Metrorail Silver Line Corridor Junction Feasibility Study and Conceptual Design

Technical Memorandum

Prepared by:

Washington Metropolitan Area Transit Authority

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1. Executive Summary

The Metrorail Silver Line Corridor Junction Feasibility Study and Conceptual Design serves as an initial alternatives analysis to explore potential track junctions for enhanced operational flexibility in the corridor shared by the Silver, Orange, and Blue Metrorail lines. This study identifies several options for additional junction infrastructure along the corridor and undertakes an initial assessment of each option's feasibility, physical requirements, service impacts, capital costs, and operating cost impacts. The study's central goal is to identify track and station configurations that would likely provide operational flexibility, improve safety and reliability, lower operating costs, and potentially expand corridor capacity. This study will inform a decision on whether to move selected options into more detailed project development.

1.1 Background

Phase I of Metrorail's Silver Line opened to the public in July 2014, providing service between the Wiehle Avenue Station in Reston, VA and the Largo Town Center Station in Prince George's County, MD. Phase II will extend the Silver Line west to Route 772 in Loudoun County by 2020. The Silver Line extended Metrorail service to one of the region's fastest-growing areas and provides great potential for ridership growth and urban development along the Dulles corridor.

However, implementation of the Silver Line has created a range of serious operational issues for the Metrorail System. The line's actual configuration and operations differ from the original plans, which intended to terminate service at the eastern merge of the Orange and Blue Lines: the D&G Junction located just northeast of the Stadium-Armory station in the District of Columbia. However, a detailed engineering review of the D&G Junction concluded that the structure as currently configured could not safely nor sufficiently serve as the eastern terminus of the Silver Line. It can handle limited turnbacks of six-car trains and deployment of relief trains but is insufficient to support consistent, all-day turnback movements. Staff recommended the Silver Line's eastern terminus be extended to Largo Town Center, an eight-mile extension that added 15 minutes in each direction to the original proposed run time.

Headway Changes

Implementation of Silver Line service also forced major changes to schedules and frequencies on all the other lines. Because the Silver Line is interlined with the Orange and Blue Lines, and the Blue Line is in turn interlined with the Yellow Line, adding a third line to the shared tracks and tunnel between Rosslyn and the D&G Junction forced major schedule adjustments. The original Silver Line Final Environmental Impact Statement (FEIS) recommended schedules of seven-minute peak service and fourteen-minute off-peak service, but Metro staff concluded those headways would be too great a departure from previous peak service levels. The FEIS

schedule also would have left the Blue Line running less often during peak hours than off-peak. As a result, staff proposed the current six- and twelve-minute schedule as shown below.

Table 1: Current Operating Headways

Line	From	To	Peak Headway	Mid-Day Headway
Silver	Wiehle Ave	Largo	6 min	12 min
Orange	Vienna	New Carrollton	6 min	12 min
Blue	Franconia-Springfield	Largo	12 min	12 min
Green	Greenbelt	Branch Ave	6 min	12 min
Yellow A	Huntington	Mount Vernon	6 min	n/a
Yellow B	Huntington	Ft. Totten	n/a	12 min
Yellow +	Franconia-Springfield	Greenbelt	12 min	n/a
Red	Shady Grove	Glenmont	3-6 min	6-12 min

Impacts on Corridor Operations and Reliability

Metro has analyzed Silver Line performance and impacts on the broader system since its implementation. The Silver Line extended the Metrorail System's reach into some of the region's fastest-growing job and commercial centers and expanded Metro's customer base, but it has also negatively impacted service reliability and headways on other lines. Metro staff noted a decline in on-time performance on all three lines serving the combined corridor immediately upon opening of the Silver Line, and performance targets have been missed consistently since. The schedules for all lines running through or connecting to the shared corridor must consider the condition of the railcar fleet, uneven passenger flows, infrastructure delays (continuing work on state-of-good repair), and the complexity of dispatching separate lines over three "major" and two "minor" junction points.

In this case, "major" junction points are defined as stations and other nodes where rail lines converge into the same right-of-way, including Rosslyn, D&G Junction, and East Falls Church. "Minor" junctions are stations that offer critical scheduled connections to other lines that do not share track infrastructure, including L'Enfant Plaza and Pentagon. The interconnection of the Metrorail System at these nodes means that service disruptions on the Blue, Orange, or Silver Lines not only directly affect service on the other two lines in the corridor, but also on connecting Yellow and Green Line schedules. The "major" junction points function much like cogs in a gear mechanism; the size of the cog and the speed at which one gear moves results in changes to interconnected gears ("minor" junctions).

Throughput on the Blue, Orange, and Silver Lines is constrained by the major junction points at Rosslyn and the D&G Junction. Metro's current operating plan schedules 25 trains per hour (TPH) through the combined corridor during peak periods. However, that operating plan is routinely impacted by service interruptions; a disruption on one line has immediate impacts on the other two, and perhaps downstream impacts on connecting lines. As a result of this variation in daily operations, the actual throughput currently being achieved is an average of 22 TPH through the Rosslyn Tunnel. In May 2015, system-wide on-time performance was only 85% during the morning peak and 82% in the evening peak period. The sharpest year-to-date drop in schedule adherence was on the Blue, Orange, and Silver Lines, with the Blue Line the worst performer at 78% in the morning and 71% in the evening peak. For purposes of this study, as well as service planning following implementation of any recommended options, Metro is establishing a more reliable target of 24 TPH through the combined corridor.

Finally, as noted above, implementation of Silver Line service forced reductions in service levels on the Blue Line. Metro continues to hear valid complaints from Blue Line riders about long waits, crowded trains and platforms, and passengers being passed up by trains already carrying crush loads. Metro is committed to providing excellent service to all its customers, and has an urgent need to restore Blue Line service levels and to maximize train and passenger throughput along the shared corridor.

Impacts on Customer Safety

The Silver Line has added thousands of riders per day to station platforms, mezzanines, and escalators in the core that were already nearing maximum safe passenger volumes. Metro has established minimum ratios for passenger volumes and station/platform capacity that define safe conditions, and beyond which the chances for accidents and injuries rise to unacceptable levels. In October 2014, the Silver Line carried around 15,000 trips originating in Northern Virginia, and 50% of those trips were heading to a station in downtown Washington, D.C. Metro's *Momentum* strategic plan noted that many of those stations were projected to hit maximum volume/capacity ratios in the near future, and that absent rail fleet expansion, greater service frequencies, and/or expanded circulation areas within stations, the system will experience crush loads and unsafe conditions throughout the core. On an average weekday in May 2015, the core stations along the shared corridor experienced 66 quarter-hour intervals during which the volume of people moving through these stations exceeded the capacity target for safety. **Figure 1** illustrates crowding in core stations during peak hours. Most stations in the core exceed target volume/capacity ratios for safe and efficient vertical circulation on escalators, stairs, and elevators during both morning and evening peak travel periods.

