH NORFOLK

From Norfolk Harbor Park to South Norfolk, the alignment follows the existing Norfolk Southern double tracked main line. The recommendation would be to add one track to the existing right-of-way, so the line would be completely triple tracked from Harbor Park to the junction of the “V-Line” at South Norfolk. These tracks could all be shared with freight trains, but in fact the westernmost track would be primarily dedicated to passenger trains; while the two eastern tracks would maintain the capacity of the existing freight line. This 2.2 mile segment would be operated at 79 mph or less and due to right-of-way restrictions, should be constructed on conventional 14’-15’ track centers. It has 6 grade crossings.

Norfolk Southern bridges 5 and 5A cross the east branch of the Elizabeth River just south of the Harbor Park station. Bridge 5 carries the two current Norfolk Southern main tracks across the river. Beside it, Bridge 5A is currently out of use but according to the DRPT Hampton Roads EIS has been maintained in serviceable condition, and could be reactivated just by reconnecting the tracks. No special maintenance issues have been noted in previous studies regarding this bridge. This should be assessed in the next phase of work to ensure not only safety, but also reliable operation of the bridge after it is restored to service. Starting just east (north) of the Harbor Park station, a third track would be added along the east side of the right-of-way, crossing Bridge 5A. This new track would become the new eastbound freight track; the existing tracks on Bridge 5 would be used for westbound freight and passenger trains, respectively.

Old track charts suggest at one time a former third track across Bridge 5A continued south to “NS Junction” where the Norfolk Southern main connects to the Norfolk & Portsmouth Belt line, about 1.4 miles south of Harbor Park station, directly underneath the US-460 highway overpass. A section of this

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passenger alignment, it is still necessary to ensure that a sufficient level of environmental documentation exists to support the formal screening of the Norfolk Southern existing rail alternative. It is recommended that this issue be discussed with FRA to determine what level of analysis of the existing NS main line will suffice to withstand any potential legal challenges. This will also be very useful to serve as public outreach material to explain why developing the “V-Line” as a dedicated passenger rail corridor makes sense.

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former third track still remains as a short siding just north of “NS Junction.” It is assumed that this siding would be subsumed into the 3<sup>rd</sup> track restoration along the east side of the right-of-way. From Harbor Park to “NS Junction,” this section will be estimated as 1.4 miles of new track on existing roadbed and also includes the base cost for one station. (This provides an allowance for expanding the capacity of the existing terminal station at Harbor Park.)

South from “NS Junction” to the V-Line at South Norfolk, a distance of 0.8 miles, the corridor passes through a densely built up urban residential area on a narrow right-of-way. Based on the position of fence lines, it would appear that the existing double track is positioned within an approximate 90’ wide right-of-way, but some existing buildings come right up to the edge of the property line. As shown in Exhibit 3-3, it appears that existing tracks are not quite centered within the right-of-way, rather they seem to be shifted a little closer to the east side of the right-of-way. As a result, south of the US-460 overpass, there is more room to add a new track on the west side than on the east side. There is no evidence that a third track ever existed in this area, so it will be costed as 0.8 miles of new track on new roadbed (15’ fill height) on 14-15’ track centers. This new track added on the west side would connect directly into the “V-Line” at South Norfolk.

**Exhibit 3-3: Norfolk  
Southern Asymmetrical  
Right-of-Way between NS-  
Junction and South Norfolk**



#### **SOUTH NORFOLK TO ALGREN**

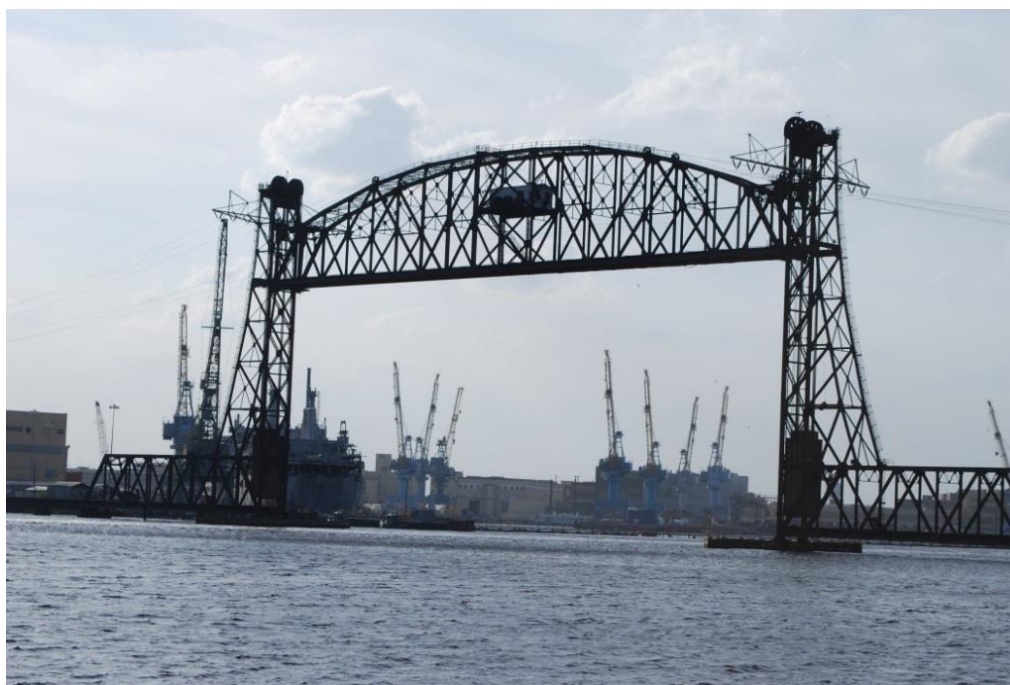
South Norfolk is where the “V” Line diverges from the main line just north of Norfolk Southern’s Portlock Yard. Algren is where the “V”-line formerly crossed the CSX Portsmouth Subdivision at grade. Geographically the Algren rail junction lies just south of the Hampton Roads Executive Airport. From South Norfolk to Algren the former Virginian tracks are still in place; west of Algren the tracks have been removed. The distance from South Norfolk to Algren is 10.3 miles. The segment has 13 grade crossings and includes the cost for one station at Bowers Hill.

From South Norfolk, the “V-Line” heads west through a residential neighborhood on an approximate 100’ right-of-way. It passes under US-460 and I-464 and emerges into an industrial and wetland area on the east bank of the south branch of the Elizabeth River. Crossing the Norfolk & Portsmouth Belt branch line at grade, the alignment spans the Elizabeth River on a large single track lift bridge (Exhibit 3-4). No special maintenance issues have been noted in previous studies in regard to this bridge. This should be

assessed in the next phase of work to ensure not only safety, but also reliable operation of the bridge in daily service.

The distance from South Norfolk across the bridge to the west bank of the Elizabeth River is 1.9 miles. Because of the relatively short length of this segment, single tracked bridge structure, freight train sharing, curves and urban environment, it is assumed that the line will be operated at 79 mph and remain single track from South Norfolk to the river bridge. It will be estimated as 1.9 miles of single new track on existing roadbed. On the west bank of the Elizabeth River, Norfolk Southern serves a Giant Cement import pier<sup>4</sup>. This pier has a permitted throughput capacity in excess of 450,000 tons, or approximately 4,000 railcars annually.

**Exhibit 3-4: “V” Line Lift Bridge over the South Branch of the Elizabeth River**



Currently, the “V” line continues west in active service for another 4.5 miles beyond the cement facility to the Cavalier Industrial park, but carries only very light industrial traffic. Beyond the industrial park, the “V”-line tracks remain in place but out of service for another 3.9 miles to Algren, the junction with the CSX Portsmouth Subdivision. There is a section of about 0.6 miles along Old Virginia Road, and 1.9 miles along Denver and Taft drives where residential development tightly hugs the rail right-of-way and will likely need sound wall protection. The proposed Bowers Hill station lies in the middle of this out-of-service segment.

From the Elizabeth River Bridge to Algren, some portions of “V Line” right-of-way appear to be wide enough and already graded for double track. However, there is no evidence from the historical track charts that double track ever existed along this section of “V Line.” Therefore the “V Line” upgrades will be estimated as 8.4 miles of single track on existing roadbed, along with 8.4 miles of second new track on

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<sup>4</sup> See <http://www.prnewswire.com/news-releases/giant-cement-holding-inc-acquires-deepwater-import-terminal-in-portsmouth-va-74506237.html>

new roadbed with approximately 15' average fill height. It will include 2.5 miles of sound wall protection for the adjoining residential development.

For supporting the 110-mph upgrade west of the Elizabeth River bridge, it is proposed to purchase the whole "V" Line from South Norfolk to Algren, which has remained intact with a track on it the whole way. The purchase would be subject to an easement for continued rail freight service. A placeholder of \$1.09 million per mile for the cost of this "V"-Line track from South Norfolk to Algren and right-of-way purchase has been estimated based on the recently-completed line sale in Michigan. However, it should be noted that the Michigan track was signalized, in active passenger service and was in much better condition than the "V"-line track. The actual purchase price will be subject to negotiations between the parties.

#### **ALGREN TO EAST SUFFOLK**

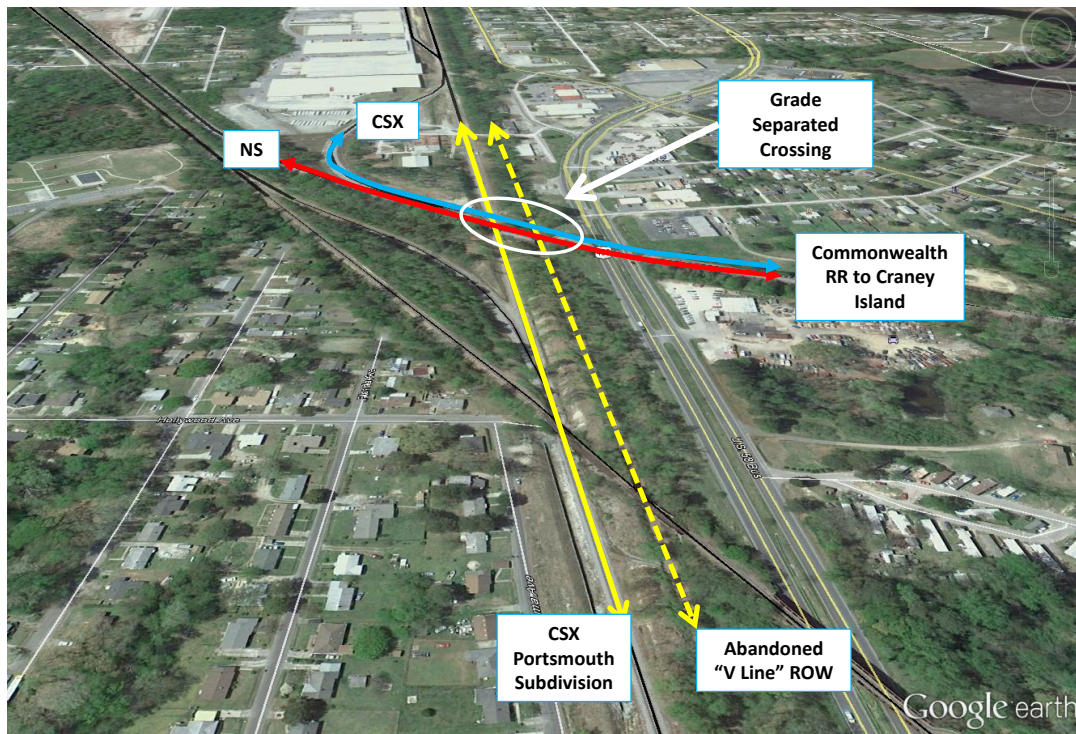
Algren is where the Norfolk Southern "V"-line formerly crossed the CSX Portsmouth Subdivision at grade just south of the Hampton Roads Executive Airport. East Suffolk is a rail junction where the Commonwealth Railway to Norfolk International Terminals, and a short remnant of a CSX branch line, both pass over and connect with the CSX Portsmouth Subdivision. At this location, a CSX industrial spur also connects south to several industries and provides a possible connection to the Norfolk Southern main line. See Exhibit 3-5.

The DRPT Tier I FEIS has assumed that the "V"-line tracks would join CSX at Algren so passenger trains could share the CSX Portsmouth Subdivision from Algren through Suffolk to Kilby. However, this study makes a different set of assumptions for separating freight trains from passenger trains as much as possible. This separation is needed to guarantee CSX unfettered access to the Portsmouth and APM Terminals, as well as to develop a dedicated passenger infrastructure on a geometrically high quality alignment.

Instead of sharing the CSX track here, it is proposed to construct new 110 mph dedicated double-track along the parallel former Virginian right-of-way. From Algren to East Suffolk, the abandoned "V-Line" right-of-way closely parallels the CSX Portsmouth subdivision (about 100' on the north side.) The distance from Algren to East Suffolk is 6.9 miles. The segment has 9 grade crossings. Since the "V-Line" right-of-way has been legally abandoned it has been estimated as a suburban land transaction at a rate of \$35 thousand per mile. However, the actual purchase price will be subject to negotiations between the parties. For completely separating passenger trains from the CSX freight line, a grade separation at Algren would be needed. A placeholder of \$50 million has been included for grade separating the rail crossing at Algren.



Exhibit 3-5: Commonwealth Rail Crossing at East Suffolk



The first 4.5 miles west from Algren cross the Dismal Swamp with wetlands areas close along the CSX right-of-way on the south side. Beyond the Dismal Swamp there is an industrial siding serving an asphalt and concrete ready-mix facility, also on the south side of the CSX tracks. From this point the CSX and “V-Line” right-of-way continue to parallel one another for the remaining 2.4 miles to East Suffolk. Housing development spreads north from Washington Street, adjoining the CSX alignment on the south side for the last mile into Suffolk.

Because of the wetland areas, ready mix plant and housing development all on the south side of the existing CSX track, it would appear that any new track should be added on the north side. In this area, the parallel “V-Line” right-of-way already exists and is graded on the north side. As a result, would appear to make sense to reclaim the “V-Line” right-of-way, so this segment will be estimated as 6.9 miles of double track on new roadbed. This is sufficient for establishing a dedicated passenger line that is totally separate from the CSX Portsmouth Subdivision. It will include 1.0 miles of sound wall protection for adjoining residential development on the east end of Suffolk.

#### EAST SUFFOLK TO KILBY

Previous studies (such as the 2002 *Richmond to South Hampton Roads High-Speed Rail Feasibility Study*<sup>5</sup>) have all assumed that passenger trains would use the CSX Portsmouth Subdivision through downtown Suffolk to Kilby, a distance of 3.9 miles. It is clear that the CSX Portsmouth Subdivision provides the highest quality passenger alignment through Suffolk. The alignment is straight, it avoids the sharp curves that would otherwise be needed to connect from the “V”-line over to the Norfolk Southern main line

<sup>5</sup> The DRPT report suggests that the CSX Portsmouth subdivision be developed for rail passenger service but assumes only a single track line, shared with freight trains, see: <http://www.drpt.virginia.gov/studies/files/SHRExecutiveSummary.pdf>



through town, and following the CSX Portsmouth Subdivision through town would fully separate passenger trains from the heavy freight trains that are operating along the Norfolk Southern alignment.

However, given the recent increase in CSX double stack traffic,<sup>6</sup> as well as the higher frequencies of passenger trains proposed by the current study, it is not realistic to assume that High Speed passenger trains can use the CSX Portsmouth Subdivision without adding enough capacity for CSX double stack trains to operate to/from the Virginia ports in an unfettered manner. Due to right-of-way limitations through downtown Suffolk it will be difficult to add enough tracks along the CSX alignment to provide dedicated infrastructure for both freight and passenger trains. Therefore, an alternative solution could be to develop a consolidated freight corridor through Suffolk, as was originally proposed by the Suffolk Rail Impact Study<sup>7</sup> as a possible grade crossing mitigation measure. As shown in Exhibit 3-6, a consolidated freight corridor would effectively remove CSX trains from the Portsmouth Subdivision through downtown Suffolk by consolidating all freight on the Norfolk Southern right-of-way through town.<sup>8</sup> This would allow cost effective grade separation of highway crossings on the freight line, while the Portsmouth Subdivision could be repurposed into a dedicated passenger alignment.

**Exhibit 3-6: Proposed Consolidated Freight and Passenger Routings through Suffolk**

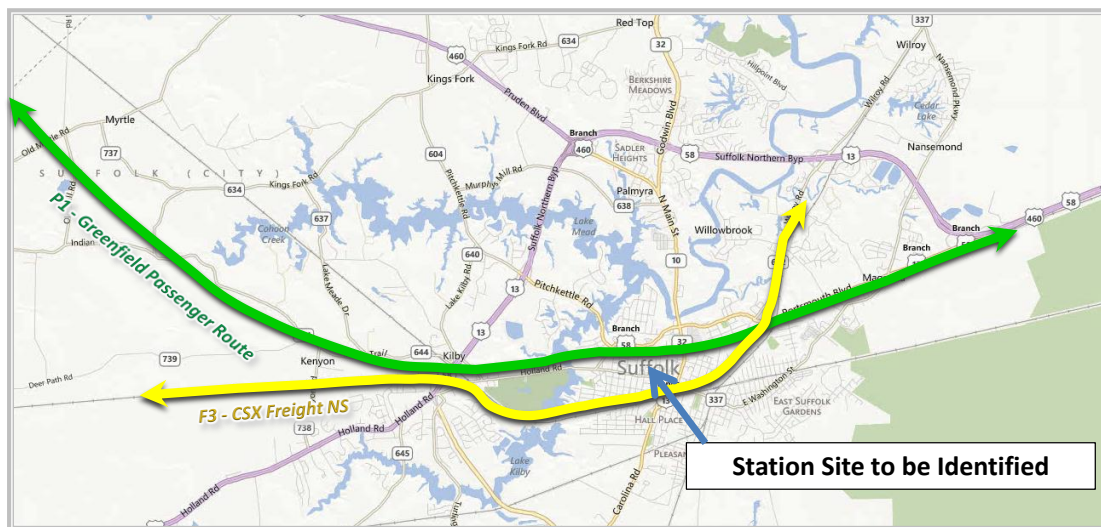


Exhibit 3-6 shows a “balloon” track connection for freight trains between the Norfolk Southern main line and CSX’s Portsmouth Subdivision at Kilby. This would be in the opposite quadrant from the “balloon” connection that the DRPT EIS proposed for passenger trains at Kilby. This connection would enable CSX trains to reenter their own line while staying on the north side of the Norfolk Southern alignment, without needing to cross any of the Norfolk Southern tracks. At the same time, rather than continuing on the Portsmouth Subdivision west of Constance Road (US 58), the passenger alignment could shift to the former Virginian right-of-way. This would avoid any conflicts with the CSX track connection at Kilby,

<sup>6</sup> Due to the Panama Canal expansion and CSX’s own National Gateway project (<http://www.nationalgateway.org/projects/project/548>), CSX double stack traffic has substantially *increased* on this line segment through downtown Suffolk. Recently, for consolidating blocks of on-dock rail container traffic, CSX added a support yard at Kilby, just west of Suffolk. The Virginia Port Authority recently opened a new port at Norfolk International Terminal. Both Norfolk Southern and CSX access this port over the Commonwealth Railway, which joins the CSX and NS main lines at East Suffolk. CSX still has substantial local freight business in Portsmouth and continues to serve the APM Container terminal as well.

<sup>7</sup> See: <http://www.hrtpo.org/uploads/docs/SuffolkRailReport.pdf>

<sup>8</sup> This could be done by adding a third track along the north side of the existing NS rail corridor. This third track could be functionally independent of Norfolk Southern operations and may be placed under CSX dispatch control. Alternatively, CSX stack trains might be shifted away from downtown Suffolk altogether, by using Norfolk Southern’s parallel rail line from Suffolk to Franklin. This could allow abandonment of the CSX Portsmouth Subdivision from Kilby to Franklin, but would require constructing a new rail connection in Franklin.

since CSX would use the existing Portsmouth Subdivision bridge under the Norfolk Southern main line, while the passenger service could use the former Virginian underpass. This track configuration could effectively separate CSX freight, NS freight and passenger trains onto their own tracks.

While this could develop an essentially dedicated infrastructure for passenger trains between Suffolk and Norfolk, the engineering design should not preclude operation of freight trains.<sup>9</sup> Therefore it is recommended that the infrastructure from Kilby to Norfolk Harbor Park should accommodate freight railroad clearance and other engineering requirements. For example, if electric catenary were installed, the 20' 6" freight railroad clearance envelope should be respected, so as not to preclude the operation of double stacked trains under the wire through downtown Suffolk or east of Suffolk.<sup>10</sup> See Exhibit 3-7.

**Exhibit 3-7: CSX Double Stack Train under SEPTA Catenary at West Trenton, NJ<sup>11</sup>**



The costs for the East Suffolk to Kilby segment have been revised and slightly increased from the original Phase 2(B) study to reflect the cost of fully separating CSX freight from passenger trains all the way from Algren to Kilby. The costing has also been made more specific in regard to costs for right-of-way acquisition and specific engineering improvements associated with the proposal. Costs have been developed both for improving the proposed passenger alignment (CSX Portsmouth Subdivision) and also for developing the consolidated grade crossing project. Inasmuch as the original Phase 2(B) study included a “placeholder” for Suffolk freight mitigation needs, this new cost although it has been revised

<sup>9</sup> For example, CSX will want to continue to serve its customers on the Portsmouth Subdivision in downtown Suffolk, will probably want to retain rights to operate some trains through downtown Suffolk, will want to be able to continue accessing its customers and port facilities in Portsmouth, and its interchange with the Norfolk & Portsmouth Belt Railroad. Similarly, Norfolk Southern will want to continue serving customers on the “V-Line,” and may also benefit from the ability to divert freight trains onto the “V-Line” if any emergency or blockage were to disrupt its main line, or during track maintenance activities.

<sup>10</sup> The European standard catenary height is 16-19 feet above the rail which is not high enough to accommodate double stack trains under the wire. The Amtrak standard is 22 feet, although it is lower in some places. High speed lines tend to use lower catenary since this promotes maximum stability of the pantograph power collector at high speeds although in France, for example, the wires are still high enough to permit operation of double-decked TGV trains. However in terminal areas where train speeds are reduced, the pantograph can extend farther up to contact the wire. Pantograph stability at 110-mph is not a serious concern.

<sup>11</sup> See: <http://www.railpictures.net/viewphoto.php?id=346306&nseq=6>

upwards still contains a number of uncertain elements, such as the costs for right-of-way acquisition, and for highway grade separations along the consolidated freight corridor that might be proposed by the City of Suffolk, that have not been fully assessed or included here. This needs more detailed examination by a future study.

First, for developing the CSX Portsmouth Subdivision into a double tracked, dedicated passenger alignment from East Suffolk to Kilby, it is assumed that this segment will be developed to 110-mph standards. It has 5 grade crossings, and will be estimated as 3.9 miles of new single track on existing roadbed, and the second track 3.9 miles on new roadbed with approximately 15' average fill height. The cost for one station at Suffolk will also be included in the cost for this segment. The cost assumes that the former Virginian right-of-way will be used between Algren and East Suffolk, but that soon after the line passes underneath the Commonwealth Railway overhead bridge the alignment will shift gradually south (by about 100') and transition onto the CSX right-of-way through downtown Suffolk.

For supporting the development of a dedicated passenger route through downtown Suffolk, it is proposed to purchase the short segment of CSX Portsmouth Subdivision from East Suffolk to Kilby and construct the consolidated freight corridor, for shifting CSX trains to the north side of the Norfolk Southern line. This track and right-of-way purchase would be subject to an easement for continued rail freight service. A placeholder of \$1.09 million per mile for the cost of this Portsmouth Subdivision track has been estimated based on the recently-completed Norfolk Southern line sale in Michigan. However, it should be noted that the Michigan track was signalized, in active passenger service and was in much better condition than the Portsmouth Subdivision track. The actual purchase price will be subject to negotiations between the parties especially since it is proposed to provide replacement capacity for the bypassed line segment.

Second for developing the consolidated freight corridor, an additional sum has been included for constructing a third track along the Norfolk Southern right-of-way. This assumes that CSX trains coming off the Commonwealth Railway instead of turning onto the CSX line will just continue south to the NS main line at Liberty Street. A third track would be added on the north side of the Norfolk Southern corridor for a distance of 4.0 miles from Liberty Street to Kilby, including the length of the balloon track connection back to the CSX line west of Kilby. The costs for this segment also include an allowance for interlockings and signal systems cost.

Development of a dedicated "V"-line access into downtown Norfolk is a priority of both the DRPT FEIS as well as a clear prerequisite for the implementation of High Speed rail as well as for enhancement of the existing Amtrak service. The segment includes the proposed Bowers Hill station which will be developed into an important suburban stop and economic development center. Therefore, it is recommended to start engaging in right-of-way discussions with CSX and Norfolk Southern, as well as to advance the Suffolk Consolidated Freight Corridor project at the earliest possible opportunity. This can be done in advance of the main High Speed rail effort since the Norfolk to Suffolk segment has independent utility.

### **3.2.2 SUFFOLK TO PETERSBURG – DEDICATED TRACK ALONG NORFOLK SOUTHERN (OPTION 1B AND 2B)**

The possibility for adding dedicated high speed tracks to the existing Norfolk Southern alignment has been considered from Suffolk to Petersburg as part of Options 1B and 2B.

Normally, geometric issues would prevent operating a true high speed service along an existing rail right-of-way, but in this highly unusual case the existing alignment is arrow-straight from Suffolk to the outskirts of Petersburg. This suggests at least the conceptual possibility for developing a high speed rail service, so a preliminary assessment has been developed. This option is considered as a "Greenfield"



alternative, since it is characterized as a dedicated segment of all-new, 220 mph capable high speed rail alignment which may or may not be co-located within an existing railroad right-of-way\*.

### KILBY TO BAKERS POND

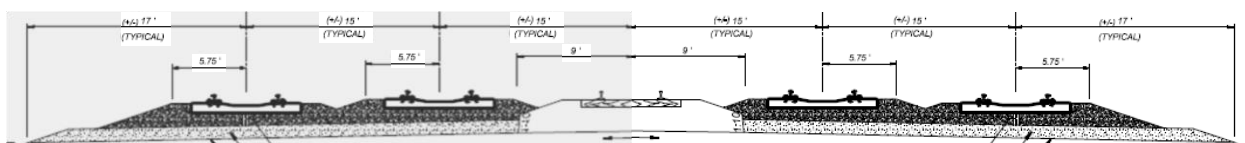
For option 2B, a possible connection from Norfolk Southern to I-295 would diverge at Bakers Pond -- approximately 0.3 miles east of the Route 156 grade crossing, about halfway between Poe and Disputanta. The distance from Kilby to Bakers Pond south of Route 156 is 46.1 miles. Continuing along the NS main line and Petersburg Belt Line, the distance from Bakers Pond to the junction of the Collier connection south of Petersburg is 9.3 miles.

In terms of the potential feasibility of a high speed option following the Norfolk Southern rail corridor, for development of reasonable alternatives planners will be constrained by the National Environmental Policy Act (NEPA), particularly Council of Environmental Policy guidance<sup>12</sup> which states:

*If a proposed action is to be located in a wetland or significantly encroaches upon a floodplain, a finding must be made that there is no practicable alternative to the wetland take or floodplain encroachment. Any alternative that does not meet the need for the action is not practicable. If the action's purpose and need are not adequately addressed, specifically delineated, and properly justified, resource agencies, interest groups, the public, and others will be able to generate one or possibly several alternatives that avoid or limit the impact and "appear" practicable. A well-described justification of the action's purpose and need may prevent long and involved negotiations or additional analyses demonstrating that an alternative is not practicable.*

It is clear in terms of alternatives being developed, that minimizing wetland impacts as well as property takes will be key to the environmental competitiveness of any alternative. For development of a Norfolk Southern corridor alternative, it became apparent that only a "Narrow Footprint" option could be economically and environmentally competitive to the other Greenfield options. This assumes placement of four tracks within a 100'-120' right-of-way footprint, as shown in Exhibit 3-8, with nominal track centers of 15', two passenger tracks would be separated from the two freight tracks by a 30'-50' track center spacing. Norfolk Southern has requested the wider spacing of 50'. This footprint leaves enough space for a fifth or sixth track in the middle, and three feet buffer on each edge of right-of-way.

**Exhibit 3-8: 100' Right-of-Way Footprint for a Passenger and Freight Rail Corridor**



The potential viability of the narrow footprint option derives directly from the issue of wetlands. According to the GIS Wetland Shapefiles in Exhibit 3-9, there is an already existing corridor along the Norfolk Southern tracks within which the wetland areas have already been compromised. This corridor appears to vary in width from 75' to 150'. A detailed on-the-ground survey, which was beyond the scope of the current study, would be needed to development a more accurate measurement of the actual conditions.

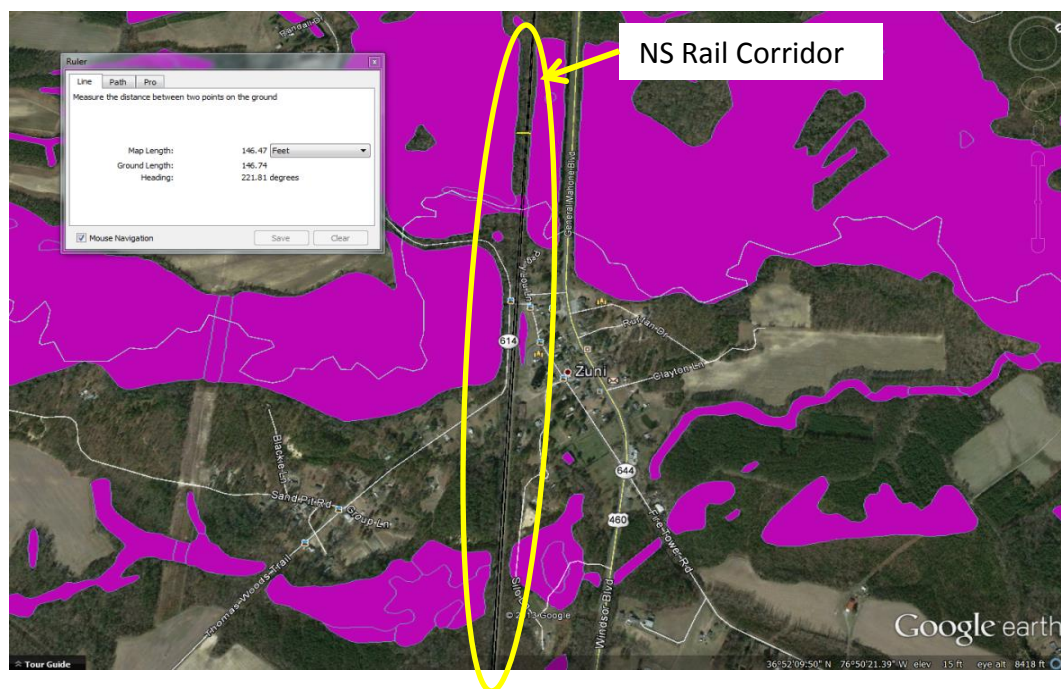
<sup>12</sup> See: <http://environment.fhwa.dot.gov/projdev/tdmalts.asp>

\*Any use, implied, explicit, or otherwise, of NS right-of-way will be subject to the concurrence of NS, and to NS' Passenger Rail Policy which governs the speed of passenger rail trains utilizing it or encroaching upon it.

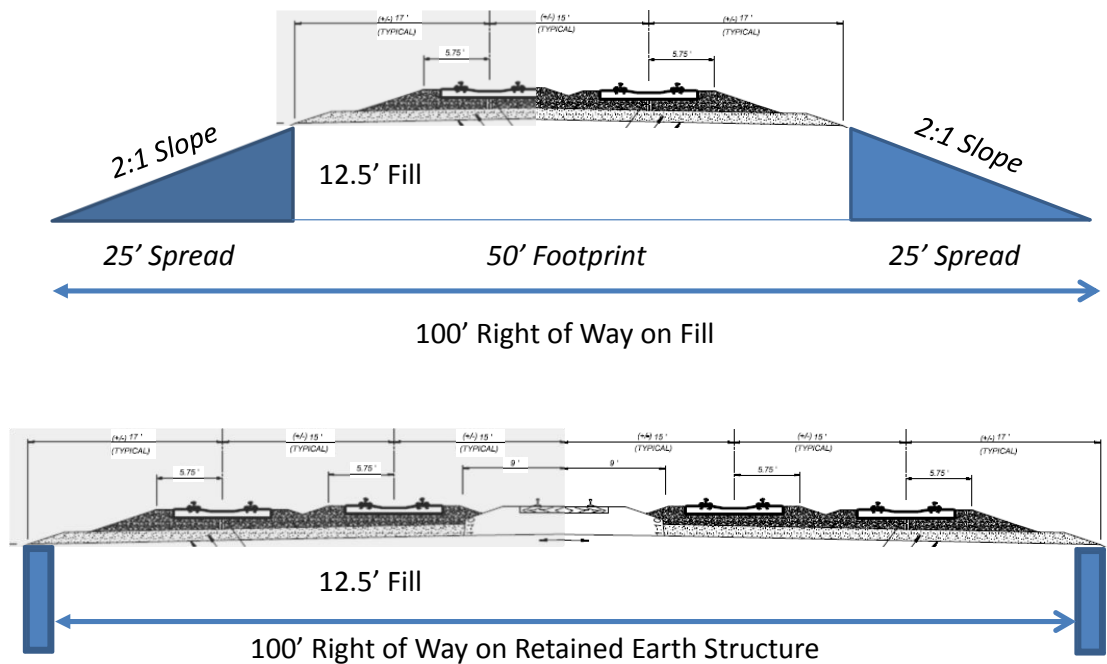


The two existing Norfolk Southern tracks require a physical footprint of approximately 50'. However, the existing tracks are not generally placed directly at ground level through wetland areas, rather they are on a fill structure with culverts underneath the track. A minimal 12.5' fill with a 2:1 slope would expand the Right-of-Way footprint to 100' as shown in Exhibit 3-10. A 17.5' fill would expand the Right-of-Way footprint to 120'. If the fill were higher, the footprint would be wider. ***However, by adding retaining walls, the same footprint could accommodate the added passenger tracks without needing to claim any wetlands.*** This shows how the proposed four track configuration with a 30' separation could be accommodated within a 100' footprint with a 30' spacing, or a 120' footprint with a 50' spacing, ***so this configuration would appear to require only a minimal need for additional wetland taking.***

Exhibit 3-9: 75'-150' Wetland Corridor along the Norfolk Southern at Zuni



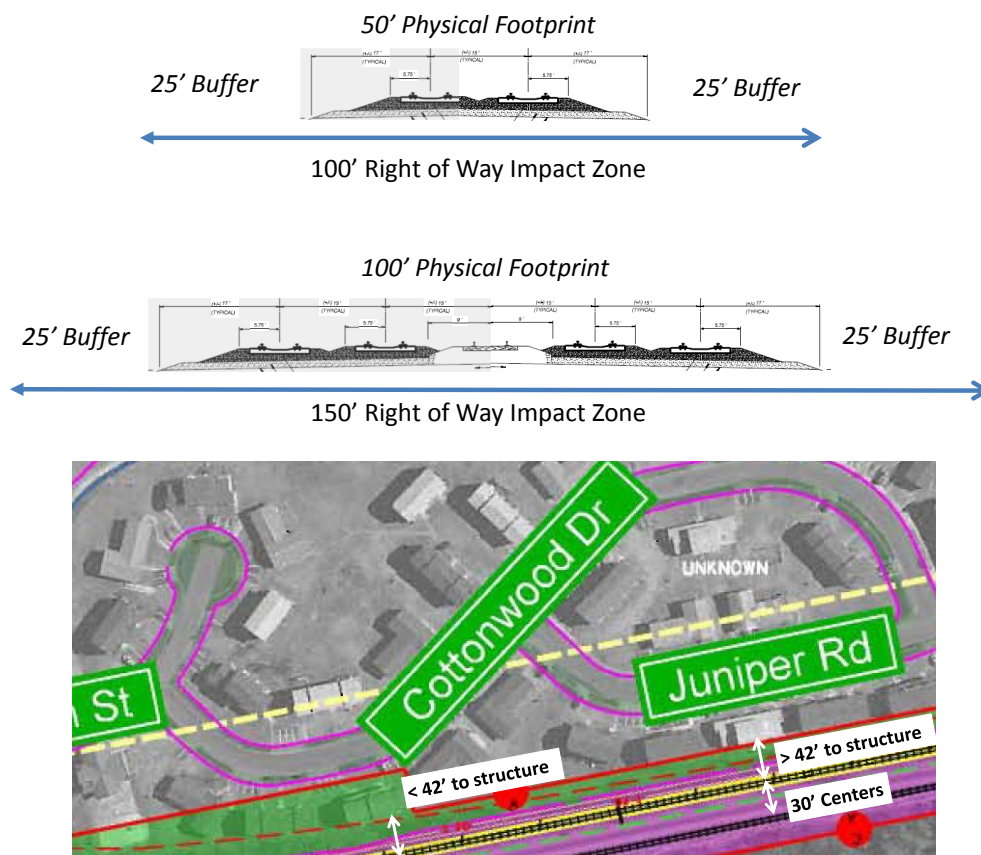
**Exhibit 3-10: Fill versus Retained Earth Structure for a 100' Footprint**



For a "Narrow Footprint" as shown in Exhibit 3-10, it has been estimated that approximately 3 miles of retained earth structure would be needed for areas where the Norfolk Southern corridor passes through wetlands. It is not possible to assess the difference between a 30' and 50' track spacing at the current level of study since this difference is well within the error margin of the available data. A more detailed engineering assessment will be needed to ascertain the difference. In contrast, if a 100' separation were required between the tracks, this would clearly place the new tracks within wetland areas: 6 to 9 miles of bridges may be needed.

The number of property takes depends on the right-of-way width. For consistency in evaluating route alternatives, as shown in Exhibit 3-11, the distance is 17' from the center of the outside track to the edge of the right-of-way, which is part of the minimum 50' footprint. Beyond this, a 25' buffer has been included.

**Exhibit 3-11: Impact Zone for Property Taking Assessment**



With a 25' buffer, the minimum distance from the outside track center to the nearest structure is 42'.

- For a new double track line on Greenfield alignment, the physical footprint is 50', but the right-of-way width is 100', consistent with industry standards.<sup>13</sup> This provides a clear buffer zone of 25' on each side of the track.
- For a greenfield double track parallel to existing track on a 30' center, the physical footprint is 100', so the right-of-way width must be expanded to 150' to provide the same 25' clear buffer zone on each side of the track. For a 50' center the physical footprint is 120', so the right-of-way width must be expanded to 170'.<sup>14</sup>
- This right-of-way standard also appears to be consistent with what the SEHSR assumed for its property taking criteria, as shown on the alignment plates through Petersburg.

For a 30' separation between the freight and passenger tracks, approximately 87 property takes would be needed to widen the right-of-way to 150' including a 25' buffer zone on both sides of the track. By comparison, for a 100' separation between freight and passenger tracks, approximately 153 residential or commercial property takes would be needed for a 220' right-of-way. It can be seen that the wide

<sup>13</sup> This is consistent with what California is using for its High Speed rail development project, see [http://www.hsr.ca.gov/docs/programs/eir-eis/statewide\\_techrpt\\_Ag\\_farmlands\\_rpt.pdf](http://www.hsr.ca.gov/docs/programs/eir-eis/statewide_techrpt_Ag_farmlands_rpt.pdf), page 3

<sup>14</sup> The width of the current Norfolk Southern right-of-way is not known for sure nor is it necessarily the same everywhere. It is assumed however, that Norfolk Southern already owns at least the 50' of right-of-way that are occupied by its existing tracks, so the land acquisition is 100' width to be added to the corridor. The land acquisition therefore is considered the same as for a new Greenfield corridor on separate right-of-way.

footprint option results in considerably more wetland impact as well as more residential and commercial property impact than would a narrower 30'-50' spacing between the freight and passenger tracks. At the extreme, the level of wetland and property take impacts needed for a 100' track spacing along the existing rail corridor would be enough to render this option uncompetitive with greenfield alternatives from an environmental point of view, whereas it appears likely that an environmentally competitive alternative could be developed based on a 30'-50' track spacing.

Summarizing, the overall segment is 46.1 miles long, of which 3.0 miles is assumed to be new double track on 15' retained earth structure and the balance 43.1 miles double track on new roadbed with approximately 15' average fill height. There are no wetland takes, and 87 property takes. There are 47 grade crossings or existing highway bridges which would all be replaced with new grade separations, averaging approximately one grade separation and 1.9 property takes per mile.

### BAKERS POND TO COLLIER CONNECTION

From Bakers Pond, continuing along the Norfolk Southern corridor to CSX connection track at Collier for Option 1B is a distance of 9.3 miles. If the new passenger tracks were constructed on the north side of the alignment, it should be possible to get around the auto facility at Poe without interfering with operations of the auto terminal. However two challenges still remain, as shown in Exhibit 3-12: At the I-95 crossing, the issue is how to get through the rail junction on the north side, without cutting off Norfolk Southern's access to its former main line through Petersburg<sup>15</sup>. Beyond this, residential development tightly hugs the rail right-of-way for the next two miles along the Petersburg Belt Line.

**Exhibit 3-12: Challenges along the Petersburg Belt Line**



<sup>15</sup> The old main line through Petersburg and Belt Line are single tracked, paired and directionally operated to create a double tracked mainline through the area. There are three possible ways for dealing with this issue:

- One alternative might be to replace the capacity of the Old Main Line by double tracking the entire Petersburg Belt Line; but this would exacerbate the right-of-way issues since four tracks (two freight and two passenger) would be needed east of Collier.
- The conflict could be eliminated by tunneling under the rail and highway junction. The length of tunnel could be short (0.5 miles) with a short box tunnel to get under the east leg of the railroad wye, and a slightly longer tunnel to get under the west leg of the rail wye and I-95. Between the two legs of the wye and on each end of the tunnel depressed open cut structures would be needed on the approaches to the tunnel portals.
- The third alternative would be to fly over the junction on a high elevated structure. The structure would need to be 60' tall to get over I-95, using a 4% maximum gradient the flyover structure would need to be at least 3,000' long. However an additional 1,800' would be needed to cross over the east leg of the railroad wye at Poe.



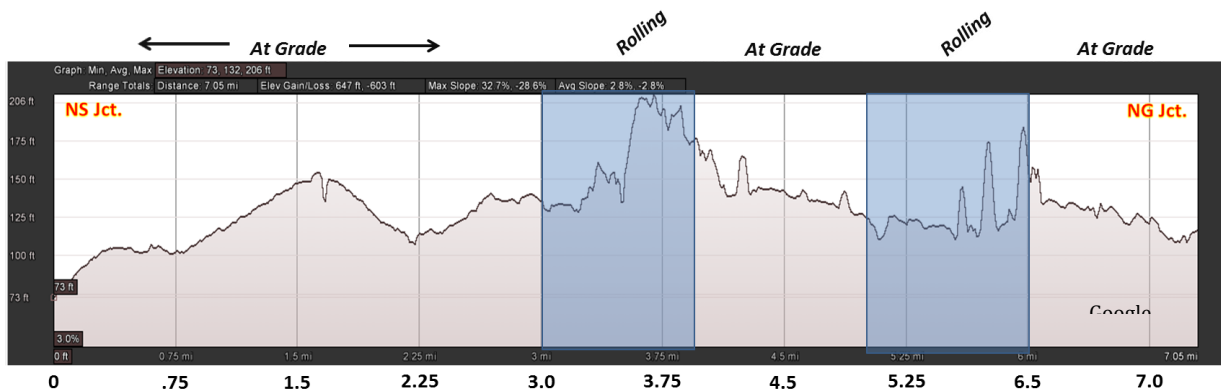
Any of these three alternatives are likely to be expensive. In round dollars a placeholder cost of \$100 million (including soft costs and contingency) is likely appropriate for dealing with the combined rail and interstate highway crossing. For a 100' rail corridor footprint, 25 property takings have been estimated over this 9.3 mile stretch. All 9.3 miles are estimated as double track on new roadbed with approximately 15' average fill height. There are no wetland takes, but there are 4 highway crossings that would have to be grade separated in addition to the \$100 million placeholder for a rail and highway grade separation at I-95.

Beyond Collier, the alignment would connect to the proposed Southeast High-Speed Rail (SEHSR) improvements through Petersburg to Richmond. The continuation of this route to Richmond will be further discussed as part of the Southern Greenfield alternative 1A.

### BAKERS POND TO I-295 VA 646 OVERPASS

Another alternative is to follow I-295 north to Richmond. For option 2B, a 7.2 mile greenfield connection would diverge from the Norfolk Southern right-of-way near Bakers Pond and would head 4.5 miles across open countryside, to enter the I-295 median. It would then continue another 2.7 miles in the I-295 median to the common point where the Northern Greenfield would enter I-295 just south of the VA-646 highway overpass. Exhibit 3-13 shows the elevation profile for this section.

Exhibit 3-13: Elevation Profile, Norfolk Southern to I-295 Connector



As shown in Exhibit 3-13, the cost of the greenfield segment of this connector track is based on 4.5 miles of new double track; 0.4 miles of which are on bridge structure over wetlands and flood plains, 1 mile of which is graded in rolling terrain, and the balance of 3.1 miles at grade. It has 13 roadway crossings, the estimated wetland taking is 0.65 acres, and a 100' right-of-way would require 7 property takings.

Upon reaching I-295, transitioning a rail line into a median strip requires a shallow angle of entry. If the rail line goes over the highway, a long approach structure is needed on either side with a straddle-bent crossing. Putting the rail line over the highway can cost \$100 million for a double track rail structure. It is usually less expensive to raise one set of highway lanes to let the railroad pass underneath, as the New Mexico Rail Runner project did as shown in Exhibit 3-14.

**Exhibit 3-14: Rail Line Transition to Interstate Highway Median (near Los Cerrillos, NM)**



A short box tunnel over the tracks about 0.1 miles long is needed to let the highway lanes pass over. This can be built for \$25-50 million. Because of the need for maintaining traffic on the highway it will be estimated at the higher figure of \$50 million. The I-295 section is estimated as 2.7 miles of double track on new roadbed, since I-295 is already graded plus a \$50 million placeholder for the median strip transition. It includes an allowance for an additional double tracked rail bridge where the I-295 median crosses over VA-634. The continuation of this route beyond the VA-646 overpass to Richmond will be further discussed as part of development of the Northern Greenfield alternative 2A.

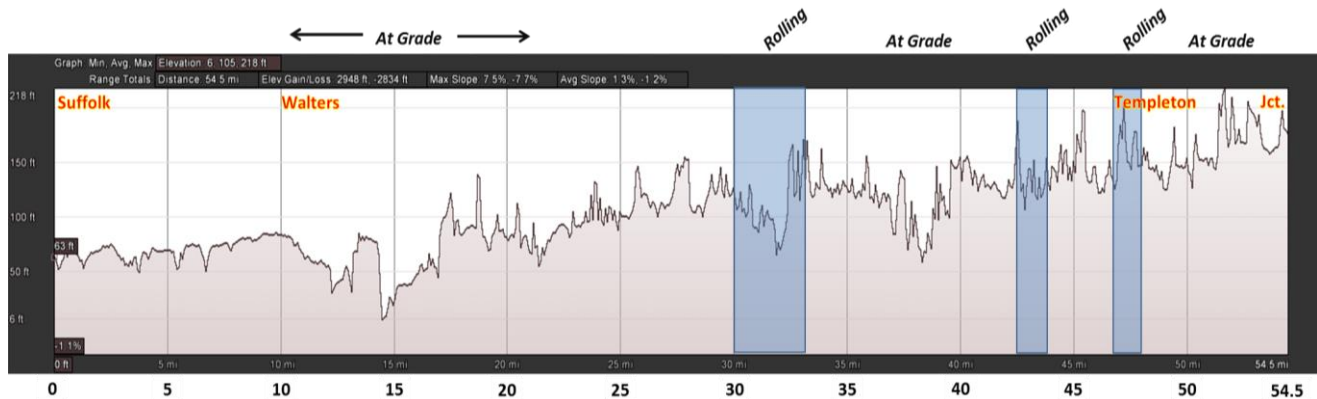
### **3.2.3 SUFFOLK TO RICHMOND VIA PETERSBURG– SOUTHERN GREENFIELD (OPT 1A)**

As previously described, the Southern Greenfield would link Kilby to Burgess, south of CSX's Collier Yard in Petersburg. From Burgess the alignment would follow the SEHSR through Petersburg to Dunlop. At Woods Edge Road, the alignment would leave the CSX rail corridor, cross the James River and utilize an "East Shore Greenfield" through open land to Richmond.

## KILBY TO COLLIER

This proposed Greenfield alternative would head west across fairly open countryside 52.3 miles from Kilby to Burgess, where it would join to the proposed SEHSR alignment. It would then follow the SEHSR alignment 2.2 miles north to Collier where the existing Norfolk Southern rail line joins the corridor. Exhibit 3-15 shows the elevation profile for this section.

Exhibit 3-15: Elevation Profile, Southern Greenfield



As shown in Exhibit 3-15, the cost from Kilby to Burgess is based on 52.3 miles of new double track; 2.9 miles of which are on bridge structure over wetlands and flood plains, 5 miles of which are graded in rolling terrain, and the balance of 44.4 miles at grade. There are 100 roadway crossings requiring grade separations. The estimated wetland taking is 25.1 acres, and a 100' right-of-way would require 63 property takings.

The cost for the 2.2 mile section that is shared with SEHSR from Burgess to Collier is based on double tracking the existing SEHSR plan, by utilizing the 30' right-of-way reservation that will already have been provided as shown in the current alignment plates. One additional track would be added between the current SEHSR (single) track and the two existing CSX "A-Line" tracks. Accordingly, 2.2 miles of single track would be added to the existing SEHSR plan. This is estimated as single track on existing roadbed. There are no additional wetland, property taking, or crossing impacts since the SEHSR would provide a fully grade separated alignment and the proposed additional track would be accommodated within the existing planned SEHSR footprint<sup>16</sup>.

## COLLIER TO WOODS EDGE ROAD

This segment of proposed alignment would share 9.4 miles of right-of-way with SEHSR from Collier to about 0.3 miles north of Woods Edge Road, where the proposed alignment would leave the CSX right-of-way and continue straight onto the East Shore Greenfield. The costing assumptions for this segment are very similar to those for Burgess-Collier since they would utilize the footprints of the improvements that are already planned by SEHSR. In particular, 9.4 miles of single track would be added to the existing SEHSR plan, estimated as additional single track on existing roadbed. There are no additional wetland, property taking, or grade crossing impacts.

The most important added cost along this segment would be the need for a double-tracked Appomattox River bridge, rather than only single track as currently planned by SEHSR. The current Appomattox River

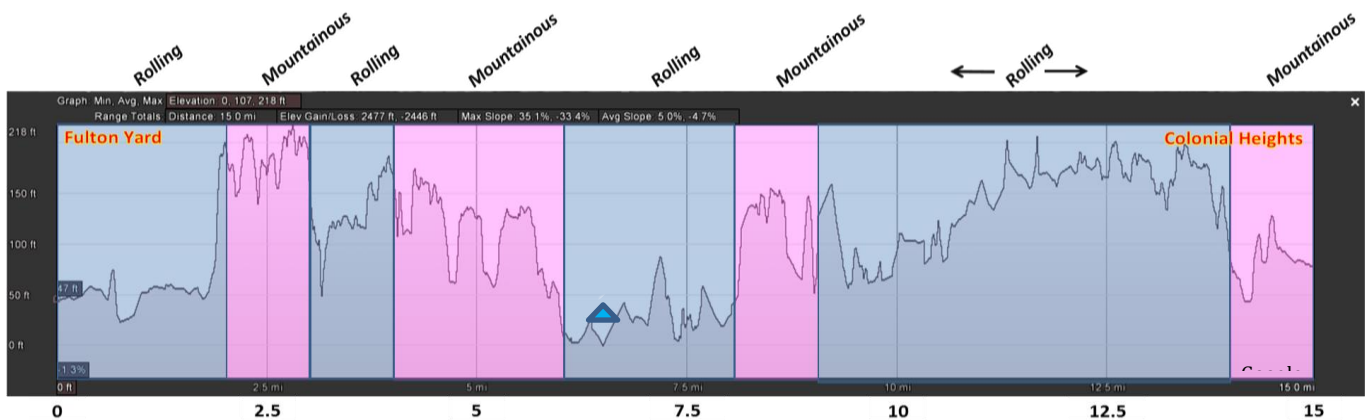
<sup>16</sup> It should be noted that CSX policy allows for co-mingling of freight and passenger trains up to 90-mph on shared track -- and the geometry of this track section won't effectively allow for train speeds much above this 90-mph limit anyway. Therefore as has been discussed previously with DRPT, it is assumed that this existing track can be added within the currently planned SEHSR footprint.

bridge is a roughly 1,300 foot long single tracked structure. By comparison, in 2009 the Union Pacific rebuilt the Kate Shelley High Bridge<sup>17</sup>, a double-tracked structure that is almost twice as long and twice as high as the Appomattox River bridge, for \$50 million. A placeholder of \$25 million is being included in the cost of this segment for the added cost of double tracking the Appomattox River bridge instead of only single tracking the new bridge. A \$20 million placeholder is also included here for the development of a high speed rail station at Petersburg.

### EAST SHORE GREENFIELD: WOODS EDGE ROAD TO FULTON GAS WORKS

The East Shore Greenfield extends for 14.9 miles from just north of Woods Edge Road on the CSX “A” Line north of Petersburg, to the Fulton Gas Works on the CSX Peninsula Subdivision just east of downtown Richmond. Heading north from Woods Edge Road, it parallels I-95 for about 3½ miles, and then follows an existing CSX branch rail line for another mile or so before the entering new alignment through an industrial area. After crossing the James River it traverses undulating, but relatively open terrain in open land on the east shore of the River to the Fulton Gas Works. Exhibit 3-16 shows the elevation profile for this section.

Exhibit 3-16: Elevation Profile, East Shore Greenfield



From the elevation profile shown in Exhibit 3-16, it is clear that significant grading would be required for constructing the East Shore Greenfield. The cost from Woods Edge Road to the Fulton Gas Works is based on 14.9 miles of new double track; 0.8 miles of which are on bridge structure over wetlands and flood plains, 0.7 miles on a high level bridge crossing the James River, 5 miles of which are graded in mountainous terrain, and the balance of 8.4 miles in rolling terrain. None of the alignment is flat so there are zero miles at grade. A placeholder cost of \$350 million is assumed for the high level James River crossing.<sup>18</sup> There are 24 roadway crossings requiring grade separations. Reflecting the relatively rugged nature of the terrain on the east shore of the James River, the estimated wetland taking is only 2.92 acres, and a 100' right-of-way would require only 2 property takings. These savings in right-of-way and wetland impacts may help offset some of the higher grading costs for developing this segment of the alignment.

<sup>17</sup> See: [http://www.uprr.com/newsinfo/attachments/media\\_kit/regional/northern/kate\\_shelley/fast\\_facts.pdf](http://www.uprr.com/newsinfo/attachments/media_kit/regional/northern/kate_shelley/fast_facts.pdf)

<sup>18</sup> The Varina-Enon Bridge over the James River near Hopewell cost only \$36 million to build in 1990. See <http://newsgroups.derkeiler.com/Archive/Misc/misc.transport.road/2008-01/msg02557.html> The Vietnam Veterans Memorial Bridge on the Pocohontas Parkway cost \$111 million in 1996, see [http://en.wikipedia.org/wiki/Vietnam\\_Veterans\\_Memorial\\_Bridge\\_\(Richmond\)](http://en.wikipedia.org/wiki/Vietnam_Veterans_Memorial_Bridge_(Richmond)). Amtrak's Susquehanna River bridge replacement is currently estimated to cost up to \$850 million but would provide two parallel double tracked bridges, including a fixed high level bridge. See [http://www.nec-commission.com/cin\\_projects/susquehanna-river-bridge-replacement](http://www.nec-commission.com/cin_projects/susquehanna-river-bridge-replacement)



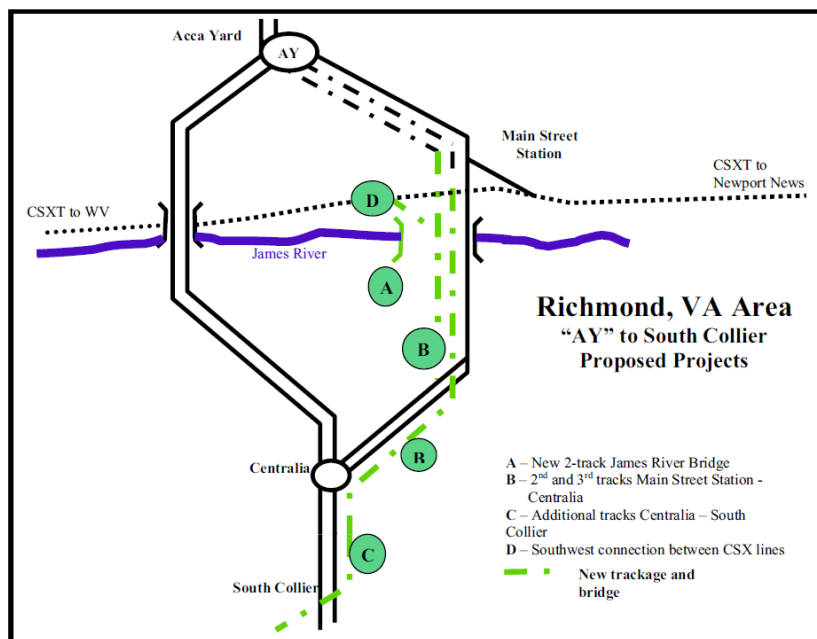
### FULTON GAS WORKS TO RICHMOND MAIN STREET

This section of 1.5 miles length would be entirely elevated as it parallels CSX's viaduct from Fulton Yard west to Main Street station. Since the East Shore greenfield approaches from the south and Main Street Station is on the north side of the CSX tracks, the first challenge would be to develop a high level elevated flyover crossing the CSX tracks. Coming down from this flyover, the passenger alignment would land on the north side of the existing CSX viaduct. To avoid the challenges associated with building a bridge structure directly over an active rail freight yard, most likely the flyover would need to be located just west of Fulton yard.

Having transitioned the passenger trains over to the north side of the CSX alignment, if a new structure were actually continued on the north side, this would place the new elevated structure directly over Dock Street. To avoid impacting the historic area, from Fulton Yard to Rivanna Junction it might make more sense to construct a new elevated structure instead on the *south* side of CSX's existing structure, then shift freight trains onto the new structure. Passenger trains could then use CSX's existing viaduct into Main Street station. Doing this would reduce the impact on the historic area.

