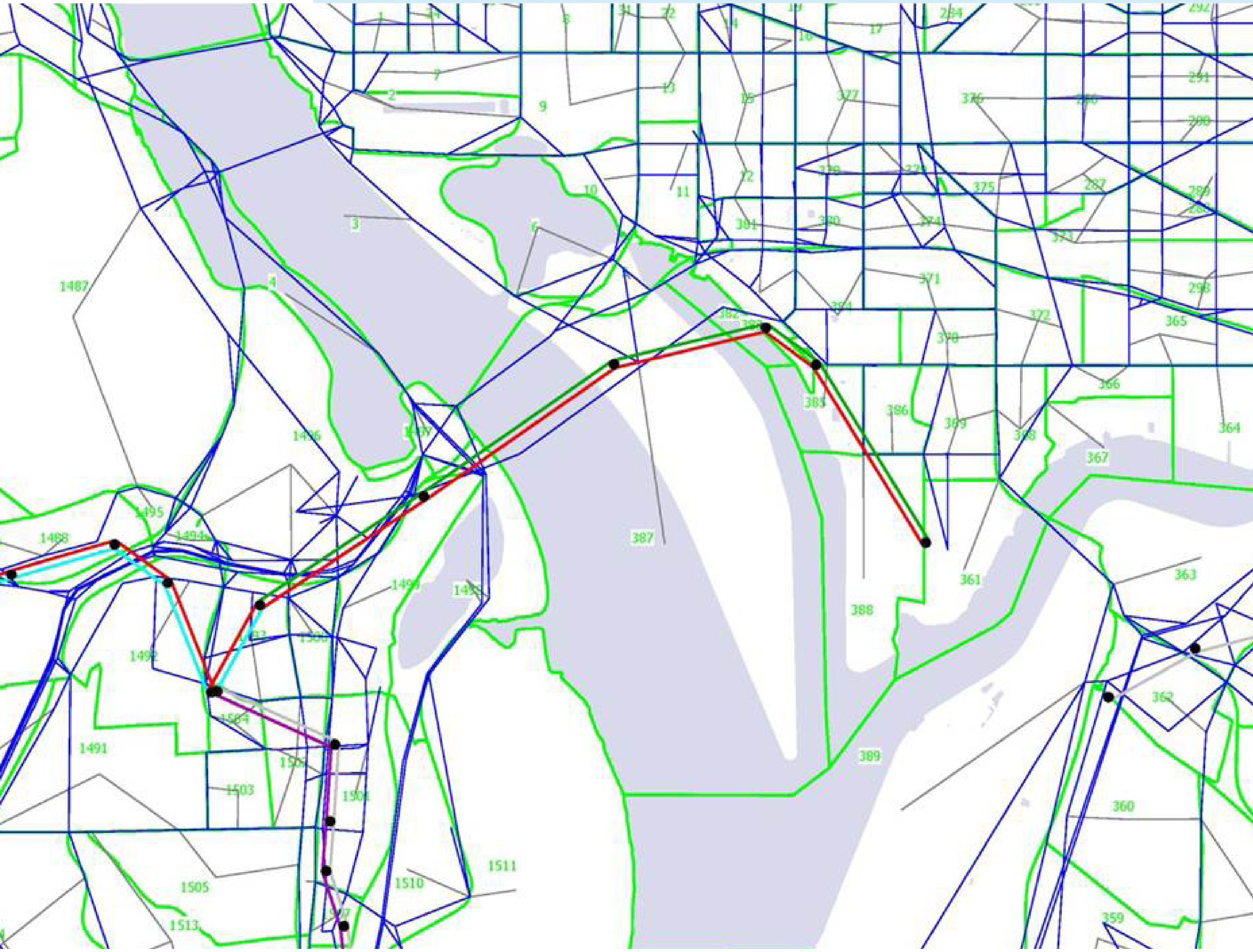
CHAPTER 5: TRANSPORTATION ANALYSIS



CHAPTER 5: TRANSPORTATION ANALYSIS

The analysis of freight and passenger rail, as well as other modes considered in the alternatives, required using a number of analysis processes and established modeling practices. The methodology for assessing rail and other transportation modes included the analysis of regional and national growth projections that are quantitatively analyzed in specialized software to calculate the individual rail and modal flows and how they will operationally perform on each defined alternative. The study reviewed a number of methodologies and modeling procedures and held workshops to formulate the best approach to produce comprehensive results.

The analysis was prepared through the execution of a number of sequential steps as shown in Figure 5.1. The process for analyzing all modes that were considered in the study proceeds through several specific steps including:

- Inputs – compilation of future land use, market and commodity projections, and the definition of alternative networks and connectivity.

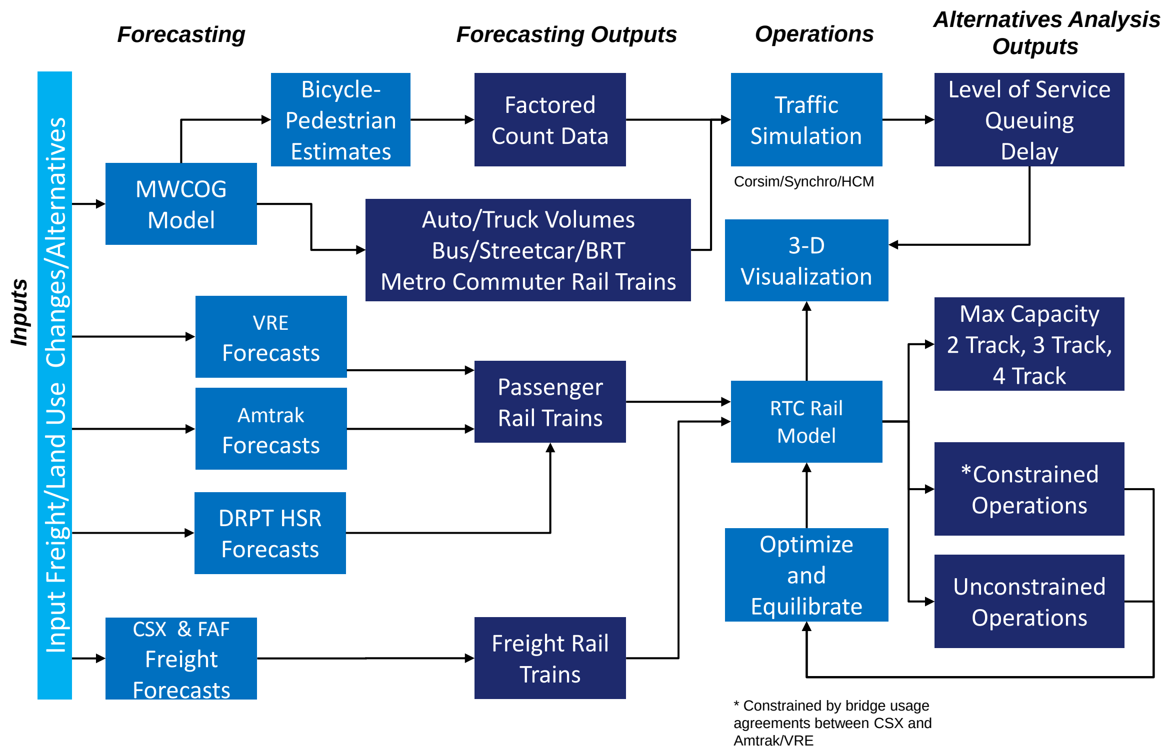
- Forecasts – synthesis of the inputs to prepare projected future year quantities of population, households, employment, rail passengers, and freight by commodity type.

- Modeling – forecasts are input to standard modeling software tools to calculate rail and traffic flows across each alternative for the rail and roadway system.

- Analysis – results of the modeling are analyzed to assess volume, flow, delay and capacity issues. Inputs for network definitions are adjusted to optimize system performance and determine if alternatives meet the future demand for rail and transportation growth.

This chapter is organized to detail these processes; first for the analysis of freight and passenger rail followed by the processes for projecting vehicular, transit, and streetcar modes. The analysis was conducted to compare 2013 conditions with projections for 2020 and 2040. A 50-year outlook is also provided.

Figure 5.1: Rail and Modal Analysis Process



Freight and Passenger Rail

Existing Track Operations

The analysis of freight and passenger rail service is an interrelated methodology. Freight, passenger, and commuter rail services share the same two-track Long Bridge and operate to maximize the throughput of freight trains and maintain on-time passenger service. Estimation of rail operations is established by using Berkeley's Rail Traffic Controller (RTC®) model software. The RTC Model uses a quantitative methodology to calculate rail system operations and performance and uses a randomized application process to determine how many additional trains can be added to a railroad system. Outputs of the modeling process provide for the comparison of train operations under different scenarios and impacts on train delay and on-time performance for passenger trains. Table 5.1 provides the current 2013 train operations of the two-track Long Bridge. Complete details of the RTC model technical analysis can be found in Appendix A memorandums 1 and 3.

Table 5.1: Two-Track Capacity

Period	Freight	Passenger	Total
Peak	5	36	41
Off-Peak	18	20	38
Daily Total	**23**	**56**	**79**

Existing Infrastructure Impact on Operations

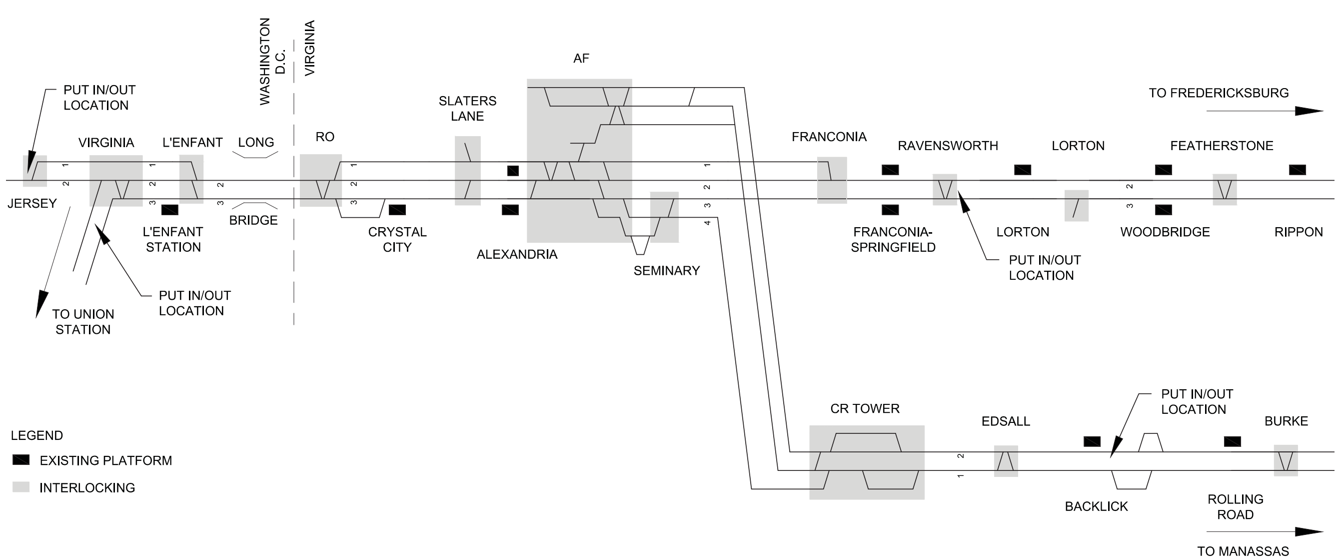
Beyond the two-track railroad system on the Long Bridge, the station platform location for passenger and commuter rail can also impact how railroad service performs. Existing L'Enfant and Crystal City station platforms are only located adjacent to Track 3, as shown in Figure 5.2, which forces trains stopping at those stations to operate only on Track 3 between Slaters Lane and Virginia Interlocking. This limits VRE passenger operations in the study area to a single track. Amtrak operates several trains in each peak period that stop at L'Enfant, and those trains must also operate single track over that track segment to make the station stop. This also restricts reverse-peak passenger train operations through the study area.

In railway signaling, an interlocking is an arrangement of signal apparatus that prevents conflicting movements through an arrangement of tracks and controls and ensures the optimization of rail operations at rail junctions or crossings. An interlocking is designed so that it is impossible to display a signal to proceed unless the route to be used is proven safe. The existing L'Enfant interlocking is not a complete universal interlocking and therefore does not allow northbound trains traveling on Track 2 over the bridge to access the L'Enfant station platform.

The "bottleneck" on the approaches surrounding the Long Bridge, where three tracks on either side of the bridge reduce to two tracks over the bridge, creates additional conflicts between passenger and freight traffic. The second track is used by either the existing reverse direction Amtrak trains in the peak periods and freight trains. The freight trains will sometimes sit on this track, north of the bridge, waiting for an opportunity to move through the area and over the bridge between passenger trains. Often, that opportunity comes after the peak period ends or is winding down.

The existing railroad infrastructure within the Long Bridge study area can support the existing operations with a limited ability to increase passenger and freight operations in the future without substantial delay to train operations.

Figure 5.2: Existing Rail Infrastructure



Future Rail Operations

The future 2020 and 2040 freight and passenger projections were developed from a combined analysis process of passenger and freight future operating plans and the use of national databases to estimate growth rates.

2040 Freight Rail Forecasts

Forecasts for freight were based on the FHWA Freight Analysis Framework version 3 (FAF3) dataset. This dataset is developed from a survey of commodity flow conducted through freight carriers. The FAF3 data provides national coverage and provides forecasts of 2040 freight movement, as well as current observations. It reports annual tons of freight movement for 43 commodity classes. For the purposes of this study, the commodity classes were configured to be carried in four train types: intermodal that transport shipping containers and truck trailers; merchandise that typically carries finished retail goods; bulk goods also known as unit trains that carry one product at a time; and open container coal cars. The data was analyzed to apply growth rates to each of the four train types to arrive at 2020 and 2040 freight forecasts.

CSX currently operates as many as 23 freight trains through the study area on a peak day as shown in Table 5.2. Based on the existing and projected freight volume data from FAF, growth factors were calculated for each train type. These growth factors from FAF, as shown in Table 5.2, were applied to the four train types for an additional 11 freight trains in 2040. These were added to the future simulation to bring the total to 34 daily freight trains operating through the study area. Projections received from CSX, as shown in Table 5.2, include a decline in the number of bulk good trains from the existing peak day trains. The difference between the two projections is due to the fact that CSX projections used average weekday trains whereas this study used peak day trains for future projection.

