Final Report

Virginia Railway Express

System Plan 2040

Study

submitted to the

Virginia Railway Express

submitted by

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Virginia Railway Express
2040 System Plan

1. Contents

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2040 System Plan

1. Introduction and Summary

1.1 Background

The VRE System Plan provides a guide for VRE's growth and development as it enters its third decade of operations. VRE's mission is to provide a safe, reliable, convenient, and cost-effective passenger rail service as an alternative to driving congested highways from the northern Virginia suburbs to Alexandria, Crystal City, and Washington DC employment centers. Each weekday, VRE now operates 12 trainsets making 30 revenue trips over the two Fredericksburg and Manassas Line branches, covering 90 route miles, and carrying upwards of 19,000 daily passengers. With the addition of a station in Spotsylvania County, currently under construction, VRE will serve a total of 19 stations in nine northern Virginia jurisdictions, plus the District of Columbia. The current VRE network is shown in **Figure 1-1**.

Organizationally, the Virginia Railway Express is a joint project of two state transportation commissions – the Northern Virginia Transportation Commission (NVTC) and the Potomac and Rappahannock Transportation Commission (PRTC) – which represent the Virginia counties and municipalities in the VRE service area. Members of both entities sit on the VRE Operations Board, which governs VRE. Daily operations and capital projects are financed from a combination of fare revenues and Federal, state and local funds.

Over the past decade, VRE has invested in new rolling stock, expanded station platforms and parking, constructed equipment maintenance facilities at each storage yard, and completed an initial set of railroad infrastructure investments that has enabled it to implement modest service expansions. VRE daily ridership has grown by about 30% over the same time period. VRE continues to deliver a high quality service to its customers and provides an important travel option for commuters and other peak period travelers in the congested Interstate 95 (I-95) and Interstate 66 (I-66) corridors of northern Virginia.

Figure 1-1 VRE System Map

With a strong regional economy and projected population and employment growth, the prospects are good for continuing ridership growth in the VRE core commute-to-work market as well as new opportunities for VRE to grow its role in the regional transportation network by serving new travel markets such as reverse-peak commuting, off-peak travel, and extension of service into new parts of its existing service area, and improving its connectivity with local public transit services and with other regional rail services.

While continued VRE investment in cars, locomotives, station expansions, and storage/maintenance facilities poses no unusual challenges, expanding the railroad capacity to allow more VRE trains requires infrastructure investments significantly larger than those made to date, especially between Alexandria and Washington Union Station. However, these track infrastructure projects will also allow more freight and regional or intercity passenger rail service in this corridor, and VRE has the need and opportunity to help develop partnerships to improve the rail corridors, and maximize regional mobility.

1.2 Goals of the System Plan

The System Plan outlines a vision for VRE system investments and the actions VRE should pursue through 2040 to sustain and grow the service to meet regional travel needs. The plan identifies capital investments to expand system capacity and defines a logical sequence of VRE service expansion as additional railroad capacity is created. The System Plan provides the framework within which decisions can be made by the VRE Operations Board with respect to implementation of capital programs and projects, partnerships with other stakeholders, and agreements with VRE's host railroads: CSX, Norfolk Southern, and Amtrak.

Specific goals of the VRE System Plan include:

- Provide passengers with rolling stock, stations, and service maintained to the highest quality.
- Improve and expand service for current VRE passengers.
- Address emerging ridership markets.
- Advance VRE's role as part of a multimodal regional mobility network.
- Invest in partnerships to add capacity in multi-use rail corridors.

As part of the process of developing the System Plan, several alternative future scenarios were analyzed and evaluated in terms of ridership, capacity needs, capital investment requirements,

phased implementation, and funding and partnership strategies. The recommended System Plan incorporates the best elements of those scenarios and packages them in way that delivers the greatest value for the capital investments that need to be made.

The System Plan is not intended to be prescriptive. It identifies recommended actions for VRE to take but cannot compel other entities to act or guarantee the availability of funding sources. Consequently, the System Plan will need to be flexible, and VRE will need to periodically revisit the plan and its underlying assumptions and make adjustments as future conditions dictate.

The System Plan shows how VRE can contribute to regional mobility and the importance of including VRE investments as part of the greater Washington DC region's transportation network. The System Plan also provides a context for developing and implementing VRE's Capital Improvement Program (CIP).

1.3 VRE Today – Growing and Cost-Effective

Since 2004, when its last long-range plan was adopted, VRE has demonstrated its ability to accommodate the rapid and substantial increase in ridership that has occurred over the past decade in two of the most heavily travelled commuter corridors in the region by balancing cost-effective investments and efficient operations. As a result VRE provides critical person-carrying capacity that is the equivalent of a full interstate lane in the peak direction in the I-95 and I-66 corridors, with less pollution, energy consumption, and accident cost than highway operations.

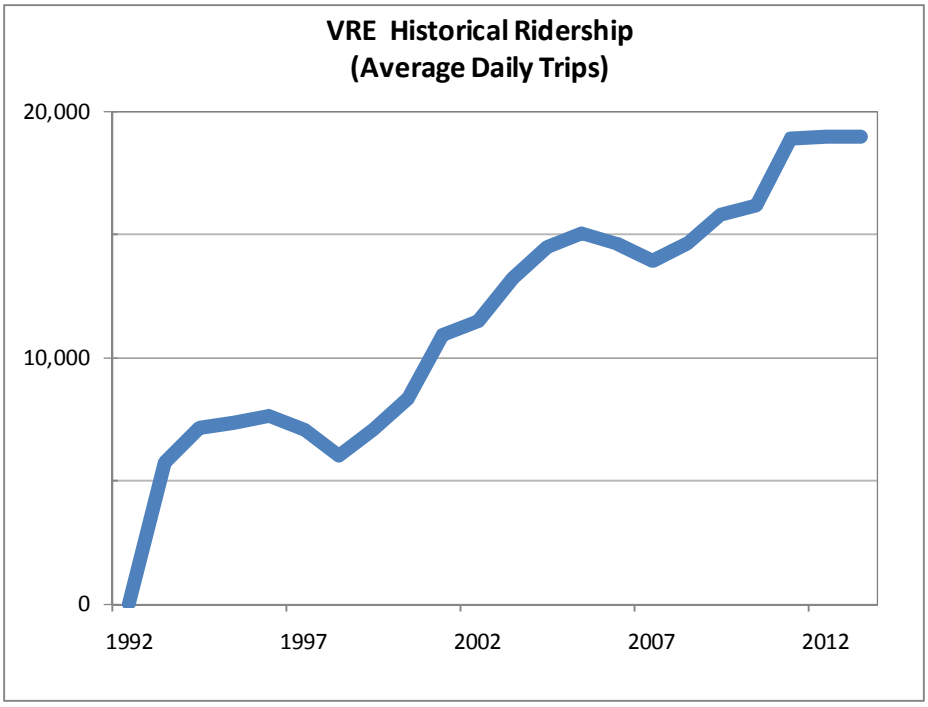
Total VRE ridership has tripled since its inception and grown by a third over the last decade, reaching 19,000 daily trips in 2012, as indicated in **Figure 1-2**. Ridership growth has been fueled by numerous factors, including:

- Population growth in the counties and cities served by VRE
- A strong regional economy and employment market in the Washington DC and northern Virginia activity centers
- The institution of the Federal transit benefit for commuters
- Increasing highway congestion,

VRE was able to handle the growth because of investments to provide more seating on VRE trains, additional parking, and longer platforms at stations. Completion of major capital improvements on the Fredericksburg Line such as the construction of a second track and bridge across Quantico Creek and the triple tracking of the line from the Potomac River to Franconia-

Springfield expanded the capacity of the railroad at critical bottlenecks. This further improved the reliability of VRE, Amtrak, and freight service and, more importantly, permitted the level of passenger service operated over the railroad to increase.

Figure 1-2 VRE Historical Ridership Growth



The Washington region's population is forecast to grow by another 2 million persons from 2010 levels to 2040, with Virginia absorbing over half of the increase. In the same period, the economy is expected to add 1.6 million new jobs, about a third of them in the inner jurisdictions that are the primary employment centers today, including Washington DC, Arlington and Fairfax Counties, and the cities of Alexandria, Fairfax, and Falls Church. Increasing congestion on the region's highway and transit systems is inevitable without additional investment to expand the person-carrying capacity.

The railroad lines owned by CSX and Norfolk Southern, and used by VRE, provide an excellent option for significant expansion of transportation capacity in the corridors parallel to I-95 and I-66, while preserving the host railroads' ability to meet their freight movement goals. Capacity expansion can take place almost entirely within the existing right-of-way, at a cost and in a time frame competitive with highway and heavy rail construction projects in the region. Investment

in these lines also expands the capacity for freight operations as well as for regional/intercity rail passenger services that Virginia, North Carolina, and Amtrak are pursuing.

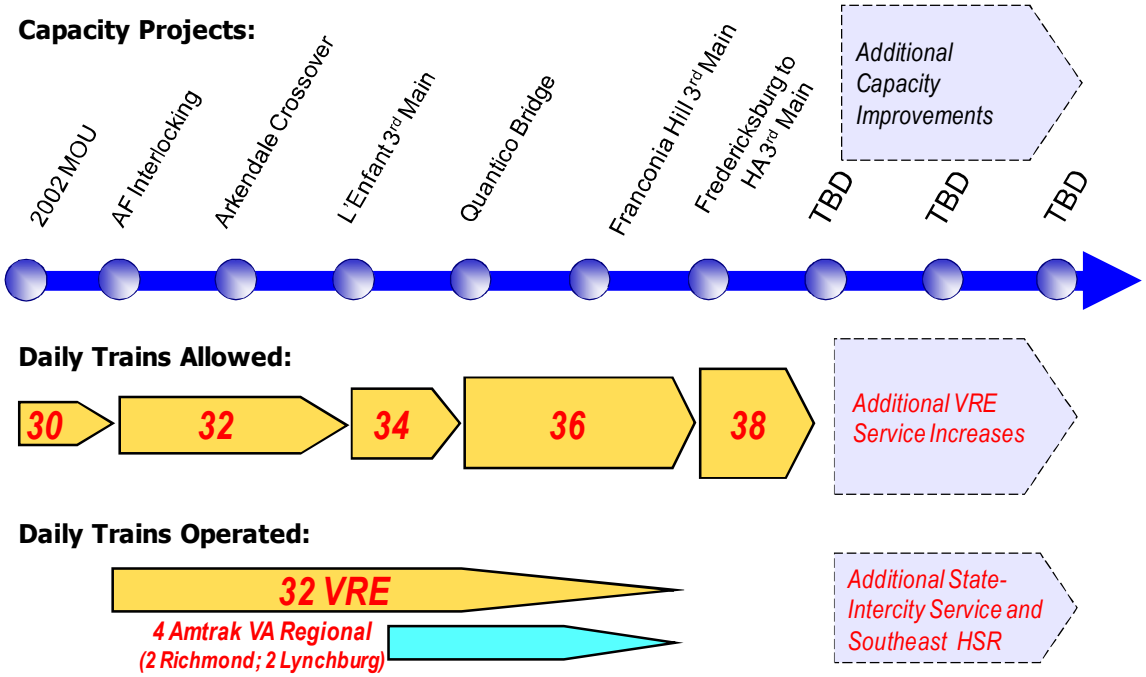
VRE is one of the most cost-effective public transportation operators in the Washington DC region, with a low rate of public subsidy per passenger mile, and a high percentage of costs covered by passenger fares – at over 50% VRE's fare recovery rate is second only to the Metrorail system in the Washington DC region. Among peer commuter railroads in the U.S., only Metro-North in New York and Caltrain in the San Francisco Bay Area have higher fare recovery rates.

1.4 Looking Ahead – VRE Approaching Capacity

While the system investments in rolling stock, stations, and storage yards made over the past decade have expanded VRE's passenger-carrying capacity, concurrent growth in ridership and demand for service has continued to fill available seats on many trains and parking at stations. In addition, railroad capacity remains a critical influence on the level of service VRE is able to operate and how quickly and to what extent VRE service is expanded. VRE trains run on rights-of-way owned and controlled by CSX, Norfolk Southern, and Amtrak. Contractual agreements with each of these host railroads limit the number of daily trains that VRE can operate, with the CSX agreement having the greatest effect on VRE operations. **Figure 1-3** illustrates the relationship between publicly-funded railroad capacity investments and the maximum number of allowable daily one-way train movements or "slots" for VRE trains on CSX's right-of-way between Spotsylvania County and Washington DC, as codified in the operating agreement between CSX and VRE.

VRE currently operates 30 daily revenue trains plus two non-revenue (or "deadhead") trains. The Virginia Department of Rail and Public Transportation (DRPT) utilizes four VRE operating slots borrowed from VRE to initiate state-sponsored Amtrak Virginia services between Norfolk/Richmond and Washington DC, and between Lynchburg and Washington DC. One additional round trip, on the Fredericksburg Line, can be added within the framework of the CSX operating existing agreement for a total of 38 daily train movements. Further growth in passenger traffic will require a new agreement among the parties to define future operating parameters.

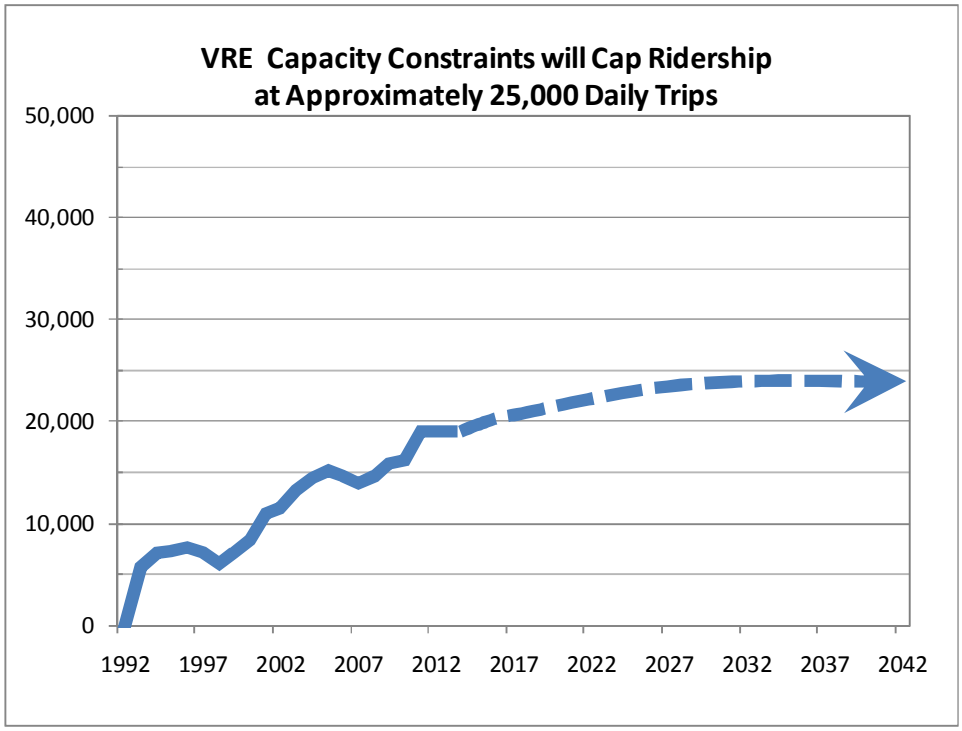
Figure 1-3 Growth in Passenger Train Service Linked to Railroad Capacity Investment



The operating agreement limit on daily trains constrains VRE's flexibility to add train service to accommodate new travel markets or to better utilize its train equipment and crews. In addition, physical constraints at VRE's storage yards in Washington DC and at its Fredericksburg and Manassas Line storage yards limit the number and length of VRE trains that can be operated and the effective maximum daily passenger capacity.

The capital projects contained in the VRE FY 2015-2020 CIP and planned service expansion will effectively maximize the number of trains VRE can operate within its existing contractual agreements. With investment in new coaches, expansion of existing storage yards and lengthening of selected station platforms, these projects increase VRE's passenger-carrying capacity to approximately 25,000 daily passengers. In order for VRE to grow beyond this level of ridership, major investment to expand the railroad capacity will be required.

Figure 1-4 Constrained Future Ridership Growth Without Major Capacity Investment



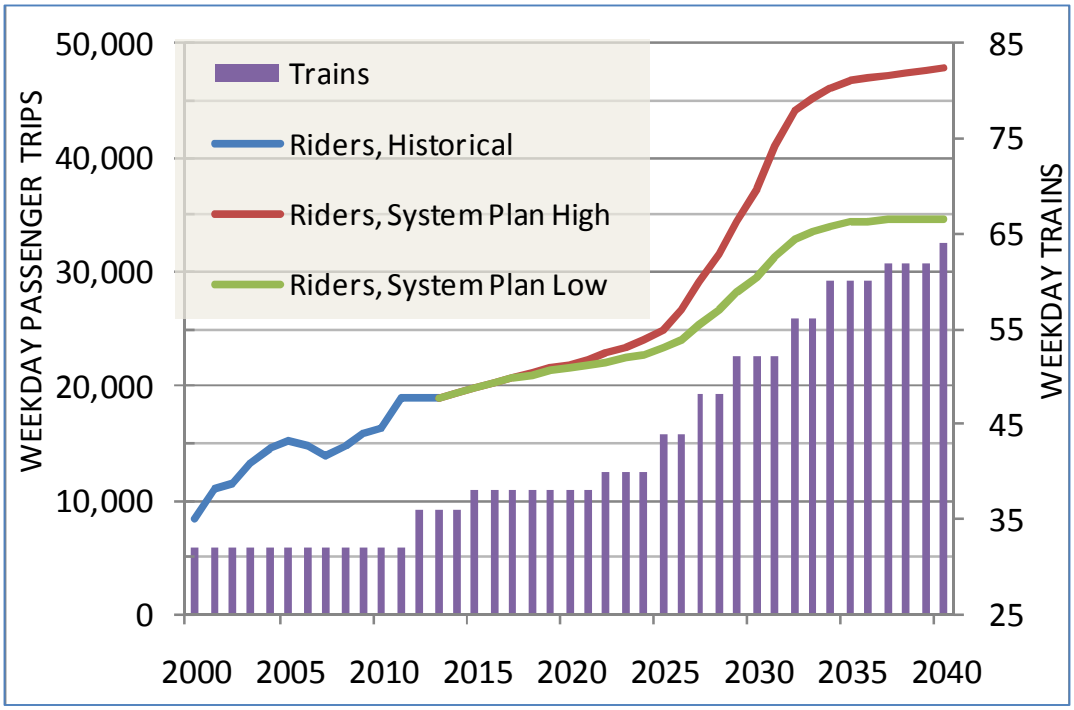
1.5 System Plan for the Future – Smart Investment, Ridership Growth and Expansion of VRE's Role in the Region

The VRE System Plan provides for the logical, incremental expansion of VRE service through 2040. The plan builds upon VRE's approved six-year CIP, which addresses VRE's short-term growth needs. The System Plan also assumes major railroad capacity improvements that offer wide-ranging passenger rail and freight benefits, including the expansion of the Long Bridge across the Potomac River and completion of the triple-tracking of the Fredericksburg Line. VRE will concurrently pursue investments in station platforms, station parking capacity, additional rolling stock, and storage yard and equipment maintenance shop expansion as well as a service extension to the Gainesville-Haymarket area of Prince William County. Implementation of the System Plan recommendations will enable VRE to incrementally increase the number of weekday peak period trains and initiate reverse-peak and off-peak service. Full bi-directional service will enable VRE to make more efficient use of train equipment, crews, and yard facilities and maintain the overall cost-effectiveness of VRE's operations.

Figure 1-5 shows the potential growth in VRE service over a 25-year period in incremental steps, expressed in the number of daily trains operated, and the associated increase in estimated

ridership over the same period, covering a relatively wide range in later years given the uncertainties of future travel conditions and regional population and jobs growth.

Figure 1-5 Projected Growth in Riders and Train Service from System Plan



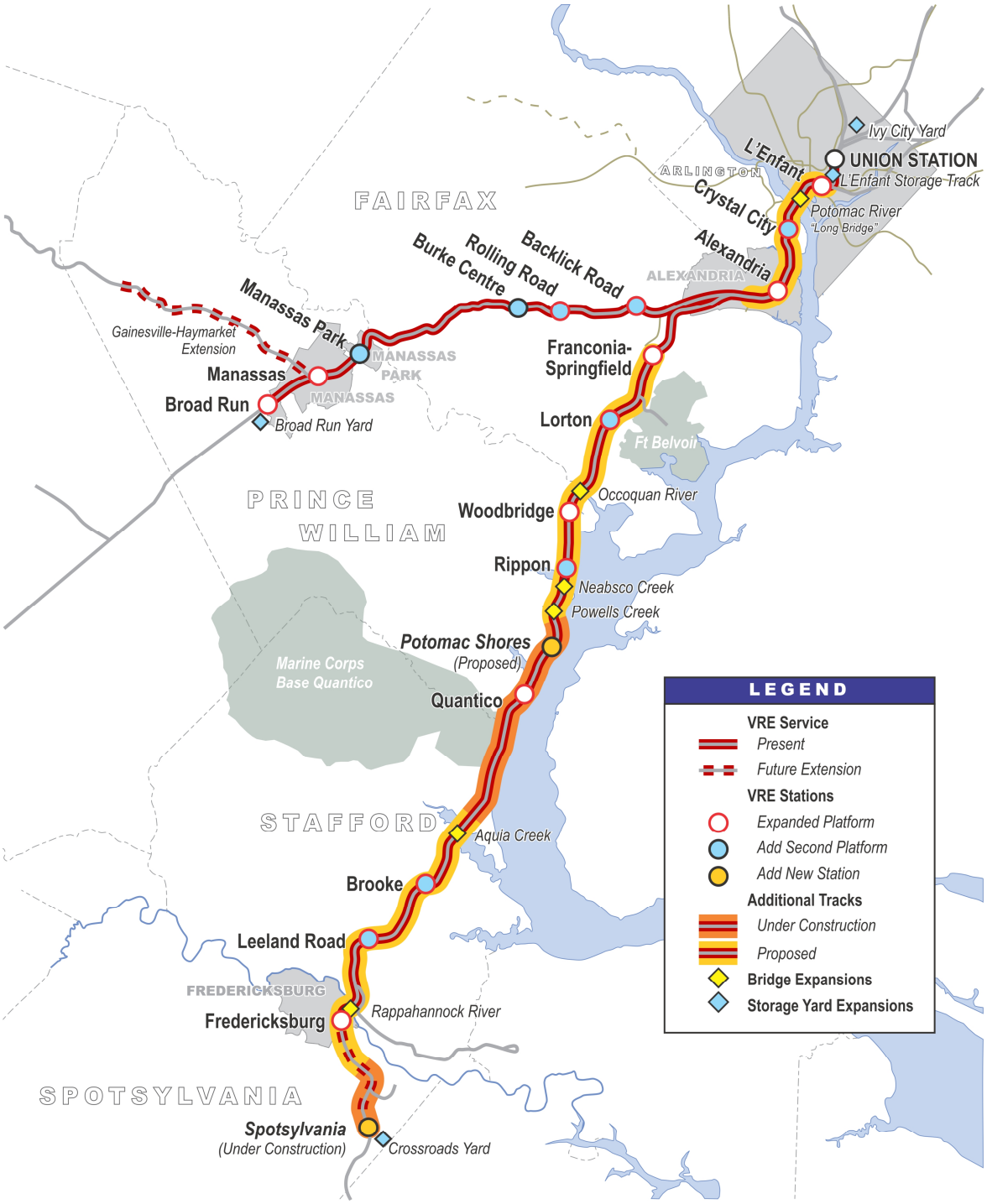
The System Plan includes the capital investments shown in **Table 1-1**, to ensure that the VRE system has sufficient capacity to serve its ridership markets.

Table 1-1 System Plan Capacity Investments by Phase

	Phase 1 2015-2020	Phase 2 2021-2030	Phase 3 2031-2040
Stations			
Platform lengthening	✓	✓	✓
Second platform at existing stations	✓	✓	✓
Parking expansion	✓	✓	✓
New stations	✓	✓	
Rolling Stock			
Additional passenger coaches and locomotives	✓	✓	✓
Yards and Shops			
Increase storage at Crossroads and Broad Run yards and at Washington Union Terminal	✓	✓	✓
Storage yard on Gainesville-Haymarket branch		✓	
Equipment maintenance facility expansion	✓		
VRE Service Extension			
11 miles from Manassas to Gainesville and Haymarket on Norfolk Southern rail line		✓	
Capacity in Long Bridge Corridor			
4-track mainline between Washington DC and Alexandria to handle heaviest service density		✓	
Replace or expand existing 2-track Long Bridge across the Potomac River		✓	
Reconfigure VRE stations at L'Enfant, Crystal City, and Alexandria for bi-directional service		✓	
CSX Fredericksburg Line Capacity			
Triple track remaining Fredericksburg Line segments between Franconia-Springfield and Fredericksburg	✓	✓	✓
4th track at critical locations			✓

Figure 1-6 shows the location of planned capital improvements envisioned in the System Plan.

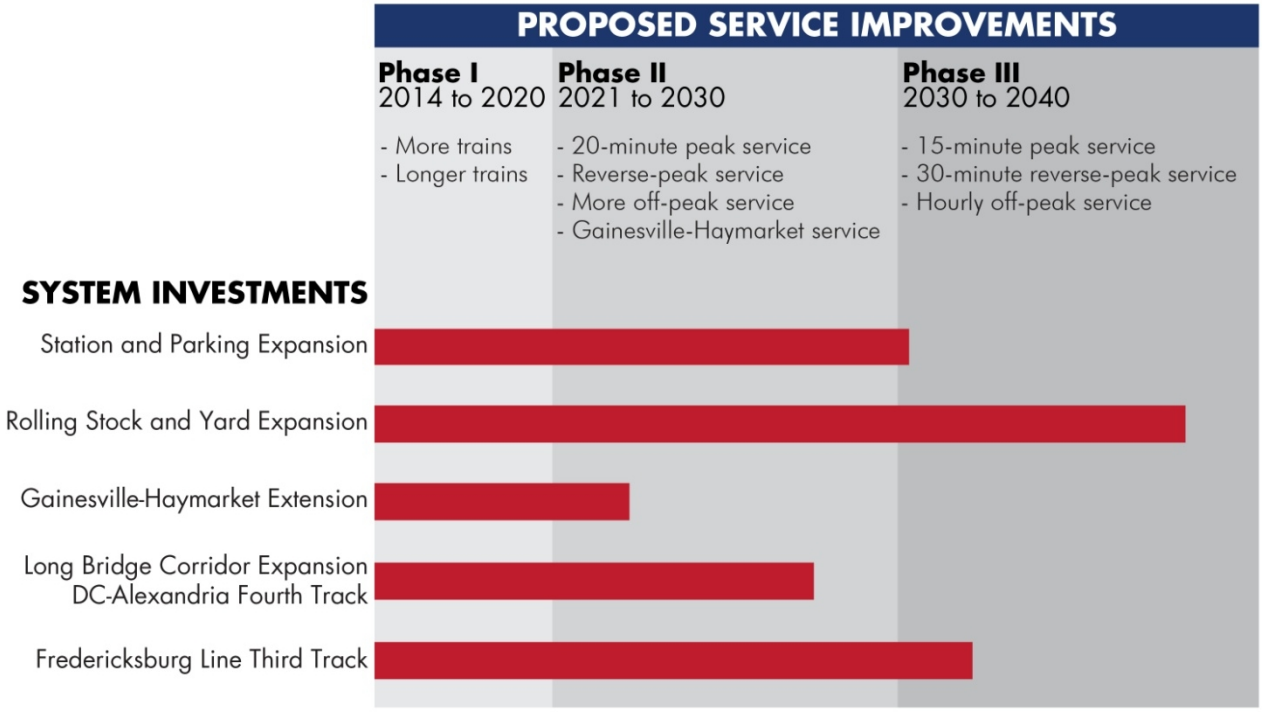
Figure 1-6 Proposed System Plan Capacity Improvements



The railroad corridors between Washington DC and northern Virginia are a significant transportation infrastructure asset. The VRE System Plan maximizes the value and utilization of that asset for regional passenger transportation purposes. The service enhancements proposed in this plan enables the two VRE lines to have a rush hour passenger-carrying capacity by 2040 equivalent to two lanes of traffic on an interstate highway.

The System Plan investments are grouped into three phases through 2040, shown in **Figure 1-7** along with the associated increases in the level of VRE service.

Figure 1-7 System Plan Timeline



In the first phase through 2020, relatively low-cost projects are recommended to maximize the capacity and service currently allowed VRE in its agreements with the CSX and Norfolk Southern railroads. A financial plan is being developed to identify funding sources to implement these projects which represent planned investments of about $50 million annually.

The second phase of the plan, from 2021 through 2030, includes major investment in relieving the key capacity bottlenecks on the VRE system, including expanding or rebuilding the Long

Bridge across the Potomac River. Without these significant capacity investments, the VRE growth potential from other improvements recommended in this phase such as the Gainesville-Haymarket extension and the additional peak hour trains would be limited and long-term system capacity still constrained. However, with increased Long Bridge corridor capacity, the full ridership potential of those improvements can be realized at relatively low incremental cost. The final phase of the System Plan, from 2031 through 2040, focuses on capital projects to enable continued growth in traffic, including completing the triple tracking of the CSX main line between Alexandria and Spotsylvania, which will position VRE to achieve its potential as a full-service regional railroad, serving the full range of travel markets in the territory in which it operates.

2. Current VRE Service, Ridership and Performance

2.1 VRE Train Service

VRE operates weekday rail service between Washington Union Station and northern Virginia on two lines – Fredericksburg and Manassas. The existing service is summarized in **Table 2-1**. Currently, VRE trains operate at approximately 30 minute headways on both lines in the peak direction over a period of about three hours in both the morning and evening peaks. Headways are slightly shorter at the height of the peak. Both lines offer a mid-day return train from Washington DC to Virginia destinations.

Table 2-1 VRE Train Service in 2013

	Fredericksburg Line	Manassas Line	Total VRE
Weekday Morning Peak Period			
Duration*	2 hrs. 40 min. 6:29-9:09am	2 hrs. 47 min. 6:18-9:05am	
Peak Headway in minutes (minimum / *average*)	22 mins. / *26 mins.*	25 mins. / *33 mins.*	
Peak Direction Trains (inbound)	7	6	13
Reverse Peak Trains (outbound)	0	1	1
Mid-Day Off-Peak Trains (both ways)	1	2	3
Weekday Evening Peak Period			
Duration*	3 hrs 05 min. 3:35-6:40pm	3 hrs 05 min. 3:45-6:50am	
Peak Headway in minutes (minimum / *average*)	30 mins. / 37 mins.	25 mins. / *37 mins.*	
Peak Direction Trains (outbound)	6	6	12
Reverse Peak Trains (inbound)	0	1	1
Non-Revenue Trains	0	2	2
Total Daily Trains	**14**	**18**	**32**
Total Daily Trainsets Operated	**7**	**5**	**12**
Total Coaches in Daily Service	**43**	**35**	**78**

* Times are of arrival in a.m. and departure in p.m. to/from Washington Union Station.

