



BL OR SV Capacity and Reliability Study

DRAFT Alternatives Development Report

January 2022



WASHINGTON METROPOLITAN AREA TRANSIT AUTHORITY

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1.0 INTRODUCTION

The Washington Metropolitan Area Transit Authority (Metro) launched the Blue, Orange, and Silver Corridor Capacity and Reliability Study (BOS Study, The Study) in 2019 to identify and evaluate potential solutions to several serious and long-standing challenges impacting transit service in the shared corridor, including:

- Passenger crowding,
- Capacity limitations,
- Issues with reliability and on-time performance,
- Lack of operational flexibility, and
- Need to further Metro’s sustainability and equity goals.

This report describes how concepts were developed into initial alternatives and then screened to select the alternatives advanced for evaluation.

1.1 Purpose and Need

Corridor needs were defined based on past corridor trends, previous studies of transit service in the corridor, forecasts of future corridor conditions, and review and comment by internal WMATA stakeholders, external stakeholders, and the public.

Four key needs for the BOS corridor are:

- Manage construction and disruptions;
- Preserve on-time performance;
- Meet ridership demand; and
- Improve operational flexibility.

Based on the corridor needs assessment, a problem statement was developed to guide the project (below). Four project goals and twelve related objectives were identified based on the project problem statement and needs assessment. These goals and objectives guided the development of solution concepts.

Problem Statement

Current Metrorail infrastructure and operational constraints in the BOS corridor limit the ability to:

- accommodate forecasted growth in population, employment, and Metrorail ridership over the next twenty years, resulting in passenger crowding at corridor stations and on trains that exceed acceptable WMATA standards;
- match service levels to variable demand across the corridor, driving up operating costs;
- respond quickly and efficiently to incidents and service disruptions, resulting in delays that rapidly spread across the corridor and to other lines in the system; and
- maximize service reliability for Metrorail riders.

Metro combined intensive data analysis and needs identification with robust stakeholder and public input to first identify a full “universe” of potential options (see section 0

Concepts), then applied a screening process (see section 0

Initial Alternatives Screening Process) to further narrow those options to the six alternatives described in section 5.0 Alternatives Evaluated.

1.2 Alternatives Development Methodology

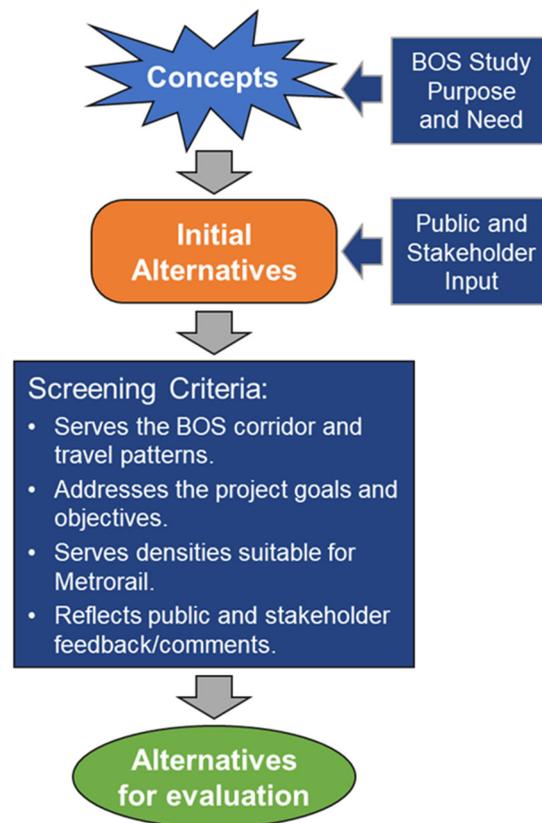
An initial set of concepts was identified that met requirements presented in the *BOS Corridor Purpose and Need Report*. The universe of alternatives included operational improvements and infrastructure investments focused on addressing corridor needs for additional transit capacity, enhanced reliability, more flexible operating plans, and sustainable development. These concepts were presented to the public through a series of open houses soliciting “creative and bold” feedback and the public delivered; public feedback resulted in a total of 275 additional concepts to consider.

These 275 concepts plus the six concepts presented during open houses were then whittled down to 16 initial alternatives. Each of these 16 alternatives was subjected to a four-step screening process, which considered whether the alternative:

1. Serves the BOS Corridor and travel patterns;
2. Addresses the project goals and objectives;
3. Serves densities suitable for Metrorail; and
4. Reflects public and stakeholder feedback/comments.

Alternatives that passed the first screen were advanced to the next screening step; those that did not pass the first screen were dropped from consideration. This process was followed for each step. Alternatives that passed the screening steps were recommended for more detailed study and evaluation.

Figure 1-1: Initial Screening Process



2.0 CONCEPTS

A set of corridor improvement concepts were developed for public review based upon the *Purpose and Need Report*. The concepts included the options recommended in previous studies, specifically the *2015 Junction Feasibility Study* and the *NOVA Core Capacity Study*. Alternatives that were deemed unworkable by stakeholders were removed from consideration. The figures below show conceptual maps along with key elements, benefits and trade-offs for each of the six concepts.