Table 5.2: 2040 Freight Factors and Forecasts

Train Type	FAF3 Growth Factor	2013 Peak Day Freight Trains			2040 Train Growth		2040 Forecasted Trains			CSX 2040 Train Forecast
		Peak	Off-peak	Total	Peak	Off-peak	Peak	Off-peak	Total	
Intermodal	87%	0	5	5	0	4	0	9	9	6
Merchandise	45%	3	9	12	2	4	5	13	18	18
Bulk	17%	2	3	5	0	1	2	4	6	2
Coal	0%	0	1	1	0	0	0	1	1	1
Total Freight Trains		**5**	**18**	**23**	**2**	**9**	**7**	**27**	**34**	**27**

2040 Passenger and Commuter Rail Forecasts

Passenger and commuter forecasts were developed based on established regional modeling processes and in coordination with passenger and commuter rail service providers based on their individual plans for future service. The MWCOG travel forecasting model provides passenger rail projections based on regional land use growth. The model creates an estimate of future transit patronage. The patronage estimate outputs are used by the passenger and commuter rail service providers to prepare future operating plans as well as internal projections for regional and interregional passenger travel. The estimate of intercity passenger travel is taken from a combination of passenger surveys and an Eastern Seaboard model that stretches from Connecticut to Florida. The Eastern Seaboard model was developed for the analysis of high-speed rail for other studies currently underway that are investigating rail service and high-speed rail service along the eastern United States. The following details and assumptions were used in the RTC model to analyze passenger and commuter rail service.

2040 Intercity Rail

Future Amtrak operations were based on the *2040 Next-Gen Stair-Step Operating Plan*. The future 2040 operating plan includes 28 daily Amtrak regional trains operating through the study area over the Long Bridge, an increase from the existing 12 daily Amtrak regional trains. Future Amtrak daily long-haul train operations were assumed the same as existing operations of 12 long-haul trains over the bridge. It was also assumed that Amtrak would continue to stop three trains in each direction at L'Enfant Station in the future.

2040 High-Speed Rail (HSR)

The 2040 future projection estimated eight daily HSR trains operating over the Long Bridge. The HSR forecasts were obtained from the 2013 Virginia Statewide Rail Plan developed by the Virginia Department of Rail and Public Transportation (DRPT). Four HSR trains operate throughout the day in each direction. These trains were forecasted to stop at the Alexandria Station within the study area. The Northeast Corridor (NEC) FUTURE Study currently underway from Washington D.C. to Boston is also developing rail forecasts that were not available at the time of this study.

2040 Commuter Rail

Virginia Railway Express (VRE) operates 32 daily commuter trains over the bridge: 14 Fredericksburg Line trains and 18 Manassas Line trains. This includes two non-revenue trains that are not on VRE's schedule. These trains operate predominantly during peak periods in the prevailing peak period direction. The proposed 2020/2040 future VRE operating plan includes reverse peak service and was developed based on future plans outlined in the VRE Strategic Plan 2004-2025 Phase 2 Report. This included 20 minute headways in the peak periods and hourly service in the off-peak periods on each line. The VRE operating plan included 84 daily commuter trains over the bridge, consisting of 21 Fredericksburg Line trains and 21 Manassas Line trains in each direction. This also includes a total of 16 VRE/MARC (Maryland Area Regional Commuter) pass-through trains operating during the peak periods.

Table 5.3 shows the forecasted 2040 passenger and commuter service. Table 5.4 combines the projections for freight, passenger, and commuter rail service to show the total number of trains that are projected to cross the Long Bridge in 2040. The projection for 2040 is 166 trains to operate over the Long Bridge. The increase is a combination of 11 additional freight trains and 76 additional passenger trains.

Table 5.3: 2040 Passenger and Commuter Train Forecasts

Period	Commuter Rail	Commuter Rail with Pass-through	Intercity Rail	High-Speed Rail	Total
Peak	31	16	13	2	62
Off-Peak	37	0	27	6	70
Daily Total	**68**	**16**	**40**	**8**	**132**

Table 5.4: 2040 Total Train Forecasts

Period	Freight	Passenger	Total
Peak	8	62	70
Off-Peak	26	70	96
Daily Total	**34**	**132**	**166**

2020 Freight and Passenger Rail Forecasts

Projection methodology for interim year 2020 freight and passenger service were identical to those used for 2040 projections. The 2020 freight train projections were developed using the FAF3 growth rate and the passenger projections were obtained from VRE and Amtrak. VRE service projections were the same for both 2020 and 2040 whereas Amtrak projected no growth in trains for 2020. This resulted in an increase of 6 freight trains and 52 passenger trains. This gives a total forecast of 137 trains to operate over the Long Bridge in 2020 as shown in Table 5.5.

Table 5.5: 2020 Passenger and Commuter Train Forecasts

Period	Freight	Passenger	Total
Peak	7	56	63
Off-Peak	22	52	74
Daily Total	**29**	**108**	**137**

The existing and forecasted freight and passenger train volume was converted into tonnage and number of passengers crossing the Long Bridge. The existing and future freight tonnage was estimated from the operations data provided by the carrier (CSX). The average daily ridership on commuter rail (VRE) is approximately 20,000 passengers (76 percent of capacity) and about 60 percent of the passengers travel to/from DC (according to the passenger survey that VRE conducts every year). This translated to 12,000 passengers traveling to/from DC over the Long Bridge. The same utilization percentage and DC share was applied to calculate future commuter passengers crossing the Long Bridge. "Average load factor" for Intercity (Amtrak) trains was obtained from their performance report. The average load factor measures usage by capacity. The average load factor of 58 percent was applied to the estimated 2013 train capacity (9,700) to come up with 5,600 passengers crossing the Long Bridge. The number of future intercity passengers crossing the Long Bridge was calculated by applying the average load factor to estimated future capacity. Table 5.6 shows the estimated existing and future freight tonnage and passengers crossing the Long Bridge.

Table 5.6: Long Bridge Freight Tonnage and Passengers

Year	Freight Rail (Tons)	Commuter Rail (Passengers)	Intercity Rail (Passengers)
2013	60,000	12,000	5,600
2020	76,000	17,500	7,600
2040	87,000	33,400	13,400
2050	92,500	41,350	16,300
2060	98,000	49,300	19,200

Alternative Analysis with Forecasted Rail Service

Rail forecasts were then analyzed to assess delay and performance on Long Bridge rail service under two-, three- and four-track systems. Analysis is performed to introduce typical random delay to reflect realistic operating conditions. The two-track operations were only analyzed for 2040 conditions for consistency with FRA analysis that was previously conducted in 1999. For the purposes of the study, the three- and four track layouts were analyzed first and then compared to the two-track results.

Three- and Four-Track Analysis

The future operational analysis included developing separate simulation models for the three-track bridge and four-track bridge alternatives. Each of the future alternative simulation models were run to analyze the performance of the system based on forecasted train operations conditions. The operations were simulated over a 24-hour period on a Wednesday, representing the busiest day of the week for freight and passenger train movements through the study area. It is assumed that trains will be capable of operating across the bridge at speeds up to 60 miles per hour when conditions are warranted.

Rail performance across the Long Bridge is determined by analyzing the projected freight and passenger services against the optimal rail performance that can be achieved and still maintain rail operations. Analyzing future operations is completed by studying the future operations to find opportunities where additional freight trains could be added to the operations. These trains were then added to the future track scenarios and simulated to determine their effect on future baseline operations.

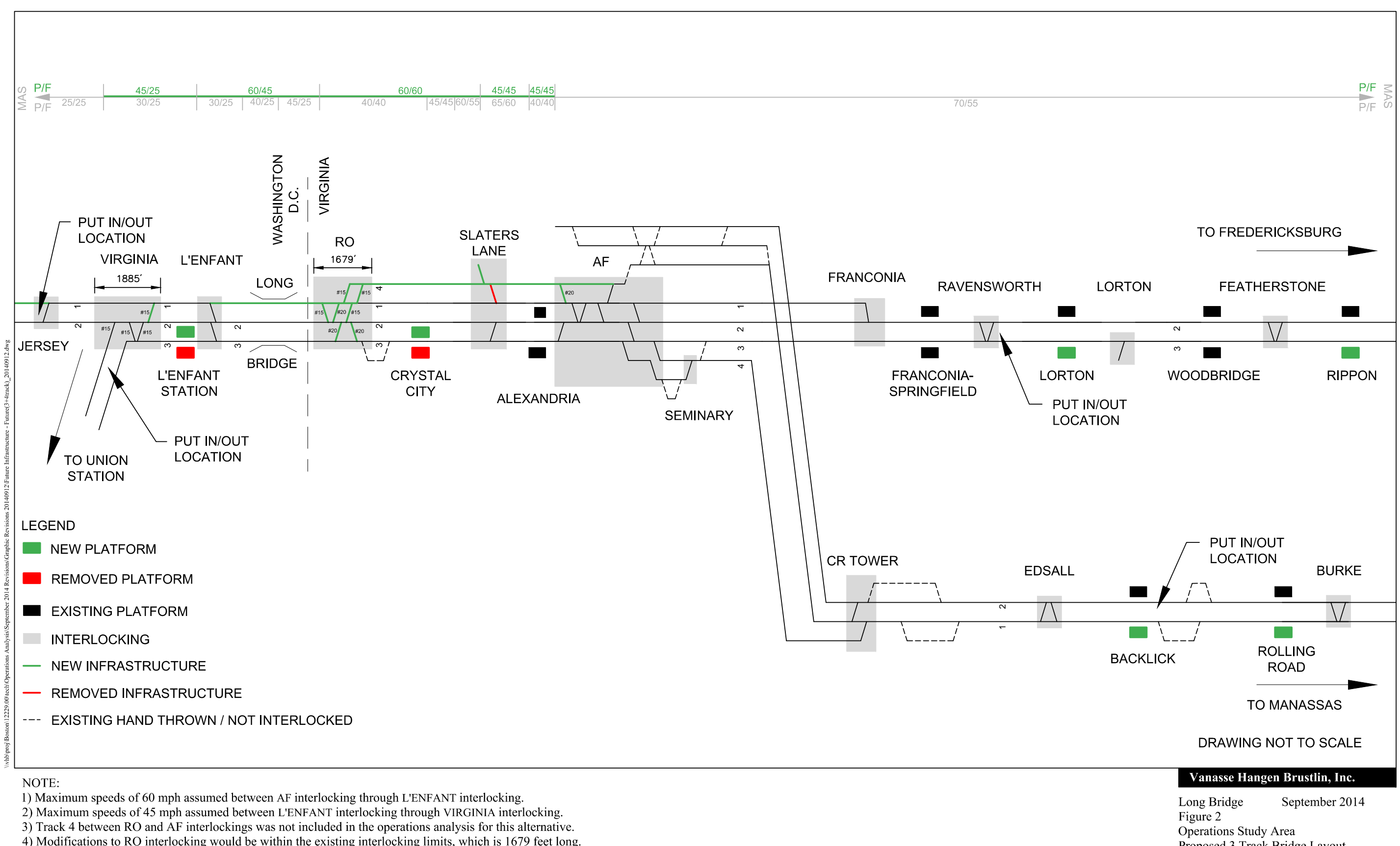
Analysis of future rail operations was performed for rail systems under optimal (no delay) conditions as well as a scenario that introduced delay that typically occurs in any given operating day. Complete details of the Rail Operations Analysis are provided in Appendix A, memorandum 1.

Proposed Three-Track Rail Infrastructure

In both the 2020 and 2040 three-track scenarios, the proposed infrastructure improvements included in the simulation model allow the projected future freight and passenger operations to successfully operate through the study area over the Long Bridge. The additional tracks across the bridge eliminate the bottleneck operation surrounding the bridge and significantly reduce the number of conflicts between the passenger and freight operations. It was determined that the track and signal improvements included in the simulation model (increased maximum operating speed over the bridge and shortened signal blocks) are required in order to increase the capacity through the study area and support the large increases in future operations.

In the 2020 and 2040 three-track scenario, a center island platform is proposed at the L'Enfant and Crystal City stations as shown in Figure 5.3. This will allow intercity and commuter trains to service those stations utilizing either the second or third track. This platform scenario is required if future service is to provide bidirectional VRE service, along with increased Amtrak operations.

Figure 5.3: Proposed Three-Track Rail Infrastructure



The reconfigured 2020 and 2040 interlockings at Alexandria, east of the L'Enfant rail platform (rail mapped as CP Virginia) and on the west bank of the Potomac River in Virginia (rail mapped as CP RO), provide the flexibility needed for increased passenger operations throughout the study area and specifically allows those Amtrak or HSR trains that do not stop between Alexandria and Washington Union Station to bypass VRE and Amtrak trains that do stop at L'Enfant and Crystal City during the peak periods. The proposed side platforms at the remaining VRE stations where only one side platform exists today allow for the future VRE operations with reverse peak service and increased headways for peak period service on the Fredericksburg and Manassas lines.

Rail Performance and Delay

The capacity of the bridge is a function of the delay percentage for both freight and passenger operations and on-time performance for passenger trains. The delay percentage is the amount of signal delay experienced by passenger and freight trains throughout the simulated day of operation. On time performance (OTP) refers to the percentage of operating passenger trains that arrive within five minutes of their scheduled arrival times.

The delay percentage represents the percentage of time the trains are operating at less than their maximum or optimal operating speed. For passenger trains this number should be very low as an operating plan should schedule trains to run as efficiently as possible, with as little delay (slow moving or stop) as possible. An acceptable delay percentage for passenger operations is in the 0% to 5% range. Obviously passengers do not enjoy being delayed or being late. Therefore, the vital statistic for determining the stability of passenger operations is the on-time performance.

For freight operations, OTP is not provided because the freight trains do not operate on fixed schedules. The delay percentage would be the vital statistic for freight operations as it shows what percentage of the time the freight trains are not running at the maximum allowable speed or their most efficient operation. Ideally, the lower the delay percentage for both passenger and freight trains the better, and it can be used to compare infrastructure alternatives as it shows the amount flexibility the given infrastructure has to support the proposed passenger and freight operations.

2020 Three-Track Delay and Passenger On-Time Performance

Table 5.7 shows the expected delay and passenger on-time performance for the three-track system in 2020. The 2020 on-time performance for passenger train service is 100 percent, which indicates that all the trains are arriving at stations on schedule. The passenger delay percentage of 0.15 also falls within the acceptable range of 0 to 5 percent. The freight delay is 0.39 percent which indicates that the freight trains are running efficiently. The total delay percent of 0.21 indicates that the three-track infrastructure can support the proposed freight and passenger operations.