VRE trains vary in length from four to eight cars, as indicated in **Table 2-2**, and all trains are able to operate bi-directionally in push-pull mode, with a locomotive generally at the south end of the train and a cab control car at the north end. Train lengths and capacities are driven by passenger demand, and by the available track lengths at VRE's storage yards at Washington Union Terminal and at the end-of-the-line Virginia yards. There is some room for VRE to add capacity by lengthening trains instead of adding new trains, but investment in the lengthening of yard storage tracks is required to support this, particularly at Washington DC where the existing available storage tracks are used to their full capacity. VRE locomotives are capable of hauling up to ten passenger coaches, although VRE's near-term plans envision a maximum train length of eight cars. All passenger cars are gallery-style bi-level coaches, with an average seating capacity of around 135 passengers per car, depending on the interior configuration.

Table 2-2 VRE Train Lengths in 2013

	Fredericksburg Line	Manassas Line	Total VRE
4 cars	1	--	1
5 cars	1	--	1
6 cars	2	2	4
7 cars	2	1	3
8 cars	1	2	3

Both the Fredericksburg and Manassas lines operate via the Amtrak-owned First Street Tunnel from Union Station to its intersection with the CSX-owned right-of-way at the railroad interlocking (switch-signal point) referred to as CP Virginia, near the intersection of Virginia Avenue and South Capitol Street. From CP Virginia to a location south of VRE's Alexandria station known as AF Interlocking, all VRE trains, as well as all Amtrak trains operating south of Washington DC, utilize the CSX-owned right-of-way that includes the Long Bridge over the Potomac River. There are three main tracks in this railroad segment on either side of the Long Bridge right-of-way and two tracks on the bridge itself.

The two VRE lines diverge at AF Interlocking. The VRE Fredericksburg Line operates on the CSX-owned railroad corridor through eastern Fairfax, Prince William, and Stafford Counties to the City of Fredericksburg. The VRE overnight storage yard and maintenance facility for the Fredericksburg Line trains is south of Fredericksburg at the Crossroads Yard in Spotsylvania County.

The VRE Manassas Line operates westward from AF Interlocking on the Norfolk Southern railroad corridor, serving Fairfax County, the municipalities of Manassas Park and Manassas, and the western portion of Prince William County, terminating at a the Broad Run station and storage and maintenance yard located adjacent to the Manassas Airport.

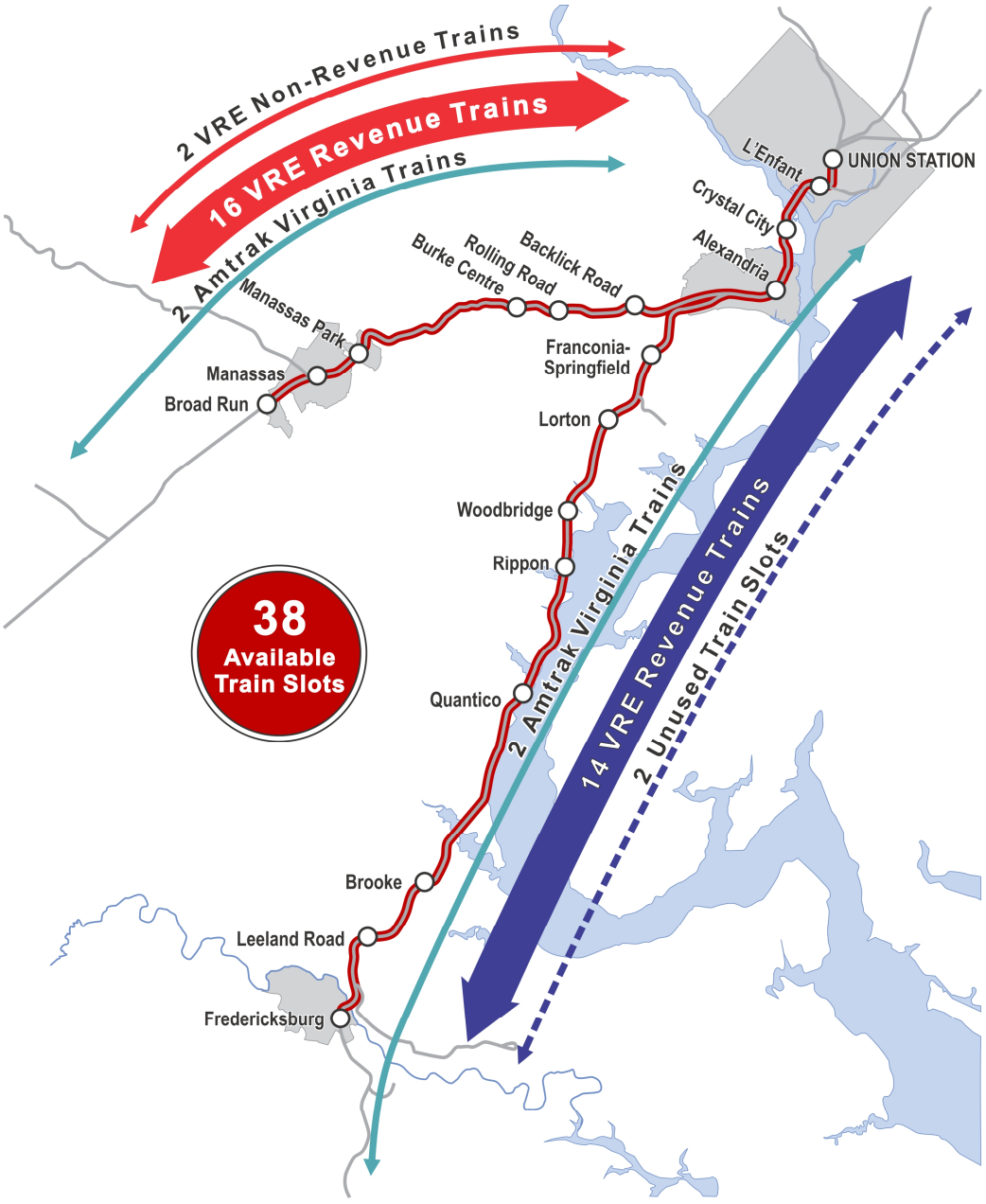
VRE's operating agreement with CSX imposes limits on the number of passenger train operations by VRE. The operating agreement with CSX covers all VRE trains, both those on the CSX line to Fredericksburg, and also Manassas Line trains once they merge onto the CSX right-of-way in Alexandria. The agreement permits VRE to operate up to 38 daily trains, 18 on the Fredericksburg Line and 20 on the Manassas Line, within designated operating periods (AM and PM peak periods and limited mid-day service). VRE currently operates 32 daily trains (30 revenue trains and 2 non-revenue trains while Amtrak Virginia trains utilize four additional daily train slots under an agreement among VRE, DRPT, and CSX[1]. Two unused slots are available for an additional round trip on the Fredericksburg Line. **Figure 2-1** graphically depicts the use of slots.

VRE's current operating agreement with Norfolk Southern is not specific as to the number of trains that may be operated, but Norfolk Southern must agree to any additional trains or changes in schedules. More importantly, Manassas Line trains must operate over CSX right-of-way between Alexandria and Washington which makes them subject to the CSX operating agreement and imposes a *de facto* cap on trains using the Manassas Line.

The current VRE service is tailored to weekday rush hour service and VRE's role in the regional public transportation network is primarily focused on weekday peak commuting to the central core activity centers in Washington DC, the Crystal City area of Arlington County, and Alexandria. As such, the passenger-carrying capacity of VRE provides an important supplement to the regional highway network and helps mitigate traffic congestion by delivering a volume of travelers into the region's core every weekday equivalent to what can be carried on a lane of traffic on an interstate highway.

[1] Amtrak also operates intercity trains to the South beyond Richmond and Lynchburg, but they are covered by a pre-VRE agreement and are not counted in the limits on passenger trains discussed in this section.

Figure 2-1 VRE Daily Trains and Available Train Slots



2.2 VRE Ridership

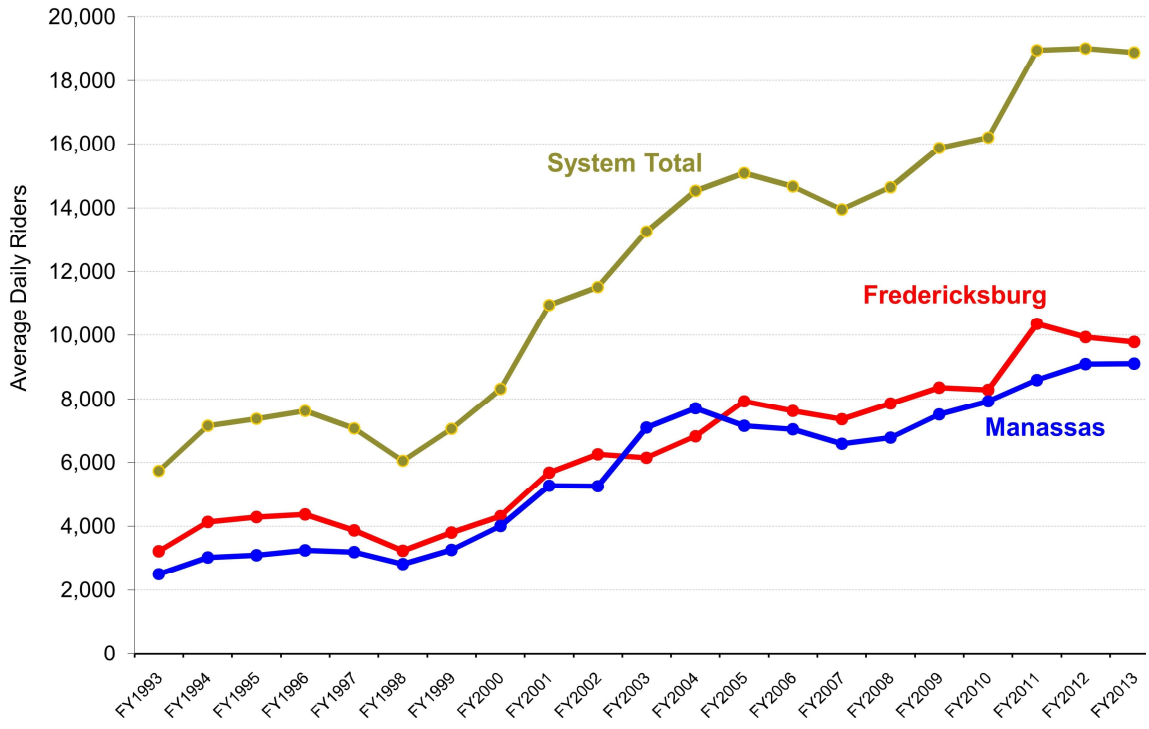
In 2013, VRE carried about 19,000 daily passenger trips. As shown in **Figure 2-2**, trips on VRE are relatively evenly distributed between the Fredericksburg and the Manassas lines. After more than a decade of steady growth, at an average rate of 8 percent per year, ridership has leveled off during the past two years as many peak hour VRE trains are filled to or beyond their seating capacity and parking lots fill up at the end-of-line stations. Nonetheless, the average passenger satisfaction is high, based on surveys conducted by VRE, and the percent of trains arriving on time is at all-time highs, as shown in **Table 2-3**.

Table 2-3 VRE Passenger Satisfaction and On-Time Arrival 2000-2013

	2000	2005	2010	2013
Average passenger satisfaction	82%	70%	75%	78%
Percent of trains arriving on time*	93%	84%	87%	96%

* Defined as arriving at final destination station within five minutes of scheduled arrival time.

Figure 2-2 VRE Weekday Trips by Line, FY 2000-2013



VRE's major travel market today is longer-distance commute trips from the middle and outer Virginia suburbs – beyond the reach of the Metrorail system (Metro) – to activity centers in Alexandria, Crystal City, Rosslyn, and downtown Washington DC. Virginia activity centers in the Franconia-Springfield, Fort Belvoir, and Quantico areas attract trips as well, and Metro distributes commuters well into other parts of the District and suburban Maryland. **Figures 2-3** and **2-4** show the geographic origins and destinations of VRE morning peak trips, based on data obtained from the 2012 annual VRE passenger survey and mapped by zip code.

VRE carries a significant share of total trips to the core activity centers of Washington DC, Arlington, and Alexandria from the catchment areas around VRE's stations in northern Virginia – in the range of 10 to 14 percent. The share in specific markets is even higher (such as Broad Run to L'Enfant, where VRE's share of the market is over 50 percent), where:

- Drives are relatively long and transit alternatives are not available or relatively inconvenient at the VRE origin station
- Employment is concentrated within walking distance of the VRE destination station
- Destination connections to Metro or other transit services are convenient and plentiful.

Figure 2-3 Origins of VRE Commuters, 2012

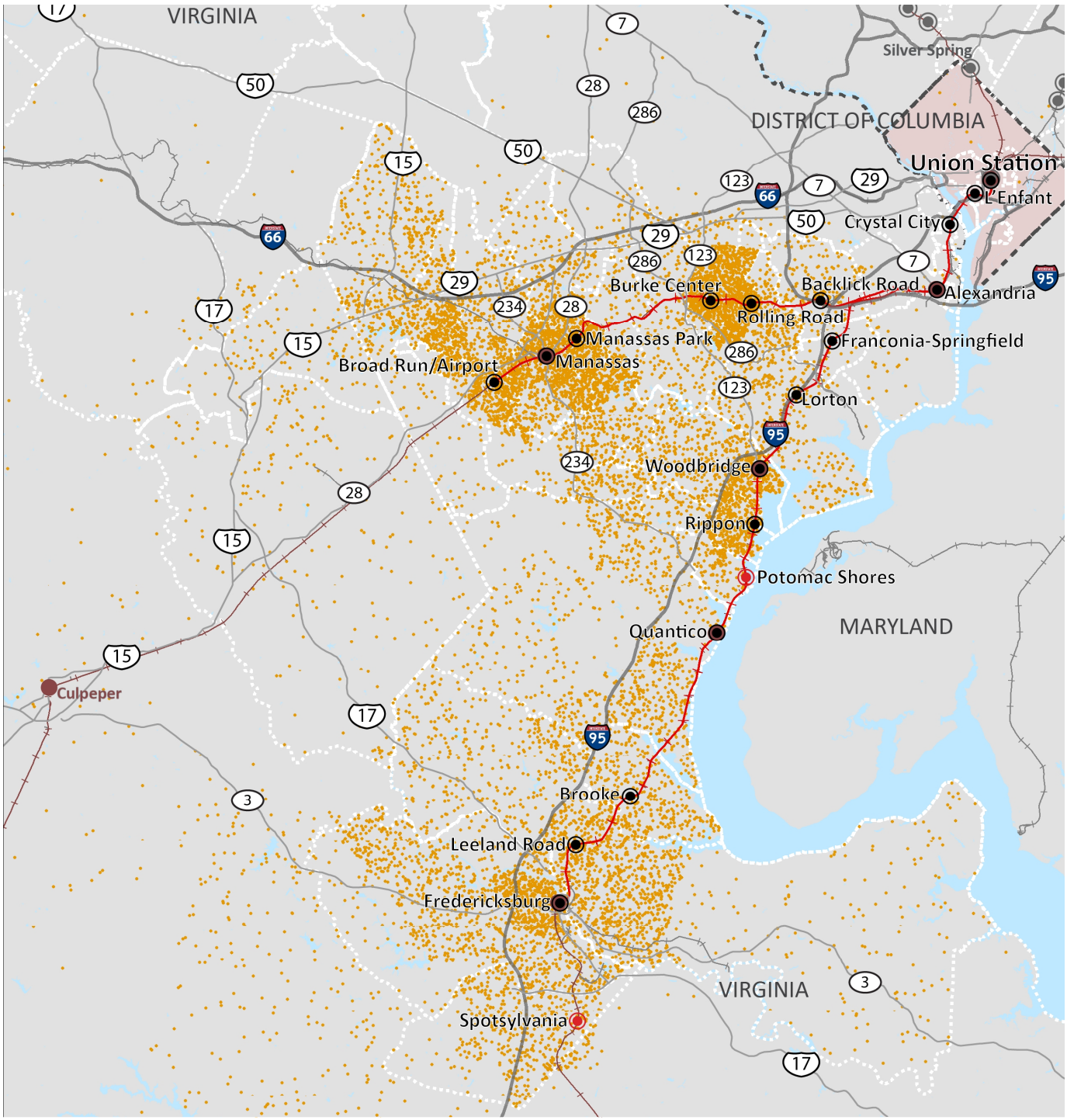
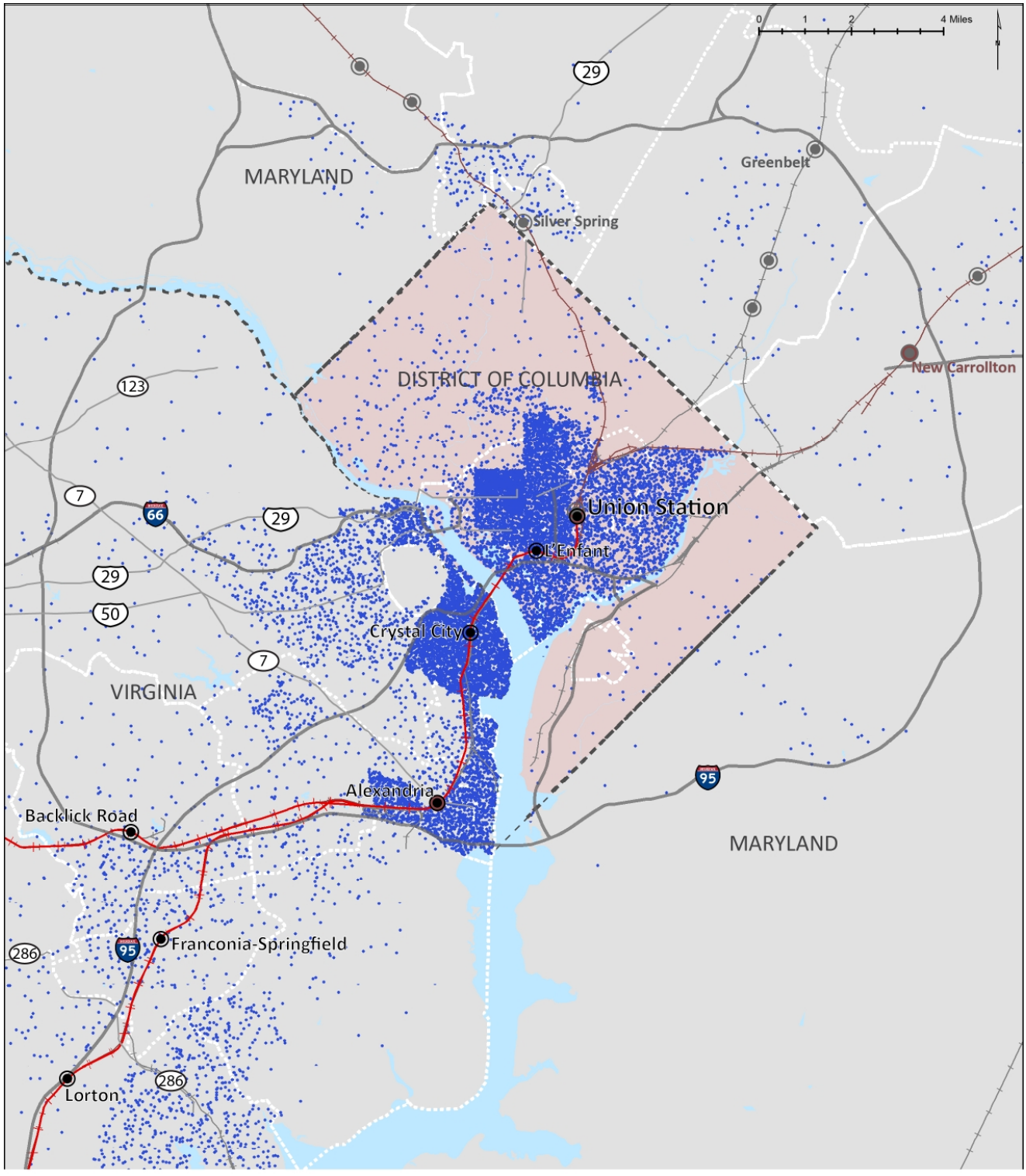


Figure 2-4 Destinations of VRE Commuters, 2012



2.3 Revenues and Operating Cost

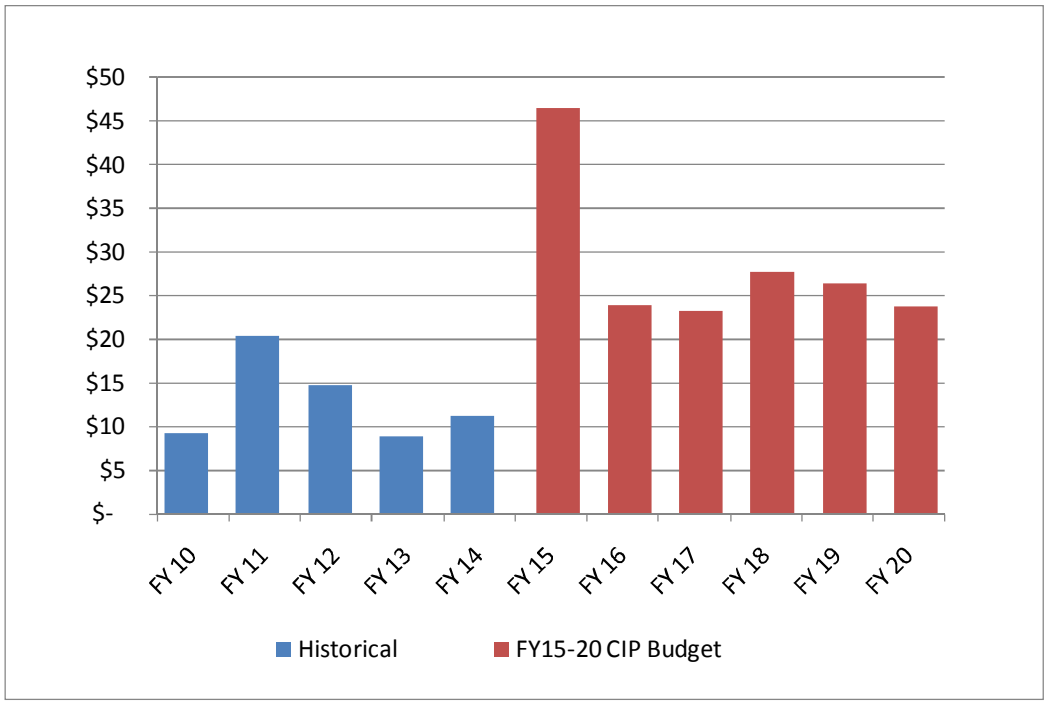
In FY 2013, VRE generated $34.7 million in revenue from passenger tickets. In the same year, an estimated 4.8 million trips were taken on VRE, resulting in an average fare per trip of $7.28.[2] In FY 2013, revenue reached $35.0 million. VRE's operating and maintenance cost (O&M cost) in FY 2013 was $60.7 million, roughly the same as the previous year. The O&M cost covers all aspects of train operations and maintenance (both performed directly by VRE and contracted out), leases and access fees to rail lines and Union Station terminal facilities, insurance, and other marketing, sales, and administrative functions.

2.4 VRE Capital Investment

Historical capital investment by VRE from 2004 to 2013 and the planned capacity expansion elements of the adopted Capital Improvement Program from 2015 to 2020 are shown in **Figure 2-5**. Spending is set to increase substantially over the next six fiscal years to support the System Plan investments and as new sources of revenue become available for capital projects.

Figure 2-5 VRE Capital Spending, 2004-2020

(millions of year-of-expenditure dollars)

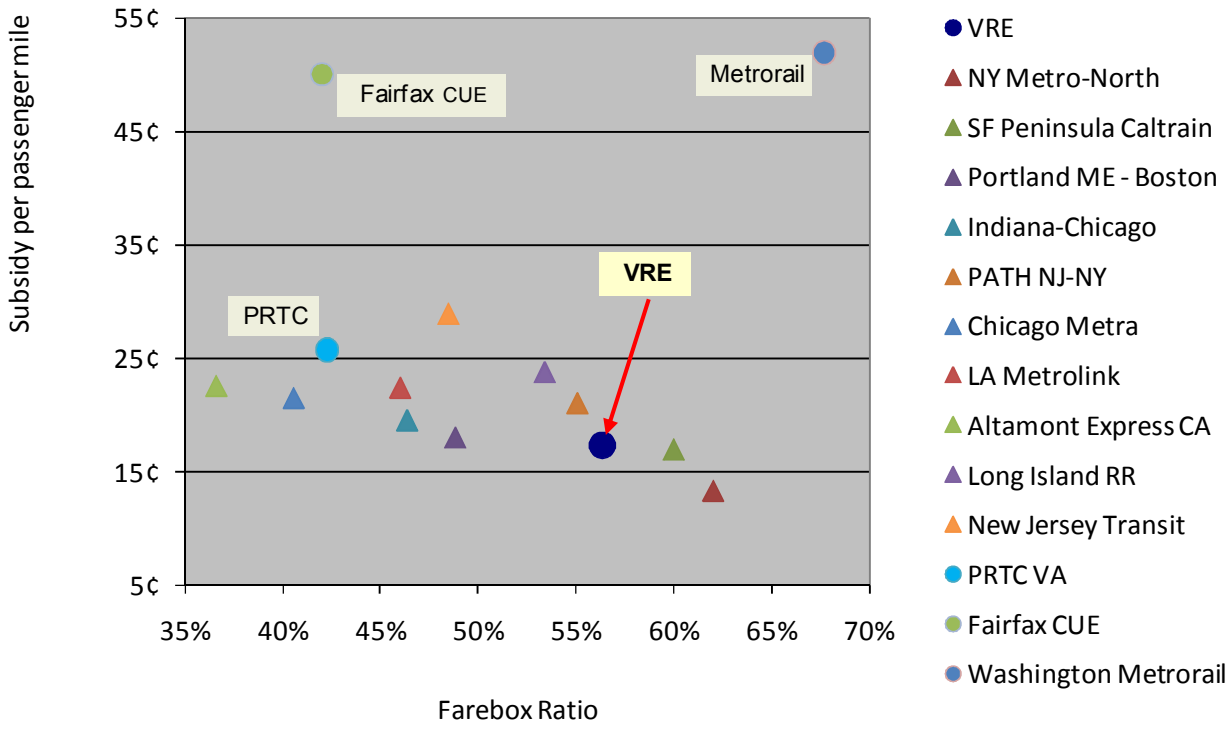


[2] VRE, "Comprehensive Annual Financial Report for the years ended June 30, 2012 and 2011", p. 46

2.5 Cost-Effectiveness Relative to Other Transit and Commuter Rail Systems

VRE is one of the most cost-effective transit operations in the greater Washington DC region, covering over half of its operating costs from ticket revenue, second only to the Washington Metro rail operation, and with a significantly lower operating subsidy per passenger mile, as shown in **Figure 2-6**. Among its commuter rail peers elsewhere in the country, VRE is in the top third with respect to both farebox ratio and subsidy per passenger mile.

Figure 2-6 Comparison of VRE and other Transit Operators



Source: National Transit Database, Time Series 2011

3. Future Travel Markets

3.1 Demographic Growth in the Washington DC Region

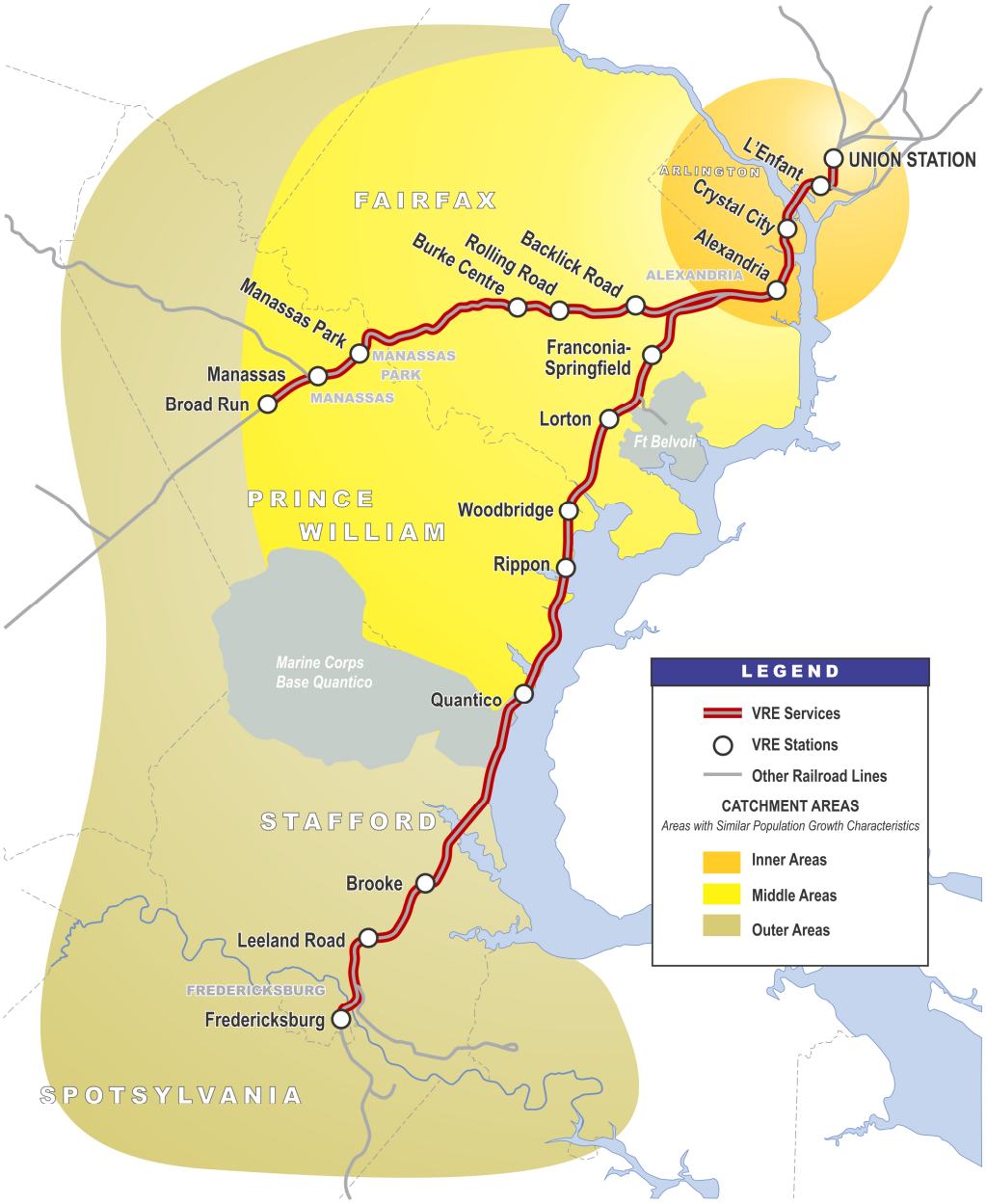
VRE's growth in riders since its opening has been driven primarily by strong residential growth in the Virginia communities along or near the commuter lines, and jobs growth in the central core area from Alexandria to the District. Work trips in the region have increased over the years and VRE's patronage has grown with them. Similar market-driving growth is forecast to continue over the next 25 years, more strongly in the first dozen years than in the last 15, but enough to increase the VRE-oriented market by 40-60 percent by 2040. As shown in **Table 3-1**, the most rapid residential growth is expected in the areas using the "outer" Fredericksburg line stations, which generate about 60 percent of the line's current riders. The areas around the more central "middle" stations on both lines grow less strongly, especially after 2025 as these areas become more fully developed. And in the "inner" station areas which are already relatively developed, growth is slowest. **Figure 3-1** shows these general areas in relation to the stations on each VRE line.