Double track would be restored on the curving section of viaduct from Rivanna Junction through Main Street station. The limited number of CSX freight trains that run over the Piedmont Subdivision or up to Acca Yard could share a short segment of restored double track on the Piedmont subdivision line. Or, by constructing a new southwest quadrant rail connection at Richmond as proposed by CSX, the number of freight trains that would need to use the track past Main Street may be reduced, see Exhibit 3-17.<sup>19</sup>

**Exhibit 3-17: Proposed Southwest Quadrant Freight Connection (Item "D") in Richmond**



<sup>19</sup> U.S. Department of Transportation, Corridors of the Future Program Application: The Southeast I-95 Corridor, CSX Transportation, May 2007. See pp. 37-38. <http://www.vhsr.com/system/files/CSX+CFP+Submission.pdf> "The proposed southeast connection between the CSXT rail lines will eliminate the need for cumbersome movements of freight trains through the Main Street Station."

As described previously, the rail infrastructure in this area such as overhead catenary height and platform tracks must be designed to accommodate the requirement for shared freight and passenger use. By doing this it is expected that impacts to wetlands and Richmond historical structures can be avoided.

- For approaching from the East Shore Greenfield, this 1.5 miles will be estimated at the standard rate for elevated double track structure, with an additional \$50 million for adding a high level flyover from the south to the north side of the rail alignment.
- For the Richmond Direct and I-295 approaches into Richmond no flyover crossing is needed since these alignments approach along the north side of the CSX right-of-way, so the standard rate for elevated double track structure can be used.

### **3.2.4 SUFFOLK TO RICHMOND VIA HOPEWELL– NORTHERN GREENFIELD (OPTION 2A)**

As previously described, the Northern Greenfield would link Kilby to I-295. From Kilby past Zuni the proposed alignment would follow an existing electric utility corridor south of the existing Norfolk Southern tracks<sup>20</sup>. At Zuni, the alignment would swing north across the Norfolk Southern main line to Proctors Bridge Road where the proposed Richmond Direct alternative would diverge. From Proctors Bridge Road to I-295 at Hopewell, the Northern Greenfield alignment to Hopewell would head northwest staying on the north side of US 460. Lining up with I-295, it would enter the I-295 median just south of the VA-646 highway overpass, then continue in the I-295 median to Richmond.

#### **KILBY TO PROCTORS BRIDGE ROAD**

The Kilby to Proctors Bridge Road segment of the Northern Greenfield extends for 20.6 miles from just west of Kilby to the vicinity of Proctors Bridge Road, north of Ivor. Passing underneath the Norfolk Southern rail bridge at Kilby, the alignment turns northwesterly across open countryside to parallel the electric line and finally join and share its right-of-way. It follows a utility line right-of-way for about 10 miles, past Zuni, before crossing to the north side of the US 460 highway alignment.

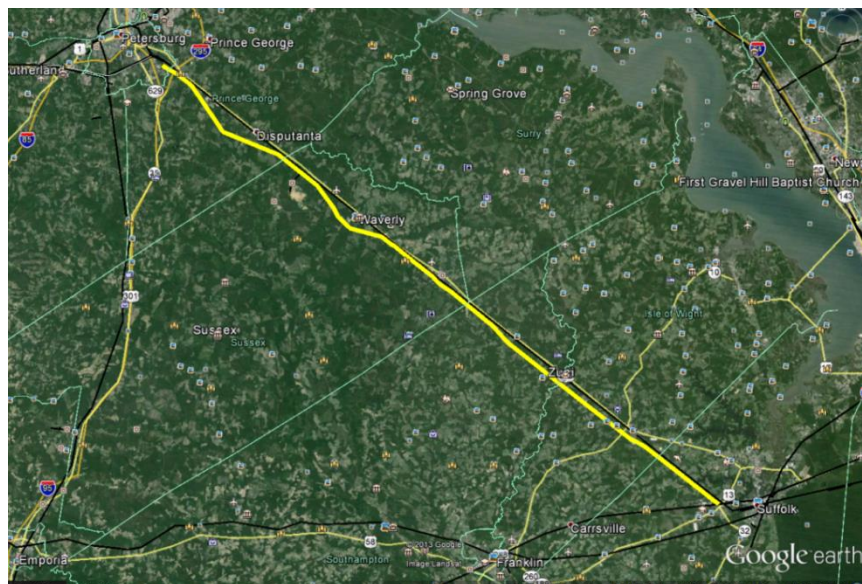
As an alternative to using the Norfolk Southern rail corridor between Kilby and Zuni, as shown in Exhibit 3-18 an electric power line right-of-way was seen to extend on a mostly straight alignment all the way from Kilby to Disputanta.<sup>21</sup> Aside from the fact that it already exists and is mostly straight, this electric utility corridor bypasses the small towns (Windsor, Wakefield, etc.) along the way. Using the utility right-of-way instead of the Norfolk Southern rail corridor could provide a way to avoid the property takings that would otherwise be needed for widening the rail right-of-way through the towns.

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<sup>20</sup> The initial concept was to develop one greenfield alignment completely south and one completely north of the existing US-460 corridor. For the Northern greenfield, an early concept was based on the idea of heading from Bowers Hill straight across the Dismal Swamp, following US-58 around the north side of Suffolk and then heading west to join I-295 at Hopewell. The main advantage of the Suffolk Bypass is that trains heading west from Bowers Hill could immediately accelerate to 220-mph. The alternative was developed to the point of preliminary discussions with Virginia DOT regarding its feasibility. However, some problems with this concept soon became apparent. Local trains that stop at a suburban Suffolk station along US-58 would not save any time, and a northern Suffolk Bypass was seen to require extensive elevated structure because of extensive wetlands and highway right-of-way restrictions. While the alternative was not considered fatally flawed, it was apparent that this segment would be very expensive to develop. Because two other options for following existing rail alignments through Suffolk could likely be developed at a much lower cost, it was considered that a northern Suffolk Bypass would likely be screened early in any prospective environmental evaluation. As a result a downtown Suffolk alternative to Kilby as previously described was developed instead.

<sup>21</sup> For the purposes of this study only the segment from Kilby to Zuni is included in the rail option. The extended use of this electric utility corridor all the way from Kilby to Disputantia could however, be developed as an additional option during the Tier I environmental study, if desired.

**Exhibit 3-18: Electric Utility Right-of-Way Paralleling the Norfolk Southern Rail Corridor**



Appendix F includes a feasibility study on transportation use of utility corridors, completed by the Maryland Department of Transportation in April 2002. While this study noted a number of concerns regarding the use of utility corridors, many of those (such as sharp turns and undulating topography) are site specific. On the other hand, the report provided a number of examples where transportation facilities have been successfully developed within utility rights of way, including both highway and rail cases. One of the key recommendations of the report was the replacement of lattice towers with the newer pole designs, if necessary to reduce the physical footprint of the utility structures. This can free some land for accommodating the transportation facility within the right-of-way. In designing the corridor it is important to provide access for maintenance of both power transmission lines and the transportation facilities. Although there are challenges associated with use of utility rights of way, there are opportunities also, and many instances of successful projects built within such rights of way.

Beyond this however, an important benefit potentially associated with using utility right-of-way is that the environmental GIS shape files show that, in many cases, the right-of-way associated with the electric power line has already been compromised. As shown in Exhibit 3-19, the power line right-of-way can be seen to cut a swath through some existing wetlands just as railroads or highways do. As a result, there is an opportunity to reduce wetland impacts by co-locating a rail line inside the existing electric power corridor.

**Exhibit 3-19: Electric Utility Right-of-Way Cuts through Wetlands**



Although there are some engineering issues associated with adding a rail line to an electric utility right-of-way, such use is not unprecedented. It would also provide a clear benefit to electrification of the rail line, since the necessary power source would be directly overhead. Exhibit 3-20 shows an existing rail line co-located with two electric power lines along Hiawatha Boulevard in Minneapolis, MN. Closer to home, Exhibit 3-21 shows the CSX Phoebe branch in Hampton, VA which shares its right-of-way along Pembroke Avenue with a high voltage electric transmission line.

**Exhibit 3-20: Rail Line Co-located with Electric Power Lines in Minneapolis, MN**





**Exhibit 3-21: Rail Line Co-located with Electric Power Lines in Hampton, VA**



**Exhibit 3-22: Elevation Profile, Northern Greenfield**

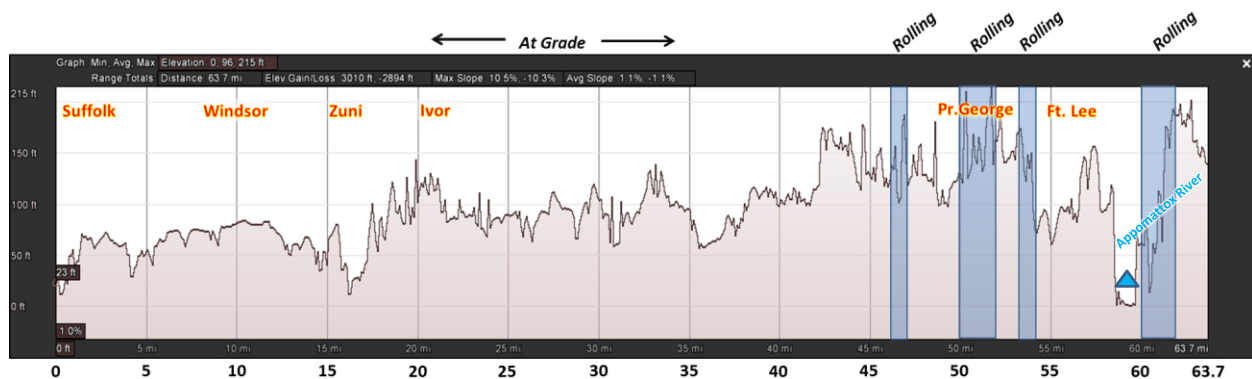


Exhibit 3-22 shows the elevation profile for the Northern Greenfield. (Please note that this profile extends from Suffolk all the way through Fort Lee to a possible connection with the East Shore Greenfield near Moore Lake.) From this exhibit, it can be seen that the first 20.6 miles west from Suffolk past Ivor are all across level terrain, but there are also significant wetland issues in this stretch. The cost from Kilby to Proctors Bridge Road is based on 20.6 miles of new double track; 2.4 miles of which are on bridge structure over wetlands and flood plains, and the balance of 18.2 miles at grade. The alignment has 32 roadway crossings. The estimated wetland taking is 12.96 acres, and assuming that utility power line towers can be avoided, 14 property takings are needed for a 100' right-of-way.

### **PROCTORS BRIDGE ROAD TO I-295 VA 646 OVERPASS**

Beyond Ivor, the proposed Northern Greenfield alternative passes through open countryside north of US 460 but must curve gently to avoid wetlands and minimize impacts. Since it is a high speed alignment curves are limited to a maximum of 15-minutes rotation per 100 feet of distance, so it is not always possible to cross wetlands at right angles. Nonetheless, an effort has been made to avoid as many wetlands as possible. According to the Virginia Natural Landscape Assessment (VaNLA, see Appendix D Section 4), this segment traverses significant stretches of contiguous natural habitat, to avoid fragmentation the need for wildlife overpasses and underpasses along this stretch of track will have to be carefully addressed, in the next phase of environmental planning.

The cost from Proctors Bridge Road to the I-295 VA 646 Overpass is based on 33.4 miles of new double track; 0.4 miles of which are on bridge structure over wetlands and flood plains, 4 miles of which are in rolling terrain, and the balance of 29 miles are at grade. The alignment has 68 roadway crossings. The estimated wetland taking is 10.71 acres, and 32 property takings are needed for a 100' right-of-way. It also includes a \$50 million placeholder (per discussion of Exhibit 3-14) for the transition into the I-295 median.

### **I-295 VA 646 OVERPASS TO OAKLAWN BOULEVARD**

This critical 2.3 mile segment of I-295 passes through the Hopewell conurbation from the south to the north; based on consultation with Virginia DOT, it is assumed that the rail alignment will be able to utilize this section of I-295 median at grade. This section is costed as 2.3 miles of double track on new roadbed, since the I-295 median is already graded. A \$20 million placeholder is also included here for the development of a high speed rail station at Hopewell.

Beyond Oaklawn Boulevard there is a possible option for heading across Fort Lee to connect with the East Shore Greenfield near Moore Lake. This section would have some rolling terrain issues and also an Appomattox River crossing. However, since Fort Lee is an active military training reservation, it is not clear that this connection would be allowed, and a tunnel option would not be cost effective. The I-295 median provides alternative to building this connection across Fort Lee, so it is assumed that the Northern Greenfield alternative will be paired with I-295 north to Richmond, rather than with the East Shore Greenfield.

### **OAKLAWN BOULEVARD TO RICHMOND AIRPORT**

From Oaklawn Boulevard, the rail alignment will remain on I-295 to the Pocahontas Parkway interchange, a distance of 14.8 miles. From this interchange a greenfield connection would leave the I-295 median and fly over to the north side of the CSX Peninsula Subdivision rail line, a distance of 2.2 miles.

The I-295 section is costed as 13.8 miles of double track on new roadbed, since the I-295 median is already graded. To avoid double counting of costs, this backs out a mile for the length of the Appomattox and James River bridges, which are accounted for by placeholders: \$50 million for a double tracked Appomattox River bridge, and \$350 million for a new high level James River crossing parallel to the current Varina-Enon Bridge<sup>22</sup>. The alignment has 3 roadway crossings that need short bridges.

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<sup>22</sup> The Øresund Bridge linking Denmark and Sweden carries a four lane highway and a double tracked railway, and like the Varina-Enon Bridge, it is also of Cable Stayed design. It is possible that by widening and strengthening the Varina-Enon Bridge a rail alignment could be added to it for less cost than building a parallel new high level rail bridge. See: [http://en.wikipedia.org/wiki/%C3%98resund\\_Bridge](http://en.wikipedia.org/wiki/%C3%98resund_Bridge)

The greenfield section that connects over to the CSX rail line is estimated as 2.2 miles of new double track, 1.5 miles of which is graded on rolling terrain and 0.7 miles of bridge structure over wetlands and flood plains. The alignment has 3 roadway crossings and one rail line crossing that need short bridges. The estimated wetland taking is 5.98 acres, and 1 property taking is needed to obtain a 100' right-of-way for this connection. It also includes a \$50 million placeholder for the transition out of the I-295 median.

#### **RICHMOND AIRPORT TO THE FULTON GAS WORKS**

From the Richmond Airport to the Fulton Gas Works, the proposed high speed alignment would parallel the CSX Peninsula Subdivision on the north side. At the Gas Works to gain access to Main Street station, the alignment would connect into the viaduct structure previously described.

One issue for this segment is where the proposed High Speed rail alignment passes 1,400 feet south of precision instrument runway 2/20 of Richmond International Airport. According to FAR Part 77 - Obstructions to Navigation<sup>23</sup> the required precision instrument approach slope is 50:1 with a buffer of 200 feet beyond the end of the runway. This means the highest vertical obstruction at 1,400 feet cannot rise more than 24 feet above the level of the runway. This should be enough vertical clearance to allow installation of electric catenary over the High Speed tracks.<sup>24</sup> A possible mitigation may be trenching to lower the High Speed tracks by a few feet if necessary to fit the electrification overhead. A more detailed engineering assessment will be needed during the Environmental study to confirm that electric catenary can be installed without any impact on aircraft operations.

This greenfield section is costed as 5.2 miles of new double track on, 4.7 miles of which is on level terrain and 0.5 miles of bridge structure over wetlands and flood plains. The alignment has 8 roadway crossings but no wetland taking. Only one property taking is needed to obtain a 100' right-of-way for this section. In conjunction with the Fulton Gas Works to Richmond Main Street segment described earlier, this completes the description of the Northern Greenfield section.

### **3.2.5 RICHMOND DIRECT (OPTION 3)**

The final remaining segment is the Richmond Direct alternative, from the Northern Greenfield at Proctors Bridge Road north of Ivor to Richmond Airport, from where it shares a common entry into Richmond with the I-295 alternative. The Richmond Direct alignment bypasses Hopewell and Petersburg, instead heading directly to Richmond over the shortest practicable route.

#### **PROCTORS BRIDGE ROAD TO RICHMOND AIRPORT**

From Ivor, the Richmond Direct alternative heads directly towards Richmond, crossing the James River just south of Charles City at a point where the river is approximately  $\frac{3}{4}$  mile wide. After this it bridges several wetland areas and crosses over the CSX Peninsula Subdivision, landing on the north side of the existing track. The alignment then follows CSX on the north side to Richmond Airport. Just like the other greenfields proposed in this study, a prospective Richmond Direct alignment was laid out on the principle of minimizing wetland impacts, while altogether avoiding protected parks and battlefields. Exhibit 3-23 shows the elevation profile for the original Richmond Direct option that includes the Suffolk Bypass. Exhibit 3-24 shows the elevation profile for the Ivor to Dendron (Proctors Bridge Road) connector that links the Northern Greenfield alignment with the Richmond Direct alignment. (East of Ivor the Northern and Richmond Direct Greenfields are the same.)

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<sup>23</sup> See: [http://www.wsdot.wa.gov/nr/rdonlyres/f2c1829f-7969-4a47-adcc-64c6b6320ba0/0/far\\_part77.pdf](http://www.wsdot.wa.gov/nr/rdonlyres/f2c1829f-7969-4a47-adcc-64c6b6320ba0/0/far_part77.pdf)

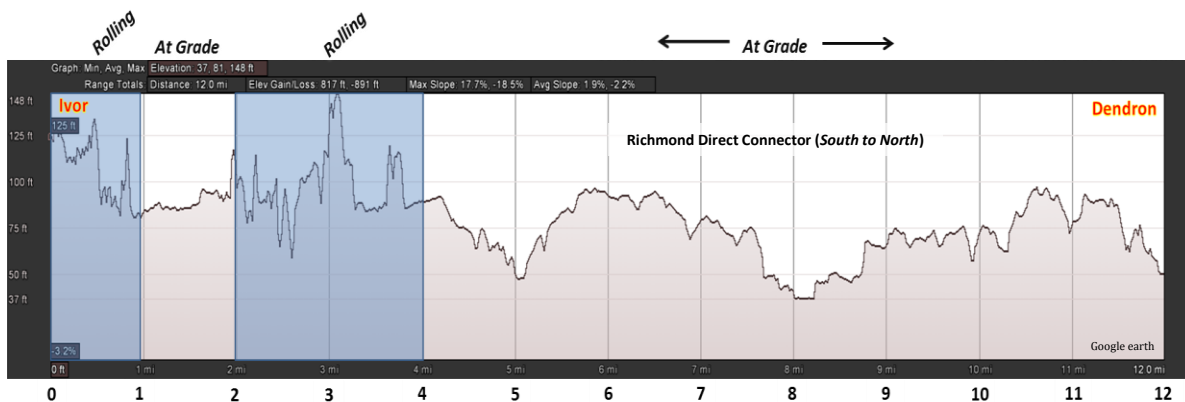
<sup>24</sup> The European height for High Speed catenary is 18-19 feet above the rail. <http://www.railpac.org/2010/01/26/high-speed-and-commuter-rail-electrification-is-catenary-height-an-issue/>

Exhibit 3-23 shows the elevation profile for the Richmond Direct option if the bypass around the northern outskirts of Suffolk were used. With this option there are no terrain issues at all until the north side of the James River, where three miles of alignment are classified as rolling terrain. Exhibit 3-24 shows the elevation profile for the alignment section connecting the Northern Greenfield at Ivor to the Richmond Direct option at Dendron. This identifies three additional miles of rolling terrain to make the connection between the Northern Greenfield (east of Ivor) and the Richmond Direct alignment (west of Dendron.)

**Exhibit 3-23: Elevation Profile, Richmond Direct Option from Suffolk to Richmond**



**Exhibit 3-24: Elevation Profile, Richmond Direct Connector from Ivor to Dendron**



The cost from Proctors Bridge Road to Richmond Airport is based on 49.6 miles of new double track; 4.6 miles of which are on bridge structure over wetlands and flood plains, 0.7 miles on a high level bridge crossing the James River, 0.6 miles on a low level bridge across Upper Chippokes Creek, 6 miles are graded in rolling terrain, and the balance of 37.7 miles at grade. A placeholder cost of \$350 million is assumed for the high level James River crossing and \$50 million for the low level crossing of Upper Chippokes Creek. Most of the wetland issues occur north of the James River. According to the Virginia Natural Landscape Assessment (VaNLA, see Appendix D Section 4), this segment traverses significant stretches of contiguous natural habitat, to avoid fragmentation the need for wildlife overpasses and underpasses along this stretch of track will have to be carefully addressed. Some of these landscape fragmentation issues could also be addressed by minor alignment shifts in the next phase of environmental planning. The segment has 76 roadway crossings and 35.24 acres of wetland taking. 23 property takings are needed to obtain a 100' right-of-way.



Costs and statistics for the overall Options 1A, 1B, 2A, 2B and 3 have been developed on an overall route basis by adding the individual segment costs together. These summary results by route option will be reported in Chapter 5.

### 3.3 SEGMENT BY SEGMENT ANALYSIS – NEWPORT NEWS TO RICHMOND

The following subsections will address environmental and engineering conditions existing along each route segment from Newport News to Richmond. As described in Chapter 2, a number of possible route options have been identified for Peninsula rail service, but only one option has been developed here for costing purposes. The other options are suggested for scoping a proposed Tier I environmental study and may be more fully assessed during the course of that study. As can be seen in Exhibit 3-2, the Peninsula representative route includes three segments:

1. Richmond Direct Segment 1: Richmond to Roxbury
2. Toano Connector Segment 2: Roxbury to Toano
3. Shared CSX Peninsula Segment 3: Toano to Newport News

However, segment #1 has already been developed as part of the Richmond Direct alignment to Norfolk and Peninsula diesel trains could use this track (130-mph on diesel power, not using the overhead electrification) for no additional capital cost. Only segments #2 and #3 will be developed here.

#### 3.3.1 NEWPORT NEWS TO TOANO - EXISTING RAIL SEGMENT #3

The segment from Newport News to Toano would follow the existing CSX rail line and be limited to a 90-mph top speed. This segment starts at downtown Newport News and continues 35 miles along the CSX corridor to Toano. It has three stations: a proposed new station at downtown Newport News, a new station currently under development at Bland Boulevard, and the existing Amtrak station at Williamsburg. The analysis assumes that the existing Amtrak station at Mercury Boulevard will already have been closed and replaced by the Bland Boulevard multi-modal station.

Because of the very early stage of current project development, some very preliminary assumptions have been made regarding costs for this segment. Pending completion of a capacity analysis, this study assumes that full double track should be the *starting point* for any discussion with CSX of capacity needs. The cost estimate for this segment assumes that the full length of the corridor (all 35 miles from downtown Newport News to Toano) will receive one added track on new roadbed. The existing corridor already includes some double track sections so this would in fact be sufficient to add some sections of third track to the Peninsula corridor. Although the existing track is in good shape and supports passenger service today, an allowance of \$1 million per mile has been provided for upgrading the existing CSX track as well. Finally an allowance of \$3.1 million per mile has been included for full bi-directional signaling, Positive Train Control and crossovers all the way from downtown Newport News to Toano.

The plan assumes the use of push-pull or double ended trains that have a diesel power car at both ends. These trains won't need turning so there is no need for wye track. The project also assumes that a train turnaround maintenance base will be located near the end-of-line station in downtown Newport News.

This results in a budget of \$253 million to restore double track on the existing (already graded) track bed and bridges for track along this 35 mile segment, and for signal improvements. In addition, there are 57 grade crossings, an average of 1.6 crossings per mile. A cost of \$1.03 million per crossing is proposed to fully quad-gate and seal the corridor. This goes beyond the requirement for 90-mph operations where only conventional gates and flashers are legally required. However the additional expenditure will enhance safety and may also allow for introduction of some "quiet zones" for mitigating noise impacts.

Overall the cost estimate for the Newport News to Toano segment is \$311 million or \$8.9 million per mile. This estimate is subject to a number of uncertainties, in regard to both the geographical and operational scope of the project:

- A decision must be made whether to extend the service all the way to a downtown Newport News station. The distance from Bland Boulevard to the proposed downtown station is approximately 11 miles, and part of this distance includes the CSX Newport News terminal complex. For this study, the downtown Newport News station has been retained; based on the assumed average cost of \$8.9 million per mile, this would give a budget of nearly \$100 million for extending rail service downtown. *This \$100 million is included in the current cost estimate for the Peninsula rail service as well as in the Cost Benefit justification.* While a Bland Boulevard station may adequately serve Newport News, a downtown station would better serve Hampton. The value of a downtown station or even a possible further service extension along the Phoebus Branch needs more study in a future assessment.
- HRTPO has proposed a new commuter rail service from Toano to downtown Newport News.<sup>25</sup> The time frame and priority of possible implementation of this service remains unclear; however, there could be an opportunity to advance the commuter project jointly with development of intercity passenger rail. Adding a commuter rail component will likely require some additional rail infrastructure, however the core capacity improvements could be shared by the two passenger rail systems as well as by freight trains. In general it has been found that where commuter rail systems are developed parallel to intercity systems, as is also occurring in northern Virginia from Fredericksburg into Washington D.C., rather than cannibalizing ridership it actually tends to boost the ridership of *both* systems -- so there could be synergies from advancing the two projects together. A decision needs to be made whether to advance Enhanced Intercity passenger rail on the Peninsula by itself or to add an optional commuter rail element into the scope of the Tier I EIS alternatives analysis. While the two projects must be kept separate and distinct, some significant economies could be achieved by coordinating the planning of the two projects. However, the current capital cost estimate provides only for the intercity rail operation, and does not include any incremental costs that might be needed for adding a commuter rail service.
- Finally, all costing assumptions, particularly in regard to the adequacy of the proposed double track for mitigating freight capacity needs, are pending the outcome of a detailed line capacity analysis<sup>26</sup> as well as formal CSX involvement. A “screening” level capacity assessment<sup>27</sup> can provide a rigorous methodology for estimating preliminary capacity needs in a Tier I EIS, while detailed simulation using the Rail Traffic Controller (RTC) tool is normally done to finalize the analysis<sup>28</sup> during a Tier II EIS. This proposal for adding passenger service to the Peninsula is still

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<sup>25</sup> See the *James City County/Williamsburg/York County Comprehensive Transportation Study*, March 2012: pages 15, 45, 46 and 47 at [http://www.yorkcounty.gov/Portals/3/ICC%20WMB%20YC%20Final%20Report\\_reduced.pdf](http://www.yorkcounty.gov/Portals/3/ICC%20WMB%20YC%20Final%20Report_reduced.pdf) and also pages ES-14, ES-20 of [http://www.drpt.virginia.gov/activities/files/Final\\_Report\\_03-17-11.pdf](http://www.drpt.virginia.gov/activities/files/Final_Report_03-17-11.pdf)

<sup>26</sup> A particular challenge will be find a cost effective way for passenger trains to reach a downtown Newport News station. One issue is that coal trains are apparently being stored on the main line if they are not wanted right away at the coal terminal. For storing trains as needed, it might make sense to propose upgrading the Receiving Yard at Newport News as an alternative to adding a mainline track downtown. Given the \$100 million that is included in the capital cost estimate for extending rail service downtown, it seems likely that this funding could support a substantial reconfiguration of the existing rail yard as needed. Doing this may allow the passenger rail service to use the existing main track on the south side of the rail corridor to reach a downtown station. This needs more discussion with CSX so if HRTPO decides to include it in the project scope for the next phase of work, a full resolution might require the use of detailed yard modeling tools like TEMS' Switch-It model in addition to normal over-the-road line capacity modeling.

<sup>27</sup> See: <http://apps.trb.org/cmsfeed/TRBNetProjectDisplay.asp?ProjectID=2918> and [http://www.dot.state.mn.us/planning/railplan/docs/mwrr/6\\_Freight\\_Capacity\\_Methodology\\_and\\_Results.pdf](http://www.dot.state.mn.us/planning/railplan/docs/mwrr/6_Freight_Capacity_Methodology_and_Results.pdf)

<sup>28</sup> The high level of infrastructure detail required by the RTC model, in particular precise locations of signals, switches, etc. may not be fully known or decided at the time of a first-cut capacity needs assessment. This level of infrastructure detail requires that Engineering design be completed to at least a Preliminary Engineering level. Earlier than this, the use of other capacity planning tools may be more cost effective.

un-negotiated and un-funded. The preliminary findings of this report are not to be construed as any commitment on the part of CSX to operate additional service or upgrade infrastructure.

### 3.3.2 TOANO TO ROXBURY – GREENFIELD CONNECTOR SEGMENT #2

This segment would be a 23.6 mile greenfield connector from Toano to Roxbury. It is assumed that this new dedicated double track will be fully grade separated and built to 220-mph geometric standards, but not electrified. Thus, high performance diesel trains could run up to 130-mph over it. Optionally if dual-mode diesel/electric trains were deployed, the segment could be electrified and operated at up to 220-mph (depending on the specific speed capabilities of the dual-mode trains) for additional time savings.

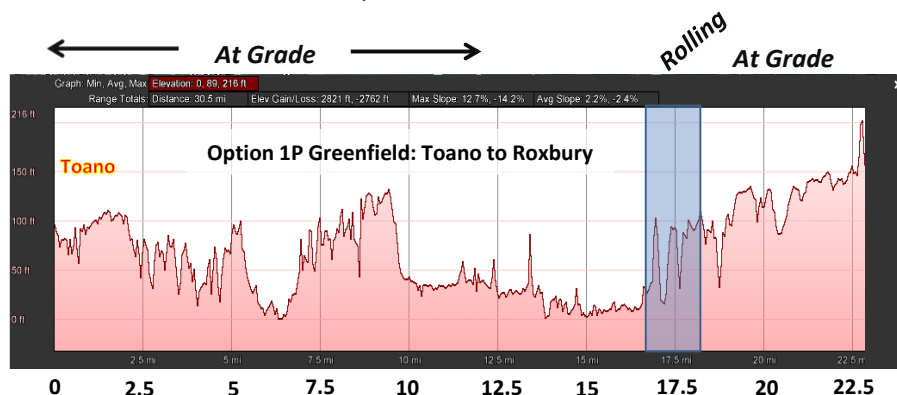
For the most part the proposed rail alignment follows an electric utility right-of-way -- although in a few places, particularly where the electric line changes direction, it is necessary to deviate from the utility right-of-way in order to ease the curves. Maximizing the use of the utility right-of-way minimizes the need for property takes, although 19 takes are still necessary because of these curve transitions.

The central portion of the power line corridor crosses the Chickahominy River. Although the river is not navigable this far north, in this area the utility right-of-way will likely require bridging to avoid wetland impacts. An allowance of 3.6 miles of low double track bridge structure is included in the overall 23.6 mile length. Because of this aggressive use of bridge structure, only 2.7 acres of lower value wetland are proposed to be filled and remediated.

While 3.6 miles are on bridge, the remaining of 20.0 miles of double track has been conservatively costed based on average 15' fill height, although as shown in Exhibit 3-25, much it could actually be at grade. All 23.6 miles have signals, Positive Train Control and interlockings and crossovers every 10 miles.

This segment also includes 22 rail and highway crossings that must be grade-separated, and average of 0.9 crossings per mile. A rural land value of \$137,000 per mile has been assumed in this area plus the cost of property takes at \$161,000 each. This leads to an overall cost for this segment of \$609 million, an average of \$25.8 million per mile for double track, *non-electrified* infrastructure.

Exhibit 3-25: Elevation Profile, Peninsula Connector from Toano to Roxbury



## 4. ENGINEERING ANALYSIS

*Building on the route development that has been described in Chapters 2 and 3, this chapter presents the unit capital costs to be used to develop study costs for the Hampton Roads-Richmond; and develops the Capital Cost estimate for all the options, based on detailed information presented in Chapters 2 and 3, and elsewhere in the report. The Chapter concludes by presenting a benchmarking analysis comparing the study results with those from comparable corridors elsewhere.*

### 4.1 INTRODUCTION

A capital costing methodology was developed to identify infrastructure rolling stock (equipment) costs and land costs. Land costs are presented separately, as a placeholder for access to railroad rights-of-way and for procurement of additional privately owned property where required to construct new passenger rail infrastructure.

The Engineering Assessment for the Vision Plan is being conducted at a feasibility level of detail and accuracy. Exhibit 4-1 highlights the levels of accuracy associated with typical phases of project development and engineering design. A 30% level of accuracy is associated with the evaluation of project feasibility; while the level of accuracy of 10% is achieved during final design and production of construction documents. This phase of the study is only the first step in the project development process. As shown in Exhibit 4-1, the cost estimate is intended to be a mid-range projection with equal probability of the actual cost moving up or down.

**Exhibit 4-1: Engineering Project Development Phases and Levels of Accuracy Development**

Development Phases	Approximate Engineering Design Level*	Approximate Level of Accuracy**
Feasibility Study	0%	+/- 30% or worse
Project Definition/Advanced Planning	1-2%	+/- 25%
Conceptual Engineering	10%	+/- 20%
Preliminary Engineering	30%	+/- 15%
Pre-Final Engineering	65%	+/- 15%
Final Design/Construction Documents	100%	+/- 10% or better

The first step in the Engineering Assessment is to divide each corridor into segments. Route segments for existing railroad rights-of-way generally begin and end at major railroad control points or rail stations. For greenfield alignments, segments begin and end at stations or junction points. Typical corridors are divided into three to five route segments. These segments are discussed and defined in Chapter 3. A systematic engineering planning process has been used to conduct the Engineering Assessment using the five basic costing elements:

- Guideway and Track Elements
- Structures – Approaches, Flyovers, Bridges and Tunnels
- Systems
- Crossings
- Stations and Maintenance Facilities



Three auxiliary costing elements have been defined in the chapter as follow:

- Right-of-Way and Land
- Vehicles
- Professional Services & Contingencies

The Engineering Assessment will be based on these eight costing elements. In addition to the field inspections and extensive work with GIS and railroad track charts, the assessment will include a thorough review of the alignment studies and estimate the costs.

## **4.2 INFRASTRUCTURE CAPITAL COSTS DEVELOPMENT**

The infrastructure capital costs are summarized in this section of the chapter were similar to that presented in Preliminary Vision Plan and have been updated to 2013 dollars. The unit cost data base and corridor infrastructure costs are appropriate for a Vision Plan Feasibility Study. The costs will be further refined in future phases of work when the Alternatives Analysis for the Tier 1 and Tier 2 EIS work is undertaken.

The infrastructure capital unit costs used in the development of the preliminary capital cost estimates were developed from TEMS library of HSR unit costs. Peer panels, freight railroads and construction contractors have reviewed these costs. In addition, a summary validation was completed comparing the TEMS unit costs with unit costs used in regional rail studies around Virginia. Capital cost categories include:

- Land and right-of-way
- Sub-grade, structures and guideway
- Track
- Signals and communications
- Electrification
- Demolition
- Stations
- Maintenance and facilities
- Highway and railroad crossings
- Fencing and corridor protection

In addition to the engineering assessment, the capital costing methodology identifies rolling stock (equipment) costs and land costs. Land costs are presented separately, as a placeholder for access to railroad rights-of-way and for procurement of additional privately owned property where required to construct new passenger rail infrastructure.

Using the Engineering News Record Construction Cost Index (ENR CCI) Indices, unit costs used in this preliminary/initial portion of the Vision Plan study were adjusted for geographic region and annual escalation. Unit Prices will be adjusted to Regional Conditions and Escalate from 2009 to 2013. The following adjustment will be made:

- Unit Prices were based on the recent Rocky Mountain Rail Authority Business Plan for Denver region which was developed in 2009 dollars.
- From ENR CCI Analysis, the Denver to Hampton Roads adjustment is 97 percent, as the benchmark prices are slightly higher in the Denver area than they are in Hampton Roads.
- According to ENR CCI, National Cost Indices cost increases from 2009 to January 2013 is the ratio of ENR CCI for 2013 divided by that of 2009<sup>1</sup> which is 1.085.

With the Regional Adjustment Factor of 0.97, and inflation of 1.085, the Escalation Factor from the Denver regional study of 2009 to Hampton Roads January 2013 costs is the product of  $0.97 * 1.085$ , which is 1.05.

The unit costs in the following section were estimated by applying this adjustment factor to the previous developed representative unit costs in previous TEMS work for the Midwest Regional Rail Authority high-speed rail studies and for the Rocky Mountain Rail Authority High-Speed Rail studies (as discussed earlier in Preliminary Vision Plan report).

### 4.3 RAIL CAPITAL UNIT COSTS

The base set of unit costs addresses typical passenger rail infrastructure construction elements including: roadbed and trackwork, systems, facilities, structures, and grade crossings. In the tables below, only a subset of the costs were actually used in Capital Cost development. Those costs are highlighted in yellow.

#### 4.3.1 TRACKWORK AND LAND ACQUISITION

The FRA requires that passenger trains operating on the general railroad system comply with stringent crashworthiness standards. For the purposes of defining requirements necessary to proceed with the study and in order to develop planning level capital costs, it has been assumed that highway traffic and adjacent high speed trains will be separated by concrete barriers. On tangent highway and track segments, there exists a small probability that automotive vehicles will leave the highway. Thus, protection against highway traffic incursions into the high speed rail median would be provided using NCHRP Report 350 Level 5 highway concrete barrier walls. In curved median segments, where accidents are more likely, we have planned for NCHRP Level 6 barriers. It is anticipated that high speed rail systems will be separated from the freight rail corridors by at least 25 feet between track centers where practicable. Chain link fencing will be provided throughout the system in all corridors to prevent the intrusion of trespassers and animals. These planning assumptions may be subject to modification as a result of federal or state rule making.

Land acquisition costs for right-of-way owned and controlled by the railroad industry is always an issue when attempting to introduce new passenger rail service. Since its inception, Amtrak has had the statutory right to operate passenger trains over freight railroad tracks and rights-of-way. When using freight tracks, Amtrak is required to pay only avoidable costs for track maintenance along with some out-of-pocket costs for dispatching.<sup>2</sup>

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<sup>1</sup><http://www.cahighspeedrail.ca.gov/assets/0/152/302/314/288d8ea6-bf10-4e14-80fc-fc92bd4ba48a.pdf> and methodology based on Unit Price Regional & Escalation Analysis Rocky Mountain Rail Authority (RMRA), High Speed Rail Feasibility Study [http://rockymountainrail.org/documents/RMRA\\_HSRBP\\_Appendix\\_F\\_03.2010.pdf](http://rockymountainrail.org/documents/RMRA_HSRBP_Appendix_F_03.2010.pdf)

<sup>2</sup> However, these payments do not cover all of the freight railroads' incremental costs associated with dispatching Amtrak's passenger trains. Railroad costs increase due to delays caused by Amtrak's tightly scheduled trains. Track capacity constraints and bottlenecks create unreliable conditions where train delays often become unavoidable. While federal regulations give passenger trains dispatch priority, railroad dispatchers often encounter congestion where it becomes difficult to control traffic and adhere to Amtrak's timetables. In some cases, Amtrak will offer the railroads a payment to provide on-time passenger train performance. On heavily used line segments, however, these incentive payments only partially compensate a railroad for the costs of increased delay, and some railroads simply refuse to accept incentive payments. On lightly used lines, the economic rationale for making these payments is questionable since passenger trains cause very little delay on such tracks.

Amtrak's payments do not include any access fee for the use of a railroad's tracks or its rights-of-way. Amtrak's federal statutory right-of-access has never required such a payment, and therefore, Amtrak avoids paying a fee or "rent" for occupying space on privately held land and facilities.

However, this study assumes a cost for access based on estimated across-the-fence land values would be included as part of the up-front capital expense, and would be used to purchase the rights to use the underlying railroad rights-of-way for the passenger service. It is assumed that railroads would receive this compensation in cases where the construction of a dedicated high speed passenger track is on their property. If new track cannot be constructed within the existing railroad rights-of-way, then this cost would fund the possible acquisition of adjacent property.

Elsewhere land will need to be purchased directly from land owners. Where highway rights-of-way are proposed, the study assumes that right-of-way or air rights access would be granted by appropriate authority at no cost to the rail system.

The outright purchase of land is not the only method whereby railroads could receive compensation for access to railroad rights-of-way. Commuter rail development provides examples of various types of payments for access rights. Some of these projects involved the purchase of the railroad rights-of-way while others provide up-front capital improvements in return for access to a railroad's tracks. The actual methods of payment remain to be determined during negotiation, and may depend on the importance of the track to the freight railroad as well as the level of capital to be invested by the passenger rail authority.

One area of possible concern is the freight railroads' ability to retain operating control over their rights-of-way. Whenever transit systems have paid full price to acquire a freight rail line, as on some commuter rail projects, the transit agencies have assumed operating control over the property. However, this study has assumed that the freight railroads would retain dispatching control over these rights-of-way. The railroads would have the right to use the increased capacity provided by the passenger system for its high speed freight services.

A 100-foot right-of-way will be assumed for the greenfield, except where the alignment falls within an existing publicly-owned right-of-way, such as a highway or street alignment, no cost to the project for that particular right-of-way has been assumed. Where the geometric requirements take the alignment outside of the public right-of-way, impacted parcels will be evaluated and a square foot quantity calculated. A unit cost per acre was developed in conjunction with other studies. Exhibit 4-14 shows the unit costs used for trackwork and land acquisition.

**Exhibit 4-2: Unit Capital Costs, Trackwork in \$2013.**

Item No.	Description	Unit	Unit Cost (Thousands of \$2013)
1.1	HSR on Existing Roadbed (Single Track)	per mile	\$1,246.11
1.2	HSR on Existing Roadbed (Double Track)	per mile	\$2,492.42
1.3	HSR on New Roadbed & New Embankment (Single Track)	per mile	\$1,872.29
1.31	HSR Single Track 15' offset added to existing corridor on 15' fill	per mile	\$2,532.29
1.4	HSR on New Roadbed & New Embankment (Double Track)	per mile	\$3,355.65
1.41	Greenfield Double Track at Grade	per mile	\$3,355.65

1.42	Greenfield Double Track Rolling Terrain	per mile	\$3,713.65
1.43	Greenfield Double Track Mountainous Terrain	per mile	\$4,785.65
1.44	HSR Double Track 15' offset added on 15' fill	per mile	\$4,807.82
1.45	HSR Double Track 30' offset added on 15' fill	per mile	\$5,599.85
1.46	HSR Double Track 30' offset added on 15' Retained Earth fill	per mile	\$17,724.11
1.5	HSR New Double Track on 15' Retained Earth Fill	per mile	\$17,724.11
1.6	Timber & Surface w/ 33% Tie replacement	per mile	\$278.62
1.7	Timber & Surface w/ 66% Tie Replacement	per mile	\$415.33
1.8	Relay Track w/ 136# CWR	per mile	\$444.29
1.9	Freight Siding	per mile	\$1,144.50
1.10	Passenger Siding	per mile	\$1,726.77
1.11	NCHRP Class 6 Barrier (on curves)	lineal ft.	\$1.38
1.12	NCHRP Class 5 Barrier (on tangent)	lineal ft.	\$0.21
1.13	Fencing, 4 ft. Woven Wire (both sides)	per mile	\$63.95
1.14	Fencing, 6 ft. Chain Link (both sides)	per mile	\$191.97
1.15	Fencing, 10 ft. Chain Link (both sides)	per mile	\$219.65
1.15a	Sound Wall Fencing	per mile	\$1,350.00
1.16	Decorative Fencing (both sides)	per mile	\$494.45
1.17	Drainage Improvements (cross country)	per mile	\$82.83
1.18	Drainage Improvements in Median or along highway	per mile	\$662.56
1.19	Land Acquisition Urban and Resort (100' of ROW)	per mile	\$410.35
1.20	Land Acquisition Rural (100' of ROW)	per mile	\$136.82
1.21a	Land Acquisition Rural US-460 Corridor	per acre	\$35.00
1.21b	Property Takes (overall average per take)	each	\$161.00
1.21c	Wetland Mitigation	per acre	\$150.00
1.21	#33 High-Speed Turnout	each	\$712.73
1.22	#24 High-Speed Turnout	each	\$564.67
1.23	#20 Turnout Timber	each	\$155.59
1.24	#10 Turnout Timber	each	\$86.55
1.25	#20 Turnout Concrete	each	\$312.45
1.26	#10 Turnout Concrete	each	\$148.06
1.27	#33 Crossover	each	\$1,425.56
1.28	#20 Crossover	each	\$625.76
1.28a	Interlockings and Crossovers every 10 miles	Per mile	\$265.00
1.29	Elevate & Surface Curves	per mile	\$72.76
1.30	Curvature Reduction	per mile	\$493.18
1.31	Elastic Fasteners	per mile	\$102.88

#### 4.3.2 STRUCTURES: APPROACHES, FLYOVERS, BRIDGES, AND TUNNELS

A complete inventory of bridges has been developed for each existing rail route from existing track charts. For estimating the cost of new bridges on either green field alignments or along existing rail beds, conceptual engineering plans will be used for a bridge to carry either single or double tracks over



highways, streams, valleys, and rivers. Some bridges require rehabilitation on the abutments and superstructure. This type of work includes pointing of stone abutment walls, painting of bridges, and replacement of bearings. Many of the major bridge cost estimates will be estimated only as placeholders, which will be subject to more detailed engineering analysis in the future. Tunneling costs lie within the \$20-73 thousand per linear foot range, where the higher cost was from the long undersea English Channel tunnel; but the estimates in Exhibit 4-3 were considered as benchmarks for the probable cost of tunnels and these costs will be used in this study.

**Exhibit 4-3: Unit Capital Costs, Structures in \$2013**

Item No.	Description (Bridges-under)	Unit	Unit Cost (Thousands of \$2013)
2.1	Four Lane Urban Expressway (Rail over Highway)	each	\$6,067.52
2.2	Four Lane Rural Expressway (Rail over Highway)	each	\$5,051.03
2.3	Two Lane Highway (Rail over Highway)	each	\$3,832.50
2.4	Rail (New Rail over Existing Rail)	each	\$3,832.50
2.5	Minor river	each	\$1,016.48
2.6	Major River	each	\$10,162.30
2.7	Double Track High (50') Level Bridge	per LF	\$15.27
2.8	Rehab for 110	per LF	\$17.61
2.9	Convert open deck bridge to ballast deck (single track)	per LF	\$5.83
2.10	Convert open deck bridge to ballast deck (double track)	per LF	\$11.77
2.11	Single Track on Flyover/Elevated Structure	per LF	\$5.30
2.12	Single Track on Approach Embankment w/ Retaining Wall	per LF	\$3.71
2.13	Double Track on Flyover/Elevated Structure	per LF	\$8.48
2.13a	Greenfield Double Track on Low Bridge	per LF	\$8.90
2.14	Double Track on Approach Embankment w/ Retaining Wall	per LF	\$6.89
2.15	Ballasted Concrete Deck Replacement Bridge	per LF	\$2.65
2.16	Land Bridges	per LF	\$3.29
2.17	Four Lane Urban Expressway (Highway over Rail)	each	\$3,675.64
2.18	Four Lane Rural Expressway (Highway over Rail)	each	\$2,619.06
2.19	Two Lane Highway (Highway over Rail)	each	\$2,388.06
2.20	Rail (Existing Rail over New Rail)	each	\$7,667.55
2.21	Two Bore Long Tunnel	route ft.	\$46.67
2.22	Single Bore Short Tunnel	lineal ft.	\$26.52

### 4.3.3 SYSTEMS

The capital cost estimates for this study include costs to upgrade the train control and signal systems. Unit costs for system elements are shown in Exhibit 4-4. Under the 110 mph or higher speed scenarios, the signal improvements include the added costs for a vital Positive Train Control (PTC) signal system. The FRA "Cab signal rule" requires that wayside signals be displayed within the engine cab for any speeds of 80 mph or high. The PTC system would do this. However it should be noted that NS policy prohibits exceeding 79 mph on its tracks. For this study PTC would only need to be applied only to new dedicated tracks and not the existing NS freight tracks.

Most US railroads that allow or provide passenger and freight service operate under manual control with wayside signals. Centralized traffic control (CTC) signaling is provided on busy corridors including Amtrak's Northeast Corridor. FRA requires that passenger service exceeding 79 mph operate with cab signaling/automatic train protection or automatic train stop to provide protection against operator errors. In addition, FRA is currently sponsoring demonstration projects to develop a universal communications based train control system, known as positive train control or PTC. New high speed passenger service will include sophisticated signal systems to comply with FRA mandates and provide safe, reliable operations. Such signal systems include train borne components and wayside equipment such as track circuits, switch operators, and wayside detectors for protection against intrusion, high water, hot bearings and dragging equipment.

Modern signal systems rely on digital communication systems for data transmission using radio, fiber optic cables or a combination of the two. In addition, the communication system provides radio for operations, supervisory control and data acquisition for power systems, passenger station public address, etc. Wayside space must be provided for ducts and enclosures to house signal and communication components.

Electrified high speed rail options require traction power substations and distribution facilities. Electric utility is expected to provide substations, transmission equipment and connections to the utility network with such costs covered in the utilization charges. As such, it is assumed that the electric utility would amortize the costs for bringing power to the substations, so the costs of modifications to the utility's grid are not included in the electrification cost estimate. Typical requirements for electrification include substations at 25 mile intervals and distribution conductors. In the case of electrified rail systems, overhead catenary conductors provide power to the train pantograph and the rails serve as return conductors. The catenary conductors are supported by poles and cross arms spaced at roughly 100-150 foot intervals. The catenary system contact wire is generally located 17 to 23 feet above the top of the rail. Additional electrical clearance or high voltage insulation is required to overhead bridge structures.

**Exhibit 4-4: Unit Capital Costs, Systems, in \$2013**

Item No.	Description	Unit	Unit Cost (Thousands of \$2013)
3.1	Signals for Siding w/ High-Speed Turnout	each	\$1,591.23
3.2	Install CTC System (Single Track)	per mile	\$229.62
3.3	Install CTC System (Double Track)	per mile	\$376.52
3.4	Install PTC System	per mile	\$181.36
3.5	Electric Lock for Industry Turnout	each	\$129.29
3.6	Signals for Crossover	each	\$878.39
3.7	Signals for Turnout	each	\$501.98
3.8	Signals, PTC, Communications & Dispatch (Double Track)	per mile	\$1,602.00
3.9	Electrification and Power Supply (Double Track)	per mile	\$5,482.00

#### 4.3.4 CROSSINGS

The treatment of grade crossings to accommodate 110-mph operations on existing rail is a major challenge to planning a high speed rail system. Highway/railroad crossing safety plays a critical role in future project development phases. A variety of devices were considered to improve safety including roadway geometric improvements, median barriers, barrier gates, traffic channelization devices, wayside

horns, fencing and the potential closure of crossings. Greenfield routes were developed with grade separations at street and roadway crossings. Exhibit 4-5 details the unit costs for highway and railroad grade crossings.

**Exhibit 4-5: Unit Capital Costs, Crossings, in \$2013**

Item No.	Description	Unit	Unit Cost (Thousands of \$2013)
4.1	Private Closure	each	\$104.15
4.2	Four Quadrant Gates w/ Trapped Vehicle Detector	each	\$617.38
4.3	Four Quadrant Gates	each	\$361.45
4.4	Convert Dual Gates to Quad Gates	each	\$188.26
4.5	Conventional Gates single mainline track	each	\$208.30
4.6	Conventional Gates double mainline track	each	\$257.30
4.7	Convert Flashers Only to Dual Gate	each	\$62.79
4.8	Single Gate with Median Barrier	each	\$225.91
4.9	Convert Single Gate to Extended Arm	each	\$18.77
4.10	Precast Panels without Roadway Improvements	each	\$100.44
4.11	Precast Panels with Roadway Improvements	each	\$188.26

#### 4.3.5 STATION/MAINTENANCE FACILITIES

Passenger stations and parking facilities include platforms, escalators/elevators and other circulation elements, passenger ticketing and waiting facilities, lighting security, and station administration facilities.

The terminal stations may require four tracks for passenger boarding, train layover and light maintenance.

A maintenance facility with sufficient capacity to service the fleet is required. The facility must provide space and equipment to service the rolling stock and maintain the track structure and systems. Storage tracks can be expanded as the fleet grows. Sophisticated component repair may be subbed out to contract shops. It is anticipated that the maintenance facility for a non-electrified system will be less sophisticated than that of an electrified rail system. Exhibit 4-6 shows the unit costs for types of stations, terminals, and maintenance facilities.

**Exhibit 4-6: Unit Capital Costs, Railroad Station/Maintenance Facilities, in \$2013**

Item No.	Description	Unit	Unit Cost (Thousands of \$2013)
5.1	Full Service - New - Low Volume - 500 Surface Park	each	\$5,303.03
5.2	Full Service - Renovated - Low Volume- 500 Surface Park	each	\$4,242.42
5.3	Terminal - New - Low Volume - 500 Surface Park	each	\$7,954.55
5.4	Terminal - Renovated - Low Volume - 500 Surface Park	each	\$6,363.64
5.5	Full Service - New- High Volume - Dual Platform - 1000 Surface Park	each	\$10,606.06
5.5a	High-Speed Rail Station	each	\$12,019.23
5.6	Terminal - New- High Volume - Dual Platform - 1000 Surface Park	each	\$15,909.09
5.7	Heavy Maintenance Facility (non-electrified track)	each	\$84,848.48
5.8	Heavy Maintenance Facility (electrified track)	each	\$106,060.61
5.9	Layover Facility	lump sum	\$10,606.06

#### 4.3.6 OTHER COSTS

Please note that contingency and professional service allowances are added for infrastructure capital costs only. They are not added for land acquisition, property taking, wetland remediation or placeholder costs since these factors are the results of benchmarking rather than engineering cost comparisons.

#### CONTINGENCY

Contingency costs will be added as an overall percentage of the total construction cost. Contingencies are an allowance added to the estimate of costs to account for items and conditions that cannot be realistically anticipated. The contingency is expected to be needed as the project develops. The contingency is estimated at 30 percent of the construction cost elements. This contingency included 15%+ for design contingency and 15%+ for construction contingency.

#### PROFESSIONAL SERVICES AND ENVIRONMENTAL

The project elements included in the Professional Services category are design engineering, program management, construction management and inspection, engineering during construction, and integrated testing and commissioning. For a project of this size, an overall program manager with several section designers is needed to provide conceptual engineering, preliminary engineering, environmental studies, geotechnical engineering, final engineering and engineering during construction. Field and construction management services and integrated testing services and commissioning of various project elements also are required. Professional services and other soft costs required to develop in this study have been estimated as a percentage of the estimated construction cost and are included in the overall cost estimates as a separate line item. Overall this category adds 28% on top of the base cost and contingency. These costs include, as a percentage of construction cost:

- Design engineering and related studies 10%
- Insurance and Bonding 2%
- Program Management 4%
- Construction management and inspection 6%



- Engineering services during construction 2%
- Integrated Testing and Commissioning 2%
- Erosion Control and Water Quality Mgmt 2%

## PLACEHOLDERS

The capital costs include allocation for special elements (placeholders) as conservative estimates for large and/or complex engineering projects that have not been estimated on the basis of unit costs and quantities. Placeholders provide lump sum budget approximations based on expert opinion rather than on an engineering estimate and are shown in the unit costs as lump sum items. Placeholders are used where detailed engineering requirements are not fully known. These costs will require special attention during the project development phase.

## 4.4 CAPITAL COST SUMMARY

The capital cost for developing a high speed 220-mph rail link between Norfolk, VA and Washington, DC with a 130-mph connecting link to Toano and Newport News has been estimated. The estimate shown in Exhibit 4-7 consists of several components:

1. Equipment cost was estimated as \$590 million, for 14 high speed (220-mph) electric trains at \$42.14 million each. This equipment cost is consistent with what was assumed for the cost of high speed trains in the Atlanta-Charlotte Tier I EIS Study. In Option 4, an additional \$264 million is added for 7 high speed (130-mph) diesel trains at \$37.71 million each.
2. The cost for the Richmond to Washington DC segment is updated to \$4.06 Billion, based on a highly conceptual greenfield between those points. This cost was drawn from the earlier 2010 Hampton Roads Progress Report C (Exhibit C-3 on page C-40) and was increased 5% for inflation. It should be noted that the original Progress Report C cost of \$2.129 billion assumed a 35% cost sharing with SEHSR. For this update however, it has been assumed that the Hampton Roads corridor would not share any of the cost with SEHSR or Amtrak, but rather to be conservative the Financial and Economic assessment assigns 100% of the cost of developing the greenfield to the HRTPO project. As a result the cost used was  $\$2.129 / 0.65 * 1.05 = \$3.439$  billion for the Richmond to Washington D.C. segment. The increase of \$600 million is fully explained by the additional cost for developing a 4-track access into Washington D.C. including the Long Bridge improvement, which has now been fully included in the updated cost for the Richmond to Washington DC segment. As a result, the Hampton Roads corridor improvement could afford to fully fund the cost of Washington D.C. rail access as part of its proposed development of a new greenfield alignment, since a positive Cost Benefit ratio was developed for the overall High Speed rail project fully including all these costs.
3. In Options 1-3, the cost for Newport News to Richmond was zero, reflecting the Step 2 3 trains per day at 90-mph scenarios that were evaluated in the DRPT EIS. Those scenarios assumed that the Peninsula service would not be upgraded beyond the currently planned level of 3 Round Trips according to the DRPT DEIS. However, for Option 4 a cost of \$920 million has been assumed for developing a High Speed connecting greenfield to Toano and for upgrading the CSX track to Newport News, as described in Chapter 3.
4. The cost for Norfolk to Richmond was based on a feasibility level engineering assessment of the options, as detailed in Chapter 4. Although Richmond Direct appears to be the most cost effective alternative (because it avoids the high cost of developing urban infrastructure through

Petersburg) costs in the \$3.1-3.3 billion range the results for all five options are very close, well within the error range of the estimates. By comparison, the original 2010 Progress Report C estimate if increased by 5% inflation to \$2.87 billion is very close to this new \$3.1-3.3 billion figure, which is based on a much more detailed environmental and engineering assessment than was possible in the earlier study. This difference in costs can be largely explained by the added cost of a high level James River Bridge in the five new options, which was not anticipated in the earlier 2010 cost estimates.

5. The total cost for the Hampton Roads-Washington Corridor for each option were also very similar with the total cost of Option 2A Northern Greenfield being \$8.03 billion while that for Option 3 Richmond Direct is \$7.83 billion. This is a cost of \$38-41 million per mile (including equipment), which is much less expensive than major new interstate highway construction costs which in urban and suburban areas typically fall in the \$100-200 million per mile range.<sup>3</sup> The cost of the rail project is held down by sharing existing rail rights of way, for example the largely abandoned "V-Line" corridor through urban areas. Although development of the rail corridor all the way to Washington D.C. would be a large project, it would have correspondingly large benefits. Its costs and affordability are not out of line with comparable highway benchmarks.