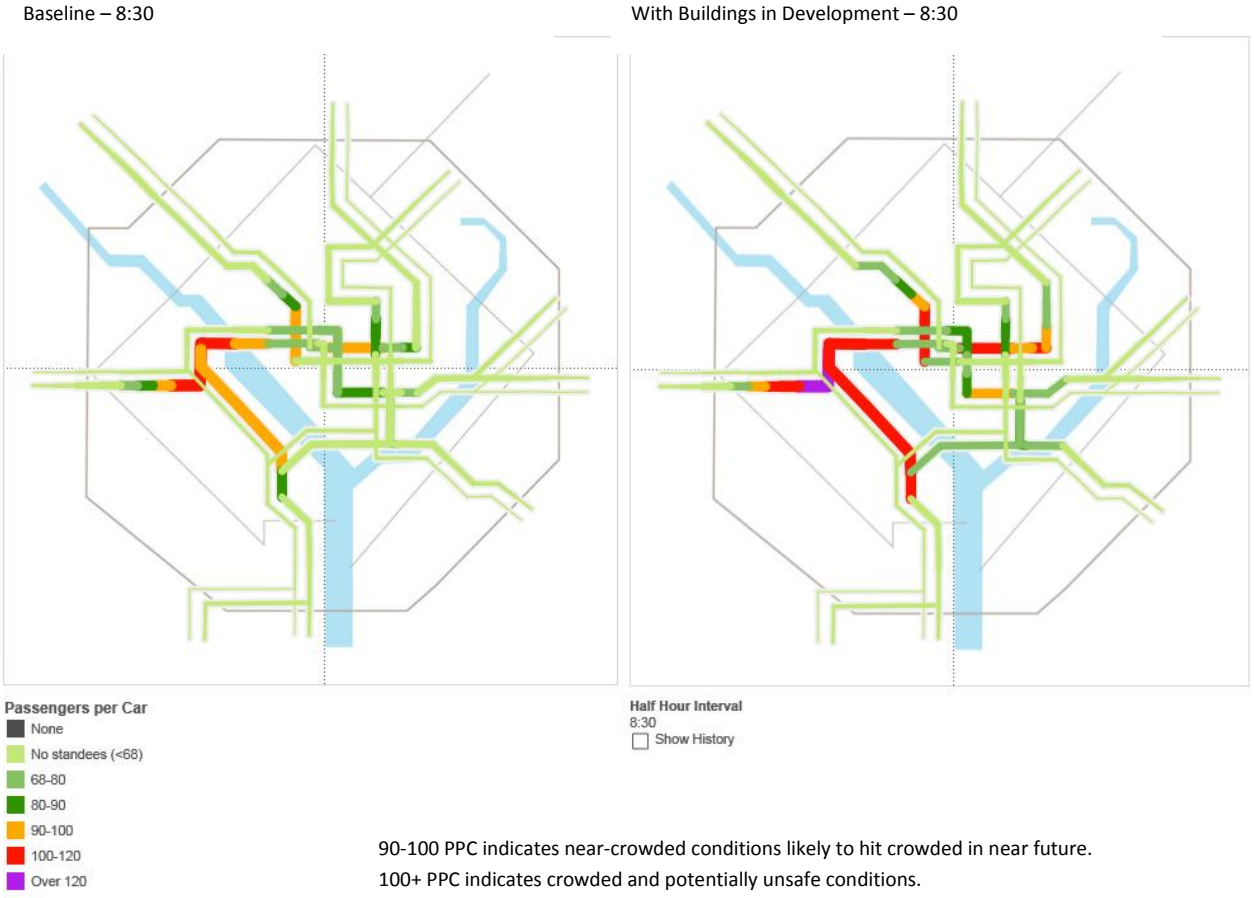
Figure 1: Current Vertical Circulation Capacity Ratio

Impacts on Passenger Loads

Crowded conditions in stations are reflected in passenger loads on trains. Metrorail is an extensive system, but its radial nature and regional job distribution patterns means the Downtown D.C. core still attracts the largest share of work-trips. The high-density Rosslyn-Ballston corridor in Arlington County already generated great demand on the Orange Line, and the implementation of Silver Line service added approximately 15,000 weekday riders to that corridor. Ridership growth in Northern Virginia, plus reduced headways on the Blue Line, plus service disruptions along the shared corridor are producing passenger loads that exceed Metro's service standards for safety and crowding. Between 8am and 9am on weekdays, the Orange and Silver lines in Virginia already routinely exceed the target of 100 passengers per railcar (100 PPC), as does the Blue Line between 8am and 8:30am. Those lines also hit crowding thresholds during the evening peak. Crowded trains not only result in less comfortable rides and dissatisfied customers, but also negatively impact service reliability and on-time performance because it takes more dwell time than is scheduled to safely off-load and board passengers. It also encourages passengers to hold doors for fear of missing the next train; this also adds dwell time, and likely delays the following train. It also presents a strong possibility the door will break and the train will have to be taken out of service. In May 2015, trains

running through 10 of the 24 maximum load points carried over 90 PPC; the Orange Line carried an average of 115 PPC at Court House station, and the Blue Line carried an average of 115 PPC through the Rosslyn and Foggy Bottom stations. As **Figure 2** and **Table 2** illustrate below, certain rail segments are already nearing or over PPC targets, particularly in Virginia, and that situation is projected to extend to every line except Yellow within five to ten years.

Figure 2: Current Operations Passengers per Car



90-100 PPC indicates near-crowded conditions likely to hit crowded in near future.
100+ PPC indicates crowded and potentially unsafe conditions.

Table 2: Metrorail System Peak Period Capacity by Line Without Fleet Expansion

	2012	2020	2025	2040
Red	✔	--	--	X
Yellow	✔	✔	✔	--
Green	✔	--	--	X
Blue	✔	--	--	X
Orange/Silver	--	X	X	X

✔ Acceptable (average passengers per car (PPC<100)
-- Crowded (PPC between 100 and 120)
X Extremely crowded (PPC>120)

Momentum and Core Capacity Constraints

Momentum is Metro's vision for the future, a medium-range strategy for meeting the challenges described above and preparing the system to better accommodate the next 30 years of growth. Furthering work already underway to rebuild the system, the strategic plan bridges the gap between the existing transit system and a full 30-year plan by focusing on nearer-term goals for 2025: http://www.wmata.com/momentum/2025.cfm.

Momentum makes a strong argument to the region that Metro is at a critical juncture. The National Capital Region has grown geometrically since the system opened and continues to do so, yet capital investments, preventative maintenance, and infrastructure upgrades have not kept pace with growth. Customers are experiencing the results of years of chronic underfunding and underinvestment. Aging equipment and deteriorating infrastructure impacts service reliability and headways, and some stations in highly developed areas experience intense crowding during peak hours. Unreliability and crowded conditions are leading to ridership losses and historically low levels of customer satisfaction.

The situation is particularly urgent in the system's core, an area that includes 26 stations across all Metrorail lines in D.C. and Arlington County. This core is the destination or primary transfer point for 80% of all rail riders system-wide. Train segments and stations within the core already experience severe crowding during peak hours, and models show that, absent fleet expansion and other major capital upgrades, all lines and most stations will hit or exceed the threshold for crowded conditions by 2025.

Momentum recommended a list of capital investments and core capacity expansion projects that would alleviate these conditions by 2025. This list of seven major initiatives included finding a new pathway and stations for the Blue Line; new pocket tracks to provide operational flexibility and capacity for turnbacks and shorter trips; and capacity improvements to several high-demand stations in the core.