Table 3-1 Forecast Population Growth per Year - VRE Region

	2010 - 2020	2020-2030	2030 - 2040
Fredericksburg line			
Outer areas	2.5%	2.1%	1.6%
Middle areas	2.0%	1.2%	0.8%
Inner areas	0.8%	0.7%	0.4%
Line average (weighted by ridership)	2.2%	1.7%	1.2%
Manassas line			
Middle areas	2.2%	1.5%	0.9%
Inner areas	0.8%	0.7%	0.4%
Line average (weighted by ridership)	1.8%	1.2%	0.8%
Source: Growth calculated from Washington COG, Round 8.1 Cooperative Forecasting, 2012; weighting from origins in VRE 2012 rider survey			

Note: The "Outer" areas aggregate the forecast growth of the counties of Spotsylvania, King George, and Stafford, and the City of Fredericksburg. The "Middle" areas aggregate the forecast growth of the counties of Prince William, Fauquier, and Loudon, and the cities of Manassas and Manassas Park. The "Inner" areas aggregate the forecast growth of Fairfax County and the city of Falls Church.

Figure 3-1 VRE Line Areas of Grouped Forecast Population Growth



At the same time, employment growth in the core of the region is forecast to continue, bolstering the other end of the home-to-work market that is VRE's primary market. The Washington DC job market is projected to grow by 25 percent, Arlington's by 38 percent, and Alexandria's by 46 percent, adding over a quarter million jobs to the portion of the region served by VRE.

Future job growth is also projected outside the inner core, increasing the potential for reverse-peak trips. The outer zones of VRE's service territory also show strong projected job growth, albeit starting from a relatively small base compared to the largest regional employment centers. Significant employment centers relatively close to VRE include Fort Belvoir (both the Main Post and the North Area adjacent to I-95 and the railroad), Marine Corps Base Quantico, the planned Potomac Shores development, Fredericksburg City, the Prince William County Innovation business district west of Manassas, the George Mason University campus, and the Gainesville area of Prince William County. **Table 3-2** shows expected job growth for areas on both VRE lines.

Table 3-2 Current and Forecast Employment in Outer Areas along VRE Lines

	2010	2040	Growth
Fredericksburg line			
Fort Belvoir	65,700	93,100	+42%
Quantico	42,400	77,900	+84%
Prince William & Stafford Route 1	78,400	143,000	+82%
Fredericksburg	70,000	116,000	+65%
Fredericksburg Line Total	256,500	430,000	+68%
Manassas line			
Western Prince William	57,200	110,000	+92%
Total of Fredericksburg and Manassas Lines	**313,700**	**540,000**	**+72%**
Source: Calculated from MWCOG, Round 8.1 Cooperative Forecasting, 2012			

Future density of population and jobs is shown in **Figures 3-2** and **3-4** for Traffic Analysis Zones (TAZ) used by the Metropolitan Washington Council of Governments (MWCOG) regional forecasting model. The forecast growth in people and jobs is shown in **Figures 3-3** and **3-5** for VRE districts designed to have broadly similar access to VRE stations. The VRE districts helped develop planning level estimates of future ridership and revenue without running the full regional travel demand model, which was beyond the scope of the System Plan analysis.[3]

[3] The current form of the MWCOG model, while reasonable for the major regional travel patterns, does not do a good job of forecasting total trips and commuter rail share in VRE's longest-distance core markets. For example the modeled daily commute trips by all modes from the Fredericksburg area to the regional core are only about 1/10th of the actual VRE ridership at the Fredericksburg station (278 vs. 2,600 trips a day). Further work will be needed to better understand the dynamics of these long-distance markets and to adjust the model to more realistically forecast VRE trip-making potential.

Figure 3-2 Forecast 2040 Population Density by Traffic Analysis Zones

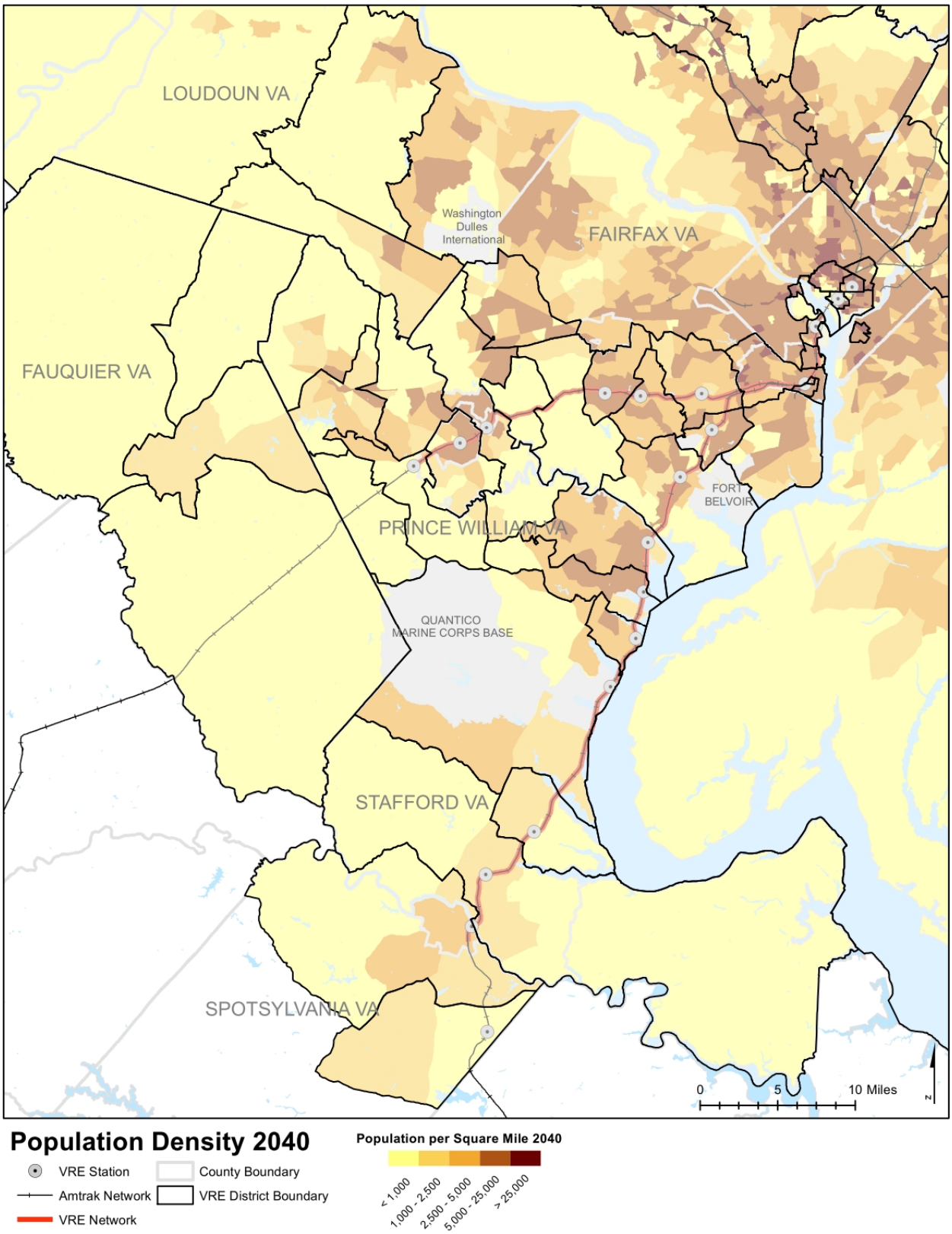


Figure 3-3 Forecast Population Growth by VRE Trip District, 2010-2040

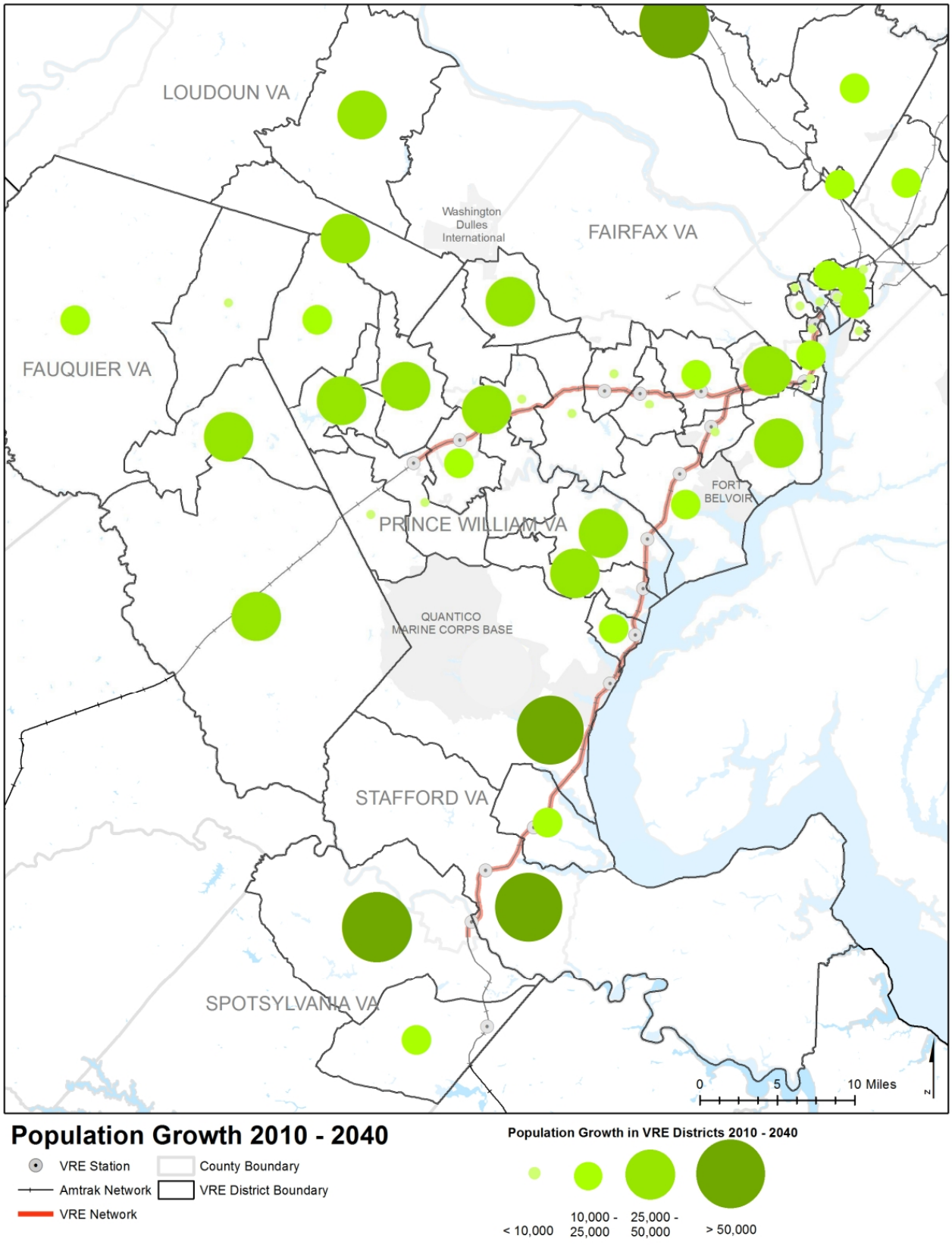


Figure 3-4 Forecast 2040 Employment Density by Traffic Analysis Zones

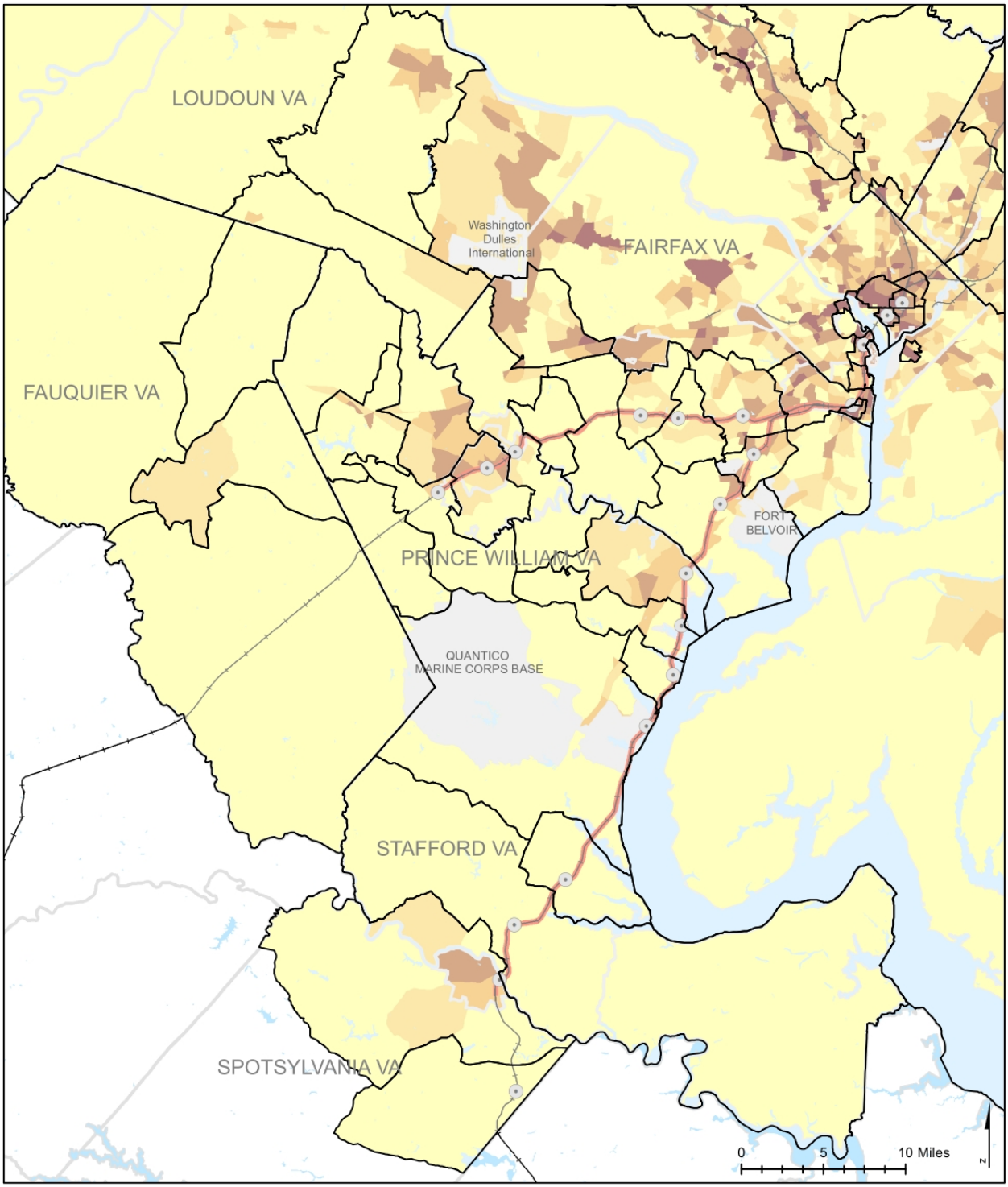
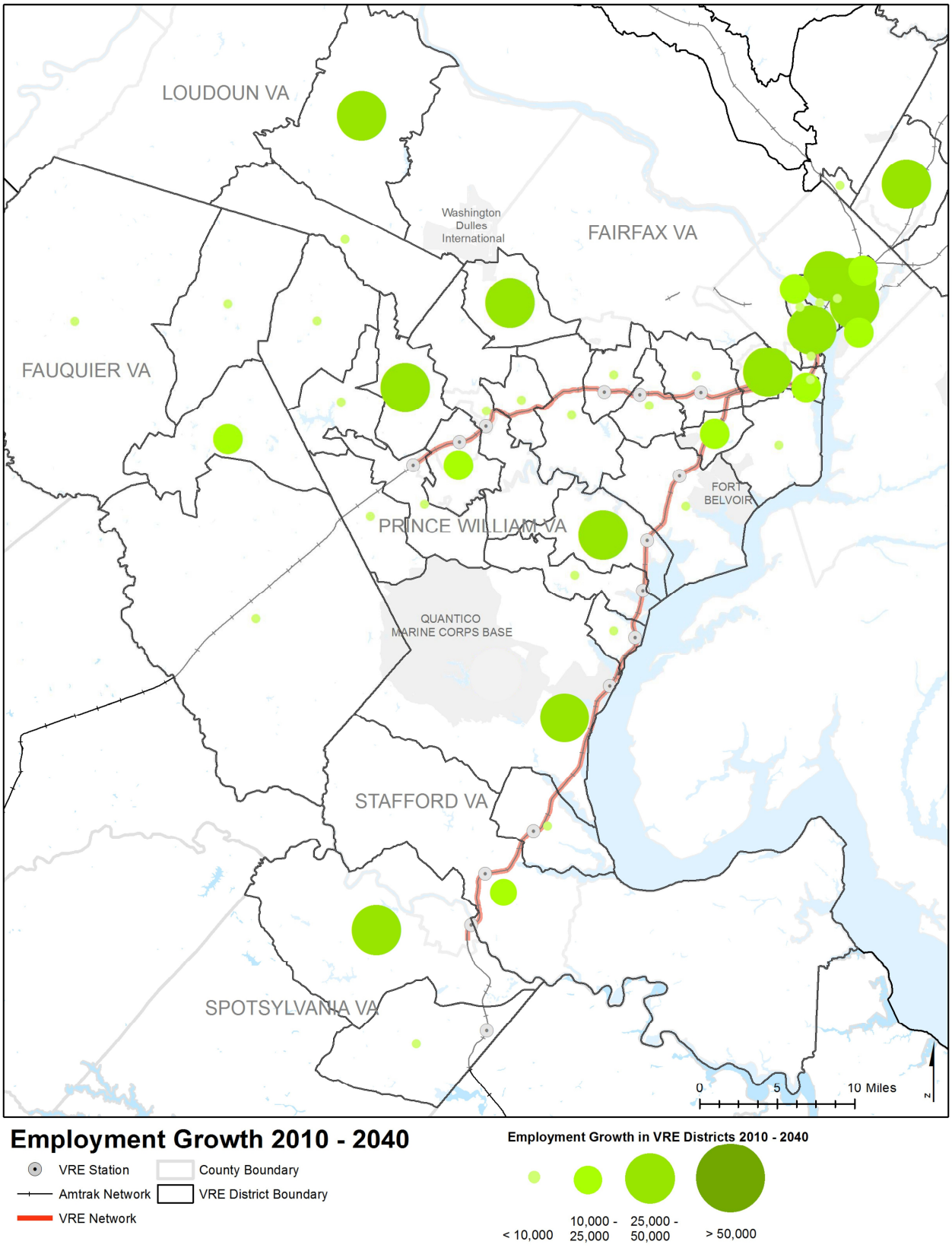


Figure 3-5 Forecast Employment Growth by VRE Trip District, 2010-2040



3.2 Growth in Current and Potential VRE Regional Travel Markets

Since its inception, VRE has served primarily the weekday peak period commute to work in Washington DC and the major activity centers of Arlington County and Alexandria. This longer-distance market is expected to continue to increase as the region grows, although at a slower rate than the population increase, since job availability will also grow in the outer areas. As noted before, a more detailed estimation of the total market and VRE's share will require refinement of the Washington regional travel model to properly portray VRE ridership today, and better define the relationship between service availability and housing location choices.

Trips in the Fredericksburg Line / I-95 corridor are expected to grow more rapidly than those on the Manassas Line / I-66 corridor, since greater population growth is projected in the longer Fredericksburg corridor which makes VRE more attractive to long-distance commuters that are the mainstay of today's VRE ridership.

To grow VRE's market share further, increases in VRE ridership will have to come either from extensions of service into new areas of population growth, or into new markets. Extension into the Gainesville - Haymarket area on the Norfolk Southern rail line is the most studied of the opportunities within the jurisdictions that help fund VRE. Commuter rail experience in Maryland and elsewhere in the US suggest that several of the travel markets not currently served by VRE could generate significant additional ridership. Each of these opportunities is discussed below.

Reverse-Peak Commutes

This market includes peak-period, reverse-direction commutes from the regional core to jobs in Crystal City or Alexandria activity centers or farther out along the Fredericksburg or Manassas lines to activity centers such as Fort Belvoir, Marine Corps Base Quantico, the planned Potomac Shores development, the Innovation business district, the George Mason University campus, the Gainesville area, or Fredericksburg City. Overall in the Washington region, these kinds of trip are less numerous than in the peak direction - roughly on the order of one-third to one half as large, but still a significant market.

Off-Peak Travel

This market includes mid-day and evening trips for a variety of purposes including work and non-work activities such as personal appointments, shopping, special events or tourist travel. Regionally, roughly four times as many trips of this kind are made on a typical weekday than are made going to and from work. While the potential VRE share of these trips would be small, it is

another significant market for added trips. For several other U.S. commuter rail operators, this market is growing faster than traditional work trips.

Extension to Gainesville - Haymarket

Improving and adding to the Norfolk Southern branch line between Manassas Junction west to Haymarket has been the subject of several feasibility studies showing a significant peak-direction commuter market which VRE could tap. The other travel markets discussed above for the existing lines also would exist in this corridor.

Short-Haul Trips Within the Urban Core

The volume of short trips in the Alexandria - Washington DC travel market is so large that Metrorail and road crossings of the Potomac are full at rush hour, and well used at other times. A by-product of increasing peak frequencies and providing peak trains in both directions to serve the markets discussed above would be an increased attractiveness of VRE for such short cross-Potomac trips. Because VRE trains are relatively full until the L'Enfant station in Washington DC, coordination with Metrorail will be needed, and the VRE fare structure would have to balance demand and capacity. Properly managed, this market could be an attractive additional source of ridership for VRE and transit capacity for the region.

Weekend Travel

This market includes weekend trips on both Saturday and Sunday or on Saturday only for work and non-work purposes. While VRE's existing railroad operating agreements do not permit weekend service, VRE may choose to pursue changing those agreements to enable weekend service in the future. Should that be the case, the best approach for VRE is to focus on specific types of trips among the large amount of travel made on weekends: trips to sporting events, museums, theater, restaurants, and other special events, especially where driving afterwards may be constrained. Maryland's MARC service has seen significant growth since starting weekend service to Washington DC in December 2013, and long-established services on other commuter railroads carry as much as half a weekday's passengers.

Run-Through or Regional Rail Service

This market would be tapped by extending VRE service beyond Washington's Union Station to Maryland and extending MARC commuter rail service southward to Virginia to serve through-Washington DC trips such as from Rockville or Baltimore to Alexandria or Manassas to Fort Meade to cite a few potential activity centers. VRE and MARC's existing railroad operating agreements do not permit run-through service; however, it is a market that could be pursued with the appropriate railroad capacity investments and agreements. The run-through market

could be as many as 100,000 weekday trips by 2040, depending on the services provided, a third of which could be work-related. Extension of VRE trains into MARC territory or vice versa could attract a share of these trips.

Extensions beyond the Existing VRE Service Area

Potential long-distance travel markets, albeit small ones, exist beyond the boundaries of VRE's existing service area to locations such as Fauquier County, Richmond, and Charlottesville or beyond. Amtrak Virginia service currently serves some of those markets. While extending VRE outside its service area has been suggested and may represent a potential market for VRE service, the VRE Operations Board indicated a preference that the System Plan focus on markets within the existing service area.

3.3 VRE Ridership Potential

The potential VRE ridership in each of the travel markets described above was estimated using several sketch planning approaches. For growth in existing peak direction commuting, population and employment growth, and standard planning-level sensitivities to increases in frequency and speed were used. The ridership potential of extending to Gainesville-Haymarket started with prior study estimates, and subtracted the estimated impact of frequency that were included in those estimates. Reverse-peak potential ridership was estimated from anticipated employment growth and market shares. Off-peak service VRE use was based on experience of other U.S. commuter railroads with both services.

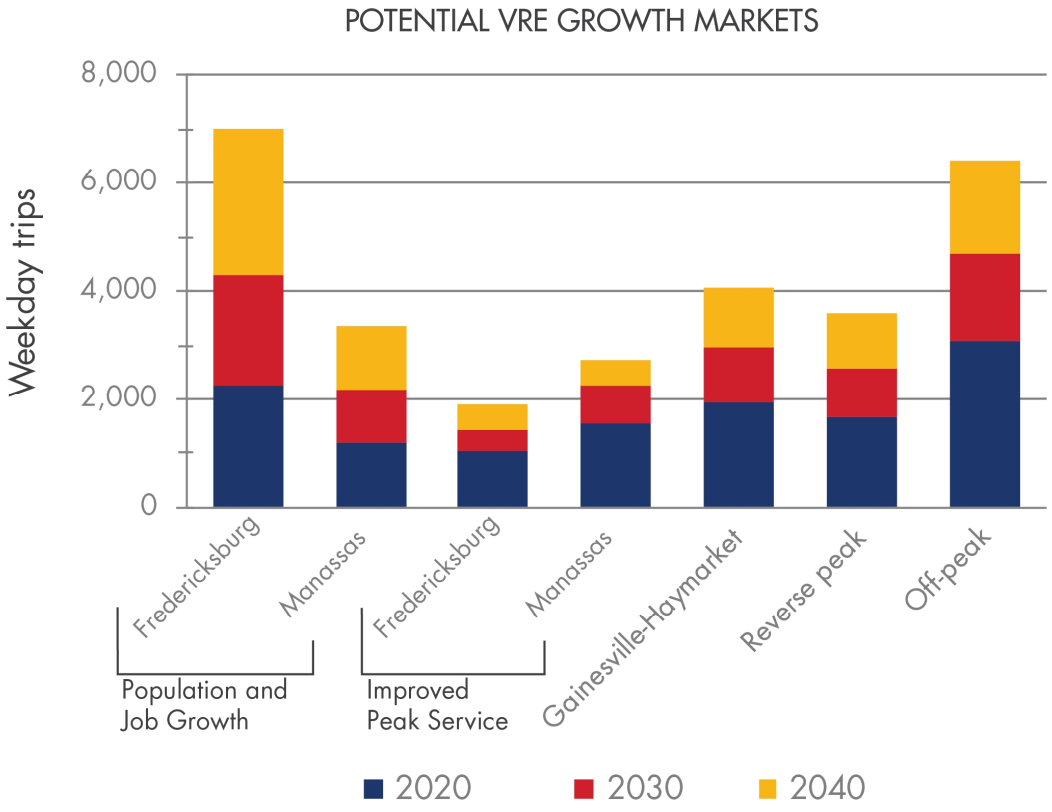
The resulting estimates of additional VRE ridership from each market is compared to the existing 2013 weekday ridership on the Fredericksburg and Manassas lines in **Figure 3-6**. Estimates are shown for the year 2040 in a high-low range to reflect the uncertainties of the sketch planning process and of future growth.

VRE's current core market – journey-to-work travel from the northern Virginia VRE service area to the central business district of Washington DC, Arlington, and Alexandria – will continue to generate the most ridership potential for VRE. The other potential new markets are relatively small individually – in the range of 2,000 to 6,000 daily trips. When taken together, however, the various markets for improved or new rail service add up to a significant boost in potential ridership.

The growth on the Manassas Line is more modest than on the longer Fredericksburg Line. However, the addition of the Gainesville-Haymarket extension to the Manassas Line effectively

equalizes the future demand potential for the two lines. The reverse-peak and off-peak markets, when taken together, generate long-range potential demand approaching 10,000 daily trips.

Figure 3-6 VRE existing weekday trips and estimated future ridership



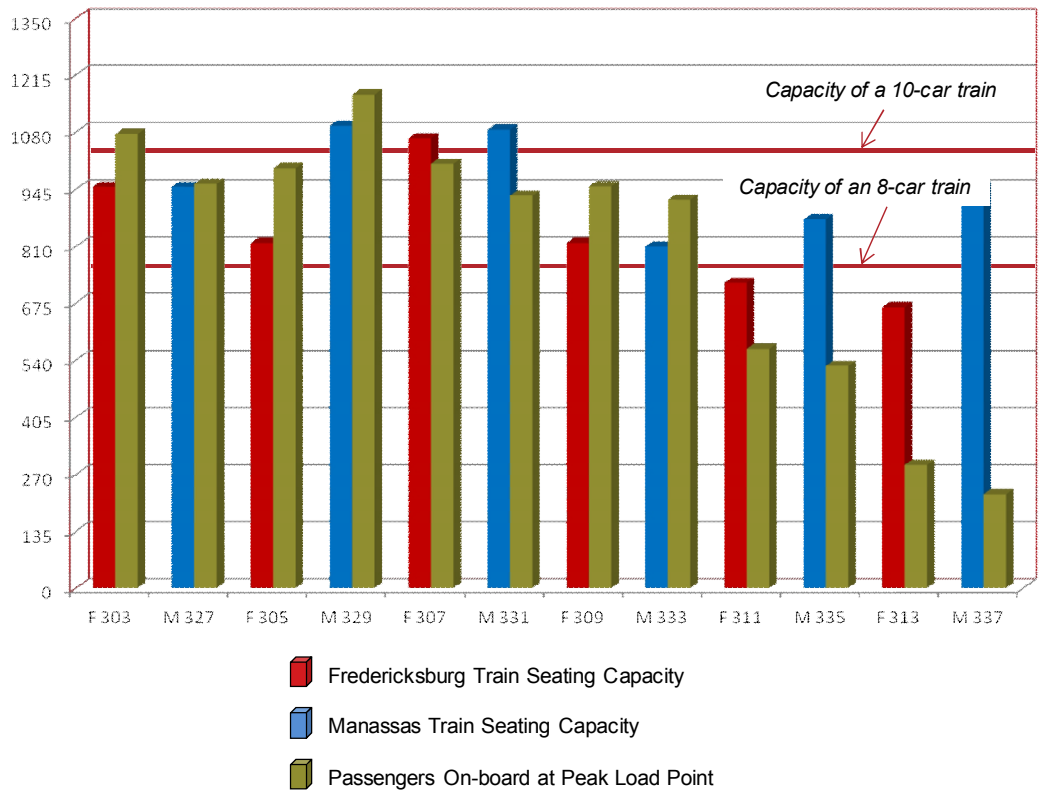
4. VRE System Plan for Improved and Expanded Service

The level of VRE service on both the Fredericksburg and Manassas Lines will need to increase substantially in order to accommodate the projected increase in weekday peak commuter demand from the VRE service area to the core central business district of Washington DC, Arlington and Alexandria, or for VRE to tap any of the potential new travel markets identified in the previous chapter.