The Berkeley's RTC® simulation software used for the rail analysis also includes the capability to introduce typical delay into the simulation to observe the effects on the performance of operations. This is more representative of typical operating conditions and is important in order to observe the overall stability of the rail operating system during periods of delay. Typical delays happen in real day-to-day rail operations

Table 5.7: 2020 Three-Track Delay and On-Time Performance

Train Group	Three-Track Bridge Alternative	
	Delay %	On-Time Performance
Passenger	0.15%	100.00%
Freight	0.39%	-
Total	**0.21%**	**100.00%**

due to signal or track maintenance, malfunctioning equipment, disabled trains, dwell times at stops, or conflicts between freight and passenger operations. In reality, freight trains do not operate on fixed schedules, so often times they create conflicts with other railroad services when they do arrive at junctions or congested areas.

Typical delay scenarios were assigned considering the passenger train established operating schedules. Passenger operations typically depart on-time from their point of origin due to their fixed time schedules. Amtrak trains passing through the study area begin as far north as Boston and as far south as Florida and New Orleans. There is potential for these long distance trains to be late at intermediate stops along runs. Due to the limited distance of the VRE commuter operations there is less likelihood of delays.

Freight trains start even farther away geographically than passenger trains. CSX operates over the entire eastern half of the United States. Since freight trains do not operate on a fixed schedule and travel over long distances, they are more unpredictable, as far as scheduling is concerned, and likely to incur delays over the course of a run. These trains can often arrive at a location, like the Long Bridge, hours ahead or behind the expected times.

Table 5.8 indicates that with the introduction of typical delay, the three-track system performs poorly for freight with an estimated delay at 30 percent. This means that approximately 30 percent of freight operations experienced delays from their original schedule and the system is operating below optimal operating speeds. On-time performance for passenger rail is maintained at 99 percent for the service provided and delay is in the acceptable range below 5 percent.

Table 5.8: 2020 Three-Track Delay and On-Time Performance with Typical Delay

Train Group	Three-Track Bridge Alternative	
	Delay %	On-Time Performance
Passenger	1.07%	99%
Freight	30.13%	-
Total	**8.66%**	**99%**

2040 Three-Track Delay and Passenger On-Time Performance

Table 5.9 shows the expected delay and passenger on-time performance for the three-track scenario in 2040. The 2040 on-time performance for passenger train service is 100 percent, which indicates that all the trains are arriving at stations on schedule. The passenger delay percentage of 0.18 also falls within the acceptable range of 0 to 5 percent. The freight delay is 0.63 percent which indicates that the freight trains are running efficiently. The total delay percent of 0.28 indicates that the three-track infrastructure can support the proposed freight and passenger operations.

Table 5.9: 2040 Three-Track Delay and On-Time Performance

Train Group	Three-Track Bridge Alternative	
	Delay %	On-Time Performance
Passenger	0.18%	100.00%
Freight	0.63%	-
Total	**0.28%**	**100.00%**

The RTC model was also run for 2040 with typical delay operations for the three-track scenario. Table 5.10 indicates that with the introduction of typical delay, the three-track systems perform well for passenger operations with a low percentage of delay while maintaining on-time performance greater than 98 percent. Freight and passenger train delay under typical delay conditions for the three-track system indicates that almost 14 percent of the operations are at less than their optimal operating speed. Freight again suffers under typical delay with approximately 45 percent of freight train operations experiencing delay from their original schedule with speeds below optimal operating speeds. This indicates that the three-track infrastructure performs poorly with the proposed 2040 freight and passenger operations once typical operating delay is introduced.

Table 5.10: 2040 Three-Track Delay and On-Time Performance with Typical Delay

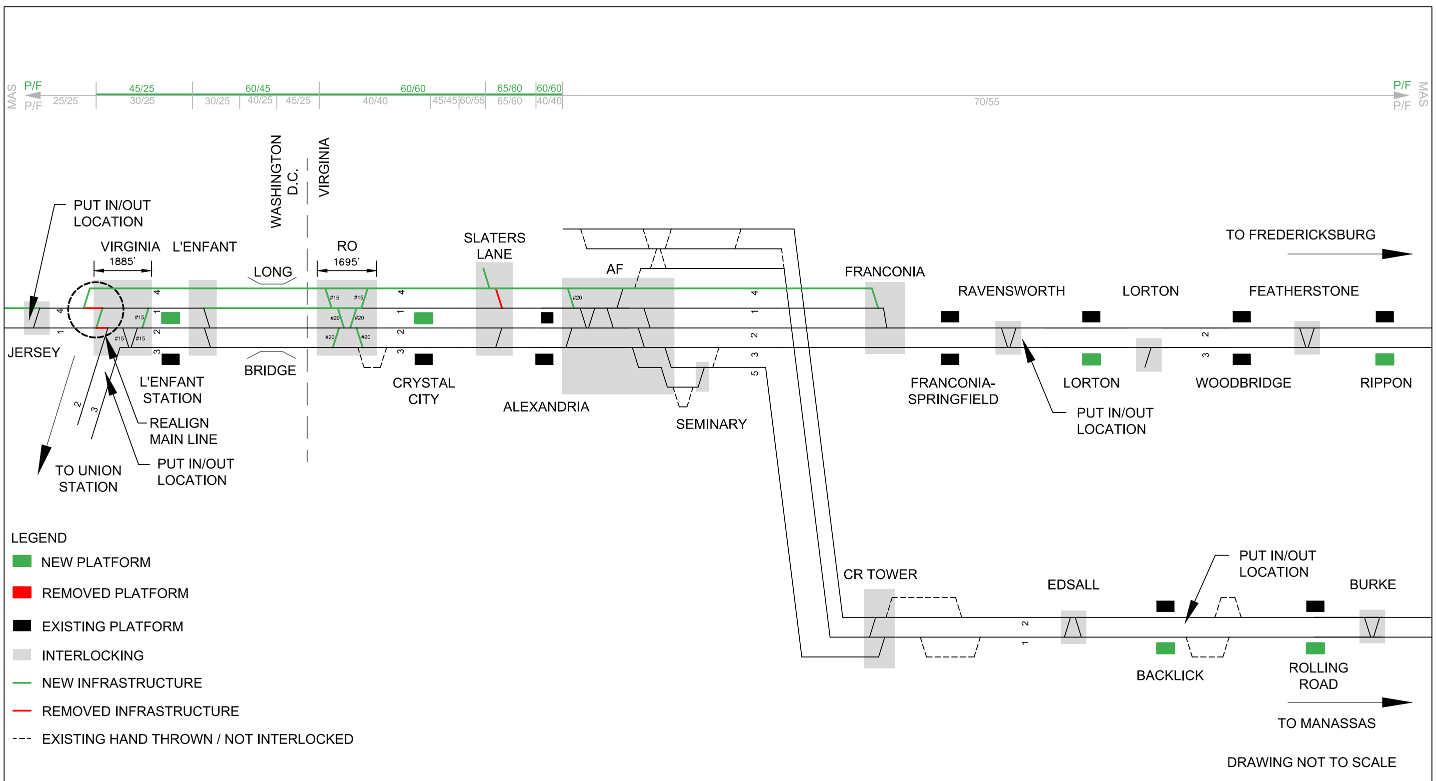
Train Group	Three-Track Bridge Alternative	
	Delay %	On-Time Performance
Passenger	3.25%	98.20%
Freight	45.30%	-
Total	**13.79%**	**98.20%**

Proposed Four-Track Rail Infrastructure

In both the 2020 and 2040 four-track scenario, the proposed additional infrastructure improvements, as shown in Figure 5.4, included in the simulation model allow for an increased separation between passenger and freight operations through the study area. The reconfiguration of CP Virginia interlocking would include the realignment of the mainline tracks to eliminate conflicts between Track 1 and 2, where the lines split.

Adding the fourth track between CP Virginia and CP Franconia interlockings provides a nearly exclusive track for freight operations through the study area. In the off-peak periods, the use of Tracks 1 and 4 also allow freight trains travelling in opposite directions to simultaneously pass through the study area without impacting passenger operations on Tracks 2 and 3. The addition of center island platforms at L'Enfant and Crystal City stations allows passenger trains the flexibility to stop at those stations on Tracks 1, 2, or 3, if necessary.

Figure 5.4: Proposed Four-Track Rail Infrastructure



NOTE:
1) Maximum speeds of 60 mph assumed between AF interlocking through L'ENFANT interlocking.
2) Maximum speeds of 45 mph assumed between L'ENFANT interlocking through VIRGINIA interlocking.
3) Modifications to RO interlocking would extend the interlocking by approximately 16 feet to the South, leaving approximately 100 feet between the RO NB home signals and the start of the curve before Crystal City.
4) Modifications to Virginia Interlocking would extend the interlocking approximately 400 feet to the South.

Vanasse Hangen Brustlin, Inc.

Long Bridge September 2014
Figure 3
Operations Study Area
Proposed 4 Track Bridge Layout

2020 Four-Track Delay and Passenger On-Time Performance

Table 5.11 shows the expected 2020 delay and passenger on-time performance for the four-track systems. The 2020 on-time performance for all passenger trains is within the five-minute window of arriving on schedule. The total delay percent of 0.21 indicates that the four-track infrastructure can support the proposed freight and passenger operations.

Table 5.11: 2020 Four-Track Delay and On-Time Performance

Train Group	4-Track Bridge Alternative	
	Delay %	On-Time Performance
Passenger	0.16%	100.00%
Freight	0.38%	-
Total	**0.21%**	**100.00%**

The RTC model was run for 2020 with typical delay operations for the four-track scenario. Table 5.12 indicates that with the introduction of typical delay, the four- track systems perform well. Passenger rail maintains on-time performance 99 percent of the time. The four-track analysis of delay for passenger and freight trains indicates acceptable delay to just over 2 percent of operations at less than maximum operating speed. Freight service is also operating with minimal delay with approximately 5 percent operations at less than the maximum operating speed. The total delay percent of approximately 2 percent indicates that the four-track infrastructure can support the proposed 2020 freight and passenger operations under typical conditions.

Table 5.12: 2020 Four-Track Delay and On-Time Performance with Typical Delay

Train Group	4-Track Bridge Alternative	
	Delay %	On-Time Performance
Passenger	0.90%	99%
Freight	5.06%	-
Total	**2.06%**	**99%**

2040 Four-Track Delay and Passenger On-Time Performance

Table 5.13 shows the expected delay and passenger on-time performance for the four-track systems. The 2040 on-time performance for all passenger trains is within the five-minute acceptable window of arriving on schedule. The total delay percent of 0.29 indicates that the four-track infrastructure performs optimally with the proposed 2040 freight and passenger operations.

Table 5.13: 2040 Four-Track Delay and On-Time Performance

Train Group	4-Track Bridge Alternative	
	Delay %	On-Time Performance
Passenger	0.19%	100.00%
Freight	0.61%	-
Total	**0.29%**	**100.00%**

The RTC model was also run for year 2040 with typical delay operations for the four-track scenario. Table 5.14 indicates that, with typical delay, the four-track systems perform well with a low percentage of passenger delay while maintaining on-time performance for greater than 98 percent of the passenger train operations. The four-track analysis of delay for passenger and freight trains eliminates unacceptable delay to just over 3 percent of operations at less than their maximum operating speed. However, the freight service is operating under a delay percentage of over 6 percent, which shows some inefficient freight operation.

Table 5.14: 2040 Four-Track Delay and On-Time Performance with Typical Delay

Train Group	4-Track Bridge Alternative	
	Delay %	On-Time Performance
Passenger	1.81%	98.50%
Freight	6.41%	-
Total	**3.05%**	**98.50%**

The analysis of a four-track bridge alternative can support future passenger and freight operations with considerable capacity for future growth. The four-track bridge provides increased separation between freight and passenger operations, further reducing conflicts and delay. The fourth track provides a nearly exclusive track for freight trains to pass by one another and avoid conflicts with passenger operations.

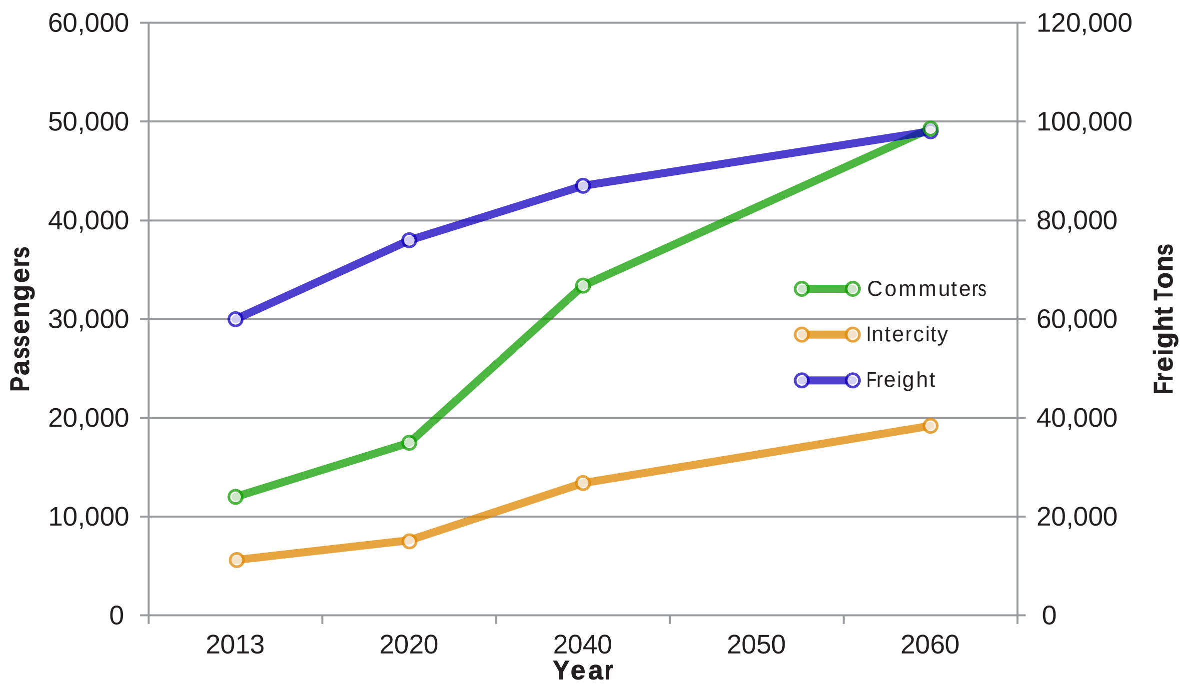
The three- and four-track bridge expansions and associated infrastructure improvements throughout the operational analysis study area improve the capacity and operational flexibility from the existing rail infrastructure. In addition to the new third or fourth track over the bridge, this analysis determined that the proposed station platforms, the reconfigured interlockings, and signal spacing could greatly increase the capacity through the study area. A key element of the four-track system is that it allows for increased freight operations throughout the day, as it provides an additional track for the freight trains to move through the study area. In the off peak periods, it would be possible for multiple freight trains to move through the study area mainly using two tracks over the Long Bridge without impacting the heavily projected increase in passenger operations on the remaining two tracks.