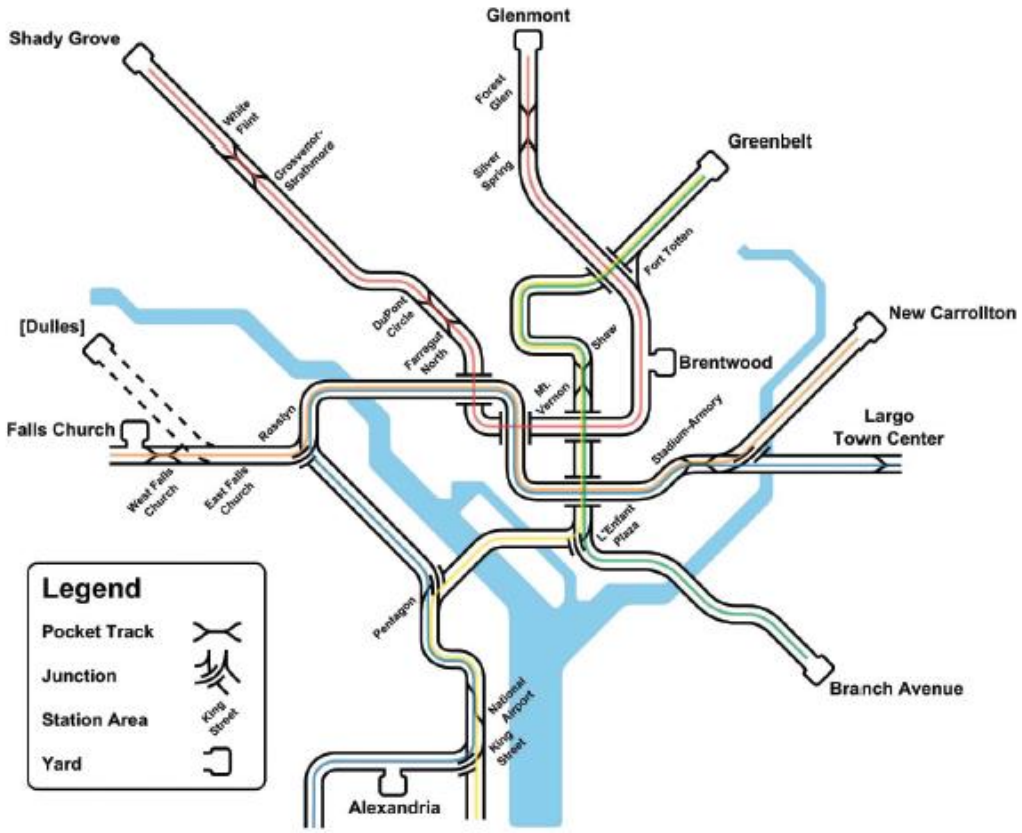
This current study is a continuation of *Momentum*, one of several projects underway to further develop the ideas identified in that plan.

1.2 Project Purpose

In pursuit of the safety and system improvements recommended in *Momentum*, in April 2015 WMATA launched a high-level feasibility scan to preliminarily identify locations for new or improved junctions and pocket tracks along the shared Blue/Orange/Silver corridor. As illustrated in **Figure 3** below, the Metrorail System has a limited number of junctions and pocket tracks, which constrains Metro's ability to circumvent service disruptions, deploy relief trains, and match service to ridership levels.

This study explores junction infrastructure treatments that would better accommodate turnbacks along the shared corridor. **The study's goal is to identify options that seem likely to provide additional operational flexibility, improve service reliability and safety, and lower operating costs.** If possible, these options should also allow Metro to consistently move at least 24 TPH through Rosslyn. This study assesses the feasibility of each alternative in terms of constructability, physical and operational limitations, initial environmental concerns, high-level impacts on train operations, estimated capital costs, and projected operating cost savings. Based on this assessment, Metro may decide to pursue further analysis of feasible alternatives through additional design refinement and detailed cost-benefit analysis.

Figure 3: Location of Existing Pocket Tracks, Junctions, and Yards



The study identified several alternatives located at or near the West Falls Church Station, East Falls Church Station, Stadium-Armory Station, and the D&G Junction, as identified in **Figure 4** on the next page. Each alternative except the D&G Junction features new platforms, new track infrastructure such as crossovers and pocket tracks, and reconfiguration of existing track right-of-way in order to safely accommodate train turnbacks. The D&G Junction option considers an extension of and structural upgrades to the existing pocket track.

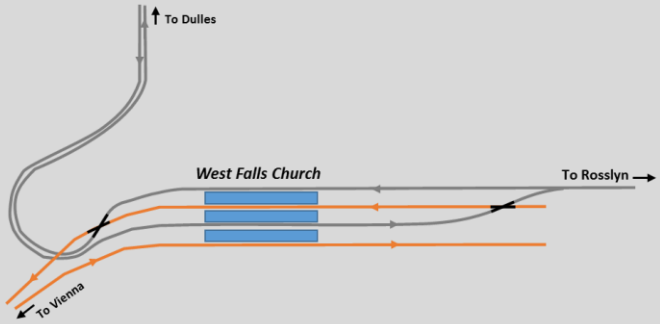
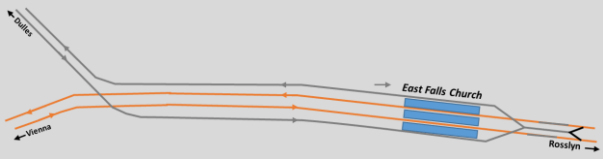
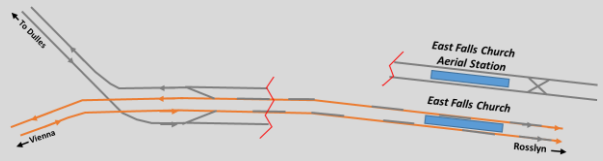
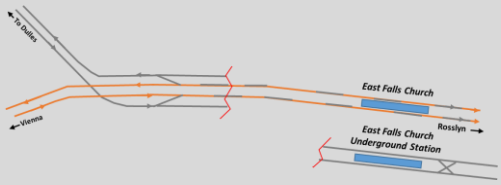
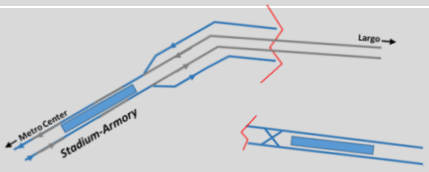
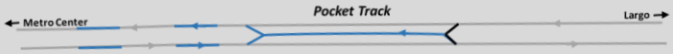
All of these alternatives can be roughly ordered into two groups: West Falls Church and East Falls Church on the western side of the system, and Stadium-Armory and D&G Junction on the eastern side. It should be assumed that all the alternatives in either group are mutually exclusive of one another (Metro would not pursue both the West Falls Church and East Falls Church options, for example), but could be combined with an alternative from the other group for additional operational flexibility and cost savings. This study assumes the western options would be used to turn back Silver Line trains, while the eastern options would turn Blue Line trains in order to maintain adequate service frequencies in eastern D.C. and Prince George's County. Additional information comparing the alternatives is detailed in **Appendix A** and **Appendix B**, and summarized in **Figure 5**.