4.1 Short-Term Measures to Increase Existing System Capacity

VRE's existing trains tend to be relatively crowded during the weekday peak periods, with some trains regularly filling beyond their seated capacity. **Figure 4-1** shows average passenger loads and the number of seats available on each evening peak train. Except for the trains at the very end of the peak period, all trains operate close to capacity, with very little room to accommodate growth in ridership. Morning peak conditions are similar.

Figure 4-1 Mid-Week PM Peak Passenger Loads and Seating Capacity by Train, 2013



Not all VRE trains have the same number of cars; most are either six or eight cars in length. One way to increase the passenger-carrying capacity of VRE is to add cars to existing trains. **Figure 4-1** also illustrates the extent to which lengthening all trains to eight or ten cars would be able to increase the number of peak seats available to commuters and potentially relieve crowded conditions.

There are constraints that impose practical limits on the length of trains, including the lengths of station platforms and storage yard tracks, the number of available rail cars in the VRE fleet, and the maximum length train that can be pulled by a diesel locomotive. VRE operates three eight-car trains today (out of twelve total trainsets), and its locomotives are capable of pulling up to ten cars. The platforms at VRE stations can be lengthened to accommodate longer trains, and capital projects can increase storage capacity for longer trains at VRE's two overnight storage yards and in Washington DC where the trains are stored mid-day (to the extent that land is available for expansion).

The second way to increase peak capacity is by adding new trains to the schedule. VRE's ability to do this in the short term is constrained by the limits on daily trains imposed by the operating agreements with its host railroads. In particular, the agreement with CSX caps daily train movements at 38, only two more than the total currently being operated by VRE (and Amtrak Virginia trains using VRE slots), as summarized in Section 2.1 and shown in **Figure 2-1**. It would be possible within the current agreement to utilize the two unused slots for an additional VRE round trip on the Fredericksburg Line – operating inbound towards Washington in the morning and returning to Fredericksburg in the evening. Adding more than a single round trip on the Fredericksburg Line would require modification of the agreement.

It also would be possible under the current agreement to convert the existing two non-revenue VRE trains on the Manassas Line into passenger-carrying revenue trains. However, these trains run in the reverse-peak direction and would not contribute to increasing VRE peak direction capacity. While it would be theoretically possible to eliminate these reverse-peak non-revenue trains and replace them with a peak Manassas Line round trip similar to what would be added on the Fredericksburg side. However, this would require two additional mid-day train storage positions in Washington Union Terminal, for which land is not readily available.

Based on all of the above considerations, VRE's near-term plan for expanding service and passenger-carrying capacity within the provisions of existing railroad agreements includes the following elements:

- Adding a peak direction round trip on the Fredericksburg Line
- Lengthening existing VRE trains to eight cars.

The investment required to support these changes includes the acquisition of additional rail cars. VRE has sufficient locomotives available to add the Fredericksburg train, and has programmed expansion of yard storage capacity at all three of VRE's train storage yards to permit lengthening of selected trainsets, lengthening of station platforms to accommodate 8-car trains, and expansion of station parking capacity to accommodate planned ridership growth.

The resulting increase in service and capacity is shown in **Table 4-1**. The six-year CIP, when complete, will provide capacity for approximately 25,000 daily passenger trips. This will accommodate ridership growth of approximately 30 percent, allowing for an increase in daily traffic from the current 19,000 to 25,000 daily VRE trips. This should allow VRE service to meet its market demand until approximately the mid-2020s, at which time a further increase in capacity would be needed.

Table 4-1 Planned Near-Term Capacity Improvements Within Current Agreements

	Existing (2013)	2020
Daily Revenue Trains	25	27
Daily passenger cars in peak direction service	149	216
Daily passenger-carrying capacity	19,000	25,000

4.2 Requirements for Increasing Service Beyond Current Capacity Limits

VRE's ridership growth beyond the mid-2020s and the 25,000 daily trip threshold is constrained by system capacity and the current railroad agreements. Further ridership growth will require:

- Increased railroad capacity – creating additional train slots that can be used by VRE as well as Amtrak, freight trains, and future higher-speed rail services
- Continued investment in VRE's core system, including station facilities, parking, rolling stock and fleet storage and maintenance facilities.
- New agreements with the host railroads, including CSX, Norfolk Southern and Amtrak

Expanding VRE service by increasing the number of daily trains operated beyond the limits identified in VRE's current railroad operating agreements is not likely without a concurrent expansion of railroad capacity such as constructing additional tracks, primarily in the CSX railroad corridor. The specific number of daily trains and future operating plan that VRE will be able to operate is contingent upon the provision of sufficient railroad capacity to preclude VRE trains and other passenger rail services from interfering with freight operations. Such a plan would require the negotiation of a new operating agreement between VRE and CSX.

Taking the next step will require a substantial step-up in the level of VRE system investment, especially in railroad infrastructure. Two major capital initiatives have been identified:

- the Long Bridge Corridor program
- CSX RF&P (Fredericksburg Line) Triple Tracking Program

These two major initiatives will be projects of statewide, regional, and even national significance – where VRE will be one among multiple stakeholders and beneficiaries. As such, it is anticipated that VRE's contribution to the cost of these projects would be only a proportion of the total cost, and smaller in percentage terms than for projects that are totally for the benefit of VRE. Additionally, new sources of funding at all levels will need to be identified and tapped for these large projects with broadly-based benefits. Railroad infrastructure capital investments are discussed in more detail Chapter 5.

The Long Bridge Corridor

VRE, Amtrak, and CSX share the rail corridor between the AF interlocking south of the VRE Alexandria station and the CP Virginia interlocking in southwest Washington DC that includes the Long Bridge across the Potomac River. The corridor has three tracks on both sides of the Long Bridge, but only two tracks on the bridge itself – which creates a major traffic choke point for all trains crossing between Washington DC and Virginia. Expanding the capacity of this critical stretch of rail line to four main tracks – two for passenger trains and two for freight trains – is considered critical to obtaining higher volumes of rail traffic and more reliable operations in the future.

Fredericksburg Line

On the Fredericksburg Line south of Alexandria, Virginia, VRE, CSX, and DRPT have collaborated on a series of capital projects aimed at increasing rail capacity by adding portions of third track to the existing 2-track main line, and relieving existing choke points such as the single-track Quantico Creek Bridge. A commitment to a continuous third track between Washington DC and the VRE Crossroads Yard south of Fredericksburg has been part of the plan for increased commuter rail and regional/intercity traffic in the Richmond-Washington DC corridor, including the introduction of higher-speed rail service from Richmond/Hampton Roads and North Carolina to Washington DC and the Northeast Corridor (NEC) – as part of the Southeast High-Speed Rail (SEHSR) corridor. The plan would construct additional third track segments on the Fredericksburg Line between Franconia and Spotsylvania, building upon the portions of three-track right-of-way that have already been built. It also includes expansion of existing two-track waterway crossings to include a third track, at the Occoquan and Rappahannock Rivers, and at the Neabsco, Powell's, and Aquia Creeks.

Manassas Line

The majority of the Manassas Line operates on a portion of the Norfolk Southern-owned Piedmont Division that has much less freight traffic the CSX RF&P line. Sufficient capacity is assumed to exist on the main line to accommodate increases in VRE traffic, once beyond the Long Bridge Corridor.

4.3 Medium-Term Service Improvements

As additional railroad capacity is created through the capital improvements described above, VRE will be able to add trains to serve both existing and new travel markets. Concepts for serving each of the markets identified in Chapter 3 were developed and assessed. An integrated plan emerged as the most effective approach, whereby the number of VRE peak commuter trains is increased and reverse-peak and off-peak service are introduced in increments, but as a package of improvements – as railroad capacity projects are completed and as overall travel demand grows. The combined approach is cost-effective in terms of equipment and crews, and it helps minimize the requirements for expanding storage yard capacity at Washington DC.

Weekday Peak Service

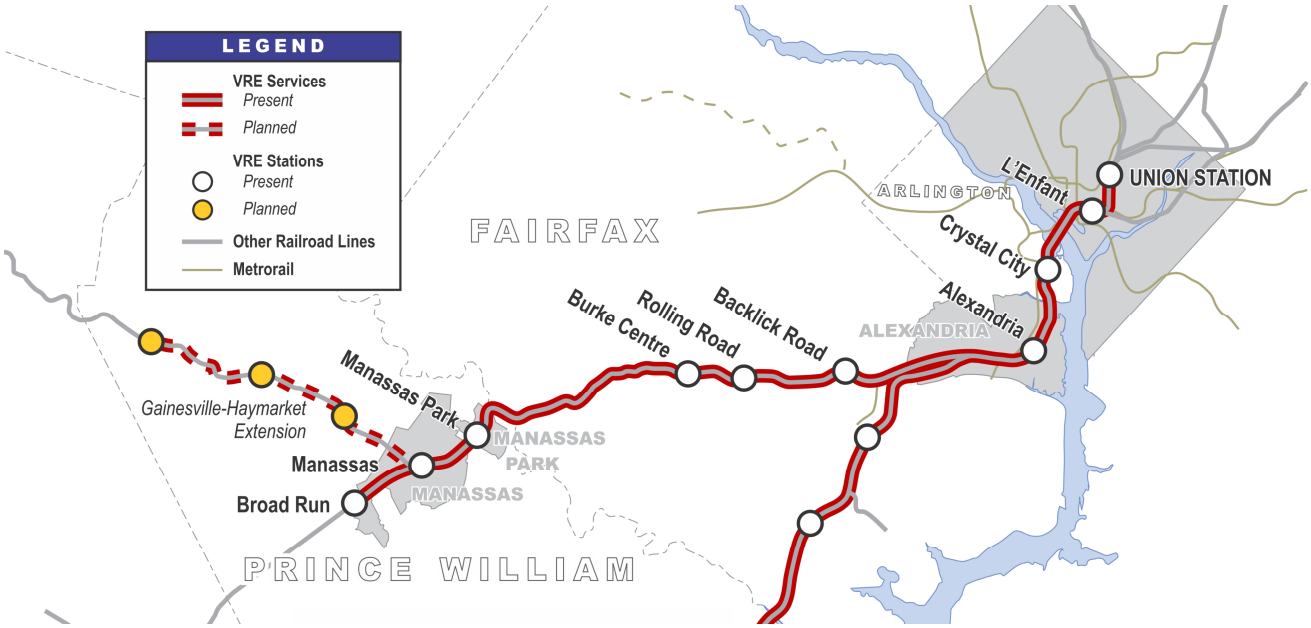
Ultimately, this concept envisions as many as four trains an hour operating on each line in the peak period and peak direction or an approximate doubling of the existing VRE peak service frequency. This expanded level of service would allow VRE to operate express trains on both lines while preserving headways at least as good as current service at every station. It is likely that expanded peak service would be implemented incrementally as capacity improvement projects on the railroad are completed and in response to increasing ridership demand and funding availability.

Gainesville-Haymarket Extension

A highly-productive VRE service improvement for the core peak commute market would be the extension of VRE Manassas Line service to Gainesville and Haymarket. The route would extend westward from Manassas for approximately 11 miles along the Norfolk Southern 'B' Line, to the Gainesville-Haymarket area of western Prince William County. This line extension, shown in **Figure 4-2**, would be parallel to the I-66 highway corridor and would serve suburban areas that are forecast to continue to grow rapidly in the next several decades. It would also serve the Innovation business district, a planned major employment, technology, and educational center that includes the Prince William County campus of George Mason University. Up to three new stations are being considered along the line – at Sudley Manor, adjacent to the Prince William Innovation Technology Park, Gainesville, and adjacent to the US15/I-66 interchange near Haymarket. All three have significant station-oriented development potential.

A service plan for the Gainesville-Haymarket extension must be developed in concert with Norfolk-Southern and coordinated with necessary railroad capacity improvements to ensure existing B-Line freight operations are not adversely affected. Ideally, peak period trains would operate at half-hour intervals (or better) all the way to Union Station, following the Manassas main line from the City of Manassas into Washington, DC. VRE service would continue to be operated on the existing Manassas Line to Broad Run Station, with Manassas Line trains at the peak alternating between the Broad Run and Haymarket branches, with potential half hour headway on each branch. At stations on the inner portion of the Manassas line, between Manassas and Union Station, peak service would be provided at up to four trains per hour.

Figure 4-2 Gainesville-Haymarket Extension



In addition to coordinating the project with Norfolk Southern, further planning and environmental studies, engineering design and other analysis will need to be completed to determine station locations and rail infrastructure requirements, prepare an operating plan, assess potential impacts and identify sources of funding for the extension before any construction would begin.

Reverse-Peak Service

Today VRE operates one Manassas line revenue train in the reverse-peak direction, primarily for the purpose of cycling one trainset for a second peak trip, enabling VRE to run six peak period trains on the line using five trainsets. The reverse-direction train does not make all VRE station stops and carries very few riders. An additional Manassas Line trainset makes a reverse-peak trip in the morning and afternoon as a non-revenue or deadhead train in order to store the trainset at the Broad Run Yard during the day. On both lines Amtrak trains provide limited reverse direction service to select VRE stations.

This concept assumes up to two trains in each peak period hour operate in the reverse-peak direction, marketed specifically to carry commuters from the DC core and Union Station to

L'Enfant, Crystal City, and Alexandria activity centers. Depending on future employment growth, the reverse-peak trains could continue farther south and west from Alexandria to existing employment centers such as Fort Belvoir, Marine Corps Base Quantico, the Innovation Technology Park and Prince William campus of George Mason University, downtown Fredericksburg or other emerging activity centers.

Off-peak service

Current VRE service is highly concentrated in the three-hour peak periods on weekday mornings and afternoons, with one early afternoon outbound train from Washington on each line to provide a limited early return option for commuters. A more substantial off-peak service would extend the time windows during which VRE operates to include additional mid-day and late evening off-peak period trains that could carry workers with non-traditional working hours and serve multiple trip purposes other than peak period commute-to-work travel.

This service is envisioned as operating initially bi-hourly during the mid-day period, with three round trips in-between the morning and evening peaks, and with one or two additional round trips after the evening rush hour. Over time, as ridership builds and as sufficient line capacity becomes available on the railroad, off-peak service could be increased to hourly intervals, consistent with the level of service offered by MARC on its Penn Line between Washington and Baltimore.

4.4 Longer-Term Service Improvements

As the VRE system matures and continues to attract increasing ridership in all of the markets it serves, the level of VRE service can continue to be expanded incrementally. In addition to the Long Bridge Corridor program and Gainesville-Haymarket extension project, the focus of new capacity investment includes completion of the triple-tracking of the Fredericksburg Line. As additional portions of triple-tracking are completed, increases in VRE and other passenger service on the corridor are anticipated to increase.

Full Bi-Directional Weekday Service

The logical objective for VRE as the System Plan evolves will be to become a full-service commuter railroad, offering bi-directional service all day long on weekdays, and as demand warrants, potentially on weekends as well. VRE would continue to grow peak, reverse-peak and

off-peak service, reaching a level where each station could have peak headways of 15 minutes, reverse-peak service at 30-minute headways, and off-peak service at one-hour headways.

Two additional service concepts were evaluated in developing the System Plan – adding weekend service on both VRE lines and implementing better-integrated regional rail service, including the potential for future run-through service at Washington Union Station. Although considerable market potential exists for both of these concepts, particularly weekend VRE service, VRE's existing railroad agreements do not permit operations on weekends or outside the existing VRE service area. Additionally the VRE Operations Board directed that, while implementation of System Plan service concepts or capital investments should not preclude the future pursuit of weekend or run-through service, any decision on a specific implementation timeline for these concepts would be deferred to the future. The general service approach envisioned for each concept is outlined in the following sections.

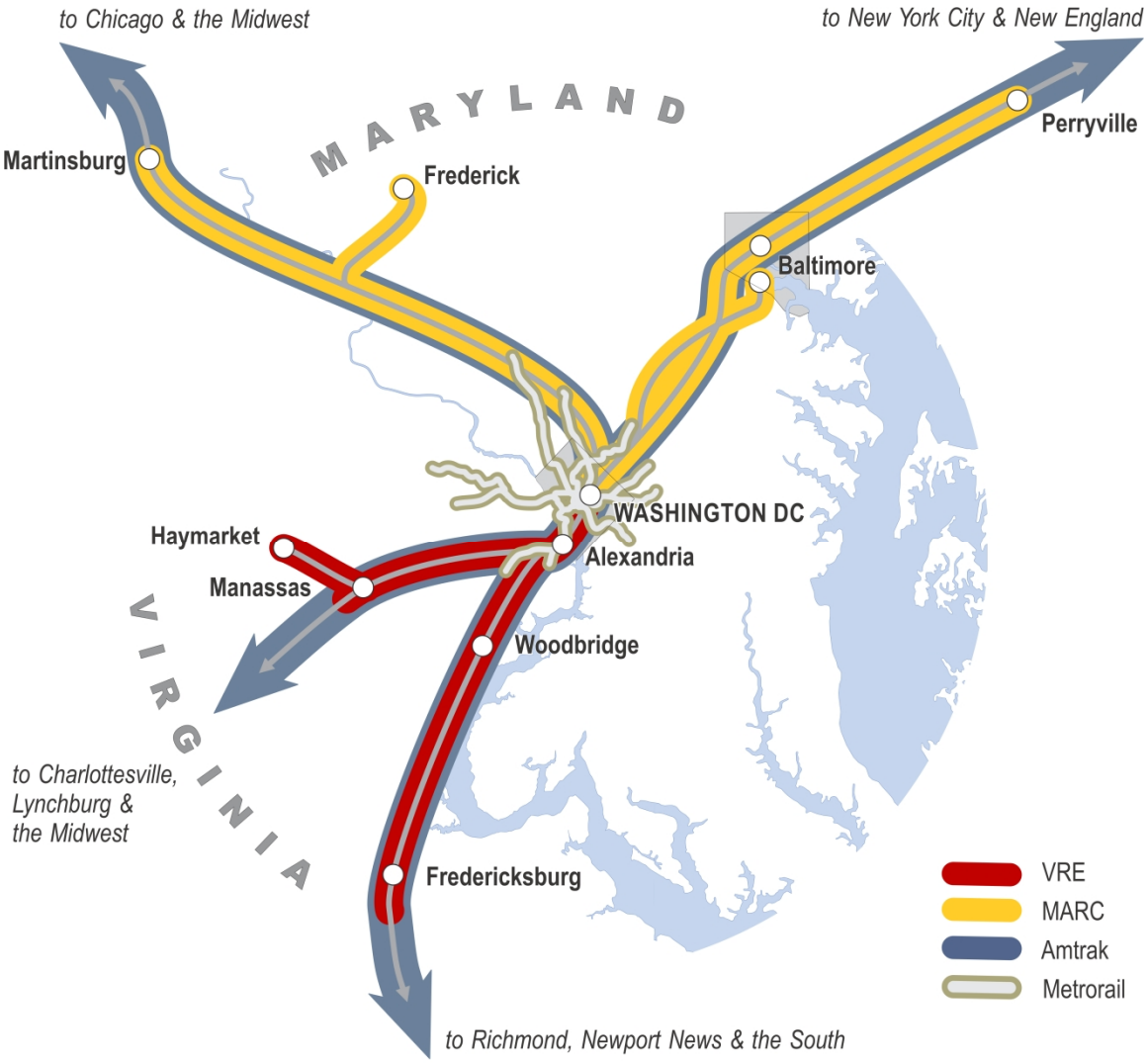
Regional Rail System Opportunities

In addition to serving the needs of travelers between Fredericksburg, Manassas and other northern Virginia communities and Washington DC, VRE capacity investments and the related Long Bridge Corridor and CSX railroad capacity expansion programs position the region's railroad network to serve a broader range of regional travel markets, including run-through regional rail service. Better integration of VRE, MARC and Amtrak regional/intercity rail services in the greater Washington region can serve longer-distance commuter, business, and leisure travel needs, as well as offer frequent rail service within the region's core to supplement or help relieve congestion on other public transit systems such as Metro as well as the highway network.

The introduction of run-through service, whether by VRE operating into Maryland or by MARC running to Alexandria or further south within Virginia, would open up new regional markets to direct rail service, provide passenger-carrying capacity through the core of the central business district that could serve to supplement Metro's core capacity, and create potential operating efficiencies, such as reducing the long-term requirement for mid-day train storage capacity at Washington Union Terminal for both VRE and MARC. While run-through service could be implemented with existing VRE and MARC fleets, regional-type service would ultimately require investment in rolling stock and/or station facilities to ensure compatible operating environments and efficient station operations with short train dwell times. It also would require new institutional arrangements for the operation of the service.

The map in **Figure 4-3** illustrates the potential connectivity of a regional rail system encompassing the areas served by VRE and MARC, providing excellent connections to the Metro network and to longer-distance rail services to the north and south of Washington.

Figure 4-3 Potential Regional Rail Connections



Other Potential VRE Service Opportunities

The railroad capacity that will be created by the major infrastructure investment programs in the Long Bridge corridor and on the CSX and Norfolk Southern main lines present the opportunity for VRE to consider additional service expansion concepts. Though considered a

lower priority for VRE than expansion of the peak commuter market and introduction of reverse-peak and off-peak service within the existing VRE service area, the following service concepts may be worthy of future consideration.

Weekend Service

Introduction of VRE service on weekends would offer travel benefits similar to the introduction of off-peak service and would utilize VRE trainset equipment that is used during weekdays but is idle on weekends. While MARC's initial experience with the introduction of weekend service has been positive, service has only been provided so far on the Amtrak Penn Line, which sees reduced levels of traffic on weekends. The two MARC branch lines that run on CSX-owned tracks do not have weekend service, in part because of increased freight train activity on weekends. VRE would face a similar situation on its lines, where CSX and Norfolk Southern seek to shift traffic to off-peak times and weekends so as to avoid the busy weekday commuter periods. In order to preserve sufficient capacity and flexibility for freight operations, additional infrastructure capacity may be needed to support weekend service.

Weekend VRE service could be implemented initially at bi-hourly intervals and later increased to hourly service, to match market demand as it grows. VRE's existing railroad operating agreements do not permit weekend service. As with other service concepts that expand VRE service outside the limits of the existing agreements, new agreements would be required with the railroads to implement this service concept, subject to available railroad capacity.

Expansion of VRE Service Territory

While not a priority for VRE at the present time, given the extensive capital needs and market potential within its existing service territory, the System Plan does not preclude future expansion of service beyond the current ends of the line at Spotsylvania (Crossroads) and Broad Run. Such expansion could be considered in the medium to long-term time horizon, provided that the key capacity improvements for the inner portions of the VRE network are made or have been committed to, as part of potential plans for other jurisdictions to join the VRE system.

4.5 Phased Implementation of VRE Service Improvements

The service improvements described above logically fit within a three-phase program for implementing the VRE System Plan. Each phase includes a set of capital investments, which provides the ability to expand or augment the level of VRE service. The key elements of the three phases are arrayed in **Table 4-2**. Each phase has a particular theme and focus:

- Phase 1 – Add peak-period peak-direction capacity within current railroad agreements
- Phase 2 – Expand service on both lines beyond the limits of current railroad agreements
- Phase 3 – Offer full bi-directional service

The three phases of development are consistent with the priorities expressed by the VRE Operations Board, which held a workshop session in July 2013 to review a wide range of service and investment scenarios and later reviewed the draft System Plan as it was developed.

The potential service improvement increments are outlined in **Table 4-3**, providing more information on the nature of the service improvements that are made during each phase.

Table 4-2

Recommended Allocation of Service Improvement Scenarios to Implementation Phases

VRE scenario	Phase 1	Phase 2	Phase 3
Add peak capacity within current railroad agreements	✓		
Add additional peak trains above and beyond the limits of current agreements		✓	
Add additional peak trains, up to four peak direction trains per hour on each line			✓
Extend Manassas Line trains to Gainesville and Haymarket		✓	
Add peak period reverse-direction trains on both lines		✓	
Add mid-day and evening trains off-peak, bi-hourly		✓	
Add mid-day and evening trains off-peak, up to hourly			✓
Add weekend service			✓
Implement integrated regional rail service / VRE- MARC run-through service			✓

Table 4-3 VRE Service Characteristics, by System Plan Phase

	Add peak period, peak direction trains	Add peak-period reverse-direction trains	Add off-peak trains	Gainesville-Haymarket Extension	Intercity Passenger Service
Phase 1 2015-2020	1 additional round trip on each line (allowed under existing railroad agreements)	N/A	N/A	N/A	Continued ability of VRE pass-holders to ride selected peak trains
Phase 2 2021-2030	Additional trains on Fredericksburg Line to provide a nominal 20 minute peak headway	30-45 minute peak headways over a two-hour period	Provide three mid-day round trips (approx. bi-hourly service) and 1-2 evening round trips	Provide bi-directional peak service to G-H Branch at 30-minute headway; provide 30-minute headway peak service from Broad Run	1-2 slots per hour on Fredericksburg Line and 1 slot per hour on Manassas Line, filled by regional or intercity corridor trains as demand warrants
Phase 3 2031-2040	15 min peak headways on each line, potentially incorporating outer zone express or limited-stop service	30 minute peak headways on each line between Union Station and Alexandria and/or points farther south and west	Increase off-peak service to hourly headways	Lengthen trains as demand builds; add shoulder-hour Broad Run trains	Up to 2 trains per hour, DC-Richmond (including SEHSR); up to 1 train per hour, DC-Charlottesville

5. System Plan Capital Investments

This chapter describes the capital improvements required for the System Plan and presents the estimated capital costs associated with the Plan.

5.1 VRE Core System Capacity Investments

VRE must continue to invest in critical core system elements that are under its direct control – rolling stock, station platforms and passenger circulation, station parking, and train storage yards and maintenance facilities – throughout the life of the System Plan so that the core system elements remain in balance with one another and no single element becomes a constraint on overall passenger-carrying capacity. Each of the core system elements needs to be able to accommodate the projected increase in both train movement activity and passenger traffic.

Rolling Stock Fleet Expansion

The size of the VRE fleet will need to incrementally grow over time as the level of VRE service increases. Initially, all existing trains would be lengthened to eight cars to alleviate crowding and provide additional passenger-carrying capacity. Additional trainsets put into service would also be eight-car consists.

The acquisition of additional passenger coaches will need to occur in each phase of System Plan development. Additional locomotives will be required in Phases 2 and 3. The size of the fleet will be determined, in part, by the service levels and the timing of the introduction of reverse-peak and off-peak service. Those new services will enable VRE trainsets to be used more productively, with most trainsets making more than one round trip in a day.

Table 5-1 summarizes the assumed growth in the VRE fleet through 2040 used to estimate an upper end of capital cost and space requirements for storage. More detailed operational analyses will be needed to define the operating plan(s) and equipment requirements.

Table 5-1 VRE Rolling Stock Fleet System Plan Assumptions

	Existing	Phase 1 2015-2020	Phase 2 2021-2030	Phase 3 2031-2040
Fredericksburg Line Trainsets	7	8	9	12
Manassas Line Trainsets	5	6	11	11
Total Trainsets	12	13	18	23
Coaches and Cab Cars in Revenue Service	78	99	140	184
New Locomotives	--	--	6	4
New Coaches and Cab Cars	--	14	46	48

Storage Yard Expansion

The initial efforts to expand passenger capacity by lengthening existing trains to eight cars to add seats will require relatively low-cost capital projects at Washington Union Terminal and VRE's storage yards at Crossroads and Broad Run to store the longer trainsets. The capital cost to further expand yard storage capacity to accommodate ten-car trains, particularly at Broad Run and in the District, would be considerably higher than what is needed to store eight-car trains. Therefore, it would be more cost-effective to equip the yards for eight car trains initially, and not preclude expansion to store ten-car trains if needed at some point in the future.

Regardless of train size, expansion of storage capacity at the Virginia yards on VRE's Fredericksburg and Manassas Lines will be required as the fleet size grows. While there is undeveloped land adjacent to the Crossroads Yard that could be acquired for yard expansion, there is minimal expansion potential at the Broad Run Yard. An alternative for the Manassas Line is to construct a new yard at another location, in conjunction with the Gainesville-Haymarket extension or as a separate project, to provide the additional fleet storage capacity.

Similar to rolling stock, planned reverse-peak and expanded mid-day service will keep a portion of the VRE fleet moving during the day and thereby reduce the demand for mid-day storage facilities in Washington DC. Some level of growth in storage capacity in the District is anticipated, however.

Table 5-2 summarizes the assumed growth in the VRE fleet storage requirements through 2040.

Table 5-2 VRE Train Storage System Plan Assumptions

	Existing	Phase 1 2015-2020	Phase 2 2021-2030	Phase 3 2031-2040
Trainsets Stored Overnight at Crossroads	7	8	9	12
Trainsets Stored Overnight at Broad Run	5	6	11	11
Trainsets Stored Mid-day at Washington	12	14	14	16
Cars Stored Overnight at Crossroads	43	55	81	96
Cars Stored Overnight at Broad Run	35	44	83	88
Cars Stored Mid-day at Washington	78	99	98	128

VRE Station Improvements

Stations are a critical core element of the VRE system. Station capacity investments fall into four main categories:

- Lengthening platforms where necessary to match the length of trains and facilitate efficient boarding and alighting
- Expanding stations by adding second platforms to enhance operational capacity and flexibility and serve bi-directional VRE operations
- Adding station parking through a combination of surface parking expansion, where feasible, or parking garage construction where space is constrained
- Constructing new stations to expand transit access in existing or emerging activity centers, either as infill stations such as the planned Potomac Shores station or as part of a service extension such as the Spotsylvania County station under development or the proposed Gainesville-Haymarket extension corridor.

Initially, existing stations platforms shorter than eight car-lengths would be lengthened accordingly to serve longer trains. As with yard storage, it is more cost-effective to equip the system for eight car trains initially, and not preclude future platform expansions to serve 10 car trains if needed at some point in the future.

At the VRE Union Station, L'Enfant, Crystal City, and Alexandria stations in the region's central core, platform modifications and the construction of island platforms, and access improvements to enhance multimodal connectivity to Metro, MARC and local and regional transit networks are envisioned.

Table 5-3 summarizes the investments in station facilities that are envisioned.