Figure 2-1: Concept 1 - Optional Train Turnbacks

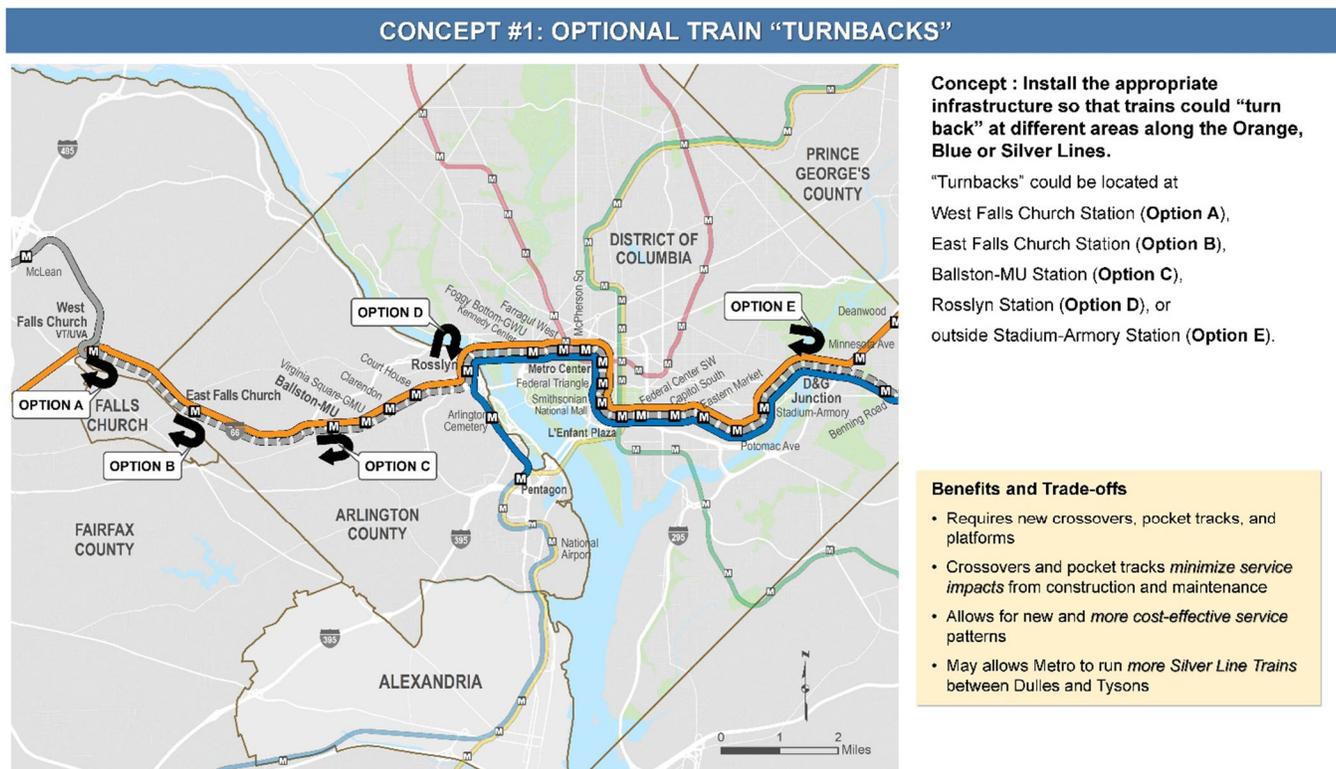


Figure 2-2: Concept 2 - NoVA Circulator

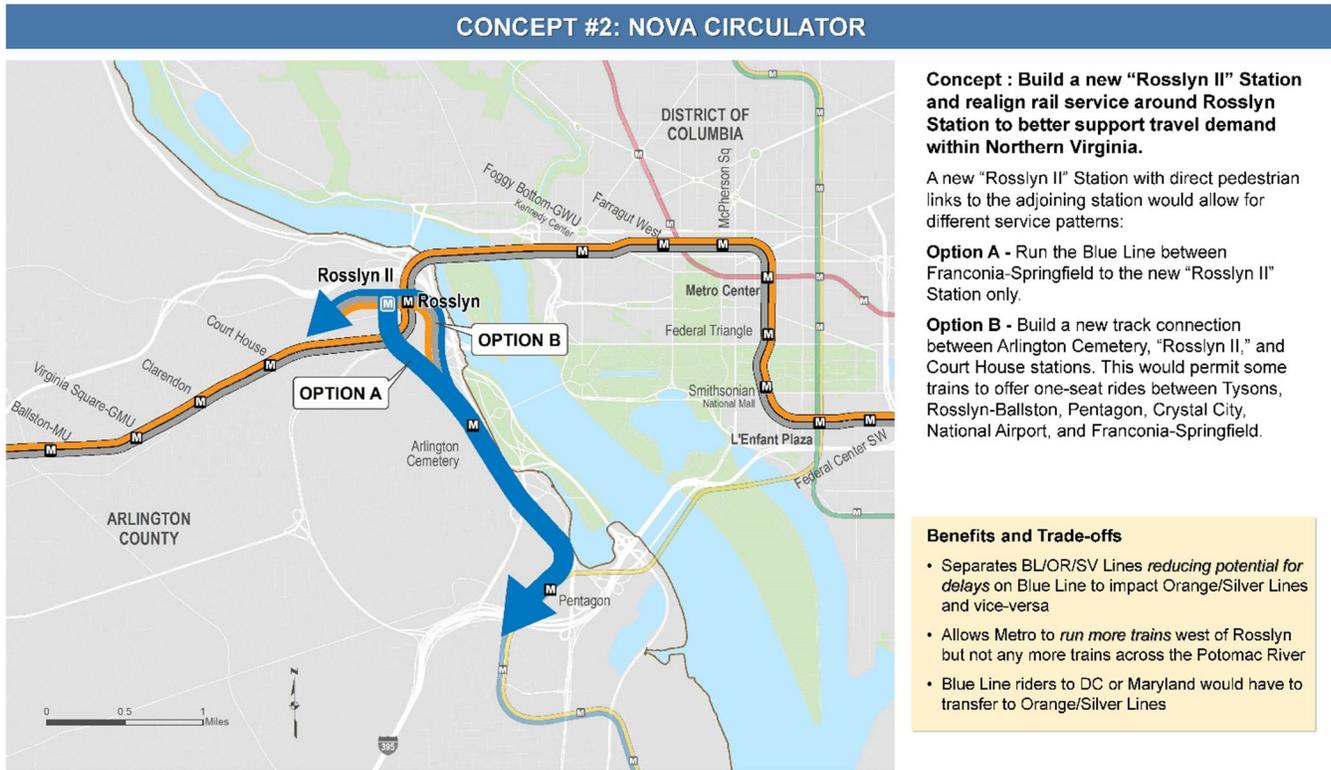