Long Term (50-Year) Freight and Passenger Outlook

According to the US Census Bureau, the population of the United States is projected to grow from 314 million in 2012 to 420 million by 2060. As the population and economic base of the US grows, the need to move more people and goods will need to keep pace. The railroad industry will continue to exhibit a consistent increase in the demand for the movement of freight and passengers. The performance of rail for moving passengers rivals highways and air travel. Moving freight commodities competes with truck freight for long-distance hauling speed and the capacity to carry more goods.

The future of freight and passenger rail development lies in the effective utilization of existing capacity and the creation of new rail capacity for the anticipated growth. The FHWA Office of Freight Management and Operations FAF data used for this study projects that US freight shipments will grow from an estimated 17.6 billion tons in 2011 to 28.5 billion tons in 2040, representing a 62 percent increase over approximately 30 years. If this trend continues, freight will grow to 36.1 billion tons by the year 2060, representing a 105 percent increase. Figure 5.5 shows the projected growth in passengers and freight tonnage across the Long Bridge from 2013 to 2060. Similar growth projections for railroads in both passenger and freight traffic is observed in other studies. According to A Vision for Railways in 2050 (May 2010), the growth projected over the next 50 years is over 60 percent for passenger traffic and over 100 percent for freight traffic.

Figure 5.5: Growth in Long Bridge Passengers and Freight Tonnage 2013-2060



According to The Amtrak Vision for the Northeast Corridor (2012), the "Northeast Megaregion," which includes five major metropolitan regions (Washington, DC, Baltimore, Philadelphia, New York, and Boston) and stretches from Virginia to Maine, is an economic powerhouse with a population of approximately 50 million and an economic base of $2.6 trillion. The report indicates that an additional 15 million residents will live in the region by 2050 and the economy will grow at 1.8 percent annually. The Washington, DC metropolitan area is forecasted to have the highest growth rate contributing to continued increases in rail passenger travel.

This anticipated growth in rail will have cost implications and considerable impact on the movement of freight and passengers. A study conducted by the Passenger Rail Working Group titled Vision for the Future, U.S. Intercity Passenger Rail Network Through 2050 (December 2007) anticipates that intercity passenger rail service would be available in all of the 48 contiguous states by 2050. It also estimated that the total cost for re-establishing the national passenger rail network by 2050 is $357.2 billion in 2007 dollars, for an annualized cost of $8.1 billion. The study showed annual rail use benefits to the roadway travelling public, including $22.5 billion vehicle miles diverted, 46.7 billion passenger miles diverted, $6.6 billion value of time saved, and $2.2 billion in net fuel savings.

The proposed Long Bridge concepts offer options for increased capacity that would address future needs of the corridor based on industry projections. There are a number of general considerations that need to be addressed for rail expansion for 30- or 50-year outlooks. The considerations are consistent between the outlook years as they pertain to any decisions for expanding freight and passenger services. The infrastructure considerations include:

- The markets that will be served for freight and passenger,
- The volume of goods or passengers in those markets,
- Use of tracks and the interlocking across all tracks for use by freight and passenger trains,
- Anticipated future needs for electrified track versus diesel, and
- Height and clearance specification as they relate to double-stack freight trains.

An additional component currently being studied for future passenger rail activity will

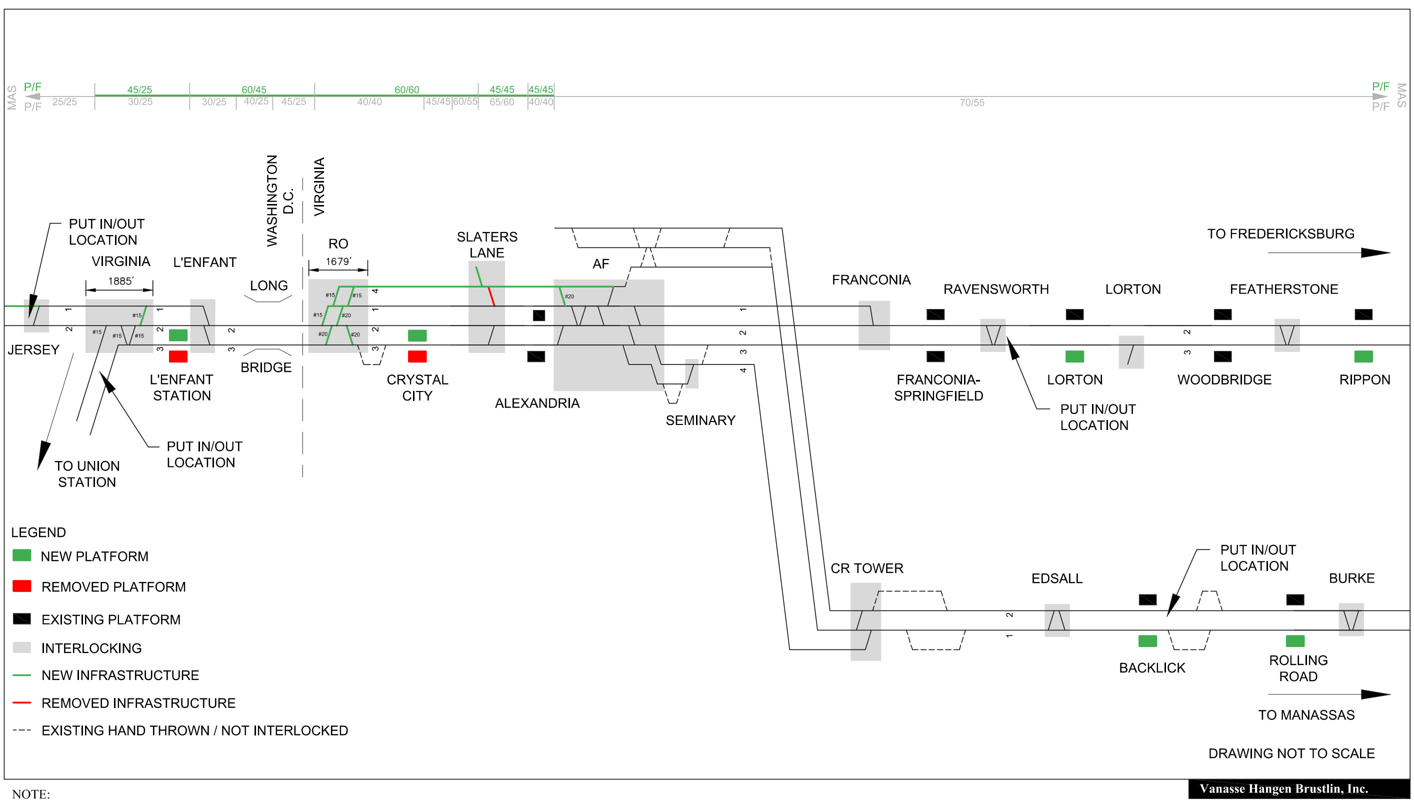
be the introduction of high-speed rail (HSR). HSR will increase the speed of passenger service and the number of passengers that can be served.

Plans for improvements to the Long Bridge in the next 50 years can continue to provide transportation benefits to achieve long-term goals for the reduction in energy consumption, improved air quality, and the provision of safe and efficient passenger travel and freight transport.

2040 Two-Track Analysis

A final analysis was conducted to assess a two-track bridge under 2040 rail operating conditions and compare these results to the three-track and four-track results. The assumptions for future infrastructure improvements are summarized for the two-track bridge alternative simulation in Figure 5.6. The Long Bridge two-track bridge structure feeds three tracks leading up to it on either side of the bridge. Beyond the immediate area of the bridge, the existing track layout and station platform locations limit VRE's passenger operations in the study area to a single track. The L'Enfant interlocking is not a complete universal interlocking thereby restricting northbound trains operating over the bridge from accessing L'Enfant Station. In addition, existing VRE platforms for L'Enfant and Crystal City Stations are accessible only from one track. To support the planned increases in future passenger and freight operations, infrastructure improvements were required while maintaining the two-track Long Bridge for this analysis. The 2040 two-track infrastructure and analysis is discussed in detail in Appendix A, memoradum 3.

Figure 5.6: 2040 Two-Track Rail Infrastructure



NOTE:
1) Maximum speeds of 60 mph assumed between AF interlocking through L'ENFANT interlocking.
2) Maximum speeds of 45 mph assumed between L'ENFANT interlocking through VIRGINIA interlocking.
3) Track 4 between RO and AF interlockings was not included in the operations analysis for this alternative.
4) Modifications to RO interlocking would be within the existing interlocking limits, which is 1679 feet long.
5) Modifications to Virginia Interlocking would extend the interlocking approximately 400 feet to the South.

Vanasse Hangen Brustlin, Inc.
Long Bridge September 2014
Figure 1
Operations Study Area
Proposed 2 Track Bridge Layout

Even under optimal conditions, with a two-track bridge and 2040 rail volumes, delays to freight trains in the peak period are unavoidable with the frequent headway of passenger trains. One northbound freight train in particular during the AM peak is delayed at the RO interlocking for over an hour waiting for a window to open between passenger trains in order to cross the bridge. This train is delayed in order to avoid delaying passenger operations.

Table 5.19 shows the simulation results of the typical delay 2040 operations for the two-track bridge alternative with the infrastructure improvements stated in the 2040 Track Infrastructure section, as well as the previously studied three- and four-track bridge alternatives.

Table 5.15: 2040 Typical Delay Operations Simulation Results

Train Group	2 Track Bridge Alternative		3 Track Bridge Alternative		4 Track Bridge Alternative	
	Delay %	On-Time Performance	Delay %	On-Time Performance	Delay %	On-Time Performance
Passenger	3.37%	97.00%	3.25%	98.20%	1.81%	98.50%
Freight	72.14%	-	45.30%	-	6.41%	-
Total	**20.50%**	**97.00%**	**13.79%**	**98.20%**	**3.05%**	**98.50%**

In the typical delay results shown in Table 5.15, it is evident that freight operations experience significantly more delay in the two-track bridge alternative as compared to the three- or four-track bridge alternative simulations. The passenger operations remain relatively consistent with only a slight decline in on-time performance from the three- and four-track bridge alternatives to the two-track bridge alternative. It should be noted that in the RTC simulation models passenger trains are assigned higher dispatch priorities as compared to the freight trains. The results shown represent dispatching prioritizing passenger operations, limiting the delay to passenger operations, and causing freight trains experience the delay more often while waiting for passenger trains in the event of a conflict. This situation is encountered significantly more in the two-track scenario as freight and passenger trains are forced to operate over the same two-tracks across the Long Bridge.

As it exists today this portion of the corridor is owned and dispatched by CSX. Passenger service on-time performance is therefore dictated by the freight dispatching and occasionally commuter trains experience significant delays waiting for freight trains to move across the bridge. If CSX continues to own and dispatch train operations across the bridge, freight trains in this scenario may continue to be granted greater priority by the CSX dispatchers, delaying passenger operations. With the frequent ten minute headways for VRE peak period service over Long Bridge, passenger train delays would cascade quickly, and not recover until the peak period has ended.

In order to see results that reflect a more even distribution of dispatch priority, the 2040 RTC simulation models were also run under typical delay conditions with equal dispatch priority assigned to the future passenger and freight trains. Table 5.16 shows the typical delay simulation results for 2040 two-track operations with equal dispatch priorities assigned.

Table 5.16: 2040 Typical Delay - Equal Dispatch Priorities

Train Group	2 Track Bridge Alternative		3 Track Bridge Alternative		4 Track Bridge Alternative	
	Delay %	On-Time Performance	Delay %	On-Time Performance	Delay %	On-Time Performance
Passenger	4.71%	94.00%	2.15%	97.60%	1.19%	99.25%
Freight	26.03%	-	9.28%	-	4.14%	-
Total	**10.08%**	**94.00%**	**4.00%**	**97.60%**	**2.01%**	**99.25%**

The typical delay equal dispatch simulation results in less freight delay with equal dispatch priorities assigned. However, the results also show that the three- and four-track bridge alternatives are much more efficient than the two-track bridge alternative. In the two-track bridge alternative, freight trains still experienced 26 percent delay as compared to approximately 9 percent and 4 percent for the three-and four-track bridge alternatives. This reduced delay translates into improved schedule recovery during unforeseen events leading to better on-time performance.

With CSX dispatching the Long Bridge area, the freight trains may actually be given even greater priority as opposed to experiencing 26 percent delay. This could cause passenger delay to increase, further reducing the on-time performance. The three- and four-track bridge alternatives provide additional tracks and therefore increased separation between passenger and freight operations, reducing the potential for conflicts and delay to passenger and freight operations.

Summary of Rail Operations

The 2014 railroad infrastructure within the Long Bridge study area can support the existing operations under certain typical delay events today. However, due to the physical constraints of the existing infrastructure there is a limited ability to increase passenger and freight operations in the future. Much of the delay experienced by today's passenger trains in the study area originates from conflicts with freight operations due to the bottleneck surrounding the Long Bridge. Current operations are hindered by a combination of poor track and infrastructure conditions leading to severe speed restrictions across the bridge and VRE's limited platforms further restricting operations that cause many of the delays experienced in this area of the corridor. The implementation of hourly off-peak service for VRE in both directions, plus 20 minute peak direction headways would make the combined future passenger and freight operations problematic with the existing infrastructure.

The proposed 2040 landside infrastructure improvements throughout the study area improve the capacity and operational flexibility from the existing infrastructure. This analysis reflects that the proposed station platforms, the reconfigured interlockings and signal spacing could greatly increase the landside capacity through the study area. The future plans to bring high-speed operations to this corridor further supports the need for additional tracks across the bridge.

The analysis of rail operations for this study were also compared to previous analysis performed by the National Railroad Passenger Corporation in the *1999 Report to Congress – Potential Improvements to the Washington-Richmond Railroad Corridor*. The 1999 report outlined many capacity improvements also identified and further defined in this report including the center island platform at L'Enfant Plaza, and additional tracks on both sides of the Potomac River. Most importantly, the 1999 report identified the Long Bridge as a resource that passes through federal parkland and over an active river that will trigger intensive environmental evaluation. This study, and the subsequent NEPA documentation (TIGER 2014) will perform the required analysis to determine what capacity improvement can be implemented.