Table 5-3 Station Improvements, by Phase

	Fredericksburg Line	Manassas Line	Gainesville-Haymarket	Core Stations	Total
Phase 1					
8-car platforms (no. of stations)	5	1	--	2	8
Second platforms (no. of stations)	3	--	--	--	3
Additional parking (spaces)	4,050	1,600	--	--	5,650
New stations	2	--	--	--	2
Phase 2					
8-car platforms (no. of stations	1	--	--	--	1
Second platforms (no. of stations)	3	3	--	2	8
Additional parking (spaces)	600	250	2,700	--	3,550
New stations	--	--	3	--	3
Phase 3					
10-car platforms (no. of stations)	1	--	--	--	1
Second platforms (no. of stations)	--	2	--	--	2
Additional parking (spaces)	1,100	450	--	--	1,550

5.2 Gainesville-Haymarket Extension

VRE service from Haymarket to Washington would operate mostly over the existing Manassas Line Norfolk Southern tracks, but the westernmost 11 miles of the route would follow the Norfolk Southern-owned 'B' Line, which currently is a single-track line, with a passing siding near Gainesville and relatively heavy freight traffic. Significant capital investment on the 'B' Line is anticipated to expand capacity in the entire Manassas-to-Haymarket corridor and improve the signal system in order to accommodate shared passenger and freight train operations. Up to three new stations and associated parking could be constructed. A storage yard is also proposed along the line to supplement the limited capacity at Broad Run and reduce the need to run non-revenue trains between Broad Run and Haymarket.

5.3 Railroad Capacity Investments

All of the service concepts except peak service expansion within the parameters of the existing VRE-CSX operating agreement exceed the limit for daily trains on the CSX right-of-way. Without a significant increase in the allowable daily VRE trains, planned service enhancements such as

the provision of reverse peak and off-peak services or the Gainesville-Haymarket extension cannot be implemented or may not realize their full potential.

The current operating agreement acknowledges the finite ability of the CSX railroad corridor to accommodate long-term growth in VRE service along with future plans to expand freight service and commitments to support intercity passenger rail service growth without expanding railroad capacity. The agreement recognizes the need for construction of a continuous third main track from Washington to the VRE Crossroads Yard as a solution to provide the needed capacity to accommodate expanded VRE service. VRE, CSX, and DRPT have entered into a separate Memorandum of Understanding (MOU) that outlines the process the parties will follow to jointly identify and implement the necessary capacity improvements within the CSX railroad corridor to enable VRE service expansion and the expansion of DRPT-sponsored passenger service beyond their currently permitted levels as well as accommodate planned Southeast higher-speed passenger rail service being developed by Virginia and North Carolina. Fundamental to the MOU is the use of public funds to construct the required railroad infrastructure, including contributions from VRE and DRPT.

The specific railroad investments necessary to support the long-term needs of all passenger rail modes proposed to operate within the CSX railroad corridor will only be determined after more detailed studies and negotiations among all beneficiaries of the expanded capacity. Based on preliminary studies completed by VRE, DRPT, and the District of Columbia (through its Long Bridge Study efforts), the expectation is that a four-track railroad will be required in the Long Bridge corridor between AF Interlocking and CP Virginia, while a third track will be required from AF Interlocking to Crossroads.

The Long Bridge Corridor program is assumed to provide a 4-track railroad between CP Virginia and Alexandria, enabling independent passenger and freight operations. Major capital projects within the corridor include replacement of the 2-track Long Bridge over the Potomac River with a span that accommodates four railroad tracks, widening of the right-of-way through L'Enfant Station to four tracks and expansion of the VRE Station, relocation or reconfiguration of the VRE Crystal City station, and construction of a fourth main track from the Potomac River through Alexandria. The targeted completion data for these improvements would be the mid-2020s, as part of Phase 2 of the System Plan development.

The CSX triple-tracking would complete the missing 3-track links in the system between Alexandria and Crossroads, and including portions of fourth track where needed for capacity, such as in the Fredericksburg to Hamilton Interlocking segment. This work is ongoing and will continue through all three phases of the System Plan. The pace of investment will dictate the

pace of growth of both VRE Fredericksburg service and the various other passenger rail services planned for the line (Southeast Corridor and Hampton Roads high-speed rail, and state-sponsored Amtrak service.

A critical prerequisite to allow full service in any of the service improvements in Phases 2 or 3 that exceed the daily trains allowed in VRE's current operating agreement is the need to complete more detailed analysis of the necessary railroad capacity expansion and negotiation of a new operating agreement with CSX.

5.4 Weekend Service and Better-Integrated Regional Rail Service

The railroad infrastructure and VRE core system capacity investments implemented to support the other VRE service enhancements would also support the introduction of weekend service, if VRE chose to pursue it.

They also support future integration of VRE, MARC, and Amtrak regional rail services. With the service improvements realized through VRE System Plan investments, VRE becomes a critical link in the regional rail travel network centered on Washington DC. Better integration of VRE, MARC, and Amtrak services will enhance travel for longer-distance commuters as well as for business and leisure travelers, offering more attractive and varied alternatives to travel by car. Enhanced connectivity to Metrorail and other high-capacity public transit services improve the reach of rail throughout the region.

5.5 System Plan Capital Costs

The VRE System Plan depends upon significant capital investment over a 25 year period to provide the railroad capacity, rolling stock, stations, and storage yard facilities necessary for VRE to grow into a full-service commuter railroad, operating bi-directional service throughout the day and serving a range of markets and types of travel. **Table 5-4** presents the estimated capital costs associated with the fleet and infrastructure projects that comprise the VRE System Plan.

Table 5-4 VRE System Plan Estimated Capital Costs

(Expressed in millions of 2013 dollars)

	Phase 1 2014-2020	Phase 2 2021-2030	Phase 3 2031-2040	Total
Additional Coaches and Locomotives				
• Coaches	$35	$100	$110	$245
• Locomotives		$25	$17	$42
Subtotal	*$35*	*$125*	*$127*	*$287*
Station Improvements				
• Extend platforms	$15	$2	$10	$27
• Second platforms	$31	$78	$24	$133
• Parking expansion	$91	$18	$30	$139
• Core station improvements	$22	$20		$42
Subtotal	*$159*	*$118*	*$64*	$341
Storage and Maintenance Facilities				
• Crossroads	$2	$12	$10	$24
• Broad Run	$1		$10	$11
• Washington Union Terminal	$3		$40	$43
• Life-Cycle Maint. Facility	$35			$35
Subtotal	*$41*	*$12*	*$60*	*$113*
Gainesville-Haymarket Extension				
• Railroad infrastructure		$130		$130
• Stations		$117		$117
• Storage Yard		$50		$50
Subtotal		*$297*		*$297*
Long Bridge Corridor Program				
• Long Bridge replacement		$700		$700
• Potomac River to CP Virginia 4th track		$180		$180 $30
• Potomac River to AF 4th track.		$30		
• VRE station reconfiguration		$200		$200
Subtotal		*$1,110*		*$1,110*
Fredericksburg Line Triple Tracking Program	*$50*	*$101*	*$439*	*$590*
TOTAL	**$285**	**$1,750**	**$690**	**$2,725**

While **Table 5-4** above identifies the total capital cost of recommended investments, historically similar VRE investments have been funded through a combination of federal, state and VRE or local jurisdiction sources. The enactment of House Bill 2313 (HB 2313) in 2013 by the Virginia General Assembly created a new potential funding source for VRE capital investments. HB 2313-generated funds are administered and competitively allocated by the Northern Virginia Transportation Authority (NVTA). As a result, it is expected that VRE, local or NVTA revenue sources will be available to match federal and/or state sources for many of these projects.

In addition, the railroad capacity investments will benefit not only VRE but also the Commonwealth of Virginia and Amtrak, by enabling expansion of regional and intercity passenger service, and the freight railroads. It is expected that VRE would only be responsible for a portion of the total capital cost to expand the railroad capacity and other beneficiaries of the capacity expansion would also pay a share of the cost.

Table 5-5 provides an estimate of the amount of funding that might be required from VRE, local or regional sources for System Plan capital investments. The estimated percentage of VRE participation is based upon historical funding sources for similar VRE projects or typical local participation rates for established federal and state capital funding programs.

Table 5-5 Estimated VRE / Local / Regional Share of Capacity Investment Projects, 2021-2040
(millions of 2013 dollars)

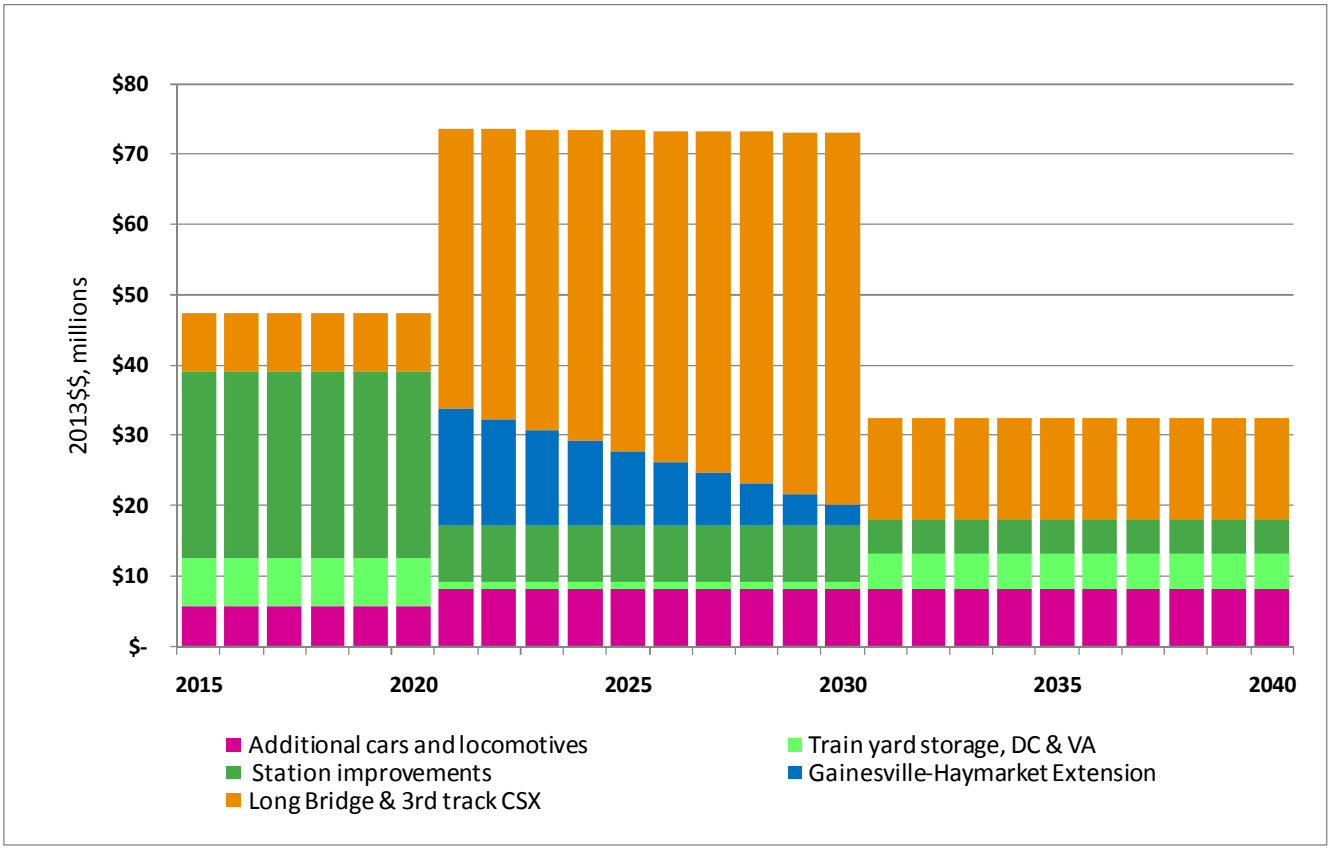
System Investments	VRE/Local/ Regional Share	Phase 1 2020	Phase 2 2030	Phase 3 2040	**Total System Plan**
Additional Coaches and Locomotives	66%	$35	$125	$125	**$285**
Expand Platforms at Stations	65%	$50	$80	$35	**$165**
Additional Parking at Stations	83%	$90	$20	30	**$140**
Central Core Station Improvements	65%	$20	$20	0	**$40**
Train Storage , DC & VA	83%	$40	$10	$60	**$110**
Gainesville-Haymarket Extension	33%	$0	$295	$0	**$295**
Long Bridge Corridor Expansion	33%	$0	$1,100	$0	**$1,100**
Fredericksburg Line Third Track	33%	$50	$100	$440	**$590**
Total Capital Cost		**$285**	**$1,750**	**$690**	**$2,725**
Estimated VRE / Local / Regional Share of Cost*		$285	$700	$300	**$1,285**

*Includes Federal formula funds as "VRE" funds and CMAQ and NVTA/HB2313 sources as "regional" funds.

The three-phase implementation plan for the VRE System Plan calls for a level of investment during the initial phase that is consistent with the current VRE six-year CiP and other projects for which funding is being sought in this time frame. Phase 1 represents roughly a doubling of recent capital investment levels. The level of investment needed to support the System Plan capital program increases substantially in Phase 2, when major increases and expansion of VRE service occur. The estimated capital investment declines in the third phase to a level similar to Phase 1.

The estimated annualized rate of capital investment through the three System Plan phases is shown in **Figure 5-1**. The Phase 1 (2015-2020) capital program (including the $50 million for CSX third track investment requested from NVTA in 2014) requires VRE participation at an average rate of approximately $48 million per year, with the emphasis on expanding existing station, fleet, and storage yard capacity. In Phase 2 (2021-2030), the focus shifts to implementing the major railroad and VRE system capacity enhancements, including the Long Bridge corridor program and the Gainesville - Haymarket extension. Expenditure also continues on VRE core system capacity, at a somewhat reduced level from Phase 1. The total annual expenditure grows to about $70 million a year for the ten year, Phase 2 period. For Phase 3 of the System Plan, (2031-2040), capital spending drops to near the $30 million a year mark, with the emphasis on completing the CSX third track program and continued investment in the VRE core system capacity to support continued passenger growth, primarily in rolling stock and storage yard capacity.

Figure 5-1 Average Annual Capital Spending on Capacity Projects, by Phase and Category



5.6 VRE System Plan Relative to Other Transportation Investments

The collective set of service improvements and capital investments that comprise the VRE System Plan, when considered together, make sense for the greater northern Virginia region and the Commonwealth, as well as for VRE. At this conceptual planning stage, the detailed information normally used for a full benefit cost analysis is not available, nor is the analysis and data to support evaluation of non-transportation impacts on community or regional development. However, broader measures can begin to indicate the potential worth of the System Plan service improvements and investments.

When the major projects in these scenarios move to formal alternatives analysis, environmental reviews, and applications for funding, detailed data will have to be developed using a variety of sophisticated and complex tools. These include the MWCOG regional travel model, reworked to better reflect the trip making patterns associated with VRE service and the interaction with

other transit and HOV/HOT projects, economic input-output models, operations simulation models to evaluate the sufficiency of specific track capacity improvements, and costing models.

For the scenarios where the capital requirements and physical improvements, if any, are minimal, such as adding off peak service once the Long Bridge and CSX third track projects are complete, VRE will control the pace at which the service is introduced, will be able to evaluate the incremental cost-effectiveness from actual results, and will make adjustments based on real-world data.

To understand the cost effectiveness of the System Plan elements from VRE's perspective, the investment packages were looked at qualitatively for their potential to increase ridership, make more efficient use of existing rail infrastructure, and keep VRE's revenues over 50 percent of operating cost. The results are summarized in **Table 5-10**.

Table 5-10 Summary of Effect of Packages on VRE Efficiency

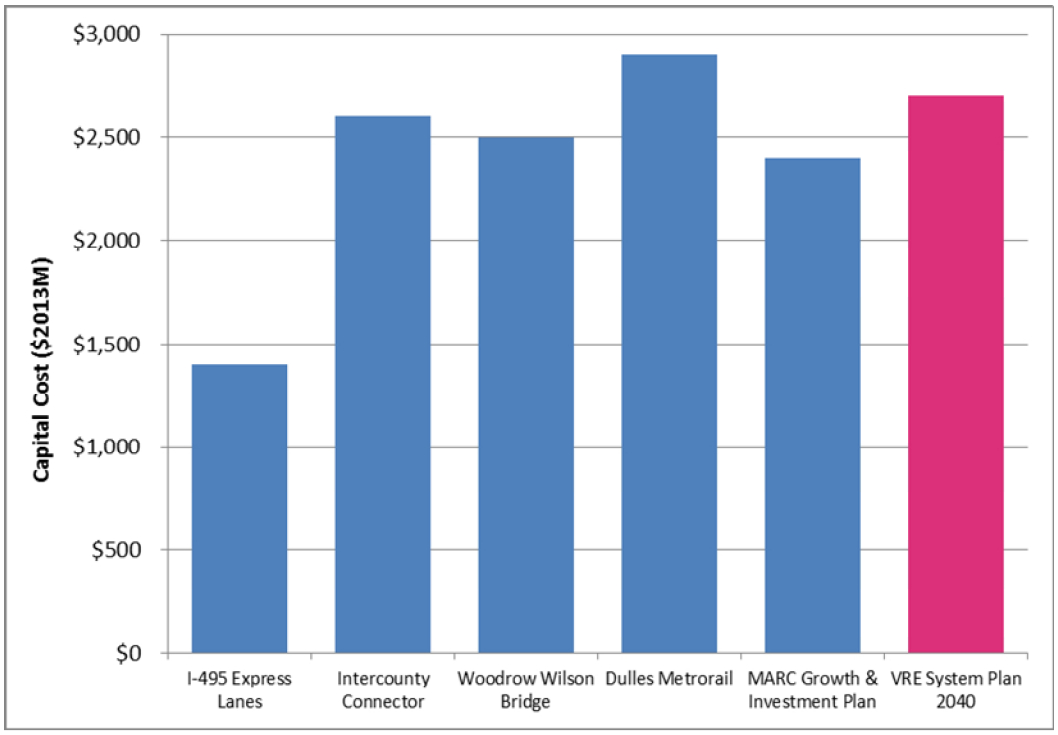
VRE scenario	Ridership	Rail facility efficiency	Cost recovery ratio
Short-Term Improvements to add capacity within existing agreements	+30%	Similar to current	Improved
Gainesville-Haymarket Extension	+10-20%	Similar to current	Improved
Medium and Longer-Term Service Improvements	+75-125%	Improved vs. current	Maintainable over 50%

From VRE's perspective, the medium and longer-term plans, which package multiple service improvements together to take advantage of operating efficiencies and the capacity generated by the major railroad infrastructure investment programs, perform well collectively. If off-peak and reverse-peak service are implemented in concert with improved peak direction service, the benefits of the investment could be spread across a greater number of riders, and the incremental cost of providing off-peak service could be much more modest, since the service does not require additional cars or locomotives or other facilities whose size is set by the peak period requirements. VRE's ability to tap several markets (peak, reverse-peak and off-peak) will help fill the significant bump up in railroad capacity that will be created. These markets utilize

the capacity in both directions of travel and at different times of day, so they can more productively make use of rolling stock, train crews, and storage yard facilities.

Improvements in VRE capacity can be achieved in less time and at a comparable cost to other highway and rapid transit projects constructed in the region. The capital cost to implement the VRE System Plan was compared to several other major highway or transit system investments in the Washington DC region, including the recently completed MARC Growth and Investment Plan Update (2013-2050). Each project has a capital cost between $1 billion and $3 billion. Investment in the existing railroad corridors used by VRE compares well in terms of the capital cost to create the incremental person-moving capacity similar to the other transportation investments. **Figure 5-2** graphically shows the cost of these projects and of the VRE System Plan.

Figure 5-2 Cost of Recent Major Washington DC Area Transportation Projects and the VRE System Plan



Looked at another way, investment in the railroad corridors will enable VRE to provide a rush hour passenger-carrying capacity equivalent to two traffic lanes in the I-95 and I-66 corridors while also augmenting freight railroad capacity and supporting future expansion of other passenger rail services.

New construction to increase the capacity of the rail system also is effective in terms of the quantity of transportation capacity generated per unit of capital investment. VRE capacity investments can take place almost entirely within the existing rights of way, at a cost and in a time frame competitive with highway and heavy rail construction projects in the region. Investment in these lines also augments rail freight capacity and provides for future expansion of regional/intercity rail passenger services. As a result, investing in VRE is a cost-effective way to increase regional mobility.

6. Recommended System Plan Actions

VRE, under the leadership of the VRE Operations Board, should take the following actions to advance the implementation of the VRE System Plan:

- Implement the Phase I program of capital improvements and service growth during the 2014-2020 period
- Continue planning, environmental clearance and design for the Gainesville-Haymarket Extension
- Continue to participate in the development of an implementation plan for the Long Bridge Corridor program, with broad funding participation by federal, state and other non-VRE stakeholders
- Work in partnership with the Virginia Department of Rail and Public Transportation (DRPT), CSX, Norfolk Southern and Amtrak to develop access and capital agreements that will allow incremental expansion of rail passenger service
- Participate in regional transportation studies to identify and evaluate long-range concepts for regional and intercity passenger rail service, including options for Virginia to Maryland "run-through" service.

It will be important for VRE to embark on all of these recommended actions in the near term, so that the additional railroad capacity needed to carry riders above the level of 25,000 daily trips will be in place by the mid-2020s, when the practical capacity of the current system is expected to be reached.

Achieving consensus among the various stakeholders on an implementation plan, time schedule and funding strategy for the major railroad capacity improvement programs – the Long Bridge Corridor and the CSX triple-tracking – will be challenging. New access agreements will be needed with the host railroads. Capacity improvements will need to be completed in a timely manner to support the intended growth in both VRE and other passenger service. Partnerships between VRE and the other regional entities with a stake in rail transportation in the Washington region will be essential for gaining broad regional support for the investment program and for ensuring that the costs of the required capital improvements are shared appropriately.

If the System Plan is implemented successfully, VRE will be able to better serve its existing customers, accommodate increasing demand for commuter rail service to the core of the region, and broaden its role in regional transportation to serve new travel markets and provide a travel option for more travelers in and around Washington DC and northern Virginia.

PARSONS BRINCKERHOFF

Virginia Railway Express 2040 System Plan

Technical Memorandum

Ridership, Capital Cost and Operations and Maintenance Cost Estimating

February 2014

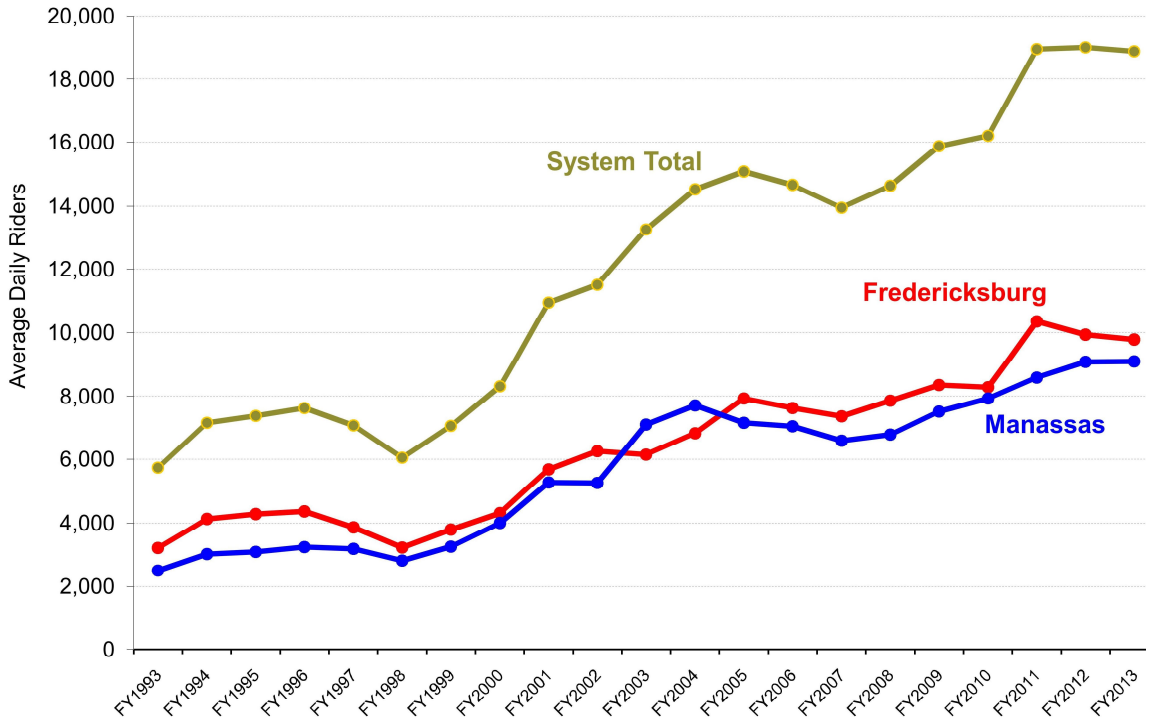
Contents

A. Ridership Estimating

1. Current VRE Ridership and Revenue

In 2013, VRE carried nearly 18,900 daily passenger trips. As shown in Figure A.1, after more than a decade of steady growth at an average rate of 8 percent per year, ridership has leveled off during the past two years as many peak-hour VRE trains are filled to or beyond their seating capacity and parking lots fill up the end-of-line stations. Trips on VRE are relatively evenly distributed between the Fredericksburg and the Manassas lines.

Figure A.1 VRE Weekday Trips by Line, FY 2000-2013



VRE's major travel markets today are longer-distance commute trips from the middle and outer Virginia suburbs – beyond the reach of the Metrorail system (Metro) – to employment centers in Alexandria, Crystal City, Rosslyn, and downtown Washington DC. Virginia employment centers in the Franconia-Springfield, Fort Belvoir, and Quantico areas attract trips as well, and Metro distributes commuters well into other parts of the District and suburban Maryland.

Figures A.2 & A.3 show the geographic origins and destinations of VRE morning peak trips, mapped by zip code. The data were based on 6,349 responses to the 2012 annual VRE passenger survey provided by VRE.[1] The surveys were distributed on inbound morning trains, and represent roughly 2/3 of the daily 9,000 inbound passengers.

Less than 0.5% of the origin zip codes was missing, or was from outside the greater Washington region. However, almost a fifth of the destination zip codes were missing. Half of the responses missing destination zip codes (a tenth of the total) did provide an address or description of the destination, but time did not permit tracking down the zip codes and including them in the mapping. A quick review suggested that somewhat more of these trips ended in Virginia than for the survey responses with zip codes.

VRE carries a significant share of total trips to the core employment centers of Washington DC, Arlington, and Alexandria from the catchment areas around VRE's stations in northern Virginia – in the range of 10 to 14 percent. The share in specific markets is even higher (such as Broad Run to L'Enfant, where VRE's share of the market is over 50 percent), where:

- Drives are relatively long and transit alternatives are not available or relatively inconvenient at the VRE origin station
- Employment is concentrated within walking distance of the VRE destination station
- Destination connections to Metro or other transit services are convenient and plentiful.

In FY 2012, VRE generated $34.7 million in revenue from passenger tickets. In the same year, an estimated 4.8 million trips were taken on VRE, resulting in an average fare per trip of $7.28.[2] In FY 2013, revenue reached the level of $35.0 million.

[1] Virginia Railway Express, "2012 VRE Psgr Survey_v1 11-26-12_BasicData.xls".