Figure 2-3: Concept 3 - New Blue Line Regional Connections

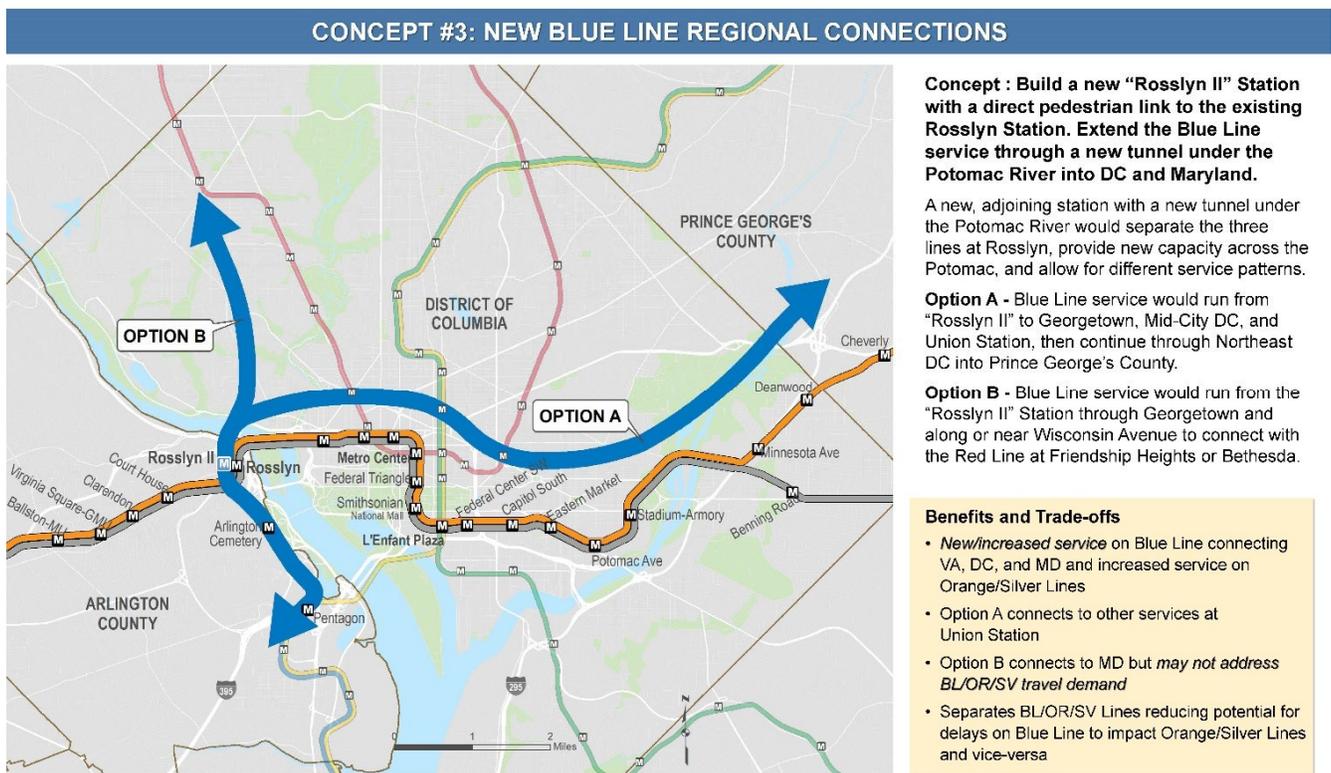


Figure 2-4: Concept 4 - New Core Loop

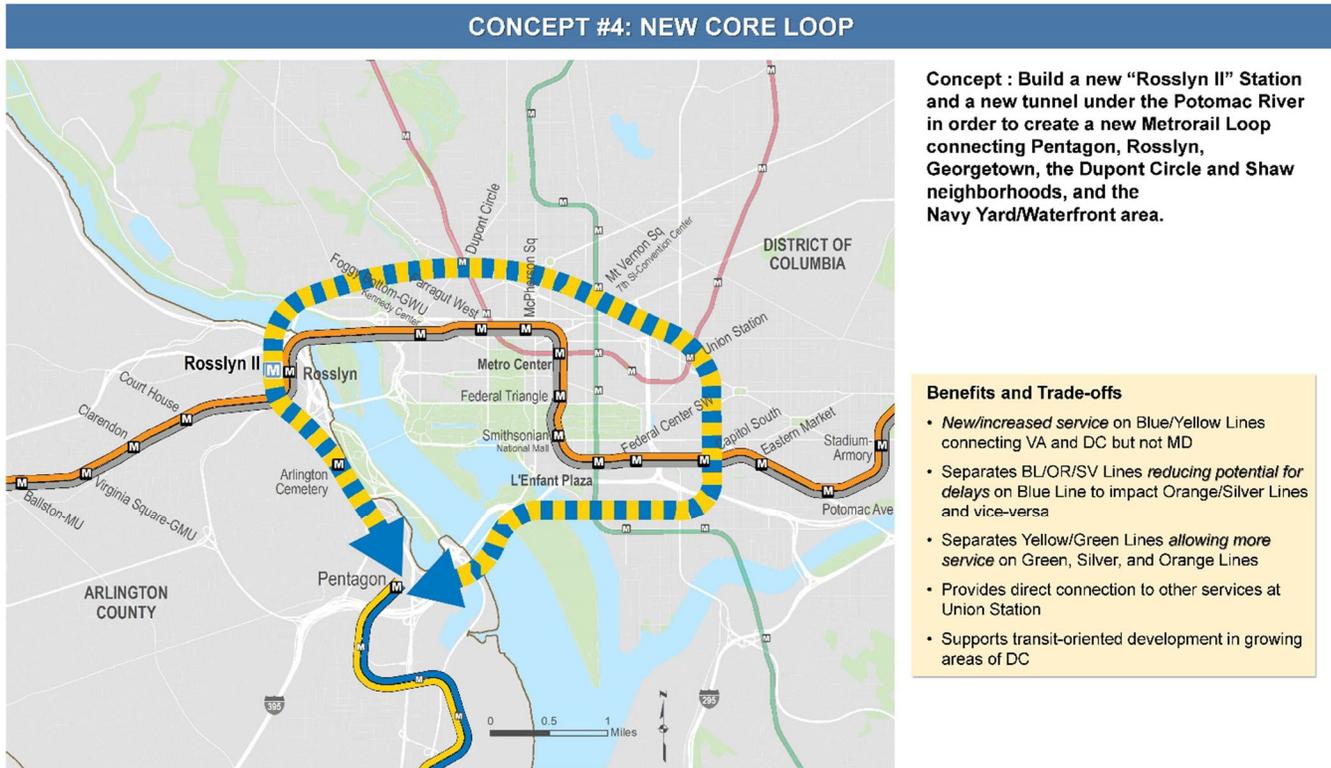