Exhibit 4-7 below breaks down the Capital Costs for a 220-mph electrified rail system from Norfolk to Washington D.C.

For Options 1A, 1B, 2A, 2B and 3, capital costs for the 130-mph diesel service were scaled based on the 220-mph estimates. At a minimum there would be some cost savings by not installing the electrification and purchasing lower cost diesel trains. If train frequencies were reduced it may be possible to single track some portions of the corridor although this was not included in the current cost estimate for 130-mph diesel service. It could be possible to save additional money by reducing the maximum speed to 110 mph and installing level grade crossings rather than grade separations. Again this was not included but if this approach were applied in the development of a diesel option, it could reduce the initial costs of developing the infrastructure.

The cost for the 130-mph diesel service was estimated by applying a factor of 73% to the 220-mph costs shown below. This factor was based on the ratio of costs calculated for 130-mph vs 220-mph service on an identical greenfield alignment by the Atlanta-Charlotte Tier I EIS Study.

Option 3 – Richmond Direct is the least expensive of all the High Speed options since it avoids the cost associated with urban infrastructure in Petersburg or Hopewell. However costs for all routes will be subject to further refinement as a part of the Tier I NEPA process. Track spacing requirements may impact the cost for options 1B and 2B that would follow part of the existing Norfolk Southern alignment. However, the Greenfield options 1A, 2A and 3 are not affected since these options do not make any use of the Norfolk Southern alignment west of Suffolk. As a result, Richmond Direct is likely to remain the most cost effective option.

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<sup>3</sup> The new Fluor express toll lanes widening I-495 around Washington D.C. cost \$138 million per mile: \$1.93 Billion for 14 miles, see <http://tollroadsnews.com/news/how-fluor-lane-widened-the-495-capital-beltway-from-8-to-12-lanes-interview> The Intercounty Connector in Maryland (MD-200) cost \$183 million per mile: \$2.56 Billion for 14 miles, see [http://en.wikipedia.org/wiki/Maryland\\_Route\\_200](http://en.wikipedia.org/wiki/Maryland_Route_200)

Exhibit 4-7: 220-mph Norfolk, VA to Washington, DC Capital Costs by Option, in \$2013 (thousands)

OPTION	1A- Southern GF/Petersburg	1B- NS via Petersburg	2A- Northern GF/Hopewell	2B- NS via I295/Hopewell	3- Richmond Direct	4- Richmond Direct Improved
Equipment	\$590,000	\$590,000	\$590,000	\$590,000	\$590,000	\$806,000
Richmond to Washington DC	\$4,064,614	\$4,064,614	\$4,064,614	\$4,064,614	\$4,064,614	\$4,064,614
Newport News to Richmond	\$0	\$0	\$0	\$0	\$0	\$920,337
Norfolk to Richmond	\$3,370,106	\$3,312,754	\$3,372,195	\$3,286,623	\$3,173,244	\$3,173,244
<b><u>TOTAL</u></b>	<b><u>\$8,024,720</u></b>	<b><u>\$7,967,368</u></b>	<b><u>\$8,026,809</u></b>	<b><u>\$7,941,237</u></b>	<b><u>\$7,827,858</u></b>	<b><u>\$8,964,195</u></b>
SEGMENT INFRASTRUCTURE COST:						
Harbor Park to Kilby	\$599,825	\$599,825	\$599,825	\$599,825	\$599,825	\$599,825
NS- Killby to Bakers Pd	\$0	\$1,256,279	\$0	\$1,256,279	\$0	\$0
NS- Bakers Pd to Collier	\$0	\$308,389	\$0	\$0	\$0	\$0
NS- Bakers Pd to I295	\$0	\$0	\$0	\$261,039	\$0	\$0
SG- Kilby to Collier	\$1,622,021	\$0	\$0	\$0	\$0	\$0
SG- Collier to Woods Edge	\$179,444	\$179,444	\$0	\$0	\$0	\$0
ESG- Woods Edge to Fulton GW	\$833,161	\$833,161	\$0	\$0	\$0	\$0
Fulton to Main St Station	\$135,656	\$135,656	\$135,656	\$135,656	\$135,656	\$135,656
NG-Kilby to Proctors Bridge Rd	\$0	\$0	\$648,346	\$0	\$648,346	\$648,346
NG-Proctors Bridge Rd to I295	\$0	\$0	\$954,545	\$0	\$0	\$0
NG- I295 through Hopewell	\$0	\$0	\$60,970	\$60,970	\$0	\$0
I295 Oakland Blvd to RIC Apt	\$0	\$0	\$827,843	\$827,843	\$0	\$0
RICHMOND Apt to Fulton GW	\$0	\$0	\$145,011	\$145,011	\$145,011	\$145,011
RICH DIR- Proctor Br Rd to RIC Apt	\$0	\$0	\$0	\$0	\$1,644,407	\$1,644,407
<b><u>Norfolk to Richmond Subtotal . . .</u></b>	<b><u>\$3,370,106</u></b>	<b><u>\$3,312,754</u></b>	<b><u>\$3,372,195</u></b>	<b><u>\$3,286,623</u></b>	<b><u>\$3,173,244</u></b>	<b><u>\$3,173,244</u></b>

*\* Newport News to Richmond in Option 4 is based on 130-mph High Speed Diesel Technology.  
Norfolk – Richmond – Washington D.C. would be all electrified. Option 4 assumes that diesels  
will run under the wire from Roxbury to Richmond to Washington D.C.*

#### 4.5 CAPITAL COST BENCHMARKING

Exhibit 4-8 shows a benchmarking cost comparison of the cost estimates for the two Peninsula segments to diesel segment costs that have been developed by other studies. For comparison, all costs are normalized to \$2013. It can be seen that HRTPO 90-mph Peninsula upgrades (\$8.9 M/mile) cost is nearly twice DRPT's plan (\$4.8 M/mile) for full capacity mitigation and grade crossing improvements (not grade separations) along the shared CSX corridor, east of Toano. As a greenfield, the Toano-Roxbury segment costs more than other diesel comparable segments, but still less expensive per mile than electrified greenfield sections such as Richmond Direct at \$34.2 M/mile.

**Exhibit 4-8: Engineering Costs per Mile, Diesel Options Comparison<sup>4</sup>**

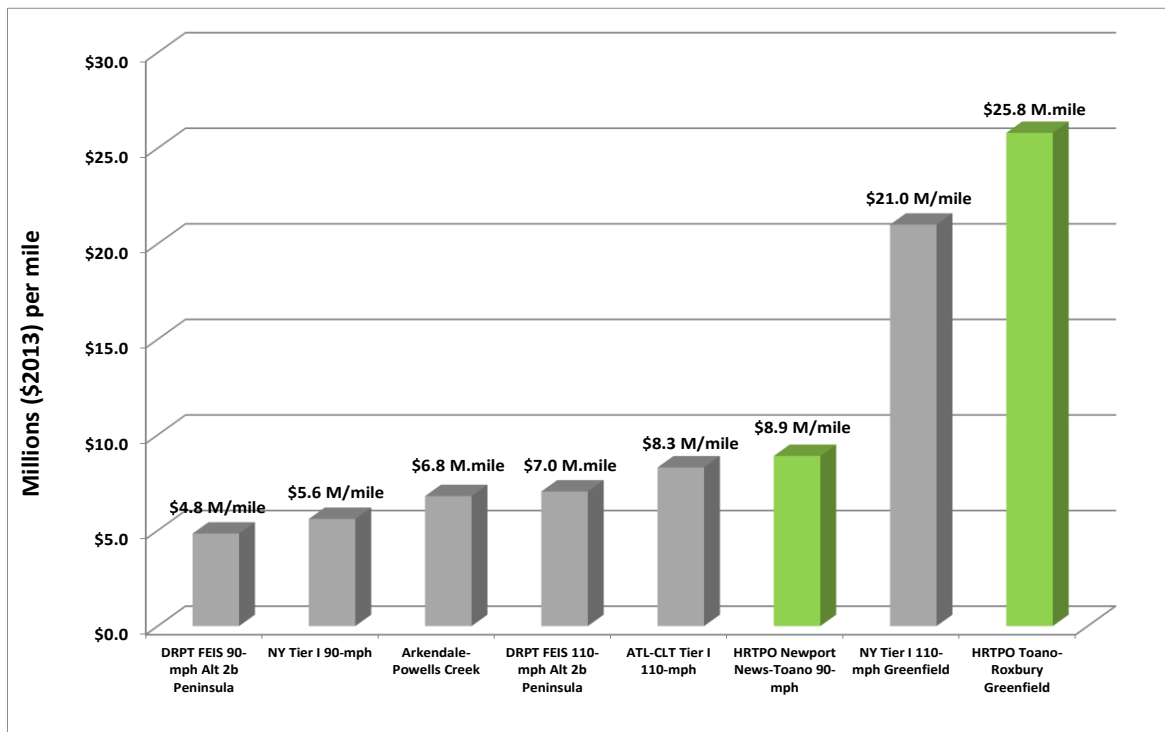
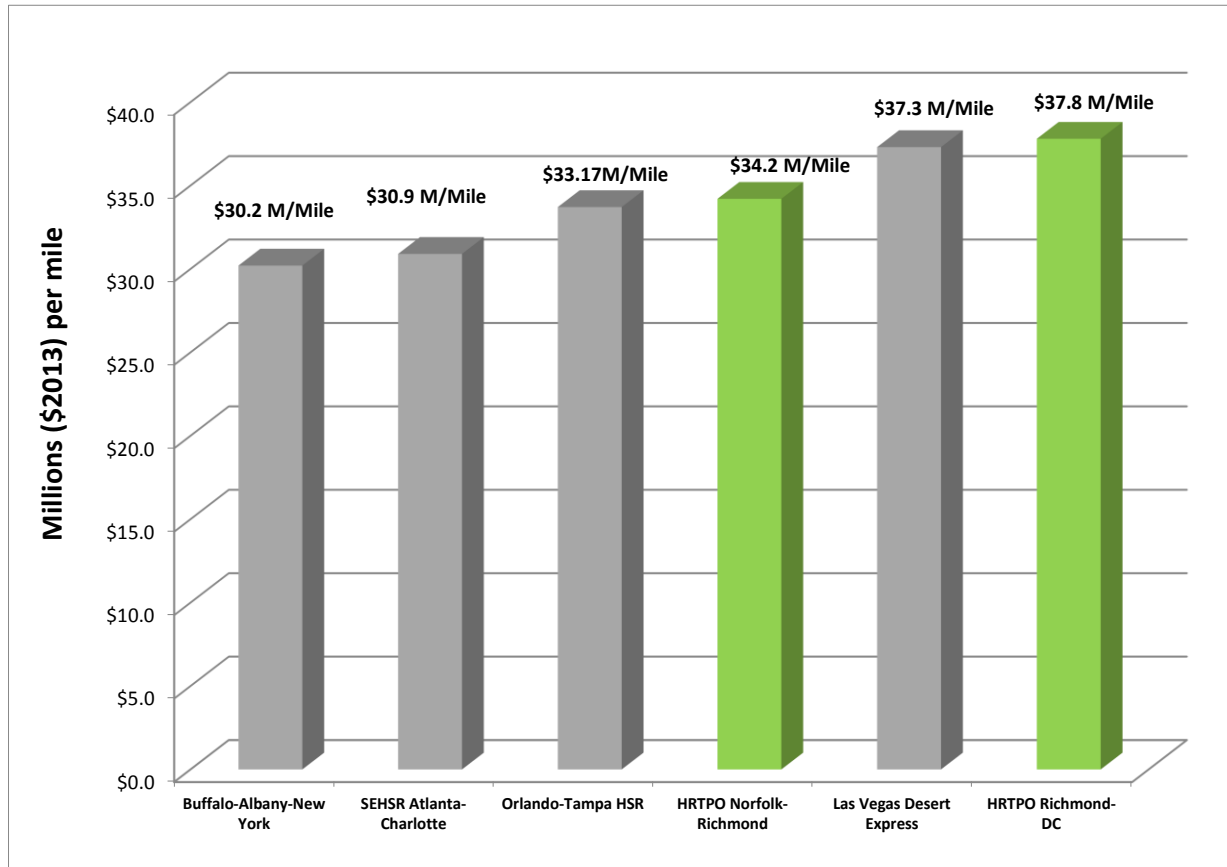


Exhibit 4-9 shows a benchmarking cost comparison of the Norfolk-Richmond and Richmond-Washington DC to electric segment costs that have been developed by other studies. All costs are normalized to \$2013. It can be seen that the Norfolk-Richmond segment has mid to high-range costs, despite mostly rural infrastructure and the availability of abandoned “V-Line” facilitating a relatively low-cost approach into downtown Norfolk. Richmond-Washington D.C. costs are even higher, in spite of the relatively low cost of adding track to the existing CSX alignment north of Aquia. This is because of the high cost of the urban segments for gaining access to downtown Richmond, as well as the high cost of Long Bridge project for 4-tracking the access into downtown Washington D.C., which has now been included in the cost estimate for this segment. Additionally, a \$100 million placeholder for an equipment maintenance base has been included as part of the Washington D.C. segment, and this also raises the average cost of that segment.

<sup>4</sup> Sources: *Hampton Roads Passenger Rail Vision Plan Alternatives Analysis*, TEMS, 2014; *Richmond to Hampton Roads Passenger Rail Project, Final Environmental Impact Statement*, DRPT, August 2012; *High Speed Rail Empire Corridor Program, Tier 1 Draft EIS*, New York State DOT; Arkendale to Powell's Creek, [http://www.hrtpo.org/uploads/docs/Presentation%206%20-%20HRTPO%20Rail%20Committee\\_DRPT.pdf](http://www.hrtpo.org/uploads/docs/Presentation%206%20-%20HRTPO%20Rail%20Committee_DRPT.pdf), p18; *Atlanta to Charlotte Passenger Rail Corridor EIS*, HNTB, 2013



**Exhibit 4-9: Engineering Costs per Mile, Electric Options Comparison<sup>5</sup>**



As such the overall costs per mile developed here are seen to be within range of average costs developed by other studies. This is because new greenfield alignment is only proposed in rural areas, where it is cost effective to construct, while existing rail alignments are upgraded for gaining access to the central cities. This is the same cost-effective development strategy for High Speed rail that has been successfully employed in Europe -- where new greenfield alignments link the major cities, but the existing tracks are used to bring High Speed trains into the downtown rail stations.

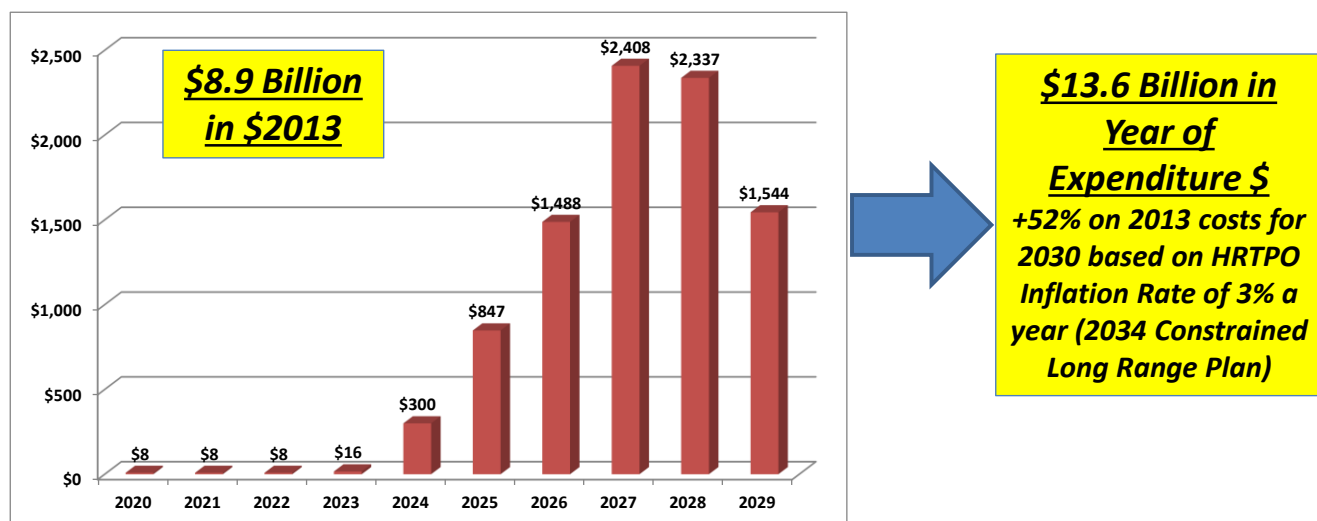
<sup>5</sup> See: Hampton Roads Passenger Rail Vision Plan Alternatives Analysis, TEMS, 2014; <sup>2</sup> High Speed Rail Empire Corridor Program, Tier 1 Draft EIS, New York State DOT; Atlanta to Charlotte Passenger Rail Corridor EIS, HNTB, 2013; Orlando-Tampa HSR, <http://www.tampabay.org/high-speed-rail>; Las Vegas Desert Express, [http://www.xpresswest.com/pdf/XpressWest\\_Media\\_Kit.pdf](http://www.xpresswest.com/pdf/XpressWest_Media_Kit.pdf)

#### 4.6 IMPLEMENTATION, FUNDING NEEDS AND YEAR-OF-EXPENDITURE ANALYSIS

Year of Expenditure (YOE) dollars are dollars that are adjusted for inflation from the present time to the expected year of construction. Planning regulations require that revenue and cost estimates in the MTP, STIP, and TIP prepared by Metropolitan Planning Organizations, must use inflation or growth rate(s) to reflect “year of expenditure dollars,” based on reasonable financial principles and information, developed cooperatively by the State, MPOs, and public transportation operators. [23 CFR § 450.216(l), § 450.322 (f)(10)(iv), and § 450.324(h)] Year of expenditure cost estimates should also be used in NEPA documentation.<sup>6</sup>

Accordingly, HRTPO requested that the Capital Cost for Option 4 be express in YOE dollars based on a 2030 implementation date. This calculation is based on a 3% annual inflation rate assumption between now and 2030 and results in a total project cost of \$13.6 Billion in YOE dollars as compared to \$8.9 Billion in current dollars. This is useful for projecting the actual funding requirement that would be needed to finance construction of the system in the future. This same distribution of capital cost is also used in the discounting (Net Present Value) calculations associated with estimation of the Benefit Cost ratios in Chapter 7.

**Exhibit4-10: Capital Spend Plan and Year-of-Expenditure Cost**



<sup>6</sup> See: [http://www.fhwa.dot.gov/ipd/project\\_delivery/resources/financial\\_plans/guidance.aspx](http://www.fhwa.dot.gov/ipd/project_delivery/resources/financial_plans/guidance.aspx)  
and [http://www.fhwa.dot.gov/planning/tpr\\_and\\_nepa/tprandnepasupplement.pdf](http://www.fhwa.dot.gov/planning/tpr_and_nepa/tprandnepasupplement.pdf)

## 5. OPERATING PLAN AND COSTS

*This chapter describes the development of an operating plan for each route, the mechanism for estimating operating cost and gives the final operating cost for each option.*

### 5.1 OPERATING PLAN

#### 5.1.1 INTERACTIVE ANALYSIS PROCESS

A key element for developing an operating plan is the technology selection from the range of alternative technologies available. In the case of the slower speed alternatives (79-110 mph), the most effective option is using existing railroad rights-of-way and where the volume of freight rail traffic is limited, to share tracks with freight traffic. As speeds and frequency of passenger rail service increase, the ability to share tracks with freight becomes more limited, although if wide enough the right-of-way may still be shared. For very high speeds the ability to even use existing railroad rights-of-way is typically lost. Of course, sharing track or using freight rail right-of-way may still occur (at lower speeds) in urban areas to gain access to downtown stations, but away from the urban area true high speed service is likely to require a greenfield route – since high speed rail operations need long stretches of straight track and very gentle curves to achieve high speed. Even sharing Interstate highway right-of-way may not be possible at full speed since highways frequently have curves that are too tight for the faster trains. In general, faster systems have fewer stops. A compromise may be needed to ensure all key communities are served, but this results in a trade-off between end-to-end speed and connecting communities. Each station stop takes three to seven minutes (including deceleration, stop time and acceleration back to speed) so multiple stops soon dramatically increase end-to-end running times.

Given that reasonable high speed rail routes can be developed then the key issue is the technology to be used. In the earlier Chapter 2, the representative routes are discussed. This chapter focuses on the following issues for speeds greater than 90 mph:

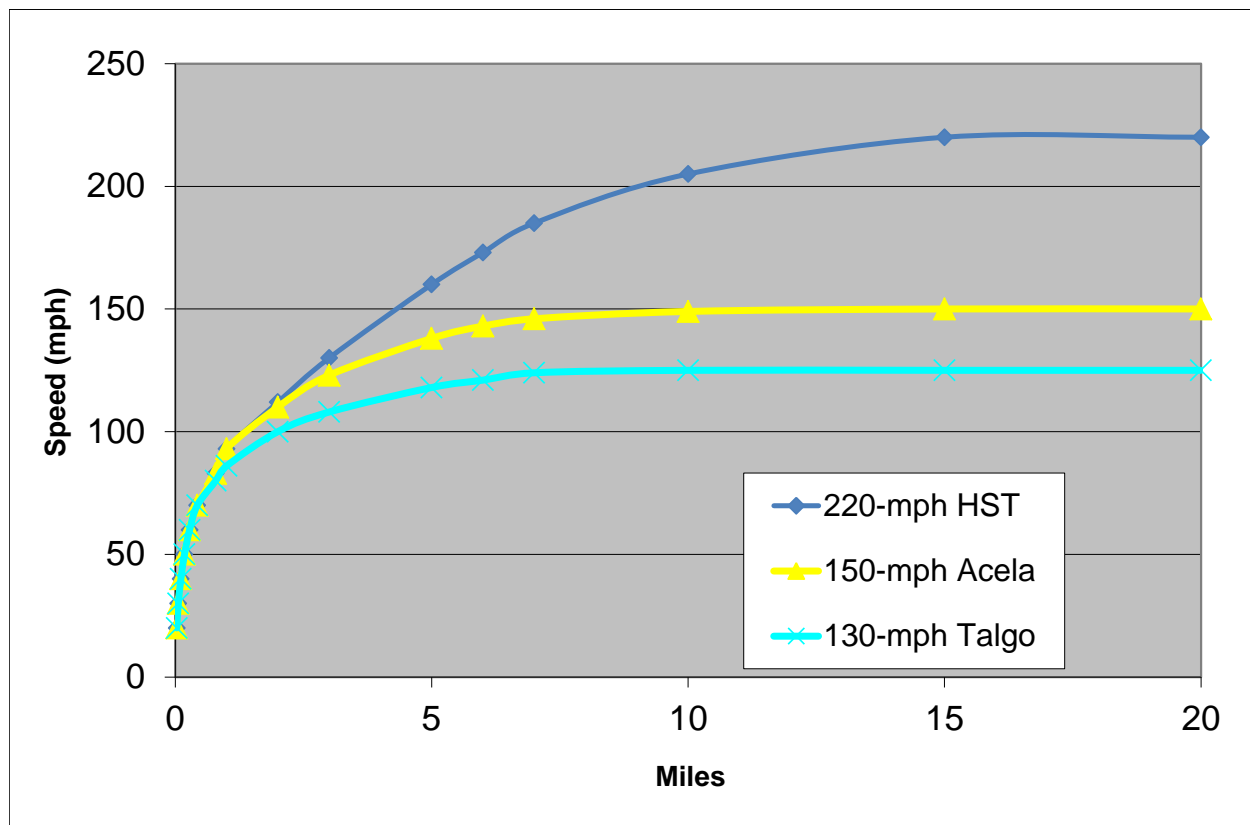
- Generic technology categories,
- *LOCOMOTION™* equipment database that was collected for the generic trains

As seen in Exhibit 5-1 of the interactive analysis process, train routes and speeds; technology and service levels; and fares; stations; and quality of service are all critical inputs in the operating plan process. *LOCOMOTION™* is the software used to calculate train travel times, train schedules for train alternatives, and to recommend train technology and rail system operating strategies. A key requirement for the analysis is to adjust the train size and frequency levels to appropriately match demand, providing enough capacity while still producing acceptable load factors, and respecting the financial constraints on the operation of the system. The results of the interactive analysis are then used to identify the system operating costs.





**Exhibit 5-2: Comparative Train Acceleration Curves<sup>1</sup>**



Purpose-built diesel higher-speed trains, such as the Talgo T21, can offer considerably improved performance over conventional diesel trains that are based on freight-derived designs. Conventional locomotive-hauled diesel trains have a practical top speed of about 100 mph, whereas purpose-built high speed diesel trains can achieve 125 mph to 135 mph and can accelerate much faster than a conventional diesel train. For speeds above 135 mph, electrified trains are needed. Some European diesel-powered 125-mph trains offer up to 500 seats, but if U.S. safety regulations were applied, the added vehicle weight (10-15 percent) would likely reduce the practical capacity of such trains down to 400-450 seats.

Up to its current top speed of 150 mph, Exhibit 5-2 shows that the Acela accelerates as fast as a TGV due to its very high power to weight ratio. This implies that the Acela could go even faster if it were given a straight enough track to run on. Acela's weight penalty however, expresses itself in terms of a higher operating cost and lower revenue generating capacity than a comparable TGV. However, this is not a serious problem in the special environment in which the Acela operates (i.e., limited capacity and a very high level of demand).

The following train technologies are described in Exhibit 5-2:

- **130-mph Talgo T21:** the technical characteristics are hauled (non-powered) axles equipped with independent wheels to prevent hunting movement and to reduce wheel-track interaction;

<sup>1</sup> Source: TEMS LOCOMOTION™ Equipment Database showing typical technology performance parameters, as developed and validated over the course of previous rail studies.

Permanently steered axles by means of robust guiding bars that keep the wheels parallel to the track at all times; high-comfort tilting suspension, with natural car body tilting toward the interior of curves; Articulated couplings between adjacent cars with anti-overturning and anti-vertical hunting mechanisms; and maximum commercial speed of 140 mph<sup>2</sup>.

- **160-mph Acela:** Acela express with standard gauge of 1,435 mm (4 ft 8 1/2 in) and maximum operating speed 160 mph (256 km/h). However since Amtrak decided not to order any more Acela equipment and instead will purchase new trains in a joint procurement with California, this category of trains will not be used here. Instead, the 220-mph category of electric train will be used.
- **220-mph AGV:** The trains that are certified to run 220-mph speed include Siemens Valero, Bombardier Zefiro, and Alstom AGV. Chinese HST are even faster with speeds up to 240 mph. The trains are constructed from units comprising three cars, each with one transformer and two traction electronics packages located underneath the cars, and from single-car trailers. A 7-car unit has two 3-car modules separated by one trailer and seating for around 245, an 11-car unit has three 3-car modules with two trailer cars with seating for around 446. The maximum commercial speed is 360 km/h (220 mph)<sup>3</sup>.

Exhibit 5-3 below summarizes the train characteristics.

**Exhibit 5-3: Train Characteristics Table**

Conventional	Higher Speed	High Speed	
<ul style="list-style-type: none"> <li>▪ 79 mph</li> <li>▪ Diesel</li> <li>▪ Non-Tilting</li> <li>▪ NEC Regional</li> </ul>	<ul style="list-style-type: none"> <li>▪ 110 mph</li> <li>▪ Diesel</li> <li>▪ Tilting</li> <li>▪ Acela Express</li> </ul>	<ul style="list-style-type: none"> <li>▪ 160 mph</li> <li>▪ Electric</li> <li>▪ Tilting</li> <li>▪ Talgo T21</li> </ul>	<ul style="list-style-type: none"> <li>▪ 220 mph</li> <li>▪ Electric</li> <li>▪ Non-Tilting</li> <li>▪ AGV</li> </ul>

The key tool used for development of pro-forma train schedules is the *LOCOMOTION*<sup>™</sup> Train Performance Calculator. *LOCOMOTION*<sup>™</sup> works in conjunction with a *TRACKMAN*<sup>™</sup> infrastructure database to estimate train speed given various types of track geometry, curves, gradients and station-stopping patterns. The *TRACKMAN*<sup>™</sup> database captures all the details of grades, curves, superelevation, speed limits and station locations along the line. *LOCOMOTION*<sup>™</sup> then calculates the train running time for each route segment and sums the running times to produce a timetable. *LOCOMOTION*<sup>™</sup> assumes a train will accelerate to a maximum possible speed and will only slow down for stations or speed restrictions due to curves, crossings, tunnels or civil speed restrictions such as grade crossings and sensitive urban areas.

The inputs for *LOCOMOTION*<sup>™</sup> consist of milepost-by-milepost data (as fine as 1/10th of a mile) defining gradient and curve conditions along the track. For this study, these data were derived from a condensed profile for existing rail alignments and the use of field inspection data along with satellite photography and GIS mapping to develop the geometry for new routes.

In addition, *LOCOMOTION*<sup>™</sup> includes a train technology database that defines the acceleration, top speed, and braking characteristics of each train technology type. The database includes many train types with

<sup>2</sup> <http://www.talgo.com/pdf/TXXIen.pdf>

<sup>3</sup> [http://en.wikipedia.org/wiki/Automotrice\\_%C3%A0\\_grande\\_vitesse](http://en.wikipedia.org/wiki/Automotrice_%C3%A0_grande_vitesse)

varying performance characteristics, ranging from heavy freight trains all the way up through very high speed rail options.

Train timetables are determined from running times and are used to calculate rolling stock requirements. Train frequencies and the number of cars required per train are determined via an interactive process using the demand forecast *COMPASS™* model.

The results taken from *LOCOMOTION™* will be faster than the actual times, since they are based on optimized performance of trains under ideal conditions. While it is assumed that passenger trains will have dispatching priority over freight, practical schedules still need to allow 5-10 percent slack time in case of any kind of operating problem, including the possibility of freight or commuter train interference, depending on the degree of track sharing with freight. Slack time is included in the train timetables and in the input provided to the *COMPASS™* model.

### **5.1.3 TRAIN TIMETABLES – NORFOLK TO WASHINGTON D.C. ONLY – OPTIONS 1A, 1B, 2A, 2B AND 3**








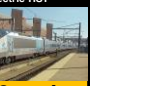
As background, Exhibit 5-4 shows the train schedule objectives that were developed for Hampton Roads service, as Exhibit B-6 on page B-13 of the earlier 2010 study *Progress Report B*. The detailed update performed here has validated this earlier work since the newest schedules are still consistent with these earlier results. However, this study has only updated Steps 3 and 4 for the Richmond to Norfolk segment – the two cells highlighted in yellow in Exhibit 5-4 below. Please note that the diesel train top speeds in Steps 3 and 4 have subsequently been raised from 110 mph to 130 mph in the current study; electric train speeds in Step 4 raised from 150 mph to 220 mph. All other train schedule assumptions have been carried forward from the previous study.

The original Phase 2(B) study developed two speed options: 130 mph and 220 mph, for each of the five Norfolk route options 1A, 1B, 2A, 2B and 3. All of these options assumed only the existing Amtrak service on the Peninsula with the addition of one more train, bring the assumed Amtrak frequency to 3 Newport News round trips.

A key output of the Operations Planning process has been the operational train schedules, based on an assumed train frequency, stopping patterns and running times. These key results are presented in Exhibit 5-5 through 5-14. These exhibits summarize the key train scheduling assumptions that were using as a direct input to the ridership forecasting process.

For implementation of both conventional and high speed rail to be efficient, it is essential to improve train schedules and frequencies in a balanced way. Typically as speeds increase, the market expands and both train size and frequency also need to be increased. The proposed implementation steps add train frequency as speeds increase in a manner that is reflective of the growth in market demand, and also equitably scaled to the relative size of the north and south side demographic bases.

**Exhibit 5-4: Schedule Objectives for Hampton Roads Service from Phase 1 Progress Report B**

	<b>Step 1</b>		<b>Step 2</b>		<b>Step 3</b>		<b>Step 4</b>	
	Conventional Amfleet	Conventional Amfleet	Conventional Amfleet	Diesel HST	Conventional Amfleet	Diesel HST	Diesel HST	Electric HST
								
	79-mph	79-mph	79-mph	90-mph	90-mph	110-mph	110-mph	150-mph
Washington to Richmond	2:45 <sup>1</sup>	2:15 <sup>2</sup>	2:20 <sup>3</sup>	2:05	2:20	1:30	1:30	1:05
Richmond to Norfolk		1:48		1:48 <sup>5</sup>		1:10		0:55
Richmond to Newport News	1:25		1:25		1:13		0:52	
<b>Total</b>	<b>4:10</b>	<b>4:03</b>	<b>3:45</b>	<b>3:53</b>	<b>3:33</b>	<b>2:40</b>	<b>2:22</b>	<b>2:00<sup>4</sup></b>

<sup>1</sup> 2:45 current Amtrak time to Main Street, 1:35 to Newport News

<sup>2</sup> 2:15 current Amtrak time to Staples Mill Road Station only, does not go to Main Street

<sup>3</sup> 2:20 to Main Street, train operates at 90 mph north of Richmond

<sup>4</sup> 2:00 proposed schedule objective for HSR electric service

<sup>5</sup> 1:38 using 79 mph south of Petersburg

In the 2010 study, schedule times were based on the train types shown and assume expected levels of infrastructure upgrade associated with each Step. Train times in Step 1 are consistent with current Amtrak schedules and with the Richmond/Hampton Roads Passenger Rail Project DEIS projection for 79-mph Richmond to Norfolk service. Times in Step 2 are consistent with the DEIS.

Washington to Richmond times for Norfolk service in Step 2 does reflect an improvement from 2:20 down to 2:05 assuming the use of high speed diesel trains<sup>4</sup> rather than conventional Amtrak equipment. This is consistent with the capabilities of locomotive hauled passive tilt trains using a very conservative 6" Cant deficiency assumption. The time is also sufficient to allow a reasonable amount of slack for co-mingled operation on shared infrastructure with freight trains.

DRPT has defined a schedule objective of 1:30 for Washington-Richmond service on existing CSXT tracks<sup>5</sup>. Preliminary performance modeling suggests that this might be possible, but it would require the use of very aggressive 9" of Cant Deficiency and allows for very little slack time in the schedule. A ninety-minute schedule may be theoretically possible for a DMU with active tilt, but would certainly require a dedicated track not only to minimize the possibility of freight train delays, but also to support the kind of precision

<sup>4</sup> This does not contradict the DEIS, since it must be recognized that Amtrak's current Amfleet coaches are already 35 years old and beyond their mid-life refurbishment. See: <http://en.wikipedia.org/wiki/Amfleet>. This equipment is already considered commercially obsolete and has been rejected by California, Washington and Oregon who purchased new equipment for their state-supported trains. Modern High-Speed Diesel trains are well able to satisfy the performance parameters of the DEIS offering similar or better environmental performance. Given DRPT's expected project development timeframes, the Amfleet equipment will be approaching 50 years of age by the time the project is implemented. Although Amfleet has been used to characterize the performance capabilities of existing trains, the DEIS certainly does not appear to exclude the possibility of actually purchasing new trains for the service by the time it is implemented.

<sup>5</sup> See: <http://www.drpt.virginia.gov/studies/files/WashingtonD.C.StudyDetails.pdf>

track maintenance and curve geometry that such high deficiency operations will require. A 1:30 schedule over existing tracks appears to be barely achievable and may not ultimately be deliverable in practice.<sup>6</sup>

In contrast, the 1:30 schedule objective shown for 130-mph high speed diesel train is achievable by assuming a Greenfield segment, using very conservative train performance assumptions even if only a *part* of the proposed greenfield alignment were complete it might enable the diesel service to comfortably attain DRPT's 90 minute schedule objective. If the entire Richmond to Aquia greenfield were completed as proposed a diesel train could complete the run in 1:05 and an electric train would need 50-55 minutes.

This leads to a potential 2:00 schedule for Norfolk to Washington D.C. 220-mph electric service and also a 2:00 schedule for Newport News to Washington D.C. 130-mph diesel service. It should be pointed out an all-electric or diesel/electric dual mode service would also eliminate the 20-30 minutes delay typically now incurred for a locomotive change in Washington, so the time savings to NEC points north of Washington would be even greater.

The rail service assumptions that were developed for Steps 3 and 4; Options 1A, 1B, 2A, 2B and 3 by the Phase 2(B) study were as follows:

- Washington D.C. to Richmond, 109 miles (Current Time 2:00, 79 mph):
  - Assumes a new conceptual greenfield due to capacity and geometric limitation of existing Right-of-Way
  - 130-mph diesel could easily achieve 1:30 on a greenfield – a very aggressive tilt train could possibly achieve this time on the existing CSX alignment
  - 220-mph electric could achieve 0:55 based on a high quality greenfield from Aquia to Richmond
- Richmond to Norfolk, 97-105 miles (Current Time 2:00, 79 mph):
  - 13 daily round trips at 130 mph for Step 3; 1:00 to 1:10 schedule times
  - 22 daily round trips at 220 mph for Step 4; 0:45 to 0:55 schedule times
- Richmond to Newport News, 75 miles (Current Time 1:25, 79 mph):
  - 3 daily round trips at 79 mph; 1:25 schedule time

Overall, the impact of the proposed improvements would be to cut Norfolk-Washington D.C. schedule time in half: from over 4 hours today at 79 mph, to 2 hours at 220 mph once the high speed rail system has been fully implemented. From Richmond to Washington D.C. the assumed running times are as shown in Exhibit 5-5. These times from Richmond to Washington D.C. are the same for all five Norfolk options 1A, 1B, 2A, 2B and 3. They are added as a constant term to the Richmond-Norfolk times for each option 1A, 1B, 2A, 2B and 3 that is presented in the subsequent exhibits.

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<sup>6</sup> Please note that SEHSR does **not** use a 90-minute schedule in its planning or demand forecasting for this segment. See FAQ # 5 of <http://www.sehsr.org/faq.html> that projects a 2 hour Richmond to Washington D.C. schedule. Also, a 2 hour (rather than 90-minute) timetable is used in DRPT's plan for Hampton Roads service, see Table 6 of the *Richmond/Hampton Roads Passenger Rail Study, Alternatives Analysis and Tier 1 Environmental Impact Statement*, DRPT, Nov 2005: <http://rich2hrrail.info/downloads/FinalAltDvpReport011706.pdf>



**Exhibit 5-5: Proposed Richmond to Washington D.C. Running Times**

130-mph Diesel				220-mph Electric			
Station	Super Express	Express	Local	Station	Super Express	Express	Local
Richmond Main St	0:00	0:00	0:00	Richmond Main St	0:00	0:00	0:00
Ashland			0:12	Ashland			0:10
Fredericksburg		0:40	0:45	Fredericksburg		0:25	0:30
Quantico			1:08	Quantico			0:45
Alexandria	1:20	1:25	1:35	Alexandria	0:43	0:48	0:58
Washington Union	1:30	1:35	1:45	Washington Union	0:53	0:58	1:08

These Richmond to Washington D.C. times are consistent with the Step 3 and 4 times of 1:30 and 1:05 for Diesel and Electric options, respectively, from 2010 Progress Report B as shown in Exhibit 5-4. The 1:30 Diesel time can be achieved on the CSX alignment using aggressive tilt technology. The 220-mph electric times are based on conceptual Greenfield route options between Richmond and Washington DC.

**NORFOLK TO WASHINGTON D.C.: OPTION 1 VIA PETERSBURG**

Two conceptual options 1A and 1B have been defined in Chapter 2 via Petersburg. Option 1A has been defined as a “Southern Greenfield” whereas Option 1B would utilize the existing Norfolk Southern rail alignment. However, since both alignments are essentially straight and about the same length, the running times for the two route variants are extremely close – within a minute of one another – so the train schedule for either variant is the same. Schedules for the Petersburg Option 1 are shown in Exhibit 5-6, and the 130-mph and 220-mph *LOCOMOTION™* speed profiles for the two train simulations are shown in Exhibit 5-7 and 5-8.

**Exhibit 5-6: Proposed Norfolk to Washington D.C. -- Option 1 Times via Petersburg**

130-mph Diesel				220-mph Electric			
Station	Super Express	Express	Local	Station	Super Express	Express	Local
Norfolk	0:00	0:00	0:00	Norfolk	0:00	0:00	0:00
Bowers Hill	0:12	0:12	0:12	Bowers Hill	0:10	0:10	0:10
Suffolk			0:17	Suffolk			0:15
Petersburg		0:53	0:58	Petersburg		0:40	0:45
Richmond Main St	1:04	1:09	1:14	Richmond Main St	0:50	0:55	1:00
Washington Union	2:36	2:46	3:01	Washington Union	1:45	1:55	2:10

*\* Allowing 2 minutes for Richmond Station Stop*

Exhibit 5-7: Norfolk to Washington D.C. -- Option 1 via Petersburg -- 2:08:25 at 130 mph

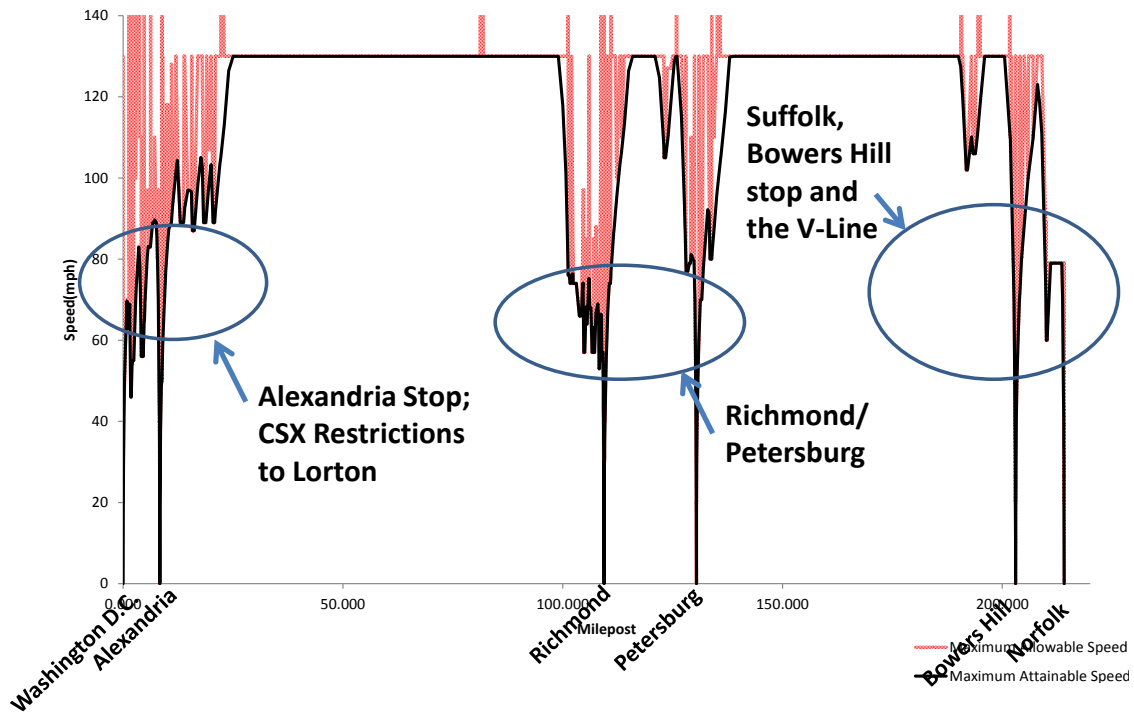
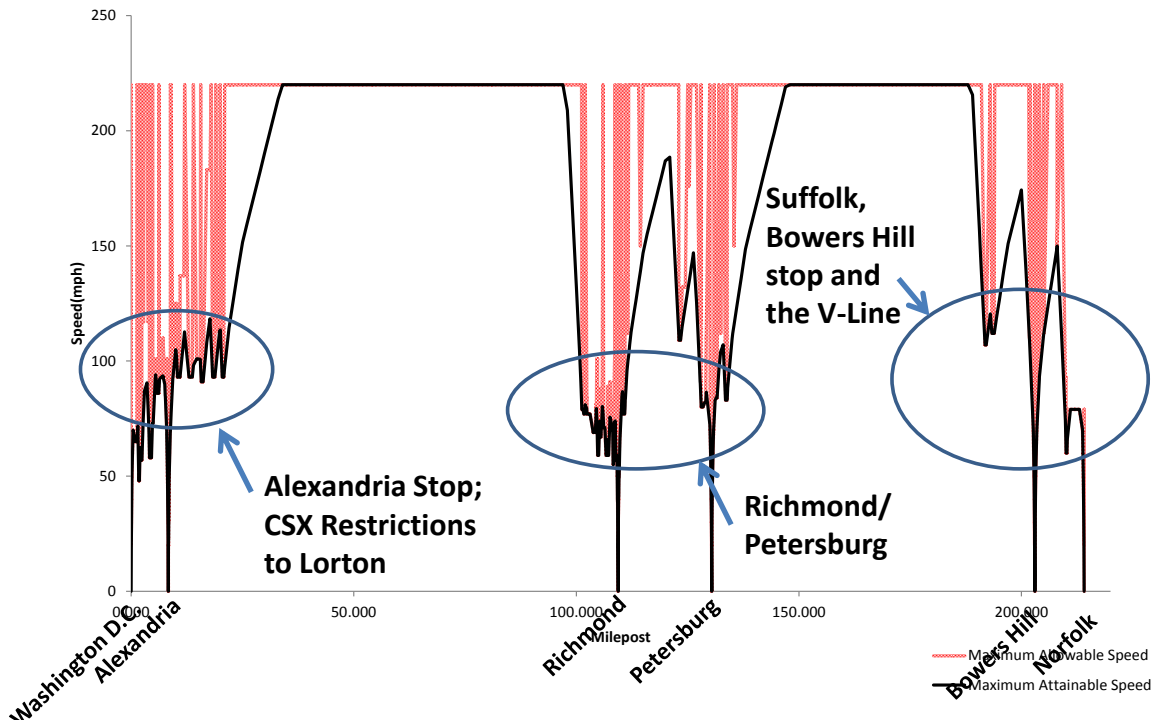


Exhibit 5-8: Norfolk to Washington D.C. -- Option 1 via Petersburg -- 1:40:36 at 220 mph



## NORFOLK TO WASHINGTON D.C.: OPTION 2 VIA HOPEWELL

Two conceptual options 2A and 2B have been defined in Chapter 2 via Hopewell. Option 2A has been defined as a “Northern Greenfield” whereas Option 2B would utilize the existing Norfolk Southern rail alignment. However, since both alignments are essentially straight and about the same length, the running times for the two route variants are extremely close – within a minute of one another – so the train schedule for either variant is the same. Schedules for the Hopewell Option 2 are shown in Exhibit 5-9, and the 130-mph and 220-mph *LOCOMOTION™* speed profiles for the two train simulations are shown in Exhibit 5-10 and 5-11.

**Exhibit 5-9: Proposed Norfolk to Washington D.C. -- Option 2 Times via Hopewell**

130-mph Diesel				220-mph Electric			
Station	Super Express	Express	Local	Station	Super Express	Express	Local
Norfolk	0:00	0:00	0:00	Norfolk	0:00	0:00	0:00
Bowers Hill	0:12	0:12	0:12	Bowers Hill	0:10	0:10	0:10
Suffolk			0:17	Suffolk			0:15
Hopewell		0:50	0:53	Hopewell		0:37	0:42
Richmond Main St	1:04	1:09	1:14	Richmond Main St	0:50	0:55	1:00
Washington Union	2:36	2:46	3:01	Washington Union	1:45	1:55	2:10

*\* Allowing 2 minutes for Richmond Station Stop*

Exhibit 5-10: Norfolk to Washington D.C. -- Option 2 via Hopewell - 2:07:19 at 130 mph

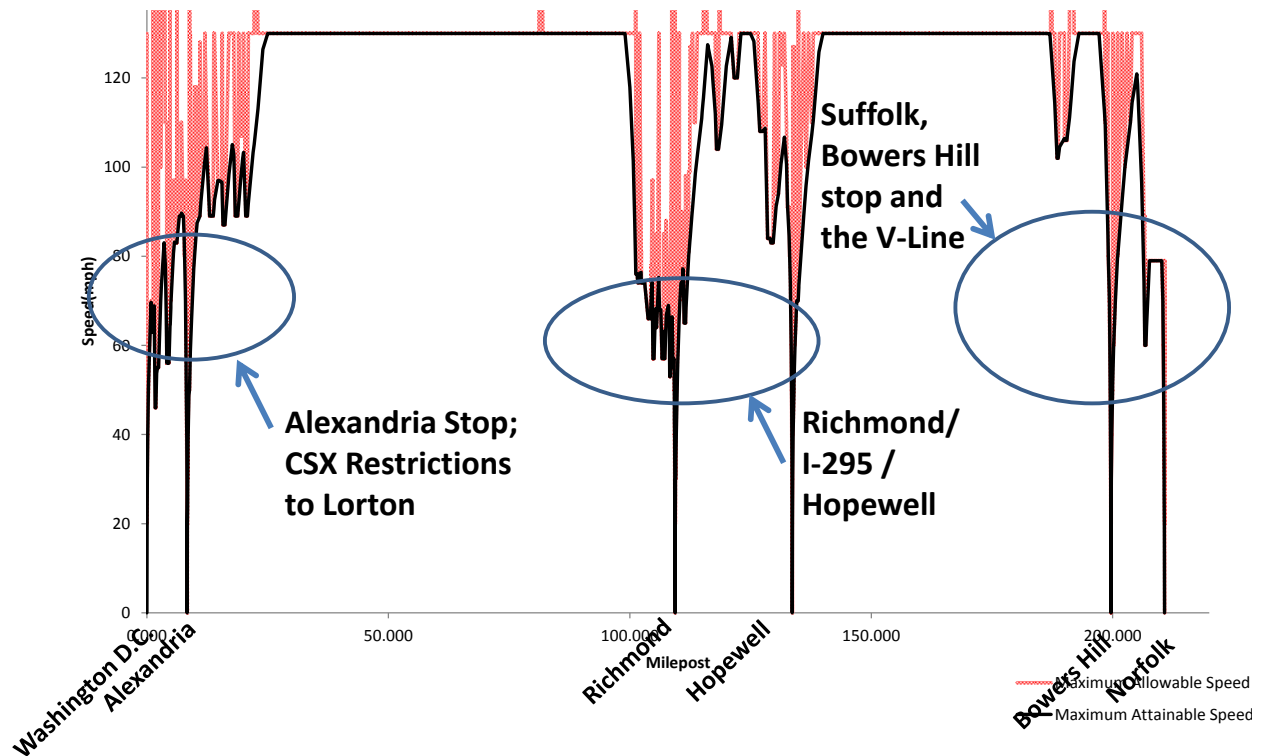
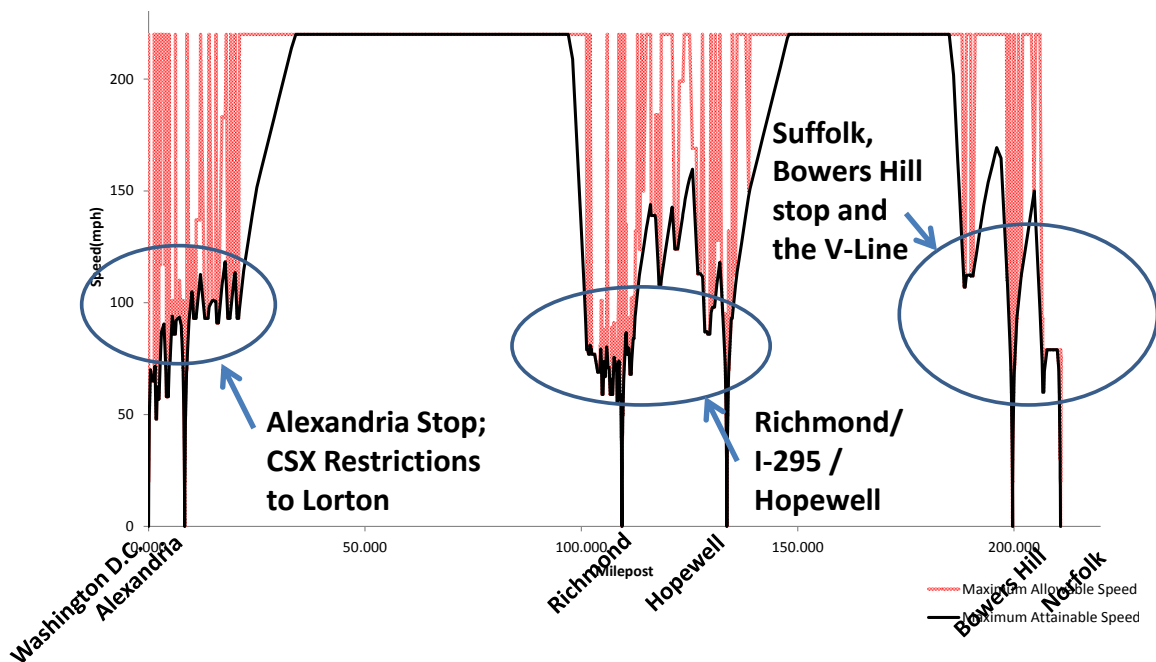


Exhibit 5-11: Norfolk to Washington D.C. -- Option 2 via Hopewell - 1:40:30 at 220 mph



## NORFOLK TO WASHINGTON D.C.: OPTION 3 RICHMOND DIRECT

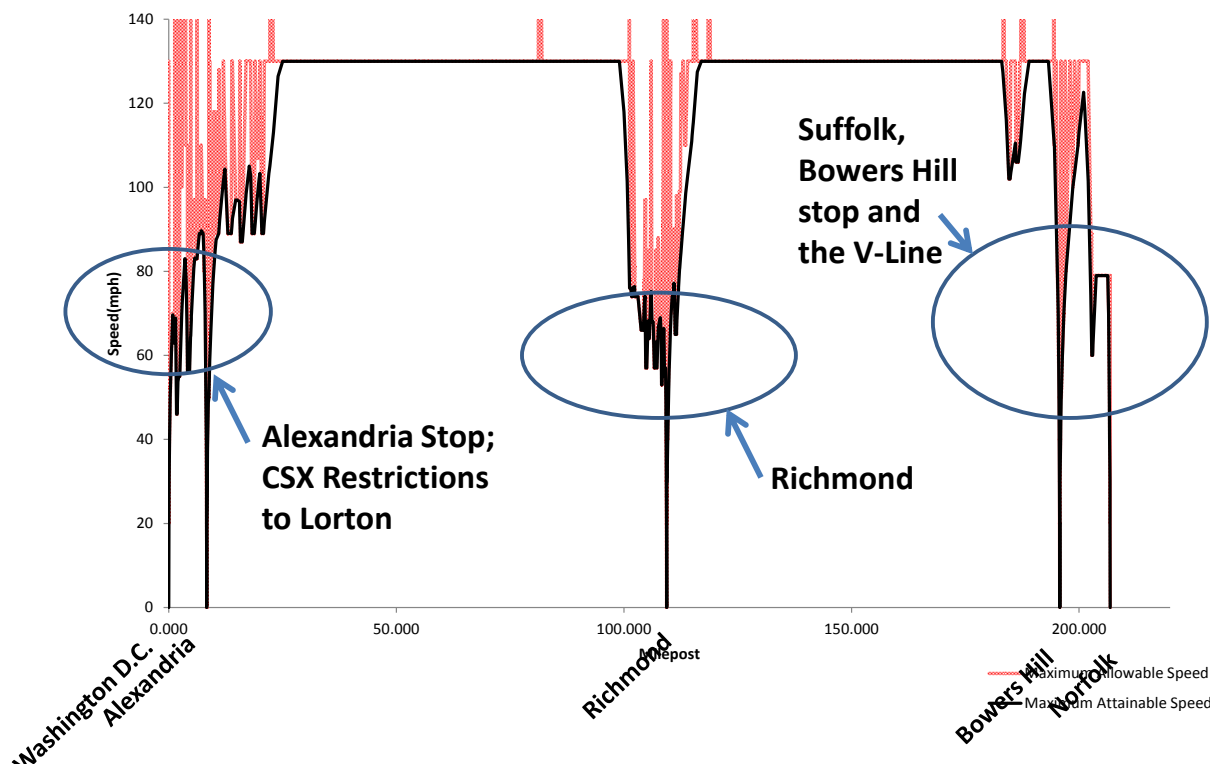
Schedules for the Richmond Direct Option 3 are shown in Exhibit 5-12, and the 130-mph and 220-mph *LOCOMOTION™* speed profiles for the two train simulations are shown in Exhibit 5-13 and 5-14. The Richmond Direct option is about five minutes faster than going via Petersburg or Hopewell for an express train; as compared to a stopping train, Richmond Direct is about 10 minutes faster

**Exhibit 5-12: Proposed Norfolk to Washington D.C. -- Option 3 Times Richmond Direct**

130-mph Diesel				220-mph Electric			
Station	Super Express	Express	Local	Station	Super Express	Express	Local
Norfolk	0:00	0:00	0:00	Norfolk	0:00	0:00	0:00
Bowers Hill	0:12	0:12	0:12	Bowers Hill	0:10	0:10	0:10
Suffolk			0:17	Suffolk			0:15
Richmond Main St	0:59	0:59	1:04	Richmond Main St	0:43	0:43	0:48
Washington Union	2:31	2:36	2:51	Washington Union	1:38	1:43	1:58

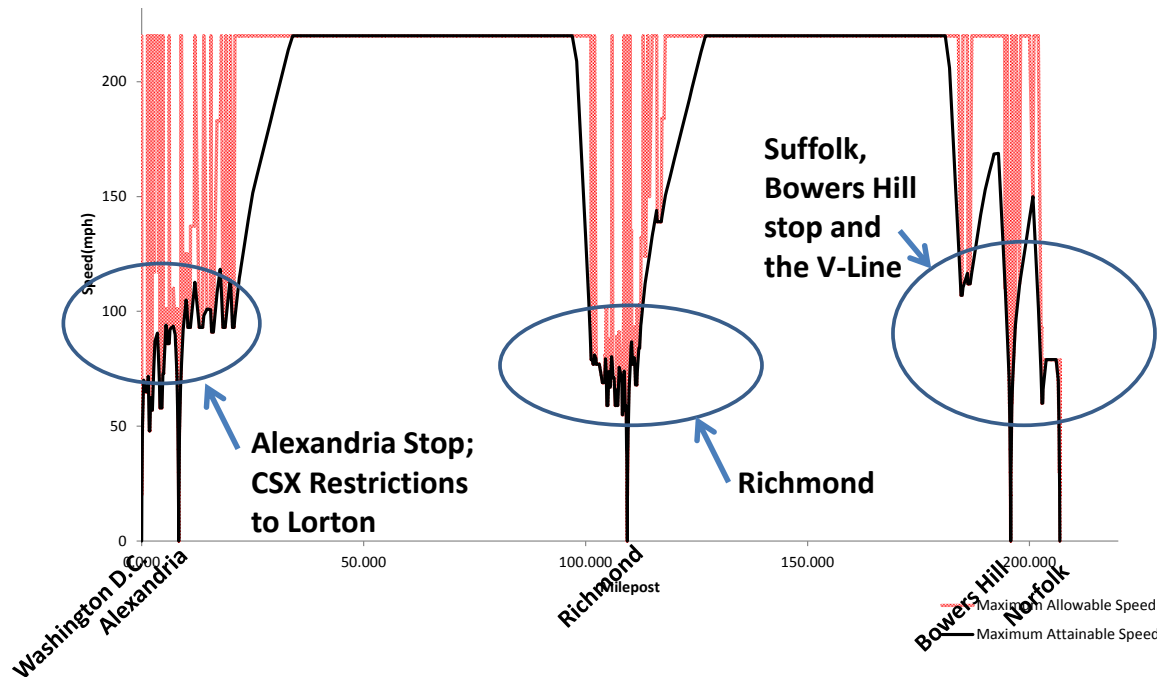
\* Allowing 2 minutes for Richmond Station Stop

**Exhibit 5-13: Norfolk to Washington D.C. -- Option 3 Direct – 2:07:19 at 130 mph**





**Exhibit 5-14: Norfolk to Washington D.C. -- Option 3 Direct – 1:40:30 at 220 mph**



#### 5.1.4 TRAIN TIMETABLES – ENHANCED PENINSULA SERVICE – OPTION 4

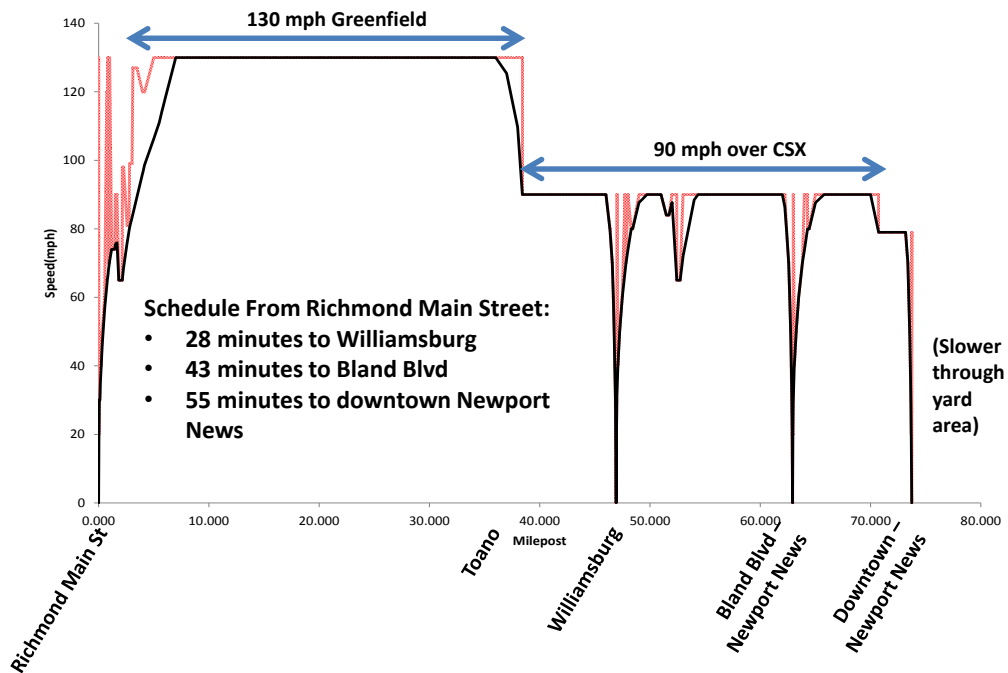
The original Phase 2(B) report suggested a sensitivity “Option 4” that would add a High Speed connecting link over to Toano, as an extension of the Richmond Direct Option 3 220-mph High Speed electric option. This would allow Peninsula diesel trains to also share a portion of the proposed Norfolk High Speed alignment. In the Phase 2(B) report this was proposed only as a sensitivity option, but in this report Option 4 has been more fully developed at a feasibility level.