According to 2040 operating plans proposed by VRE, Amtrak and freight operations, an increase of 87 new daily trains (an approximate 112 percent increase) are proposed over today's operation, bringing the 2040 total to 166 trains per day operating over Long Bridge. This analysis determined the 2040 landside infrastructure included in this simulation of the future two-track bridge alternative can execute 2040 VRE, Amtrak and freight operations with randomized typical delay events. However, freight trains will experience significant delay approaching the bridge during the peak periods due to the frequent headways proposed for the future passenger operations.

Due to the randomized nature of freight traffic, trains operating through the area during the peak periods are consistently delayed until there is available infrastructure to travel across the Long Bridge. If CSX continues to own and dispatch train operations across the bridge, freight trains may continue to be granted greater priority by the CSX dispatchers. With future increases in freight volumes and the frequent ten minute headways for VRE peak period service over Long Bridge, passenger train delays would cascade quickly, and not recover until the peak period has ended for the existing two-track bridge configuration.

Additional analysis with equal dispatching priorities assigned to passenger and freight trains further demonstrated the increased operating efficiencies of a three- or four-track bridge as compared to the two-track bridge. Freight trains in the two-track bridge alternative experienced more than double the delay then in the three-track bridge alternative, and more than six times the delay when compared to the four-track bridge alternative. Passenger train on-time performance in the two-track bridge alternative was 94 percent, much less than the 97.6 percent and 99.25 percent in the three- and four-track bridge alternatives.

Rebuilding a two-track Long Bridge to accommodate train speeds in excess of 60 miles per hour without expanding to three- or four-tracks across the Long Bridge does not alleviate the bottleneck operation surrounding the bridge and does not allow for an increased separation between passenger and freight operations.

Additional tracks across Long Bridge would reduce the bottleneck for operations and limit the amount of conflicts between passenger and freight operations in this area. The four-track bridge alternative provides the most separation between freight and passenger operations, and allows for efficient use of future high-speed rail on the corridor.

Non-Rail Forecasting

Vehicular Traffic

Existing and future vehicular analysis is performed using the Metropolitan Washington Council of Government's (MWCOG's) Transportation Planning Board (TPB) forecasting model (MWCOG 2.3.52). The base validation year for the model is 2010. The MWCOG 2.3.52 model uses round 8.2 land use, which is unchanged in the District from the previous round 8.1 land use. This land use forecast does not reflect activity associated with tourist attractions and visitors. MWCOG Round 8.2 land use by traffic analysis zone is shown in Appendix A-2.1.

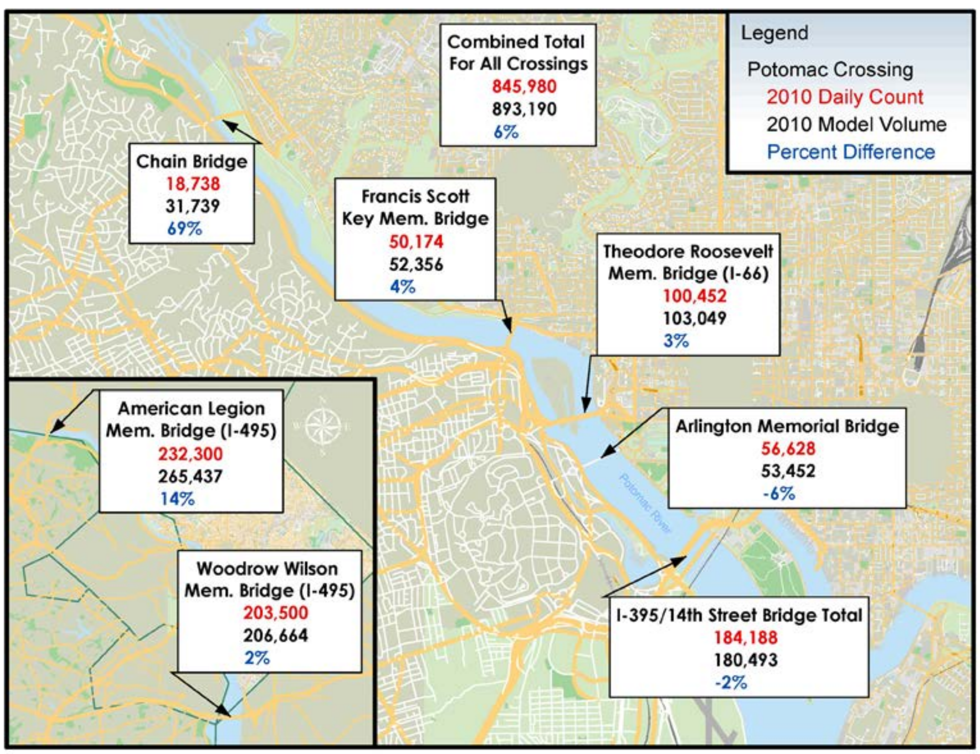
The MWCOG model was recently recalibrated and incorporates a number of refinements from the previous model versions that include updates to the highway network, substituting k-factors across the Potomac River with bridge time penalties to improve cross-river trip estimation, improvements to the trip generation and trip distribution processes based on household travel survey data, and adjustment to the non-motorized trip share model.

MWCOG Model Preparation

The updates to the model for this study are focused primarily on evaluation and refinement of the highway network within the Long Bridge Study area. Vehicular analysis included the collection of data elements that were used to analyze existing conditions as well as the impacts of alternatives. Data elements included counts, speed data, signal timing and the physical layout of the study area roadway intersections. The key roadway variables which were evaluated and modified include the number of lanes in each time period and the facility type coding as shown in Appendix A-2.2. These variables determine the capacities and speeds used by the model to calculate travel time and congestion and have the greatest impact on the number of trips being assigned to the roadways.

For the preparation of modal results for study alternatives, the analysis begins with the review and validation of existing conditions in the MWCOG model. Within the study area, validation statistics consist of comparing daily traffic counts to model volumes for bridges crossing the Potomac River and a statistical comparison of estimated model volumes versus observed daily counts. Figure 5.7 shows that the Potomac River crossings demonstrate a good match between estimated volumes and daily traffic counts with the exception of the Chain Bridge, which is overestimated by 13,000 daily vehicles. The proximity of the Chain Bridge on the Potomac River has little impact to the traffic activity in the Long Bridge study area. Important to the performance of the

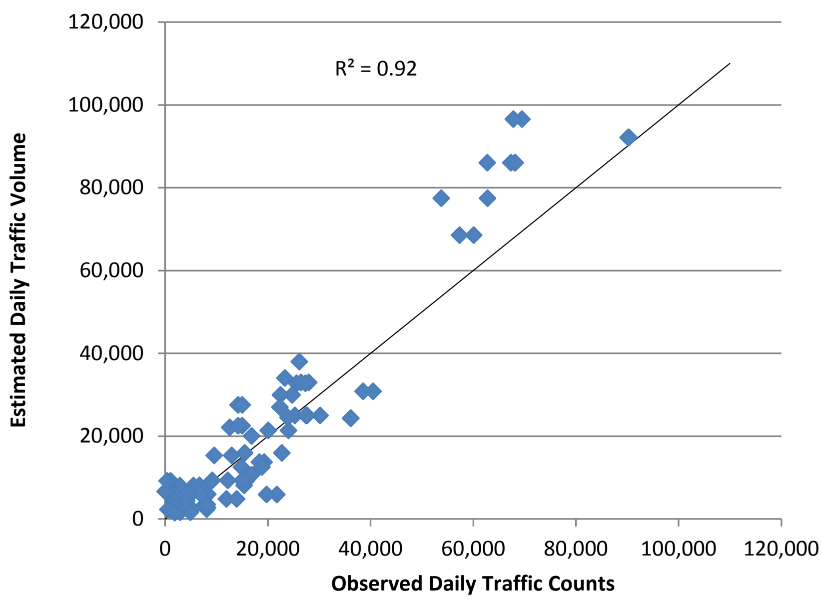
Figure 5.7: Existing Conditions Model Results for Potomac River Crossings



model within the study area are the 14th Street and I-395 bridges that show a model estimate that is within 2 percent of the observed daily counts.

A second measure of the closeness between model estimated volumes and daily traffic counts as presented in Figure 5.8 is called the coefficient of determination or R^2. The x-axis of the chart identifies daily traffic volume and the y-axis identifies the corresponding model estimated volumes. The closer each location is to the diagonal line, the more accurate the model. Model accuracy using the R^2 statistic considers models to be acceptable for use with R^2 values in the 0.85 to 1.00 range. The MWCOG model used for this study produced an R^2 of 0.92.

Figure 5.8: Comparison of Estimated and Observed Daily Traffic



Vehicular Alternatives Results

The calibrated base year model serves as the foundation for the development of future year models. This study built upon the established MWCOG future models which include network definitions as detailed in the 2013 MWCOG Constrained Long Range Transportation Plan (CLRP), as well as adopted MWCOG Round 8.2 land use available at the time of this study. The CLRP details transportation projects currently planned and/or programmed for development in the Metropolitan Washington planning area, from the present through 2040. The CLRP includes all "regionally significant" highway, transit, and bicycle and pedestrian projects, and studies that the Transportation Planning Board at MWCOG realistically anticipates can be implemented by 2040. The six alternatives for this study were analyzed by adding vehicular roadway definitions for each alternative to the 2040 MWCOG model and then allowing the model to estimate the demand for the new roadways. Details of the MWCOG modeling process are provided in Appendix A, Memo 2.

For the purposes of preparing 2040 model networks, Alternative 1 (No Build) through Alternative 5 were grouped together because they did not include modal options that can be analyzed in the MWCOG model. Alternatives 6 (streetcar), 7 (shared streetcar/ general-purpose) and 8 (shared streetcar/general-purpose + 2 general-purpose lanes) were each modeled separately. Vehicular inputs to the model include speed (35 miles per hour), capacity (500 vehicles per hour per lane), number of lanes, and the development of the roadway segments from Long Bridge Park Drive in Virginia to Maryland Avenue at 7th Street, SW. This included the modeling of Maryland Avenue from 12th Street, SW, to 7th Street, SW.

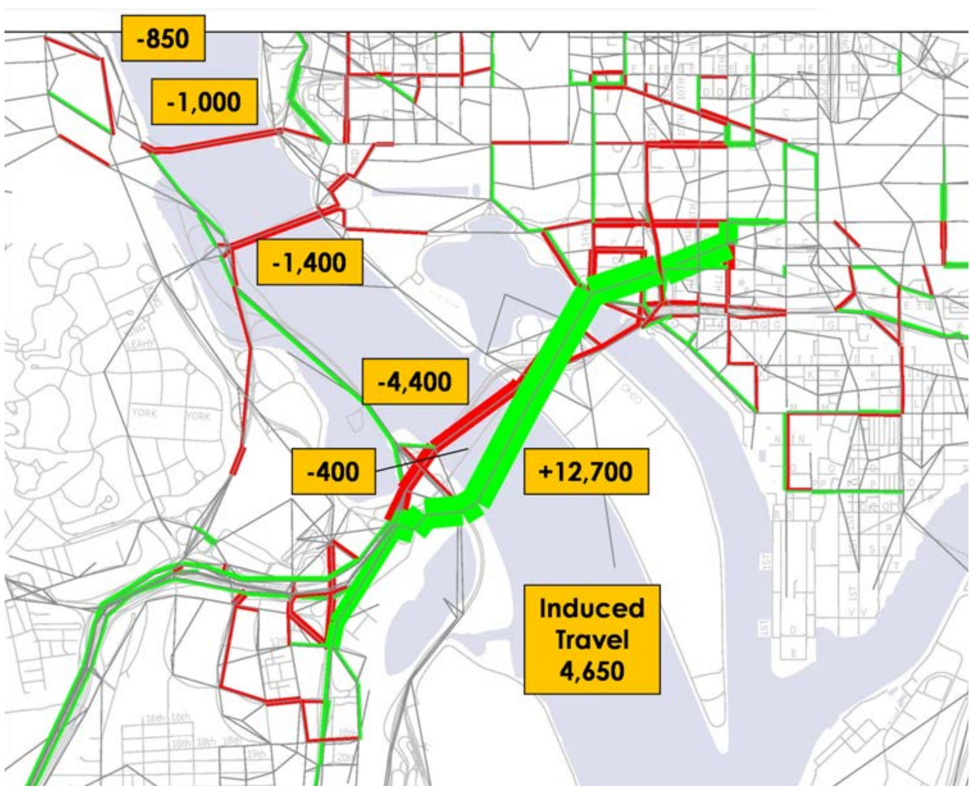
Table 5.17: Existing Conditions Model Results for Potomac River Crossings

Potomac River Roadway Crossings	Base Year		2040 Alt1 through Alt5		2040 Alt 6		2040 Alt 7		2040 Alt 8	
	2010 Daily Count	2010 Model Daily Volume	2040 Daily Volume	Growth 2010 to 2040	2040 Daily Volume	Growth 2010 to 2040	2040 Daily Volume	Growth 2010 to 2040	2040 Daily Volume	Growth 2010 to 2040
American Legion Memorial Bridge (I-495)	232,300	265,437	322,892	22%	322,960	22%	322,494	21%	322,776	22%
Chain Bridge	18,738	31,739	43,787	38%	43,882	38%	43,703	38%	43,503	37%
Francis Scott Key Memorial Bridge	50,174	52,356	56,312	8%	56,213	7%	55,931	7%	55,843	7%
Theodore Roosevelt Memorial Bridge (I-66)	100,452	103,049	113,498	10%	113,489	10%	113,004	10%	112,489	9%
Arlington Memorial Bridge	56,628	53,452	62,821	18%	62,831	18%	62,117	16%	61,440	15%
I-395/14th Street Bridge Total*	184,188	180,493	198,681	10%	198,344	10%	196,067	9%	194,259	8%
Woodrow Wilson Memorial Bridge (I-495)	205,300	206,664	256,677	24%	256,839	24%	256,057	24%	256,274	24%
Long Bridge New Crossing							7,029		12,716	
Total	**845,980**	**893,190**	**1,054,668**	**18%**	**1,054,558**	**18%**	**1,056,402**	**18%**	**1,059,300**	**19%**

Table 5.17 presents a comparison of the vehicular volumes by alternative produced by the MWCOG model. The crossing of the Potomac River served as the comparison location for vehicular, Metrorail, bus, and streetcar volumes between alternatives. The 2040 No Build as compared to the 2010 base year shows an 18 percent increase in vehicular volume across the Potomac River. In the immediate study area, I-395/14th Street Bridge showed a 10 percent increase and the Woodrow Wilson Memorial Bridge showed a 24 percent increase in vehicular traffic. Vehicular options were developed in Alternatives 7 and 8.