Figure 2-5: Concept 5 - New Silver Line Connections, North of I-66

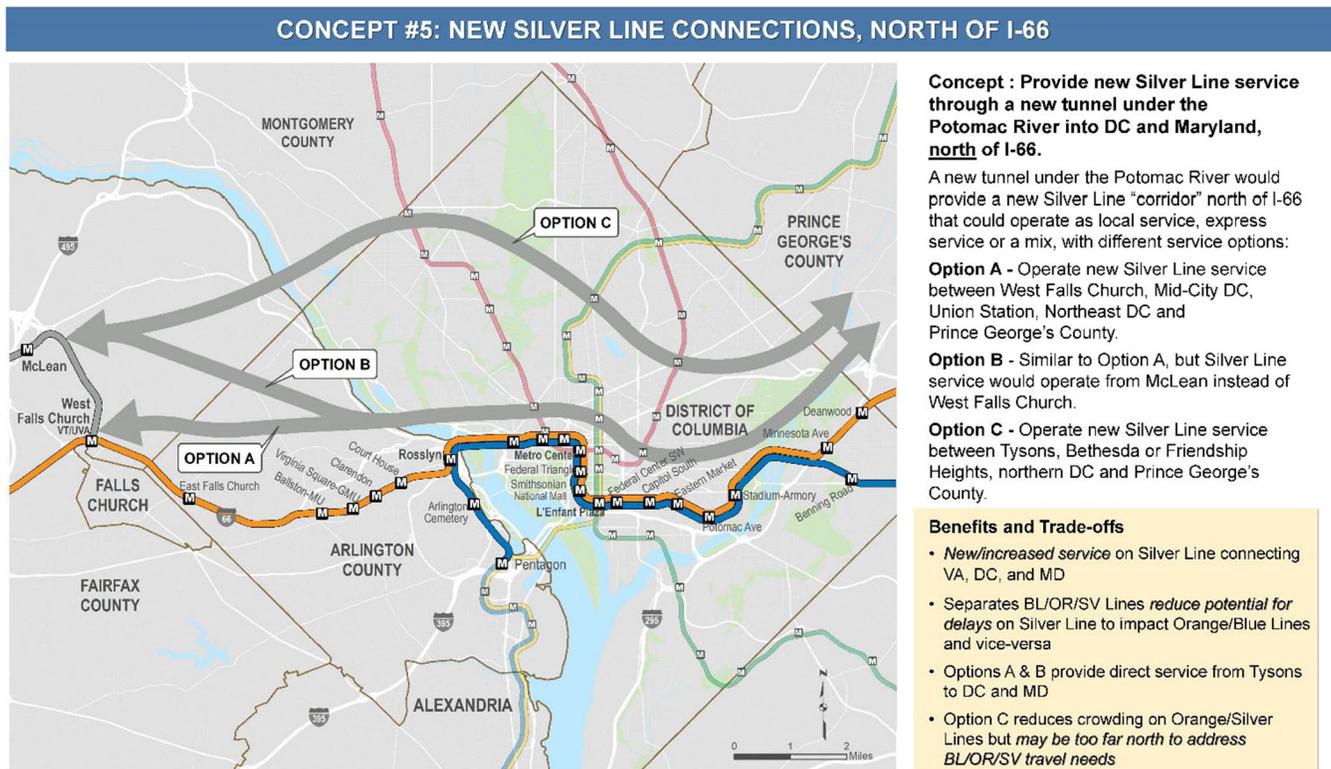
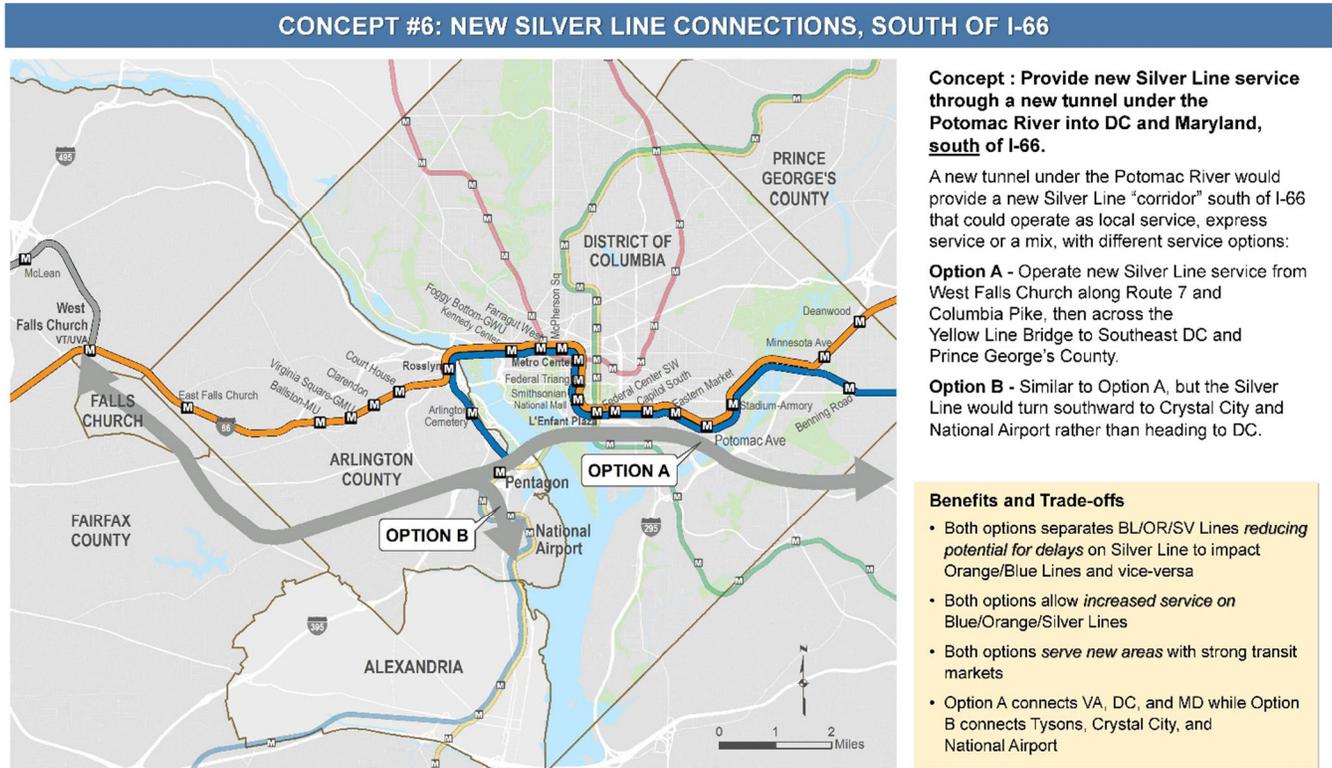


Figure 2-6: Concept 6 - New Silver Line Connections, South of I-66



In addition to the mapped concepts, an additional range of ideas for non-capital system-wide and operational improvements that could help address the study’s goals.