[2] VRE, "Comprehensive Annual Financial Report for the years ended June 30, 2012 and 2011", p. 46

Figure A.2 Origins of VRE Commuters, 2012

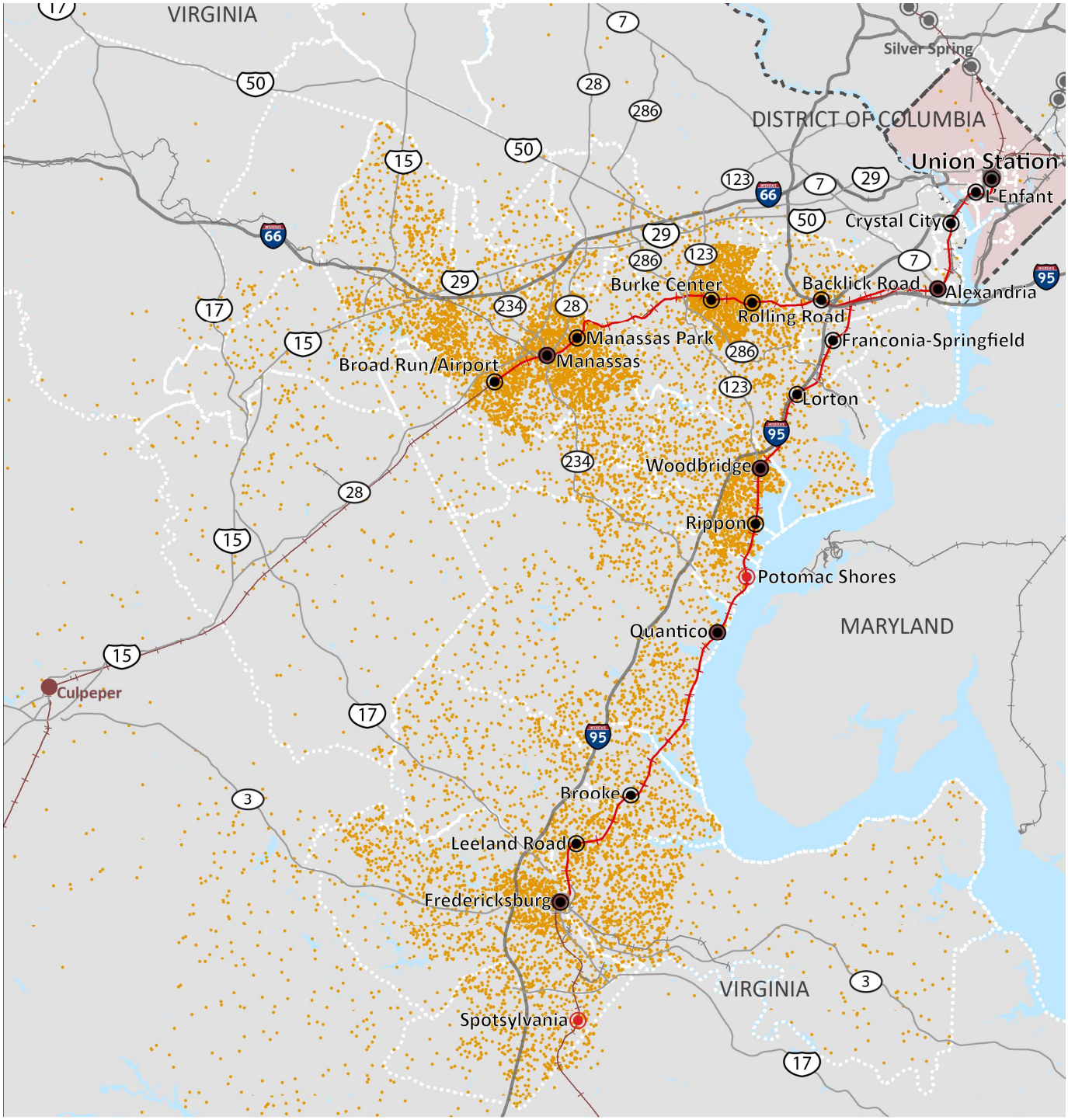
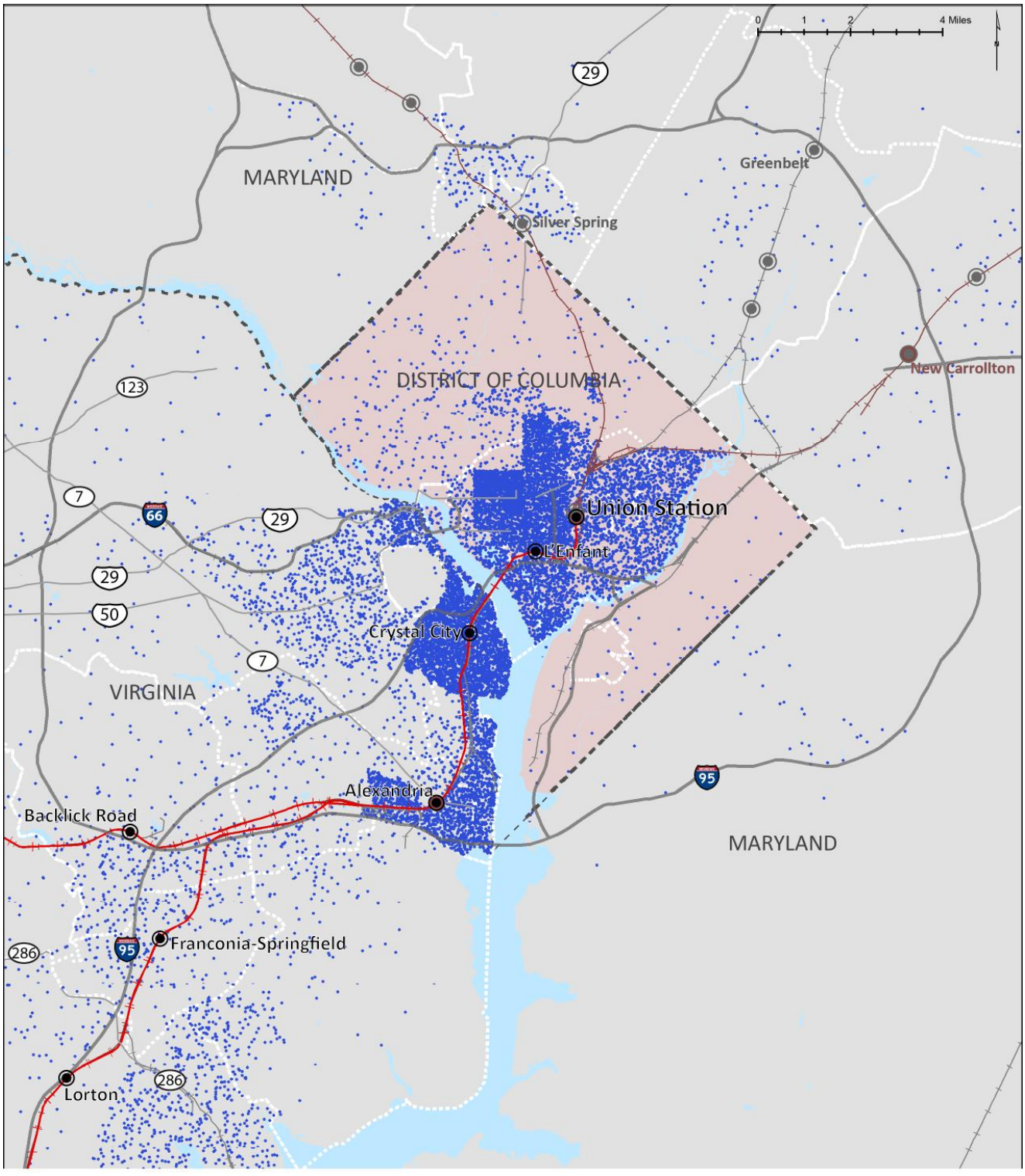


Figure A.3 Destinations of VRE Commuters, 2012



2. Population and Employment Forecasts to 2040

VRE's growth in riders since its opening has been driven by strong residential growth in the Virginia communities along or near the commuter lines, and jobs growth in the central core area from Alexandria to the District. Continued growth in both population and jobs through 2040 is forecast by the Metropolitan Washington Council of Governments (MWCOG) with the greater Washington region adding 2 million people and 1.6 million jobs over the 2010 levels.

MWCOG population and employment forecasts cover its jurisdictions as well as neighboring counties that affect the region's traffic and growth, as shown in Figure A.4. The latter include five Virginia counties, the City of Fredericksburg, one West Virginia county, and six Maryland counties.

Figure A.4 Washington COG Forecast Area

Population Forecasts

Table A.1 shows the population growth forecast by at this high-level county/city jurisdiction breakdown.

Table A.1 Population forecast by county/jurisdiction (000s)

	2010	2015	2020	2025	2030	2035	2040
Washington DC	602	654	676	702	723	741	771
Montgomery	972	1,015	1,065	1,110	1,154	1,186	1,204
Prince George's	863	881	900	927	950	973	995
Frederick	232	240	255	275	295	312	327
Carroll	176	184	192	200	207	214	220
Howard	284	299	312	321	328	333	333
Anne Arundel	533	547	557	566	574	582	582
Calvert	92	97	100	103	105	107	109
St. Mary's	105	118	130	141	151	163	174
Charles	145	160	176	191	203	214	225
Maryland sub-total	3,402	3,541	3,687	3,834	3,967	4,084	4,169
Alexandria City	140	147	157	166	172	182	189
Arlington	208	223	233	242	246	249	252
Fairfax/Cities of Fairfax/Falls Church	1091	1131	1186	1236	1274	1307	1325
Loudon	312	352	396	436	457	471	481
Prince William/Manassas/Manassas Park	454	506	552	589	622	649	673
King George	24	27	30	34	38	41	45
Stafford	129	149	170	191	213	232	252
Fredericksburg City	24	26	27	29	31	32	34
Spotsylvania	99	114	128	143	157	170	183
Fauquier	75	86	99	115	132	152	176
Clarke	15	16	17	18	19	20	21
Virginia sub-total	2,571	2,777	2,995	3,199	3,361	3,505	3,631
Jefferson, WV	51	57	62	69	76	83	91
Greater Washington Region Total	6,626	7,029	7,420	7,804	8,127	8,413	8,662

Source: Washington COG, Round 8.1 Cooperative Forecasting, 2012

As shown in Table 2, the most rapid population growth is expected in the jurisdictions served by the Fredericksburg line's "outer" stations: the counties of Spotsylvania, King George, and Stafford, and the City of Fredericksburg. The pace of growth is expected to be strongest in the 2010 to 2020 decade and to taper off in the two subsequent decades.

On both the Manassas and Fredericksburg lines, the jurisdictions closer to the center of the region are forecast to grow less strongly, and to taper off after 2030. Prince William County contains three stations on the Fredericksburg line, and contributes to growth around two Manassas line stations along with the cities of Manassas and Manassas Park, and Fauquier and Loudon counties. Prince William/Manassas Park/Manassas is forecast to grow more slowly than all the jurisdictions together, resulting in slightly slower growth in the "middle" area of the Fredericksburg line compared to the "middle" area of the Manassas line.

The "inner" areas for both lines are the same, including Fairfax County and the City of Falls Church. This area grows most slowly in percentage terms because of its large existing population and relatively built-out status.

Table A.2 also shows the projected growth for the population along each line as a weighted average of the three areas. Boarding information was taken from the 2012 VRE riders' survey and used for weighting. Around 60% of the Fredericksburg line boardings come from the outer area stations, 30% from the middle area stations, and 10% for the inner area stations. On the Manassas line, the middle to inner ratio is about 70:30.

Table A.2 Forecast Population Growth per Year along VRE Lines

	2010 - 2020	2020-2030	2030 - 2040
Fredericksburg line			
Outer areas	2.5%	2.1%	1.6%
Middle areas	2.0%	1.2%	0.8%
Inner areas	0.8%	0.7%	0.4%
Line average (weighted by ridership)	2.2%	1.7%	1.2%
Manassas line			
Middle areas	2.2%	1.5%	0.9%
Inner areas	0.8%	0.7%	0.4%
Line average (weighted by ridership)	1.8%	1.2%	0.8%
Source: Growth calculated from Washington COG, Round 8.1 Cooperative Forecasting, 2012; weighting from origins in VRE 2012 rider survey			

Note: On the Fredericksburg Line, the outer area includes the Spotsylvania, Fredericksburg, Leeland Road, and Brooke stations; the middle area includes the Quantico, Rippon, and Woodbridge stations; the inner area includes the Lorton and Franconia-Springfield stations.

On the Manassas Line, the middle area includes the Broad Run, Manassas and Manassas Park stations and the Gainesville-Haymarket corridor; the inner area includes the Burke Centre, Rolling Road and Backlick Road stations.

Employment Forecasts

Table A.3 shows the employment forecast by county/jurisdiction for 2010 to 2040 at five-year intervals.

Table A.3 Jobs forecast by county/jurisdiction (000s)

	2010	2015	2020	2025	2030	2035	2040
Washington DC	783	813	866	903	930	956	983
Montgomery	510	542	585	633	684	714	737
Prince George's	343	357	378	403	428	457	498
Frederick	99	99	104	107	110	112	114
Carroll	84	87	88	89	90	91	92
Howard	195	215	231	248	262	268	275
Anne Arundel	339	363	386	404	420	435	435
Calvert	35	41	45	46	47	48	49
St. Mary's	63	68	72	75	77	79	81
Charles	62	68	72	75	77	80	83
Maryland sub-total	1,730	1,840	1,961	2,080	2,195	2,284	2,364
Alexandria City	106	116	123	135	143	150	155
Arlington	223	247	276	292	303	306	308
Fairfax/Cities of Fairfax/Falls Church	680	722	786	836	875	906	935
Loudon	144	168	206	236	257	271	285
Prince William/Manassas/Manassas Park	144	163	186	207	230	254	278
King George	16	18	19	21	23	24	26
Stafford	47	52	58	64	70	77	84
Fredericksburg City	31	36	40	44	48	51	55
Spotsylvania	43	46	50	53	56	60	65
Fauquier	22	25	29	32	35	39	43
Clarke	5	5	6	6	6	7	7
Virginia sub-total	1,461	1,598	1,779	1,926	2,046	2,145	2,241
Jefferson, WV	17	19	21	23	24	26	29
Greater Washington Region Total	3,992	4,271	4,624	4,932	5,195	5,411	5,618

Source: Washington COG, Round 8.1 Cooperative Forecasting, 2012. (Totals may not add exactly because of rounding.)

Strong employment growth in the core of the region is forecast to continue, bolstering the other end of the home-to-work market that is VRE's current primary market. The Washington DC job market is projected to grow by 25 percent, Arlington's by 38 percent, and Alexandria's by 46 percent, adding over a quarter million jobs to the portion of the region served by VRE.

Future job growth is also projected outside the inner core, increasing the potential for reverse-peak trips. While two of the region's largest employment centers, Tyson's Corner and the Dulles Airport corridor, are not served directly by VRE, nevertheless, the outer zones of VRE's service territory also are shown to have strong projected job growth, albeit starting from a smaller base, and significant employment centers are located in relatively close proximity to the railroad. These include Fort Belvoir (both the Main Post and the North Area adjacent to I-95 and the railroad), Marine Corps Base Quantico, the planned Potomac Shores development, Fredericksburg City, the Prince William County Innovation business district west of Manassas, the George Mason University campus, and the Gainesville area of Prince William County. Table A.4 shows expected job growth for areas on the Fredericksburg and Manassas lines.

Table A.4 Jobs in outer areas along VRE line 2010 & 2040

	2010	2040	Growth
Fredericksburg line			
Fort Belvoir	65,700	93,100	+42%
Quantico	42,400	77,900	+84%
Prince William & Stafford Route 1	78,400	143,000	+82%
Fredericksburg	70,000	116,000	+65%
Line total	256,500	430,000	+68%
Manassas line			
Western Prince William	57,200	110,000	+92%
Total of two lines	313,700	540,000	+72%
Source: Calculated from MWCOG, Round 8.1 Cooperative Forecasting, 2012			

In order to try and further understand the potential effect of growth in the suburban areas on VRE ridership, the 3,675 detailed zones used by the Council of Governments for travel forecasting were aggregated into "VRE districts" intended to have relatively similar access and development characteristics. VRE districts were defined around each station, in areas such as Haymarket or Gainesville where future stations might be located, in areas away from stations that generate ridership for VRE, and areas in Washington DC and Maryland that have Metrorail or MARC service that might generate future ridership. Areas outside these VRE districts were felt to have less potential VRE riders and were grouped together as "Other".

An overview of the VRE districts is shown in Figure A.5, and detail of the Alexandria, Washington DC, and inner suburban Maryland is shown in Figure A.6. Zones 1-7 are located in Washington DC. Zones 8-45 are found in Virginia. Zones 46 -53 lie in Maryland. Zone 54 encompasses all of the remaining area in the greater Washington region used by the Council of Governments for travel forecasting.

Figure A.5 VRE Districts for Analysis

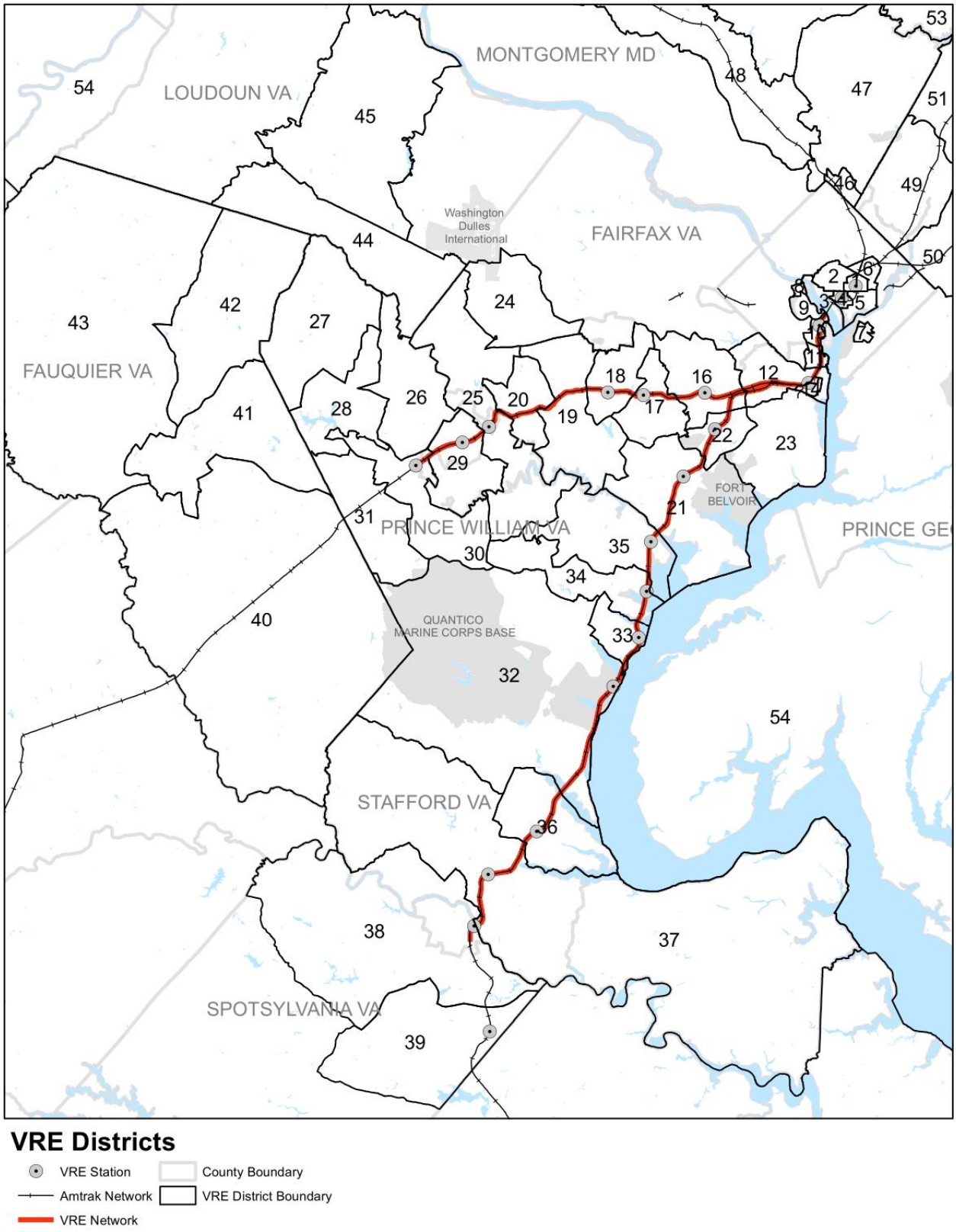
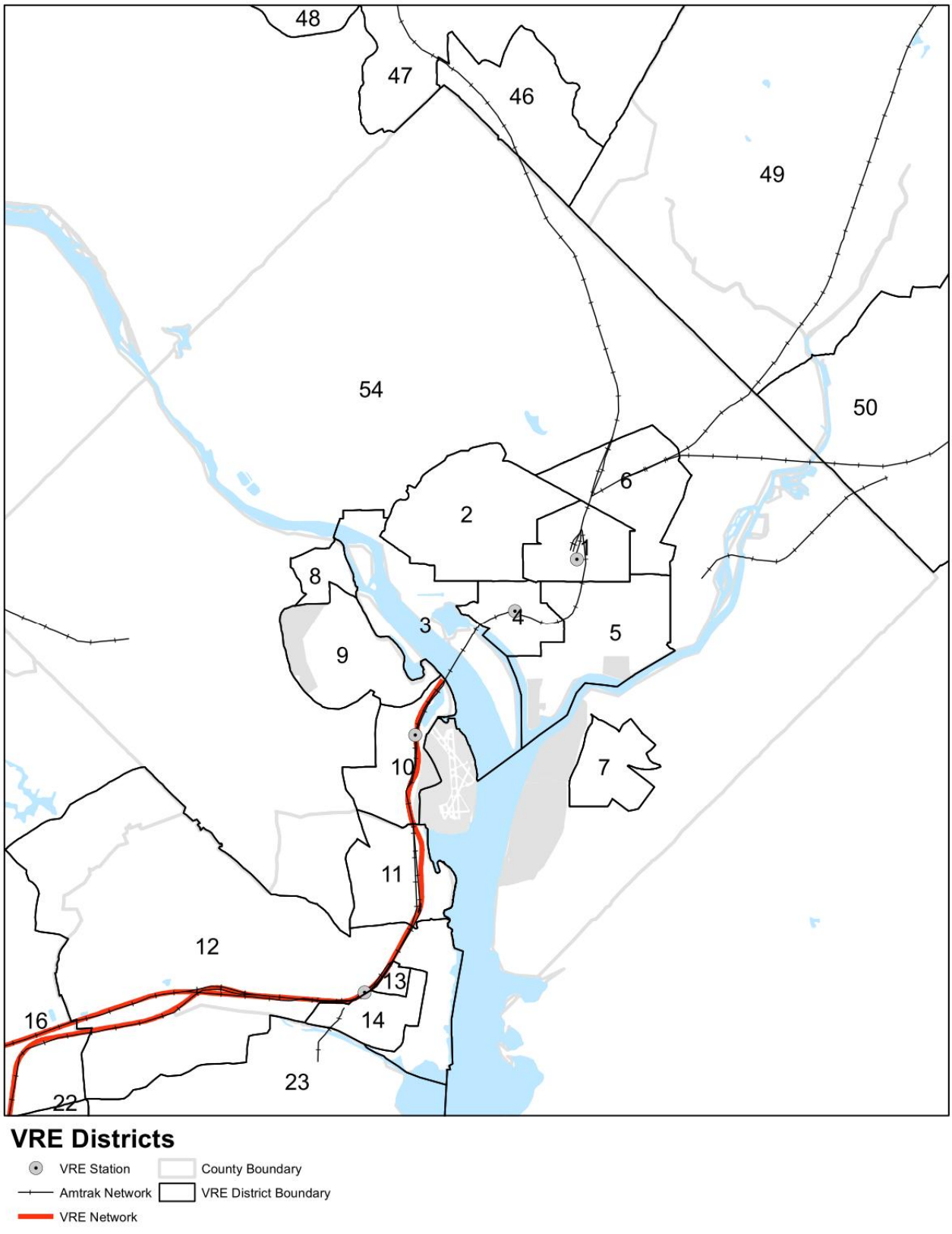


Figure A.6 - VRE Districts for Analysis - detail of central area



Estimated growth in population and jobs from 2010 to 2040 is shown in Table A.5 (on the following page) for each of the VRE districts. The forecast growth was extracted from MWCOG's database for the year 2035, the year for which travel model forecasts were available. In order to meet VRE's request for 2040 estimates, the forecasts were factored up by using the aggregate growth rate from 2035 to 2040 of the county/city grouping in which each district lies. The "Other" district was adjusted to meet the regional total forecast of employment and population.

The forecast density of population and jobs in 2040 is shown visually in Figures A.7 & A.9, respectively, through the background shading of each of the smaller Traffic Analysis Zones that make up the VRE districts. The growth in population and in jobs from 2010 to 2040 is also shown in Figures A.8 and A.10 respectively for the VRE districts. The size and the shading of each circle shows the increase in absolute numbers for the VRE district.

Thus for population, the figures show that the outer areas will add the largest numbers of people, but that the center will also grow and will remain more densely populated. And for jobs, the figures show the central areas adding the most jobs, but that numerous other centers of job growth and density are distributed throughout the region.

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Table A.5 Population and Jobs by VRE District, 2010 - 2040

VRE Districts by Line (green fill:Manassas) (yellow fill:Fredericksburg) (no fill: Destinations / Other)		Year 2010 VRE District Actuals		Year 2035 VRE District Forecast		Jurisdiction	Jurisdiction growth 35-40		Year 2040 VRE District Estimates		Estimated Population Growth 2010-'40		Estimated Jobs Growth 2010-'40	
		Population	Jobs	Population	Jobs		Pop	Jobs	Population	Jobs	Change	% chge	Change	% chge
45	Leesburg / US 15	60,301	26,068	86,266	55,312	Loudon	2.1%	5.2%	88,100	58,170	27,799	46%	32,102	123%
40	Calverton / Bealeton	31,932	5,243	65,316	8,233	Fauq	15.0%	10.3%	75,130	9,080	43,198	135%	3,837	73%
41	Warrenton / New Baltimore	28,579	18,783	64,599	34,517	Fauq	15.0%	10.3%	74,310	38,060	45,731	160%	19,277	103%
43	Delaplane / Hume	12,130	2,337	20,565	3,647	Fauq	15.0%	10.3%	23,660	4,020	11,530	95%	1,683	72%
42	The Plains	2,121	861	2,107	1,354	Fauq	15.0%	10.3%	2,420	1,490	299	14%	629	73%
44	South Loudon	37,280	7,316	69,434	15,885	Loudon	2.1%	5.2%	70,910	16,710	33,630	90%	9,394	128%
27	Haymarket	28,965	2,204	43,452	6,031	PW - Man	2.3%	9.0%	44,430	6,570	15,465	53%	4,366	198%
28	Gainesville	28,769	7,508	52,672	15,474	PW - Man	2.3%	9.0%	53,860	16,860	25,091	87%	9,352	125%
26	Sudley Manor	42,296	27,268	69,905	57,338	PW - Man	2.3%	9.0%	71,490	62,480	29,194	69%	35,212	129%
24	Centreville / Chantilly	95,928	107,972	120,533	144,294	Fairfax - FC	4.0%	2.8%	125,410	148,370	29,482	31%	40,398	37%
31	Nokesville	3,188	763	7,130	1,100	PW - Man	2.3%	9.0%	7,290	1,200	4,102	129%	437	57%
30	Broad Run / Airport	19,711	4,561	24,438	7,102	PW - Man	2.3%	9.0%	24,990	7,740	5,279	27%	3,179	70%
29	Manassas	49,524	25,414	64,240	36,506	PW - Man	2.3%	9.0%	65,690	39,780	16,166	33%	14,366	57%
25	Manassas Park	100,670	19,519	125,169	25,231	PW - Man	2.3%	9.0%	128,000	27,490	27,330	27%	7,971	41%
20	Clifton	3,536	638	3,673	647	Fairfax - FC	4.0%	2.8%	3,820	670	284	8%	32	5%
19	Fairfax Station	23,725	2,878	24,661	3,085	Fairfax - FC	4.0%	2.8%	25,660	3,170	1,935	8%	292	10%
18	Burke Centre	65,308	12,851	67,593	14,077	Fairfax - FC	4.0%	2.8%	70,330	14,470	5,022	8%	1,619	13%
17	Rolling Road	70,951	7,473	71,967	8,280	Fairfax - FC	4.0%	2.8%	74,880	8,510	3,929	6%	1,037	14%
16	Backlick Road	90,409	44,804	107,579	52,579	Fairfax - FC	4.0%	2.8%	111,930	54,060	21,521	24%	9,256	21%
39	Spotsylvania	24,247	13,249	44,296	19,916	Spots	8.3%	8.3%	47,970	21,580	23,723	98%	8,331	63%
38	Fredericksburg	106,381	70,019	173,565	107,118	FredCit	6.3%	7.8%	184,410	115,520	78,029	73%	45,501	65%
37	Leeland Road	70,828	29,518	121,918	44,757	Staff	8.6%	9.1%	132,430	48,830	61,602	87%	19,312	65%
36	Brooke	13,794	5,456	23,127	7,924	Staff	8.6%	9.1%	25,120	8,640	11,326	82%	3,184	58%
32	Quantico	91,034	40,257	149,105	66,309	Staff	8.6%	9.1%	161,960	72,340	70,926	78%	32,083	80%
33	Potomac Shores	16,894	2,110	35,738	5,141	PW - Man	2.3%	9.0%	36,550	5,600	19,656	116%	3,490	165%
34	Rippon	69,246	8,541	92,678	14,368	PW - Man	2.3%	9.0%	94,770	15,660	25,524	37%	7,119	83%
35	Woodbridge	118,343	34,884	160,896	64,157	PW - Man	2.3%	9.0%	164,530	69,910	46,187	39%	35,026	100%
21	Lorton	67,939	43,927	83,135	52,046	Fairfax - FC	4.0%	2.8%	86,500	53,520	18,561	27%	9,593	22%
22	Franconia / Springfield	35,060	21,736	42,652	38,492	Fairfax - FC	4.0%	2.8%	44,380	39,580	9,320	27%	17,844	82%
23	Mt. Vernon	109,051	27,447	134,396	35,943	Fairfax - FC	4.0%	2.8%	139,840	36,960	30,789	28%	9,513	35%
7	Anacostia / DHS	10,128	3,084	18,516	23,761	DC	4.0%	2.8%	19,270	24,430	9,142	90%	21,346	692%
11	Potomac Yard	14,449	5,370	22,691	11,478	ArlCo	1.2%	0.7%	22,960	11,550	8,511	59%	6,180	115%
6	DC Metro North East	25,303	18,970	33,394	40,888	DC	4.0%	2.8%	34,750	42,040	9,447	37%	23,070	122%
1	Union Station	18,310	80,178	30,819	117,992	DC	4.0%	2.8%	32,070	121,320	13,760	75%	41,142	51%
14	Alexandria Inner Ring	7,715	28,210	13,853	38,082	AlexCit	3.8%	3.3%	14,390	39,350	6,675	87%	11,140	39%
10	Crystal City / Airport	15,144	50,773	21,731	86,133	ArlCo	1.2%	0.7%	21,990	86,700	6,846	45%	35,927	71%
8	Rosslyn	10,815	34,226	15,170	55,628	ArlCo	1.2%	0.7%	15,350	55,990	4,535	42%	21,764	64%
48	Rockville / Germantown	326,437	220,748	451,747	344,349	Mont	1.6%	3.2%	458,990	355,440	132,553	41%	134,692	61%
5	DC Metro South East	33,443	57,347	44,700	83,988	DC	4.0%	2.8%	46,510	86,360	13,067	39%	29,013	51%
51	Outer PG	141,322	61,806	159,584	94,438	PG	2.3%	9.0%	163,190	102,910	21,868	15%	41,104	67%
12	Alexandria Outer Ring	130,260	85,811	162,675	117,615	AlexCit	3.8%	3.3%	168,930	121,540	38,670	30%	35,729	42%
54	Other	3,063,355	1,590,388	3,812,111	2,089,712	Other	2.4%	2.0%	3,904,020	2,131,510	840,665	27%	541,122	34%
46	Silver Spring	37,442	34,127	49,755	41,893	Mont	1.6%	3.2%	50,550	43,240	13,108	35%	9,113	27%
4	L'Enfant Plaza	4,985	82,860	7,281	89,875	DC	4.0%	2.8%	7,580	92,410	2,595	52%	9,550	12%
53	SE Howard	244,562	152,869	282,357	209,939	Howard	0.0%	2.6%	282,360	215,420	37,798	15%	62,551	41%
49	West PG	183,273	75,004	206,293	98,124	PG	2.3%	9.0%	210,960	106,930	27,687	15%	31,926	43%
52	NW Anne Arundel	338,060	248,993	372,070	324,053	PG	2.3%	9.0%	380,480	353,130	42,420	13%	104,137	42%
47	East Montgomery	238,826	60,651	256,388	78,943	Mont	1.6%	3.2%	260,500	81,490	21,674	9%	20,839	34%
50	Mid PG	181,651	83,695	199,451	104,053	PG	2.3%	9.0%	203,960	113,390	22,309	12%	29,695	35%
2	DC Metro North West	74,799	330,537	89,568	349,055	DC	4.0%	2.8%	93,190	358,910	18,391	25%	28,373	9%
13	Alexandria King Street Corri	2,247	2,999	2,568	2,964	AlexCit	3.8%	3.3%	2,670	3,060	423	19%	61	2%
3	DC Parks West	3,713	33,052	4,078	33,426	DC	4.0%	2.8%	4,240	34,370	527	14%	1,318	4%
9	Pentagon	1,005	29,079	1,003	28,479	ArlCo	1.2%	0.7%	1,020	28,670	15	1%	(409)	-1%
	Total	6,625,384	3,992,382	8,410,608	5,411,731		3.0%	3.8%	8,660,700	5,617,200	1,194,651	18%	1,336,777	-67%

Source: Washington COG, Round 8.1 Cooperative Forecasting, 2012; PB calculations.