1.3 Concept Locations and Study Area

Figure 4: Turnback Concept Locations

1.4 Concepts Evaluation Summary

Figure 5: Simplified Comparison Matrix

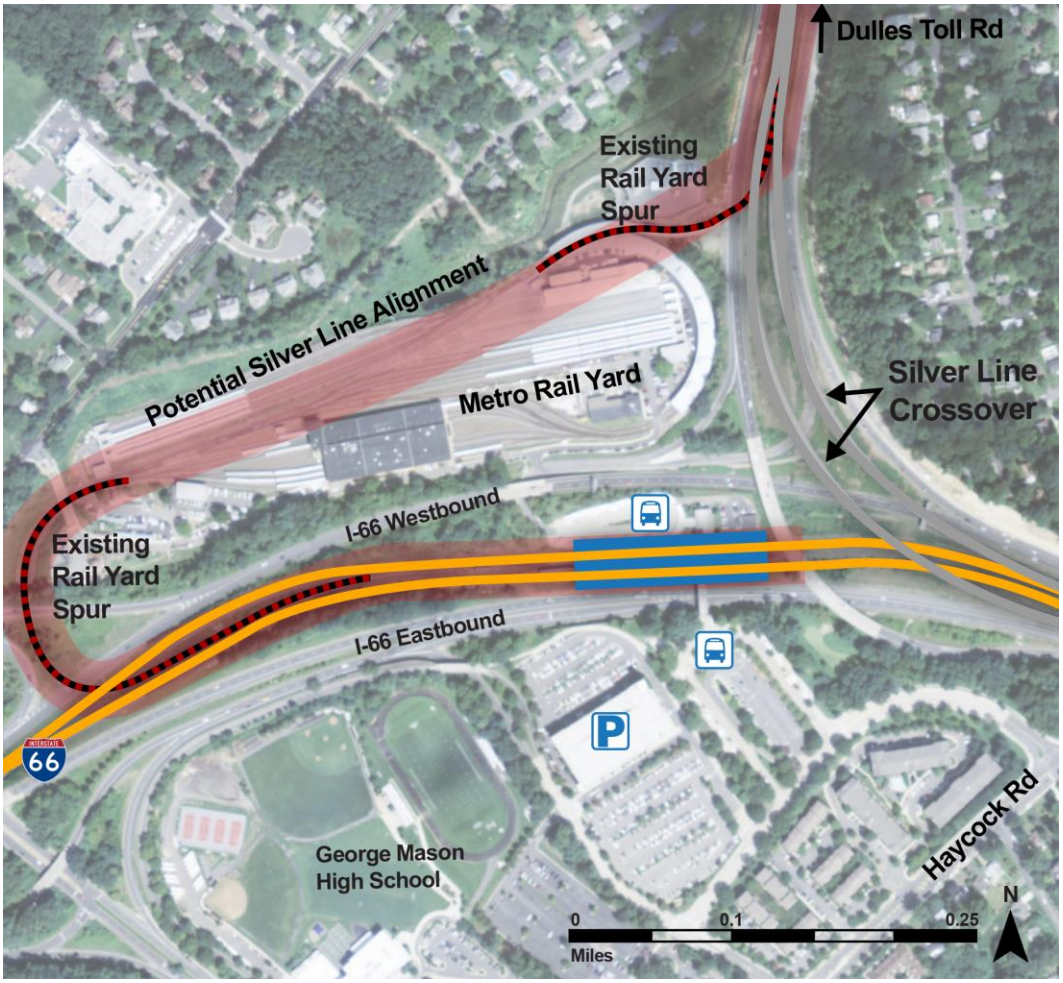
Concept	Concept Schematic	Criteria	
		Operations Plan	**Annual Savings on Silver Line Operating Hours**
WFC		Silver Line trains are turned back at new station platform, except for 2 Silver Line trains per hour that operate through to Largo.	77,410 fewer Silver Line hours, 60,617 additional Orange line hours. Total hours reduced by 16,793. Creates 8 slots per hour east of WFC for use by other trains.
EFC Alt 1 Crossover East and Pocket Track		Silver Line trains are turned back at either pocket track or new station platform, except for 2 Silver Line trains per hour that operate through to Largo.	77,410 fewer Silver Line hours, 60,617 additional Orange line hours. Total hours reduced by 16,793. Creates 8 slots per hour east of EFC for use by other trains.
EFC Alt 2 Aerial Platform			
EFC Alt 3 Tunnel			
RFK Turnout North and New Station		All Blue Line trains turn back on new above-grade track north of Stadium-Armory Station	Zero reduction in Silver Line hours. There is a savings of 13,034 Blue Line train-hours. Saves 5 Blue Line trains per hour.
D&G Junction		All Blue Line trains turn back at modified (lengthened) D&G pocket track	Zero reduction in Silver Line hours. There is a savings of 13,034 Blue Line train-hours. Saves 5 Blue Line trains per hour.

	Criteria					
Annual Savings O&M Costs (million)	**Constructability**	**Capital Cost Estimates (000s)**	**Capital Cost Amortized over 30 years at 3% inflation**	**Benefit Minus Cost (000)**	**Improve Reliability of 24-26 TPH thru Rosslyn?**	**Other Considerations**
$79.4 million reduction in Silver Line. $65.1 million increase in Orange line. Net savings = $14.3 million.	Relocate existing rail yard. Neighborhood and community impacts due to below-grade configuration.	$298,000	$15,197	-$896	Yes	Potential to shift balance OR/BL service through Rosslyn. TOD 0pportunities. No train movement conflicts. Majority of SV trips would require passenger transfer to continue downtown. 3 FTE O&M staff on-site.
$80.5 million reduction in Silver Line. $65.2 million increase in Orange line. Net savings = $15.4 million.	Relocate I-66 lanes and bridges	$350,000	$17,857	-$2,457	Yes	Potential to shift balance OR/BL service through Rosslyn. Majority of SV trips require passenger transfer to continue downtown. Options 2 & 3 require vertical circulation for passenger transfer. Options 2 & 3 offer potential long-term separation of OR & SV.
$77.7 million reduction in Silver Line. $65.2 million increase in Orange line. Net savings = $12.6 million.		$412,000	$21,020	-$8,420	Yes	
	Tunnel beneath existing tracks, platform and I-66	$1,013,000	$51,683	-$39,083	Yes	
$0 reduction in Silver Line. There is a savings of $10.5 million in Blue Line O&M costs	Cut & Cover – Environmental Impacts	$375,000	$19,132	-$8,632	No	New station could support development in this area. Land is federally owned.
$0 reduction in Silver Line. There is a savings of $13.3 million in Blue Line O&M costs	Aerial structure – train operations and environmental impacts	$13,000	$663	$12,636	No	Extending pocket track and adding #10 turnouts provides adequate capacity for train layover.

2. West Falls Church

The West Falls Church Station is an at-grade station located in Fairfax County, Virginia near the border with the City of Falls Church. **Figure 6** depicts the station, which is within the center median of I-66 just west of the I-66 and Dulles Toll Road interchange, and is surrounded by the I-66 highway right-of-way. Pedestrian and park and ride access to the station is located south of the I-66 thoroughfare and is linked by a pedestrian bridge. Access to the north is limited to a bus transfer loop that is also within the center median of I-66. The station is located immediately west of the split between the Orange and Silver Lines and serves the Orange Line branch to Vienna.