Figure 2-7: System-wide and Operational Improvements

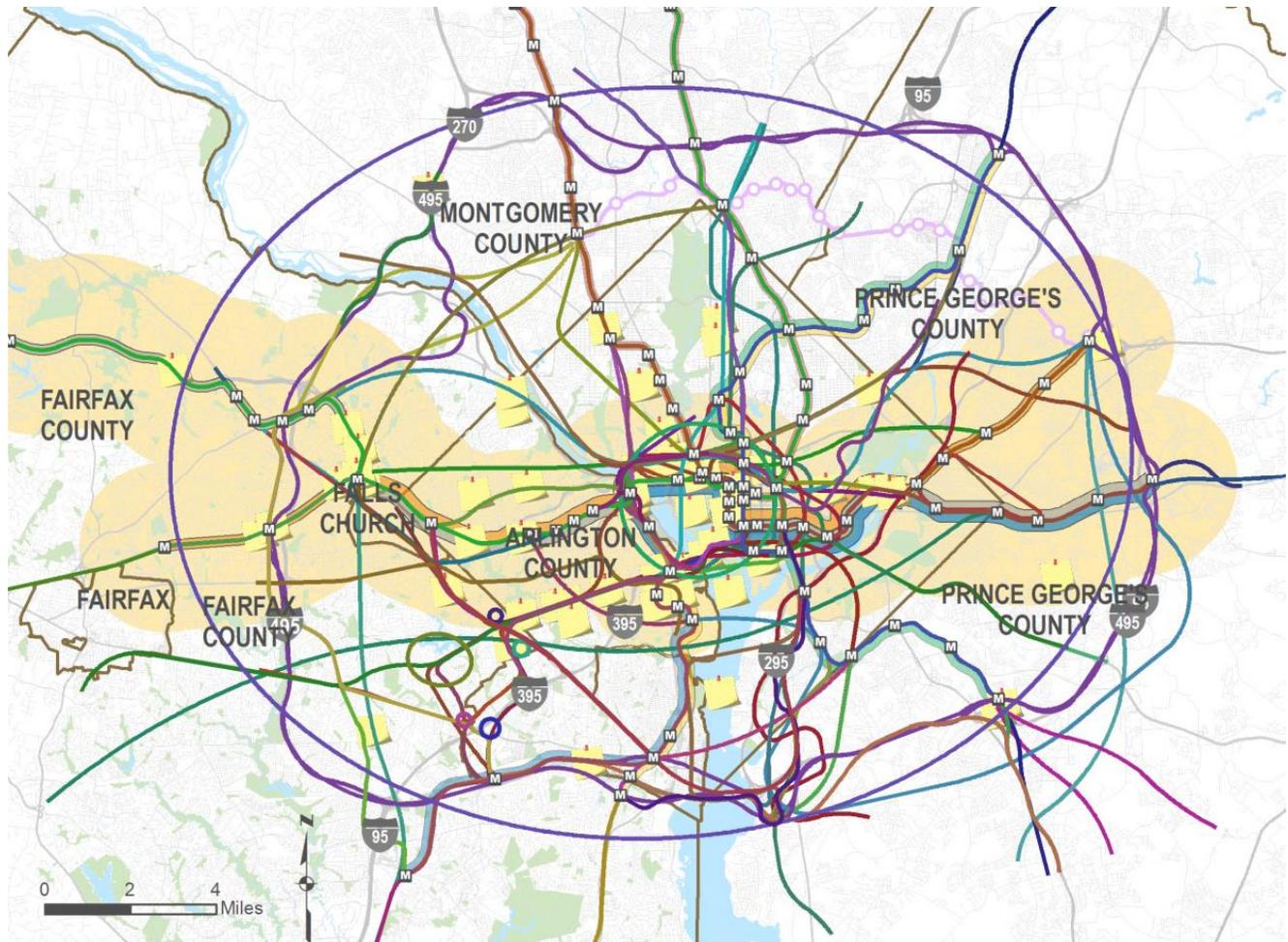
Operational strategies and general, systemwide improvements are identified that may increase capacity, reliability, flexibility, and sustainability on the Blue, Orange, and Silver Lines.

<div style="background-color: #f0f0f0; padding: 10px; border: 1px solid #ccc;"> <p>Pocket tracks and crossovers</p> <p>Install more pocket tracks and crossovers to allow Metro to better recover from incidents and minimize extent of single-tracking.</p> <p><i>Implementation*: 5-10 years</i></p> </div>	<div style="background-color: #f0f0f0; padding: 10px; border: 1px solid #ccc;"> <p>Expand core stations</p> <p>Create new entrances and pedestrian connections in the highest-traffic Blue, Orange, and Silver stations, to reduce crowding and move people faster.</p> <p><i>Implementation*: 5 years</i></p> </div>
<div style="background-color: #f0f0f0; padding: 10px; border: 1px solid #ccc;"> <p>Reconfigure train seats</p> <p>Reduce number of train seats or reconfigure seating arrangements to provide more space.</p> <p><i>Implementation: Depends on train overhaul schedule</i></p> </div>	<div style="background-color: #f0f0f0; padding: 10px; border: 1px solid #ccc;"> <p>Enhanced train control</p> <p>Explore the potential costs and benefits of implementing new train control technology. Note: this would be a very large and expensive capital project.</p> <p><i>Implementation*: 10-20 years</i></p> </div>
<div style="background-color: #f0f0f0; padding: 10px; border: 1px solid #ccc;"> <p>Enhance connections to stations</p> <p>Build or improve bike and pedestrian connections to stations. This will grow ridership by expanding the neighborhoods in easy walking and biking distance from stations, and support transit-oriented development.</p> <p><i>Implementation*: 1-5 years, ongoing</i></p> </div>	<div style="background-color: #f0f0f0; padding: 10px; border: 1px solid #ccc;"> <p>Enhancing parallel bus service</p> <p>Reduce crowding on rail by transferring some ridership demand to higher-frequency bus routes.</p> <p><i>Implementation*: 1-2 years</i></p> </div>

* - implementation timeframes are approximate.