Option 4 specifically assumes that 130-mph High Speed diesel trains will operate on the Peninsula (the same trains that were assumed for the Step 3 analysis) and that 220-mph electric trains will operate to Norfolk (the same trains that were assumed for the Step 4 analysis.) Option 4 thus reflects a hybrid that combines both electric and diesel technologies in a single option. This reflects the ability of 130-mph diesel trains to run “under the wire” on a 220-mph electrified track. As a result, the Peninsula rail service can substantially benefit from development of the Norfolk -Richmond-Washington D.C. High Speed line even if electrification does not extend all the way to Newport News.

As shown in Exhibit 5-15, Peninsula diesel trains would run on high quality greenfield alignment at 130-mph as far as Toano, where they would enter the existing CSX alignment and be limited to 90-mph. The schedule time from Richmond Main Street would only be 55 minutes to downtown Newport News. Coupled with a 1:05 schedule from Washington D.C. to Richmond, the timetable would be 2 hours.<sup>7</sup>

<sup>7</sup> If the Roxbury-Toano segment were electrified and dual model trains with a 220-mph top speed capability were introduced, Peninsula trains would save an additional 15 minutes and achieve a 1:45 schedule.

Exhibit 5-15: Richmond to Newport News Speed Profile



**0:55 Newport News-Richmond plus 1:05 Richmond-Washington DC\* = 2:00 Overall Schedule Objective**

**\* 1:05 Time for 130-mph diesel train based on a Greenfield alignment north of Richmond**

### SCHEDULE SUMMARY

The result of this operational analysis along with recommended train frequencies for the two speed options are summarized in Exhibit 5-16. As can be seen, the overall running times via Petersburg and Hopewell are essentially the same; Richmond Direct is five to ten minutes faster.

Exhibit 5-16: Norfolk to Washington D.C. – Schedule Results Summary

Stations	Super Express	Express	Local
Norfolk	√	√	√
Bowers Hill	√	√	√
Suffolk	–	–	√
Petersburg/Hopewell*	–	√	√
Richmond Main St	√	√	√
Ashland	–	–	√
Fredericksburg	–	√	√
Quantico	–	–	√
Alexandria	√	√	√
Washington Union	√	√	√
<b>130-mph Total Trains</b>	<b>4 trains</b>	<b>5 trains</b>	<b>4 trains</b>
<b>130-mph Time via Petersburg/Hopewell</b>	<b>2:36</b>	<b>2:46</b>	<b>3:01</b>
<b>130-mph Time Richmond Direct</b>	<b>2:31</b>	<b>2:36</b>	<b>2:51</b>
<b>220-mph Total Trains</b>	<b>5 trains</b>	<b>10 trains</b>	<b>3 trains</b>
<b>220-mph Time via Petersburg/Hopewell</b>	<b>1:45</b>	<b>1:55</b>	<b>2:10</b>
<b>220-mph Time Richmond Direct</b>	<b>1:38</b>	<b>1:43</b>	<b>1:58</b>

\* Stations Bypassed by Richmond Direct

In Exhibit 5-16, “Super Express” trains stop only at the main urban stations. “Express” trains add stops in Petersburg and Fredericksburg. Local trains make all stops. The schedule times of all four route options are very close. The results of this more detailed assessment support the findings of the earlier 2010 study, Progress Report B. Petersburg and Hopewell route options have the same times. These route options are 5 minutes slower than Richmond Direct, plus an additional 5 minutes if they add a stop.<sup>8</sup>

The overall train schedule and equipment assumption for Option 4, which provides High Speed Rail service to the southside and Enhanced service on the Peninsula, is summarized in Exhibit 5-17. Norfolk service times in Exhibit 5-17 are the same as shown for Richmond Direct in Exhibit 5-16.

<sup>8</sup> Although every minute of time savings attracts more riders, the time difference between options is not enough to drive significant differences in ridership between the options. Going via Petersburg or Hopewell would add ridership from this intermediate market but the added time would marginally reduce ridership from Norfolk and Bowers Hill. As a result, the route selection will likely be made based on cost, environmental factors and synergies with other routes, including the relative degree of benefit to the Peninsula and SESHR services and the degree to which the Peninsula and SESHR ridership is responsive to such benefits.

Exhibit 5-17: Option 4 Schedule Summary



- **Used for Southside**
- **Speeds up to 220-mph on dedicated high speed ROW**
- **79-mph on NS; 90-mph on CSX ROW\***



- **Used for Peninsula**
- **Speeds up to 130-mph on dedicated high speed ROW**
- **79-mph on NS; 90-mph on CSX ROW\***

Timetable	WAS-NRF 220-mph Super Express 5 Stops to DC	WAS-NRF 220-mph Express 7 Stops to DC	WAS-NRF 220-mph Local 10 Stops to DC	WAS-NPN 130-mph Express 7 Stops to DC	WAS-NPN 130-mph Local 10 Stops to DC
Total Trains	5 trains	10 trains	3 trains	4 trains	4 trains
Schedule Time	1:38	1:43	1:58	2:00	2:10

\* Maximum Speeds for Sharing Freight Rail Rights of Way in accordance with Railroad Letters of Principle

## 5.2 OPERATING AND MAINTENANCE COSTS

### 5.2.1 OPERATING AND MAINTENANCE COSTS METHODOLOGY





This section describes the build-up of the unit operating costs that have been used in conjunction with the operating plans, to project the total operating cost of each corridor option. A costing framework originally developed for the Midwest Regional Rail System (MWRRS) was adapted for use in this study. Following the MWRRS methodology<sup>9</sup>, nine specific cost areas have been identified. As shown in Exhibit 5-18, variable train-mile driven costs include equipment maintenance, energy and fuel, and train and onboard (OBS) service crews. Passenger miles drive insurance liability, while ridership influences marketing, and sales. Fixed costs include administrative costs, station costs, and track and right-of-way maintenance costs. Signals, communications and power supply are included in the track and right-of-way costs.

This framework enables the direct development of costs based on directly-controllable and route-specific factors, and allows sensitivity analyses to be performed on the impact of specific cost drivers. It also enables direct and explicit treatment of overhead cost allocations, to ensure that costs which do not

<sup>9</sup> Follow the links under "Midwest Regional Rail Initiative (MWRI)" at <http://www.dot.state.mn.us/planning/railplan/studies.html>

belong to a corridor are not inappropriately allocated to the corridor, as would be inherent in a simple average cost-per-train mile approach. It also allows benchmarking and direct comparability of HRTPO costs with those developed by other high speed rail studies across the nation, including those with which the proposed corridor route would connect.

**Exhibit 5-18: Operating Cost Categories and Primary Cost Drivers**

Drivers	Cost Categories
Train Miles	 Equipment Maintenance Energy and Fuel Train and Engine Crews Onboard Service Crews
Passenger Miles	 Insurance Liability
Ridership and Revenue	 Sales and Marketing
Fixed Cost	 Service Administration Track and ROW Maintenance Station Costs

For development of costs, since there are a number of different corridor and technology options, it is essential to maintain consistency of the costing basis across all options. For developing a fair comparison:

- Unit Costs that depend on the propulsion/speed should reflect legitimate differences between technologies and routes; and
- Unit Costs that do not depend on propulsion/speed should remain the same across all technologies and routes.

Operating costs can be categorized as variable or fixed. As described below, fixed costs include both Route and System overhead costs. Route costs can be clearly identified to specific train services but do not change much if fewer or additional trains were operated.

- Variable costs change with the volume of activity and are directly dependent on ridership, passenger miles or train miles. For each variable cost, a principal cost driver is identified and used to determine the total cost of that operating variable. An increase or decrease in any of these will directly drive operating costs higher or lower.
- Fixed costs are generally predetermined, but may be influenced by external factors, such as the volume of freight tonnage, or may include a relatively small component of activity-driven costs. As a rule, costs identified as fixed should remain stable across a broad range of service intensities. Within fixed costs are two sub-categories:
  - Route costs such as track maintenance, train control and station expense that, although fixed, can still be clearly identified at the route level.
  - Overhead or System costs such as headquarters management, call center, accounting, legal, and other corporate fixed costs that are shared across routes or even nationally. A portion of overhead cost (such as direct line supervision) may be directly identifiable but



most of the cost is fixed. Accordingly, assignment of such costs becomes an allocation issue that raises equity concerns. These kinds of fixed costs are handled separately.

Operating costs have been developed based on the following premises:

- Based on results of recent studies, a variety of sources including suppliers, current operators' histories, testing programs and prior internal analysis from other passenger corridors were used to develop the cost data. However, as the rail service is implemented, actual costs will be subject to negotiation between the passenger rail authority and the contract rail operator(s).
- Freight railroads will maintain track and right-of-way that they own, but ultimately, the actual cost of track maintenance will be resolved through negotiations with the railroads. For this study, a track maintenance cost model will be used that reflects actual freight and passenger railroad cost data.
- Maintenance of train equipment will be contracted out to the equipment supplier.
- Train operating practices follow existing work rules for crew staffing and hours of service. Average operating expenses per train-mile for train operations, crews, management and supervision were estimated through a bottoms-up staffing approach based on typical passenger rail organizational needs.

The MWRRS costing framework was developed in conjunction with nine states that comprised the MWRRS steering committee and with Amtrak. In addition, freight railroads, equipment manufacturers and others provided input to the development of the costs. However, the costing framework has been validated with recent operating experience based on publicly available data from other sources, particularly the Midwest 403B Service trains Northern New England Passenger Rail Authority's (NNEPRA) Downeaster costs and data on Illinois operations that was provided by Amtrak. It has been brought to a \$2013 costing basis and additional cost categories not included in the original MWRRS study, such as for electrification, have been added into the framework.

The original concept for the MWRRS was for development of a new service based on operating methods directly modeled after state-of-the-art European rail operating practice. Along with anticipated economies of scale, modern train technology could reduce operating costs when compared to existing Amtrak practice. In the original 2000 MWRRS Plan, European equipment costs were measured at 40 percent of Amtrak's costs. However, in the final MWRRS plan that was released in 2004, train-operating costs were significantly increased to a level that is more consistent with Amtrak's current cost structure. However, adopting an Amtrak cost structure for financial planning does not suggest that Amtrak would actually be selected for the corridor operation. Rather, this selection increases the flexibility for choosing an operator without excluding Amtrak, because multiple operators and vendors will be able to meet the broader performance parameters provided by this conservative approach.

### **5.3 VARIABLE COSTS**

These costs include those that directly depend on the number of train-miles operated or passenger-miles carried. They include train equipment maintenance, train crew cost, fuel and energy, onboard service, and insurance costs.

#### ***TRAIN EQUIPMENT MAINTENANCE***

Equipment maintenance costs include all costs for spare parts, labor and materials needed to keep equipment safe and reliable. The costs include periodical overhauls in addition to running maintenance. It also assumes that facilities for servicing and maintaining equipment are designed specifically to accommodate the selected train technology. This arrangement supports more efficient and cost-effective maintenance practices. Acquiring a large fleet of trains with identical features and components, allows for

substantial savings in parts inventory and other economies of scale. In particular, commonality of rolling stock and other equipment will standardize maintenance training, enhance efficiencies and foster broad expertise in train and system repair.

The MWRRS study developed a cost of \$9.87 per train mile for a 300-seat train in \$2002. This cost was increased to \$12.70 per train mile in \$2013. Available evidence suggests that the maintenance cost for a conventional electric train should be about 9 percent cheaper per equivalent seat-mile than that of a diesel train leading to a unit cost of \$11.27 per mile for a 150-mph locomotive hauled electric train. However, high speed electric trains have a more than proportional increase in power: a typical 130-mph diesel train has about 18 kw/Seat; the 220-mph Alstom AGV has 24 kw/Seat<sup>10</sup> while the 160-mph Acela is rated at 30kw/Seat. However, the Acela needs this much power due to the high weight of the steel coaches and low seating capacity of the train. As a result, the maintenance cost per mile for the 220-mph electric train benchmarked only slightly higher than that for the 130-mph diesel of equivalent capacity; a cost of \$14.08 per mile was assumed for the 220-mph electric train. The 79-mph conventional Amtrak train benchmarked at a higher cost of \$15.43 due primarily to a lack of economies of scale associated with typical lighter density Amtrak corridors.

For this study:

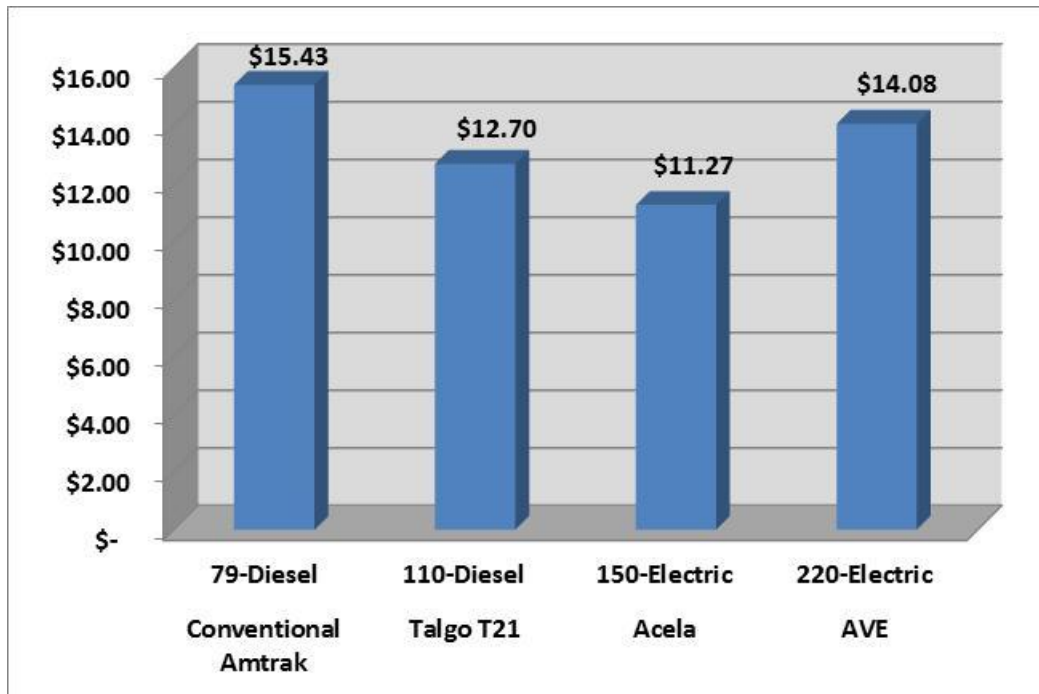
- A \$15.43 cost will be assumed for low frequency 79-mph options. These are characteristic of the current Amtrak service to Norfolk and Newport News, but were not part of any options assessed in this study.
- The intermediate \$12.70 cost will be assumed for the 130-mph diesel options.
- A lower \$11.27 level of cost would be assumed for electric trains running at 150 mph maximum. As a result, the extra power and traction motors are not needed, so the lower maintenance cost could be assumed. However, these trains were not used in any options assessed in this study.
- The highest \$14.08 cost will be used for the 220-mph electric train operating on a Greenfield.

These costs are summarized in Exhibit 5-19.

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<sup>10</sup> See: [http://en.wikipedia.org/wiki/Automotrice\\_%C3%A0\\_grande\\_vitesse](http://en.wikipedia.org/wiki/Automotrice_%C3%A0_grande_vitesse)

Exhibit 5-19: Equipment Maintenance Cost per Mile (\$2013)



#### TRAIN AND ENGINE CREW COSTS

The train operating crew incurs crew costs. Following Amtrak staffing policies, the operating crew would consist of an engineer, a conductor and an assistant conductor and is subject to federal Hours of Service regulations. Costs for the crew include salary, fringe benefits, training, overtime and additional pay for split shifts and high mileage runs. An overtime allowance is included as well as scheduled time-off, unscheduled absences and time required for operating, safety and passenger handling training. Fringe benefits include health and welfare, FICA and pensions. The cost of employee injury claims under FELA is also treated as a fringe benefit for this analysis. The overall fringe benefit rate was calculated as 55 percent. In addition, an allowance was built in for spare/reserve crews on the extra board. Costing of train crews was based on Amtrak's 1999 labor agreement, adjusted for inflation to 2013.

Crew costs depend upon the level of train crew utilization, which is largely influenced by the structure of crew bases and any prior agreements on staffing locations. Train frequency strongly influences the amount of held-away-from-home-terminal time, which occurs if train crews have to stay overnight in a hotel away from their home base. Since a broad range of service frequencies and speeds have been evaluated here, a parametric approach was needed to develop a system average per train mile rate for crew costs. Such an average rate necessarily involves some approximation, but to avoid having to reconfigure a detailed crew-staffing plan whenever the train schedules change, an average rate is appropriate for the current feasibility level study. A more specific and detailed level of assessment would be appropriate for a Tier 2 EIS. For this study:

- An intermediate value of \$4.92 per train mile was assumed for the high frequency 130-mph diesel options. This is a moderate level of crew cost that includes the need for some away-from-home layover.
- 79-mph service would cost \$6.59 per train-mile because of poor crew utilization in these very low-frequency scenarios. With trains operating less frequently there is less opportunity to return

crews to their home base on the same day, leading to more split shifts and overnight layovers. However, these trains were not part of any options assessed in this study.

- The 220-mph Greenfield scenario used \$4.60 per train mile, reflecting operating efficiencies related both to higher speeds and more frequent trains in this scenario only, both of which tend to reduce the need for away-from-home layovers.

#### **FUEL AND ENERGY**

An average consumption rate of 2.42 gallons/mile was estimated for a 110-mph 300-seat train, based upon nominal usage rates of all three technologies considered in Phase 3 of the MWRRS Study. Assuming \$3.60 a gallon in late 2013 for diesel fuel according to Energy Information Administration (EIA)<sup>11</sup>, this translates into a cost of \$8.71 per train mile, more than tripling (375%) the cost of diesel fuel that was prevalent at the time of the earlier MWRRS study. During the same time period however, electricity costs did not rise nearly so much. For example, Virginia electric power costs rose only by 46%.

However, electric traction has an advantage over diesel since it can be powered from any energy source, not just petroleum-based fuel. Even taking typical peaking demands into account, electricity is typically cheaper than diesel fuel. As a result, the rapid rise of petroleum costs over the past ten years has tipped the cost advantage towards electrification.

However, there is a large regional variation in electricity and peak usage rate structures. For example, electric power has in the past been more expensive than diesel traction in the northeastern United States. But the southeast enjoys lower average electricity rates than do northeastern states:<sup>12</sup> in 2010, for example, Virginia electric power for transportation averaged only 7.7¢ per kWh as compared to 11.9¢ per kWh in New Jersey. The actual price paid is also driven by the peak hour surcharges that can more than double a railroad's electric energy bill.

However, by employing power smoothing techniques such as onboard and wayside energy storage, as well as by regenerating electric power while braking, the rail operator might reduce the level of fluctuation in its energy usage so it pays closer to the base average kilowatt-hour power generation charge. Given the high cost associated with electric power purchases, the issue of demand smoothing is an issue that should receive careful attention in the train equipment procurement, as well as in the design of the electric traction system. The structure of peak usage charges should be negotiated with the electric utilities to ensure that the operator can purchase the power it needs at the lowest possible cost.

As shown in Exhibit 5-20, and including the Peak Usage charge, the comparable electric cost for an Acela 150-mph locomotive-hauled electric train is just \$2.80 per train mile as compared to \$8.71 for the diesel 130-mph train. But because it weighs less than the Acela, the 220-mph electric multiple unit is even more efficient at \$2.46 per train mile. Also, the 220-mph electric train on a greenfield needs to accelerate and brake less than a train operating over an existing rail or highway alignments would. This results in a more uniform electric load which should lead to a more favorable utility rate negotiation.

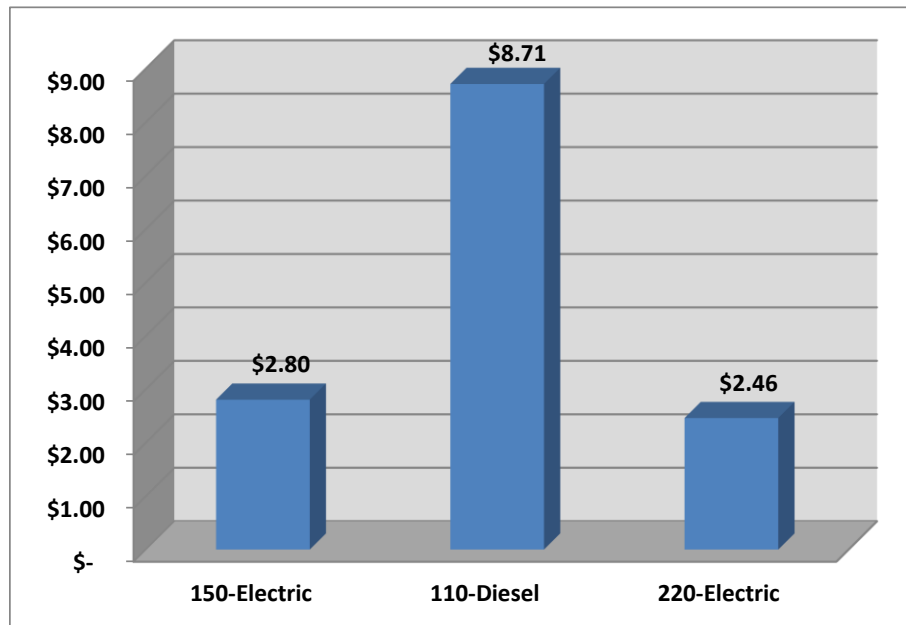
On the other hand, the 220-mph electric train does go faster. This speed increases its energy consumption, largely offsetting the weight improvement. As a result, all diesel options assume a 2013 fuel cost of \$8.71 per train mile, and all electric options assume an electric cost of \$2.80 per train mile. These energy costs are then adjusted each year in line with the relevant Energy Information Administration forecasts.

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<sup>11</sup> EIA diesel retail price in 2013 excluding the taxes <http://www.eia.gov/petroleum/gasdiesel/>

<sup>12</sup> See <http://www.eia.gov/electricity/state/>

Exhibit 5-20: Fuel and Energy Cost per Mile (\$2013)



### ONBOARD SERVICES (OBS)

Onboard service (OBS) costs are those expenses for providing food service onboard the trains. OBS adds costs in three different areas: equipment, labor and cost of goods sold. Equipment capital and operating cost is built into the cost of the trains and is not attributed to food catering specifically. Small 200-seat trains cannot afford a dedicated dining or bistro car. Instead, an OBS employee or food service vendor would move through the train with a trolley cart, offering food and beverages for sale to the passengers.

The goal of OBS franchising should be to ensure a reasonable profit for the provider of on-board services, while maintaining a reasonable and affordable price structure for passengers. In previous studies, it has been found that the key to attaining OBS profitability is selling enough products to recover the train mile related labor costs. For example, if small 200-seat trains were used, given the assumed OBS cost structure, even with a trolley cart service the OBS operator will be challenged to attain profitability. However, the expanded customer base on larger 300-seat trains can provide a slight positive operating margin for OBS service. 400-seat electric trains should usually provide a comfortable positive profit margin for the OBS operator.

Because the trolley cart has been shown to double OBS revenues, it can result in profitable OBS operations in situations where a bistro-only service would be hard-pressed to sell enough food to recover its costs. While only a limited menu can be offered from a cart, the ready availability of food and beverages at the customer's seat is a proven strategy for increasing sales. Many customers appreciate the convenience of a trolley cart service and are willing to purchase food items that are brought directly to them. While some customers prefer stretching their legs and walking to a bistro car, other customers will not bother to make the trip.

The cost of goods sold is estimated as 50 percent of OBS revenue, based on Amtrak's route profitability reports. Labor costs, including costs for commissary support and OBS supervision, have been estimated at:

- An intermediate value of \$2.56 per train mile was assumed for the 130-mph diesel options. This is a moderate level of crew cost that includes the need for some away-from-home layover.



- Existing rail 79-mph scenarios would cost \$3.66 per train-mile because of poor crew utilization in these very low-frequency scenarios. With trains operating less frequently there is less opportunity to return crews to their home base on the same day, leading to more split shifts and overnight layovers. However, these trains were not part of any options assessed in this study.
- The 220-mph Greenfield scenario used \$2.41 per train mile, reflecting operating efficiencies related both to higher speeds and more frequent trains in this scenario only, both of which tend to reduce the need for away-from-home layovers.

These costs are generally consistent with Amtrak's level of wages and staffing approach for conventional bistro car services. However, this Business Plan recommends that an experienced food service vendor provide food services and use a trolley cart approach. A key technical requirement for providing trolley service is to ensure the doors and vestibules between cars are designed to allow a cart to easily pass through. Since trolley service is a standard feature on most European railways, most European rolling stock is designed to accommodate the carts. Although convenient passageways often have not been provided on U.S. equipment, the ability to support trolley carts is an important equipment design requirement for the planned service.

#### ***INSURANCE COSTS***

Liability costs were estimated at 1.4¢ per passenger-mile, the same rate that was assumed in the earlier MWRRS study brought to \$2013. Federal Employees Liability Act (FELA) costs are not included in this category but are applied as an overhead to labor costs.

The Amtrak Reform and Accountability Act of 1997 (§161) provides for a limit of \$200 million on passenger liability claims. Amtrak carries that level of excess liability insurance, which allows Amtrak to fully indemnify the freight railroads in the event of a rail accident. This insurance protection has been a key element in Amtrak's ability to secure freight railroad cooperation. In addition, freight railroads perceive that the full faith and credit of the United States Government is behind Amtrak, while this may not be true of other potential passenger operators. However, a General Accounting Office (GAO) review<sup>13</sup> has concluded that this \$200 million liability cap applies to commuter railroads as well as to Amtrak. If the GAO's interpretation is correct, the liability cap may also apply to potential franchisees. If this limitation were in fact available to potential franchisees, it would be much easier for any operator to obtain insurance that could fully indemnify a freight railroad at a reasonable cost. It is recommended that Virginia DOT seek qualified legal advice on this matter.

#### **5.4 FIXED ROUTE COSTS**

This cost category includes those costs that, while largely independent of the number of train-miles operated, can still be directly associated to the operation of specific routes. It includes such costs as track maintenance, which varies by train technology, and station operations.

#### ***TRACK AND RIGHT-OF-WAY COSTS***

Currently, it is industry practice for passenger train operators providing service on freight-owned rights-of-way to pay for track access, dispatching and track maintenance. Rates for all these activities are ultimately based upon a determination of the appropriate costs that result from negotiations between the parties. The purpose here is to provide estimates based on the best available information; however, as the project moves forward, additional study and discussions with the railroads will be needed to further refine these costs.

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<sup>13</sup> See: <http://www.gao.gov/highlights/d04240high.pdf>

To accommodate passenger trains, the Norfolk Southern existing rail corridor would need a substantial increase in capacity or else a new Greenfield alignment would need to be constructed. Once built, these improvements would need to be maintained to FRA standards required for reliable and safe operations. The costing basis assumed in this report is that of incremental or avoidable costs<sup>14</sup> for shared tracks. The passenger operator, however, must take full cost responsibility for maintaining any tracks that it must add to the corridor either for its own use, or for mitigating delays to freight trains. The following cost components are included within the Track and Right-of-Way category:

- **Track Maintenance Costs.** Costs for track maintenance were estimated based on Zeta-Tech's January 2004 draft technical monograph Estimating Maintenance Costs for Mixed High-Speed Passenger and Freight Rail Corridors.<sup>15</sup> Zeta-Tech costs have been adjusted for inflation to \$2013. However, Zeta-Tech's costs are conceptual and subject to negotiation with the freight railroads.
- **Dispatching Costs and Out-of-Pocket Reimbursement.** Passenger service must also reimburse a freight railroad's added costs for dispatching its line, providing employee efficiency tests and for performing other services on behalf of the passenger operator. If the passenger operator does not contract a freight railroad to provide these services, it must provide them itself. As a result, costs for train dispatching and control are incurred on dedicated as well as shared tracks and are now shown under a separate "Operations and Dispatch" cost category.
- **Costs for Access to Track and Right-of-Way.** Access fees, particularly train mile fees incurred as an operating expense, are specifically excluded from this calculation. Any such payments would have to be calculated and negotiated on a route-specific and railroad-specific basis. Such a calculation would have to consider the value of the infrastructure improvements made to the corridor for balancing up-front capital with ongoing operating payments.<sup>16</sup>

Exhibit 5-21 shows the conceptual relationship between track maintenance cost and total tonnage that was calibrated from the 2004 Zeta-Tech study. It shows a strong relationship between tonnage, FRA track class (4 through 6, corresponding to a 79-mph to 110-mph track speed) and maintenance cost. At low tonnage, the cost differential for maintaining a higher track class is not very large, but as tonnage grows, so too does the added cost. For shared track, if freight needs only Class 4 track, the passenger service would have to pay the difference, called the "maintenance increment", which for a 25 MGT line as shown in Exhibit 5-21, would come to about \$22,000 per mile per year (in \$2002), including capital costs<sup>17</sup>. The required payment to reimburse a freight railroad for its added cost would be less for lower freight tonnage, more for higher freight tonnage.

Exhibit 5-21 also breaks out the operating versus total track maintenance cost, showing that capital (the difference between total and operating cost) is a significant share of the total cost. For track maintenance:

<sup>14</sup> Avoidable costs are those that are eliminated or saved if an activity is discontinued. The term incremental is used to reference the change in costs that results from a management action that increases volume, whereas avoidable defines the change in costs that results from a management action that reduces volume.

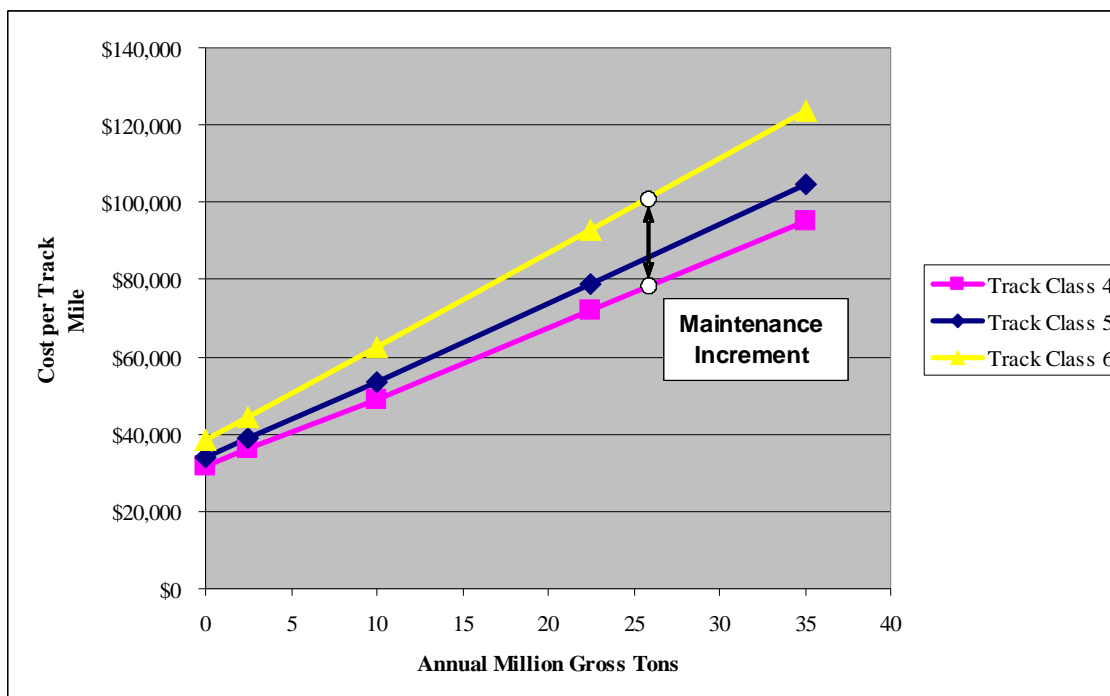
<sup>15</sup> Zeta-Tech, a subsidiary of Harsco (a supplier of track maintenance machinery) is a rail consulting firm who specializes in development of track maintenance strategies, costs and related engineering economics. See a summary of this report at <http://onlinepubs.trb.org/onlinepubs/trnews/trnews255rpo.pdf>. The full report is available upon request from the FRA.

<sup>16</sup> For 110-mph service, the level of infrastructure improvements to the corridor called for in this study should provide enough capacity to allow superior on-time performance for both freight and passenger operations

<sup>17</sup> Calculated as  $\$38,446 - \$31,887 + (\$2,440 - \$1,810) * 25 = \$22,309$  per year. Note that the yellow highlighted cells in the table correspond to the three lines shown on the graph.

- **Operating costs** cover expenses needed to keep existing assets in service and include both surfacing and a regimen of facility inspections.
- **Capital costs** are those related to the physical replacement of the assets that wear out. They include expenditures such as for replacement of rail and ties, but these costs are not incurred until many years after construction. In addition, the regular maintenance of a smooth surface by reducing dynamic loads actually helps extend the life of the underlying rail and tie assets.

**Exhibit 5-21: Zeta-Tech 2004 Calibrated Track Class vs. Tonnage Total Cost Function**  
(“Middle Line” Case, in \$2002)



TOTAL	LOW		MIDDLE		HIGH	
	Intercept	Slope	Intercept	Slope	Intercept	Slope
Class 3 <sup>1</sup>	\$17,880	\$0.917	\$21,683	\$1.231	\$25,487	\$1.548
Class 4	\$26,294	\$1.348	\$31,887	\$1.810	\$37,481	\$2.277
Class 5	\$28,072	\$1.509	\$33,937	\$2.020	\$39,801	\$2.530
Class 6	\$31,714	\$1.837	\$38,446	\$2.440	\$45,178	\$3.035

OPER	LOW		MIDDLE		HIGH	
	Intercept	Slope	Intercept	Slope	Intercept	Slope
Class 3	\$6,558	\$0.579	\$8,216	\$0.726	\$9,873	\$0.872
Class 4	\$9,644	\$0.852	\$12,082	\$1.067	\$14,519	\$1.283
Class 5	\$11,283	\$0.997	\$14,135	\$1.249	\$16,987	\$1.501
Class 6	\$14,640	\$1.293	\$18,371	\$1.623	\$22,101	\$1.953

Exhibit 5-21 shows that the cost of shared track depends strongly on the level of freight tonnage, since passenger trains are relatively lightweight and do not contribute much to the total tonnage. In fact, following the Zeta-Tech methodology, the “maintenance increment” is calculated based on freight tonnage only, since a flat rate of \$1.56 per train mile as used in the Zeta-Tech report (in \$2002) was already added to reflect the direct cost of added passenger tonnage regardless of track class. This cost, which was developed by Zeta-Tech’s TrackShare® model, includes not only directly variable costs, but also an allocation of a freight railroad’s fixed cost. Accordingly, it complies with the Surface Transportation Board’s definition of “avoidable cost.” Inflated to \$2013 (an approximate 52% increase, a higher rate of inflation than CPI, reflecting the energy-intensity of construction materials) this avoidable cost allocation would come to \$2.37 per train mile. It should be noted that Norfolk Southern policy does not allow for upgrading shared freight tracks above 79-mph. Accordingly, this \$2.37 per train mile is the rate that would be assumed for shared use of Norfolk Southern freight tracks. The “maintenance increment” as described earlier is not relevant to this case since it is assumed that the tracks are not upgraded beyond what are needed for freight use.

On top of this, an allowance of 39.5¢ per train-mile (in \$2002) was added by Zeta-Tech for freight railroad dispatching and out-of-pocket costs. Inflated to \$2013 based on the Consumer Price Index (approx. 29% increase) this dispatching and out-of-pocket cost now comes to 50.8¢ per train mile, which is applied both to dedicated and shared tracks. This cost is now separated from track maintenance under the “Operations and Dispatch” category.

The same cost function shown in Exhibit 5-21 can also be used for costing dedicated passenger track. With dedicated track, the passenger system is assumed to cover the entire operating cost for maintaining its own track. (Freight may then have to reimburse the passenger operator on a car-mile basis for any damage it causes to the passenger track.) Because passenger train tonnage is very low however, it can be seen that the cost differential between Class 4, 5 and 6 track is very small. Adjusting Zeta-Tech’s \$2002 costs shown in Exhibit 5-21 up to \$2013:

- The Total cost per track-mile for maintaining dedicated Class 4 track is about \$48,468; the cost for Class 6 track rises to \$58,438. For a shared-use scenario, this assumes that Norfolk Southern would require this level of support each year for maintaining the additional tracks that it must add to its existing rail corridor, for supporting the needs of passenger rail service.
- The Operating cost per track-mile for maintaining dedicated Class 4 track is about \$18,365; the cost for Class 6 track rises to \$27,924.
- The Capital cost per track-mile for maintaining dedicated Class 4 track reflects the difference of about \$30,103; similarly for Class 6 track is \$30,514. The capital cost for maintaining Class 4 versus Class 6 track under light tonnage density is not much different; most of cost differential is in operating cost needed to maintain the more precise alignment of the higher class track.
- Adding \$26,859 per track-mile for overhead electric catenary, the overall operating maintenance cost for electrified dedicated track rises to  $\$27,924 + \$26,859 = \$54,783$  per track mile per year. We do not account for separate capital cost replacement for catenary, since the \$26,859 per track-mile estimate accounts for both operating and normalized capital power system maintenance.

Reducing axle loads as is a common design practice for 220-mph high speed equipment. This helps keep guideway maintenance costs low and in line with the above assumed costs. French experience<sup>18</sup> showed

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<sup>18</sup> See Maintenance Costs of High-Speed Lines in Europe: State of the Art, Transportation Research Record, Railways 2008: <http://trb.metapress.com/content/gg76453p458327qr/?genre=article&id=doi%3a10.3141%2f2043-02>

that the maintenance cost of a dedicated high speed track was actually lower (just 55%) of the cost of a conventional track with equivalent traffic. According to the French railways, the justification for such a difference was due basically to three causes: the uniformity of TGV rolling stock, the reduced axle loading (17 metric tons) and the strict quality conditions imposed during the construction of the line. Table 6 of this same report showed that the mixture of traffic operated over a line influences track maintenance cost much more than does the top speed. This finding is consistent with United States experience as shown in Exhibit 5-21. As a result, considering the maintenance of a 220-mph dedicated track costs as equivalent to that of a Class 6 line shared with freight trains is, if anything, conservative.

While operating costs are needed every year, capital maintenance costs for dedicated tracks are gradually introduced using a table of ramp-up factors provided by Zeta-Tech, see Exhibit 5-22.

**Exhibit 5-22: Capital Cost Ramp-Up Following Upgrade of a Rail Line**

Year	% of Capital Maintenance	Year	% of Capital Maintenance
0	0%	11	50%
1	0%	12	50%
2	0%	13	50%
3	0%	14	50%
4	20%	15	75%
5	20%	16	75%
6	20%	17	75%
7	35%	18	75%
8	35%	19	75%
9	35%	20	100%
10	50%		

A fully normalized capital maintenance level is not reached until 20 years after completion of the rail construction program. This is used for calculating “Cyclic Maintenance” in the Benefit Cost Analysis. But because Cyclic Maintenance is not an Operating Cost under GAAP accounting methodology, it is not normally included in the Operating Ratio calculation.

### **STATION OPERATIONS**

A simplified fare structure, heavy reliance upon electronic ticketing and avoidance of a reservation system will minimize station personnel requirements. Station costs include personnel, ticket machines and station operating expenses.

- Staffed stations will be assumed at major stations. All stations will be assumed open for two shifts. The cost for the staffed stations includes eight positions at each new location, costing \$644,640 per year, as well as the cost of utilities, ticket machines, cleaning and basic facility maintenance.
- The cost for unstaffed stations covers the cost of utilities, ticket machines, cleaning and basic facility maintenance, costing \$80,580 per year. (These costs are also included in the staffed station cost.) Volunteer personnel such as Traveler’s Aid, if desired could staff these stations.

Costing of the Richmond Direct option assumes 9 staffed stations, and the Petersburg/Hopewell option is based on 10 staffed stations.

## **5.5 SYSTEM OVERHEAD COSTS**

The category of System Overhead largely consists of Service Administration or management overheads, covering such needs as the corporate procurement, human resources, accounting, finance and information technology functions as well as call center administration. A stand-alone administrative



organization appropriate for the operation of a corridor system was developed for the MWRRS and later refined for the Ohio Hub studies. This organizational structure, which was developed with Amtrak's input and had a fixed cost of \$8.9 million plus \$1.43 per train-mile (in \$2002) for added staff requirements as the system grew. Inflated to \$2013, this became \$11.45 million plus \$1.84 per train mile. However, the Sales and Marketing category also has a substantial fixed cost component for advertising and call center expense, adding another \$2.9 million per year fixed cost, plus variable call center expenses of 70.9¢ per rider, all in \$2013.<sup>19</sup> Finally, credit card (1.8% of revenue) and travel agency commissions (1%) are all variable.

Therefore, the overall financial model for a Stand-alone organization therefore has \$14.35 million (\$11.45 + \$2.9 million) annually in fixed cost for administrative, sales and marketing expenses. In addition, the system operator was allowed a 10 percent markup on certain direct costs as an allowance for operator profit.

## 5.6 RESULTS/TABLES

Exhibit 5-23 summarizes the Unit Cost factors used for developing Operating costs for each alternative. Following the original MWRRS methodology, those costs marked with an asterisk (\*) are subject to the 10% Operator Profit markup.

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<sup>19</sup> In the MWRRS cost model, call center costs were built up directly from ridership, assuming 40 percent of all riders call for information, and that the average information call will take 5 minutes for each round trip. Call center costs, therefore, are variable by rider and not by train-mile. Assuming some flexibility for assigning personnel to accommodate peaks in volume and a 20 percent staffing contingency, variable costs came to 57¢ per rider. These were inflated to 66¢ per rider in \$2008 and now 70.9¢ per rider in \$2013.

Exhibit 5-23: Unit Operating and Maintenance Costs

Unit Cost	Driver	Shared 79-mph diesel	Shared 110-mph diesel	Greenfield 130-mph diesel	Greenfield 220-mph electric
Equipment Maintenance	Train-Miles	\$15.43	\$15.43	\$12.70	\$14.08
Train Crew *	Train-Miles	\$6.59	\$6.59	\$4.92	\$4.60
Fuel or Energy *	Train-Miles	\$8.71	\$8.71	\$8.71	\$2.80
On Board Services (Labor) *	Train-Miles	\$3.66	\$3.66	\$2.56	\$2.41
On Board Services (Goods Sold) *	% of OBS Revenue	50%	50%	50%	50%
Insurance	Passenger-Mile	1.4¢	1.4¢	1.4¢	1.4¢
Track (Shared)	Train-Miles over Shared Track	\$2.37	\$2.37	N/A	N/A
Track and Electrification (Dedicated)	Dedicated Track Miles	\$48,468	\$58,438	\$27,924 plus Cyclic Capital	\$54,783 plus Cyclic Capital
Operations and Dispatch *	Train-Miles	50.8¢	50.8¢	50.8¢	50.8¢
Stations * - Staffed	Per Station	\$644,640	\$644,640	\$644,640	\$644,640
Stations* - Unstaffed	Per Station	\$80,580	\$80,580	\$80,580	\$80,580
Administration and Management (Fixed) *	Fixed	\$14.35 mill	\$14.35 mill	\$14.35 mill	\$14.35 mill
Administration and Management (Variable Train-Mile) *	Train-Miles	\$1.84	\$1.84	\$1.84	\$1.84
Administration and Management (Call Center: Variable Riders) *	Riders	70.9¢	70.9¢	70.9¢	70.9¢
Credit Card and Travel Agency Commissions *	Percent of Revenue	2.8%	2.8%	2.8%	2.8%
Operator Profit Markup	Selected (*) Costs	10%	10%	10%	10%

Exhibit 5-24 shows the Operating Costs for each rail route and speed option. It can be seen that each of the 130 mph options cost between \$150-155 million in 2035 while the 220-mph options cost around \$200 million in the same year. As a result it can be seen that the 220-mph options only cost an extra \$50 million per year despite operating more train miles as a result of the increased frequency offered at higher speed. However, Option 4 costs an addition \$65 million which reflects the cost of the additional trains to Newport News which are added under that option.

Exhibit 5-24: 2035 Operating and Maintenance Costs Results

Financial 2035 (mill. 2013\$)	Southern Option 1 Via Petersburg				Northern Option 2 -Via Hopewell				Option 3 Richmond Direct		Option 4 Richmond Direct Improved
	Southern Option 1A Greenfield		Southern Option 1B Norfolk Southern		Northern Option 2A Greenfield		Northern Option 2B Norfolk Southern				
	130mph	220mph	130mph	220mph	130mph	220mph	130mph	220mph	130mph	220mph	220mph
Train Crew	\$12.85	\$18.16	\$12.85	\$18.16	\$12.70	\$17.78	\$12.70	\$17.78	\$13.05	\$18.19	\$24.71
OBS	\$16.04	\$25.01	\$16.04	\$25.01	\$15.77	\$24.50	\$15.77	\$24.50	\$16.44	\$25.18	\$36.97
Equipment	\$33.16	\$55.58	\$33.16	\$55.58	\$32.78	\$54.43	\$32.78	\$54.43	\$33.69	\$55.67	\$75.64
Fuel	\$24.36	\$10.66	\$24.36	\$10.66	\$24.08	\$10.44	\$24.08	\$10.44	\$24.75	\$10.67	\$14.51
Track	\$11.95	\$23.45	\$11.95	\$23.45	\$11.78	\$23.12	\$11.78	\$23.12	\$11.56	\$22.68	\$25.47
Insurance	\$8.77	\$13.26	\$8.77	\$13.26	\$8.67	\$12.99	\$8.67	\$12.99	\$8.91	\$13.28	\$18.05
Call Ctr Variable	\$3.13	\$4.43	\$3.13	\$4.43	\$3.09	\$4.33	\$3.09	\$4.33	\$3.26	\$4.58	\$6.16
T-Agent and CC Comm	\$6.55	\$10.85	\$6.55	\$10.85	\$6.42	\$10.63	\$6.42	\$10.63	\$6.75	\$10.96	\$16.81
Stations	\$6.45	\$6.45	\$6.45	\$6.45	\$6.45	\$6.45	\$6.45	\$6.45	\$5.91	\$5.91	\$6.98
Admin and Mgt	\$19.15	\$21.61	\$19.15	\$21.61	\$19.10	\$21.46	\$19.10	\$21.46	\$19.23	\$21.62	\$24.24
Operation & Dispatch	\$1.09	\$1.70	\$1.09	\$1.70	\$1.07	\$1.67	\$1.07	\$1.67	\$1.05	\$1.64	\$2.61
Operator Profit 10% selected items	\$8.96	\$9.89	\$8.96	\$9.89	\$8.87	\$9.73	\$8.87	\$9.73	\$9.05	\$9.87	\$13.30
Total Cost	\$152.46	\$201.03	\$152.46	\$201.03	\$150.78	\$197.52	\$150.78	\$197.52	\$153.66	\$200.25	\$265.45

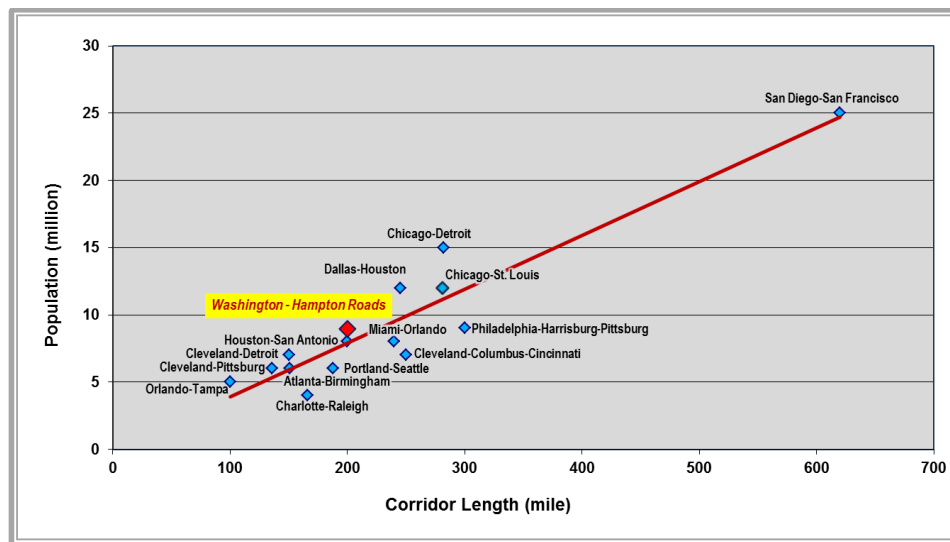
## 6. MARKET ANALYSIS

*The Market Analysis provides an assessment of the overall travel market and its comparison with other US high speed rail corridors. It describes the development of the very high quality travel demand model, its zones, and data sources used to develop forecasts. The socioeconomic growth projections and transport conditions for the corridor are also provided. A key input to the demand model was the Stated Preference Survey that estimated the responsiveness of the community to their travel options. Finally, the forecasts of ridership and revenue are described for each of the route and technology options.*

### 6.1 OVERVIEW OF EXISTING TRAVEL MARKET

The Hampton Roads-Richmond-Washington Corridor is one of the top intercity corridors in the U.S., being comparable with California's San Francisco-San Diego, Florida's Miami-Orlando, Texas' Dallas-Houston Ohio's Cleveland-Columbus-Cincinnati, Pennsylvania's Philadelphia-Harrisburg-Pittsburgh, and Midwest's Chicago-St. Louis and Chicago-Detroit corridors; and is much stronger than many other corridors like Atlanta-Birmingham, Portland-Seattle, or Charlotte-Raleigh (Exhibit 6-1). As such, the corridor has independent utility as a high-speed corridor

Exhibit 6-1: Corridor Comparison



In addition to this corridor having independent utility in its own right, it should be recognized that is really the southern extension of the Northeast corridor and a logical part of the “East Coast Mega Region” that stretches from Boston to New York to Philadelphia to Washington and on to Richmond and Hampton Roads. The impact of being linked to this Mega Region is to effectively double the volume of trips that the corridor would have as a freestanding corridor, and thus significantly enhances its potential for High Speed and Enhanced Intercity Passenger Rail.

Like many intercity passenger rail corridors the demand for travel in the corridor is strong. In 2012 the Hampton Roads – Richmond - Washington Corridor had a population of nearly ten million. The corridor also hosts large number of finance and business services, research and high-tech industry, government agencies and military bases. In 2012 the total employment in the corridor was over six million and per capita income was \$39,648. Projections indicate that the corridor's demographic and economic growth will continue over the next several decades, the population is projected to be over 12 million in 2040, employment will be 8.5 million in 2040, and per capita incomes will grow to \$53,227 in 2040 in 2012

dollars. As a result, the Hampton Roads – Richmond – Washington Corridor has a high level of business and commuter travel between its urban areas together with significant social and tourist travel. The total annual intercity one-way trips in the corridor is estimated to be 59 million in 2012. This means the average resident takes 6.6 one way or 3.3 round intercity trips per year.

## **6.2 BASIC STRUCTURE OF THE COMPASS™ TRAVEL MARKET FORECAST MODEL**

For the purpose of this study, the ridership and revenue forecast will be produced using the COMPASS™ Travel Demand Model. The COMPASS™ Multimodal Demand Forecasting Model is a flexible demand forecasting tool used to compare and evaluate alternative passenger rail network and service scenarios. It is particularly useful in assessing the introduction or expansion of public transportation modes such as air, bus or high speed rail into markets. Exhibit 6-2 and 6-3 show the structure and working process of the COMPASS™ Model. As shown, the inputs to the COMPASS™ Model are base and proposed transportation networks, base and projected socioeconomic data, value of time and value of frequency from Stated Preference surveys, and base year travel data obtained from government agencies and transportation service operators.

The COMPASS™ Model structure incorporates two principal models: a Total Demand Model and a Hierarchical Modal Split Model. These two models are calibrated separately. In each case, the models are calibrated for origin-destination trip making in the study area. The Total Demand Model provides a mechanism for replicating and forecasting the total travel market. The total number of trips between any two zones for all modes of travel is a function of (1) the socioeconomic characteristics of the two zones and (2) the travel opportunities provided by the overall transportation system that exists (or will exist) between the two zones. Typical socioeconomic variables include population, employment and income. The quality of the transportation system is measured in terms of total travel time and travel cost by all modes, and the induced demand is estimated by considering the change in quality of travel offered by all modes.

The role of the COMPASS™ Modal Split Model is to estimate relative modal shares of travel given the estimation of the total market by the Total Demand Model. The relative modal shares are derived by comparing the relative levels of service (as estimated by generalized costs) offered by each of the travel modes. Four levels of binary choice were used in this study (see Exhibit 6-3). The first level separates two routes from Hampton Roads area to other areas in the corridor by rail. The second level separates rail services from bus services. The third level of the hierarchy separates air travel, the fastest and most expensive mode of travel, from surface modes of rail and bus services. The fourth level separates auto travel with its perceived spontaneous frequency, low access/egress times, and highly personalized characteristics, from public modes (i.e., air, rail and bus). The model forecasts changes in riders, revenue and market share based on changes travel time, frequency and cost for each mode as measured by the generalized costs for each mode. A more detailed description of the COMPASS™ Model is given in Appendix 2.