Figure 6: West Falls Church Station Context



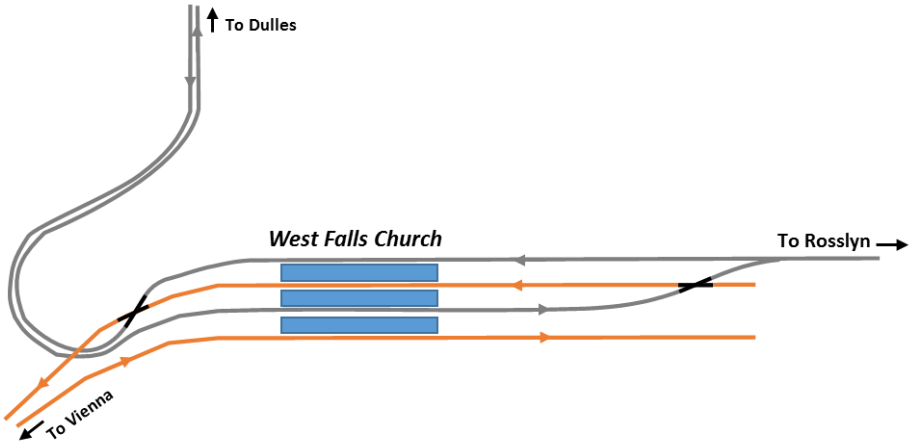
The station is adjacent to significant transportation infrastructure and facilities. A WMATA rail yard is located north of I-66 and is linked to the Orange Line tracks through a tunnel beneath the I-66 and Route 7 interchange. The Route 7 and I-66 interchange is a modified cloverleaf

configuration that is bounded on all sides by existing development, including residential neighborhoods and schools. The rail yard tunnel segment emerges within the I-66 median between the operational eastbound and westbound Orange Line tracks. Overpass bridges connect I-66 with Dulles Toll Road to the north and the Silver Line tracks located within the highway median.

The proposed design routes eastbound Silver Line trains to the West Falls Church Station, where they are then turned back at a new pocket track and station platform. A new platform would be constructed north of the existing platforms, with a new crossover and pocket track east of the platform area. Trains would be turned back westward along a new track running parallel to the existing yard track and linking back to the existing Silver Line track in the median of the Dulles Toll Road. This option assumes relocation of the existing rail yard facility elsewhere in Northern Virginia, likely in the area around Dulles Airport. To mitigate any noise impacts caused by slower train movements along tight curves, this alternative would require approximately three FTE O&M staff on-site. This alternative is further detailed in **Figure** 7. Detailed plan drawings are provided in **Appendix C**.

The West Falls Church alternative assumes that all but two Silver Line trains per hour would be turned around at West Falls Church Station. Turned trains would travel back northwest to the end of the line at Ashburn Station; the other two trains per hour would continue service to Largo Town Center. Passengers on short-turn trains would be required to transfer to the Orange Line to continue east towards Downtown D.C. This results in savings of 21 Silver Line trains during peak period operations and creates eight slots per hour east of West Falls Church for use by other trains. Due to heavy demand and crowding west of Rosslyn, it is assumed that the eight slots per hour would be filled by Orange Line trains.

Figure 7: West Falls Church Alternative Operations Schematic

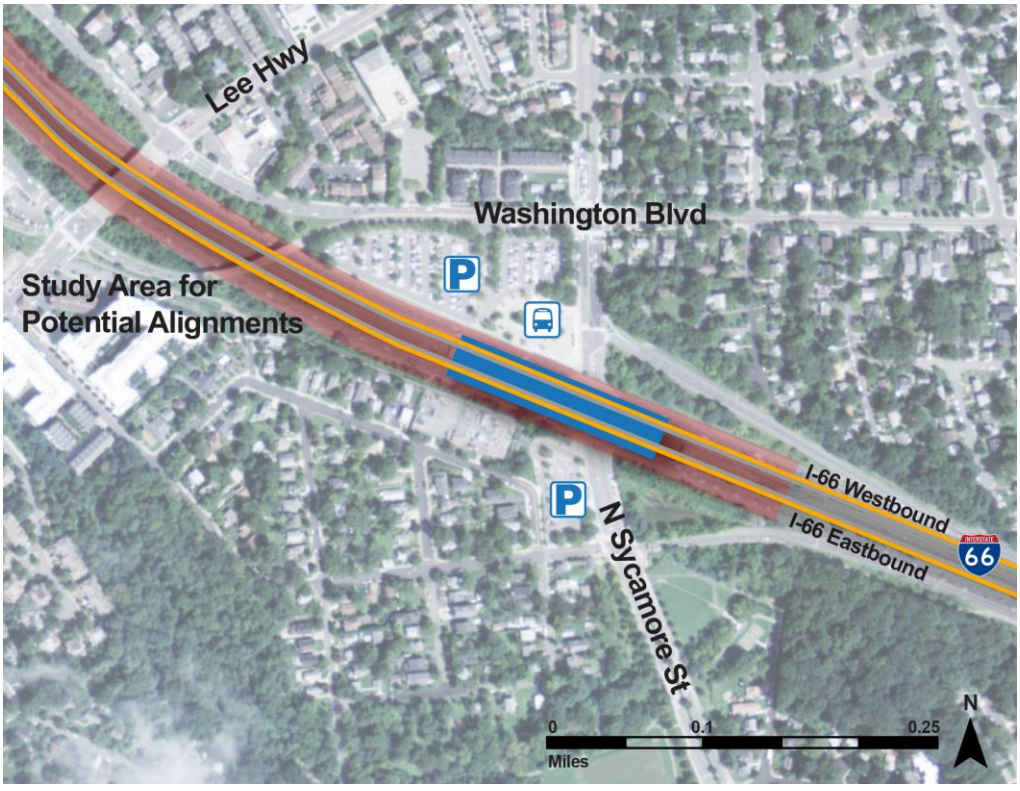


3. East Falls Church

East Falls Church Station is an at-grade station located in Arlington, Virginia near the border with the City of Falls Church. The station, shown in **Figure 8**, is located within the center median of I-66, and is surrounded by highway right-of-way. Pedestrian access to the station is provided off of North Sycamore Street below the Metrorail and I-66 rights-of-way. East Falls Church is the westernmost station that serves both Silver and Orange Lines before the lines split at the I-66 and VA-267 interchange. The Silver and Orange Line split occurs about 1.5 miles west of the East Falls Church Station, at the Great Falls Street overhead bridge.

The station is surrounded by several infrastructure elements. As the rail segment is within the I-66 median, several local roads traverse either underneath or above the Metrorail alignment. Overhead bridges are located west of the station at Great Falls Street, 25th Street, Lee Highway, and eastbound Washington Boulevard. A pedestrian bridge connecting to the Washington and & Old Dominion (W&OD) Trail and Ohio Street sits east of the station. Underpasses exist west of the station at Williamsburg Boulevard and Westmoreland Street, and east of the station at Sycamore Street. The current track configuration includes a rail crossover just east of the station platforms.

Figure 8: East Falls Church Station Context



Several junction alternatives were developed and assessed for East Falls Church. All of the alternatives looked at providing separate tracks for the Orange and Silver Lines from the existing split at I-66 and VA-267. Separating the Orange and Silver Lines at the East Falls Church Metrorail Station would provide Metro with greater flexibility in matching service to demand and responding to service disruptions. One of the three options would also set the stage for a long-term separation of the Orange and Silver Lines all the way to Rosslyn, and perhaps into the District of Columbia, if the region decides doing so is a priority. These alternatives require a total of four (two existing, two new) fully separated tracks along some portion of the Metrorail right-of-way between the existing Orange/Silver junction and East Falls Church, as well as modifications to the existing rail right-of-way, platforms, and station layout.

Like the West Falls Church Alternative, the East Falls Church Alternative assumes that all but two Silver Line trains per hour would be turned around at East Falls Church Station. Turned trains would travel back northwest to the end of the line at Ashburn Station; the other two trains per hour would continue service to Largo Town Center. Passengers on short-turn trains would be required to transfer to the Orange Line to continue east towards Downtown D.C. This results in savings of 21 Silver Line trains during peak period operations and creates eight slots per hour east of West Falls Church for use by other trains. Due to heavy demand and crowding west of Rosslyn, it is assumed that the eight slots per hour would be filled by Orange Line trains.