Vehicular estimates for Alternative 7 shows approximately 7,000 vehicles crossing on the alternative roadway. This volume increases to 12,700 for Alternative 8 when an additional two general-purpose lanes are added. As shown in Figure 5.9 for Alternative 8, the 12,700 trips are a function of trip reductions on the adjacent I-395/14th Street vehicular bridges (-4,800), other bridges northwest (-3,250), and new "induced" travelers (+4,650) on the new general-purpose bridge. Appendix A-5 provides details on the files and outputs created as part of the transportation modeling analysis.

Figure 5.9: Daily Vehicular Volume Difference (Alternative 8 minus No Build)



Vehicular Level of Service Analysis

Congestion and capacity issues in the 2010 base year provide a comparison point for future alternatives based on collected data and capacity analysis methodology using the 2000 Highway Capacity Manual. Data, such as turning movement counts, signal timing, speeds, and traffic queuing, measure system performance. The performance of key intersections in these areas provides an indication of the overall performance of vehicular travel and congestion in the study area. Speed data is taken from Analysis of 2010 Speed Data in the District of Columbia and speed limit signs in Google Street

View. Timing data for signalized intersections were provided by DDOT. Geometric data, including number of lanes, is taken from Google Street View and aerial photo and checked against the lane sketches in the counts data.

Morning and evening peak hour turning movement counts for analysis intersections, as shown in Figure 5.10, were collected between May and June 2013. Analysis of the peak hour data found that the evening peak hour exhibits more volume than the morning peak hour. The evening peak hour was selected to assess the worst traffic of the day as part of the level of service analysis.

Figure 5.10: Study Area Analysis Intersections

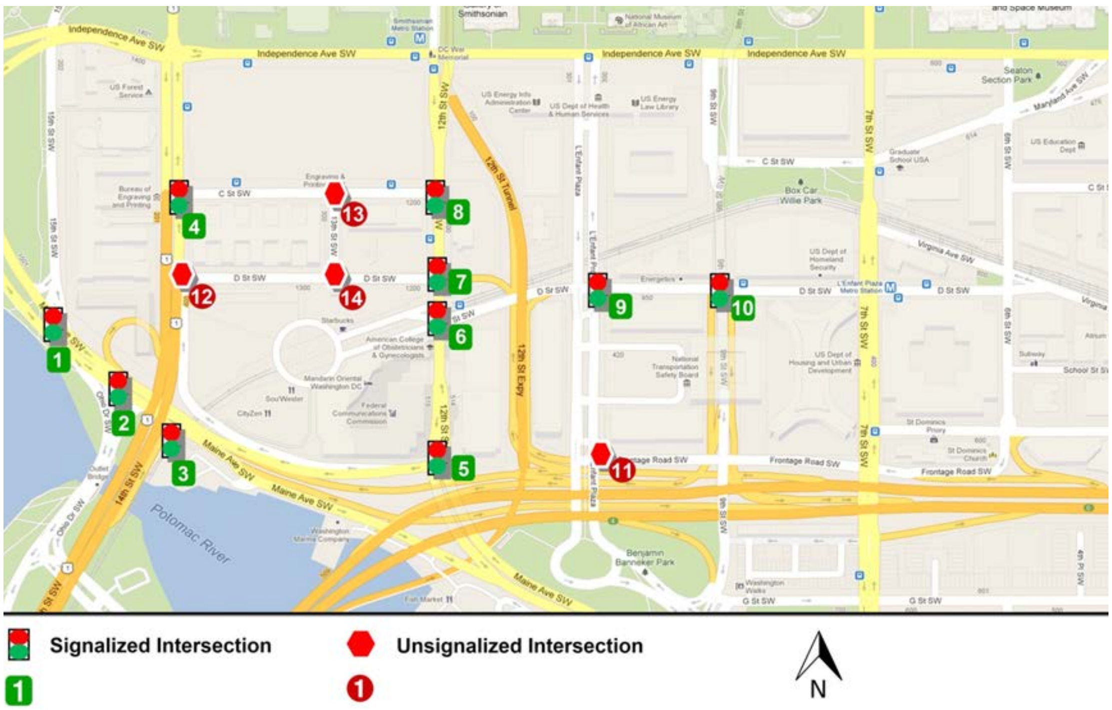


Table 5.18 shows the LOS of intersections within the study area for current conditions and future alternatives. LOS is a function of the volumes that can be accommodated as compared to the roadway capacity and the amount of delay that is produced. LOS results are assigned a letter grade gauging signalized intersection performance as follows: LOS A-B is considered optimal with less than 20 seconds of delay per vehicle; LOS C-D indicates intersection is starting to experience delay with 21 to 55 seconds of delay per vehicle; LOS E indicates heavy congestion; and, LOS F identifies an intersection as failing with over 80 seconds of delay per vehicle and extreme congestion. Appendix A-3 provides detailed traffic information for each alternative and a detailed description of the LOS grading system. All signalized intersections under existing conditions operate at satisfactory level of service during the evening peak hour except for the intersection at 12th Street, SW, and C Street, SW, which is operating at a failing level of service F.

All the minor approaches of unsignalized intersections operate at a satisfactory level of service. The threshold for LOS delay per vehicle is less for unsignalized intersection, broken down as: LOS A-B less than 15 seconds of delay; LOS C-D at 15 to 35 seconds; LOS E at 35 to 50 seconds; and, failing LOS F at greater than 50 seconds.

Table 5.18: Intersection PM Peak Hour Level of Service

NB – Northbound
SB – Southbound
EB – Eastbound
WB - Westbound

HCM 2000 Results - Intersection Conditions			PM Peak Hour		
			2013 Existing	2040 Alts 1-6	2040 Alts 7-8
1: Maine Ave, SW & 15th St, SW	Signalized	Overall	C	D	D
2: Maine Ave, SW & Ohio Dr., SW	Signalized	Overall	C	E	E
3: Maine Ave, SW & US 1, NB off-ramp	Signalized	Overall	B	C	C
4: 14th St, SW & C St, SW	Signalized	Overall	B	C	C
5: 12th St, SW & Maine Ave, SW	Signalized	Overall	C	C	C
6: 12th St, SW & Maryland Ave, SW	Signalized	Overall	B	C	C
7: 12th St, SW & D, St SW	Signalized	Overall	C	C	C
8: 12th St, SW & C, St SW	Signalized	Overall	**F**	**F**	**F**
9: D St, SW & 10th St, SW	Signalized	Overall	B	B	B
10: D St, SW & I-395 ramps	Signalized	WB	B	C	D
		EB	A	A	A
11: Frontage Road, SW & 10th St, SW	Unsignalized	SB Left	B	B	B
		SB Right	A	A	A
12: US 1/14th St, SW & D St, SW	Unsignalized	WB Right	B	B	B
13: C St, SW & 13th St, SW	Unsignalized	NB	C	D	C
14: D St, SW & 13th St, SW	Unsignalized	SB	B	C	B

Signalized Intersection **Unsignalized Intersection**

Traffic volume for analysis of future alternatives is derived by applying the growth factors by approach at each intersection as taken from the future year alternative divided by the base year model. Factors are developed from the results of the alternative analysis using the MWCOG regional model. Factors for each intersection approach in the regional model provide a volume increase or decrease factor from existing to each alternative.

Alternative 1 (No Build) through Alternative 6 did not include a new general-purpose component that crosses the Potomac River. These six alternatives effectively performed the same in the regional model. Four intersections showed a reduced performance between the existing traffic volumes and the alternatives as shown in Table 5.22. Maine Avenue, SW, at 15th Street, SW, and C Street, SW, at 13th Street, SW, went from an LOS C to LOS D, which is still an acceptable intersection performance. Maine Avenue, SW, at Ohio Drive, SW, exhibited the worst change in performance going from LOS C to LOS E. This intersection adjacent to the 14th Street Bridges includes merge lanes onto the bridge, which will exhibit congestion with the additional future traffic. The intersection of 12th Street, SW, at C Street, SW, continues to show a failing LOS F for both the existing and future alternatives. This is a function of vehicles moving eastbound on C Street, SW, and trying to make a left onto 12th Street, SW. These vehicles have to not only consider crossing the vehicle traffic in the westbound C Street, SW, direction but also encounter over 750 pedestrians crossing 12th Street, SW, immediately north of the intersection.

Alternatives 7 and 8 included the addition of new local lanes crossing the Potomac River. These alternatives connect to Maryland Avenue at 12 Street, SW, and produce river crossing volumes of approximately 7,000 vehicles for Alternative 7 and 12,700 vehicles for Alternative 8. Analyzing these alternatives in the regional model produced nearly the same resulting level of service between the two alternatives. Table 5.23 shows the performance of Alternatives 7 and 8. With the exception of three intersections, these alternatives exhibited the same level of service as Alternative 1 through Alternative 5. D Street, SW, at the I-135 ramps was the only intersection that presented worse performance at LOS D, which is still an acceptable intersection performance. Intersection on 13th Street, SW, at C Street, SW, and D showed improved performance. Alternatives 7 and 8 provide a local direct connection to Maryland Avenue at 12th Street, SW, and some traffic shifted from C and D Streets, SW, reducing the congestion at these intersections. The intersection at 12th Street, SW, and C Street, SW, continues to perform at a failing LOS E.

The interstate traffic on the 14th Street Bridge and I-395 shows minimal change in the LOS when the general-purpose lanes are introduced in Alternatives 7 and 8. As previously detailed in Table 5.18, the introduction of two general-purpose lanes in Alternative 7 reduced 2040 daily traffic on the 14th Street Bridge by approximately 2,600 trips or a 1.3 percent reduction in daily traffic. Alternative 8 introduced four general-purpose lanes and the reduction was approximately 4,400 trips per day or a 2.2 percent reduction in daily traffic. Reduction on the Woodrow Wilson Memorial Bridge (I-495) under Alternatives 7 and 8 was negligible, with a 0.2 percent reduction in daily trips.

The local, general-purpose lanes for Alternatives 7 and 8 result in a minimal impact to the future performance of the interstate roadways crossing the Potomac River next to the alternatives. Table 5.19 shows the PM peak hour level of service at locations along the14th Street Bridge and I-395 for existing and 2040 alternative conditions. In all instances, the introduction of general-purpose lanes has no impact on the level of service performance, which remains the same from existing conditions through the future Alternative 1 – No Build and the introduction of Alternatives 7 and 8 general-purpose lanes.

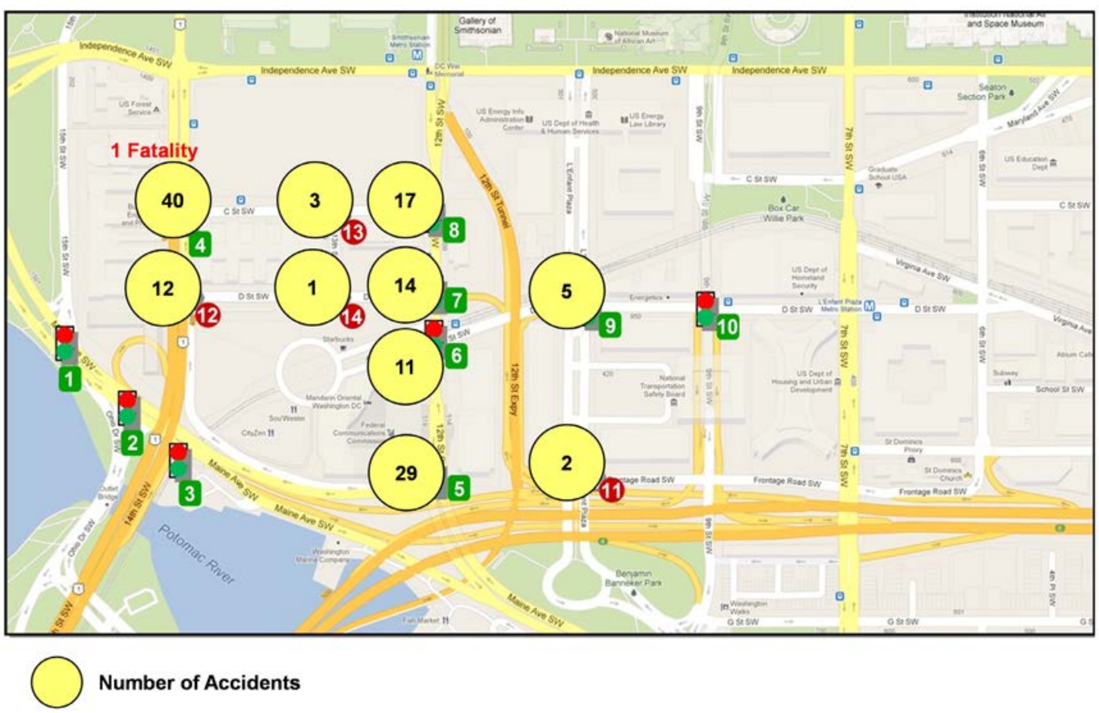
Table 5.19: Interstate PM Peak Hour Level of Service

HCM 2000 Results - Intersection Conditions	PM Peak Hour		
	2010 Existing	2040 Alts 1-6	2040 Alts 7-8
14th Street Bridge Mainline Southbound	E	E	E
14th Street Northbound Ramp to Eastbound Maine Avenue	B	B	B
I-395 Mainline Southbound	E	E	E
I-395 Northbound Ramp to 12th Street Expressway	F	F	F

Incident and Accidents Trends

In addition to the roadway performance from a capacity and LOS perspective, accident data provides an indication of roadway safety and how well the roadway system functions. Accident data at key intersections in the study area was analyzed for the previous three years. Intersections for which accident data was available experienced 134 accidents between 2010 and 2012 with one fatality for 14th Street, SW, at C Street, SW. Of all accidents approximately one-third resulted in some type of injury, with only two considered disabling injuries. Over 65 percent of these accidents

Figure 5.11: 2010-2012 Accident Locations



occurred around the evening peak period under daylight and clear weather conditions, with over 67 percent involving passenger vehicles. Appendix A-3.5 provides a detailed accident data summary. Accident data was not available for study area intersections along Maine Avenue, SW, at 15th Street, Ohio Drive and US 1 northbound, and for D Street, SW, at 10th Street.

Figure 5.11 presents the occurrence of accidents at study intersections over the past three years. The highest occurrence of accidents was identified along the 14th Street and 12th Street corridors. Alternatives for this study focused on multimodal connections from the Long Bridge to the intersection at 12th Street, SW, and Maryland Avenue in front of the Mandarin Oriental Hotel. Intersection design and the reduction of accidents on the 12th Street, SW, corridor is a key component for safety and traffic flow from modal alternatives for the Long Bridge into the Southwest waterfront area.