Once the concepts were developed, they were presented to the public for feedback at four public open houses. At the open houses, participants could either sketch their ideas on maps or describe them on comment sheets. There were 137 attendees across the four open houses. In addition to the open houses, feedback was also obtained through an online survey that produced more than 2,000 responses. Survey respondents were invited to submit either general comments and ideas, or specific comments regarding each concept. Additional members of the public submitted ideas directly to Metro via email. Together, public engagement resulted in 275 additional concept ideas. **Figure 2-8** visualizes the range and extent of the new ideas that were suggested as part of the engagement process.

Figure 2-8: Corridor Improvement Ideas Submitted



Such a large “universe” of improvement concepts needed to be whittled down before a more detailed screening could be completed. The total 281 (six plus 275) concepts were reduced to 16 initial alternatives (section 3.0 Initial Alternatives) that were then screened according to the process described in section 0

Initial Alternatives Screening Process.

Four factors were used to eliminate concepts from further consideration:

1. Does the concept duplicate one of the six concepts presented to the public/stakeholders? *If yes, the concept was eliminated.*
2. Does the concept connect to an existing railyard? *If no, the concept was eliminated.*

3. Does the concept serve dominant BOS origin-destination pairs and travel patterns? *If no, the concept was eliminated.*
4. Can the concept be incorporated into one of the six concepts presented to the public/stakeholders? *If yes, the concept was incorporated into the relevant concept previously presented.*

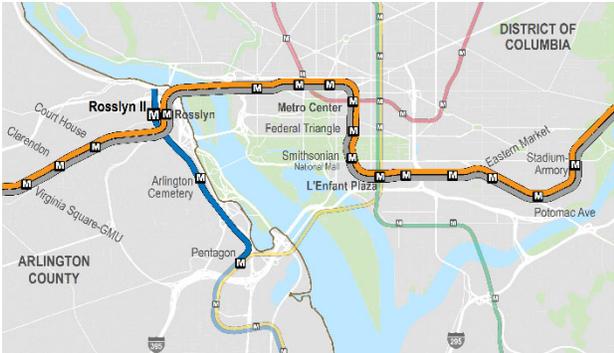
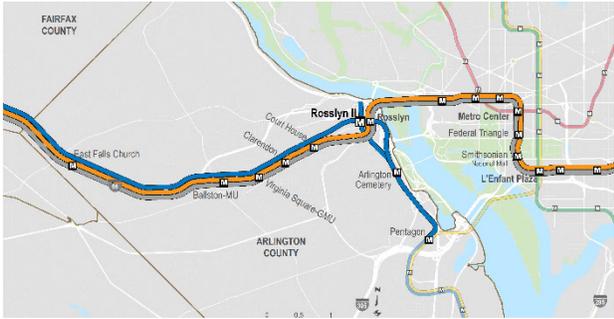
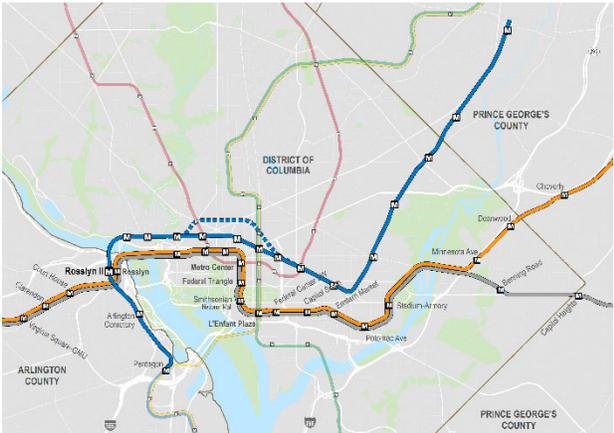
These factors ensured that advancing concepts were feasible from an operations perspective—connections to existing railyards—and would address the project’s Purpose and Need. Factors one and four ensured that concepts were mutually exclusive and of a reasonable total number to subject to additional screening.

Concepts eliminated through the refinement process have been saved as part of Metro’s intellectual library for future system planning efforts.

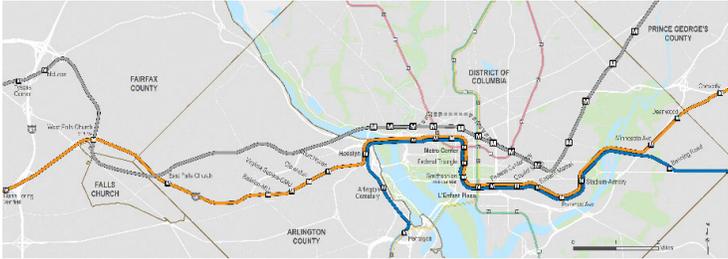
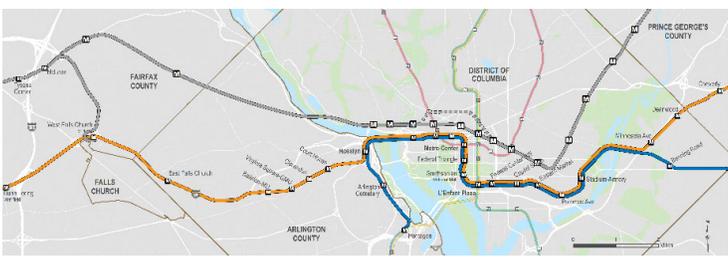
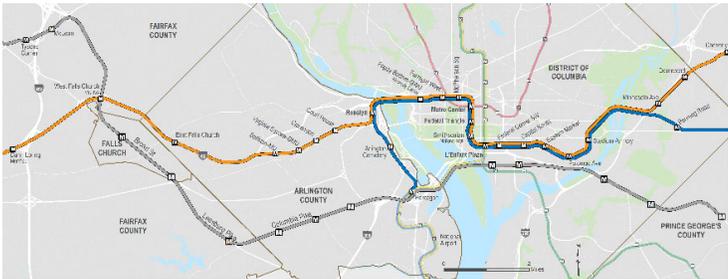
3.0 INITIAL ALTERNATIVES