Alternative-specific details are discussed in the following subsections, and include a general overview of the alternative, constructability considerations, operational improvements, and potential costs. Detailed plan drawings are provided in **Appendix C**.

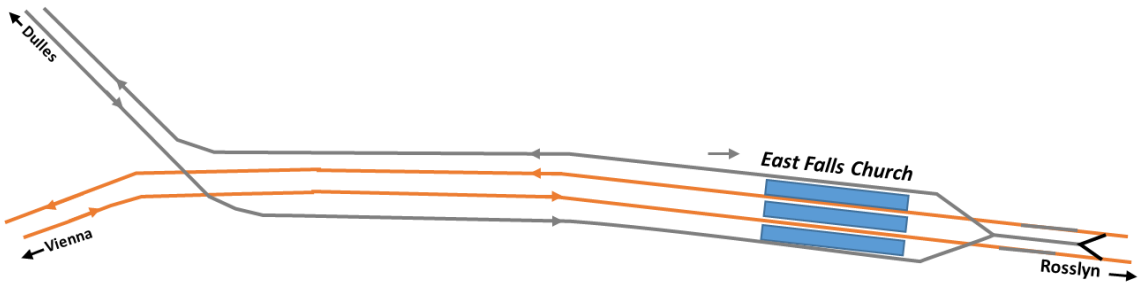
3.1 East Falls Church Alternative 1 – Crossover East

East Falls Church Alternative 1 consists of adding two at-grade tracks, two additional platforms at the existing station, and a 650 ft. long pocket track east of the station. The two new tracks would tie into the existing Silver Line tracks at the existing junction and would travel adjacent to the existing Orange Line tracks. The tracks would keep the Orange and Silver Lines separate, with the Silver Line running on the two exterior tracks and the Orange Line operating on the interior tracks (existing tracks). New crossovers would be needed east of the existing station. The station would include two new side platforms, with the existing platform serving as a center platform.

The additional tracks would require realigning existing I-66 lanes to accommodate the expanded Metrorail right-of-way. The alternative also impacts adjacent structures and would require replacing/reconstructing the overhead bridges for Lee Highway, 25th Street, Great Falls Street, and the ramp to eastbound Washington Boulevard. Additional structures would be necessary at roadway underpasses. An existing substation south of the East Falls Church Platform would also need to be relocated. In addition, the existing platform at East Falls Church is on a structure, and therefore the proposed platforms on either side would also need to be on structure.

Passengers wanting to continue their trip eastbound would need to cross the platform and transfer to the Orange Line and conversely for the westbound trip; doors on both sides of the trains would have to be opened to accommodate the transfer of passengers. Eastbound trains turning-back would clear the new platforms at the station and switch to the crossover tracks to directly access the pocket track, rather than running in the mainline, before turning around for the westbound trip. Careful operational consideration would need to be given to the placement of special trackwork as it follows existing grades; slopes that exceed 2% are not ideal. See **Figure 9** and **Appendix C** for the proposed track layout and operations for East Falls Church Alternative 1.

Figure 9: East Falls Church Alternative 1 (Crossover East) Operations Schematic



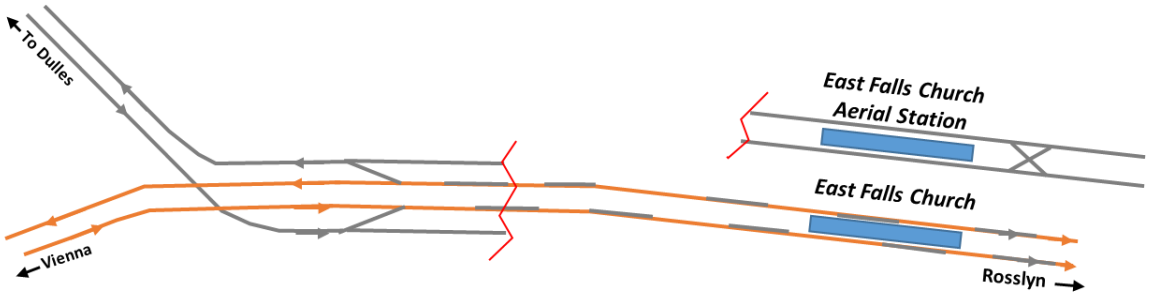
3.2 East Falls Church Alternative 2 – Aerial Station

East Falls Church Alternative 2 consists of two elevated tracks above the current right-of-way and a new platform above the existing station. This alternative would involve approximately 5,000 feet of elevated structure. The foundations of the proposed aerial structure would be driven under I-66, potentially resulting in temporary closures and/or permanent realignment of the highway. However, it would avoid relocating overhead bridges and other structures by building over them.

Every Silver Line train turning-back would bypass the existing Orange/Silver line merge and continue to two elevated tracks accessing the new aerial platform; the two Silver Line trains continuing through to Largo would use the existing Orange Line merge and access the existing station platform. Eastbound Silver Line trains turning-back would clear the new platform at the aerial station and switch to the crossover tracks before turning around for the westbound trip.

Passengers wanting to continue their trip eastbound would need to transfer from the aerial platform to the lower platform and transfer to the Orange Line and conversely for the westbound trip. This alternative requires vertical circulation for passenger transfers; however, it also offers the potential long-term separation of Orange and Silver Lines. See **Figure 10** and **Appendix C** for the proposed track layout and operations for East Falls Church Alternative 2.

Figure 10: East Falls Church Alternative 2 (Aerial Station) Operations Schematic



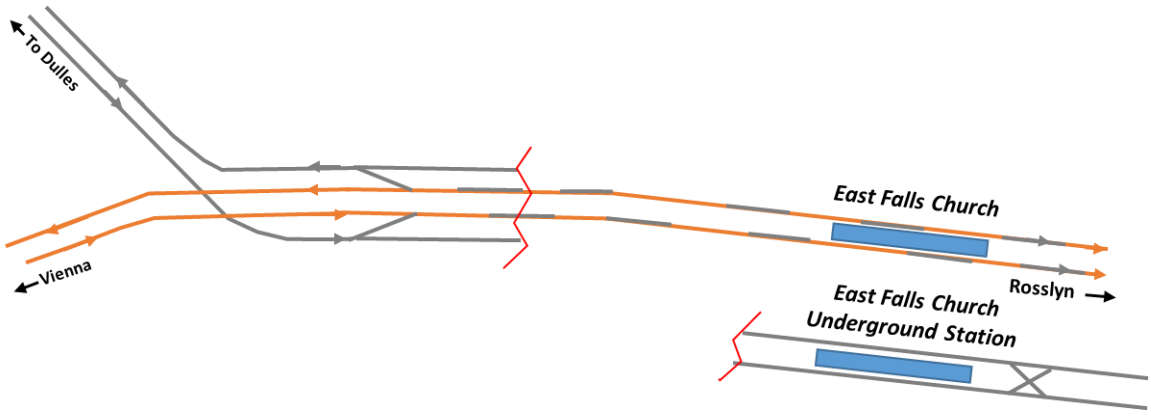
3.3 East Falls Church Alternative 3 – Underground Station

East Falls Church Alternative 3 is an underground station with a configuration comparable to the aerial structure proposed in Alternative 2. Two new tracks and a platform are added below the existing station platform and tracks. Two new tracks would carry Silver Line trains from the Dulles Toll Road to a new subway portal east of Great Falls Street, where the new Silver Line right-of-way would travel underground to the new subsurface station. Impacts to the foundations of the existing station and the adjacent I-66 highway would need to be assessed. East Falls Church Alternative 3 would have the same constructability considerations as Alternative 2 (See **Section 3.2**).