Transit

Existing and future transit analysis is also performed using MWCOG's TPB forecasting model (MWCOG 2.3.52). Model inputs for the streetcar included the location of the alignment and the operating frequency, speeds, and station locations. The streetcar alternative developed for the study connects on the Virginia side to the Arlington County streetcar at PenPlace and the District L'Enfant Metro Station at 7th Street, SW, and Virginia Avenue. Both the Arlington County and District streetcars that are in the MWCOG model are included in the 2040 transit networks as stipulated by the 2013 MWCOG CLRP.

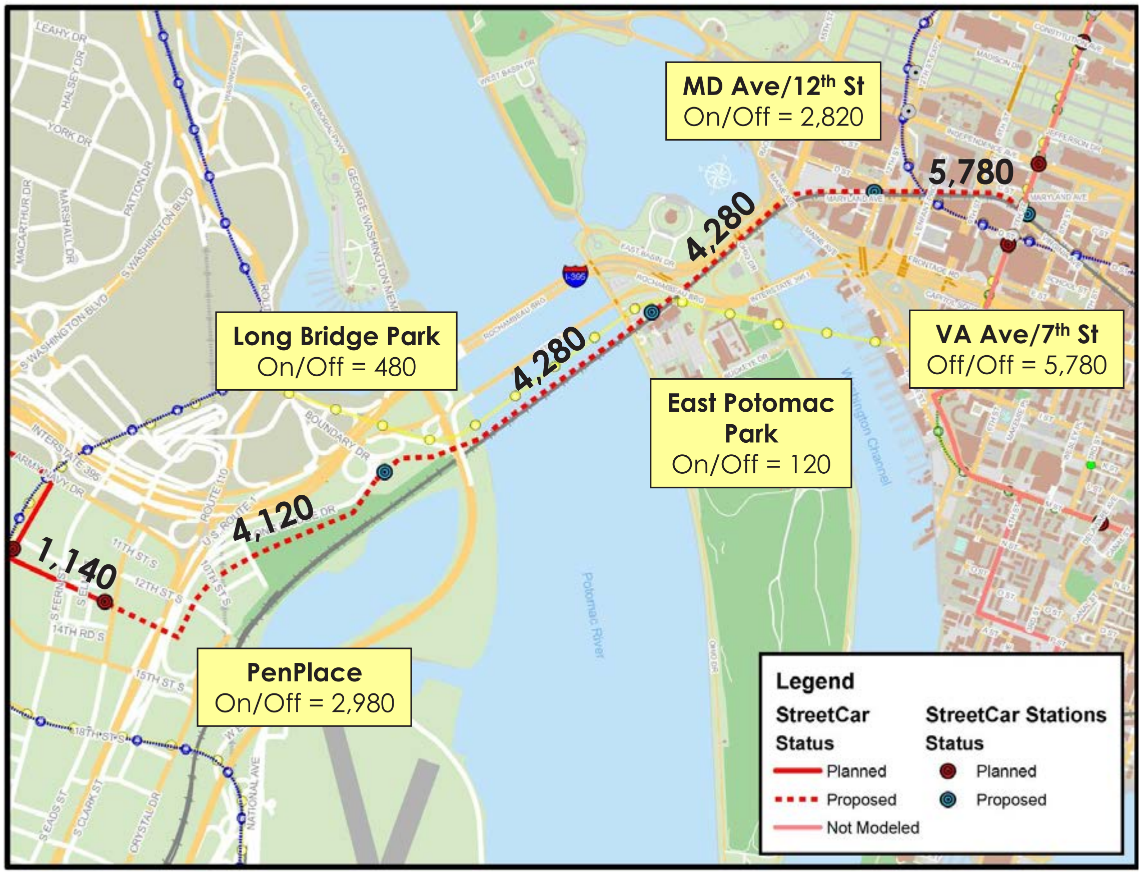
Streetcar estimates for Alternatives 6, 7, and 8 showed a stable estimate from the model of between 4,200 to 4,300 riders as shown in Table 5.20. The Metrorail Yellow Line, crossing the Potomac River immediately northwest of the alternative crossings, experienced less than a 1 percent change in riders, or approximately a 1,250 difference in ridership. Buses crossing the Potomac River on the I-395/14th Street Bridge experienced about a 10 percent decrease (1,350 riders) when streetcar was introduced in Alternatives 6, 7, and 8.

Figure 5.12 shows the riders on each segment of the streetcar for Alternative 8. The highest of the three alternatives that included streetcar, Alternative 8, produced 4,280 riders across the Potomac River. Alternatives 6 and 7 were only slightly lower,

Table 5.20: Transit Results by Alternative

Potomac River Roadway Crossings	Base Year		2040 Alt1 through Alt5		2040 Alt 6		2040 Alt 7		2040 Alt 8	
	2010 Daily Count	2010 Model Daily Volume	2040 Daily Volume	Growth 2010 to 2040	2040 Daily Volume	Growth 2010 to 2040	2040 Daily Volume	Growth 2010 to 2040	2040 Daily Volume	Growth 2010 to 2040
Metrorail Yellow Line		72,044	117,040	62%	115,921	61%	116,816	62%	117,289	63%
Potomac River Bus Crossings		11,924	15,090	27%	13,685	15%	13,797	15%	13,741	15%
Long Bridge Streetcar					4,216		4,252		4,280	

Figure 5.12: 2040 Alternative 8 - Daily Streetcar Passengers



with 40 to 60 fewer riders. This would indicate that about 40 percent of the 4,280 riders on the streetcar are "induced" new riders.

Stations that had the greatest on/off riders included Virginia Avenue at 7th Street, SW, (5,780), the Conference Center Station in Virginia (2,980), and Maryland Avenue at 12th Street, SW, (2,820). The lowest on/off volumes were at Long Bridge Park (480) and East Potomac Park (120). The Long Bridge streetcar presents a new service that enhances transit options in the District's Southwest area and provides a direct link to the Columbia Pike streetcar in Virginia.

A better understanding of streetcar rider activity can be seen by reviewing the station activity along the streetcar route during different periods of the travel day. Figure 5.13 shows riders, from the District to Virginia, representing the first trip of the day. The MWCOG modeling process estimates transit ridership that is balanced across the travel day. This indicates that for every trip that crosses the Potomac River from the District to Virginia, the model will also predict a return trip for the rider. Effectively, Figure 5.13 shows the initial trip from the District to Virginia which is then "balanced" later with a mirror image trip from Virginia to the District. The purpose of this one-directional analysis is that it shows the true origin of the rider. Figure 5.13 indicates that the greatest number of streetcar riders originates at Virginia Avenue/7th Street, SW, (1,910) and that the majority of riders (1,290) travel across the Potomac River to the PenPlace Station in Virginia. Only about 240 additional riders get on at the three intermediate stops between these two stations.

Figure 5.13: 2040 Alternative 8 - Daily District to Virginia Streetcar Passengers

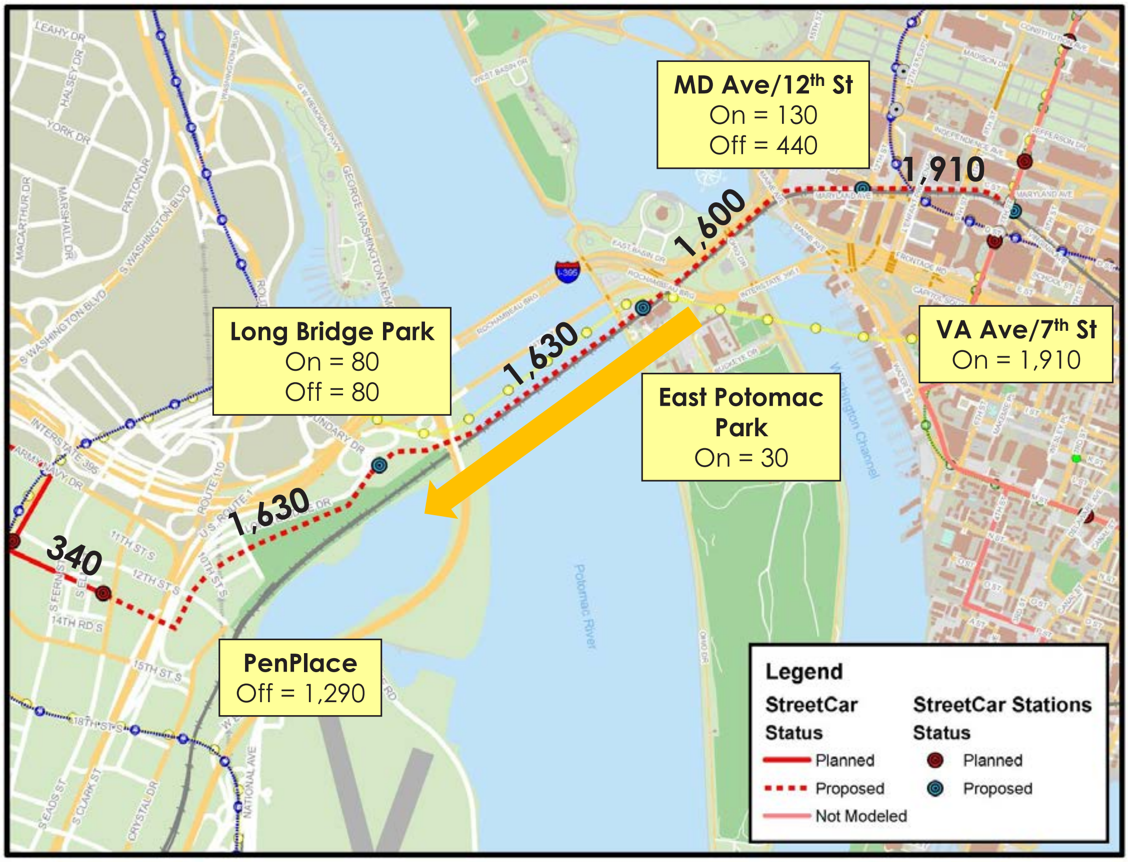


Figure 5.14 shows the reverse complement to Figure 5.13 for first trip riders of the day from Virginia to the District. Comparing the two directions across the Potomac River, riders from Virginia to the District (510) are only one-third of the number of riders that travel from the District to Virginia (1,630). Those coming from the Arlington County streetcar (230) represent almost half the riders that get onto the streetcar before crossing the Potomac River. The largest rider volume in the Virginia to the District direction is actually presented within the District with 980 riders between Maryland Avenue/12th Street, SW, and Virginia Avenue/7th Street, SW.

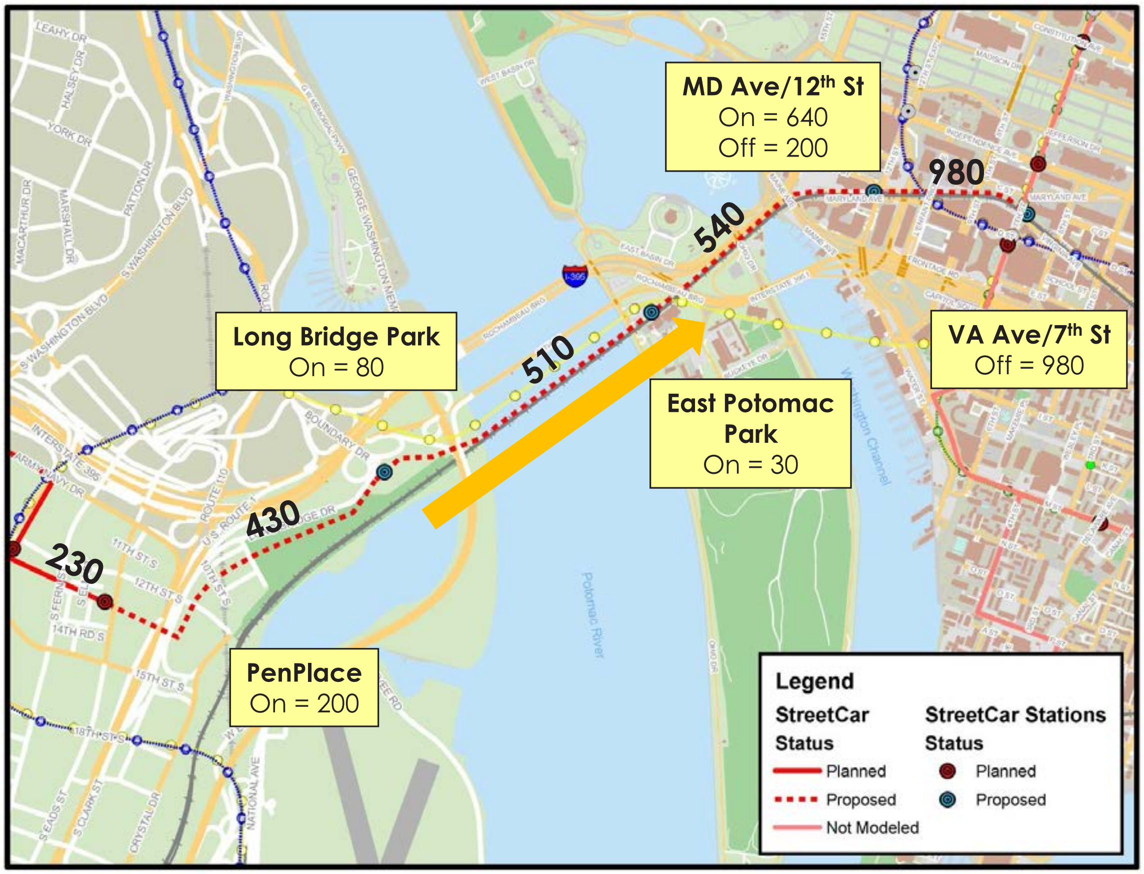


Figure 5.14: 2040 Alternative 8 - Daily Virginia to District Streetcar Passengers

To better understand peak versus off-peak rider activity, the MWCOG model for streetcar riders can be summarized for work rider versus non-work activity riders. Table 5.21 summarizes the 2,140 riders (half the 4,280 riders) for Alternative 8. Again, this is shown as the first trip of the day without the return trip so that the true location of trip origin can be seen. Of those streetcar riders, approximately 67 percent of the trips are work related and the remaining 33 percent are non-work related.