Exhibit 6-2: Structure of the COMPASS™ Model

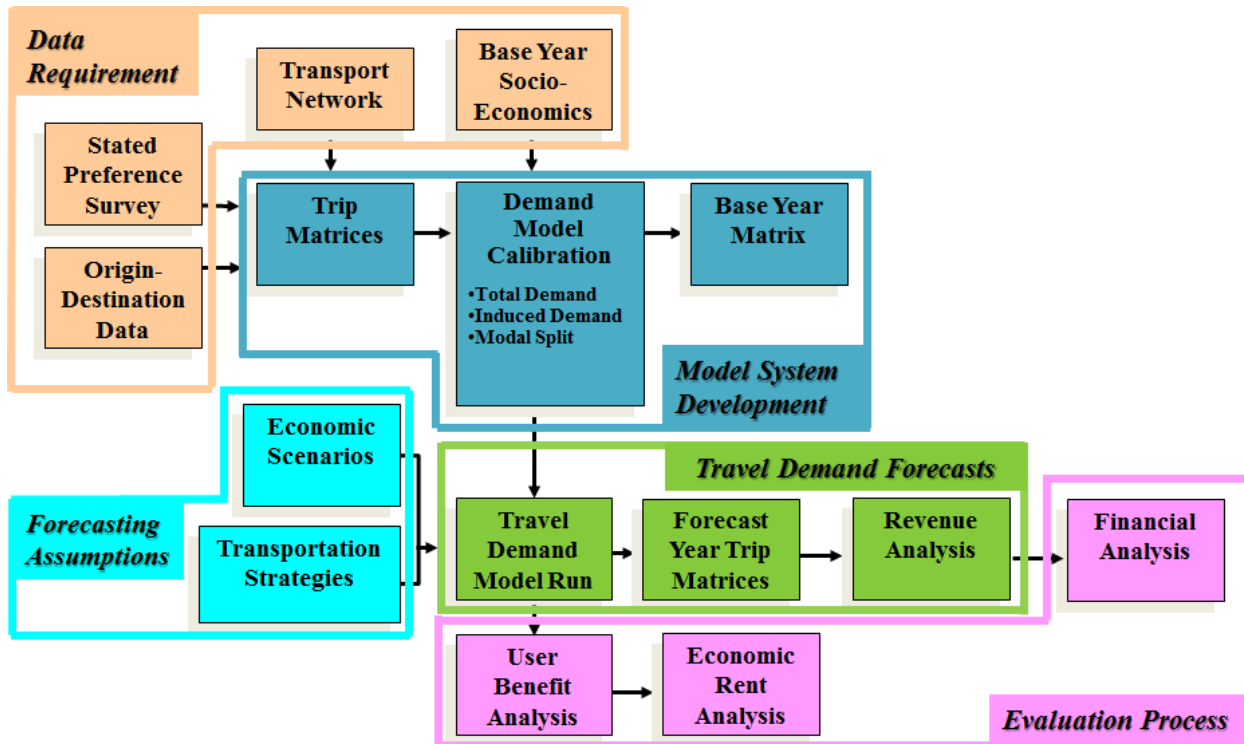
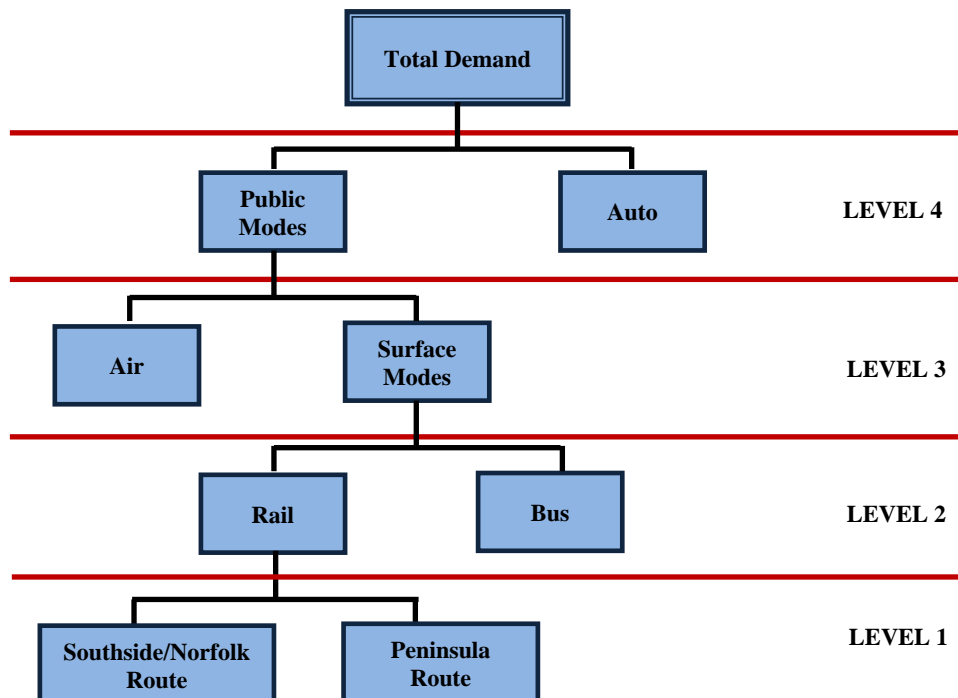


Exhibit 6-3: Hierarchical Structure of the Modal Split Model



A key element in evaluating passenger rail service is the comprehensive assessment of the travel market in the corridor under study, and how well the passenger rail service might perform in that market. For the purpose of this study, this assessment was accomplished using the following process:

- Building the zone system that enables more detailed analysis of the origin-destination travel market and the development of base year and future socioeconomic data for each zone.
- Compiling information on the service levels (times, fares, frequency, costs) in the corridor for auto, air, bus, and the proposed passenger rail travel.
- Identifying and quantifying factors that influence travel choices, including values of time, frequency and access/egress time.
- Developing strategies that quantify how travel conditions will change, including future gas price, future vehicle fuel efficiency improvement, and highway congestion.
- Developing and calibrating total travel demand and modal split models for travel demand forecasting.
- Forecasting travel, including total demand and modal shares.

The following sections document the modeling process and the forecasting results.

### **6.3 ZONE DEFINITION**

The zone system provides a representation of the market areas among which travel occurs from origins to destinations. For intercity passenger rail planning, most rural zones can be represented by larger areas. However, where it is important to identify more refined trip origins and destinations in urban areas, finer zones are used. The travel demand model forecasts the total number of trip origins and destinations by mode and by zone pair. Because Hampton Roads – Richmond - Washington Corridor is closely related to the Northeast Corridor and Southeast Corridor, a zone system is needed that incorporates all areas that are part of the Northeast and Southeast corridors. To meet this need, a 333-zone system was developed for the whole study area based on aggregation of the 2010 census tracts and traffic analysis zones (TAZs) of local transportation planning agencies. Exhibit 6-4 shows the zone system for the whole study area. Exhibit 6-5 shows the zones in the Hampton Roads area.

Exhibit 6-4: Study Area Zone System

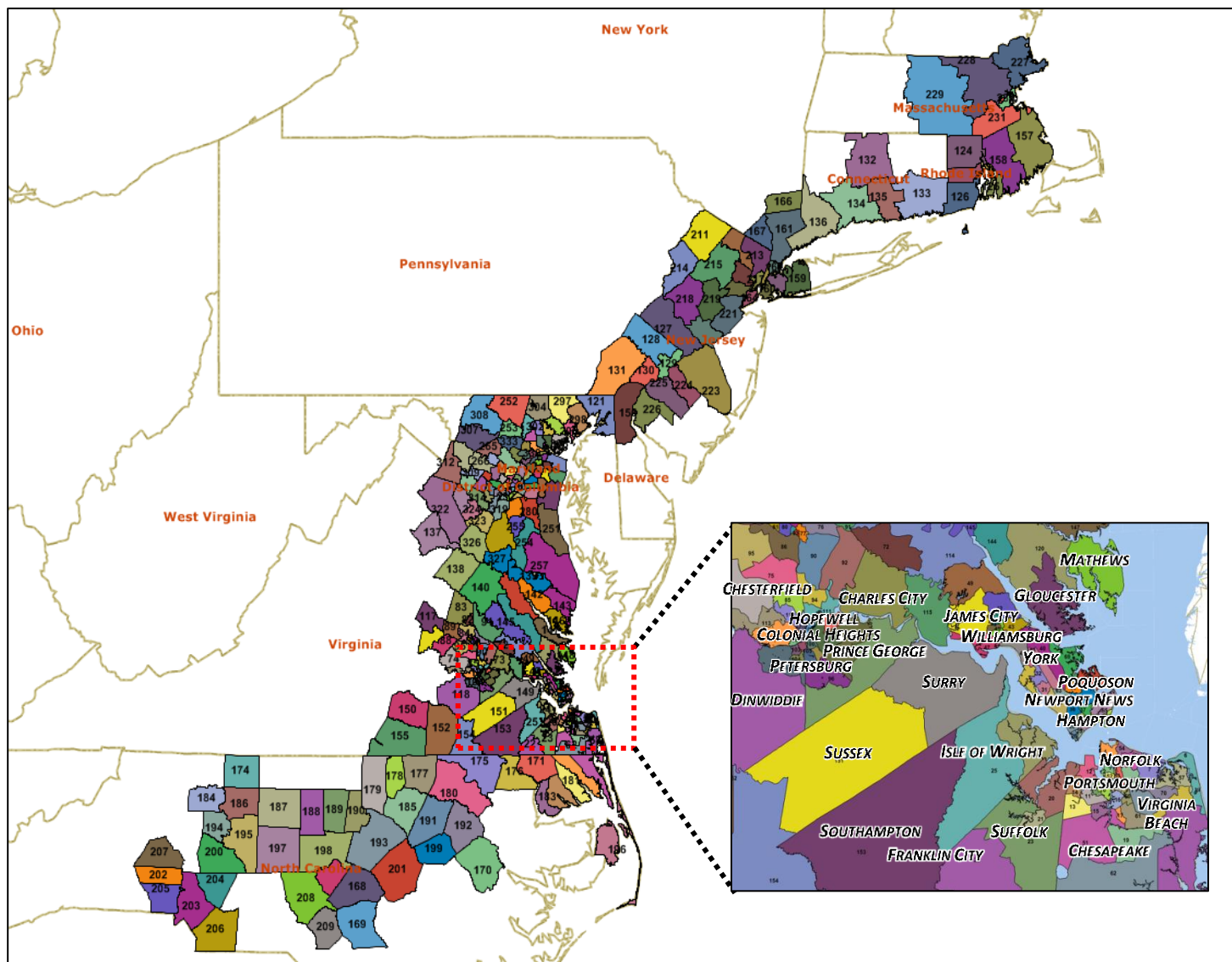
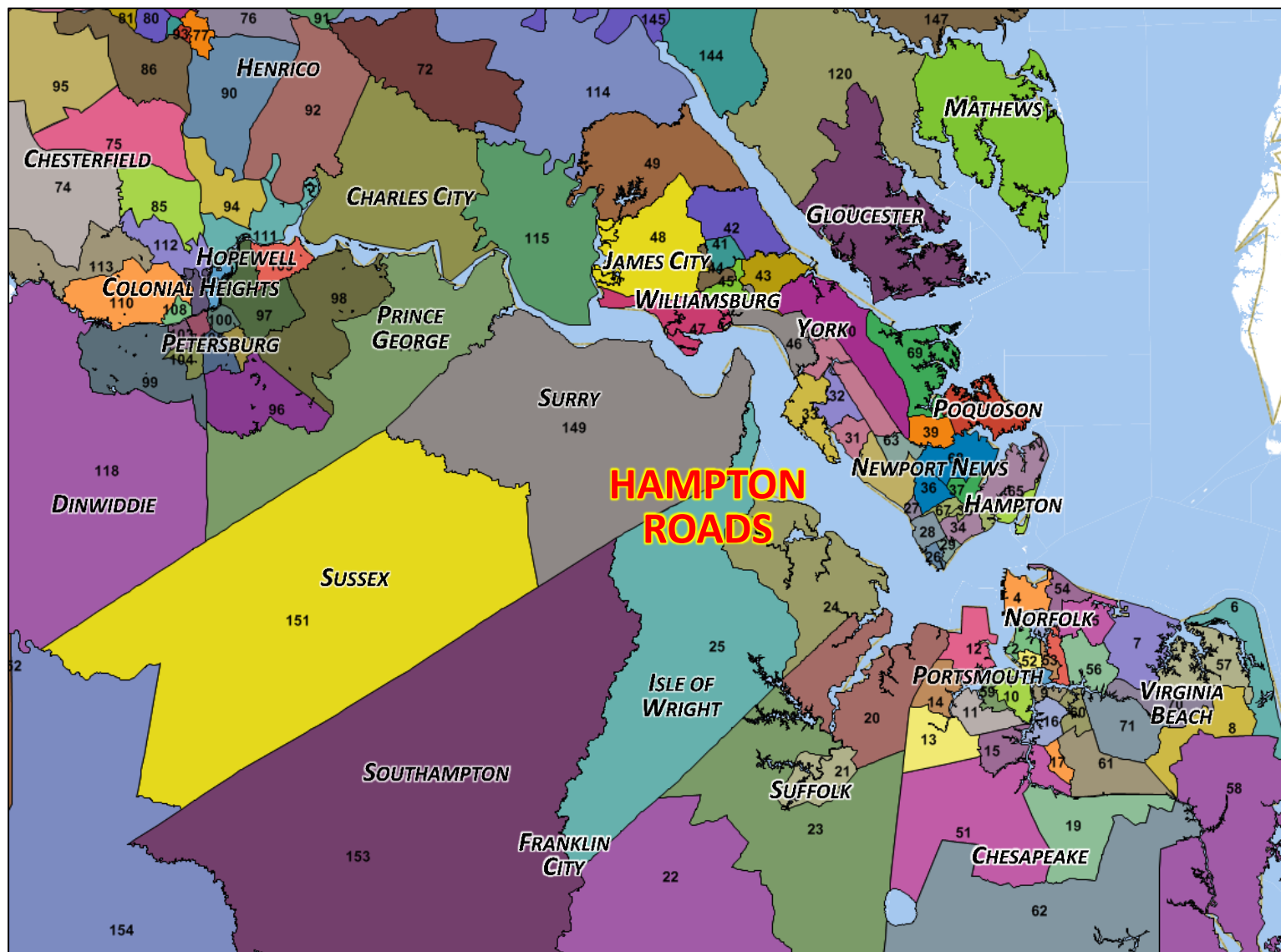


Exhibit 6-5: Hampton Roads Area Zones



## 6.4 SOCIOECONOMIC BASELINE AND PROJECTIONS

The travel demand forecasting model requires base year estimates and future growth forecasts of three socioeconomic variables of population, employment and per capita income for each of the zones in the study area. A socioeconomic database was established for the base year (2012) and for each of the forecast years (2015-2050). The data was developed at five-year intervals using the most recent data from the following sources:

- U.S. Census Bureau
- Hampton Roads Planning District Commission
- Richmond Regional Planning District Commission
- Crater Planning District Commission
- Virginia Employment Commission
- Metropolitan Washington County of Governments
- Baltimore Metropolitan Council
- Bureau of Economic Analysis
- Woods & Poole Economics, Inc.

Exhibit 6-6 shows the base year and projected socioeconomic data for the whole study area including Northeast and Southeast corridor regions. According to the data developed from these sources, the population will increase from 50.62 million in 2012 to 64.36 million in 2050, the total employment of the study area will increase from 30.99 million to 46.2 million in 2050, and per capita income will increase from \$35,611 in 2012 to \$52,304 in 2050 in 2012 dollars.

**Exhibit 6-6: Base and Projected Socioeconomic Data for the Whole Study Area  
that Extends from Boston to Charlotte**

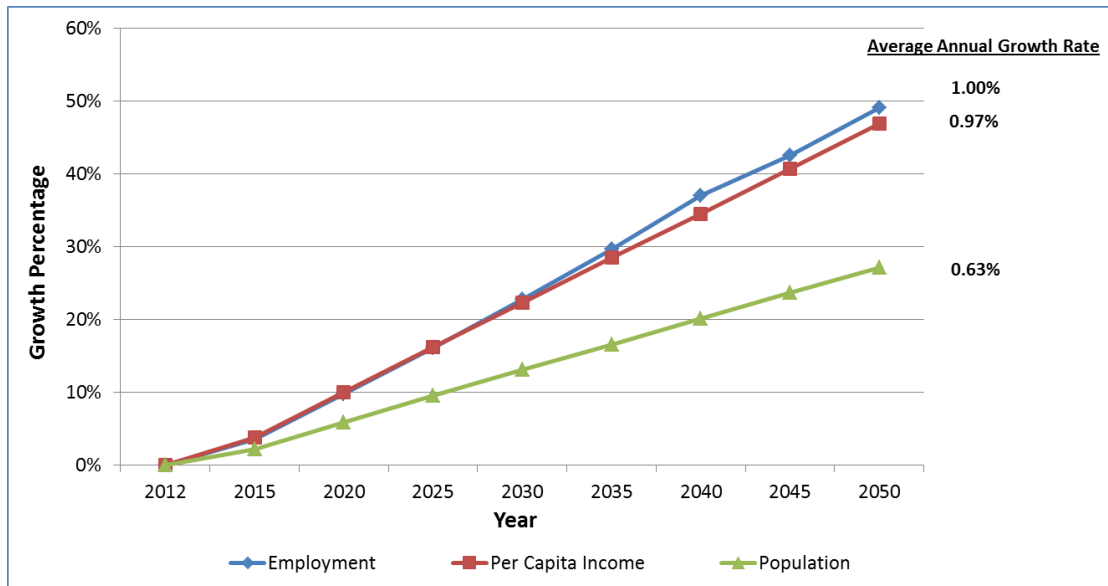
Year	2012	2015	2020	2025	2030	2035	2040	2045	2050
<b>Population</b>	50,618,637	51,715,458	53,583,628	55,434,004	57,232,413	59,012,616	60,811,800	62,596,572	64,364,454
<b>Employment</b>	30,986,211	32,082,878	34,008,141	35,986,164	38,044,681	40,173,357	42,443,934	44,161,365	46,196,616
<b>Per Capita Income (2012\$)</b>	35,611	36,957	39,176	41,378	43,567	45,745	47,889	50,120	52,304



Exhibit 6-7 shows the socioeconomic growth projections for the study area. The exhibit shows that there is higher growth of employment and income than population. Furthermore, travel increases are historically strongly correlated to increases in employment and income, in addition to changes in population. Therefore, travel in the corridor is likely to continue to increase faster than the population growth rates, as changes in employment and income outpace population growth, and stimulate more demand for traveling.

The exhibits in this section show the aggregate socioeconomic projection for the whole study area. It should be noted that in applying socioeconomic projections to the model, separate projections were made for each individual zone using the data from the listed sources. Therefore, the socioeconomic projections for different zones are likely to be different and thus may lead to different future travel sub-market projections. A full description of socioeconomic data of each zone can be found in the Appendix 1.

**Exhibit 6-7: Socioeconomic Growth Projection for the Whole Study Area  
that extends from Boston to Charlotte**



## 6.5 EXISTING TRAVEL MODES

In transportation analysis, travel desirability/utility is measured in terms of travel cost and travel time. These variables are incorporated into the basic transportation network elements that provide by mode the connections from any origin zone to any destination zone. Correct representation of the existing and proposed travel services is vital for accurate travel forecasting. Basic network elements are called nodes and links. Each travel mode consists of a database comprised of zones and stations that are represented by nodes, and existing connections or links between them in the study area. Each node and link is assigned a set of travel attributes (time and cost). The network data assembled for the study included the following attributes for all the zone pairs.

For public travel modes (air, rail, bus):

- Access/egress times and costs (e.g., travel time to a station, time/cost of parking, time walking from a station, etc.)
- Waiting at terminal and delay times
- In-vehicle travel times
- Number of interchanges and connection times
- Fares
- Frequency of service

For private mode (auto):

- Travel time, including rest time
- Travel cost (vehicle operating cost)
- Tolls
- Parking Cost
- Vehicle occupancy

The transportation travel attribute or service data of different modes available in the study corridor were obtained from a variety of sources and coded into the COMPASS™ networks as inputs to the demand model. The major sources are as follows.

The highway network was developed to reflect the major highway segments within the study area. The sources for building the highway network in the study area are as follows:

- State and Local Departments of Transportation highway databases
- National Highway System (NHS) database

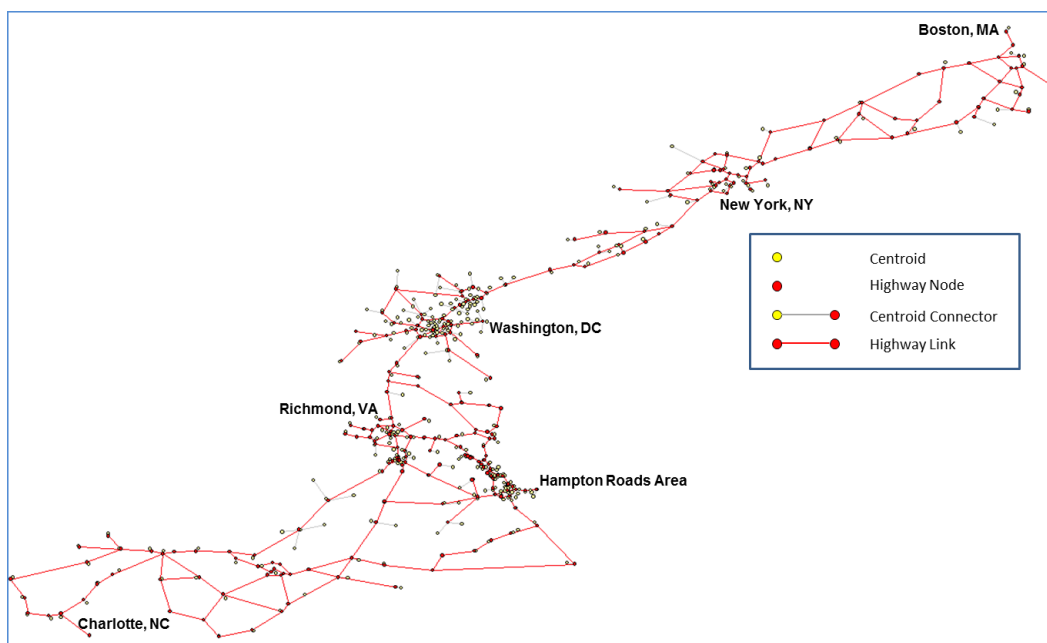
The main roads included in the highway network are shown in Exhibit 6-8

**Exhibit 6-8: Major Roads in the COMPASS™ Highway Network**

Highway Description	Segment Description
Interstate-64	Norfolk to Richmond
US 460	Suffolk to Richmond
Interstate-95	Richmond to Boston
Interstate-295	Petersburg to Richmond

The highway network of the corridor area coded in COMPASS™ is shown in Exhibit 6-9.

**Exhibit 6-9: COMPASS™ Highway Network for the Study Area**



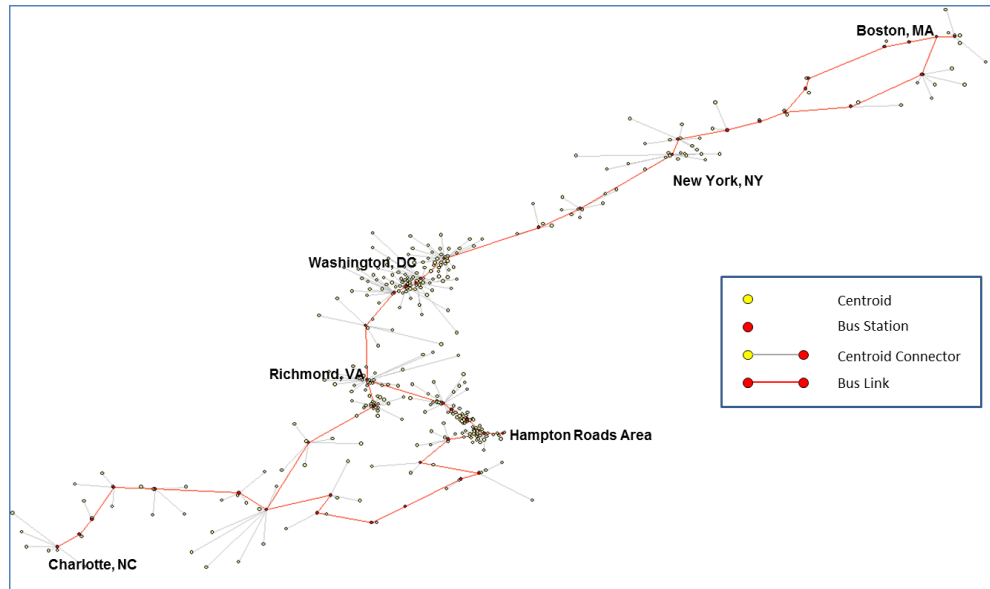
Air network attributes contain a range of variables that include time and distance between airports, airfares, and connection times. Travel times, frequencies and fares were derived from official airport websites, websites of the airlines serving airports in the study area, and the BTS 10% sample of airline tickets. Exhibit 6-10 shows the air network of the study area coded in COMPASS™.

**Exhibit 6-10: COMPASS™ Air Network for the Study Area**



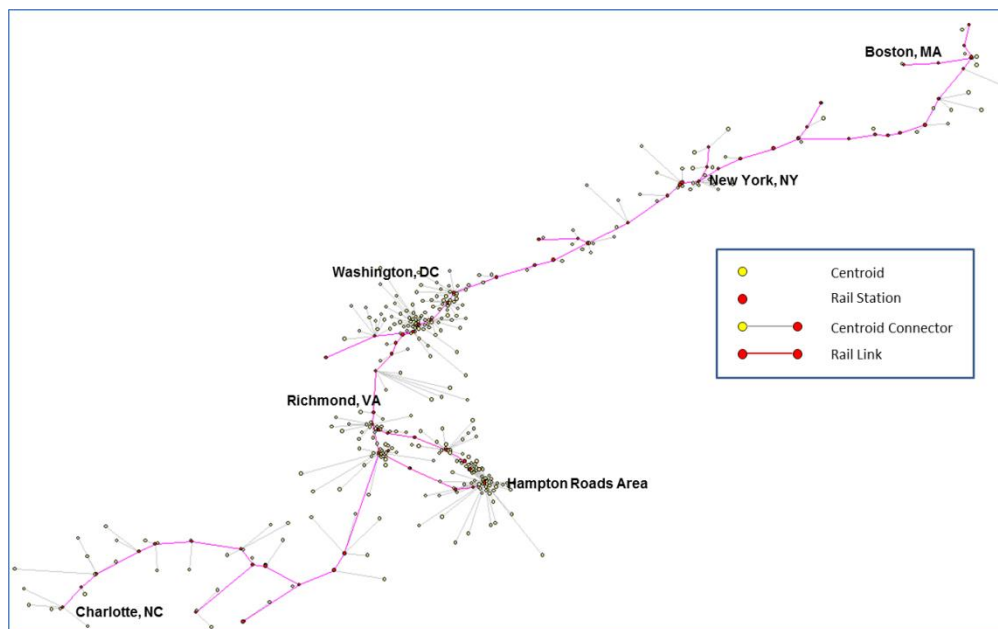
Bus travel data of travel time, fares, and frequencies, were obtained from official schedules of Greyhound and MegaBus. Exhibit 6-11 shows the bus network of the study area coded in COMPASS™.

Exhibit 6-11: COMPASS™ Bus Network for the Study Area



Current passenger rail travel data of travel time, fares, and frequencies, were obtained from official schedules of Amtrak. Exhibit 6-12 shows the passenger rail network of the study area coded in COMPASS™.

Exhibit 6-12: COMPASS™ Passenger Rail Network for the Study Area



## 6.6 ORIGIN-DESTINATION TRIP DATABASE

The multi-modal intercity travel analyses model requires the collection of base year 2012 origin-destination (O-D) trip data describing annual personal trips between zone pairs. For each O-D zone pair, the annual personal trips are identified by mode (auto, air, and bus) and by trip purpose (Business and Non-Business). Because the goal of the study is to evaluate intercity travel, the O-D data collected for the model reflects travel between zones (i.e., between counties, neighboring states and major urban areas) rather than within zones.

TEMS extracted, aggregated and validated data from a number of sources in order to estimate base travel between origin-destination pairs in the study area. The data sources for the origin-destination trips in the study are:

- The Airline Origin and Destination Survey (DB1B) Air Ticket Database
- T-100 Air Market and Segment Database
- Greyhound and Megabus Schedules
- Previous travel origin-destination surveys
- State department of transportation (Virginia, Maryland, Washington, DC, North Carolina, Delaware, Pennsylvania, New Jersey, New York, Connecticut, Rhode Island and Massachusetts) highway traffic volume Average Annual Daily Traffic (AADT) data
- Amtrak passenger rail ridership data
- Amtrak station volume data
- TEMS 2012 Virginia Travel Survey

The travel demand forecast model requires the base trip information for all modes between each zone pair. In some cases this can be achieved directly from the data sources, while in other cases the data providers only have origin-destination trip information at an aggregated level (e.g., AADT data, station-to-station trip and station volume data). Where that is the case, a data enhancement process of trip simulation and access/egress simulation needed to be conducted to estimate the zone-to-zone trip volume. The data enhancement process is shown in Exhibit 6-13.

For the auto mode, the quality of the origin-destination trip data was validated by comparing it to AADTs and traffic counts on major highways and adjustments have been made when necessary. For public travel modes, the origin-destination trip data was validated by examining station volumes and segment loadings.



**Exhibit 6-13: Zone-to-Zone Origin-Destination Trip Matrix Generation and Validation**

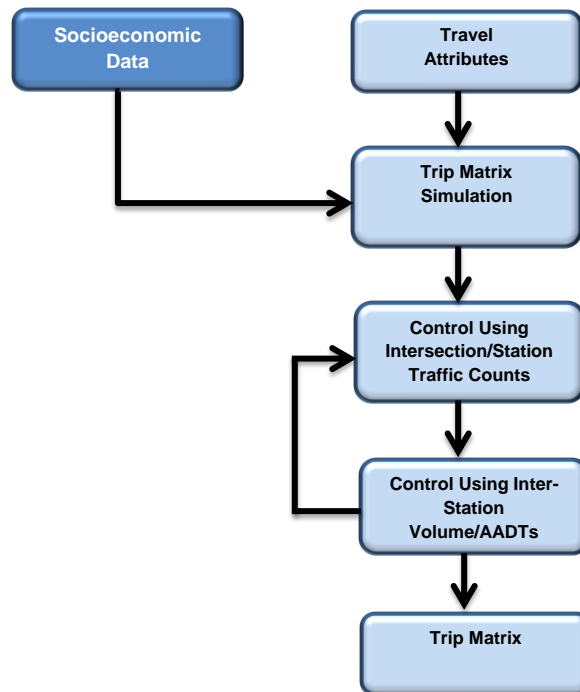
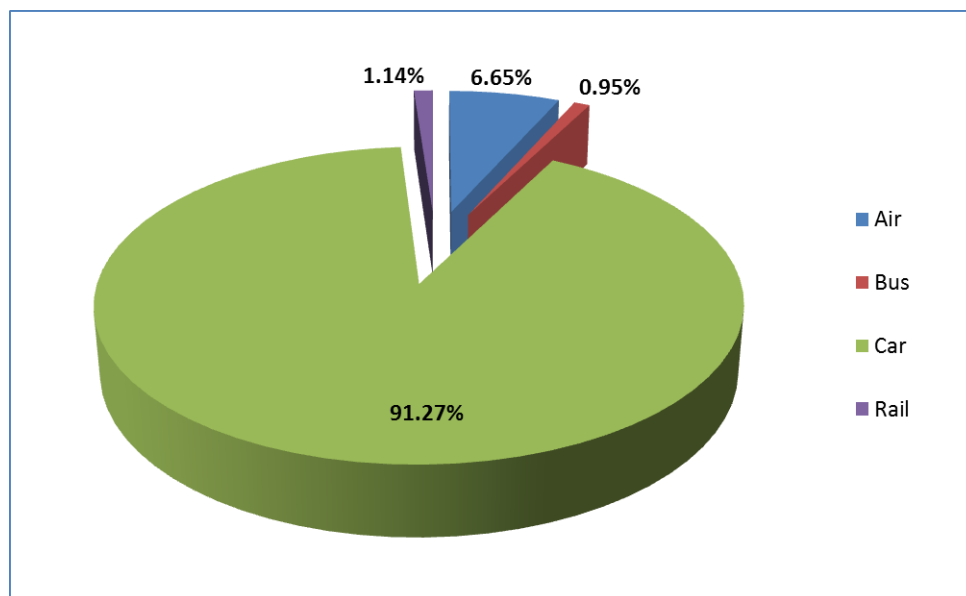


Exhibit 6-14 shows the base 2012 travel market share of rail, air, bus, and auto modes. It can be seen that auto mode dominates the travel market with 91 percent of market share. Public modes have 9 percent of travel market share.

**Exhibit 6-14: 2012 Base Travel Market Share by Mode**



## 6.7 STATED PREFERENCE SURVEY

The Stated Preference Analysis was based on results from a broad range of collected stated preference survey forms. Stated Preference Survey method uses a quota sampling approach as a fast and effective way of gathering consumer information on the importance of different travel decisions. This includes such issues as how travelers value travel time (for auto and transit modes) and how they value frequency of service and access time (for transit modes). A quota survey, as opposed to a random survey or a focus group study, is particularly effective in ensuring that all the important travel attributes are measured for the whole population at minimum cost. The quota survey, which has been widely adopted for public opinion surveys, is based on the development of representative “quotas” of the traveling public. The TEMS analysis requires that, two sets of data be collected: (1) the data that define the “travel behavior” quota and (2) the data that define the “personal profile” quota for the individuals surveyed. This allows the data to be stratified by such factors as trip length, income, and group size.

This section describes the stated preference survey process including the methodology used, sample size, survey forms, target locations, and dates of survey deployment along with survey results and analysis.

### 6.7.1 SURVEY PROCESS

The essence of the stated preference technique is to ask people making trips in the corridor to make a series of trade-off choices based on different combinations of travel time, frequency and cost. Stated preference analysis has been used extensively by TEMS to assess new travel options relating to time, fares, frequency, comfort and reliability for rail, air, and bus services. Tests of the technique in a series of before and after evaluations in North America have produced exceedingly good results. In particular, these tests found that the use of "abstract mode" questions in conjunction with "trade-off analysis" produced reliable results.

Two specific trade-offs were analyzed and used for this study:

- Choices between travel times and travel costs to derive incremental Values of Time for all modes
- Choices between headway times (frequency of service) and travel costs to derive incremental Values of Frequency for transit users.

One part of the survey contains revealed preference questions while the other part contains questions that aim on defining the travel behavior of the surveyed individuals. The revealed preference questions which are the profile data collected from the surveys are used in conjunction with origin-destination and census data to ensure that the stated preference survey can be effectively expanded to properly represent the total population. The collected travel behavior data provides the critical part of the data needed to estimate the generalized cost of travel.

Generalized cost of travel between two zones estimates the impact of improvements in the transportation system on the overall level of trip making. It is typically defined in travel time (i.e., minutes) rather than dollars. Costs are converted to time by applying appropriate conversion factors, as shown in Equation 1. The generalized cost (GC) of travel between zones *i* and *j* for mode *m* and trip purpose *p* is calculated as follows:

## Equation 1:

$$GC_{ijmp} = TT_{ijm} + \frac{TC_{ijmp}}{VOT_{mp}} + \frac{VOF_{mp} * OH * \exp(\alpha * F)}{VOT_{mp} * \alpha * F^2_{ijm}}$$

Where,

$TT_{ijm}$  = Travel Time between zones i and j for mode m (in-vehicle time + station wait time + connection wait time + access/egress time + interchange penalty), with waiting, connect and access/egress time multiplied by a factor (greater than 1) to account for the additional disutility felt by travelers for these activities<sup>1</sup>

$TC_{ijmp}$  = Travel Cost between zones i and j for mode m and trip purpose p (fare + access/egress cost for public modes, operating costs for auto)

$VOT_{mp}$  = Value of Time for mode m and trip purpose p

$VOF_{mp}$  = Value of Frequency for mode m and trip purpose p

$F_{ijm}$  = Frequency in departures per week between zones i and j for mode m

$\alpha$  = Frequency damping factor

OH = Operating hours per week

Value of time is the amount of money (dollars/hour) an individual is willing to pay to save a specified amount of travel time, the value of frequency is the amount of money (dollars/hour) an individual is willing to pay to reduce the time between departures when traveling on public transportation, and the value of access is the amount of money (dollars/hour) an individual is willing to pay for the access time to a mode (e.g. the airport, HSR station, railroad station, bus station) to gain easier access to someplace (e.g., an airport). Station wait time is the time spent at the station before departure and after arrival. On trips with connections, there would be additional wait times incurred at the connecting station. Wait times are weighted higher than in-vehicle time in the generalized cost formula to reflect their higher disutility as found from previous studies.

In terms of the size of the survey for each of the quota groups identified - usually up to 12 primary groups. It has been shown that a sample as small as 20 individuals<sup>2</sup> is statistically significant to define the behavioral choices of each group. These primary groups are based on 4 mode groups - auto and transit (that includes air, rail and bus) to 3 purpose groups commuter, business, and other (that includes shopping and social). To improve statistical reliability, TEMS typically seeks 40 to 100 respondents per quota. This means that between 500 and 1,500 surveys are needed for a stated preference survey analysis. The minimum of 1,200-2,000 surveys was set as a goal.

<sup>1</sup> Travel time includes the rest time if travel is by private auto.

<sup>2</sup> According to Stirrings Approximation where the ratio of the actual value (n) and its factorial (n!) is closer to 1.



- All Four Mode Users: With the help of Public and Private Organizations such as Virginia Beach Vision, Inc., Greater Williamsburg Chamber & Tourism, Hampton Roads Economic Development Alliance (HREDA) and U.S. NAVY, online survey responses were collected from individuals located in Hampton Roads area, Williamsburg and Newport News area.

Pilot surveys were also conducted prior to actual field and online surveys to test the survey questionnaire. This provided a validation of the survey design and helped the scaling of the stated preference questions so that respondents did “trade” time and cost when filling in the survey forms. Minor adjustments to wording of questions and format were made to improve the readability of the forms. The surveys were kept to one-page, one-side only. Most interviewees filled out the form themselves in 5-10 minutes.

Field and online survey deployment are shown in Exhibit 6-16 The survey was conducted in May 2012 with interviews between May 11, 2012 and May 20, 2012 TEMS collected 2,736 surveys, and exceeded their target range and these results will be discussed in the following section.

Exhibit 6-16: On-Site Survey Team Actual Deployment & Online Survey

	Fri	Sat	Sun	Mon	Tue	Wed	Thu	Fri	Sat	Sun
	11-May	12-May	13-May	14-May	15-May	16-May	17-May	18-May	19-May	20-May
Newport News-Richmond Amtrak Service										
Richmond Central Auto Users										
Chesapeake Auto Users										
Virginia Beach Auto Users										
Norfolk-BWI, Philadelphia, New York Air Travelers										
Richmond-Hampton Roads, Washington,DC Bus Service										

	Mon	Tue	Wed	Thu	Fri	...	...	Wed	Thu	Fri
	30-Apr	1-May	2-May	3-May	4-May	...	...	6-Jun	7-Jun	8-Jun
Online Survey										

## 6.7.2 SURVEY RESULTS AND ANALYSIS

TEMS collected 2,736 surveys, and exceeded their target of 1,900 as shown in Exhibit 6-17 showing exceeded actual survey counts against the survey targets for each location except for bus locations, which almost achieved the target.

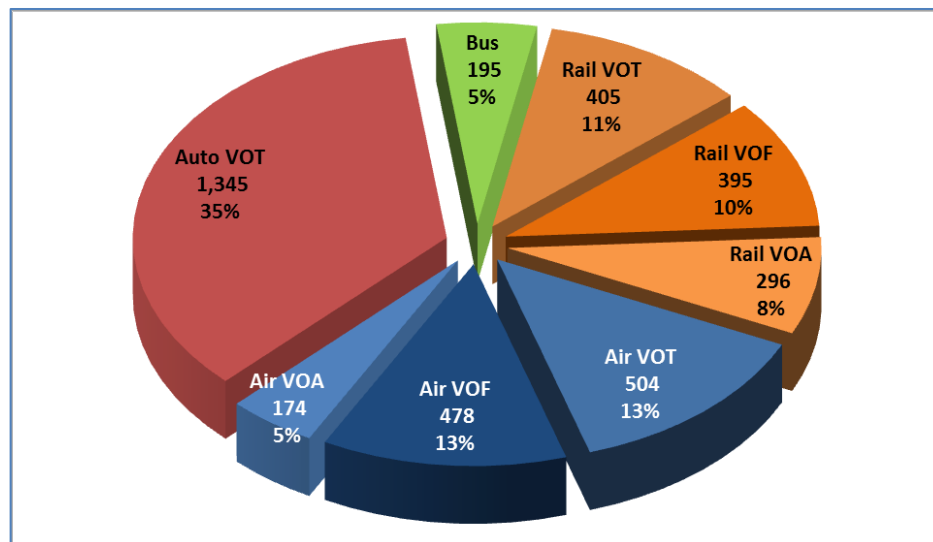


**Exhibit 6-17: Target vs. Actual Survey Count per Location**

Location	Survey Target	Field + Online Count (Actual)
DMV	800	1,377
Airport	500	573
Amtrak	500	690
Bus	100	96
<b>Total</b>	<b>1,900</b>	<b>2,736</b>

Behavioral attributes reflect the behavior of the respondent when travel conditions change. For the purpose of this study, stated preference surveys collected the information necessary to identify the Value of Time (VOT)<sup>3</sup> for all travelers, the Value of Frequency (VOF)<sup>4</sup> and the Value of Access (VOA)<sup>5</sup>. There were separate forms for each mode and questions were unique for VOT, VOF and VOA. Exhibit 6-18 shows that a total of VOT, VOF and VOA responses for all modes were 3,792.

**Exhibit 6-18: VOT, VOF, VOA Counts per Mode<sup>6</sup>**



The responses captured by the revealed part of the questionnaire, show that 9% of responses were from commuters and travel to/from school, 14% from business travelers, 77% response was from leisure

<sup>3</sup> Value of Time (VOT) is the amount of money (dollars/hour) an individual is willing to pay to save a specified amount of travel time.

<sup>4</sup> Value of Frequency (VOF) is the amount of money (dollars/hour) an individual is willing to pay to reduce the time between departures when traveling on public transportation.

<sup>5</sup> Value of Access (VOA) is the amount of money (dollars/hour) an individual is willing to pay for the improved access time to a mode (e.g. the airport, HSR station, railroad station, bus station) to gain easier access to someplace (like airport).

<sup>6</sup> This total count of VOT, VOF and VOA per mode equals 3,792 and these counts are not equal to total survey counts as each transit respondent (most of them) filed out two stated preference questionnaires.

travelers for all modes as shown in Exhibit 6-19. Other as indicated by the respondents include visit family, friends, graduation, baseball game, etc.

**Exhibit 6-19: Purpose of Travel Responses**

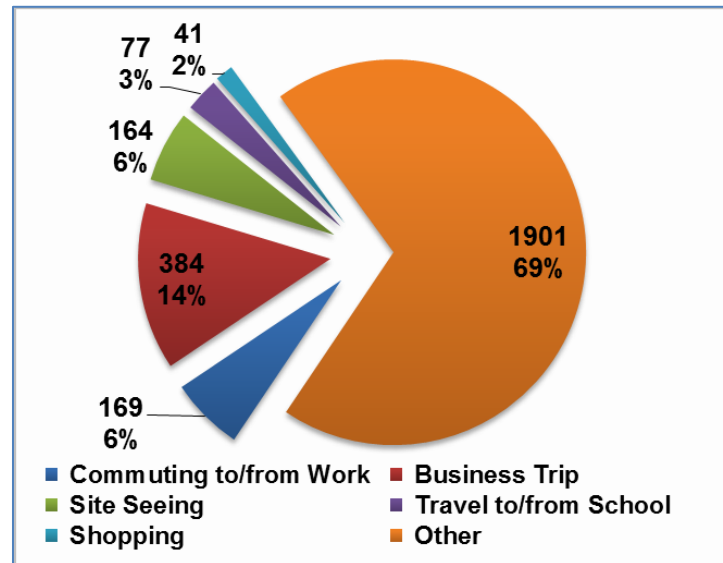
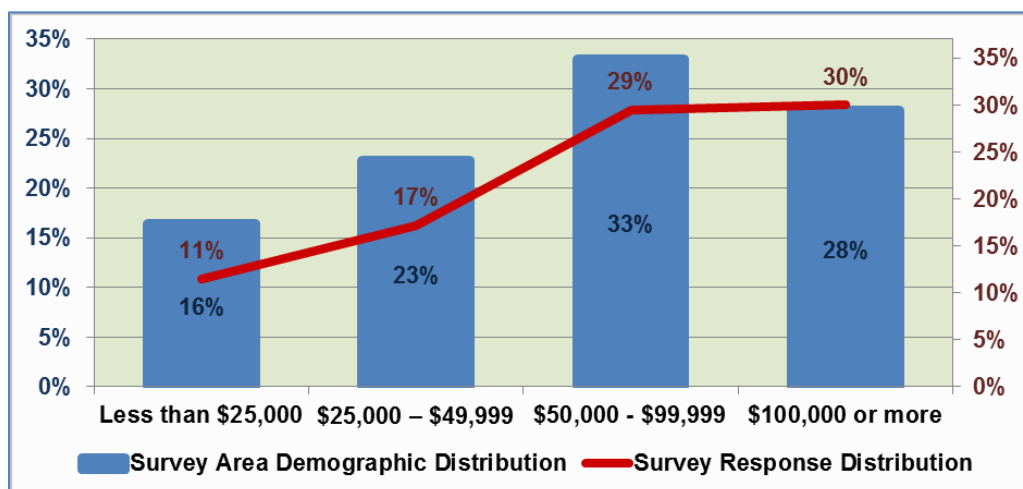


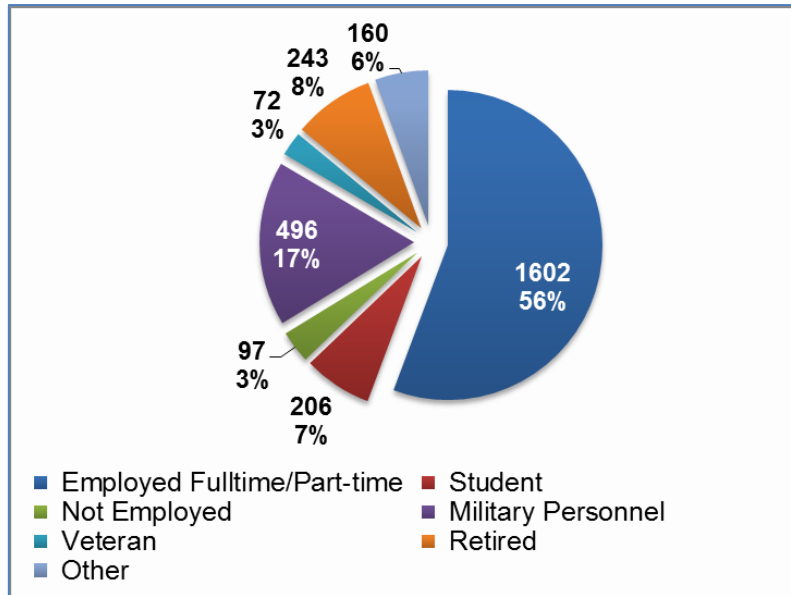
Exhibit 6-20 illustrates distribution of average number of household by income groups along the Survey Study Area corridor in comparison with statistical and survey data. It is seen in the Exhibit that survey responses closely followed most of the demographic distribution with a very slight increase of greater than \$100,000 income group. This shows that the survey responses were effectively represented, and the margin of error is only  $\pm 6\%$ .

**Exhibit 6-20: Distribution of Average Number of Households by Income**



The employment type responses from the survey as shown in Exhibit 6-21 was that 56% of the responses were from employed individuals, 17% were from military personnel's, 8% were from retired individuals, 7% were from students, 3% were from veterans, 3% were from unemployed individuals, and 6% were from other where other as indicated by individuals were home-maker, self-employed, etc.

Exhibit 6-21: Employment Type Responses<sup>7</sup>



### 6.7.3 BEHAVIORAL ATTRIBUTES

Each of these three variables (VOT, VOF and VOA) has been analyzed using the “trade-off” method. The Trade-Off Analysis identifies how individuals choose between time and money in selecting travel options. Two trade-off analysis methods, Binary Logit Method and Direct Comparison Method, were employed to analyze the Attitudinal Survey Data and determine Values of Time (VOT’s), Values of Frequency (VOF’s), and Values of Access (VOA’s).

In the Comparison Method, the trade-off choices made by individuals are ranked in descending or ascending (VOT, VOF or VOA) order, along with the individual’s choice between time and money and the degree of preference the individual had for that specific trade-off choice. The individual’s VOT, VOF or VOA is then determined by identifying the point of inflection, or the point at which an individual changes from spending more time to save money or preferring to spend more money to save time in making a given journey. The Comparison Method provides a clear and detailed understanding of how travelers react to the series of binary choice trade-off questions. Once the individual trade-off values are determined, the results are averaged to give overall population values.

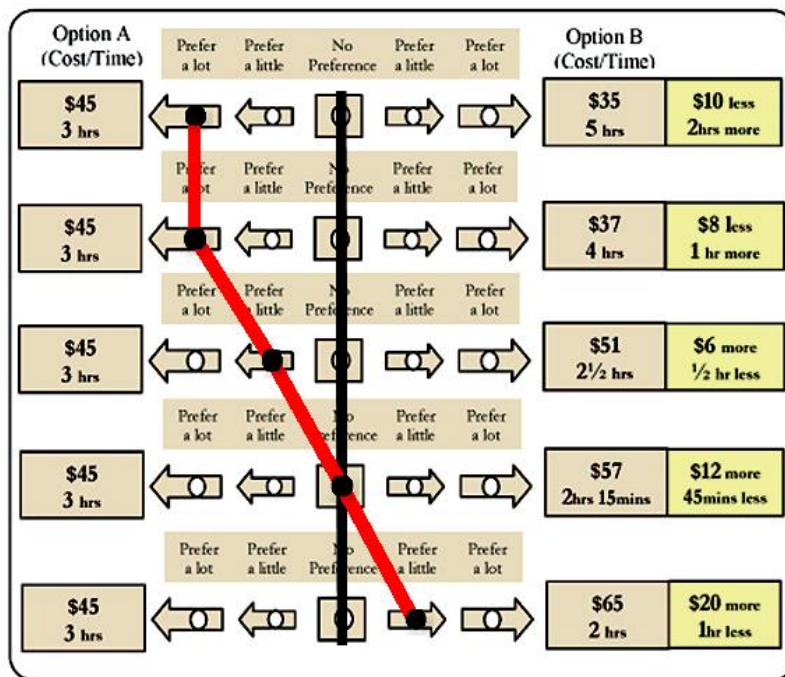
The Binary Logit Method uses a logit curve to calculate the coefficients of the time and cost variables. The individual’s VOT, VOF or VOA is derived as the ratio of time and cost coefficients. While this method is a less subjective and more automatic process than the Comparison Method, the statistical rigidity of the Binary Logit Method frequently provides less understanding of travel behavior and less ability to interpret behavior effectively. Furthermore, because this method cannot incorporate the results for individuals who quite rationally do not make a trade-off (preferring time or money options consistently

<sup>7</sup> The total count in Exhibit 2-19 is 2,876 which is more than the actual survey count. The reason being respondents with more than one response were counted separately. For example, student respondents who are employed are counted twice.

over the whole range of trade-off choices), the Binary Logit Method can only be used at most aggregate level.

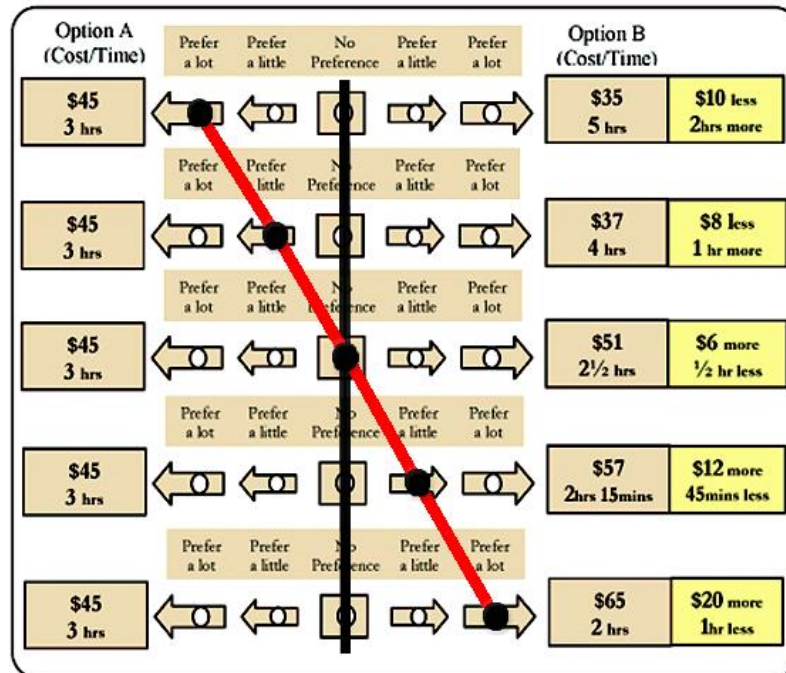
Exhibit 6-22 and 6-23 provides an example of the respondent's trading behavior and illustrates how VOT is calculated using 'trade-off' method. Exhibit 6-23 provides an example of the respondent's non trading behavior<sup>8</sup>. The VOT is calculated for the 'neutral point' located in the intersection between the line indicating 'no preference' and the line connecting the points indicated by the respondent. As seen in Exhibit 6-22 the neutral point or no preference line is located at the fourth row indicating that the respondent is willing to spend \$12 more for 45 minutes less. This implies the respondent is willing to spend \$16 more for one hour of time saving. Thus, the respondent has a VOT value of \$16 per hour.

**Exhibit 6-22: VOT calculation based on "Trade-Off" Method: "Trading Behavior"- Example #1**



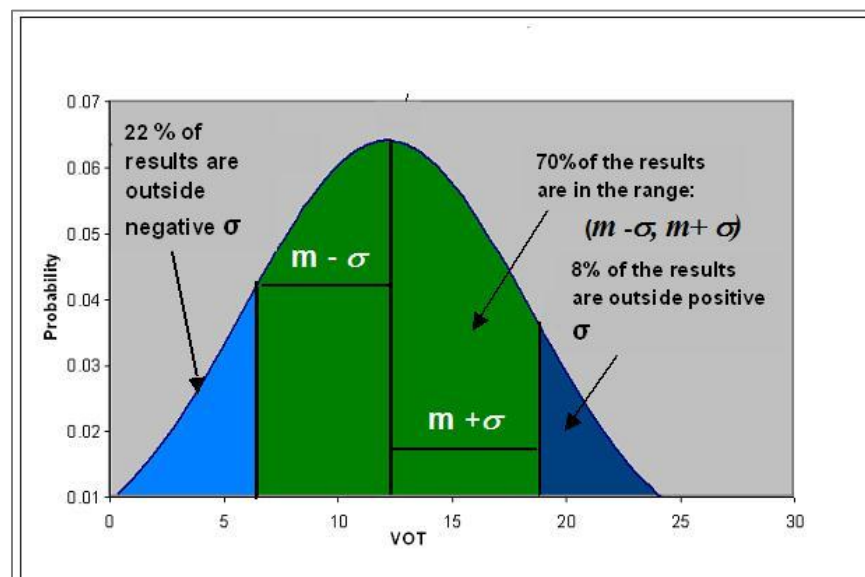
<sup>8</sup> These examples (Exhibit 1-22, 1-23, and 1-25) are drawn from previous TEMS Stated Preference Surveys, and are designed to show how travelers 'trade-off' or 'do not trade-off' between time and cost options.

Exhibit 6-23: VOT calculation based on "Trade-Off" Method: "Trading Behavior" - Example # 2



Not all survey respondents illustrated perfect trading behavior (similar to those shown in Exhibit 6-22 or 6-23). For the data collected, about 30% of the respondents were identified as 'non-traders'. This is shown in Exhibit 6-24, where the 30% (i.e. 22% of very low values of time and 8% of very high values of time) non-traders are equally proportioned between individuals with either very high values of time or very low values of time. The survey is intended to obtain VOT's from the 70% in the middle (i.e., one standard deviation). This is illustrated in Exhibit 6-24. The 30% non-trading behavior example is shown in Exhibit 6-25.

Exhibit 6-24: Distribution of the Non Respondent Error in the Trade-off Analysis of the Collected Survey Data<sup>9</sup>

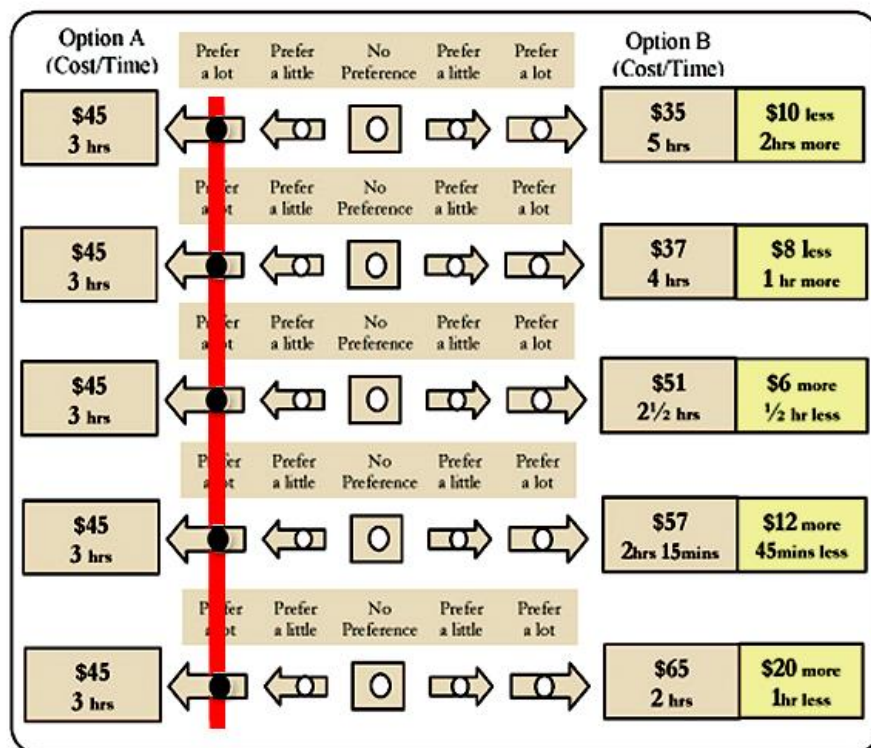


<sup>9</sup> Normal distribution with one standard deviation above the mean.



VOT calculated based on the example shown in Exhibit 6-25 is assumed to be \$45 for three hours (\$15 per hour) or less as there is no trading, and the individual is showing a preference to spend time rather than money.