Every Silver Line train turning-back would bypass the existing Orange/Silver line merge and continue to two underground tracks accessing the new underground platform; the two Silver Line trains continuing through to Largo would use the existing Orange Line merge and access the existing station platform. Eastbound Silver Line trains turning-back would clear the new platform at the underground station and switch to the crossover tracks before turning around for the westbound trip.

Passengers wanting to continue their trip eastbound would need to transfer from the underground platform to the existing platform and transfer to the Orange Line and conversely for the westbound trip. As with Alternative 2, this alternative requires vertical circulation for passenger transfers; however, it also offers the potential long-term separation of Orange and Silver Lines. See **Figure 11** and **Appendix C** for the proposed track layout and operations for East Falls Church Alternative 3.

Figure 11: East Falls Church Alternative 2 (Underground Station) Operations Schematic

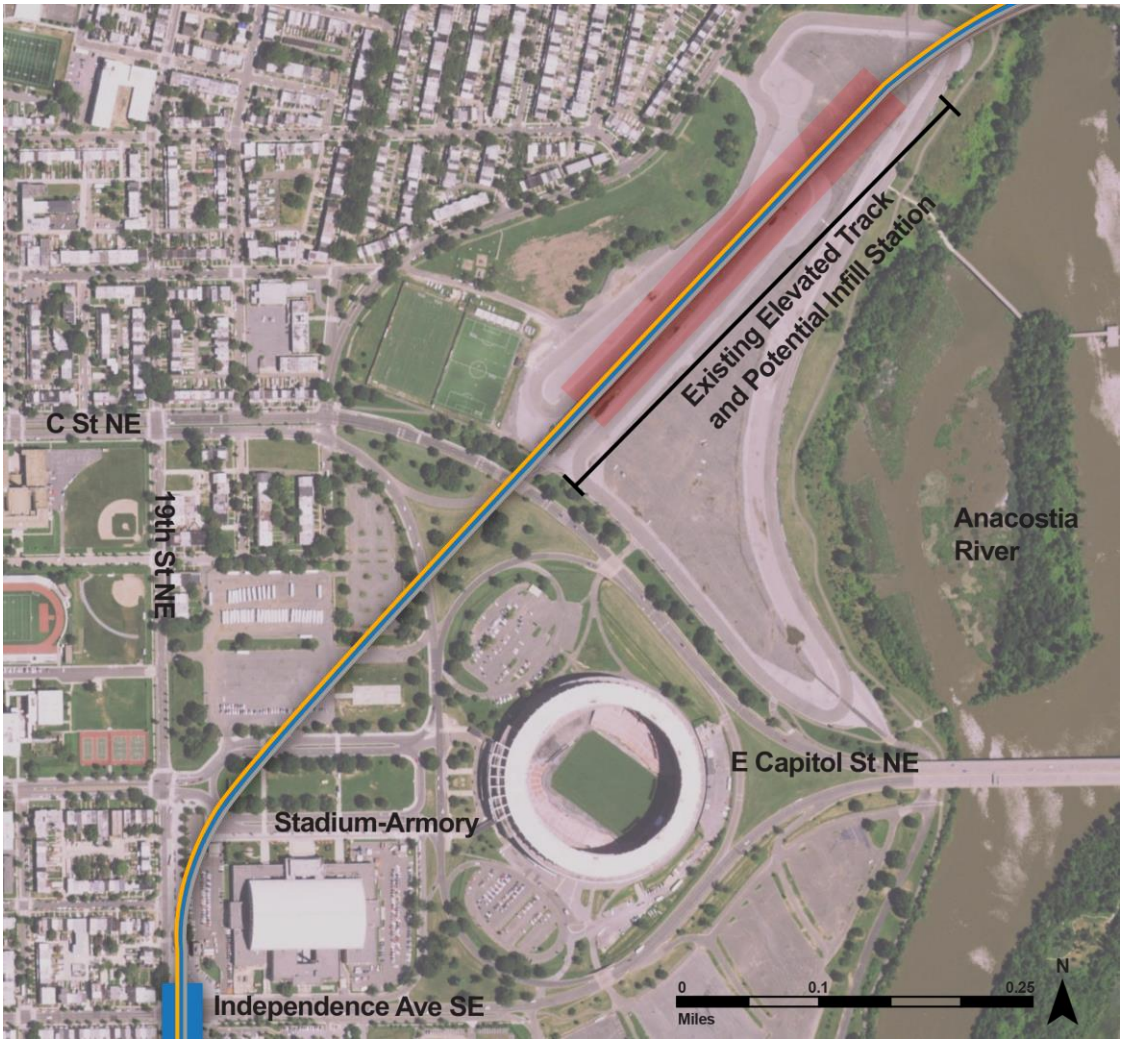


4. Stadium-Armory

Stadium-Armory Station is a below-grade station located in Washington, D.C. near the Anacostia River. Pedestrian access to the station is provided by two entrances, one located at 19th Street SE and C Street SE, and the other at 19th Street SE and A Street SE. This is the last eastbound station that serves all three lines (Orange, Silver, and Blue) before the D&G Junction, where the Orange Line splits from the Silver and Blue Lines. At this junction, the Orange Line travels towards New Carrollton and the Silver and Blue Lines travel towards Largo Town Center.

West of the station, Metrorail tracks travel below ground towards downtown D.C. East of the station, the Metrorail tracks gradually incline from below ground to an aerial structure traversing Benning Road NE. The aerial structure parallels Benning Road and includes a pocket track and the D&G Junction.

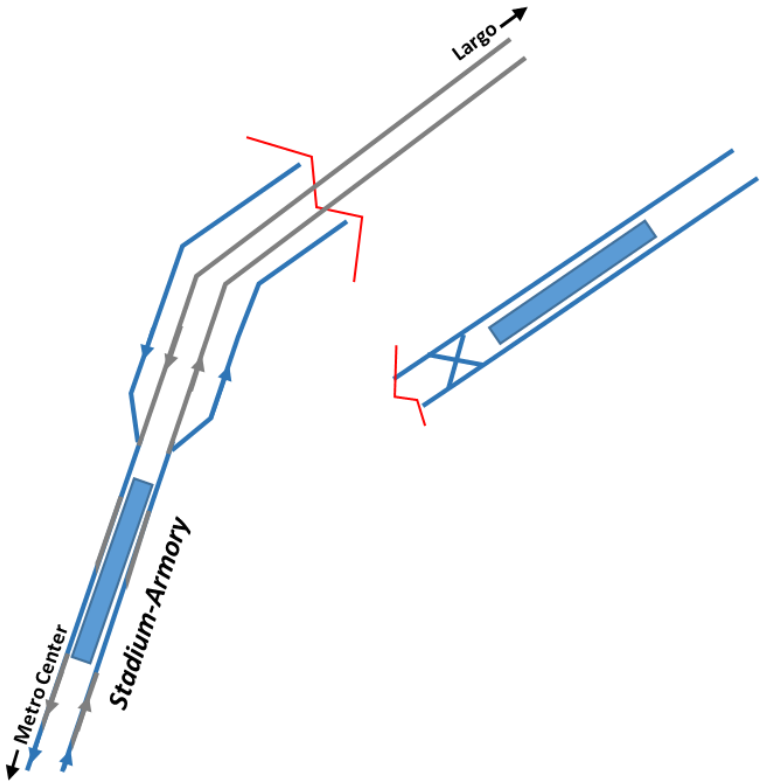
Figure 12: Stadium-Armory Station Context



The Stadium-Armory alternative anticipates all Blue Line trains to turn back and terminate at a new station. The turn back of Blue Line trains will save five trains per hour from peak period operations, presumably 8-car trains as noted in the base case scenario. Using this new facility to turn Blue Line trains rather than Silver trains would enable Metro to retain adequate service to all stations east of Stadium-Armory Station and maintain service standards of six-minute frequencies during peak periods.