Table 5.21: 2040 Alternative 8 - Work and Non-Work Streetcar Riders

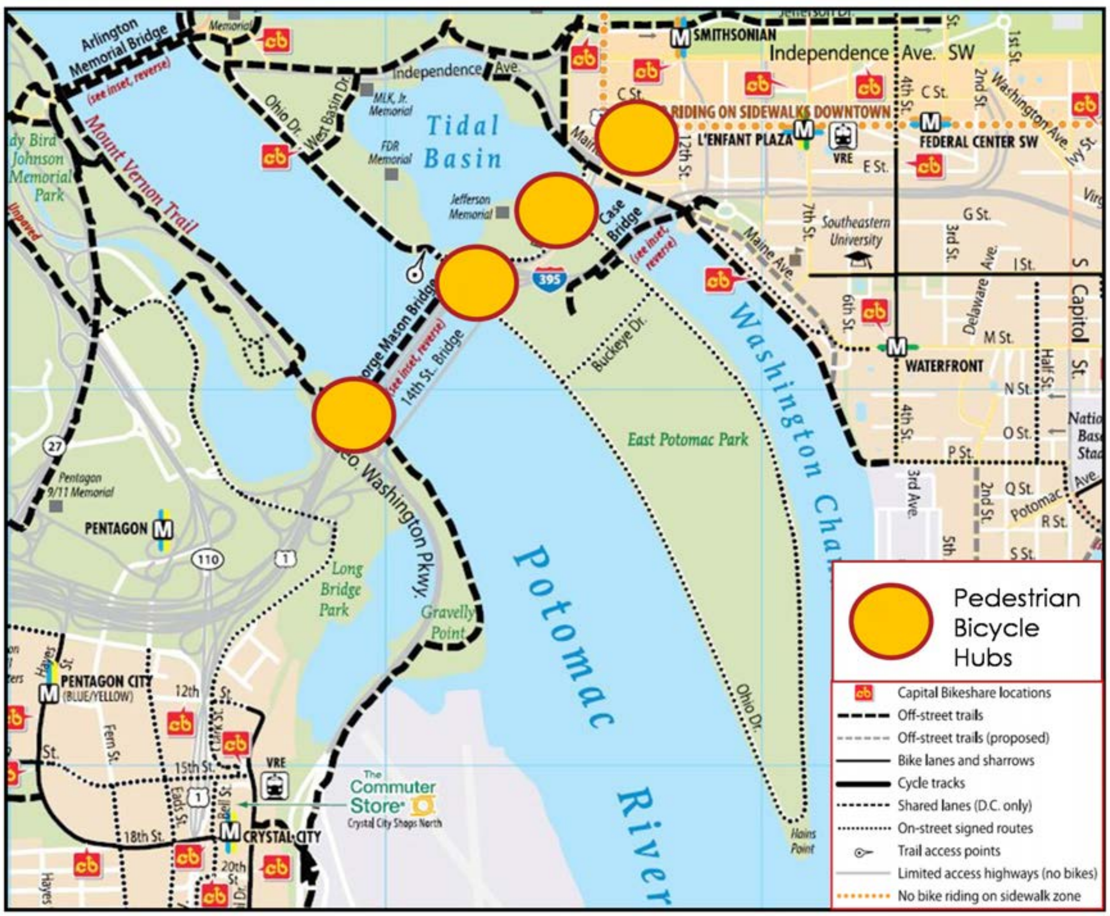
	District to VA	VA to District	Total
Work Trips	1,090	355	1,425
Non-Work Trips	540	175	715
Total	**1,630**	**510**	**2,140**

Streetcar analyzed in Alternatives 6 through 8 provides the opportunity to connect the future planned streetcar in the District to the Arlington County streetcar, and presents a new transit service that enhances travel options across the Potomac River. This study provides a starting point that shows there is user demand for streetcar to cross between the District and Virginia and provides riders with an additional option for daily travel.

Pedestrian/Bicycle

The Long Bridge study area features a number of pedestrian/bicycle facilities as shown in Figure 5.15. These facilities would connect with pedestrian/bicycle options for each of the Long Bridge alternatives. Key locations from the alternatives include ramp and staircase options to the Mount Vernon Trail in Virginia, two locations on East Potomac Park, and District options along Maine Avenue, SW. Either end of an alternative will also carry pedestrians and bicycles to Long Bridge Park in Virginia and 12th Street, SW, at the Mandarin Oriental Hotel.

Figure 5.15: Study Alternatives Connections to Existing Pedestrian/ Bicycle Paths



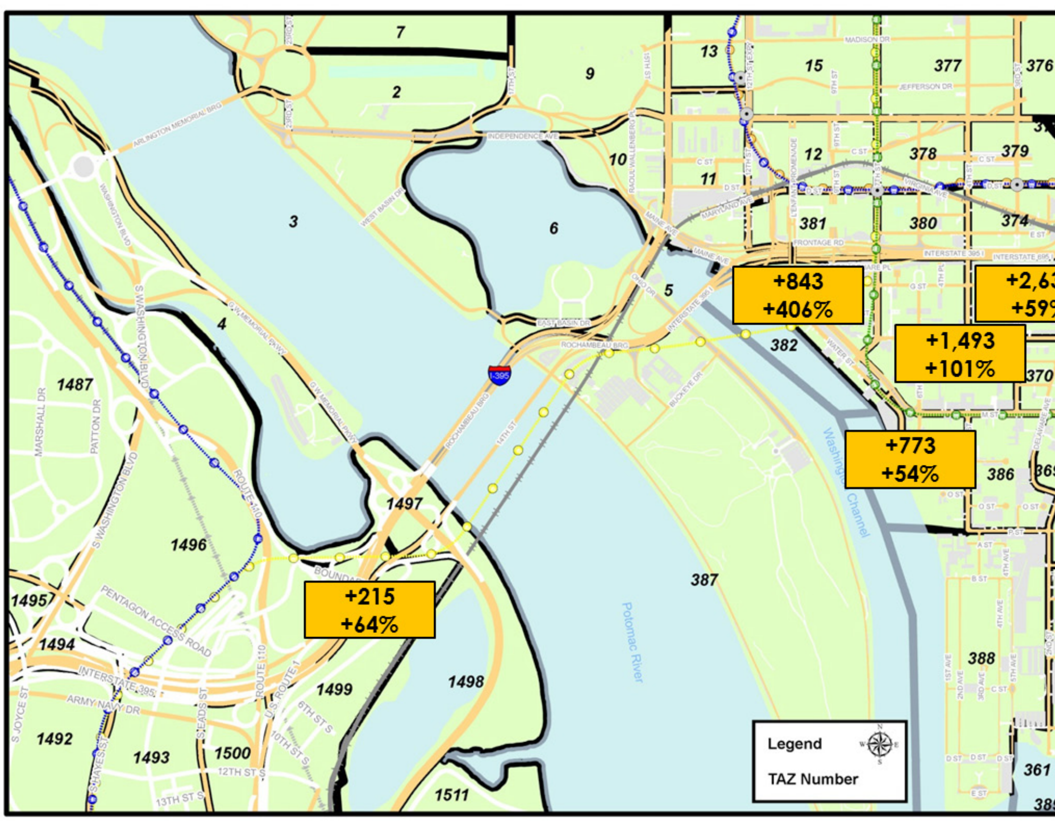
The MWCOG model develops an estimate of non-motorized trips that are either generated or destined to these locations as defined by the zonal system in the model. The model only predicts the magnitude of trips at each of these locations and does not provide detail on how non-motorized trips are routed along the pedestrian/ bicycle path system. Pedestrian Environment Factors (PEFs) are considered in generating these trips. Walking environment can be captured using parameters that can be estimated based on a GIS street layer and include block density, ratio of four-way intersections to cul-de-sacs, and major/minor street density. All these parameters were considered in the MWCOG non-motorized model; however, only block density proved to be a significant predictor of non-motorized trip percentage.

Table 5.22 details the pedestrian/bicycle trips that are estimated by the MWCOG model for the study area detailed by District versus Virginia trips. The MWCOG zone level detail of these trips is provided in Appendix A–4. District non-motorized trip estimates from 2010 to 2040 increase by approximately 37 percent, while, for the same time period, the Virginia trips increase by approximately 24 percent. Within the Long Bridge study area, the District commands almost three-and-a-half times as many pedestrian/bicycle trip estimates as the Virginia side, which is reasonable based on the current and projected land uses. The high-density household and employment area in the District has a much higher density than the Virginia waterfront and the area that extends to the west of Long Bridge Park, making it a much larger and less dense pedestrian and bicycle area.

Table 5.22: Pedestrian/ Bicycle Trip Estimates within the Study Area

	District		Virginia		Total	
	2010	2040	2010	2040	2010	2040
Trips Generated From	8,869	15,333	1,387	1,619	10,256	16,952
Trips Generated To	47,905	62,455	15,842	19,725	63,747	82,180
Total	56,774	77,788	17,229	21,344	74,003	99,132

Figure 5.16: 2010 to 2040 Pedestrian/Bicycle Growth - Key Population Locations for Trips



A review of key locations summarized in Table 5.26 provides an estimate of where pedestrian/bicycle trips begin and where they end. Figure 5.16 shows the key population locations where pedestrian/bicycle trips are produced. The District population locations are below the L'Enfant Plaza area in residential neighborhoods, with the largest increase along the Southwest Waterfront and over four times the current number on pedestrian/bicycle trips. Virginia presents a modest amount of growth with only 215 additional pedestrian/bicycle trips predicted in 2040. The MWCOG model adopted land use projections dictate the percentage of pedestrian/bicycle trips. The addition of a new pedestrian/bicycle crossing at the Long Bridge would require MWCOG to revisit these estimates and determine a new round of land use projections if a new project is included in the CLRP.

Figure 5.17 shows the key employment locations where pedestrian/bicycle trips are produced and the work end of daily activity. The highest amount of trips for the 2010 to 2040 period in the District occurs in the immediate vicinity of government buildings, in the L'Enfant area as well as the Southwest waterfront. Increased employment and the density of activity indicate that the study area within the District will continue to grow and increase the demand for pedestrian/bicycle movements. Virginia also shows an increase of approximately 1,500 trips, driven by the MWCOG models future estimates for employment, which is currently relatively low.

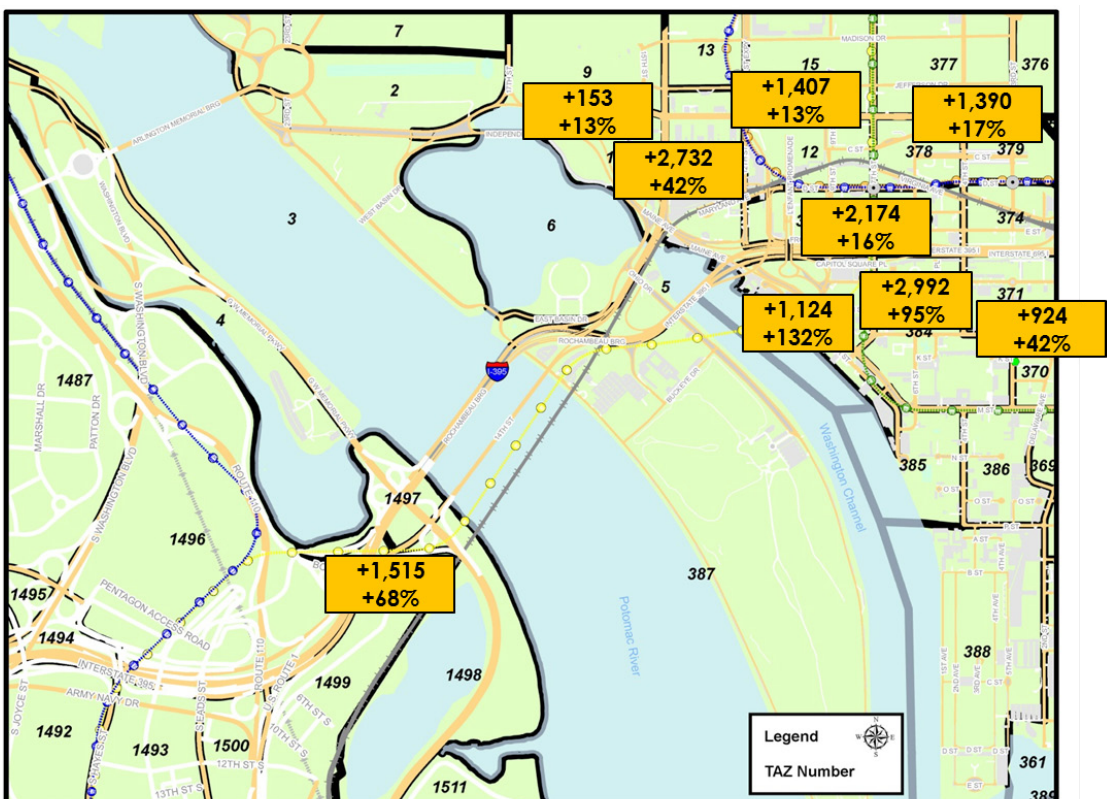


Figure 5.17: 2010 to 2040 Pedestrian/ Bicycle Growth - Key Employment Locations for Trips

Although the pedestrian/bicycle trips are not routed onto any sidewalk or pathway system in the MWCOG model, there is considerable opportunity for pedestrian/bicycle trips to use a new crossing if destinations are provided in Virginia. These trips only represent the activity of individuals that live or work within the study area. Pedestrian/bicycle activity related to visitor and recreational activity would add additional demand to moving without a vehicle across a Potomac River alternative.

The alternative analysis for the Long Bridge Study presents two distinct markets of need for future travel. Freight, passenger, and commuter rail demand will continue to grow and require the addition of a third and fourth track to accommodate the demand. Based on this analysis, freight trains will increase by almost 50 percent from a current count of 23 to a 2040 estimate of 34. The increase in passenger trains is even more pronounced predicted to increase by 235 percent from 56 current trains to an estimated 132 trains, with new services added for expanded Commuter Rail, Intercity Rail, and High-Speed Rail. All study alternatives have identified this need and included rail expansion as a primary mode that needs to be addressed to accommodate rail operations across the Potomac River well beyond the 2040 out year of this study.

A second market beyond rail has identified how other modes of travel would also expand and benefit from a new crossing of the Potomac River. Vehicular alternatives would provide local travel options independent of the current interstate crossings on I-395/14th Street Bridges. This could help connect the District and Virginia waterfronts providing an incentive for continued growth and investment within the study area. Streetcar has the potential to move thousands of riders between the District and Virginia and connect to existing streetcar systems planned for both sides in the future. Streetcar plans in the District are a major transportation element of future travel options, and these study alternatives have provided insight into the potential for making an important connection across the Potomac River.

Pedestrian/bicycle alternatives augment the already extensive network of paths and walkways in the District and serve to expand the walkability of Long Bridge Park in Virginia. The demand from residents and visitors alike for connections between all activity areas also continues to increase. An additional Potomac River crossing will offer entirely new options for activity.

The analysis of these two markets serves to identify the specific needs for future freight and the potential for moving the travelling public with new alternatives for crossing the Potomac River.