Exhibit 6-25: VOT calculation based on “Trade-Off” Method: “Non Trading Behavior”



The Stated Preference Survey results of VOT, VOF and VOA calculated for four modes (auto, rail, bus, and air) and three types of purpose (commuter, business and other) are presented in Exhibits 6-26 through 6-28. Based on the calculations, the following observations were made:

- The hierarchical order of VOT is higher for Air access, rail, auto and then bus users., which is the typical trend;
- Business trips have larger VOT, VOF and VOA values than commuter and other trips;
- The VOT, VOF and VOA values are consistent with those of previous studies (e.g., Bay Bridge Travel Survey, 2006, Rocky Mountain Rail Authority (RMRA), 2008) after adjusting to 2012 dollars for similar trip length
- Intercity value of time is larger than intraurban value of time due to longer trip length, this explains why commuters have lower value of time, which have more intraurban trips than other trip purposes

Exhibit 6-26: VOT values by Mode and Purpose of Travel

Value of Time VOT	Business	Commuter	Social
<b>Auto</b>	\$19.42	\$14.80	\$16.88
<b>Bus</b>	\$11.07	\$7.15	\$8.54
<b>Rail</b>	\$22.51	\$18.80	\$17.88
<b>Air</b>	\$44.45	-	\$31.76

Exhibit 6-27: VOF values by Mode and Purpose of Travel

Value of Frequency VOF	Business	Commuter	Social
<b>Bus</b>	\$7.33	\$6.50	\$7.75
<b>Rail</b>	\$18.58	\$13.67	\$16.13
<b>Air</b>	\$28.81	-	\$26.28

Exhibit 6-28: VOA values by Mode and Purpose of Travel

Value of Access VOA	Business	Commuter	Social
<b>Bus</b>	-	\$8.89	\$10.77
<b>Rail</b>	\$42.73	\$29.15	\$37.66
<b>Air</b>	\$62.91	-	\$47.94

## 6.8 FUTURE TRAVEL MARKET STRATEGIES

### 6.8.1 FUEL PRICE FORECASTS

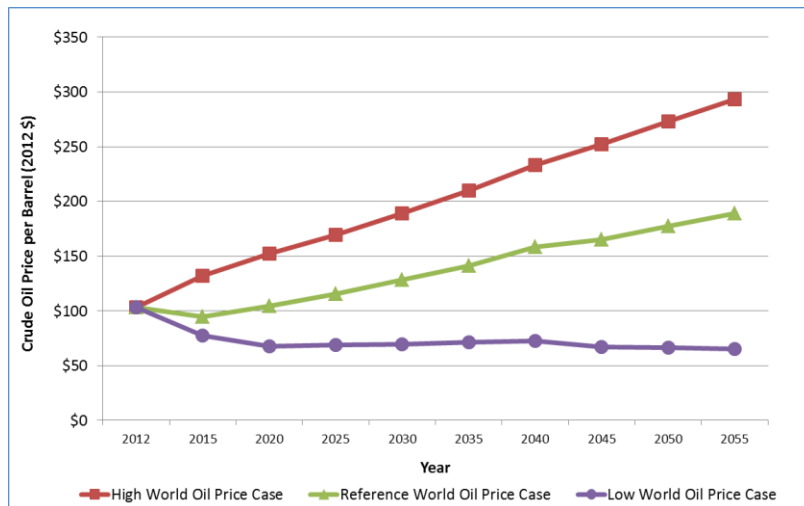
An important factor in the future attractiveness of passenger rail is fuel price. Exhibit 6-28 shows the Energy Information Agency (EIA)<sup>10</sup> projection of crude oil prices for three oil price cases, namely high world oil price case that is aggressive oil price forecast, reference world oil price case that is moderate and is also known as the central case forecast, and the conservative low world oil price case. In this study, the reference case oil price projection was used to estimate transportation cost in future travel market. EIA projects oil price to 2040, the oil price projections after 2040 were estimated based on historical prices and EIA projections. The EIA reference case forecast suggests that crude oil prices are expected to

<sup>10</sup> EIA periodically updates historical and projected oil prices at [www.eia.gov/forecasts/aeo/tables\\_ref.cfm](http://www.eia.gov/forecasts/aeo/tables_ref.cfm)

be \$116 per barrel (2012\$) in 2025 and will remain at that high level and will increase to \$142 per barrel (2012\$) in 2035.

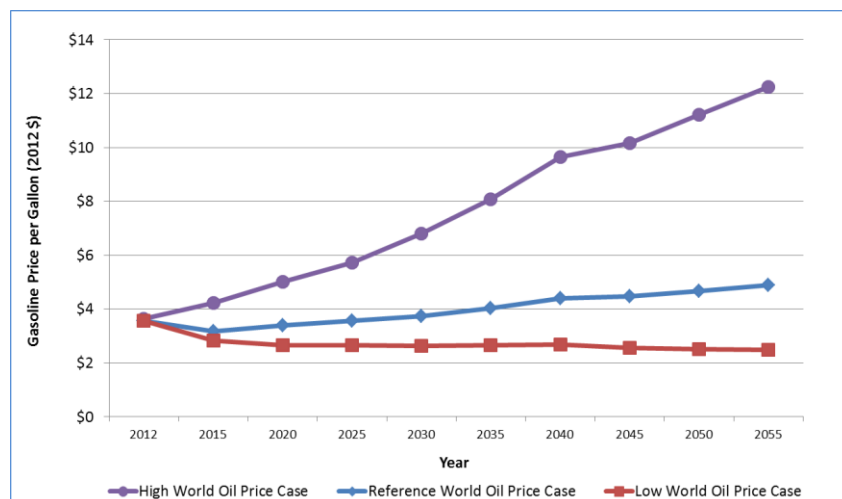
EIA has also developed a future retail gasoline price forecast, which is shown in Exhibit 6-29. The implication of this is a reference case gasoline price of \$3.6 per gallon (2012\$) in 2025, with a high case price of \$5.7 per gallon and a low case price of \$2.7 per gallon. Since 2012 annual average gas price of Midwest region is about \$3.6<sup>11</sup> per gallon in a weak economy environment, \$4~5 per gallon once the economy starts to grow again seems likely.

**Exhibit 6-28:  
Crude Oil Price Forecast by EIA**



\*EIA projections go to 2040, projections beyond 2040 were extrapolated

**Exhibit 6-29:  
U.S. Retail Gasoline Prices  
Forecast by EIA**



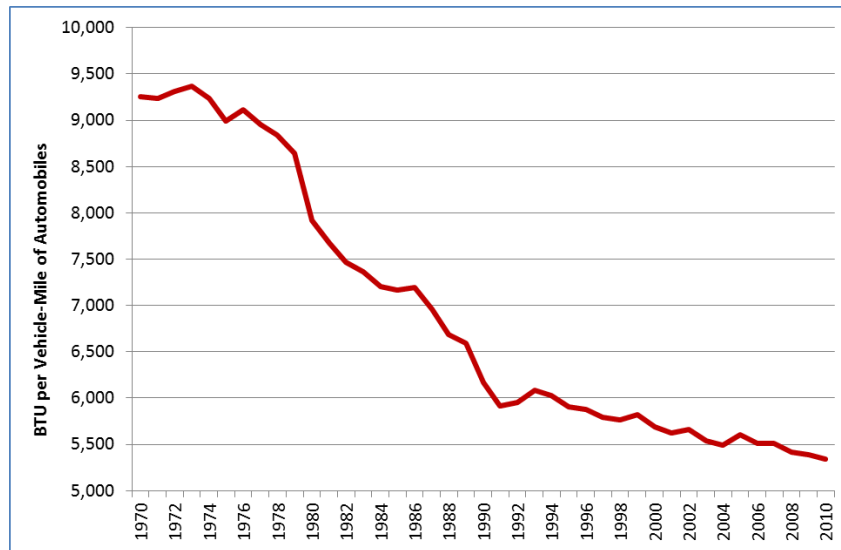
\*EIA projections go to 2040, projections beyond 2040 were extrapolated

<sup>11</sup> Weekly Retail Gasoline and Diesel Prices from EIA [http://www.eia.gov/dnav/pet/pet\\_pri\\_gnd\\_a\\_epmr\\_pte\\_dpgal\\_a.htm](http://www.eia.gov/dnav/pet/pet_pri_gnd_a_epmr_pte_dpgal_a.htm)

## 6.8.2 VEHICLE FUEL EFFICIENCY FORECASTS

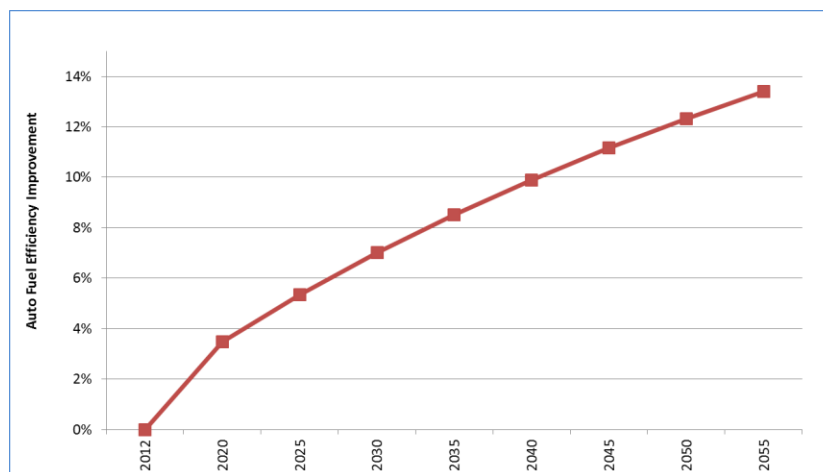
Future improvement in automobile technology is likely to reduce the impact of high gas prices on automobile fuel cost with better fuel efficiency. The Oak Ridge National Laboratory (ORNL) Center for Transportation Analysis (CTA) historical automobile highway energy intensities data has the historical Btu (British thermal unit) per vehicle-mile data for automobiles since 1970 as show in Exhibit 6-30.

**Exhibit 6-30: ORNL Historical Highway Automobile Energy Intensities Data**



From Exhibit 6-31 it can be seen that automobile fuel efficiency has been improving gradually during the past few decades but the improvement has slowed down in recent years. Future automobile fuel efficiency improvement that was projected and shown in Exhibit 6-31 was based on the historical automobile fuel efficiency data. It shows that the automobile fleet fuel efficiency is expected to improve by nearly 13 percent by 2055.

**Exhibit 6-31: Auto Fuel Efficiency Improvement Projections**



### 6.8.3 HIGHWAY TRAFFIC CONGESTION

The average annual travel time growth in the corridor is estimated with the projected highway traffic volume data and the BPR (Bureau of Public Roads) function that can be used to calculate travel time growth with increased traffic volumes:

$$T_f = T_b * [1 + \alpha * \left(\frac{V}{C}\right)^\beta]$$

where

$T_f$  is future travel time,

$T_b$  is highway design travel time,

$V$  is traffic volume,

$C$  is highway design capacity,

$\alpha, \beta$  are calibrated coefficients.

The future highway link volumes are forecasted based on the historic Annual Average Daily Traffic (AADT) from VDOT<sup>12</sup>. Exhibit 6-32 shows historic AADTs and annual average growth rate (AAGR) for six segments on two major highway corridors of the study areas: Interstate 64 and Route 460. As shown in the exhibit, the traffic growth in these two corridors since 2000 is strong. Without significant improvement on these two corridors or building new alternatives, the congestions on these highways will become more and more serious.

**Exhibit 6-32: Historic AADT of I64 and Route 460**

Route	From	To	2011	2010	2009	2005	2000	AAGR
I64	I-295	New Kent County Line	69,000	68,000	69,000	67,000	62,000	1.0%
I64	SR 33 Eltham Rd	James City County Line	52,000	53,000	54,000	47,000	39,000	2.6%
I64	SR 238 Yorktown Rd	SR 105 Ft Eustis Blvd	88,000	88,000	83,000	86,000	71,000	2.0%
Rte. 460	I-295	74-629	14,000	15,000	16,000	16,000	13,000	0.7%
Rte. 460	Windsor East County Line	Suffolk West County Line	17,000	14,000	14,000	16,000	11,000	4.0%
Rte. 460	Suffolk East County Line	I-664	67,000	67,000	68,000	67,000	55,000	1.8%

<sup>12</sup> <http://www.virginiadot.org/info/ct-TrafficCounts.asp>



Exhibit 6-33 shows the estimated travel time growths in 2025 for two city pairs in the study area due to increasing highway traffic volumes.

**Exhibit 6-33: Highway Travel Time Projections for Two City Pairs**

	2012 Travel Time	2025 Estimated Travel Time
Norfolk, VA - Richmond, VA	1Hour40Min	1Hour55Min
Norfolk, VA - Petersburg, VA	1Hour35Min	1Hour43Min

The projected travel times in Exhibit 6-33 are calculated by applying BPR function with forecasted link volumes and capacity. The key assumptions of parameter are same as used in 2004 HRTPO Roads Travel Demand Model<sup>13</sup>. For example, suburban Interstate has the following parameters

- $\alpha = 0.15$
- $\beta = 4$
- Lane capacity = 1875
- Highway link capacity does not change with time

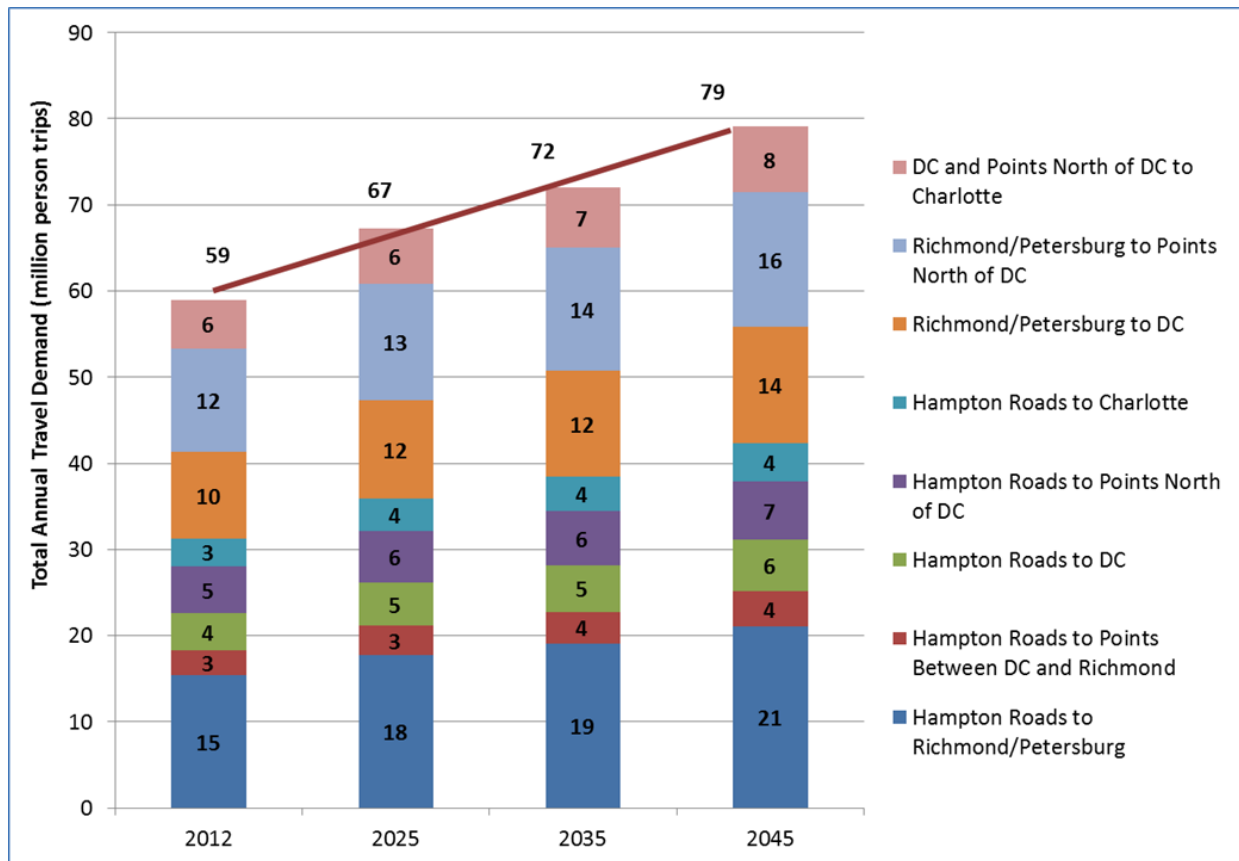
For example, a highway segment around on I64 has seen a traffic volume increase from 39,000 vehicles per day to 85,500 vehicles per day from 2011 to 2025. By applying the BPR function while assuming same route is used between these two cities in the future, it can be calculated that travel time on this highway segment will increase by about 0.5% per year with the BPR function.

## 6.9 CORRIDOR TOTAL TRAVEL MARKET DEMAND FORECAST

This section presents the Hampton Roads – Richmond - Washington Corridor Total Travel Demand Forecast produced from the results of the *COMPASS*™ Total Demand Model application. While the *COMPASS*™ analysis considers intercity travel from Boston to Charlotte (See Exhibit 6-4) but is presenting in this section only the demand in the Hampton Roads – Richmond – Washington Corridor. Exhibit 6-34 shows the Hampton Roads – Richmond - Washington Corridor total travel demand forecasts for 2025, 2035, and 2045. It can be seen that the corridor travel demand will increase to 67 million in 2025, to 72 million in 2035, and increases to 79 million in 2045. The average annual corridor travel market growth rate is 0.9 percent, which is in line with the socioeconomic growth within the corridor.

<sup>13</sup> 2000 Hampton Roads Model Validation Memorandum, Virginia Department of Transportation, May 2004

**Exhibit 6-34: Study Area Travel Market Forecast – Annual Person Trips for the Whole Study Area that Extends from Boston to Charlotte**



## 6.10 CORRIDOR TRAVEL MARKET FORECASTS FOR PASSENGER RAIL

The specific ridership and revenue is dependent on the level of train service proposed. Exhibit 6-35 presents the summary of passenger rail service assumptions (strategies) for the passenger rail ridership and revenue forecast. The rail service plan includes station stopping pattern number, train running times for 130 mph and 220 mph options.

Exhibit 6-35: Norfolk to Washington High Speed Train Stopping Pattern

Stations	Super Express	Express	Local
Norfolk	√	√	√
Bowers Hill	√	√	√
Suffolk	—	—	√
Petersburg/Hopewell*	—	√	√
Richmond Main St	√	√	√
Ashland	—	—	√
Fredericksburg	—	√	√
Quantico	—	—	√
Alexandria	√	√	√
Washington Union	√	√	√
130-mph Total Trains	4 trains	5 trains	4 trains
130-mph Time via Petersburg/Hopewell	2:36	2:46	3:01
130-mph Time Richmond Direct	2:31	2:36	2:51
220-mph Total Trains	5 trains	10 trains	3 trains
220-mph Time via Petersburg/Hopewell	1:45	1:55	2:10
220-mph Time Richmond Direct	1:38	1:43	1:58

\* Stations Bypassed by Richmond Direct

The Richmond Direct option swings quite far to the east to access Richmond. This leaves open the possibility of services from the Peninsula using the Richmond Direct route from near Roxbury to Richmond, a distance of some 20 miles. This would allow Peninsula trains to operate on a portion of the Norfolk-Richmond segment and would provide an increase in Peninsula train speed to 130 mph going from Roxbury to Richmond and to Washington, DC. Such a connection would also dramatically increase Peninsula traffic to a level beyond just 3 trains per day.

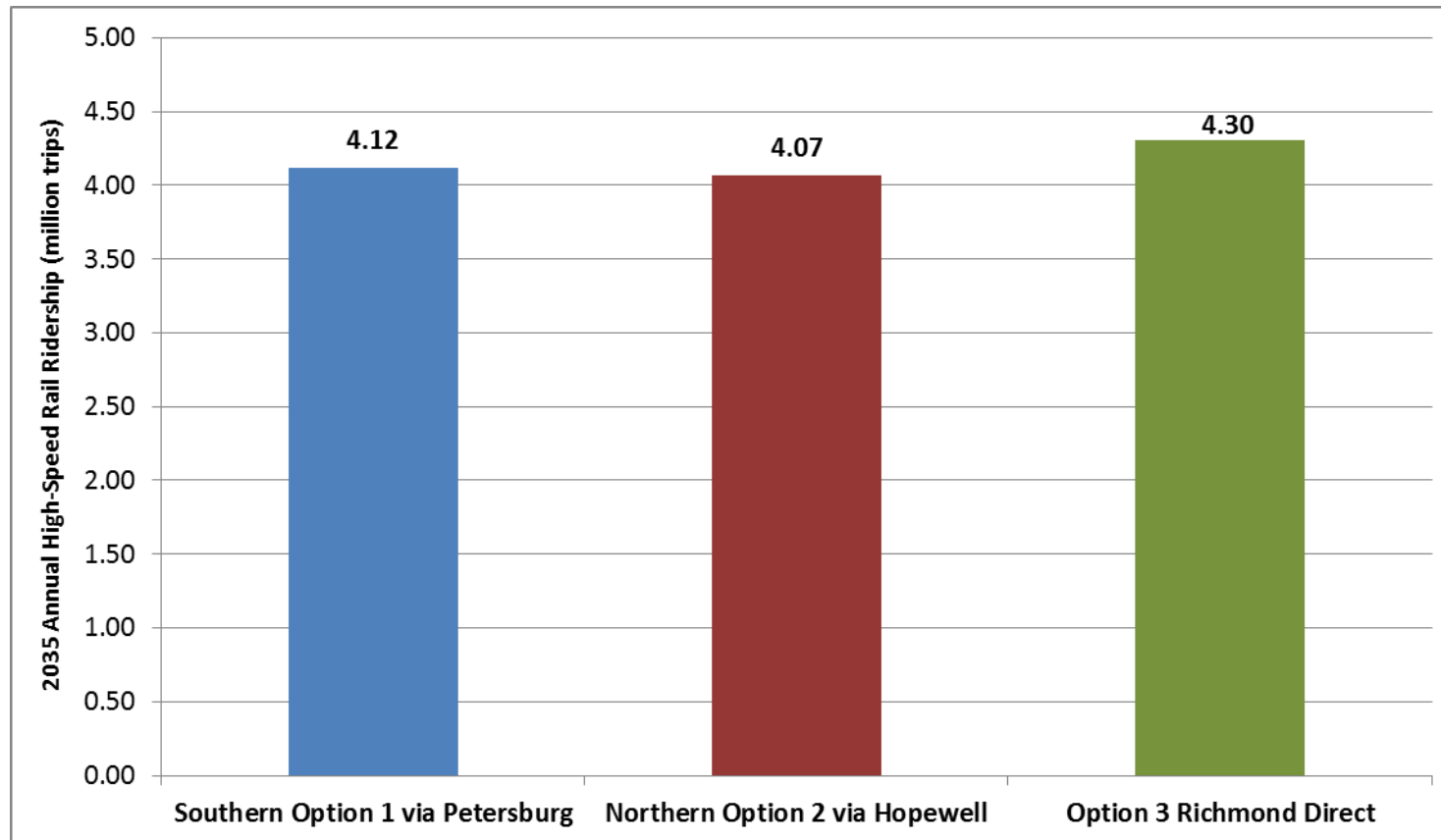
Given this potential synergy of the Richmond Direct Route with the Peninsula, an evaluation was made in Option 4 of developing a high speed connection towards Newport News. This evaluation of a high speed connection considered the geography, topology, and environment along the Peninsula corridor between Roxbury and Newport News. As a preliminary estimate, it was decided that a short (20 mile) connection going from the Richmond Direct route at Roxbury to Toano just outside Williamsburg, would be the most effective option. The terrain for these twenty miles is rural and mostly follows an existing utility right-of way. Development of the Peninsula connection would face similar issues to those faced by Richmond Direct, Option 3.

The preliminary Option 4 route analysis suggests an extension from Roxbury to Toano just outside Williamsburg as being feasible and further route variations may be possible for making this connection. This is a distance of 40 miles from Richmond and would allow high speed diesel operation from just outside Williamsburg to Washington at 130 mph “under the wire” of an electrified Richmond Direct option. This option was identified as the Richmond Direct Improved alternative, Option 4.

Using different route and train service plans, Exhibits 6-36 and 6-37, present the passenger rail ridership forecasts for the Hampton Roads – Richmond – Washington Corridor for 2035. The passenger rail system generates 4.07 to 4.30 million trips in 2035 for 130-mph options. For 220-mph options, the ridership ranges from 5.75 to 6.11 million trips, and the ridership of Option 4 is 8.55 million. A trip is defined as a passenger making a one-way trip and a round trip generates two one way trips.

Exhibits 6-38 and 6-39 shows the annual fare-box revenue for years 2035. It can be seen that the annual revenue of 2035 is \$216 to 228 million for the 130-mph options and is 362 to 374 million for 220-mph options, and the revenue of Option 4 is 592 million. All revenue forecasts are presented in 2012 dollar values.

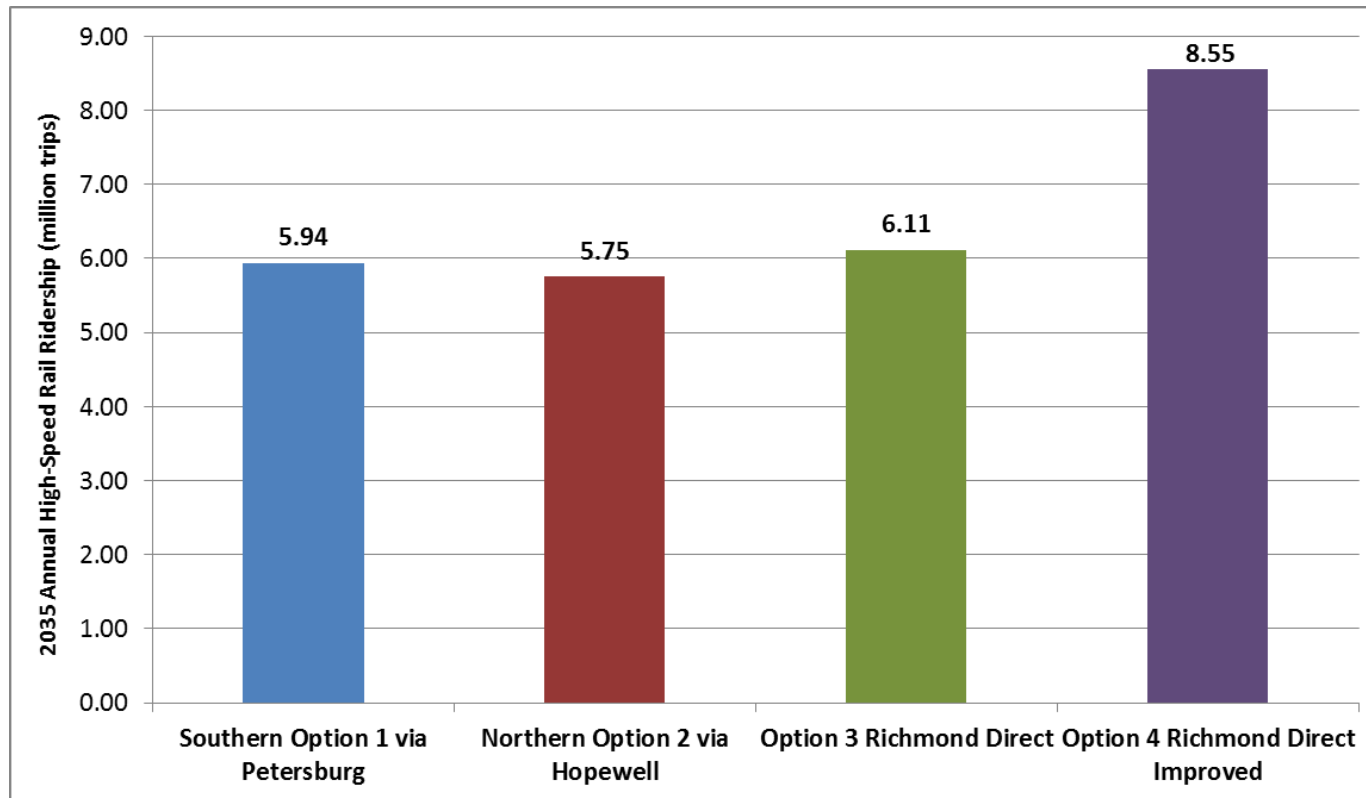
**Exhibit 6-36: 130-mph High Speed Passenger Rail Ridership Forecast-Annual Person Trips  
for the Southside Option that Extends from Boston to Charlotte**



	Southern Option 1 via Petersburg	Northern Option 2 via Hopewell	Option 3 Richmond Direct
Hampton Roads to Richmond/Petersburg	0.33	0.33	0.38
Hampton Roads to Points Between DC and Richmond	0.55	0.55	0.68
Hampton Roads to DC	0.79	0.79	0.93
Hampton Roads to Points North of DC	0.34	0.34	0.39

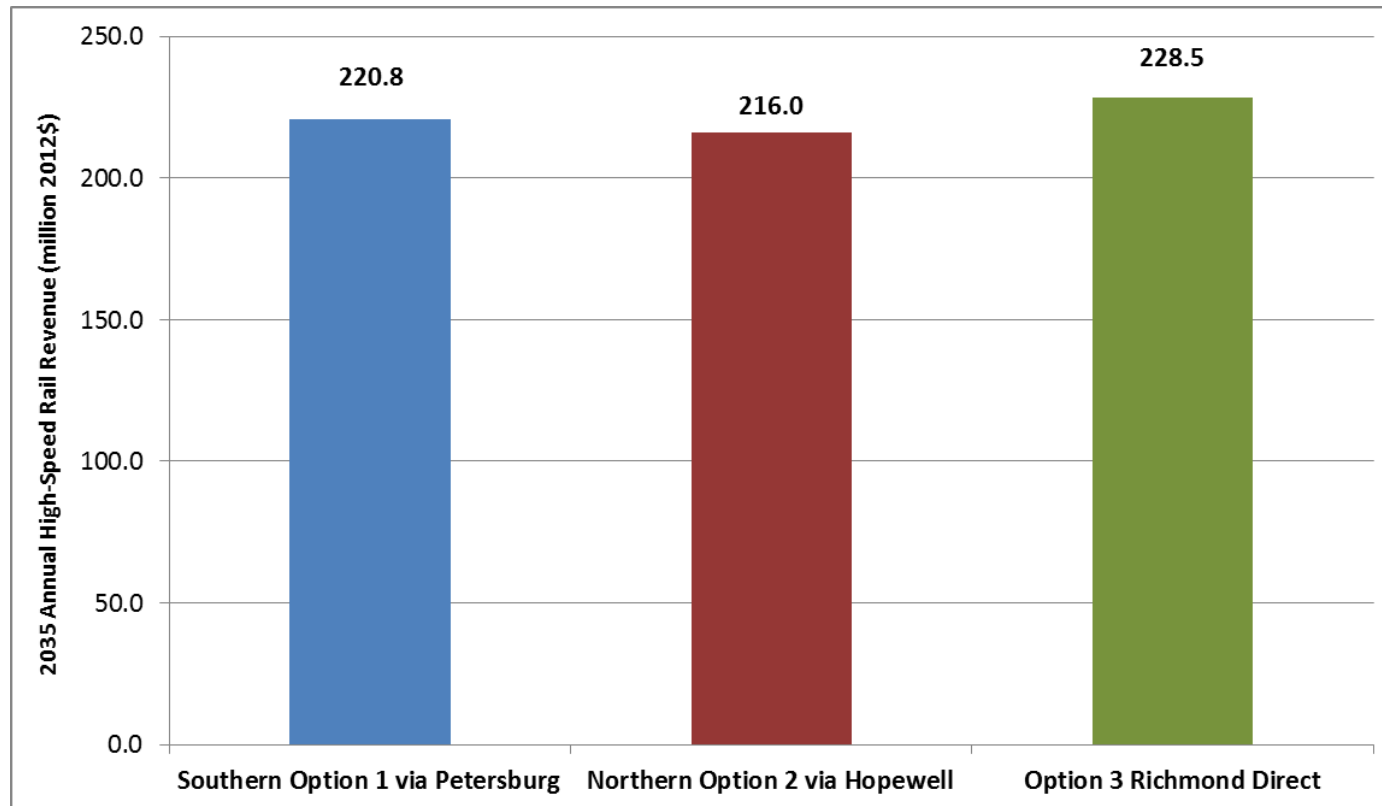


**Exhibit 6-37: 220-mph High Speed Passenger Rail Ridership Forecast-Annual Person Trips  
for the Southside Option and Option 4 Richmond Direct Improved that Extend from Boston to Charlotte**



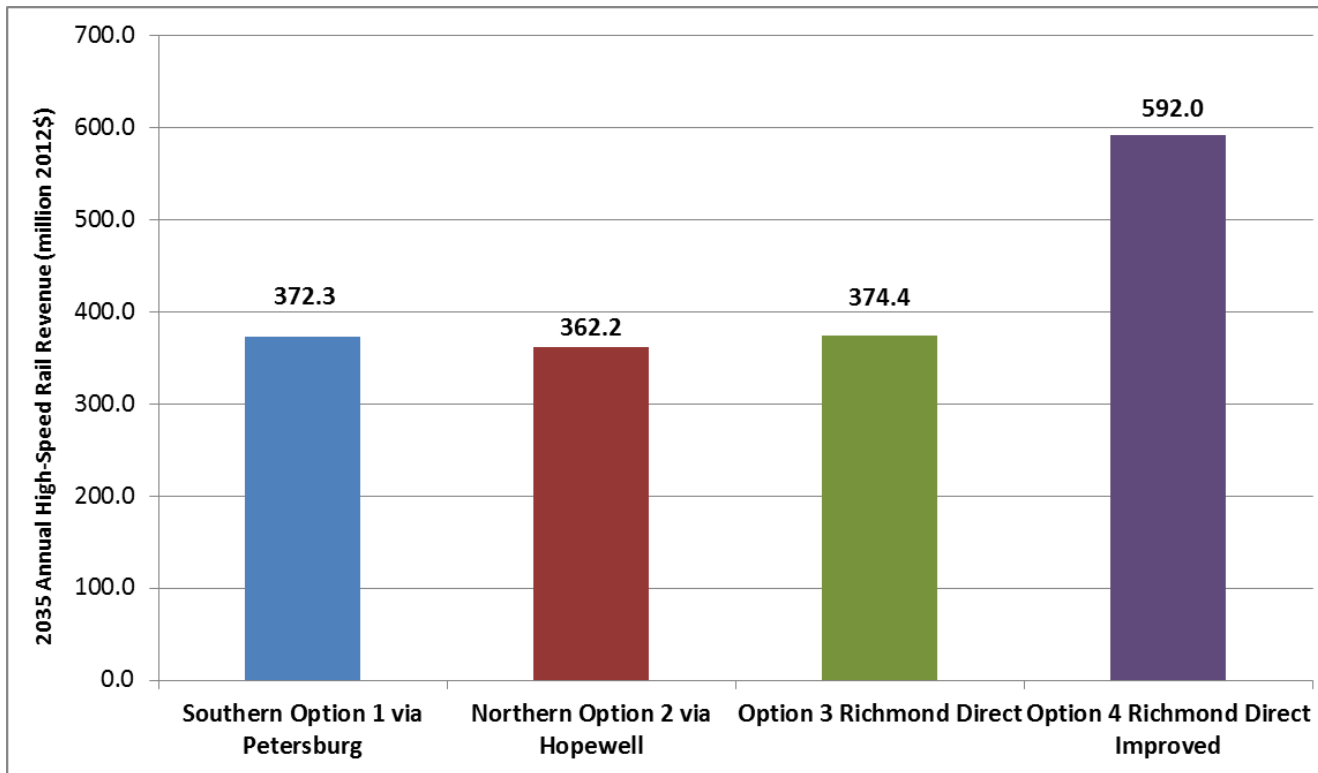
	Southern Option 1 via Petersburg	Northern Option 2 via Hopewell	Option 3 Richmond Direct	Option 4 Richmond Direct Improved
Hampton Roads to Richmond/Petersburg	0.51	0.51	0.58	0.97
Hampton Roads to Points Between DC and Richmond	0.99	0.99	1.14	1.91
Hampton Roads to DC	1.25	1.25	1.39	2.15
Hampton Roads to Points North of DC	0.67	0.66	0.75	1.26

**Exhibit 6-38: 130-mph High Speed Passenger Rail Revenue Forecast-Annual Revenue  
for the Southside Option that Extends from Boston to Charlotte**



	Southern Option 1 via Petersburg	Northern Option 2 via Hopewell	Option 3 Richmond Direct
Hampton Roads to Richmond/Petersburg	8.87	8.80	9.86
Hampton Roads to Points Between DC and Richmond	40.82	40.79	47.69
Hampton Roads to DC	67.53	67.50	75.55
Hampton Roads to Points North of DC	27.81	27.83	30.51

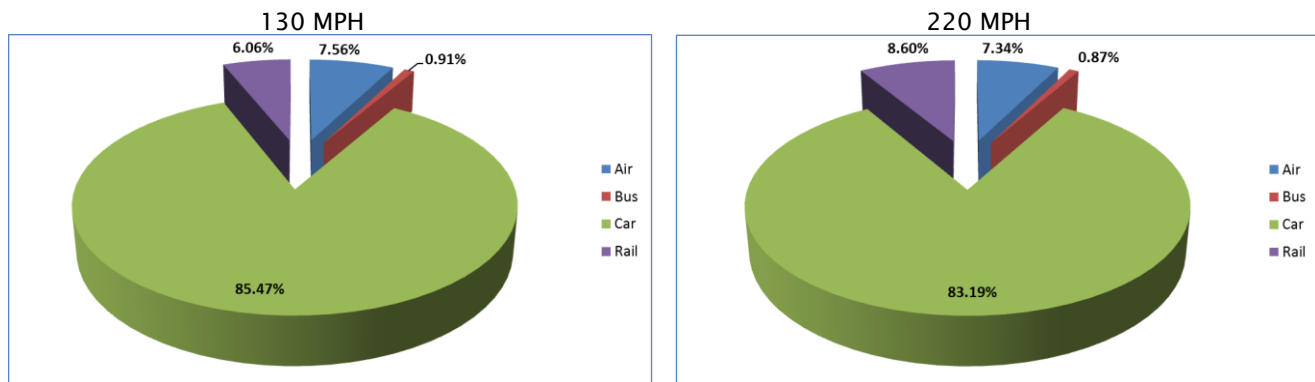
**Exhibit 6-39: 220-mph High Speed Passenger Rail Revenue Forecast-Annual Revenue for the Southside Option and Option 4 Richmond Direct Improved that Extend from Boston to Charlotte**



	Southern Option 1 via Petersburg	Northern Option 2 via Hopewell	Option 3 Richmond Direct	Option 4 Richmond Direct Improved
Hampton Roads to Richmond/Petersburg	17.22	17.10	18.72	36.40
Hampton Roads to Points Between DC and Richmond	79.07	78.98	86.07	150.52
Hampton Roads to DC	113.53	113.43	119.73	200.57
Hampton Roads to Points North of DC	60.98	60.64	65.80	120.01

The corridor transportation mode market share forecasts in 2025 are shown in Exhibits 6-40 thru 6-43. The auto mode continues to demonstrate its dominance in the corridor maintaining a market share above 80 percent in 2025. Rail market share will increase to more than five percent for 130-mph options, and will be around eight to eleven percent for 220-mph options. Air market share will be around seven percent. Bus market share will remain less than one percent.

**Exhibit 6-40: Intercity Travel Market Share Forecast – Southern Option 1 via Petersburg 2035**



**Exhibit 6-41: Intercity Travel Market Share Forecast – Northern Option 2 via Hopewell 2035**

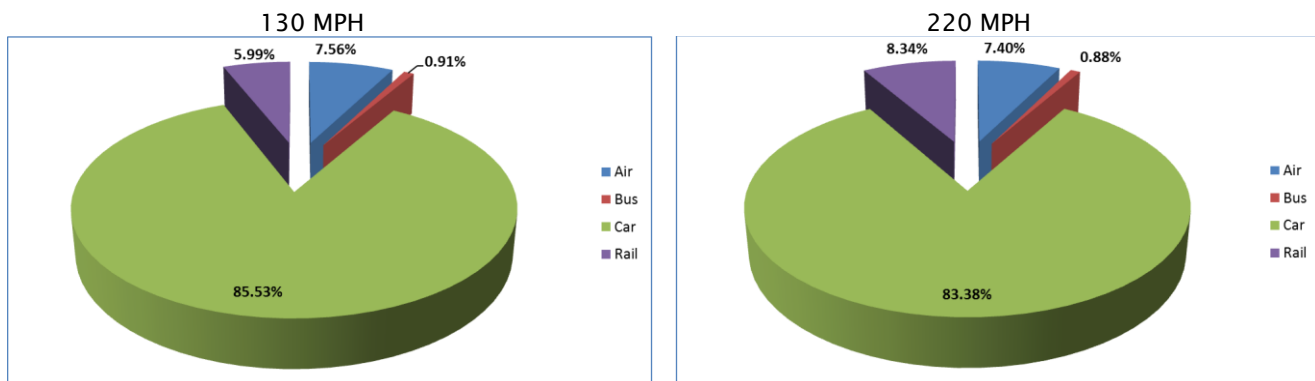


Exhibit 6-42: Intercity Travel Market Share Forecast – Option 3 Richmond Direct 2035

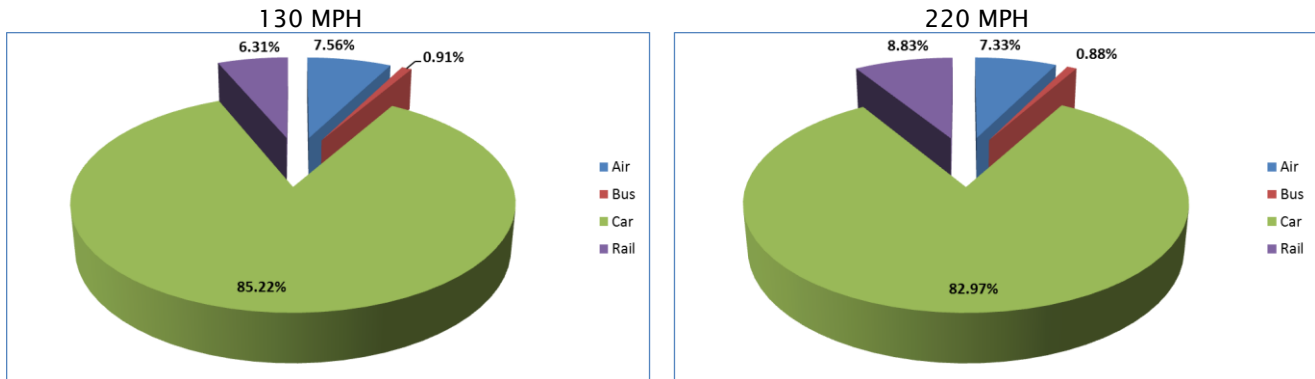
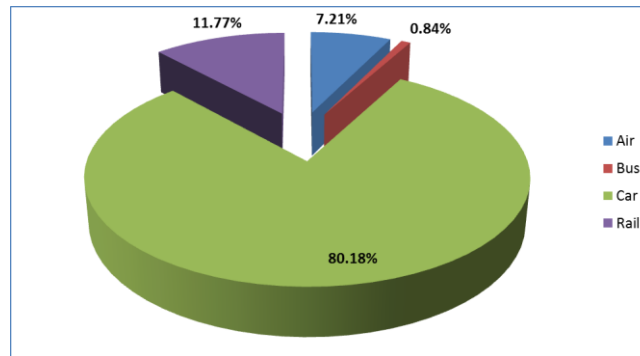


Exhibit 6-43: Intercity Travel Market Share Forecast – Option 4 Richmond Direct Improved 2035



Exhibits 6-44 thru 6-47 illustrate the sources of the rail trips. The trips diverted from other modes—primarily auto, are the most important source of rail trips, which accounts for 62 to 68 percent of overall rail travel market. Induced travel demand in the corridor as result of the new passenger rail service is 7.8 to 16 percent of the rail travel market. As for the diverted trips from other modes, more than 90 percent trips are from auto mode, but the auto driving still dominates future travel market, as this is still a very effective option for shorter trips in the current Hampton Roads – Richmond – Washington Corridor.



Exhibit 6-44: Sources of HSR Trips- Southern Option 1 via Petersburg 2035

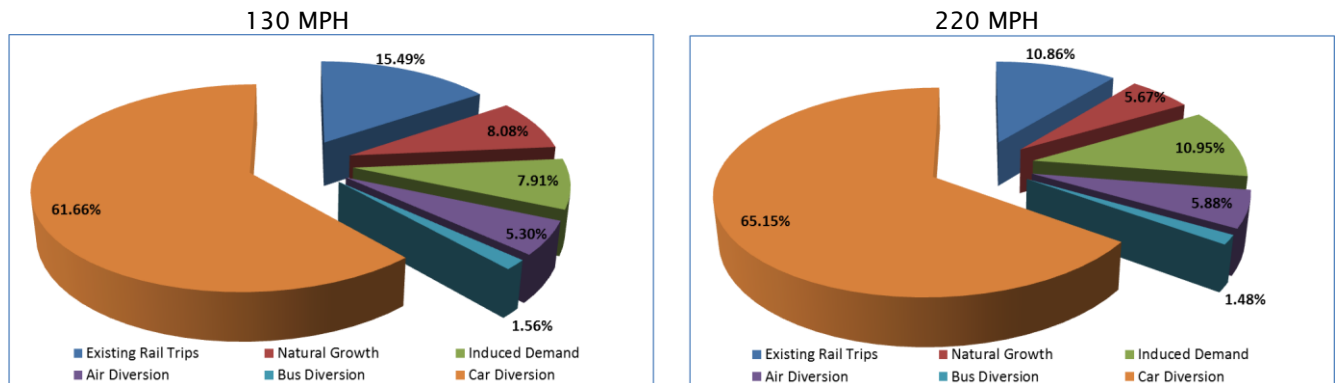


Exhibit 6-45: Sources of HSR Trips- Northern Option 2 via Hopewell 2035

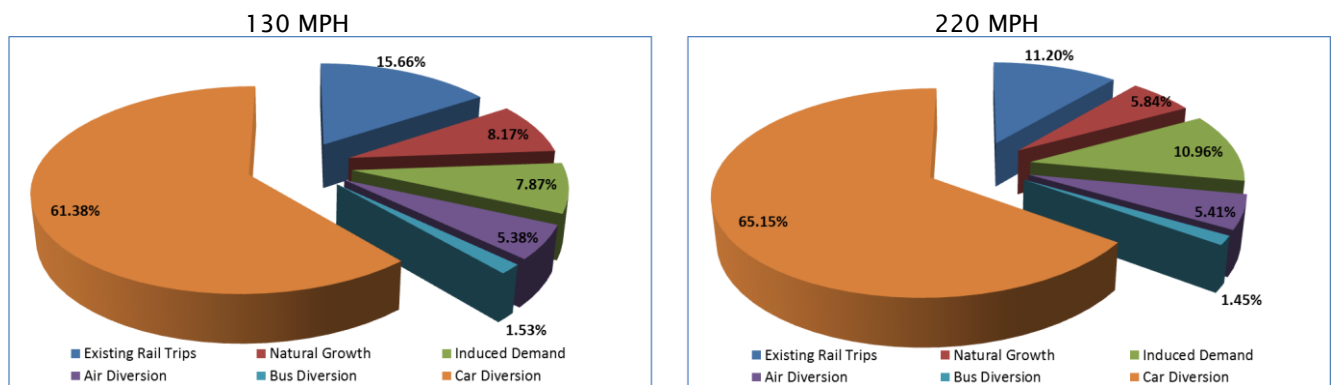


Exhibit 6-46: Sources of HSR Trips- Option 3 Richmond Direct 2035

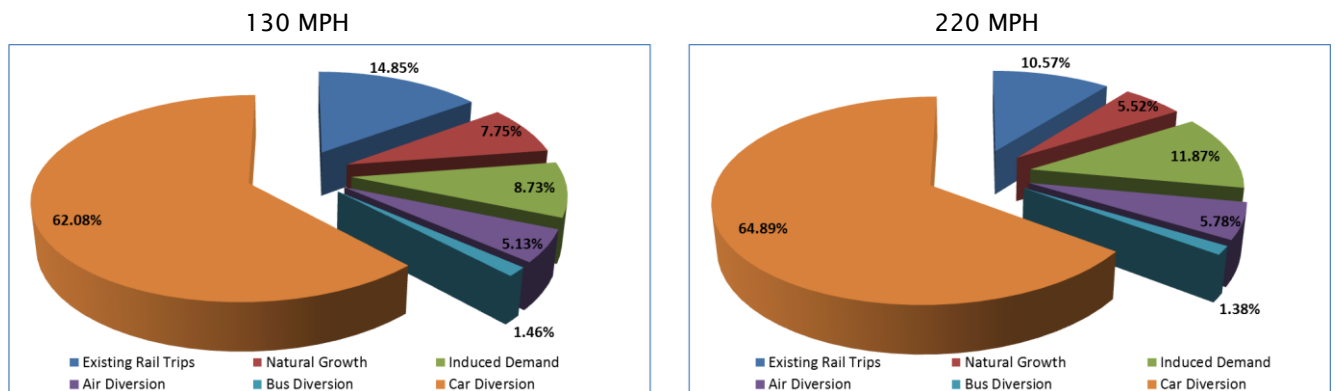
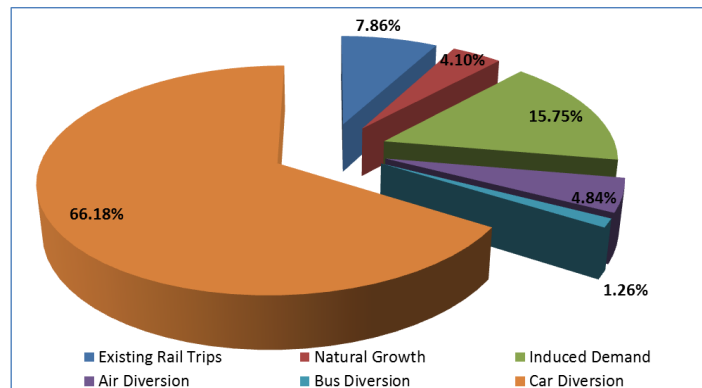


Exhibit 6-47: Sources of HSR Trips- Option 4 Richmond Direct Improved 2035



## 6.11 CORRIDOR TRAVEL MARKET FORECASTS BENCHMARKING

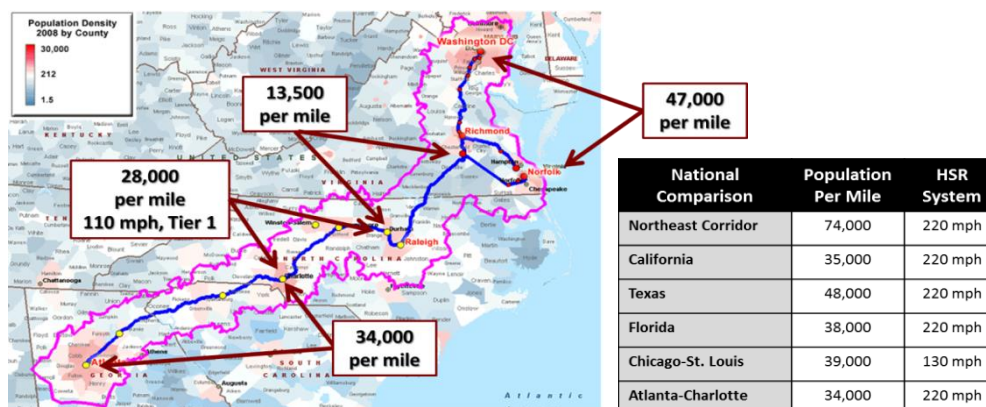
Benchmarking or making comparisons with other established rail systems/corridors is also an important factor for evaluating new rail projects. Rail projects that compare well with existing rail corridors are more likely to behave similarly and thus are likely to achieve similar success.

Exhibit 6-48 shows that the Washington-Richmond-Hampton Roads corridor has the highest population density in the SEHSR corridor, and its population density is higher than the California, Texas, Florida,, and Chicago-St. Louis corridors.

Exhibit 6-49 is a comparison of the TEMS forecast model and the DRPT FEIS model. It can be seen that by using the same rail levels-of-services as in the FEIS model, the TEMS model produces similar rail ridership and revenue forecast results.

As shown in Exhibit 6-50, the NEC NYC-DC Corridor is expected to have a rail trip rate of 18.86 to 22.19 trips per 10,000 persons per day by year 2030 and California's High Speed Ridership is expected to be about 24.27 trips, the Hampton Roads – Washington Corridor at 7.10 – 10.51 trips per 10,000 person per day by year 2030, compares well with similar sized corridors such as the Atlanta to Charlotte Corridor.

Exhibit 6-48: Washington-Richmond-Hampton Roads Corridor Population Density



**6-49: Comparison of Demand Forecasts to FEIS Study Option 1\***

	Time	Daily Round Trips	2025 Annual Hampton Roads-Based Rail Trips (million)	2025 Annual Hampton Roads-Based Rail Revenue (million \$)
DRPT FEIS* Alternative 1 90 mph	1:35	6	1.11	\$73.71 (\$2012)
TEMS Southern Option via Petersburg Assuming FEIS Option 1 Levels of Service	1:35	6	1.16	\$76.70 (\$2012)

\*Richmond to Hampton Roads Passenger Rail Project, Final Environmental Impact Statement, Virginia Department of Rail and Public Transportation (DRPT), August 2012. 2008 dollars adjusted to 2012 for comparison purposes.

**Exhibit 6-50: Apples-to-Apples Demand Forecast Rail Trip Rate Comparison with Other Corridors**

	2030 Hampton Roads-Washington Corridor - 130 MPH <sup>1</sup>	2030 Atlanta-Charlotte Corridor - 130 MPH <sup>2</sup>	2030 Hampton Roads-Washington Corridor - 220 MPH <sup>1</sup>	2030 Atlanta-Charlotte Corridor - 220 MPH <sup>2</sup>	2030 NEC Master Plan NYC-DC Corridor (Constrained Acela) <sup>3</sup>	2030 NEC Next-Gen HSR NYC-DC Corridor - 220 MPH <sup>4</sup>	2030 California High-Speed Rail Ridership Forecast - 220 MPH <sup>5</sup>
<b>Rail Trip Rate (trips per 10,000 person per day)</b>	<b>7.10</b>	<b>10.30</b>	<b>10.51</b>	<b>12.06</b>	<b>18.86</b>	<b>22.19</b>	<b>24.27</b>

<sup>1</sup> Hampton Roads Passenger Rail Vision Plan Alternatives Analysis, TEMS, 2014

<sup>2</sup> Atlanta to Charlotte Passenger Rail Corridor EIS, Steer Davies Gleave, 2013

<sup>3</sup> The Northeast Corridor Infrastructure Master Plan, The NEC Master Plan Working Group, 2010

<sup>4</sup> The Amtrak Vision for the Northeast Corridor, Amtrak, 2012

<sup>5</sup> Bay Area/California High-Speed Rail Ridership and Revenue Forecasting Study, Cambridge Systematics, Inc., 2007

## 7. FINANCIAL AND ECONOMIC ANALYSIS

*The Financial and Economic Analysis describes the USDOT FRA criteria used to assess the route and technology options. It defines the criteria and describes the process used to estimate the financial and economic benefits of the system. It provides both the financial and economic results for each option.*

### 7.1 EVALUATION OF ALTERNATIVES

#### 7.1.1 STUDY OBJECTIVES

This analysis uses the same criteria (updated to include Tiger Grant criteria) and structure as the 1997 FRA Commercial Feasibility Study. This study set out criteria for establishing a public-private partnership between the Federal government, State and local communities, and the private sector for intercity rail projects. The study described two conditions that were considered essential for receiving Federal funding support for proposed intercity passenger rail projects:

- An operating cost ratio of at least 1.0, defined as a pre-condition for an effective public/private partnership, so that once the system has been constructed, a private operator could operate the system on a day-to-day basis without requiring an operating subsidy, and
- A benefits/cost ratio greater than 1.0, to ensure that the project makes an overall positive contribution to the economy, at both the regional and national levels.

The Commercial Feasibility Study makes it clear that “federal consideration of specific High-Speed Ground Transportation project proposals could apply additional criteria that could differ from, and be much more stringent than, this report’s threshold indicators for partnership potential.”

Operating ratios are usually expressed on a year-by-year basis, but they can also be expressed as a Present Value of Revenue / Present Value of Operating Cost over the lifetime of a project.

Benefit Cost ratios are usually expressed as a Present Value of Total Benefit / Present Value of Total Cost over the lifetime of a project.

At a feasibility level of study, analysis is based on a number of assumptions that are needed to carry out the analysis. These assumptions include such factors as: rate of socioeconomic growth, rate of demographic growth, rate of energy price increase and the capital cash flows in accordance with a multi-year, implementation plan. Once more detailed assessments are made and more specific information on the rate of ridership and revenue growth and a system implementation plan detailing the capital cash flows become available, then that information can be included to further refine the initial estimates of the Financial Return and Benefit Cost ratio.

This chapter describes the process by which the alternatives were evaluated and how this analysis lead to the identification of a number of feasible options based on the economic and financial criteria adopted.

### 7.2 FINANCIAL AND ECONOMIC OBJECTIVES

For each alternative being evaluated, measures of financial and economic efficiency were calculated. These measures were determined from assessments integrating the forecasted capital, operating and maintenance

costs with the forecasted revenue projections over the lifetime of the project. Specifically, the analysis was based on the following components:

- Operating and implementation plans for the alternative passenger rail service options
- Cost estimates for operations, infrastructure and acquisition of rolling stock
- Ridership and revenue estimates based on projected travel demand. These forecasts include assumptions regarding fare levels and oil prices, highway congestion and the responsiveness of the air industry to the introduction of the Diesel 130-mph and Electric 220-mph Alternatives.
- Cash flow analysis that includes statements of revenues and expenses for each alternative.

Two measures, net present value (NPV) and Benefit Cost ratio were used to evaluate the economic returns of the system. Similar measures, net present value (NPV) and Operating ratio, were used to evaluate the financial returns and the potential for franchising the operations

Both measures require the development of a project's year-by-year financial and economic returns, which are then discounted to the base year to estimate present values (PV) over the lifetime of the project. For this analysis, a 25-year project life from 2030 to 2055 was assumed, with a fifteen year implementation period from 2015-2029. Revenues and cost cash flows were discounted to the 2013 base year using two discount rates: 3 percent and 7 percent. The 3 percent discount rate reflects the real cost of money in the market as reflected by the long term bond markets, and the 7 percent discount rate reflects the Federal government's desire to establish a benchmark comparison by discounting long term benefits at a greater rate than the market for public securities.

The operating ratios reported here in this chapter, follow a commercial criteria definition; but are different from the commercial operating ratio calculations that are typically presented by freight railroads and intercity bus companies. For the current analysis, the selected feasibility criteria were as follows:

- The Operating Ratio as calculated here includes direct operating costs only. The operating ratio calculations presented here do not include capital costs, depreciation or interest. The costs used are incremental costs.
- The Operating Ratio presented here is defined as Revenues/Costs. It should be noted that freight railroads and intercity bus companies typically define it as the reciprocal Costs/Revenues.