Figure A.7 Forecast 2040 Population Density by Traffic Analysis Zone

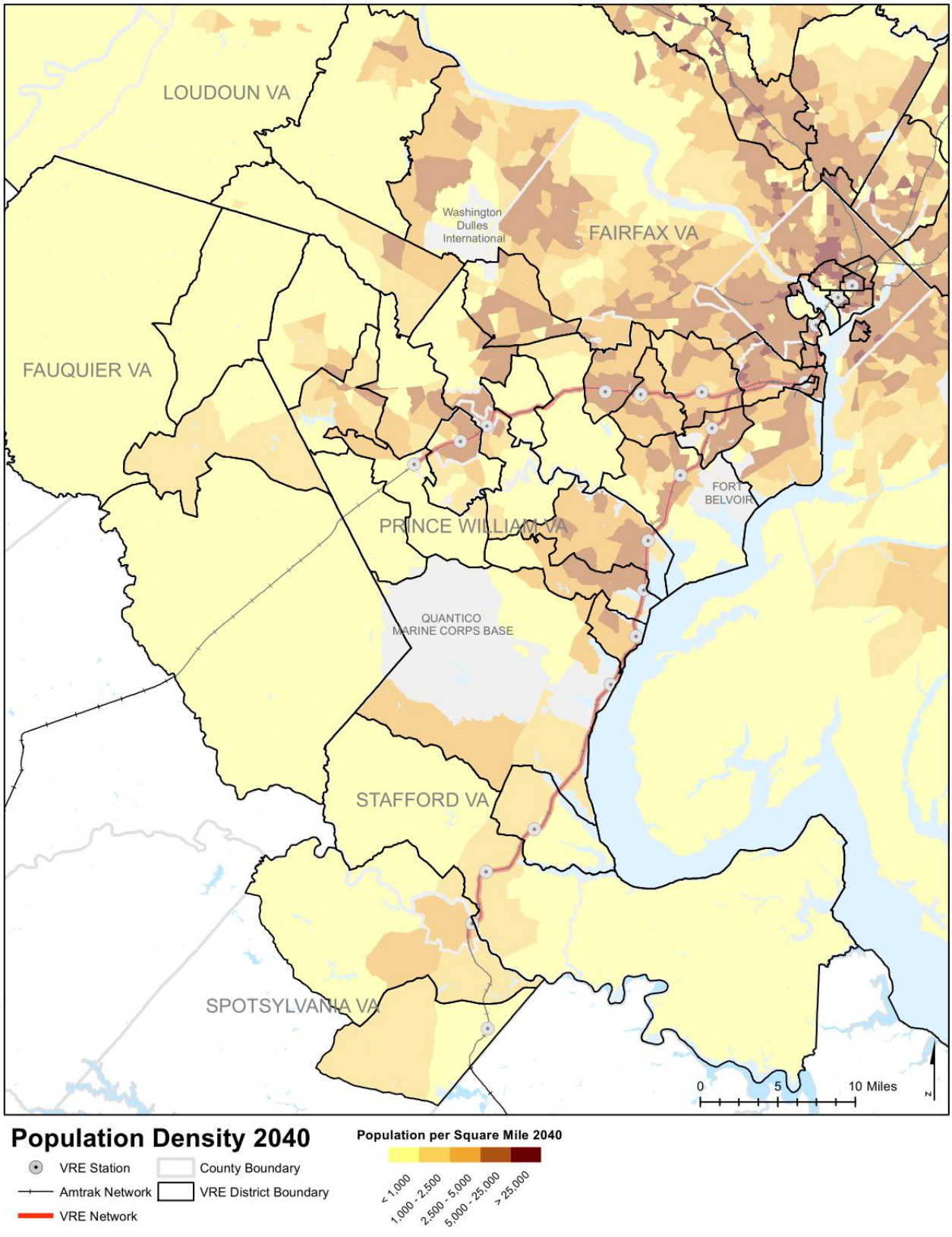


Figure A.8 Forecast Population Growth by VRE Trip District, 2010-2040

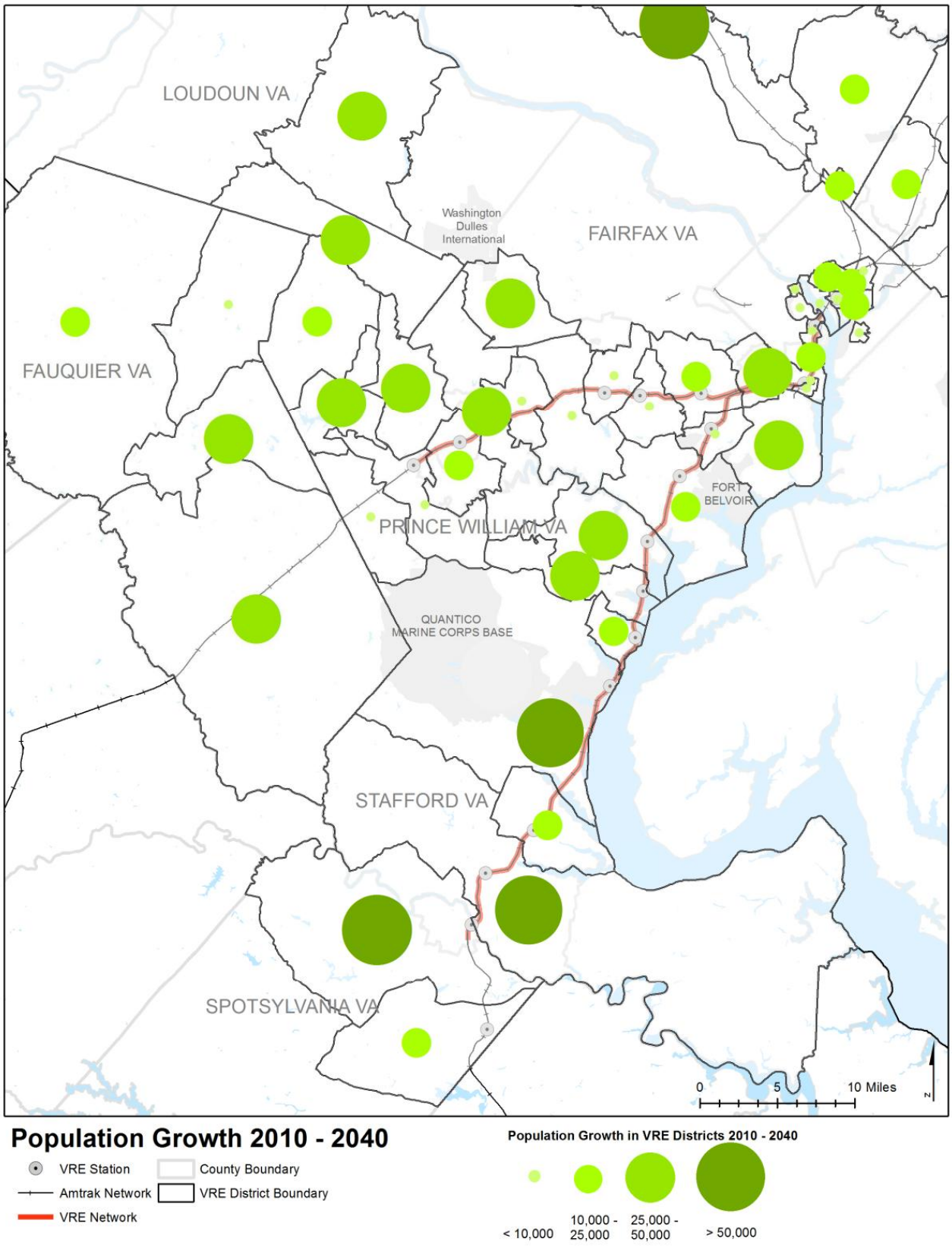


Figure A.9 Forecast 2040 Employment Density by Traffic Analysis Zone

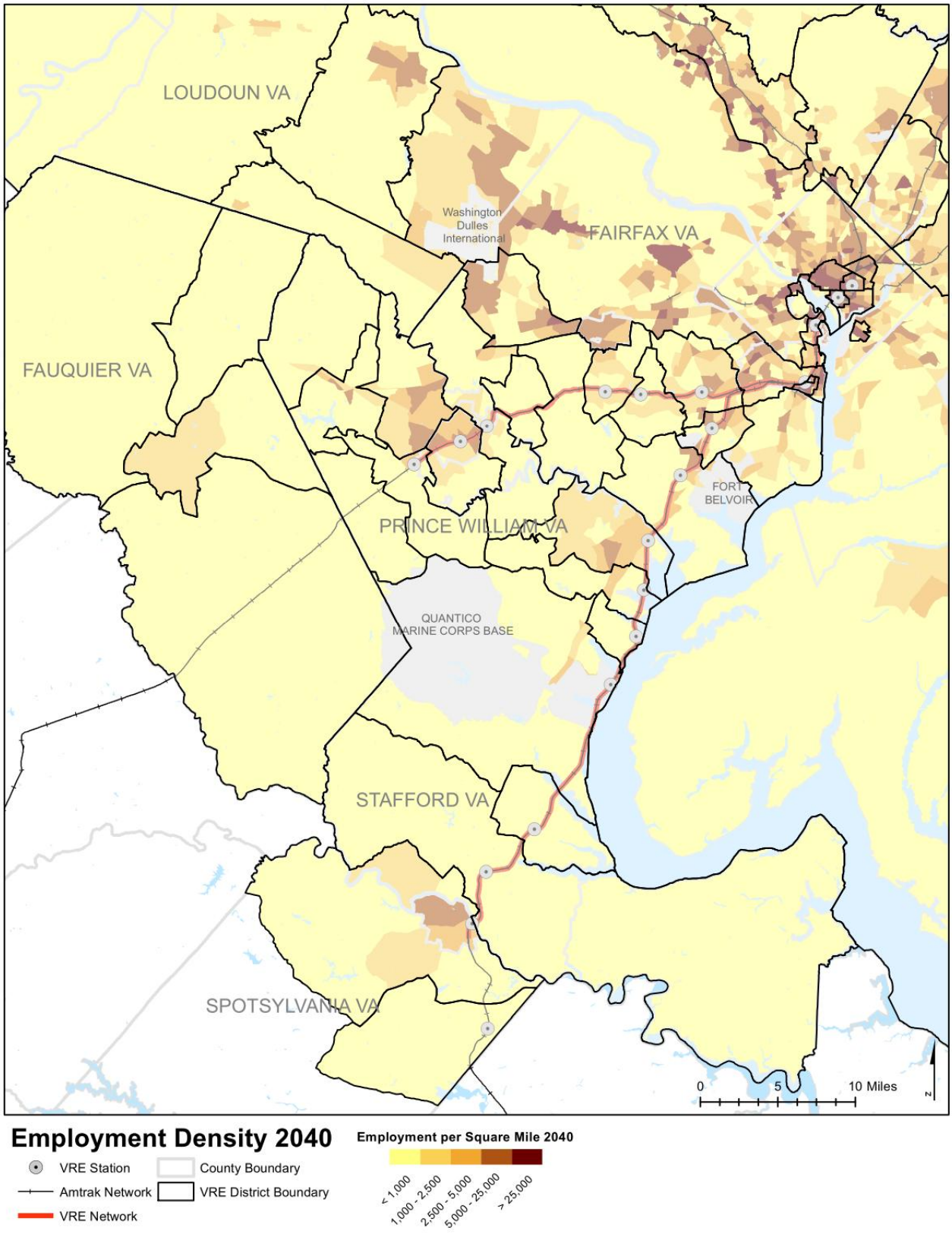
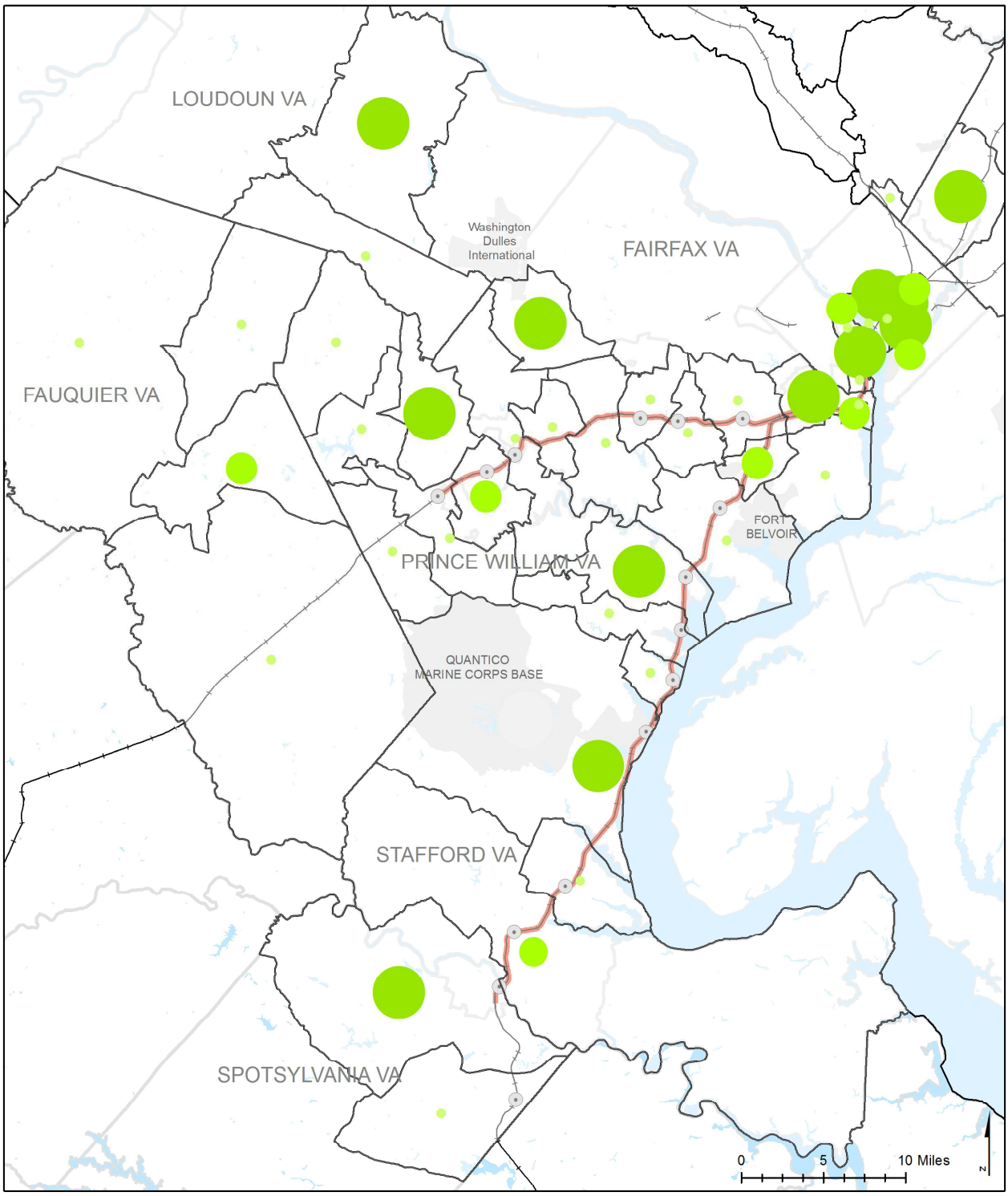


Figure A.10 Forecast Employment Growth by VRE Trip District, 2010-2040



3. Estimating VRE Ridership Growth Potential

Review of MWCOG travel model 2035 forecasts

Normal practice for major project ridership estimating is to use the existing regional travel model to compare the effects of various service changes. In some cases, as in Parsons Brinckerhoff's recent work on Maryland's Capital Corridor Transitway running parallel to I-270, the Metrorail Red Line, and the MARC commuter service on the CSX rail line from Frederick County, the existing Washington regional travel model had to be re-worked to correctly estimate current MARC ridership, and to be sensitive to the changes in service from the proposed transit project, a lengthy and complicated undertaking.

For evaluating scenarios for the VRE System Plan, Parsons Brinckerhoff examined the output of the modelling efforts for the Capital Corridor Transitway (CCT) to see whether data could be used in the conceptual estimating of ridership. Since the model covers the entire Washington region, it produced not only the desired estimates of travel in the CCT corridor, but also estimates of all other travel in the region, including on VRE and the parallel I-95, I-66, and Metrorail facilities. Although review and adjustment of the travel forecast and service assumptions outside of the Maryland corridors had not been part of the CCT work, it was hoped that the overall modelling might still be useful.

Data was aggregated from the 3,675 Traffic Analysis Zones used in the model to the 54 VRE districts described in the prior section. The model estimation for the year 2010 the forecast for the year 2035 were available. District to district estimates for overall trips, transit trips, and commuter rail trips as well as estimated boardings by line were provided.

Unfortunately, the data for the VRE area travel were problematic. The model's 2010 estimate for 2010 VRE ridership was 40% below VRE's actual 2010 riders on both lines (see Table A.6). The model especially under-predicted longer trips such as from the Fredericksburg VRE district to the regional core (Washington, Arlington, Alexandria), where the model estimated that the *total* trips by all modes were only about 1/10th of the actual VRE boardings at the Fredericksburg station (278 modeled total trips vs. 2,600 VRE trips a day).

The forecast changes in VRE travel to 2035 also did not appear explainable. The Manassas line was forecast to grow 40%, and the Fredericksburg line to drop 10% from 2010, although population growth was strong on both lines. Some of this may have been be due to assumed increases in Metrorail Blue line frequency, and a decrease in Fredericksburg VRE frequency, but the changes in VRE riders did not seem logical. For example while VRE trips from Rippon and Woodbridge to the regional core dropped 25-50%, trips from Franconia/Springfield right around the Metro station increased 17%. Table A.7 shows a sample of the changes in VRE and other trips.

Table A.6 Comparison of predicted and actual commuter rail boardings

COMMUTER RAIL LINE BOARDINGS SUMMARY
Estimated compared to Observed

	All Boardings								
	2010				2010 Est vs 2005 Obs		2035	2035 vs 2010 Ests	
LINE NAME	Estimated	Observed [2]	Difference	Ratio	Change	Ratio	Estimated	Difference	Ratio
MARC Rail Lines									
Camden	1,838	5,389	(3,551)	0.34	(2,149)	0.46	2,293	455	1.25
Brunswick	11,962	7,822	4,140	-	5,642	1.89	8,953	(3,009)	-
Frederick	-	-	-	-			2,038	2,038	-
Frederick + Brunswick	11,962	7,822	4,140	1.53			10,991	(971)	0.92
Penn	14,235	20,419	(6,184)	0.70	(1,479)	0.91	13,164	(1,071)	0.92
Sub Total	*28,035*	*33,630*	*(5,595)*	*0.83*	*(320)*	*0.99*	*26,448*	*(2,042)*	*0.94*
VRE Rail Lines									
MANASSAS	4,544	7,926	(3,382)	0.57	(2,704)	0.63	6,299	1,755	1.39
FREDERICKSBURG	4,602	8,282	(3,680)	0.56	(2,645)	0.64	4,168	(434)	0.91
Sub Total	*9,146*	*16,208*	*(7,062)*	*0.56*	*(5,348)*	*0.63*	*10,467*	*1,321*	*1.14*
Grand Total	*37,181*	*49,838*	*(12,657)*	0.75	*(5,668)*	*0.87*	*36,915*	*(266)*	*0.99*

Notes

2 - Penn Line 2009 from http://en.wikipedia.org/wiki/Penn_Line_(MARC) may include non-WASCOG trips
- Brunswick line 2009 from http://en.wikipedia.org/wiki/Brunswick_Line
- Camden line, 29009 from http://en.wikipedia.org/wiki/Camden_Line
- VRE figures from VRE spreadsheet "Historical Ridership_updatethisfile.xls on PS2 site

Table A.7 Model changes in travel to the regional core 2010-2035, selected travel markets (CR= VRE)

Change from 2010	CR	%	Transit	%	Tot Trips	%
GOING TO CORE						
From Potomac Shores - Spotsylvania	103	11%	78	2%	609	5%
From Rippon	(197)	-23%	(25)	-1%	(2,537)	-20%
From Woodbridge	(434)	-47%	759	10%	(1,838)	-6%
From Lorton -Franconia/Springfield	101	17%	1,822	19%	2,223	4%
GOING TO DC DISTRICTS						
From Potomac Shores - Spotsylvania	42	8%	(229)	-11%	(406)	-10%
From Rippon	(174)	-33%	(437)	-19%	(1,685)	-31%
From Woodbridge	(47)	-9%	88	2%	(40)	0%
From Lorton -Franconia/Springfield	40	10%	(61)	-1%	(318)	-2%

Finally, the model predicts a drop in overall travel to the regional core from many of the outer VRE markets, despite their population growth See Table A.8. Further work will be needed to better understand the dynamics of these long-distance markets and to adjust the model to more realistically forecast VRE trip-making potential.

Table A.8 Comparison of forecast population and jobs growth and trips to the regional core

VRE DIST	VRE districts, roughly from furthest out to nearest in for each line Green fill: Manassas Line Yellow: Fredericksburg Line No fill: Destinations/Other	Population 2010-'35		Employment 2010-'35		Avg Change Pop & Emp 2010-'35	Total Person trips going to Alexandria/Arlington/DC core 2035		
		Change	% chge	Change	% chge	% chge	Total 2035 trips	% Chg fr '10	per capita
45	Leesburg / US 15	25,965	43%	29,244	112%	78%	709	165%	0.01
40	Calverton / Bealeton	33,384	105%	2,990	57%	81%	1,756	1045%	0.03
41	Warrenton / New Baltimore	36,020	126%	15,734	84%	105%	188	129%	0.00
43	Delaplane / Hume	8,435	70%	1,310	56%	63%	446	487%	0.02
42	The Plains	(14)	-1%	493	57%	28%	28	298%	0.01
44	South Loudon	32,154	86%	8,569	117%	102%	1,121	8%	0.02
27	Haymarket	14,487	50%	3,827	174%	112%	176	-51%	0.00
28	Gainesville	23,903	83%	7,966	106%	95%	585	-15%	0.01
26	Sudley Manor	27,609	65%	30,070	110%	88%	624	-26%	0.01
24	Centreville / Chantilly	24,605	26%	36,322	34%	30%	5,709	-28%	0.05
31	Nokesville	3,942	124%	337	44%	84%	52	-32%	0.01
30	Broad Run / Airport	4,727	24%	2,541	56%	40%	621	-9%	0.03
29	Manassas	14,716	30%	11,092	44%	37%	712	-10%	0.01
25	Manassas Park	24,499	24%	5,712	29%	27%	4,033	-26%	0.03
20	Clifton	137	4%	9	1%	3%	291	-32%	0.08
19	Fairfax Station	936	4%	207	7%	6%	3,322	-21%	0.13
18	Burke Centre	2,285	3%	1,226	10%	7%	11,964	-12%	0.18
17	Rolling Road	1,016	1%	807	11%	6%	18,479	-18%	0.26
16	Backlick Road	17,170	19%	7,775	17%	18%	34,033	3%	0.32
39	Spotsylvania	20,049	83%	6,667	50%	67%	213	247%	0.00
38	Fredericksburg	67,184	63%	37,099	53%	58%	1,695	59%	0.01
37	Leeland Road	51,090	72%	15,239	52%	62%	1,296	40%	0.01
36	Brooke	9,333	68%	2,468	45%	56%	163	-26%	0.01
32	Quantico	58,071	64%	26,052	65%	64%	2,277	-21%	0.02
33	Potomac Shores	18,844	112%	3,031	144%	128%	2,186	18%	0.06
34	Rippon	23,432	34%	5,827	68%	51%	6,210	-23%	0.07
35	Woodbridge	42,553	36%	29,273	84%	60%	16,966	-8%	0.11
21	Lorton	15,196	22%	8,119	18%	20%	17,290	-5%	0.21
22	Franconia / Springfield	7,592	22%	16,756	77%	49%	15,965	1%	0.37
23	Mt. Vernon	25,345	23%	8,496	31%	27%	73,709	17%	0.55
7	Anacostia / DHS	8,388	83%	20,677	670%	377%	17,307	111%	0.93
11	Potomac Yard	8,242	57%	6,108	114%	85%	37,720	40%	1.66
6	DC Metro North East	8,091	32%	21,918	116%	74%	48,328	39%	1.45
1	Union Station	12,509	68%	37,814	47%	58%	61,396	40%	1.99
14	Alexandria Inner Ring	6,138	80%	9,872	35%	57%	30,222	59%	2.18
10	Crystal City / Airport	6,587	43%	35,360	70%	57%	56,276	15%	2.59
8	Rosslyn	4,355	40%	21,402	63%	51%	19,112	14%	1.26
48	Rockville / Germantown	125,310	38%	123,601	56%	47%	48,030	11%	0.11
5	DC Metro South East	11,257	34%	26,641	46%	40%	73,308	22%	1.64
51	Outer PG	18,262	13%	32,632	53%	33%	31,497	-2%	0.20
12	Alexandria Outer Ring	32,415	25%	31,804	37%	31%	118,578	13%	0.73
54	Other	748,749	24%	480,735	32%	28%	1,109,894	12%	0.29
46	Silver Spring	12,313	33%	7,766	23%	28%	23,205	26%	0.47
4	L'Enfant Plaza	2,296	46%	7,015	8%	27%	31,733	12%	4.36
53	SE Howard	37,795	15%	57,070	37%	26%	8,885	-34%	0.03
49	West PG	23,020	13%	23,120	31%	22%	69,749	7%	0.34
52	NW Anne Arundel	34,010	10%	75,060	30%	20%	21,877	-17%	0.06
47	East Montgomery	17,562	7%	18,292	30%	19%	57,246	-4%	0.22
50	Mid PG	17,800	10%	20,358	24%	17%	86,061	9%	0.43
2	DC Metro North West	14,769	20%	18,518	6%	13%	155,982	6%	1.74
13	Alexandria King Street Corrido	321	14%	(35)	-1%	7%	5,168	7%	2.01
3	DC Parks West	365	10%	374	1%	5%	9,271	-10%	2.27
9	Pentagon	(2)	0%	(600)	-2%	-1%	5,738	-17%	5.72
	Total	1,785,217	27%	1,400,760	36%	31%	2,349,402	11%	0.28

General Approach to Estimation

A variety of approaches were taken to estimating potential riders for existing and new VRE services, depending on the available data and apparent applicability of experience in other commuter rail operations to the VRE situation.

The specific approach to each potential market is described in the sections following. In addition to estimating a reasonable "mid-range" potential, "high" and "low" estimates were made by adding and subtracting percentages, as described in each section below. Estimates of growth over time were also made, and the potential of each market is shown at ten-year intervals from 2020 to 2040, assuming the necessary service is fully in place.

Annual passenger figures were calculated by multiplying average weekday riders by 250, a ratio calculated from daily and annual data on page 46 of the VRE 2012 annual financial report. Annual revenue in 2013$$ was calculated, assuming that the current average fare of $7.28 would be maintained by the addition of the new passengers. The average fare also was calculated from data in the VRE 2012 annual financial report.

The result is a "menu" at various points in time, sufficient to provide an order of magnitude of potential ridership to help in conceptual planning. More rigorous ridership estimation, requiring significantly more time and resources than available in the System Plan study, will certainly be needed for major capital projects and new railroad and jurisdictional agreements.

Existing VRE Service, Peak Period, Peak Direction Trips

The potential growth in peak-period trips were estimated in two steps, first assuming that no additional trains would be run, and that existing schedules would be maintained, and then by assuming additional service frequency up to four trains per hour on each line to Alexandria where the two lines join, effectively providing service every 7-8 minutes across the Potomac.

Existing ridership from 2013 was taken as the starting point on each line, and a rate of growth in passengers was assumed in line with the population growth projections shown in Table A.2, which are half or less of VRE's 4.2% a year traffic growth rate of the past dozen years (see Figure A.1). The Fredericksburg line traffic was assumed to grow at 2.2% a year until 2020, dropping to 1.7% a year until 2030, and then to 1.2% yearly until 2040. The Manassas line was assumed to grow at 1.8%, 1.2%, and 0.8% a year for each of those same periods.

For the "Low" and "High" estimates, 70% and 130% of each annual growth rate was used. The range was meant to encompass the potential effects of changes in the forecast growth, patterns of development, and other transportation system changes.

Table A.9 shows the range of expected demand on each line by decade assuming no expansion in frequency or speed beyond that provided today. Table A.9A shows the increase in demand from 2020 to 2040 in the same circumstances.

Table A.9 Estimated Demand for Existing VRE Peak Direction Service, 2013-2040

	2013	2020	2030	2040
Weekday trips	(actual)	(mid-range estimates)		
Fredericksburg Line	9,780	11,300	13,300	15,000
Manassas Line	9,100	10,200	11,300	11,900
Total	18,880	21,500	24,600	26,900
Annual trips (millions)	4.7	5.6	6.1	6.7
Weekday trips (in 000s)		(low to high range estimates in 000s)		
Fredericksburg Line		10.8 - 11.8	12.1 - 14.6	13.2 - 17.0
Manassas Line		9.8 - 10.5	10.6 - 12.0	11.0 - 12.8
Total		20.7 - 22.3	22.7 - 26.6	24.1 - 29.2

Table A.9A Growth in Demand for Existing VRE Peak Direction Service, 2020-2040

	2020	2030	2040
Weekday trips	(mid-range estimates)		
Fredericksburg Line	1,500	3,500	5,200
Manassas Line	1,100	2,200	2,800
Total	3,000	5,700	8,000
Annual trips (millions)	0.8	1.4	2.0
Weekday trips (in 000s)	(low to high range estimates in 000s)		
Fredericksburg Line	1.0 - 2.0	2.3 - 4.8	3.4 - 7.2
Manassas Line	0.7 - 1.4	1.5 - 2.9	1.9 - 3.7
Total	1.7 - 3.4	3.8 - 7.7	5.3 - 10.9

The effect of additional peak period, peak direction VRE trains, some of which would skip stops and as such run faster, was estimated using reported sensitivities to service changes in other rail transit systems, and relative levels of trips carried by other commuter rail services, both primarily in the U.S. Where trains run 20 minutes or more apart, an elasticity to headway of -0.5

was used, as the mid-point of the range of -0.4 to -0.6 given in the Transportation Research Board's (TRB's) 2003 Transit Capacity and Quality of Service Manual, 2nd edition, page 1-11, in the last paragraph related to short-headway commuter rail services. To estimate the impact of headway changes where the end point was less than 20 minutes apart, the elasticity was lowered to 0.4, at the less optimistic end of the TRB's range.

Today's services run at an average of 22.85 minutes apart for the Fredericksburg line and 27.5 minutes apart for the Manassas line. Going to trains every 15 minutes would lower headway by 34% and 45% respectively, increasing estimated ridership by about 13% and 18% respectively.