The Stadium-Armory Alternative involves adding two tracks within the tunnel, using new No. 15 turnouts northeast of the Stadium-Armory Station platform to tie in to a new infill station at the north end of the RFK Stadium site. This new infill station would serve as the terminus for the Blue Line; passengers needing to continue eastbound would have to transfer at the Stadium-Armory Station before the Blue Line and Silver Line split. A tail track beyond the new infill station could be used for train layover as feasible based on track geometry and potential right-of-way and environmental constraints. In order to add a No. 15 Turnout north of the existing RFK stadium platform, careful operational consideration would be required as the available information indicates a slope of approximately 4%, which is very steep for special trackwork. See **Figure 13** and **Appendix C** for the proposed track layout and operations for the Stadium-Armory Alternative.

Figure 13: Stadium-Armory Alternative - Operations Schematic



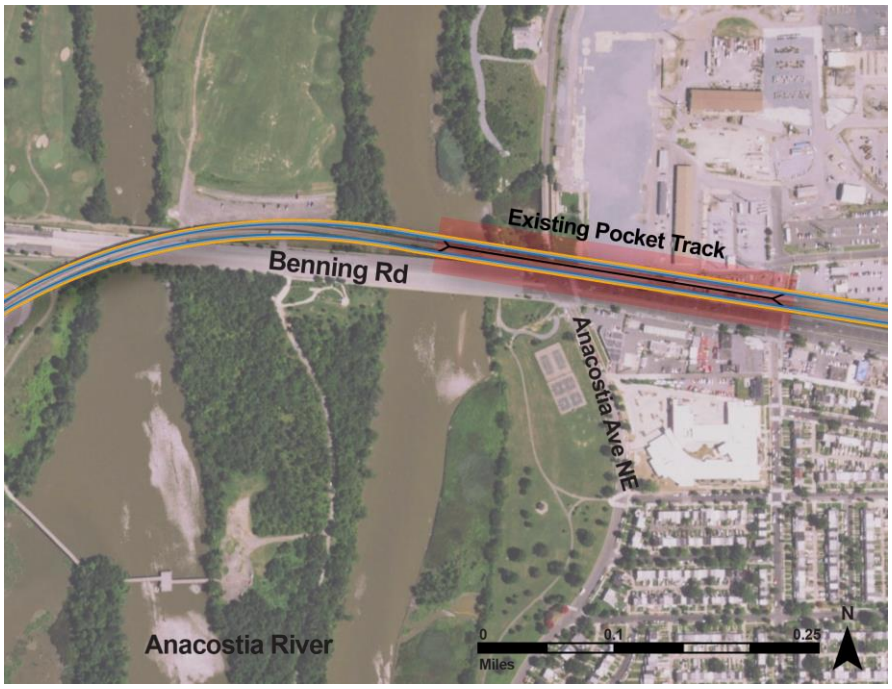
5. D&G Junction

The D&G Junction is an existing aerial junction located northeast of the Stadium-Armory Station (see **Figure 14**). The junction is near the intersection of Benning Road NE and 34th Street NE in the Washington, D.C. At this junction, Orange Line tracks from New Carrollton merge with Silver and Blue Line tracks from Largo Town Center. The elevated structure above Benning Road includes a pocket track located above Kingman Island.

The original operating plan for the Silver Line intended to turn all trains at the D&G junction using this pocket track, rather than continuing on to Largo Town Center. However, the pocket track's structure and configuration were determined to be insufficient as a terminus location, so trains are sent on to Largo Town Center. The existing pocket track can store one six-car train and stage relief trains, but it is not structurally suited for continual, all-day operations; is not long enough to store and deploy eight-car trains; and cannot provide enough start-up speed for trains re-entering service during peak periods without impacting schedules.

West of the junction, Metrorail tracks gradually decline from an aerial structure traversing Benning Road to below ground tunnels. East of the junction, the Orange Line splits from the Silver and Blue Lines. The Orange Line continues at-grade, paralleling CSX right-of-way, while the Silver and Blue Lines descend below ground.

Figure 14: D&G Pocket Track Context



In 2011, when preparing for Silver Line operations, Metro staff reassessed the FEIS operations and alignment and recommended significant changes. A detailed engineering review of the D&G Junction concluded that the structure could not safely nor sufficiently support consistent, all-day turnback movements, nor is the pocket track sufficient to handle eight-car trains. That engineering analysis identified several specific operational concerns:

- The pocket track at D&G junction is only 650 feet long, which is only 50 feet longer than an eight-car train. This would not allow the acceleration and deceleration required for Silver Line trains to move back into mainline service without major impacts on service headways.

- The existing #6 switch would need to be upgraded to at least a guarded #8 switch, as per National Transportation Safety Board (NTSB) recommendations; however, the structure lacks space to make this change. A #10 or greater switch is required to re-insert trains into peak-hour service without forcing schedule adjustments.

- The aerial structure needs to be reconstructed to allow a longer pocket track with higher-speed switches, but it would be expensive and time-intensive. Even if the reconstruction had begun in 2013, it would not have been ready in time for opening of Silver Line Phase I. The structure would also need to be retrofitted to support additional vibrations and stresses from short-turning additional trains.

This alternative seeks to action those recommendations by extending the pocket track westward as far as possible *without* requiring realignment and reconstruction of the entire bridge structure. Under that guideline, the existing pocket track can be extended approximately 170 feet from 650 feet in length to approximately 820 feet with minimal structural impacts. This alternative would also include upgrading the #6 turnouts (normal operating speed 22 mph) from the pocket track to the mainline tracks with #10 turnouts (normal operating speed 28 mph), which would provide enough distance and speed for stored trains to re-enter revenue service without disrupting peak-period schedules. The entire structure of the pocket track and turnouts would be rebuilt in order to ensure the structure can safely handle continuous, all-day train turnbacks. See **Figure 15** and **Appendix C** for the proposed track layout and operations for the D&G Junction alternative.

The D&G Junction operations impact analysis assumes use of the pocket track to turn Blue Line trains rather than sending them to Largo Town Center, saving five Blue Line trains per hour. Using base case scenario assumptions, this operational change will result in saving one 6-car train and one 8-car train during peak-period operations. Blue Line trains will use the D&G

Junction pocket track every twelve minutes during peak periods. Using a modified D&G Junction to turn Blue Line trains would enable Metro to retain Silver Line service to all stations east of Stadium-Armory Station and maintain service standards of six-minute frequencies during peak periods.

Figure 15: D&G Pocket Track Operations Schematic