As defined by this analysis, a positive operating ratio does not imply that a passenger service can attain full financial profitability by covering its capital costs, but it does allow the operation to be franchised and operated by the private sector. The definition puts passenger rail on the same basis as other passenger transportation modes, such as intercity bus and air, where the private sector operates the system but does not build or own the infrastructure it uses. It does, however, pay access fees to the freight railroads where they own the track. In the case of passenger rail, these would include track access costs. All calculations are performed using the standard financial formula, as follows:

**Financial Measure:**

$$\text{Operating Ratio} = \frac{\text{Financial Revenues}}{\text{Operating Costs}}$$



**Economic Measures:**

Net Present Value = Present Value of Benefit – Present Values of Costs

Benefit Cost Ratio =  $\frac{\text{Present Value of Revenues}}{\text{Present Value of Costs}}$

Present Value is defined as:

$$PV = \sum_t \frac{C_t}{(1+r)^t}$$

Where:

PV = Present value of all future cash flows

$C_t$  = Cash flow for period t

r = Discount rate reflecting the opportunity cost of money

t = Time

In terms of Economic Benefits, a positive NPV and Benefit Cost Ratio imply that the project makes a positive contribution to the economy. For this analysis, revenues and cost cash flows were discounted to the 2013 base year using two discount rates: 3 percent and 7 percent. The 3 percent discount rate reflects the real cost of money in the market as reflected by the long term bond markets, and the 7 percent discount rate reflects the Federal government's desire to establish a benchmark comparison by discounting long term benefits at a greater rate than the market for public securities. Consistent with standard practice, Benefit Cost ratios are calculated from the perspective of the overall society without regard to who owns particular assets receives specific benefits or incurs particular costs.

### 7.2.1 KEY ASSUMPTIONS

The analysis projects travel demand, operating revenues and operating and maintenance costs for all years from 2030 through 2055. The financial analysis has been conducted in real terms using constant 2013 dollars. Accordingly, no inflation factor has been included and a real discounting rate of 3 to 7 percent was used. Revenues and operating costs have also been projected in constant dollars over the time frame of the financial analysis. A summary of the key efficiency measure inputs are presented below.

### RIDERSHIP AND REVENUE FORECASTS

Ridership and revenue forecasts were originally prepared for 2025, 2035 and 2045. Revenues in intervening years were projected based on interpolations, reflecting projected annual growth in ridership. Revenues included not only passenger fares, but also onboard service revenues. Because of this, the revenues are slightly higher than those that were forecasted in Chapter 3.

## **CAPITAL COSTS**

Capital costs include rolling stock, track, freight railroad right-of-way purchase or easement fees, bridges, fencing, signaling, grade crossings, maintenance facilities and station improvements. The capital cost projections are based on year-by-year projections of each cost element and include all of the capital costs, plus some selected elements of additional costs as needed to support year-by-year capacity expansion of the system. A year-by-year implementation plan was developed (as shown in Exhibit 4-10) which detailed the Capital cash flows and funding requirements. Using this information, the Benefit Cost calculations were able to be assessed.

## **OPERATING EXPENSES**

Major operating and maintenance expenses include equipment maintenance, track and right-of-way maintenance, administration, fuel and energy, train crew and other relevant expenses. Operating expenses were estimated in 2013 constant dollars so that they would remain comparable to revenues. However, these costs do reflect the year-by-year increase in expense that is needed to handle the forecasted ridership growth, in terms of not only directly variable expenses such as credit card commissions, but also the need to add train capacity and operate either larger trains, or more train-miles every year in order to accommodate anticipated ridership growth.

Operating costs are included as a cost, whereas system revenues are included as a benefit in the discounting calculation over the life of the system. In this way they directly offset one another in the Net Present Value calculation and are also reflected in the Benefit Cost calculation. It can be seen that a system that requires an operating subsidy, e.g., where costs exceed revenues, will tend also to reflect this in the Benefit Cost ratio. This is why slow speed options such as conventional Amtrak services often fail on both the Operating Ratio and Benefit Cost ratio criteria.

## **IMPLEMENTATION PERIOD**

According to the implementation plan, the planning and construction period for this corridor will take up to fifteen years with the start-up of full system operations not occurring until 2030. This represents a very slow and conservative planning process. If the start-up can be achieved earlier, say 2025 then both the financial and economic returns would be enhanced.

### **7.2.2 ESTIMATE OF ECONOMIC BENEFITS**

A key requirement is the need for public capital investment to be supported by the economic benefit that will be generated by the rail system. Calculation of the economic benefit includes both consumer surplus and revenues generated by the system and environmental and external mode benefits; while costs include both capital and operating costs. Similar to the way most highway projects are justified, the primary justification for intercity rail projects relies on time savings multiplied by the user's value of time. The consumer surplus term equates to the passenger user's value of time savings as being the benefit an individual receives over and above the fare charged for using the system.

Calculation of benefit cost ratios requires a detailed, year-by-year forecast to support the calculation of Net Present Values for all the costs and benefits associated with the project. Specifically, a year-by-year estimate of system revenues, consumer surplus, operating costs, capital costs, and external benefits is needed to develop the Benefit Cost Analysis.

In line with Federal, State and Municipal projections, the rate of population growth, the increasing price of oil, and the increasing congestion on Virginian highways (e.g., I-95, I-64), means that there is a gradual increase in rail users over the life of the project. This has several consequences for the correct calculation of Benefit/Cost ratios for the project –

- It would be inappropriate to increase the ridership and revenue of the system in future years, without also reflecting the added operating and capital costs that will be needed to accommodate this growth in traffic.
- The result is a steady improvement in the system financial performance that reflects improved economies of scale over the 30-year life of the system. While the Benefit Cost ratios calculated do take this forecast growth into account, they also add the additional capital cost for providing the capacity needed to handle it. The economic benefits to be used in the analysis include two main categories:
  - User Benefits (Consumer Surplus)
  - Other Mode and Resource Benefits

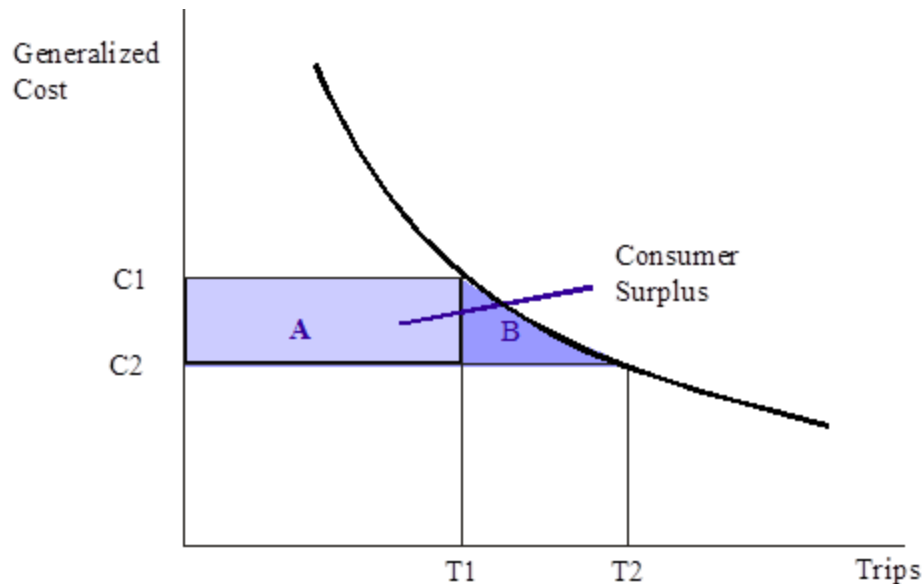
### USER BENEFITS

The analysis of user benefits for this study is based on the measurement of Generalized Cost of Travel, which includes both time and money. Time is converted into money by the use of Values of Time. The Values of Time (VOT) used in this study were derived from stated preference surveys conducted in previous study phases of work and used in the COMPASS™ multimodal demand model for the ridership and revenue forecasts. These VOTs are consistent with previous academic and empirical research and other transportation studies conducted by TEMS.

Benefits to users of the rail system are measured by the sum of system revenues and consumer surplus. Consumer surplus is used to measure the demand side impact of a transportation improvement on users of the service. It is defined as the additional benefit consumers (users of the service) receive from the purchase of a commodity or service (travel), above the price actually paid for that commodity or service. Consumer surpluses exist because there are always consumers who are willing to pay a higher price than that actually charged for the commodity or service, i.e., these consumers receive more benefit than is reflected by the system revenues alone. Revenues are included in the measure of consumer surplus as a proxy measure for the consumer surplus forgone because the price of rail service is not zero. This is an equity decision made by the USDOT to compensate for the fact that highway users pay zero for use of the road system (the only exception being the use of toll roads). The benefits apply to existing rail travelers as well as new travelers who are induced (those who previously did not make a trip) or diverted (those who previously used a different mode) to the new passenger rail system.

The RENTS™ financial and economic analysis estimates passenger travel benefits (consumer surplus) by calculating the increase in regional mobility, traffic diverted to rail, and the reduction in travel cost measured in terms of generalized cost for existing rail users. The term generalized cost refers to the combination of time and fares paid by users to make a trip. A reduction in generalized cost generates an increase in the passenger rail user benefits. A transportation improvement that leads to improved mobility reduces the generalized cost of travel, which in turn leads to an increase in consumer surplus. Exhibit 7-1 presents a typical demand curve in which Area A represents the increase in consumer surplus resulting from cost savings for existing rail users and Area B represents the consumer surplus resulting from induced traffic and trips diverted to rail.

Exhibit 7-1: Consumer Surplus Concept



The formula for consumer surplus is as follows –

$$\text{Consumer Surplus} = (C_1 - C_2) \cdot T_1 + ((C_1 - C_2) \cdot (T_2 - T_1)) / 2$$

Where:

- $C_1$  = Generalized Cost users incur before the implementation of the system
- $C_2$  = Generalized Cost users incur after the implementation of the system
- $T_1$  = Number of trips before operation of the system
- $T_2$  = Number of trips during operation of the system

The passenger rail fares used in this analysis are the average optimal fares derived from the revenue-maximization analysis that was performed for each alternative. User benefits incorporate the measured consumer surplus, as well as the system revenues, since these are benefits are merely transferred from the rail user to the rail operator.

#### OTHER MODE BENEFITS

**Other Mode and Resource Benefits:** In addition to rail-user benefits, travelers using auto or air will also benefit from the rail investment, since the system will contribute to highway congestion relief and reduce travel times for users of these other modes. For purposes of this analysis, these benefits were measured by identifying the estimated number of auto passenger trips diverted to rail and multiplying each by the updated monetary values derived from previous stated preference studies updated to 2013.

**Highway Congestion:** The highway congestion delay savings is the time savings to the remaining highway users that results from diversion of auto users to the rail mode. To estimate travel time increase within the corridor, historical highway traffic volumes were obtained from the State DOTs and local planning agencies. The average annual travel time growth in the corridor was estimated with the historical highway traffic volume data and the BPR (Bureau of Public Roads) function that can be used to calculate travel time growth with increased traffic volumes.

**The Airport Congestion Delay Savings:** The Airport Congestion Delay Savings were based 1997 FRA Commercial Feasibility Study and updated to 2013 value. The Airport Congestion Delay Savings includes the airport operation delay saving and air passenger delay saving.

**Auto Operating Cost (Non Business):** Vehicle operating cost savings for non-business travelers have been included in the current analysis as an additional resource benefit. This reflects the fact that social/leisure travelers do not accurately value the full cost of driving when making trips. As a result, the consumer surplus calculation for commuters, social, leisure and tourist travelers has not fully reflected the real cost of operations of an automobile, but only the cost of gas. The difference between the cost of gas and the full cost of driving reflects a real savings that should be included in a Benefit Cost analysis.

**Emissions:** The diversion of travelers to rail from the auto mode generates emissions savings. The calculated emissions savings are based on changes in energy use with and without the proposed rail service. This methodology takes into account the region of the country, air quality regulation compliance of the counties served by the proposed rail service, the projection year, and the modes of travel used for access/egress as well as the line-haul portion of the trip. Highway Reduced Emissions were estimated from the vehicle miles traveled (VMT) and flight reductions derived from the ridership model. The assumption is that a reduction in VMT or flights is directly proportional to the reduction in emissions. The pollutant values were taken from the latest TIGER III Grant Benefit-Cost Analysis (BCA) Resource Guide<sup>1</sup>.

**Public Safety Benefits:** Public Safety is calculated from the diverted Vehicle-Miles times the NHTSA<sup>2</sup> fatality and injury rate per Vehicle mile and then times the values of fatality and injury from the latest TIGER III Grant Benefit-Cost Analysis (BCA) Resource Guide<sup>1</sup>. This was calculated for 2025, 2035 and 2045 then interpolated or extrapolated for all other years.

### 7.3 FINANCIAL RESULTS

The financial evaluation was completed for all route options (1, 2, 3 and 4) that are being assessed in the Route Analysis. Options 1 and 2 each included two route variants and two technology options for each route, reflecting different access routes into Richmond and are defined as sub-options. Specifically, the five sub-options are as follows:

- Southern Option 1A – Greenfield via Petersburg
- Southern Option 1B – Norfolk Southern (NS) via Petersburg
- Northern Option 2A – Greenfield via Hopewell
- Northern Option 2B – Norfolk Southern (NS) via Hopewell
- Option 3 – Richmond Direct
- Option 4 - Richmond Direct Improved (Option 3 w/Peninsula Service added)

For Options 1, 2 and 3, two technology options were developed for the 130-mph diesel technology, and the 220-mph electric technology. Option 4 is defined as a combination of diesel and electric technology so only Financial and Economic evaluation needed to be performed for that option.

The Financial Analysis methodology followed typical financial cash flow analysis and USDOT-Tiger Grant guidelines, as well as OMB discount procedures for the economic analysis. There are two key operating financial performance factors for the system, which are the key drivers of the financial evaluation:

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<sup>1</sup> [http://www.dot.gov/sites/dot.dev/files/docs/TIGER\\_BCA\\_RESOURCE\\_GUIDE.pdf](http://www.dot.gov/sites/dot.dev/files/docs/TIGER_BCA_RESOURCE_GUIDE.pdf)

<sup>2</sup> <http://www.nhtsa.gov/>

- **System Revenues:** These include the fare box revenues and revenues from onboard sales. Revenues were derived from the Ridership and Revenue Analysis.
- **Operating Costs:** These are the operating and maintenance costs associated with running the train schedules and include onboard service costs. The operating costs for the system were developed using the methodology.

The **Operating Surplus**, which is defined as Revenues minus Operating Cost, is a critical factor in the overall business case as it determines the ability to franchise the operation.

- **If the operating surplus is positive**, the system will not require any operating subsidy, and it will even be able to make a contribution towards its own Capital cost, as the Northeast Corridor does today. In addition because the system is generating a positive cash flow, a Private-Public Partnership or other innovative financing methods can be used to construct and operate the system. This absolves the local entity of any need for providing an operating subsidy but more than this, it is not uncommon for the operating cash flow to be sufficient to cover the local match requirement as well.
- **If the operating surplus is negative**, the system will not only require a grant of capital to build the system, but in addition it will also require an ongoing operating subsidy. An operating subsidy not only prevents the project from being a Public Private Partnership, but casts doubt on the efficiency of the system and the reason for the project. In addition, a subsidy will reduce the economic performance of the system as it will actually offset part of the economic benefits of the system (e.g. Consumer Surplus, Environmental Benefits). This will depress the Benefit Cost ratio. If the subsidy is not too great and the capital cost is not too high, in some cases it may still be possible to maintain a positive Benefit Cost ratio. But the larger the subsidy and the higher the capital cost, the harder it is to show a positive Benefit Cost ratio. It is not uncommon for passenger rail systems that operate slower than 100-mph<sup>3</sup> to fail both FRA's Operating Ratio and Benefit Cost criteria.

### 7.3.1 OPERATING RATIOS

Exhibit 7-2 shows the revenues, operating costs and operating ratios for each route option variant for year 2035. Exhibit 7-3 displays bar charts that compare 2035 revenues and operating costs for 130-mph vs 220-mph technology options.

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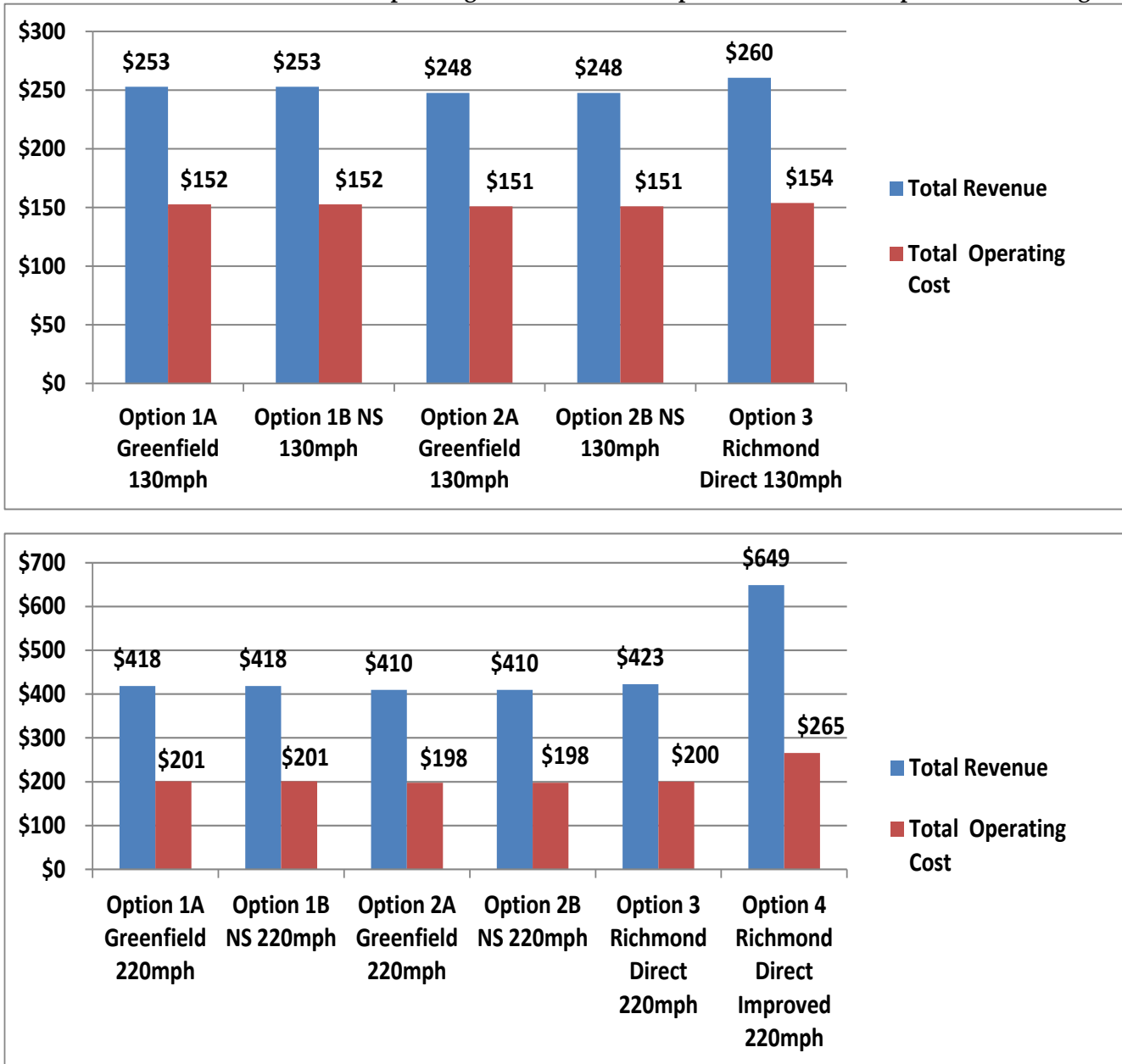
<sup>3</sup> *Atlanta-Charlotte Tier I EIS*, in publication, and *Cost-Benefit Analysis of Washington-Richmond High-Speed Rail*, George Mason University for Amtrak, May 14, 2010. See: [http://policy.gmu.edu/wp-content/uploads/Cost\\_Benefit\\_Analysis\\_of\\_Washington\\_Richmond\\_High\\_Speed\\_Rail.pdf](http://policy.gmu.edu/wp-content/uploads/Cost_Benefit_Analysis_of_Washington_Richmond_High_Speed_Rail.pdf)



Exhibit 7-2: Years 2035 Revenues and Operating Ratios for all HRTPO Rail Options

Financial 2035 (mill. 2013\$)	Southern Option 1 Via Petersburg				Northern Option 2 -Via Hopewell				Option 3 Richmond Direct		Option 4 Richmond Direct Improved
	Southern Option 1A Greenfield		Southern Option 1B Norfolk Southern		Northern Option 2A Greenfield		Northern Option 2B Norfolk Southern		Option 3 Richmond Direct		Option 4 Richmond Direct Improved
	130mph	220mph	130mph	220mph	130mph	220mph	130mph	220mph	130mph	220mph	220mph
<b>Revenue</b>											
Ticket Revenue	\$233.97	\$387.38	\$233.97	\$387.38	\$229.19	\$379.49	\$229.19	\$379.49	\$241.19	\$391.26	\$600.48
OBS Revenue 8%	\$18.72	\$30.99	\$18.72	\$30.99	\$18.33	\$30.36	\$18.33	\$30.36	\$19.30	\$31.30	\$48.04
<b>Total Revenue</b>	<b>\$252.68</b>	<b>\$418.37</b>	<b>\$252.68</b>	<b>\$418.37</b>	<b>\$247.52</b>	<b>\$409.85</b>	<b>\$247.52</b>	<b>\$409.85</b>	<b>\$260.49</b>	<b>\$422.56</b>	<b>\$648.52</b>
<b>COSTS</b>											
Train Crew	\$12.85	\$18.16	\$12.85	\$18.16	\$12.70	\$17.78	\$12.70	\$17.78	\$13.05	\$18.19	\$24.71
OBS	\$16.04	\$25.01	\$16.04	\$25.01	\$15.77	\$24.50	\$15.77	\$24.50	\$16.44	\$25.18	\$36.97
Equipment	\$33.16	\$55.58	\$33.16	\$55.58	\$32.78	\$54.43	\$32.78	\$54.43	\$33.69	\$55.67	\$75.64
Fuel	\$24.36	\$10.66	\$24.36	\$10.66	\$24.08	\$10.44	\$24.08	\$10.44	\$24.75	\$10.67	\$14.51
Track	\$11.95	\$23.45	\$11.95	\$23.45	\$11.78	\$23.12	\$11.78	\$23.12	\$11.56	\$22.68	\$25.47
Insurance	\$8.77	\$13.26	\$8.77	\$13.26	\$8.67	\$12.99	\$8.67	\$12.99	\$8.91	\$13.28	\$18.05
Call Ctr Variable	\$3.13	\$4.43	\$3.13	\$4.43	\$3.09	\$4.33	\$3.09	\$4.33	\$3.26	\$4.58	\$6.16
T-Agent and CC Comm	\$6.55	\$10.85	\$6.55	\$10.85	\$6.42	\$10.63	\$6.42	\$10.63	\$6.75	\$10.96	\$16.81
Stations	\$6.45	\$6.45	\$6.45	\$6.45	\$6.45	\$6.45	\$6.45	\$6.45	\$5.91	\$5.91	\$6.98
Admin and Mgt	\$19.15	\$21.61	\$19.15	\$21.61	\$19.10	\$21.46	\$19.10	\$21.46	\$19.23	\$21.62	\$24.24
Operation & Dispatch	\$1.09	\$1.70	\$1.09	\$1.70	\$1.07	\$1.67	\$1.07	\$1.67	\$1.05	\$1.64	\$2.61
Operator Profit 10% selected items	\$8.96	\$9.89	\$8.96	\$9.89	\$8.87	\$9.73	\$8.87	\$9.73	\$9.05	\$9.87	\$13.30
<b>Total Cost</b>	<b>\$152.46</b>	<b>\$201.03</b>	<b>\$152.46</b>	<b>\$201.03</b>	<b>\$150.78</b>	<b>\$197.52</b>	<b>\$150.78</b>	<b>\$197.52</b>	<b>\$153.66</b>	<b>\$200.25</b>	<b>\$265.45</b>
<b>Operating Surplus</b>	<b>\$100.23</b>	<b>\$217.34</b>	<b>\$100.23</b>	<b>\$217.34</b>	<b>\$96.74</b>	<b>\$212.33</b>	<b>\$96.74</b>	<b>\$212.33</b>	<b>\$106.82</b>	<b>\$222.31</b>	<b>\$383.06</b>
<b>Operating Ratio</b>	<b>1.66</b>	<b>2.08</b>	<b>1.66</b>	<b>2.08</b>	<b>1.64</b>	<b>2.07</b>	<b>1.64</b>	<b>2.07</b>	<b>1.70</b>	<b>2.11</b>	<b>2.44</b>

Exhibit 7-3: Year 2035 Revenues vs Operating Costs Diesel 130-mph and Electric 220-mph Rail Technologies



It can be seen that all route variants have positive operating surpluses and positive operating ratios in year 2035, with the Electric 220-mph options having better results due to higher ridership and revenues despite the higher operating costs. The results of this analysis also show that all of the proposed route options are franchisable with a positive cash flow that is greater than the system operating costs.

Option 3, the Richmond Direct route using 220-mph technology, is seen to have slightly better cash flows than the other options, although they are all very comparable to each other. However, the best option by far is seen to be the Option 4 which adds a diesel service at 130-mph on top of the Option 3 Richmond direct 220-mph electric service. Adding rail service to the Peninsula as well as the Southside in Option 4 substantially boosts the revenue and ridership potential of the overall system.

## 7.4 ECONOMIC RESULTS

The Demandside Economic Analysis was completed using data derived from the Ridership and Revenue Analysis, the Infrastructure Analysis, and the Operating Analysis. This provided:

- **System Revenues** - Fare box and onboard revenue
- **Operating Costs** - Operating and maintenance costs
- **Capital costs** - Infrastructure costs

In addition, the Economic benefits of the system to be assessed for the analysis include –

- **Consumer Surplus** – benefit to system users
- **Revenues**
- **Highway Congestion Savings** – benefits to road users of less congestion
- **Airport Delay Savings** – benefits to air travelers
- **Safety Benefits** – benefit of less accidents
- **Reduced Emissions** – benefit of lower emissions levels
- **Highway Resource Savings**

### 7.4.1 COST BENEFIT RATIOS AND NET PRESENT VALUE

The economic results for all options and technology variants are shown in exhibit 7-4. The exhibit shows the NPV break down of benefits, costs and the resulting Benefit/Cost ratio at the 3% and 7% discount rates. Exhibit 7-5 graphically compares the total benefits vs total costs for each of the route technology options at 3% and 7% discount rates.

Exhibit 7-4: Comparing the Benefit-Cost and NPV Surplus results at the 3% and 7% Discount rates  
for all route and technology variants

Southern Option 1 - Via Petersburg

million \$	3% Discount				7% Discount			
	Option 1A Greenfield 130mph	Option 1A Greenfield 220mph	Option1B NS 130mph	Option1B NS 220mph	Option 1A Greenfield 130mph	Option 1A Greenfield 220mph	Option1B NS 130mph	Option1B NS 220mph
System Passenger Revenues	\$2,844	\$4,673	\$2,844	\$4,673	\$945	\$1,563	\$945	\$1,563
OBS	\$228	\$374	\$228	\$374	\$76	\$125	\$76	\$125
Users Consumer Surplus	\$2,248	\$2,805	\$2,248	\$2,805	\$760	\$949	\$760	\$949
Highway Congestion Savings	\$1,668	\$2,381	\$1,668	\$2,381	\$536	\$769	\$536	\$769
Airport Delay Saving	\$265	\$418	\$265	\$418	\$86	\$135	\$86	\$135
Safety Benefits	\$506	\$799	\$506	\$799	\$170	\$269	\$170	\$269
Highway Reduced Emissions	\$112	\$177	\$112	\$177	\$37	\$59	\$37	\$59
<b>Total Benefits</b>	<b>\$7,871</b>	<b>\$11,626</b>	<b>\$7,871</b>	<b>\$11,626</b>	<b>\$2,610</b>	<b>\$3,870</b>	<b>\$2,610</b>	<b>\$3,870</b>
Capital Cost	\$3,713	\$5,136	\$3,686	\$5,099	\$2,094	\$2,897	\$2,079	\$2,876
O&M Costs	\$1,820	\$2,366	\$1,820	\$2,366	\$609	\$798	\$609	\$798
Cyclic Mtn	\$65	\$65	\$65	\$65	\$18	\$18	\$18	\$18
<b>Total Costs</b>	<b>\$5,598</b>	<b>\$7,567</b>	<b>\$5,571</b>	<b>\$7,530</b>	<b>\$2,721</b>	<b>\$3,713</b>	<b>\$2,706</b>	<b>\$3,692</b>
<b>NPV(Surplus)</b>	<b>\$2,273</b>	<b>\$4,059</b>	<b>\$2,300</b>	<b>\$4,096</b>	<b>(\$110)</b>	<b>\$158</b>	<b>(\$95)</b>	<b>\$178</b>
<b>Benefit/Cost Ratio</b>	<b>1.41</b>	<b>1.54</b>	<b>1.41</b>	<b>1.54</b>	<b>0.96</b>	<b>1.04</b>	<b>0.96</b>	<b>1.05</b>

Exhibit 7-4: Comparing the Benefit-Cost and NPV Surplus results at the 3% and 7% Discount rates  
for all route and technology variants (cont)

Northern Option 2 - Via Hopewell

million \$	3% Discount				7% Discount			
	Option 2A Greenfield 130mph	Option 2A Greenfield 220mph	Option 2B NS 130mph	Option 2B NS 220mph	Option 2A Greenfield 130mph	Option 2A Greenfield 220mph	Option 2B NS 130mph	Option 2B NS 220mph
System Passenger Revenues	\$2,786	\$4,583	\$2,786	\$4,583	\$926	\$1,531	\$926	\$1,531
OBS	\$223	\$367	\$223	\$367	\$74	\$122	\$74	\$122
Users Consumer Surplus	\$2,224	\$2,732	\$2,224	\$2,732	\$753	\$924	\$753	\$924
Highway Congestion Savings	\$1,652	\$2,344	\$1,652	\$2,344	\$531	\$757	\$531	\$757
Airport Delay Saving	\$263	\$376	\$263	\$376	\$86	\$122	\$86	\$122
Safety Benefits	\$498	\$788	\$498	\$788	\$167	\$265	\$167	\$265
Highway Reduced Emissions	\$111	\$175	\$111	\$175	\$36	\$58	\$36	\$58
<b>Total Benefits</b>	<b>\$7,757</b>	<b>\$11,364</b>	<b>\$7,757</b>	<b>\$11,364</b>	<b>\$2,573</b>	<b>\$3,780</b>	<b>\$2,573</b>	<b>\$3,780</b>
Capital Cost	\$3,714	\$5,137	\$3,674	\$5,082	\$2,095	\$2,897	\$2,072	\$2,867
O&M Costs	\$1,800	\$2,327	\$1,800	\$2,327	\$602	\$784	\$602	\$784
Cyclic Mtn	\$64	\$64	\$64	\$64	\$18	\$18	\$18	\$18
<b>Total Costs</b>	<b>\$5,578</b>	<b>\$7,528</b>	<b>\$5,538</b>	<b>\$7,473</b>	<b>\$2,714</b>	<b>\$3,699</b>	<b>\$2,692</b>	<b>\$3,668</b>
<b>NPV(Surplus)</b>	<b>\$2,180</b>	<b>\$3,836</b>	<b>\$2,219</b>	<b>\$3,891</b>	<b>(\$141)</b>	<b>\$81</b>	<b>(\$119)</b>	<b>\$111</b>
<b>Benefit/Cost Ratio</b>	<b>1.39</b>	<b>1.51</b>	<b>1.40</b>	<b>1.52</b>	<b>0.95</b>	<b>1.02</b>	<b>0.96</b>	<b>1.03</b>

Exhibit 7-4: Comparing the Benefit-Cost and NPV Surplus results at the 3% and 7% Discount rates  
for all route and technology variants (cont)

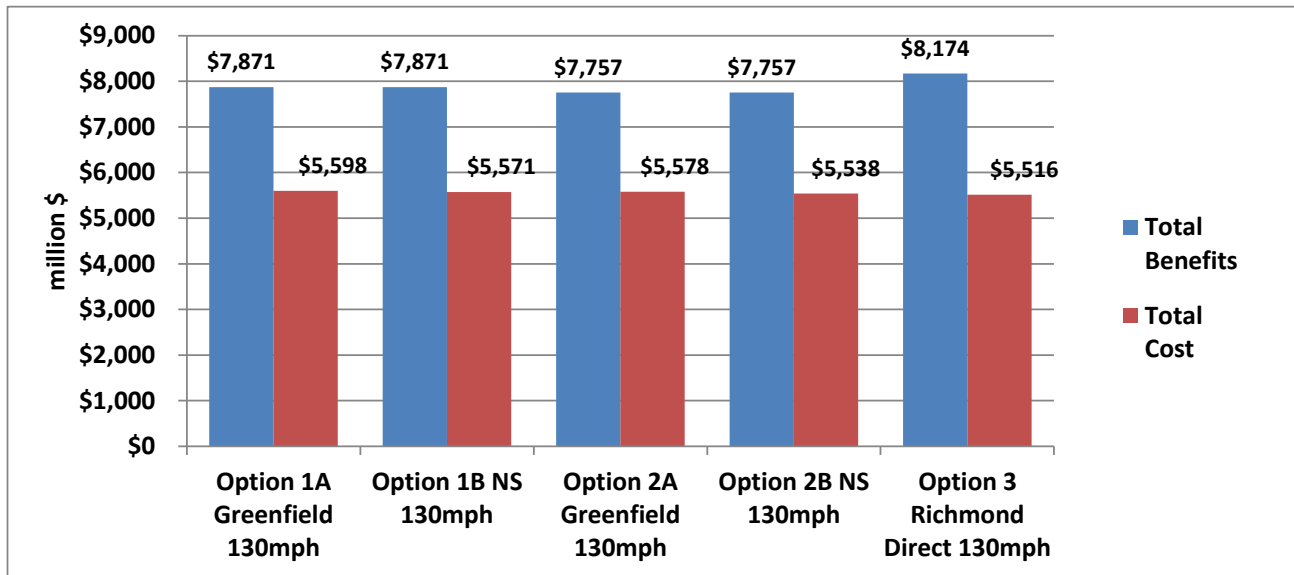
Richmond Direct Options 3 and 4

million \$	3%			7%		
	Option 3 Richmond Direct 130mph	Option 3 Richmond Direct 220mph	Option 4 Richmond Direct Improved 220mph	Option 3 Richmond Direct 130mph	Option 3 Richmond Direct 220mph	Option 4 Richmond Direct Improved 220mph
System Passenger Revenues	\$2,925	\$4,718	\$7,142	\$974	\$1,578	\$2,399
OBS	\$234	\$377	\$571	\$78	\$126	\$192
Users Consumer Surplus	\$2,326	\$2,920	\$5,870	\$787	\$987	\$1,990
Highway Congestion Savings	\$1,790	\$2,454	\$2,934	\$576	\$794	\$952
Airport Delay Saving	\$267	\$424	\$479	\$87	\$137	\$155
Safety Benefits	\$517	\$801	\$1,101	\$173	\$270	\$372
Highway Reduced Emissions	\$115	\$178	\$244	\$38	\$59	\$81
<b>Total Benefits</b>	<b>\$8,174</b>	<b>\$11,872</b>	<b>\$18,340</b>	<b>\$2,714</b>	<b>\$3,952</b>	<b>\$6,140</b>
Capital Cost	\$3,622	\$5,010	\$5,737	\$2,043	\$2,826	\$3,236
O&M Costs	\$1,832	\$2,357	\$3,116	\$613	\$795	\$1,054
Cyclic Mtn	\$63	\$63	\$78	\$17	\$17	\$22
<b>Total Costs</b>	<b>\$5,516</b>	<b>\$7,429</b>	<b>\$8,931</b>	<b>\$2,673</b>	<b>\$3,638</b>	<b>\$4,311</b>
<b>NPV(Surplus)</b>	<b>\$2,658</b>	<b>\$4,443</b>	<b>\$9,409</b>	<b>\$40</b>	<b>\$314</b>	<b>\$1,829</b>
<b>Benefit/Cost Ratio</b>	<b>1.48</b>	<b>1.60</b>	<b>2.05</b>	<b>1.02</b>	<b>1.09</b>	<b>1.42</b>



Exhibit 7-5: Comparing the total benefits vs costs for each of the route technology options at 3% and 7% discount rates

Diesel 130 mph Technology Options at 3% Discount Rate



Electric 220 mph Technology Options at 3% Discount Rate

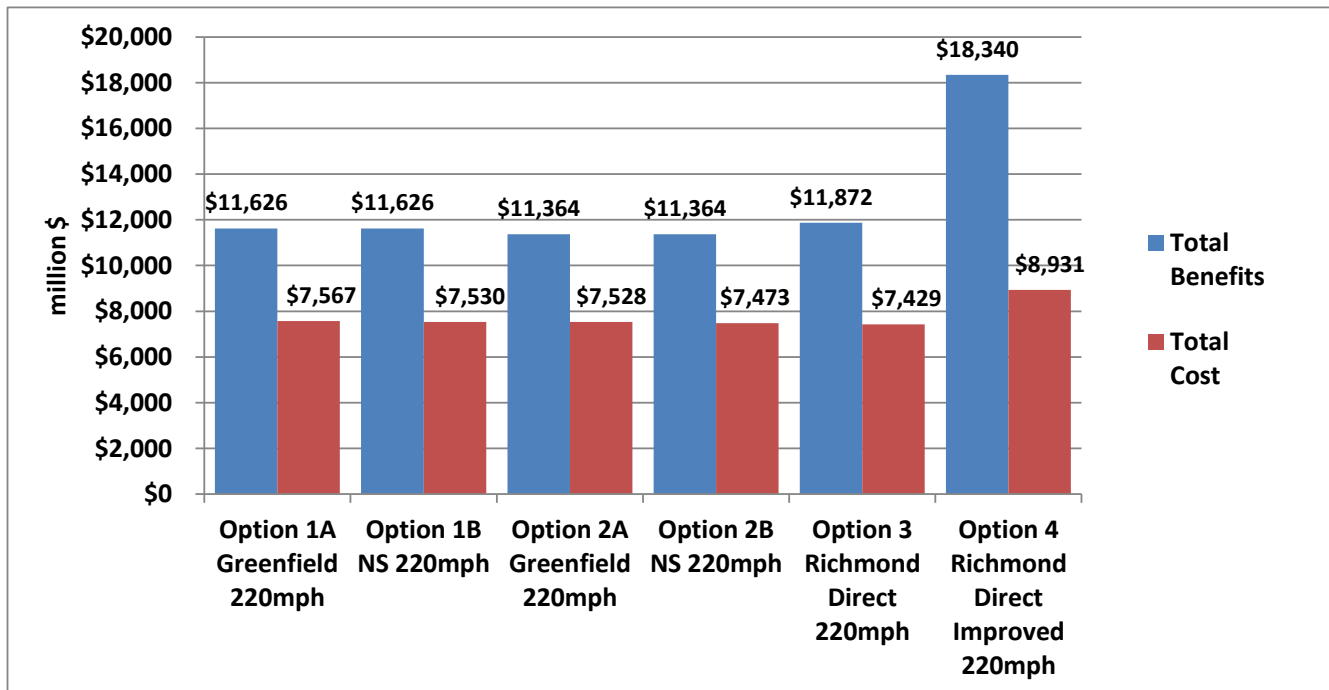
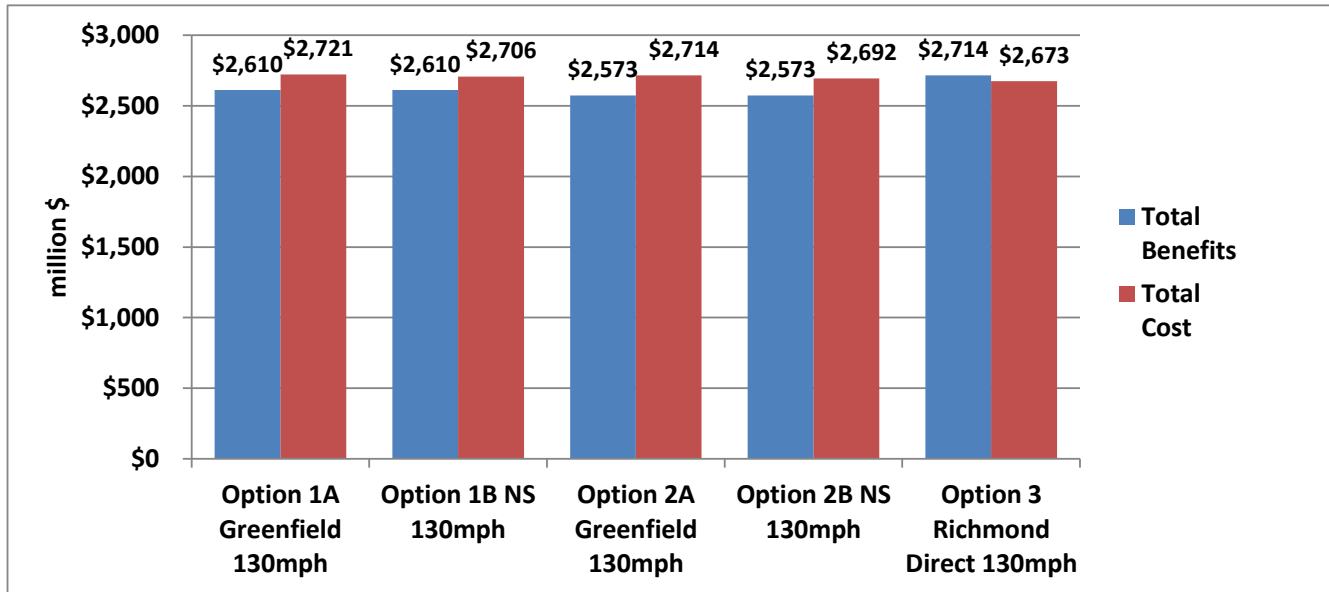
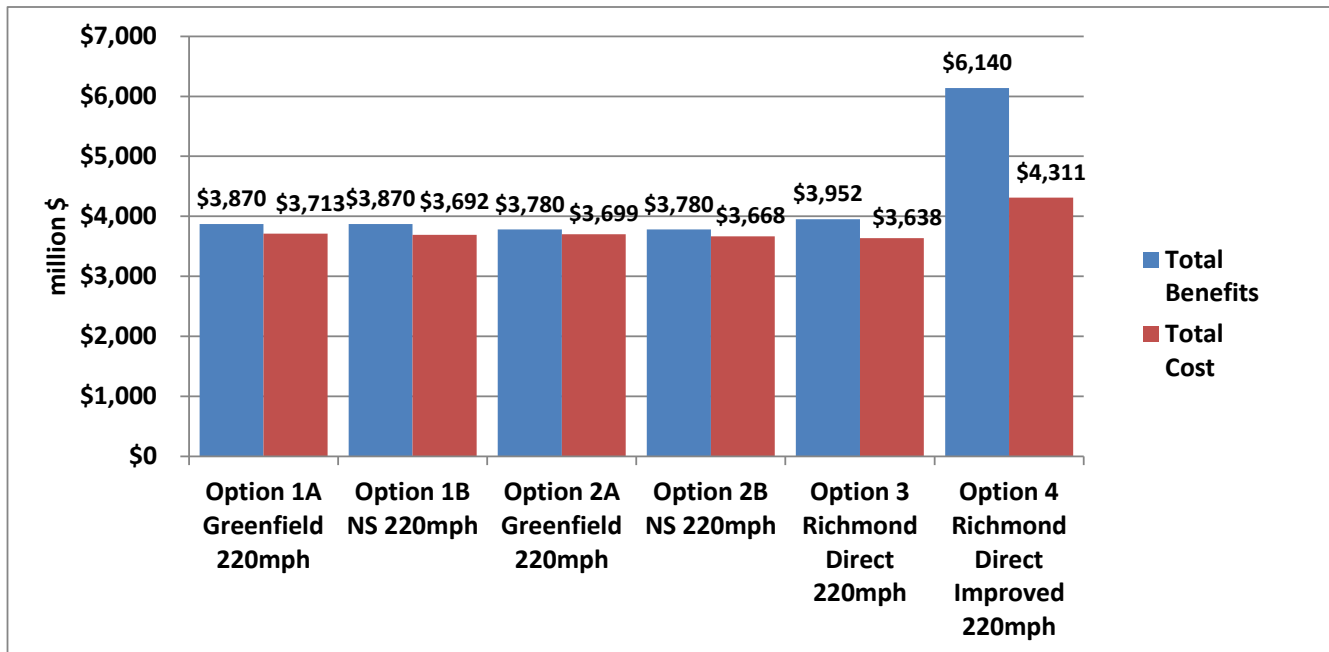


Exhibit 7-5: Comparing the total benefits vs costs for each of the route technology options at 3% and 7% discount rates (cont)

Diesel 130-mph Technology Options at 7% Discount Rate



Electric 220-mph Technology Options at 7% Discount Rate



This analysis begins by performing an apples-to-apples comparison of the five Norfolk-Washington D.C. route options 1A, 1B, 2A, 2B and 3:

- As can be seen in the exhibits, all route options show positive benefit/cost ratios with Option 3 (Richmond Direct) using 220-mph technology showing the best results of all the Norfolk-Washington D.C. options at the 3% discount level (B/C: 1.60). However, all Norfolk-Washington D.C. options have results that are comparable to each other at both the 3% and 7% discount rates. Also, all route options using the 220-mph electric train technology have better financial results vs the options that use 130-mph diesel technology, although with much lower gains at the 7% discount rates. NPV Surpluses, in particular, are higher for all route options using the 220-mph electric technology with surpluses being much greater at the 3% discount rate vs the 7% discount rate. In fact, 130-mph technology Norfolk-Washington D.C. options 1A, 1B, 2A and 2B have negative NPV values at the 7% discount rate. NPV surpluses for the 220-mph technology options are greater despite their higher costs due to the increases in ridership and overall benefits that using a more efficient higher speed rail technology would bring. In conclusion, the results show that all Norfolk-Washington D.C. options and technology variants are viable at the 3% discount rate; however, only Option 3 Richmond Direct remains viable at the 7% discount rate for all technology variants.
- Based on these results, the most viable route option for Norfolk-Washington D.C. is found to be Option 3 Richmond Direct using electric 220-mph train technology. For this option an initial 130-mph implementation step is even possible given that 130-mph technology is viable at a 7% discount rate.

Based on this finding that Option 3 Richmond Direct gave the best standalone result for Norfolk-Washington D.C., an additional Option 4 Richmond Direct Improved was developed by noting that a substantial portion of this same alignment could also potentially be shared by a Peninsula rail service.

Adding a Peninsula rail service makes Option 4 clearly stand above all the others. It is clear that adding additional ridership and revenue from the Peninsula significantly enhances the economics of the overall Hampton Roads – Richmond – Washington D.C. rail corridor. The most significant metric is the Cost Benefit ratio at 7% which jumps from 1.09 for Option 3 up to 1.42 for Option 4.

Given the fact that the 7% discount rate is actually a capital rationing rate, the ability to project a 1.42 Cost Benefit ratio at such a high interest rate shows that development of the Hampton Roads – Richmond – Washington D.C. corridor including Peninsula rail service is truly an outstanding project. Its implementation would strongly benefit Hampton Roads, Virginia and the US economy as a whole.

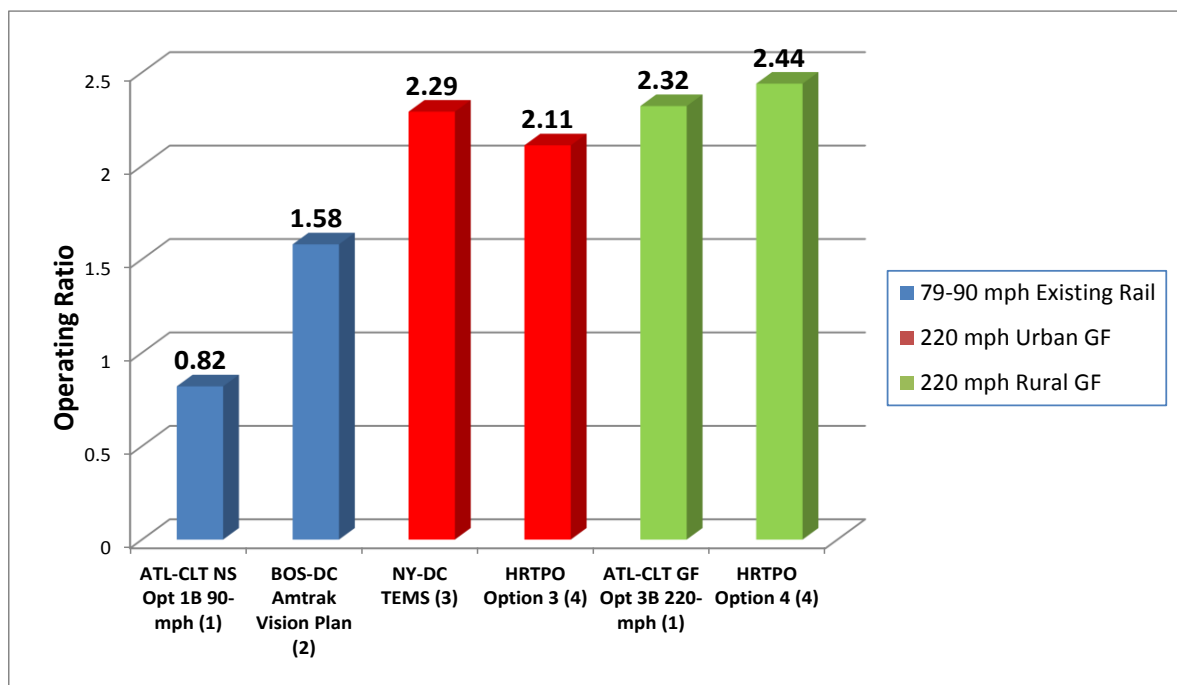
## 7.5 BENCHMARKING COMPARISONS

Benchmarking comparisons have been developed to put the current study results into context of the findings of other studies. The comparison divides projects into three groups:

- (1) **Projects based on upgrading existing rail lines at 79-90 mph.** These tend to be rail lines where, although the underlying market may be strong, train speeds are severely limited due to geometric considerations. As a result these projects have difficulty in producing travel times that are auto competitive.
- (2) **NEC Projects based on extensive use of Urban Greenfield.** These projects typically entail massive bridging and tunneling, e.g. long urban tunnels (such as under Baltimore, Philadelphia and New York) and often underwater tunnels (e.g. Hudson and East Rivers) at double to triple the cost of normal tunnels. California High Speed rail also has some segments of urban greenfield which add considerably to its cost.
- (3) **National Projects based on extensive use of Rural Greenfield.** High Speed rail can be economical in corridors that are less dense than the NEC, if costs can be kept in proportion to the ridership forecast. Typically this is done by maximizing the use of greenfields in rural areas where construction is relatively economical, but avoiding the use of urban greenfield where costs can be an order of magnitude higher.

As shown in Exhibit 7-6, projects in the low speed range tend to have negative operating ratios <1.0 (e.g. require operating subsidies) whereas faster speeds make the service a lot more attractive to riders allows high enough fares to be charged so the need for operating subsidies can be eliminated. Typically 220-mph High Speed rail systems produce operating ratios in the 2.0-3.0 range spinning off substantial positive cash flows that can cover at least of portion of the system's capital cost.

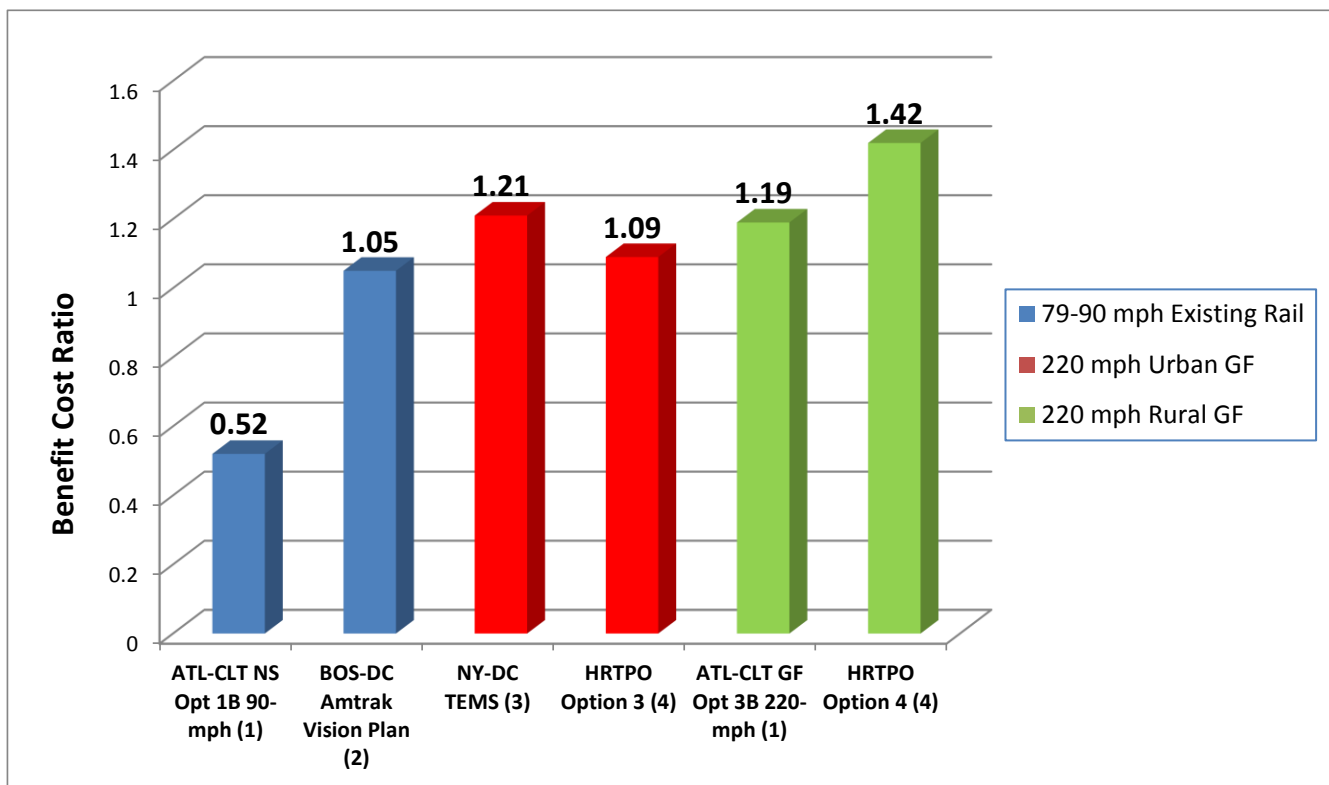
Exhibit 7-6: Benchmarking on Operating Ratio Results



In Exhibit 7-6, the Amtrak Vision Plan result (although strongly positive) is a little lower than TEMS since it includes regional operations over existing tracks all the way to Boston, as well as some corridor extensions (e.g. Springfield and Harrisburg). The TEMS result is only for the core New York to Washington High Speed spine and is based on a moderate fare that is intended to promote the broad market applicability of the service, rather than the narrow market extremely high fare focus of Amtrak's current Acela service. This NEC moderate fare assumption would produce operating results that are very similar to the proposed Hampton Roads service. If an Acela-level average fare continued to be applied, the NEC operating ratio results would be better than shown, but the Cost Benefit results would be depressed undermining the case for public investment in the infrastructure. The moderate fare scenario as proposed is more socially beneficial and since the fare is lower, it would result in a higher ridership and better Cost Benefit result. The moderate fare scenario would require however, more capital contribution from the Public sector than the high fare scenario.

Regarding the Cost Benefit results shown in Exhibit 7-7, a key finding is that results for low speed intercity services tend to be negative, as was found to be the case for upgrades to the Atlanta-Charlotte<sup>4</sup> existing NS rail line. These projects tend to produce negative cost benefit ratios <1.0. A handful of very inexpensive projects for upgrading light density branch lines have been seen to produce positive cost benefit ratios >1.0 but they still have negative operating ratios < 1.0 (e.g. require operating subsidies.) However given the high costs for adding capacity to major mainline freight routes, and the operating restrictions and service reliability impacts that tend to go along with those kinds of strategies, negative economic results tend to be the norm for these kinds of projects.

Exhibit 7-7: Benchmarking on Cost Benefit Results



<sup>4</sup> Reference (1) in Exhibit 7-7: Atlanta-Charlotte Tier I EIS, in publication

Regarding Cost Benefit results for High Speed rail, it should be noted that the cost for Urban Greenfield is much higher than that for Rural Greenfield development. While rural greenfield typically costs \$30-40 million a mile for a double track section, urban tunnels can cost \$300 million a mile and underwater tunnels \$1 billion a mile. The cost of these extensive bridges and tunnels can be seen Amtrak's average cost of \$274 million per mile<sup>5</sup> for NEC improvements<sup>6</sup> all the way to Boston. These include major tunnels under Baltimore, Philadelphia and New York City.<sup>7</sup> Nonetheless it is interesting to note that even with such high costs Amtrak has projected a positive Cost Benefit ratio (1.05 at 7%) for this investment.

This classic European approach to development of High Speed rail is to limit development of greenfields to rural areas to keep the cost down, and use existing rail lines to gain access to the urban cores. In development of High Speed Rail options for Hampton Roads TEMS has followed the classic European approach, intentionally seeking to avoid the kinds of massive bridging and tunneling that have been proposed for the NEC north of Washington, D.C. By doing this, it is possible to hold costs to affordable and economically justifiable levels.

As a result, in terms of Cost Benefit results for High Speed proposals that are primarily based on rural Greenfields, these are seen to be just as satisfactory if not more so than the higher density, but much more expensive corridor investments such as the NEC. This is not to say that such approaches are not necessary or justified for the NEC. But the key in every case is to appropriately match the infrastructure to market demand, as has been done in development of this High Speed Rail plan for Hampton Roads.