With the increased frequency, selected trains can be speeded up for longer travel by not stopping at all trains at the more lightly used stations, while still preserving reasonable frequency of service at the skipped stations. The effect of speeding up service on ridership was estimated using an elasticity of -0.35, the average of (a) -0.1, middle of range from AM values for US transit in Dowling, cited p. 47 of Littman 2013, Victoria Transport Policy Institute, and (b) Lago et al., "Transit Service Elasticities", Journal of Transport Economics and Policy, May 1981, Table 10, which reported a mean of -0.6 for London commuter rail.

Skip-stop service was assumed to save varying amounts of time and affect differing numbers of passengers from the outer and middle areas of the Fredericksburg line and from the middle areas of the Manassas line, as shown in Table A.10. The line's weighted average savings per passenger was multiplied by the elasticity to arrive at the ridership increase from speeding up service.

Table A.10 Assumptions on Skip Stop Run Time Savings and Passengers Affected

	Manassas line	Fredericksburg line	
	Middle area	Middle area	Outer area
Minutes saved on skip stop train	5	6	11
Normal run time (minutes)	59	45	82
% change	-8%	-13%	-13%
% of riders from the area	67%	30%	60%
% of these riders benefitting	80%	50%	80%
Weighted average time savings	5%	8%	
Increase in passengers	2%	3%	

In order to create a range of sensitivity for the relatively well documented effect of more frequent trains and of faster service, the sensitivity was increased and lowered by 10%.

Table A.11 shows the range of expected demand on each line by decade with the four trains per hour on each line and the skip-stop service.

Table A.11 Incremental Demand for Improved VRE Peak Direction Service, 2020-2040

	2020	2030	2040
Weekday trips	(mid-range estimates)		
Fredericksburg Line	1,900	2,200	2,500
Manassas Line	2,000	2,200	2,400
Total	3,900	4,400	4,900
Weekday trips (in 000s)	(low to high range estimates in 000s)		
Fredericksburg Line	1.6 - 2.2	1.8 - 2.7	2.0 - 3.2
Manassas Line	1.6 - 2.3	1.7 - 2.6	1.8 - 2.8
Total	3.2 - 4.5	3.5 - 5.3	3.8 - 6.0

Gainesville-Haymarket Extension Peak Period, Peak Direction Trips

Estimated ridership for a Gainesville - Haymarket extension to the Manassas line, was adapted from the 2004 Strategic Plan. That estimate, for the year 2025, was for an additional 3,100 to 5,500 weekday trips, assuming half-hourly service from this line and included the effect of the increased frequency on the Manassas line[3]. The current estimate starts with the middle of that range, 4,300 trips, and backs out the effect of frequency to portray only those riders added because of the extension.

The 2004 estimate assumed 9 trains during the peak east of the Manassas Junction, with three a.m. trains from Broad Run and six from Haymarket, three more trains than then running. The headway change east of the junction was about 33%, from about 30 minutes to 20 minutes. The estimate also assumed some skip-stop service. Because detail was not available on how many passengers were added east of Manassas Junction due to the frequency and speed increase, an estimate was made by comparing two scenarios without the Gainesville-Haymarket extension in the current System Plan work. The difference in passengers from the scenario shown in Table A.11 with 15 minute headway and some skip stop service and an intermediate scenario with 23.6 minute headway (a similar 36% decrease in frequency) and no skip stop service was 1,400. These 1,400 trips were subtracted from the mid-range year 2025 estimate, resulting in 2,900 estimated trips.

[3] Parsons Brinckerhoff, "Virginia Railway Express - Strategic Plan 2004-2025", May 2004, pp. 21 and 76.

The high and low end of the range was assumed to be proportional to the 2004 estimates (roughly +/- 30%), and the growth rate of the Manassas line as a whole was used to extrapolate forward to 2040 and back to 2020. The resulting increment in riders is shown in Table A.12.

Table A.12 Estimated Incremental Trips for Gainesville - Haymarket Service, 2020-2040

	2020	2030	2040
Weekday trips	(mid-range estimates)		
Gainesville-Haymarket	2,700	3,000	3,100
Weekday trips (in 000s)	(low to high range estimates in 000s)		
Gainesville-Haymarket	2.0 - 3.4	2.1 - 3.9	2.2 - 4.1

Reverse-Peak Commute Trips

Potential VRE trips in this market were estimated as a small share of trips from the regional core to growing employment areas along the two lines (See Table A.4). The total reverse trips were taken from the 2035 MWCOG model travel forecast discussed at the start of this section, increased to 2040 for ongoing growth, and are shown in Table A.13. The table also shows an initial estimate of VRE mode share of 0.3%, subtotaled by line.

Table A.13 Total 2040 Weekday Reverse Trips and Potential VRE Peak Trips

	Total trips	Potential VRE trips
Ft. Belvoir area	186,200	560
Quantico area	145,800	470
Eastern Prince William & Stafford (Rte. 1)	286,000	700
Fredericksburg	232,000	860
Fredericksburg Line		2,590
Western Prince William	220,000	660
Manassas Line		660

The reverse-peak commute trips were then compared to the 2040 peak-trips without improvements, and expressed as percents: 15% of peak trips for the Fredericksburg line and 5% of peak trips for the Manassas line. This ratio of off-peak riders to peak is much lower than for Caltrain whose data show 2/3 of the trips in the "reverse" direction to San Jose in the morning and back towards San Francisco in the evening, and Metro North, who reportedly carry as many

people on some lines in the reverse-peak direction as in the peak direction.[4] However, the much lower percentage reflects the nature of development in VRE's corridors, which does not have as much population, employment and density along its lines, once outside of the central core.

These percentages were then applied to the peak direction riders for the peak-direction without improvements scenario to estimate the market potential. The improvement of peak direction service and extension of service to Haymarket are not included in this estimate of reverse-peak riders.

A range of +/- 20% was applied for the high and low scenarios. Table A.14 shows the estimated incremental riders for reverse-peak service in ten year increments.

Table A.14 Estimated Incremental Trips for Reverse-Peak Service, 2020-2040

	2020	2030	2040
Weekday trips	(mid-range estimates)		
Both lines	2,200	2,600	2,800
Weekday trips (in 000s)	(low to high range estimates in 000s)		
Both lines	1.7 - 2.8	1.9 - 3.3	2.0 - 3.8

[4] This ratio of off-peak riders to peak is much lower than for Caltrain whose data show 2/3 of the trips in the "reverse" direction to San Jose in the morning and back towards San Francisco in the evening, and Metro North, carries as many people in the reverse-peak direction as in the peak direction. However, the much lower percentage reflects the nature of development in VRE's corridors, which does not have as much population, employment and density along its lines outside of the central core.

Caltrain, "February 2013 Caltrain Annual Passenger Counts - Key Findings", 2013;

Jeff Stagle, "Inside New York City's Metro-North Railroad" Progressive Railroading, May 2006, accessed online at http://www.progressiverailroading.com/passenger_rail/article/Inside-New-York-Citys-MetroNorth-Railroad--31828.

Off-Peak Weekday Trips

Mid-day and evening off-peak service would attract new markets as well as increase the attractiveness of VRE to traditional peak commuters, who could travel home if needed in the mid-day or later in the evening. A brief literature review found two points on which to base mid-day service estimates: Caltrain survey data previously cited in the reverse-peak section, and Maryland MARC information in a paper documenting the modelling approach for the 2004 VRE Strategic Plan.[5]

According to these sources, mid-day hourly service between the rush hours would add between 8% to peak hour service (PB 2002), and 12% (Caltrain 2013 Passenger Survey). For the System Plan a value of 7% was chosen for the mid-range: the average of the two values, 10%, minus 3% to account for the volume of passengers that VRE already carries on three mid-day trains.

For evening service the PB 2002 forecasting methodology paper stated that MARC experience showed, and other literature supported, that evening service generated both new trips in the evening, and new trips in the normal peak hours, since additional commuters with less-than-perfectly regular work hours could rely on commuter rail even if they had to work late. The effect of three evening trains was stated as a 24% increase over peak-only service, and of two trains as an 18% increase. Caltrain's passenger survey showed that 6% of its total riders were "night" passengers, but had no information on riders added at the peak because of the night service. For the System Plan, a mid-range value of 12% was chosen to represent the increment of riders from evening service.

A range of +/- 20% was used to construct the high and low ends of the forecast for any given year. Table A.15 shows the resulting incremental trips.

Table A.15 Estimated Incremental Trips for Mid-day & Evening Service, 2020-2040

	2020	2030	2040
Weekday trips	(mid-range estimates)		
Both lines	4,100	4,700	5,100
Weekday trips (in 000s)	(low to high range estimates in 000s)		
Both lines	3.1 - 5.1	3.5 - 6.1	3.7 - 6.8

[5] Parsons Brinckerhoff, "Virginia Railway Express Patronage Forecasts, Lon-range Forecasting Model Methodology", Task D, 17809VRE, LONGEST.DOC, undated, believed to be 2002.

Short cross-Potomac Weekday Trips

The volume of short trips between close-in Northern Virginia areas and Washington DC and inner Maryland areas is so large that Metrorail and road crossings of the Potomac are full at rush hour, and well used at other times. The imminent opening of the Silver Line (in summer 2014) will increase Metro's volumes of Potomac crossings, and in the short to medium term, Metro riders from the inner area of the Fredericksburg lines will see a slight reduction in service, as Metro reallocates available Blue Line capacity to handle the expected new demand.

As a result the inner areas of the VRE lines will be a fertile ground for additional cross-Potomac service. Already, the two-stop 20- to 25-minute VRE trip from Union Station to Alexandria is competitive with Metro's 25- to 29-minute one-transfer trip, as are times between intermediate stations. However, today the VRE service is relatively infrequent and expensive compared to Metro and attracts only a small share of this traffic.

A by-product of increasing peak frequencies and providing peak trains in both directions as discussed above would be to increase rush hour frequency between Alexandria and Washington DC every 7-8 minutes, and additional capacity. VRE trains are most full south and west of Alexandria station, and about a tenth of the passengers get off inbound or board outbound there, leaving seats free to/from DC.

Metro's peak period fare is currently $3.70 one-way Alexandria to Union Station; VRE's fares range from $6.45 for a single ride, to about $4.45 with a monthly pass used twice a day for 20 days. The fare differential is even higher for the intermediate trips such as Crystal City to L'Enfant. Closer coordination with Metro fare levels and use of fares to keep the demand within the available capacity would provide incremental trips and revenue to VRE at little extra cost.

An idea of the magnitude of the market potential is given by VRE space availability between Alexandria and Crystal City, if 10% of seats are open. With 8 car trains with 125 seats, this would provide 100 seats for eight trains an hour or 800 passengers per hour in the peak direction, and half of that in the reverse-peak direction. In addition, some travellers might be willing to stand for the five minutes from Alexandria to Crystal City, where additional long distance commuters get off, and sit for the remaining portion of the trip. This additional capacity is roughly the equivalent of one Metro 8-car train with 65 seats each and standing passengers.

Weekend Trips

This market includes weekend trips on both Saturday and Sunday or on Saturday only for work and non-work purposes. While VRE's existing railroad operating agreements do not permit weekend service, VRE may choose to pursue changing those agreements to enable weekend service in the future. Should that be the case, the best approach for VRE is to focus on specific types of trips among the large amount of travel made on weekends: trips to sporting events, museums, theater, restaurants, and other special events, especially where driving afterwards may be constrained. Maryland's MARC service has seen significant growth since starting weekend service to Washington DC in December 2013, and long-established services on other commuter railroads carry as much as half a weekday's passengers.[6]

A range of +/- 20% was used to construct the high and low ends of the forecast for any given year. Table A.16 shows the resulting incremental trips.

Table A.16 Estimated Incremental Trips for Weekend Service, 2020-2040

	2020	2030	2040
Weekend trips	(mid-range estimates)		
Both lines	2,100	2,500	2,700
Weekend trips (in 000s)	(low to high range estimates in 000s)		
Both lines	1.7 - 2.7	1.8 - 3.2	1.9 - 3.6

[6] On Saturdays Caltrain, which has run weekend service for decades, carries 29% of the volume of trips for a typical weekday, and on Sundays, 22%. Together, this is 51% of a typical weekday, representing an overall increase in riders of 10% (5½ weekdays/ 5 weekdays -1). Source is data from Caltrain 2013, cited previously.

MARC started weekend service on the Penn Line in December 2014, carrying 4,100 a weekend. Four months later, in March, MTA reported carrying 6,500 passengers on weekends, up more than 50%, and about 26% of the average weekday riders on the Penn Line. Source: Maryland State Statistics on-line, https://data.maryland.gov/Transportation/MTA-Average-Weekday-Ridership-by-Month/ub96-xxqw, line 74.

Inter-regional Trips

This refers to extending VRE service beyond Washington's Union Station to Maryland and extending MARC commuter rail service southward to Virginia to serve through-DC trips such as from Rockville or Baltimore to Alexandria or Manassas to Fort Meade to cite a few potential activity centers. VRE and MARC's existing railroad operating agreements do not permit run-through service; however, it is a market that could be pursued with the appropriate railroad capacity investments and agreements.

The run-through travel market could be as many as 100,000 weekday trips by 2040, depending on the services provided, a third of which could be work-related. Extension of VRE trains into MARC territory or vice versa could attract a share of these trips.

B. Capital Cost Estimating

A spreadsheet based model was developed to estimate the capital costs associated with implementing the VRE System Plan through 2040. This spreadsheet model is similar in scale and level of detail to the capital cost tables generated for the 2004 VRE Strategic Plan. Although this model is intended to be as accurate as possible, the purpose of the model is not to produce investment grade estimates but to capture the order of magnitude of cost, relative to historical investment levels, of various alternative system plan scenarios.

1. Methodology and Assumptions

The capital cost model provides a list of capital project line items and an estimation of the total capital cost of each project, either with a lump sum allowance or with a high-level quantity take-off and unit cost where applicable. The model allocates the costs for each line item among four phases of investment. The first phase of capital investment is equivalent to VRE's six-year (FY 2015-2020) Capital Improvement Program (CIP). Phases 2 and 3 each represent 10-year intervals, covering the time period from 2021 through 2040. Phase 4 provides a repository for additional capital investments that are not deemed necessary to implement or support the System Plan through 2040 but which may be deferred from the plan or may be necessary to support additional ridership and service growth in the long term. Costs for Phase 4 elements do not appear in the System Plan totals, but the project line items and estimated costs are retained for reference and potential future use.

The capital cost model also identifies as line items selected existing projects for which funding already has been committed. These projects do not have costs attached, as they have already been funded, are expected to be completed in the short term, and are not carried within the 6-year CIP.

All costs are presented in constant 2013 dollars, rather than year-of-expenditure dollars, because of uncertainty in the timing and prioritization of various capital investments. Unit costs or line item costs from sources prior to the current year were inflated to current (2013) dollars at an annual rate of 4.0 percent.

Contingency factors are generally included within the unit costs, at a level appropriate for the high-level of conceptual planning of the VRE System Plan, i.e. on the order of 30-40%.

2. Cost Categories

Capital cost line items are grouped thematically, to enable costs to be aggregated and summarized. The VRE System Plan developed a framework for organizing capital investment in basic system infrastructure into three fundamental categories, described as the "3S" investments:

- Seats (i.e., new rolling stock)
- Stations (station facilities and parking)
- Storage (yards and maintenance facilities).

Investment in each of the '3S' categories is needed as the level of service and ridership grows over time, and each of these categories of investment must remain in balance with each other in order to have a system that functions optimally without either capacity constraints or excess capacity in certain areas.

A fourth 'S' category, for "slots," encompasses railroad infrastructure projects on the railroads on which VRE operates, which increase the capacity of these rail lines and thereby create opportunities for running more VRE trains amongst the freight and Amtrak services that also operate on these lines. The term "slots" derives from the notion that the signal system, the configuration of tracks, and other aspects of the rail line limit the number trains per hour that can be operated on a line. This practical capacity provides a fixed number of slots for trains that then can be allocated, either informally or by agreement, among the various rail operators on the line. An example is VRE's agreement with CSX, which prescribes the number of daily train slots available to VRE. Generally, increasing the number of allowable slots requires capital investment in railroad infrastructure (such as constructing additional main line tracks or building new interlockings).

The capital cost model includes the following types of cost line items within each of the main categories:

Rolling Stock ("Seats")

- New locomotives
- New cab cars
- New coaches
- Line items for mid-life overhauls of existing equipment, but requirements not estimated as part of this project.

Stations ("Stations")

- Platform lengthening (to 8 or 10 car-lengths)
- Second platforms at stations that currently have only a single platform, and associated pedestrian crossings and access
- Parking spaces (new or expanded) – in surface lots or in parking structures

- Core station improvements (line items for the four inner stations, which each have unique capital investment needs) – Washington Union Station, L'Enfant, Crystal City, and Alexandria)
- New stations

Yards and Maintenance Facilities ("Storage")

- Crossroads Yard Expansion
- Broad Run Yard Expansion
- Washington Terminal Yard Storage
- L'Enfant Storage Track
- Life-Cycle Maintenance Facility

Rail Infrastructure to Increase Main Line Capacity ("Slots")

- Major Initiatives
  - Long Bridge Corridor Program
  - CSX Fredericksburg Line Triple Tracking Program
  - Gainesville-Haymarket Extension

The major rail capacity initiatives each comprise several cost line items:

Long Bridge Corridor Program

- Maryland Avenue railroad realignment
- Long Bridge replacement/expansion
- 4th track between RO (south end of Long Bridge) and AF (just south of Alexandria) interlockings
- L'Enfant Station reconstruction
- Crystal City Station relocation

CSX Fredericksburg Line Triple Tracking Program

(Capital project line items defined by segment of new track construction – these may not correspond with the actual scope and extents of capital projects as they are and funded and implemented)

- Franconia to Ravensworth, 3rd track (including Franconia-Springfield Station)
- Ravensworth to Colchester (Occoquan), 3rd track
- Colchester (Lorton) to Powell's Creek, 3rd track
- Occoquan River Bridge expansion
- Neabsco, Powells Creek Bridge expansion
- Powells Creek to Arkendale, 3rd track
- Arkendale to Aquia Creek, 3rd track (including Aquia Bridge expansion)

- Aquia Creek to Dahlgren Jct., 3rd track
- Dahlgren Jct. to FB, 3rd track (including Rappahannock River Bridge expansion)
- HA (Hamilton) to XR (Crossroads), 3rd track

Gainesville-Haymarket Extension

- Additional rail infrastructure, Norfolk Southern 'B' and Main Lines
- Three new stations
- Yard facility

The capital cost estimates do not include right-of-way or property acquisition, nor do they include costs related to customer service initiatives or upgrades to existing fare collection and passenger information systems.

3. Unit Costs

Table B.1 presents the unit costs used to develop estimated capital costs for fleet and station facilities. The unit costs were taken from VRE sources, based on recent experience or previous planning studies or designs.

Table B.1 Unit Costs for Capital Cost Estimates

Rolling Stock Costs	Unit	Unit Cost (millions)
New bi-level coaches (legacy coach replacement)	Ea	$ 2.08
New bi-level coaches (new capacity)	Ea	$ 2.50
New bi-level cab cars	Ea	$ 3.00
New locomotives	Ea	$ 4.24
Bi-level coach overhaul	Ea	$ 1.035
Bi-level cab car overhaul	Ea	$ 1.50
Gallery 10-yr rail truck overhaul	Ea	$ 0.222
Locomotive overhaul	Ea	$ 2.50
Station Costs	**Unit**	**Unit Cost**
Platform Lengthening	LF	$ 7,000
Second Platforms and Pedestrian Crossings	Ea	$ 10-14 M
Surface Parking	Space	$ 8,000
Structured Parking	Space	$ 25,000
New Station – double platform	Ea	$ 40 M
New Station – single platform	Ea	$ 15 M

Capital costs for expanding yard storage facilities or building new facilities are presented as lump sums, based on estimates for comparably sized facilities elsewhere, or factored up from previous facility expansion estimates for VRE.

Railroad infrastructure costs, particularly for the Long Bridge corridor program, Fredericksburg Line triple-tracking program, and Gainesville-Haymarket extension, were updated from estimates contained in previous studies.

4. Summary of Estimated Capital Costs

Table B.2 presents the estimated capital costs associated with the fleet and infrastructure projects that comprise the VRE System Plan. These represent the total estimated capital cost of the recommended investment program and do not include assumptions about allocation of costs among VRE and other project sponsors or among potential sources of funding.

Table B.2 – VRE System Plan Estimated Capital Costs

(Expressed in millions of 2013 dollars)

	Phase 1 2014-2020	Phase 2 2021-2030	Phase 3 2031-2040	Total
Additional Coaches and Locomotives				
• Coaches	$35	$100	$110	$245
• Locomotives		$25	$17	$42
Subtotal	*$35*	*$125*	*$127*	*$287*
Station Improvements				
• Extend platforms	$15	$2	$10	$27
• Second platforms	$31	$78	$24	$133
• Parking expansion	$91	$18	$30	$139
• Core station improvements	$22	$20		$42
Subtotal	*$159*	*$118*	*$64*	$341
Storage and Maintenance Facilities				
• Crossroads	$2	$12	$10	$24
• Broad Run	$1		$10	$11
• Washington Union Terminal	$3		$40	$43
• Life-Cycle Maint. Facility	$35			$35
Subtotal	*$41*	*$12*	*$60*	*$113*
Gainesville-Haymarket Extension				
• Railroad infrastructure		$130		$130
• Stations		$117		$117
• Storage Yard		$50		$50
Subtotal		*$297*		*$297*
Long Bridge Corridor Program				
• Long Bridge replacement		$700		$700
• Potomac River to CP VA 4th track		$180		$180
• 4th track, Potomac River to AF 4th track.		$30		$30
• VRE station reconfiguration		$200		$200
Subtotal		*$1,110*		*$1,110*
CSX Fredericksburg Line Triple Tracking Program	*$50*	*$101*	*$439*	*$590*
TOTAL	$285	$1,750	$690	$2,725

C. Operations and Maintenance Cost Estimating

A spreadsheet based model was developed to estimate operating and maintenance costs (O&M) for the proposed service initiatives. This model relates service changes to operating costs using an array of cost drivers and unit cost inputs. Although we attempt to make it as accurate as possible, the purpose of the model is not to produce investment grade numbers but to capture the relative change in operating cost of the initiatives as the service is scaled up through the initiatives.

1. Methodology and Assumptions

The model pivots off of the existing VRE cost structure to estimate costs for alternate operating scenarios. It uses existing service inputs and unit costs derived from the VRE FY2013 budget to develop costs for the following categories:

- Train miles
- Car miles
- Total number of cars
- Daily train movements
- Number of crews
- Fixed costs

All costs from the FY2013 budget were allocated to one of these six cost drivers. Existing service metrics were applied to these costs to develop unit costs for input into the model for future scenarios. These unit costs are presented in Table C.1.

Table C.1 Unit Costs for Annual Operations and Maintenance Costs

Unit Costs - Train Mile			
Access Fee - CSX	$	20.44	2013 $ / train mile
Access Fee - NS	$	20.44	2013 $ / train mile
Fuel	$	12.74	2013 $ / train mile
Facilities Maintenance	$	10.44	2013 $ / train mile
Engineering/Construction per train mile	$	2.10	2013 $ / train mile
Total Equip Ops (minus fuel/mant.)	$	4.99	2013 $ / train mile
Variable Portion of (Fixed + Variable)	$	5.38	2013 $ / train mile
Unit Costs - Car Mile			
Equipment Maintenance	$	3.21	2013 $ / car mile
Unit Costs - Train Movement			
WUT Access	$	557	2013 $ / per train - daily
Unit Costs - Crew			
3 Man Crew Costs - 11 hour day	$	1,993	2013 $ /day / crew
3 Man Crew Costs - 8 hour day	$	1,386	2013 $ /day / crew
Unit Costs - Car			
Storage	$	17,547	2013 $ / car - annual
Unit Costs - Fixed Costs			
Fixed Costs	$	6,052,669	2013 $
Fixed Portion of (Fixed + Variable)	$	17,936,492	2013 $

2. Service Inputs

Specifications for future service plans were developed for each of the initiatives. These included:

- Peak Direction/peak hour trains
- Reverse peak direction/peak hour trains
- Off peak trains per hour
- Peak service hours
- Off peak service hours
- Consist length
- Service days

These service specification assumptions were used to derive the cost drivers that are required to generate operating costs. The O&M costs for each of the initiatives are then calculated by multiplying each of the unit costs by the associated cost driver and summed.

3. Summary of Estimated Annual O&M Costs

Prototypical service plans were developed for Phases 1, 2 and 3 of the VRE System Plan, for purposes of estimating fleet and storage facility planning, and to provide input to the O&M cost estimates. The principal service drivers of O&M costs are presented in Table C.2

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Table C.2, p. 1 of 2 Estimated Service Levels – Fredericksburg Line – Phases 1, 2 and 3

Fredericksburg		Existing	Phase 1	Phase 2	Phase 3
Train Frequencies					
Peak Direction / Peak Hour	trains / hour	2.33	2.67	3	4
Reverse Peak Direction / Peak H	trains / hour	0	0	1.333333	2
Off Peak / Hour	trains / hour	0	0	1	1
Peak Hours	hours	3	3	3	3
Off Peak Hours	hours	0	0	3	8
Direction		2	2	2	2
Total Daily Revenue Trains	daily trains	14	16	32	52
Total Daily Non-Revenue Trains	daily trains	0	0	0	0
Equipment					
Required Train Sets	trainset	7	8	9	12
Consist Length	cars	6.14	6.9	9	8
Seats per Car	seats	130	130	130	130
Total Seats per direction	seats	5,590	7,176	18,720	27,040
Peak Seats per Direction	seats	5,580	7,180	10,530	12,480
Reverse Peak Seats	seats	0	0	4,680	6,240
Off Peak Seats	seats	0	0	3,510	8,320
Total Cars	cars	43	55	81	96
Total Cars Stored	cars	43	55	45	64
Other Inputs					
Weekday Days	days	250	250	250	250
Weekend / Holidays Days	days	115	115	115	115
Weekend Service	y/n	0	0	0	0
Route Miles	miles	59.1	59.1	59.1	59.1
Train Miles / Car Miles					
Weekday Train Miles	miles	206,850	236,400	472,800	768,300
Weekend Train Miles	miles	0	0	0	0
Total Train Miles	miles	206,850	236,400	472,800	768,300
Weekday Car Miles	miles	1,270,650	1,631,160	4,255,200	6,146,400
Weekend Car Miles	miles	0	0	0	0
Total Car Miles	miles	1,270,650	1,631,160	4,255,200	6,146,400

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Table C.2, p. 2 of 2 Estimated Service Levels – Manassas Line – Phases 1, 2 and 3

Manassas

Train Frequencies		Existing	Phase 1	Phase 2	Phase 3
Peak Direction / Peak Hour	trains / hour	2	2.33	4	4
Reverse Peak Direction / Peak H	trains / hour	0.33	0.33	1.666667	2
Off Peak / Hour	trains / hour	0.125	0.125	1	1
Peak Hours	hours	3	3	3	3
Off Peak Hours	hours	8	8	3	8
Direction		2	2	2	2
Total Daily Revenue Trains	daily trains	16	18	40	52
Total Daily Non-Revenue Trains	daily trains	0	0	0	0
Equipment					
Required Train Sets	trainset	5	6	11	11
Consist Length	cars	7.00	7.3	7.5	8
Seats per Car	seats	130	130	130	130
Total Seats per direction	seats	7,280	8,541	19,500	27,040
Peak Seats per Direction	seats	5,460	6,630	11,700	12,480
Reverse Peak Seats	seats	900	940	4,880	6,240
Off Peak Seats	seats	910	950	2,930	8,320
Total Cars	cars	35	44	83	88
Total Cars Stored	cars	35	44	61	64
Other Inputs					
Weekday Days	days	250	250	250	250
Weekend / Holidays Days	days	115	115	115	115
Weekend Service	y/n	0	0	0	0
NS Route Miles	miles	26.1	26.1	31.5	31.5
CSX Route Miles	miles	7.4	7.4	7.4	7.4
% trains to G-H					
Train Miles / Car Miles					
NS					
Weekday Train Miles	miles	104,400	117,450	315,000	409,500
Weekday Car Miles	miles	730,800	857,385	2,362,500	3,276,000
CSX					
Weekday Train Miles	miles	29,600	33,300	74,000	96,200
Weekday Car Miles	miles	207,200	243,090	555,000	769,600
Total					
Weekday Train Miles	miles	134,000	150,750	389,000	505,700
Weekday Car Miles	miles	938,000	1,100,475	2,917,500	4,045,600

Table C.3 presents estimates of annual O&M costs associated with VRE service enabled by the Phase 1, 2 and 3 capital investments, based on the prototypical service plans. These costs are not to be used for budget estimating purposes. Rather, they provide an indication of the extent to which the magnitude of the VRE operation may increase as investments are made and service expands to meet potential future demand and respond to travel market opportunities.

Table C.3 Estimated VRE Annual Operations and Maintenance Costs

BY COST DRIVER		c.2020	c.2030	c.2040
	EXISTING	Phase 1	Phase 2	Phase 3
Total Train Mile Based Costs	$ 21,700,000	$ 24,600,000	$ 54,700,000	$ 80,100,000
Total Car Mile Based Costs	$ 8,900,000	$ 11,000,000	$ 28,600,000	$ 40,600,000
Total Car Based Costs	$ 1,400,000	$ 1,700,000	$ 2,900,000	$ 3,200,000
Total Train Movement Based Costs	$ 4,200,000	$ 4,700,000	$ 10,000,000	$ 14,500,000
Total Labor Cost	$ 6,200,000	$ 7,200,000	$ 10,400,000	$ 11,900,000
Total Fixed Costs	$ 24,000,000	$ 24,000,000	$ 24,000,000	$ 24,000,000
Total O & M Costs	$ 66,400,000	$ 73,300,000	$ 130,600,000	$ 174,300,000
		Scenario A2	Scenario B6	Scenario B5

BY OPERATIONAL CATEGORY		c.2020	c.2030	c.2040
	EXISTING	Phase 1	Phase 2	Phase 3
Access Fees	$ 11,700,000	$ 13,300,000	$ 29,200,000	$ 42,500,000
Fuel	$ 5,600,000	$ 6,400,000	$ 14,100,000	$ 20,700,000
Storage	$ 1,400,000	$ 1,700,000	$ 2,900,000	$ 3,200,000
Equipment Maintenance	$ 8,900,000	$ 11,000,000	$ 28,600,000	$ 40,600,000
Labor	$ 6,200,000	$ 7,200,000	$ 10,400,000	$ 11,900,000
Facilities Maintenance / Engineerin	$ 4,600,000	$ 5,300,000	$ 11,700,000	$ 17,200,000
Other	$ 28,000,000	$ 28,400,000	$ 33,700,000	$ 38,200,000
Total O & M Costs	$ 66,400,000	$ 73,300,000	$ 130,600,000	$ 174,300,000
		Scenario A2	Scenario B6	Scenario B5

All costs in 2013 dollars.