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<sup>5</sup> Reference (2) in Exhibit 7-7: *A Vision for High-Speed Rail in the Northeast Corridor*, Amtrak, September 2010.  
<http://www.amtrak.com/ccurl/214/393/A-Vision-for-High-Speed-Rail-in-the-Northeast-Corridor.pdf>

<sup>6</sup> Reference (3) in Exhibit 7-7: TEMS' own studies have identified a number of segments between Washington D.C. and New York that could be improved for a fraction of this cost. For example, the New Jersey "Raceway" from Trenton to Newark is very straight and could accommodate 220-mph service with just a few curve easements. Similarly there is a long stretch of open countryside between Baltimore and Wilmington that could allow development of a 220-mph priority Greenfield segment. We would recommend that these two areas be the first NEC segments to be upgraded to 220-mph. After that however still remain the more difficult built-up areas through downtown Baltimore to Washington, from Wilmington through Philadelphia to Trenton, and from Newark into New York City where adding the needed capacity will be much more expensive. These stretches of Urban Greenfield are why the NEC costs are so much higher than other comparable High Speed rail projects.

<sup>7</sup> However, even in Europe although some projects like this have been completed (for example, the Channel Tunnel Rail Link to King's Cross station on the north side of London) this type of project is clearly the exception rather than the rule.



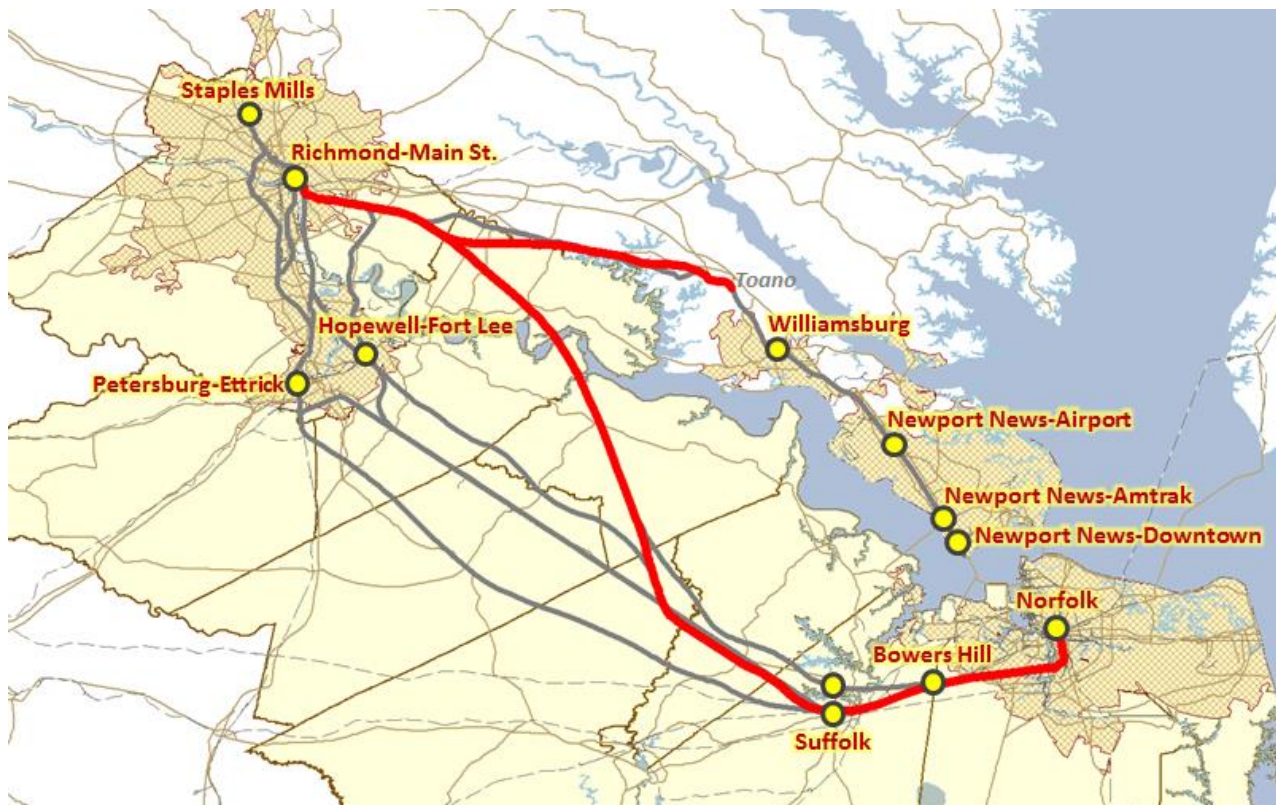
## 8. PREFERRED OPTION DEVELOPMENT

*In this chapter the concept of a preferred option is defined and assessed, and considers how the external benefits to Southeast High-Speed Rail could potentially improve the results for the basic Hampton Roads-Richmond-Washington D.C. service. The assessment is a sensitivity analysis of how these external factors might improve the Financial and Economic results.*

### 8.1 OPTION 4, RICHMOND DIRECT IMPROVED

All of the outcomes of the Phase 2(B) Financial and Economic Analysis for the original Norfolk to Richmond Options 1-3 were very close, but the inclusion of a Peninsula connection in Option 4 dramatically improves the financial and economic performance of the system. As shown in Exhibit 8-1, this study has developed Option 4, Richmond Direct Improved (see Exhibit 8-1) to the same level of detail as the original Option 1-3. This would add a high speed connection to the Peninsula -- from Roxbury to the existing CSX line near Toano. The connection would be only 20 miles in length but would offer Peninsula trains some 140 miles of high speed operation from just outside Williamsburg to Washington. The connector would provide a relatively low cost link to the proposed Richmond Direct alignment.

Exhibit 8-1: Option 4, Richmond Direct Improved



Building this link would improve average train speeds on the Peninsula to a level that would significantly increase demand and would require a train service of 8-10 trains per day. This is comparable with what was envisaged by the HRTPO Board Objective of Enhanced Passenger Rail Service for the Peninsula. Because it would use 130-mph high speed train technology, this connection would provide a two hour connection from Newport News to Washington, and a 1 ½ hour schedule from Williamsburg to Washington. This schedule is also very close to the schedule outlined for the Peninsula Enhanced Passenger Rail Service in Step 4 of the passenger rail development program set out by HRTPO and DRPT.<sup>1</sup>

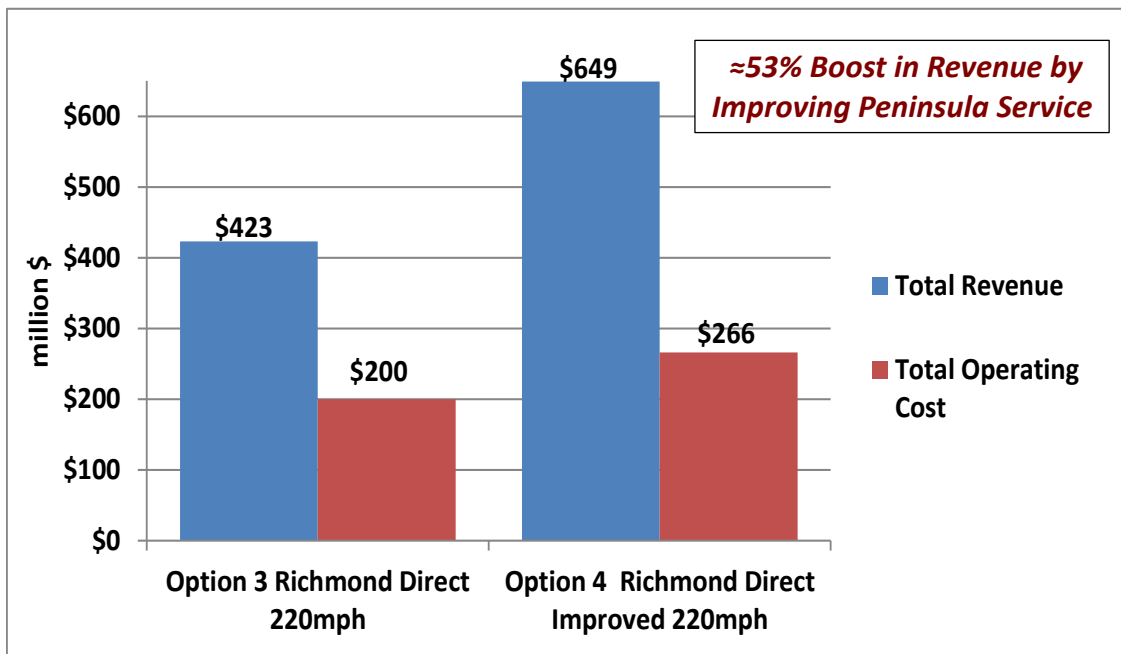
Exhibit 8-2 compares the revenues, operating costs and operating ratios for Richmond Direct Improved, Option 4 with the best of the original options, Richmond Direct, Option 3 for year 2035. Exhibit 8-3 provides a bar chart comparison of revenues and operating costs for Option 4 Richmond Direct Improved and Option 3 Richmond Direct.

**Exhibit 8-2: Option 3, Richmond Direct vs Option 4 Richmond Direct Improved  
Comparison of Year 2035 Financial Results**

Financial 2035 (mill. 2013\$)	Option 3 Richmond Direct	Option 4 Richmond Direct Improved
	220mph	220mph
<b><u>Revenue</u></b>		
Ticket Revenue	\$391	\$600
OBS Revenue 8%	\$31	\$48
<b>Total Revenue</b>	<b>\$423</b>	<b>\$649</b>
<b>Total Operating Cost</b>	<b>\$200</b>	<b>\$266</b>
<b>Operating Surplus</b>	<b>\$222</b>	<b>\$383</b>
<b>Operating Ratio</b>	<b>2.11</b>	<b>2.44</b>

<sup>1</sup> Step 4 assumed 79-mph operation in the urban areas of Newport News and Williamsburg, 110-mph operation from Williamsburg to Richmond, and 130-mph operation from Richmond to Washington. On the Richmond-Washington segment, the train would use the same tracks as the true high speed option from Norfolk. As a result, the high speed diesel train could operate at a top speed of 130-mph. Option 4 provides for 90-mph operation on the existing CSX alignment and 130-mph running on a new dedicated greenfield passenger alignment from Toano north. As such, Option 4 has a slightly better train time than that proposed in the original development program Step 4.

**Exhibit 8-3: Bar Chart Comparing Total Revenue and Operating Cost for  
Option 3 Richmond Direct vs Option 4, Richmond Direct Improved (Year 2035)**



It can be seen that the Operating Ratio is significantly improved for Option 4, rising from 2.11 to 2.44. This considerably improves the case for a public private partnership and/or franchising the system, as it shows a higher level of operating profitability so the system could contribute a higher share of its own capital cost. Exhibit 8-2 and 8-3 show that the proposed Option 4 significantly improves revenues over costs, due to better service of 8-10 trains per day in the Peninsula corridor. These extra trains are required to service the extra demand that the connection to the Richmond Direct route generates. In addition, there are operating cost synergies associated with running Peninsula trains on the Richmond Direct route. These include signal and track maintenance, station staffing, marketing administrative and management costs.

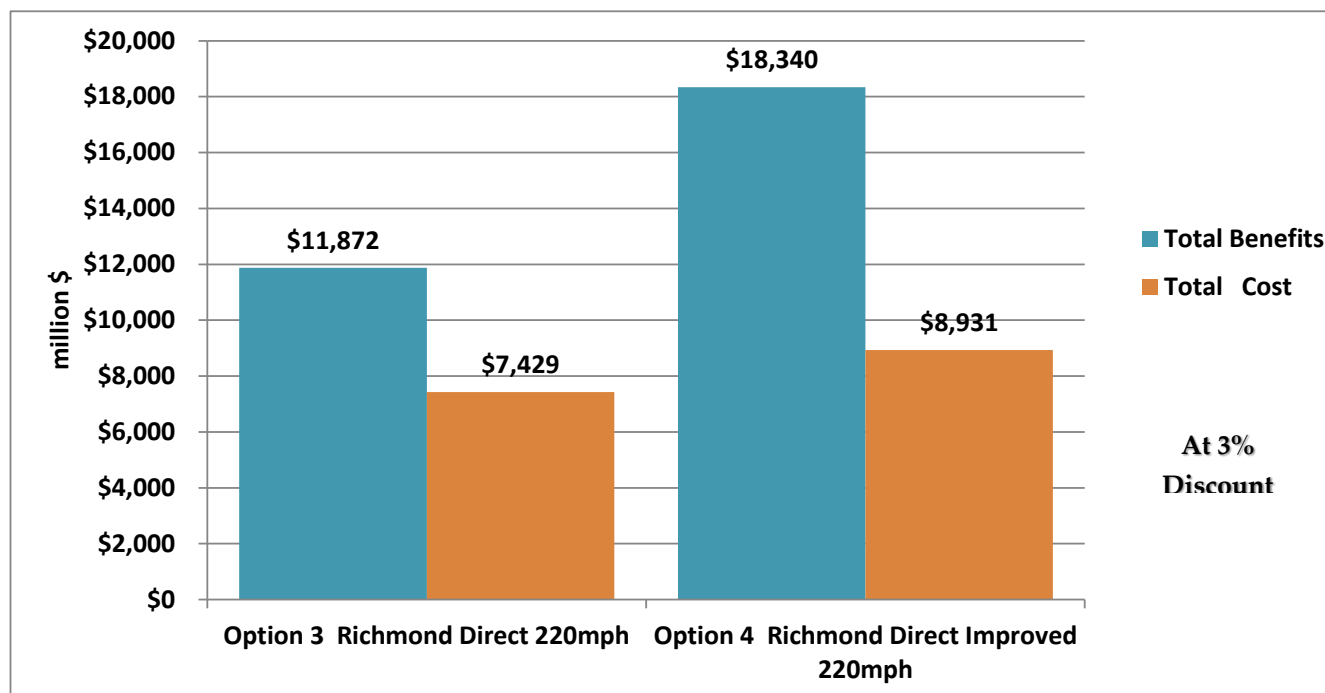
Exhibit 8-4 shows a comparison of the economic results for Option 4 Richmond Direct Improved vs Option 3 Richmond Direct. Exhibit 8-5 and 8-6 compare total benefits vs total costs for Option 4 and Option 3 at the 3% and 7% discount rates. It can be seen that the economic Net Present Value and the Cost Benefit Ratio is enhanced for Option 4. At 3% discount rate, Option 4 has close to a return of twice the capital and operating cost, and even at 7% discount rate it has a significantly higher than 1.0 Cost Benefit Ratio. This is essentially the same high rate of economic return that was developed by the earlier 2010 Preliminary Vision Plan assessment that included both Peninsula and Norfolk service<sup>2</sup>.

<sup>2</sup> July 2, 2010, HRTPO Board Presentation, Slide 27

**Exhibit 8-4: Comparison of Economic Results at 3% & 7% Discount Rates  
for Option 3 Richmond Direct vs Option 4 Richmond Direct Improved**

	3% Discount Rate		7% Discount Rate	
Discount (million 2013\$)	Option 3 Richmond Direct 220mph	Option 4 Richmond Direct Improvement 220mph	Option 3 Richmond Direct 220mph	Option 4 Richmond Direct Improvement 220mph
System Passenger Revenues	\$4,718	\$7,142	\$1,578	\$2,399
OBS	\$377	\$571	\$126	\$192
Users Consumer Surplus	\$2,920	\$5,870	\$987	\$1,990
Highway Congestion Savings	\$2,454	\$2,934	\$794	\$952
Airport Delay Saving	\$424	\$479	\$137	\$155
Safety Benefits	\$801	\$1,101	\$270	\$372
Highway Reduced Emissions	\$178	\$244	\$59	\$81
<b>Total Benefits</b>	<b>\$11,872</b>	<b>\$18,340</b>	<b>\$3,952</b>	<b>\$6,140</b>
Capital Cost	\$5,010	\$5,737	\$2,826	\$3,236
O&M Costs	\$2,357	\$3,116	\$795	\$1,054
Cyclic Mtn	\$63	\$78	\$17	\$22
<b>Total Costs</b>	<b>\$7,429</b>	<b>\$8,931</b>	<b>\$3,638</b>	<b>\$4,311</b>
<b>NPV(Surplus)</b>	<b>\$4,443</b>	<b>\$9,409</b>	<b>\$314</b>	<b>\$1,829</b>
<b>Benefit/Cost Ratio</b>	<b>1.60</b>	<b>2.05</b>	<b>1.09</b>	<b>1.42</b>

**Exhibit 8-5: Comparison of Total Benefits and Costs for Option 3 Richmond Direct vs  
Option 4 Richmond Direct Improved at 3% Discount Rate**



**Exhibit 8-6: Comparison of Total Revenues and Costs for Option 3 Richmond Direct vs Option 4 Richmond Direct Improved at 7 % Discount Rate**

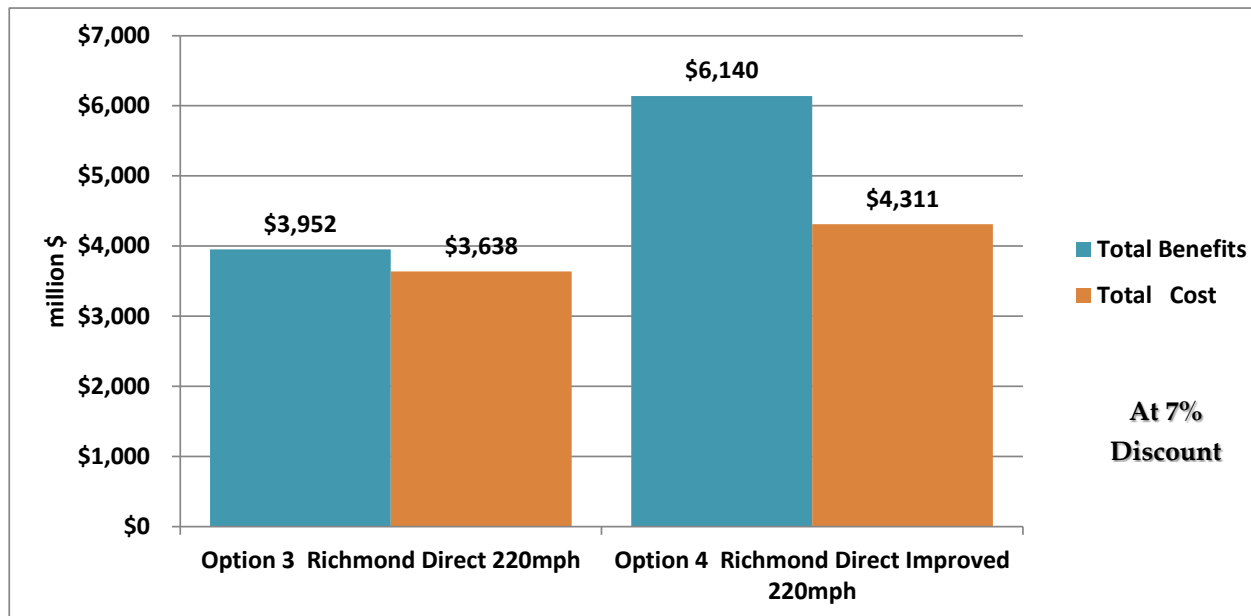


Exhibit 8-7 shows the Economic Cash Flow Analysis for the proposed Option 4, Richmond Direct Improved for the period 2020 (the first year of construction) to 2055 (the assumed life of the project). In the exhibit, economic cash flows were discounted at 3 percent, which is in line with OMB requirements. It can be seen that the project makes a significant operating surplus in its first year of operation that steadily increases over the life of the project, i.e. 2055. This positive cash flow provides a basis for a public/private partnership with a likely contribution of \$3-5 billion to total project costs of \$6-7 billion, or about a 50% share of total project costs.

Although the Norfolk-Richmond-Washington D.C. corridor investment satisfies the FRA/OMB requirement for achieving a positive cost benefit ratio at 7%, it is clear that adding a Peninsula rail service greatly improves the cost benefit result. While the Norfolk service stands on its own, adding the Peninsula service dramatically improves both the financial and Cost Benefit results of the system. As a result it is recommended that the Peninsula rail service also be included in any future High Speed rail evaluations for this corridor.

Finally, the proposed Hampton Roads-Richmond-Washington D.C. High Speed rail investment would provide a complementary service to the regional incremental and commuter rail systems that are being developed by DRPT between Richmond and Washington. As was found in British Rail experience and elsewhere<sup>3</sup>, where commuter and regional rail systems develop parallel to High Speed systems, as is occurring on the north end of the corridor from Fredericksburg into Washington D.C., this actually tends to boost the ridership of both systems. As such the Hampton Roads-Richmond-Washington High Speed Rail corridor can be developed independently of the current planned upgrades to existing rail since each project has independent utility, and the two projects although complementary do not depend on one another for their operational or economic viability.

<sup>3</sup> *Connecting California, 2014 Business Plan*, California High Speed Rail Authority, page 9. "The 2012 Business Plan created the foundation for a statewide rail modernization program with high-speed rail at its core, and with parallel investments in urban, commuter and intercity rail systems that together will significantly improve mobility and connectivity throughout the state." (emphasis added.) See: [http://www.hsr.ca.gov/docs/about/business\\_plans/BPlan\\_2014\\_Business\\_Plan\\_Final.pdf](http://www.hsr.ca.gov/docs/about/business_plans/BPlan_2014_Business_Plan_Final.pdf)

Exhibit 8-7: Option 4, Richmond Direct Improved  
Detailed Economic Benefits and Costs Flows by Year (\$2013 Millions)

Benefit and Costs Items		Year	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031
<b>Benefits to Users</b>		<b>NPV at 3%</b>												
	System Passenger Revenues	\$7,141.82	-	-	-	-	-	-	-	-	-	-	559.37	567.36
	OBS	\$571.35	-	-	-	-	-	-	-	-	-	-	44.75	45.39
	<b>Total Operating Revenues</b>	<b>\$7,713.17</b>	-	-	-	-	-	-	-	-	-	-	<b>604.12</b>	<b>612.75</b>
	Users Consumer Surplus	\$5,869.63	-	-	-	-	-	-	-	-	-	-	482.68	487.86
	<b>Total User Benefits</b>	<b>\$13,582.79</b>	-	-	-	-	-	-	-	-	-	-	<b>1,086.80</b>	<b>1,100.61</b>
<b>Benefits to Public at Large</b>														
	HWY Congestion Savings	\$2,933.91	-	-	-	-	-	-	-	-	-	-	183.50	190.53
	Airport Delay Saving	\$478.62	-	-	-	-	-	-	-	-	-	-	30.56	31.47
	Safety Benefits	\$1,100.72	-	-	-	-	-	-	-	-	-	-	89.20	90.26
	Highway Reduced Emissions	\$243.88	-	-	-	-	-	-	-	-	-	-	17.91	18.29
	<b>Total Public at Large Benefits</b>	<b>\$4,757.12</b>	-	-	-	-	-	-	-	-	-	-	<b>321.16</b>	<b>330.53</b>
<b>Total Benefits</b>		<b>\$18,339.91</b>	-	-	-	-	-	-	-	-	-	-	<b>1,407.96</b>	<b>1,431.15</b>
<b>Costs</b>														
	Capital Cost	\$5,737.14	8.10	8.10	8.10	16.20	299.78	847.48	1,487.55	2,407.95	2,336.65	1,544.27	-	-
	O&M Costs	\$3,115.98	-	-	-	-	-	-	-	-	-	-	257.34	258.94
	Cyclic Mtn	\$77.96	-	-	-	-	-	-	-	-	-	-	-	-
<b>Total Costs</b>		<b>\$8,931.09</b>	<b>8.10</b>	<b>8.10</b>	<b>8.10</b>	<b>16.20</b>	<b>299.78</b>	<b>847.48</b>	<b>1,487.55</b>	<b>2,407.95</b>	<b>2,336.65</b>	<b>1,544.27</b>	<b>257.34</b>	<b>258.94</b>
<b>Benefit - Costs</b>		<b>\$9,408.83</b>	<b>(\$8.10)</b>	<b>(\$8.10)</b>	<b>(\$8.10)</b>	<b>(\$16.20)</b>	<b>(\$299.78)</b>	<b>(\$847.48)</b>	<b>(\$1,487.55)</b>	<b>(\$2,407.95)</b>	<b>(\$2,336.65)</b>	<b>(\$1,544.27)</b>	<b>\$1,150.62</b>	<b>\$1,172.20</b>



Exhibit 8-7: Option 4, Richmond Direct Improved  
Detailed Economic Benefits and Costs Flows by Year (\$2012 Millions) (con't)

Benefit and Costs Items		Year	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043
<b>Benefits to Users</b>		<b>NPV at 3%</b>												
	System Passenger Revenues	\$7,141.82	575.46	583.68	592.02	600.48	609.59	618.84	628.23	637.76	647.44	657.26	667.24	677.36
	OBS	\$571.35	46.04	46.69	47.36	48.04	48.77	49.51	50.26	51.02	51.80	52.58	53.38	54.19
	<b>Total Operating Revenues</b>	<b>\$7,713.17</b>	<b>621.50</b>	<b>630.38</b>	<b>639.39</b>	<b>648.52</b>	<b>658.36</b>	<b>668.35</b>	<b>678.49</b>	<b>688.78</b>	<b>699.23</b>	<b>709.84</b>	<b>720.61</b>	<b>731.55</b>
	Users Consumer Surplus	\$5,869.63	493.10	498.39	503.74	509.15	514.48	519.87	525.32	530.82	536.38	542.00	547.68	553.41
	<b>Total User Benefits</b>	<b>\$13,582.79</b>	<b>1,114.60</b>	<b>1,128.77</b>	<b>1,143.13</b>	<b>1,157.67</b>	<b>1,172.84</b>	<b>1,188.22</b>	<b>1,203.81</b>	<b>1,219.60</b>	<b>1,235.61</b>	<b>1,251.84</b>	<b>1,268.29</b>	<b>1,284.96</b>
<b>Benefits to Public at Large</b>														
	HWY Congestion Savings	\$2,933.91	197.82	205.40	213.27	221.44	228.37	235.52	242.89	250.49	258.33	266.42	274.76	283.36
	Airport Delay Saving	\$478.62	32.40	33.36	34.36	35.38	36.56	37.78	39.04	40.34	41.68	43.07	44.51	45.99
	Safety Benefits	\$1,100.72	91.33	92.41	93.51	94.62	95.74	96.88	98.03	99.19	100.37	101.56	102.76	103.98
	Highway Reduced Emissions	\$243.88	18.67	19.07	19.47	19.88	20.28	20.68	21.10	21.52	21.95	22.39	22.83	23.29
	<b>Total Public at Large Benefits</b>	<b>\$4,757.12</b>	<b>340.23</b>	<b>350.25</b>	<b>360.61</b>	<b>371.32</b>	<b>380.95</b>	<b>390.86</b>	<b>401.05</b>	<b>411.54</b>	<b>422.33</b>	<b>433.44</b>	<b>444.86</b>	<b>456.62</b>
<b>Total Benefits</b>		<b>\$18,339.91</b>	<b>1,454.83</b>	<b>1,479.02</b>	<b>1,503.74</b>	<b>1,528.99</b>	<b>1,553.79</b>	<b>1,579.08</b>	<b>1,604.86</b>	<b>1,631.15</b>	<b>1,657.95</b>	<b>1,685.28</b>	<b>1,713.16</b>	<b>1,741.59</b>
<b>Costs</b>														
	Capital Cost	\$5,737.14	-	-	-	-	-	-	-	-	-	-	-	-
	O&M Costs	\$3,115.98	260.56	262.18	263.81	265.45	268.79	272.17	275.60	279.06	282.57	286.13	289.72	293.37
	Cyclic Mtn	\$77.96	-	-	3.14	3.14	3.14	5.49	5.49	5.49	7.84	7.84	7.84	7.84
<b>Total Costs</b>		<b>\$8,931.09</b>	<b>260.56</b>	<b>262.18</b>	<b>266.95</b>	<b>268.59</b>	<b>271.93</b>	<b>277.66</b>	<b>281.09</b>	<b>284.55</b>	<b>290.41</b>	<b>293.97</b>	<b>297.57</b>	<b>301.21</b>
<b>Benefit - Costs</b>		<b>\$9,408.83</b>	<b>\$1,194.27</b>	<b>\$1,216.84</b>	<b>\$1,236.79</b>	<b>\$1,260.40</b>	<b>\$1,281.86</b>	<b>\$1,301.42</b>	<b>\$1,323.77</b>	<b>\$1,346.59</b>	<b>\$1,367.53</b>	<b>\$1,391.31</b>	<b>\$1,415.59</b>	<b>\$1,440.38</b>

Exhibit 8-7: Option 4, Richmond Direct Improved  
Detailed Economic Benefits and Costs Flows by Year (\$2012 Millions) (con't)

Benefit and Costs Items		Year	2044	2045	2046	2047	2048	2049	2050	2051	2052	2053	2054	2055
<b>Benefits to Users</b>		<b>NPV at 3%</b>												
	System Passenger Revenues	\$7,141.82	687.64	698.07	708.66	719.42	730.33	741.41	752.66	764.08	775.68	787.44	799.39	811.52
	OBS	\$571.35	55.01	55.85	56.69	57.55	58.43	59.31	60.21	61.13	62.05	63.00	63.95	64.92
	<b>Total Operating Revenues</b>	<b>\$7,713.17</b>	<b>742.65</b>	<b>753.92</b>	<b>765.36</b>	<b>776.97</b>	<b>788.76</b>	<b>800.73</b>	<b>812.87</b>	<b>825.21</b>	<b>837.73</b>	<b>850.44</b>	<b>863.34</b>	<b>876.44</b>
	Users Consumer Surplus	\$5,869.63	559.21	565.07	570.99	576.97	583.01	589.12	595.29	601.53	607.83	614.19	620.63	627.13
	<b>Total User Benefits</b>	<b>\$13,582.79</b>	<b>1,301.86</b>	<b>1,318.98</b>	<b>1,336.34</b>	<b>1,353.94</b>	<b>1,371.77</b>	<b>1,389.84</b>	<b>1,408.16</b>	<b>1,426.73</b>	<b>1,445.56</b>	<b>1,464.63</b>	<b>1,483.97</b>	<b>1,503.57</b>
<b>Benefits to Public at Large</b>														
	HWY Congestion Savings	\$2,933.91	292.23	301.37	310.81	320.54	330.57	340.92	351.59	362.59	373.94	385.64	397.72	410.16
	Airport Delay Saving	\$478.62	47.53	49.11	50.75	52.44	54.19	56.00	57.86	59.79	61.79	63.85	65.98	68.18
	Safety Benefits	\$1,100.72	105.21	106.46	107.72	109.00	110.29	111.60	112.93	114.27	115.62	116.99	118.38	119.78
	Highway Reduced Emissions	\$243.88	23.76	24.23	24.71	25.21	25.71	26.22	26.75	27.28	27.83	28.38	28.95	29.53
	<b>Total Public at Large Benefits</b>	<b>\$4,757.12</b>	<b>468.72</b>	<b>481.18</b>	<b>494.00</b>	<b>507.19</b>	<b>520.76</b>	<b>534.74</b>	<b>549.13</b>	<b>563.93</b>	<b>579.18</b>	<b>594.87</b>	<b>611.02</b>	<b>627.65</b>
<b>Total Benefits</b>		<b>\$18,339.91</b>	<b>1,770.58</b>	<b>1,800.16</b>	<b>1,830.34</b>	<b>1,861.12</b>	<b>1,892.53</b>	<b>1,924.58</b>	<b>1,957.29</b>	<b>1,990.67</b>	<b>2,024.73</b>	<b>2,059.50</b>	<b>2,094.99</b>	<b>2,131.22</b>
<b>Costs</b>														
	Capital Cost	\$5,737.14	-	-	-	-	-	-	-	-	-	-	-	-
	O&M Costs	\$3,115.98	297.06	300.79	304.58	308.41	312.28	316.21	320.19	324.22	328.29	332.42	336.60	340.84
	Cyclic Mtn	\$77.96	7.84	11.76	11.76	11.76	11.76	11.76	15.68	15.68	15.68	15.68	15.68	15.68
<b>Total Costs</b>		<b>\$8,931.09</b>	<b>304.90</b>	<b>312.56</b>	<b>316.34</b>	<b>320.17</b>	<b>324.05</b>	<b>327.98</b>	<b>335.87</b>	<b>339.90</b>	<b>343.98</b>	<b>348.11</b>	<b>352.29</b>	<b>356.52</b>
<b>Benefit - Costs</b>		<b>\$9,408.83</b>	<b>\$1,465.68</b>	<b>\$1,487.61</b>	<b>\$1,514.00</b>	<b>\$1,540.95</b>	<b>\$1,568.49</b>	<b>\$1,596.61</b>	<b>\$1,621.42</b>	<b>\$1,650.77</b>	<b>\$1,680.75</b>	<b>\$1,711.39</b>	<b>\$1,742.71</b>	<b>1,774.70</b>

## 8.2 IMPLICATIONS FOR FRANCHISABILITY

For quite some time, the private sector has been providing contract operations of transit systems. For example, VRE's commuter rail service has been operated by Keolis<sup>4</sup> since 2010. In 2012, Maryland awarded the operating contract for its MARC Camden and Brunswick lines to Bombardier.<sup>5</sup> Under PRIIA §209, states are even entitled to contract out state-supported intercity rail corridor operations in part or in whole.<sup>6</sup> Indiana has recently competitively bid the Chicago to Indianapolis "Hoosier State" train.<sup>7</sup>

However, unlike the transit services above, one of the implications of having a positive cash flow is that it expands the potential scope for private sector participation in the project. This means that the private sector can directly contribute to the capital cost of the project, and can also assume a more active role in making key business decisions and directly managing the service under a variety of possible franchise arrangements. These range from total ownership and control of the project, to more limited arrangements that involve a greater degree of public participation. The public sector has also applied similar models to highway system development, particularly toll roads.

An example of a highly successful Public-Private Partnership (PPP) project in Virginia are the I-495 toll lanes recently completed by Transurban<sup>8</sup> and Fluor,<sup>9</sup> where private sector funds covered more than ¾ of the cost of the project. Maryland has recently requested private sector input on best practices and innovative approaches to deliver and finance the Maryland National Capital Purple Line and Baltimore Red Line projects.<sup>10</sup> A PPP approach is also appropriate for High Speed rail as was advocated by the US Federal Railroad Administration in their groundbreaking 1997 *Commercial Feasibility Study*.<sup>11</sup> This fundamental USDOT policy document laid the groundwork for numerous rail PPP initiatives:

- British Rail/Bechtel Michigan in 1985<sup>12</sup>
- Florida FOX in 1996<sup>13</sup>
- Texas TGV in 1990<sup>14</sup>
- Tampa-Orlando HSR in 2011<sup>15</sup>
- Victorville to Las Vegas in 2012<sup>16</sup>
- Orlando-Miami: All Aboard Florida, ongoing<sup>17</sup>
- Dallas-Houston: Texas Central Railway, ongoing<sup>18</sup>

<sup>4</sup> See <http://news.fredericksburg.com/transportation/2014/04/18/vre-re-ups-contract-with-operator-keolis/>

<sup>5</sup> See <http://www.railwayage.com/index.php/passenger/commuter-regional/bombardier-to-operate-marc-camden-brunswick-lines.html?channel=>

<sup>6</sup> See: <http://www.railwayage.com/index.php/blogs/frank-n-wilner/competitive-bidding-for-corridor-passenger-rail-service-in-play.html> and Item #6 of <http://www.highspeed-rail.org/Documents/PRIIA%20305%20DocSpec%20and%20other%20NGEC%20Documents/PRIIA%20Section%20209%20%20FAQs%20061011.pdf>

<sup>7</sup> See <http://www.ijb.com/four-private-companies-bid-on-hoosier-state-route/PARAMS/article/47507>, <http://indianaeconomicdigest.com/main.asp?SectionID=31&SubSectionID=66&ArticleID=74153>, <http://www.indystar.com/story/news/politics/2014/04/02/wanted-operator-keep-hoosier-state-track/7235971/>

<sup>8</sup> <http://www.transurban.com/>

<sup>9</sup> See: <http://tollroadsnews.com/news/how-fluor-lane-widened-the-495-capital-beltway-from-8-to-12-lanes-interview>

<sup>10</sup> Maryland transit officials request private-sector input on Purple, Red line light-rail projects, see [http://www.progressiverailroading.com/passenger\\_rail/news/Maryland-transit-officials-request-private-sector-input-on-Purple-Red-line-light-rail-projects--35857](http://www.progressiverailroading.com/passenger_rail/news/Maryland-transit-officials-request-private-sector-input-on-Purple-Red-line-light-rail-projects--35857)

<sup>11</sup> See: <https://www.fra.dot.gov/Elib/Document/1177>

<sup>12</sup> See: <http://news.google.com/newspapers?nid=1988&dat=19850727&id=xGMiAAAAIBAI&sjid=yasFAAAAIBAI&pg=1434,2228266>

<sup>13</sup> See: <http://www.alstom.com/press-centre/1999/1/Statement-on-Florida-TGV-19990114/>

<sup>14</sup> See: <http://www.psmag.com/navigation/business-economics/how-high-speed-rail-died-in-texas-thrived-in-spain-32021/>

<sup>15</sup> See: <http://www.politifact.com/florida/statements/2011/aug/11/rick-scott/gov-scott-says-rail-would-have-cost-state-taxpayer/>

<sup>16</sup> <http://www.xpresswest.com/>

<sup>17</sup> See: <http://www.allaboardflorida.com/>

A common thread in past “failures” has never been the private sector’s willingness to participate. Rather without exception, it has been a failure of political will on the part of the public sector partner that prevented projects from moving forward.<sup>19</sup> Instead, the fundamental strength of the Florida and Texas markets, coupled with an opportunity to economically develop new infrastructure, has repeatedly stimulated private sector interest in these corridors:

- *All Aboard Florida’s* effort represents the third attempt by the private sector to improve passenger rail in that state and by all accounts, it looks like it will succeed this time and likely even extend to Tampa and/or Jacksonville in the next development phase.<sup>20</sup>
- *Texas Central Railway’s* effort is the second serious attempt by the private sector in Texas. The private sector is able to completely finance the cost for building rural greenfields from Dallas to Houston. They will need help covering the capital cost for extending the line into Fort Worth because of higher urban greenfield construction costs.<sup>21</sup> Once the line is built however, it can be expected to operate profitably.
- *XpressWest’s* Los Angeles to Las Vegas connection has long been identified as a key opportunity for introduction of High Speed rail, and so the corridor has been subject of numerous competing private sector proposals. Although the RRIF loan application was denied for Victorville to Las Vegas based on a park-and-ride concept, the private consortium remains in place and still engaged in active development of the corridor. Currently they are attempting to resolve connectivity issues with California HSR so the system can provide a single seat ride to downtown Los Angeles. It seems reasonable to assume that this project will resume on a firmer economic foundation once this issue is resolved.

It can be seen that PPP initiative can be a viable approach to development of a High Speed rail system and that similar PPP funding mechanisms have been successfully applied in Virginia. Given an overall capital cost of around \$9 Billion (in 2013 dollars) and an assumed 40% private sector contribution of \$3.6 Billion, an USDOT FRA contribution of 30-40 percent based on previous PPP projects (USDOT offered 35% to the Florida FOX project). Virginia would need to find a way to fund 20-25 percent of the remaining capital share, or \$1.8 to \$2.2 Billion over 10 years.

As noted, much of this remaining capital funding would likely be provided by Federal dollars but this expenditure is clearly justifiable since it has been shown to provide a strong positive Cost Benefit ratio at the OMB’s rationing hurdle rate of 7%. In fact there are very few infrastructure projects in Virginia or nationally that can demonstrate such a strong positive economic result.

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<sup>18</sup> See: <http://www.texascentral.com/>

<sup>19</sup> “Fares, Finance and Funding” Presentation to High Speed Rail Association, March 2012, Dr. Alexander E. Metcalf

<sup>20</sup> See <http://tbo.com/news/business/tampa-wants-all-aboard-florida-rails-to-run-its-way-20131003/>

<sup>21</sup> *Texas Central Railway said it will use a market-driven approach, which includes picking routes and stations based on consumer demand, not politics. It also wants no grants or subsidies. . . The catch is that the private, for-profit company won’t build the 30-mile spur. Unlike the longer line from Dallas to Houston, the numbers don’t work on a shorter line, because construction costs are much higher in urban areas.* See: <http://www.dallasnews.com/business/columnists/mitchell-schnurman/20140407-public-tie-could-slow-bullet-train-plan.ece>

### 8.3 POSSIBLE SYNERGIES WITH SOUTHEAST HIGH SPEED RAIL

One of the major problems with the currently proposed triple track expansion of passenger rail service north from Richmond to Washington D.C. is a lack of sufficient capacity to accommodate Hampton Roads' needs. As a result there is clearly no room north of Richmond for the proposed High Speed services from Norfolk and Newport News to Washington D.C. as proposed in Option 4, so the development of an alternative greenfield route and a capacity improvement plan that goes beyond DRPT's current plan is needed.

One option therefore might be to consider moving the planned SEHSR services to the new HRTPO High Speed route north of Richmond. If SEHSR chooses to do this, they could run their diesel trains up to 130-mph "under the wire" just as has been proposed for the Peninsula diesel service. On this basis the SEHSR trains could reduce their running time from 2:00 down to 1:05 by using the proposed new greenfield alignment to Washington D.C.

Doing this would afford SEHSR a significant travel time savings so the proposed greenfield would undoubtedly offer an attractive route alternative for them. This would also develop additional economic benefits that are not currently included in the Cost Benefit analysis. Clearly SEHSR's planned four round trips<sup>22</sup> are not enough to support greenfield route development on their own; but since Hampton Roads would provide the base volume needed to support development of this greenfield corridor, SEHSR could take advantage of it as an incremental user. This would also relieve CSX of the responsibility for hosting these passenger trains on its tracks north of Richmond.

These cost sharing opportunities and the additional benefits to SEHSR might be worth as much as a 15% capital sharing opportunity which would boost the Cost Benefit ratio (at 7%) from 1.42 up to the neighborhood of 1.6. This potential for SEHSR integration clearly makes the business case for developing Option 4 even stronger and may even further expand the potential scope for private sector participation in funding this project.

### 8.4 CONCLUSION

In addition to improving ridership and relieving traffic congestion within the Norfolk to Richmond corridor, the Option 4, Richmond Direct Improved 220-mph technology option would benefit ridership and revenues for the system and relieve traffic congestion outside the Norfolk to Richmond corridor (i.e. benefits to the Peninsula and Richmond to DC segments). Option 4 also provides a superior Financial and Economic return (Operating Ratio, Benefit-Cost Ratio) when compared with results for addressing only the Norfolk to Richmond corridor. This could be further improved by considering integration with SEHSR in the next phase of work.

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<sup>22</sup> See FAQ #11 of <http://www.sehsr.org/faq.html>

## 9. CONCLUSIONS

*This chapter describes the key results of the study.*

### 9.1 RESULTS

The analysis shows that the potential for developing a true high speed system for the Hampton Roads Corridor is very real. It is clear that greenfield routes can be developed that, from the initial market operations, engineering and environmental analysis, would attain USDOT FRA financial and economic requirements, have independent utility both in their entirety and on a segmented basis, and also could avoid obvious<sup>1</sup> environmental “fatal flaws” that would prevent their construction.

In terms of the specific results, it was found that all of the initial Norfolk-Richmond Corridor Options 1-3 were very close. All the options produced positive financial operating ratios although 220-mph options showed better economic returns than 130-mph options. The results for Richmond Direct (Option 3) were marginally better than the two Southern routes (Options 1A and 1B) via Petersburg or the two Northern routes (Options 2A and 2B) via Hopewell (Exhibit 7-2) because Option 3 avoids the need for high-cost construction within the built-up urban areas that lie south of Richmond.

However, it was also noticed that Option 3 in particular creates an opportunity for significant track sharing with the Peninsula east of Richmond, whereas Option 1 offers no such opportunity, and Option 2 would allow sharing only to a limited extent. Since Option 3 was also the best-performing Richmond to Norfolk option, it was enhanced in Option 4 by adding a Peninsula rail connection. This was shown to significantly boost the financial and economic performance of the system, so now Option 4 stands clearly above any of the other Options 1-3.

***The projected financial and economic performance of the corridor now ranks it among one of the best opportunities for development of High Speed Rail in the United States outside the Northeast Corridor.*** In the case of all the options, but in particular with the Richmond Direct Improved Option 4, the results show a great potential for attracting a Public Private Partnership (P3). A P3 will be attracted by the strong financial result that suggests an operating surplus exceeding \$300 million per year could be generated by 2035 (See Exhibit 8-6). The P3 potential is also enhanced by the efficient infrastructure development approach where greenfields are maximized in rural areas where they can be economically constructed, while existing rail lines are enhanced to add the capacity needed to directly reach the urban core markets of Norfolk, Newport News, Richmond and Washington D.C. As has been shown in Europe and elsewhere this is the most cost effective approach to the development of High Speed rail systems since it makes the cost affordable as compared to highways, airports, upgrading existing rail tracks or other options for expanding intercity transportation capacity.

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<sup>1</sup> This is based on an environmental scan level of review. Environmental data has been collected and assessed at a landscape level consistent with FRA’s requirements for a Service NEPA. A landscape level of review refers to preliminary overview of the area and prospective alignments based on mapping, and aerial and ground level photographs, without detailed on-site inspection.



To move towards implementing the HRTPO Objectives, it is recommended to:

- Clarify with DRPT that there is no room for HRTPO high and higher speed train on the CSX route from Richmond to Washington. A greenfield route is the only solution if high and higher speed rail is to be a possible mechanism for improving mobility in Eastern Virginia.
- Continue development of the Richmond-Washington D.C. segment to define greenfield alternatives and develop a preliminary assessment at the feasibility level is critical. This would lead to the creation of a Service NEPA document and in the short term, some possible additional alternatives, such as greenfield bypasses around Ashland and Fredericksburg, might even be incorporated as useful adjuncts to DRPT's current Tier II EIS planning for incremental rail. For longer term development needs, establishing route reservations in Master Planning documents to protect the needed rights-of-way to prevent the kinds of cost escalation that were experienced by California's system.
- Continue development of the Richmond Direct Improved Option for the benefit of both the North and Southside Hampton Roads communities. Feasibility work still remains to be completed for defining, refining and optimizing additional greenfield Peninsula route options as well as working with CSX on capacity analysis east of Toano, and for possible development of a downtown Newport News station and how that might impact CSX's Newport News terminal operations. (However, the Option 4 proposed budget of \$100 million for the passenger service extension east of Bland Blvd provides ample room for needed capacity mitigation here.) The Richmond Direct Improved Option is a very cost effective way of developing higher speed options for the Peninsula, as well as achieving the high speed objectives of the Southside. It will give both communities the higher and high speed options the HRTPO Board is seeking.
- Continue discussions with Portsmouth and Suffolk to advance development of the "V-Line" and Bowers Hill stations in the short to medium term.
- Engage SEHSR in a discussion of the synergies and benefits potentially associated with sharing a new High Speed alignment, particularly north of Richmond up to Washington D.C. SEHSR trains are capable of 110 to 130 mph but will be significantly (50-60 mph) constrained on the Richmond to Washington CSX route.
- Develop the institutional framework to support a process for Public Private Partnership Development throughout the Environmental Process. This involves holding regular workshops with potential P3 partners through the environmental process. Identify the potential financial parameters for a public-private partnership considering: Design, Build, Operate, Maintain and Finance (DBOM-F) options similar to the approach in Florida that attracted \$1.8 Billion in USDOT FRA money for a P3 project between Miami-Orlando-Tampa. USDOT FRA is emphasizing the need for Public Private Partnerships as the mechanism to build High Speed Rail.
- Develop partnership with freight railroads for engaging in right-of-way discussions, and further develop line capacity simulations of shared segments east of Toano, north of Aquia and on a short stretch through downtown Richmond to confirm the adequacy of planned infrastructure for accommodating both High Speed rail and future freight capacity needs.

## **PUBLIC COMMENTS**



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3 Commercial Place  
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Chris Wichman  
Transportation Planner  
Hampton Roads Transportation Planning Organization  
723 Woodlake Drive  
Chesapeake, VA 23320

Mr. Wichman,

Norfolk Southern (NS) appreciates the opportunity to continue to comment on the Hampton Roads Passenger Rail Vision Plan. NS submitted comments to HRTPO in February, and those comments were incorporated into a revised version of the study. We believe that there is still some ambiguity related to the use of NS right-of-way between Norfolk, VA and Petersburg, VA, even in this revised version. Hopefully the material we describe below will resolve those ambiguities.

We would appreciate two sets of clarifications in the final version of the study. The language appearing first below should appear at the front of the report to provide clarity and context regarding the use of NS right-of-way. Additionally, where there is a reference, textual, visual, or otherwise to our right-of-way, we ask that a footnote be placed on that page that reminds the reader of the restrictions NS places on high-speed passenger trains utilizing its corridors. That footnote language appears below as well.

#### Section 1.1.1

Throughout this study, there will be textual and visual references, explicit or otherwise, to the Norfolk Southern (NS) right-of-way that runs from Norfolk, VA to Petersburg, VA where it then connects to CSX to head to Richmond, VA and points north. NS has strict policies regarding passenger rail and how fast passenger trains may travel on NS right of way (ROW). Those policies are summarized below:

- Where higher speed passenger trains share tracks with conventional freight trains, those high speed trains may not exceed 79 mph.
- Passenger trains operating in excess of 79 mph will require dedicated tracks, and may not exceed 90 mph.
- Passenger trains exceeding 90 mph require their own private right-of-way with at least a 50 foot separation between high speed tracks and freight tracks.

These policies are important in the context of this report as they govern any and all high speed passenger train options utilizing NS right-of-way.



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Footnote to be placed at any mention, textual, visual or otherwise, of Norfolk-Petersburg, Norfolk Southern, Norfolk – Richmond along 460 and any other mention where use of NS ROW is referred to either explicitly or is inferred.

\*Any use, implied, explicit, or otherwise, of NS right-of-way will be subject to the concurrence of NS, and to NS' Passenger Rail Policy which governs the speed of passenger trains utilizing it or encroaching upon it.

We believe this additional language is necessary to ensure that readers clearly understand the use of NS right-of-way, if permitted, would only be permitted in a manner that consistent with NS policy, which has conditions not completely compatible with high-speed rail service.

Additionally, NS requests that its passenger policy requirements regarding passenger rail speeds be included in any and all future presentations where NS right-of-way is referred to in any manner.

Lastly, NS requests that any and all references to its Michigan line transaction, specifically in Section 3.1.1 on page 3-3, be removed from future versions of these reports. That transaction was unique and NS does not intend to pursue such a transaction with the Norfolk-Petersburg corridor.

NS appreciates having a voice at the table with the HRTPO and we look forward to continuing our relationship in the future.

Best regards,

A handwritten signature in blue ink, appearing to read "Scott Plum". The signature is fluid and cursive, with a long horizontal stroke extending to the right.

Scott Plum

September 25, 2014

**RESOLUTION BY THE BOARD OF DIRECTORS, FUTURE OF HAMPTON ROADS, INC.**

Whereas the Hampton Roads Transportation Planning Organization (HRTPO) began the development of a High Speed Rail Vision Plan in 2009 to evaluate the potential of high speed and enhanced passenger rail service alternatives for the region, the search has resulted in a number of technical reports and has been described as near completion; and

Whereas rail service, specifically high speed rail, has been identified by Future of Hampton Roads as the key transportation element necessary to maintain regional economic competitiveness by effectively connecting the region to economic centers in the northeast, southeast and around the country; and

Whereas it is the opinion of Future of Hampton Roads' Board of Directors that a final report "High Speed Rail Vision Plan" from HRTPO is vital to the region's ability to pursue funding and support for key studies, and improvements in infrastructure for rail service;

Therefore, be it resolved by the Board of Directors for Future of Hampton Roads that the organization formally urges the HRTPO to complete and release the High Speed Rail Vision Plan as soon as possible.

Respectfully submitted,



William W. Crow  
Chairman, Future of Hampton Roads





## COMMONWEALTH of VIRGINIA

Jennifer L. Mitchell  
Director

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October 28, 2014

Camelia Ravanbakht  
Interim HRTPO Executive Director  
The Regional Building  
723 Woodlake Drive  
Chesapeake, VA 23320

**HRTPO**  
OCT 30 2014  
**RECEIVED**

Dear Camelia:

Thank you for the opportunity to work with the Hampton Roads Transportation Planning Organization (HRTPO) and provide comments to HRTPO's High Speed Rail Vision Plan Alternatives Analysis. As the Alternatives Analysis has been underway, the Department of Rail and Public Transportation (DRPT) has enhanced intercity passenger rail service to Hampton Roads, as evidenced by new service to Norfolk, concluded the Richmond to Hampton Roads Tier I EIS in 2012, and the included three Hampton Roads area legislators in the Virginia-North Carolina Rail Compact. Additionally, DRPT has programmed \$82 million in funding in the approved FY2015 – FY2020 six-year plan for service expansion to Norfolk and \$20 million in rail funds for the proposed multimodal station in Newport News. As always, we urge the HRTPO to work with DRPT, FRA and the host railroads for coordinated intercity passenger rail improvements. We are committed to working with HRTPO to advancing higher speed rail improvements in a constructive manner that is consistent with Federal priorities and reasonably expected estimates for future funding.

In 2002, the Federal Railroad Administration published the Tier I Record of Decision (ROD) for the Southeast High Speed Rail (SEHSR) from Washington D.C. to Charlotte, North Carolina. The Tier I ROD identified the CSX right-of-way (ROW) as the preferred corridor between Richmond, VA and Washington, D.C. for high speed rail in order to minimize impacts, reduce initial capital investment, and generate benefits of higher speeds in an achievable timeframe. Since 2003, DRPT has been working in collaboration with the North Carolina Department of Transportation and the Federal Railroad Administration (FRA) to conduct the Southeast High Speed Rail (SEHSR) Tier II Environmental Impact Statement (EIS) from Richmond, Virginia, to Raleigh, North Carolina.

In 2010, DRPT was awarded funding from the FRA's High Speed Rail Program to advance the SEHSR Washington D.C. to Richmond segment Tier II EIS. DRPT is actively advancing the

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*[www.drpt.virginia.gov](http://www.drpt.virginia.gov)*



SEHSR Washington D.C. to Richmond Tier II EIS, as well as other potential capital improvements in the corridor that would benefit current passenger rail services. It is critical that DRPT strictly adhere to the requirements of National Environmental Policy Act (NEPA) of 1969 and that clear communication is provided to the public throughout the Washington D.C. to Richmond Tier II EIS process.

FRA has demonstrated that it will support and invest in rail projects that are consistent with its nationwide policies, and projects that have clear and consistent support from the residents of the region. The Alternatives Analysis has been presented as a parallel/concurrent study (to SEHSR efforts) that has the effect of confusing the audience and potentially risking FRA's support of existing plans in the region. As such, DRPT requests that the HRTPO discontinue making reference to the HRTPO High Speed Passenger Rail Vision Plan Alternatives Analysis as a parallel/concurrent study to the FRA sponsored SEHSR studies that are being conducted by DRPT and/or in collaboration with North Carolina DOT in written format and/or public forum.

DRPT wishes to provide the following observations regarding assumptions that have been made in the HRTPO's Hampton Roads High Speed Passenger Rail Vision Plan Alternatives Analysis that have recently been conducted.

- The 2025 ridership forecast assumptions include development of SEHSR service and NEC Future service. This level of ridership is based on approximately \$165 billion of capital improvements in the NEC, for which there is no committed sources of funding identified. Absent any committed sources of state or Federal revenues, there is no guarantee that SEHSR service will be implemented by 2025, and NEC Future service is currently projected out to 2040. As such, we believe the 2025 ridership forecasts may be overly optimistic.
- The market analysis was based on travel markets outside of the SEHSR corridor and well outside of the Hampton Roads Region travel market. The ridership forecasts assume speeds of 130MPH and 220MPH that are unobtainable between Richmond and Washington, D.C. without a fully separated greenfield alignment. This assumption is inconsistent with the SEHSR Tier I EIS ROD issued in 2002.
- The Alternatives Analysis report claims no environmental fatal flaws for the recommended alternative. However given the significant presence of wetlands and sensitive resources in this corridor, DRPT has serious concern with this assumption. The U.S. Route 460 Location Study: Draft Supplemental EIS prepared by VDOT documents many of the environmental impacts associated with a potential greenfield project in this corridor. This study assumes use of CSX and Norfolk Southern (NS) ROW in the description of alternatives at speeds of 130MPH and 220MPH. The HRTPO staff and their consultant have been notified that speeds of 79MPH on NS and 90MPH on CSX ROW are the maximum allowable speeds. Further, ROW is not available for the barrier separation that has been identified in the Alternatives Analysis report to accommodate speeds in excess of 130MPH on the CSX or NS ROW.



- The HRTPO study assumes the use of push-pull or double ended trains that have diesel power cars; however, Amtrak does not allow push-pull or double ended trains and will require a "wye" track to turn the trains.
- DRPT is concerned that the capital cost estimate of \$8B (\$2013) for 193 mile greenfield project between Washington D.C. and Norfolk, VA may be low. Compared to the capital costs identified in the 2010 Amtrak's Vision for High Speed Rail in the Northeast Corridor, which provides a 220MPH service on the existing Northeast Corridor ROW between Washington D.C. and New York City and separate ROW between New York City and Boston MA at \$117B for 439 miles. At \$260M/mile, the actual cost of the 220MPH service between Washington D.C. to Norfolk, VA would cost in the neighborhood of \$51B. We understand and appreciate that the costs of purchasing a 100-foot section of right-of-way in the proposed corridor would be lower than urban greenfield costs in the northeast corridor. However based on this benchmarking, the actual costs of positive train control systems and electrification, and the number of river crossings in the corridor that will require new infrastructure, we are concerned that the capital cost estimates identified in the Alternative Analysis may be understated. As such the resulting cost-benefit ratios to be overly optimistic. As stated in section 4.4, additional capital cost estimating will need to be conducted during any future studies.
- Any assessment of project delivery methods, including public-private partnerships, should be based on realistic prospective of funding resources including the availability of state and Federal funding sources. The comparison of potential project delivery options to the public-private partnerships for managed lane projects does not take into account that in the managed lane projects, the developer has assumed toll revenue risk. The study has cited a number of news articles as evidence of a viable business model for this project. While section 8.2 cites "the lack of political will on the part of the public sector partner" as the primary reason that these previous initiatives have failed, we suspect that the actual reasons are much more complicated and market-driven. DRPT would expect that any future analyses of higher speed rail alternatives would provide a more detailed analysis of project delivery options that would take into account Virginia's legislative framework, market conditions, approaches to risk allocation and achievable implementation timeframes.

Thank you for your ongoing collaboration in transportation and high speed rail planning initiatives. We appreciate your strong support and advocacy for passenger rail service in the Commonwealth, and we look forward to working with HRTPO to advance these initiatives in the future. Please feel free to contact me if you have any questions or concerns.

Best regards,



Jennifer Mitchell