After subjecting the 281 concepts to the refinement process described above, 16 initial alternatives remained. These are shown in **Table 3-1**.

Table 3-1: Initial alternatives.

No.	Alternative	Map
1	Optional Train Turnbacks Install the appropriate infrastructure so that trains could turn back at different areas along the Orange, Blue or Silver Lines.	
2A	Blue Line Terminus at Rosslyn II Station Build a new Rosslyn II station and realign Blue Line Between Franconia-Springfield and Rosslyn II station	
2B	NoVA Circulator Build a new track connection between Arlington Cemetery, Rosslyn II, and Court House Station. This would permit some trains to offer one-seat rides between Dulles Airport, Tysons, Rosslyn-Ballston, Pentagon, National Airport	
3A	New Blue Line – Georgetown, Union Station, Bladensburg Rd to College Park Blue Line service would run from Rosslyn II to Georgetown, Mid-City DC, and Union Station, then continue through Northeast DC into Prince George’s County.	

No.	Alternative	Map
3B	New Blue Line – Georgetown, Wisconsin Ave, to Bethesda	
	Blue Line service would run from the Rosslyn II station through Georgetown and along or near Wisconsin Avenue to connect with the Red Line at Friendship Heights to Bethesda	
3C	New Blue Line – Georgetown, Wisconsin Ave, to Bethesda	
	Blue Line service would run from Rosslyn II to Georgetown, Mid-City DC, and Union Station, then continue South connecting from Navy Yard to Anacostia Oxon Hill, National Harbor and crossing into VA	
4	New Core Loop	
	Build a new Rosslyn II station and a new tunnel under the Potomac River in order to create a new Metrorail Loop connecting Pentagon, Rosslyn, Georgetown, Union Station, and the Navy Yard/Waterfront area.	

No.	Alternative	Map
5A	New Silver Line – West Falls Church, Mid-City DC, Union Station and to College Park	
<p>Provide new Silver Line service through a new tunnel under the Potomac River into DC from West Falls Church, Mid-City DC, Union Station and to College Park</p>		
5B	New Silver Line – McLean, Mid-City DC, Union Station and to College Park	
<p>Provide new Silver Line service through a new tunnel under the Potomac River into DC from McLean, Mid-City DC, Union Station and to College Park</p>		
5C	New Silver Line – McLean Friendship Heights, Rhode Island and to College Park	
<p>Provide new Silver Line service through a new tunnel under the Potomac River into DC from McLean, Friendship Heights, Rhode Island and to College Park</p>		
5D	New Silver Line – Rosslyn II, Mid-City DC, Cheverly and to New Carrollton	
<p>Provide new Silver Line service through a new tunnel under the Potomac River into DC from Rosslyn II, Georgetown, Mid-City DC, Cheverly and to New Carrollton</p>		
6A	New Silver Line - West Falls Church, Rt 7, Columbia Pike, Southeast DC and to Prince George’s County	
<p>Provide new Silver Line service from West Falls Church along Route 7 and Columbia Pike, then across the Yellow Line Bridge, Southeast DC, and to Penn and Silver Hill Rd in Prince George’s County</p>		

No.	Alternative	Map
6B	New Silver Line - West Falls Church, Rt 7, Columbia Pike, Pentagon, and to National Airport	
Provide new Silver Line service from West Falls Church along Route 7 and Columbia Pike, then turn southward to Crystal City and National Airport		
6C	New Silver Line - West Falls Church, Rt 7, Columbia Pike, Southeast DC and to Union Station	
Provide new Silver Line service from West Falls Church along Route 7 and Columbia Pike, then across the Yellow Line Bridge, Southeast DC, and to Union Station		
6D	New Silver Line - West Falls Church, Rt 7, Columbia Pike, Farragut, 16 th St, and to Silver Spring	
Provide new Silver Line service from West Falls Church along Route 7 and Columbia Pike, then across the new tunnel under Potomac to Farragut and along 14/16th St to Silver Spring		
6E	New Silver Line - West Falls Church, Rt 7, King Street, National Harbor, Anacostia and to Union Station	
Provide new Silver Line service from West Falls Church along Route 7 to Old Town Alexandria, then across the Potomac to National Harbor, and turn North along South Capitol St to Union Station		

4.0 INITIAL ALTERNATIVES SCREENING PROCESS

The 16 initial alternatives were then screened based on the four criteria listed below. Each initial alternative was assessed against the criteria in order; if an initial alternative did not meet the first criteria, it was eliminated. If it did meet the first criteria, it moved on to be assessed against the second, and so on.

- Does the alternative serve BOS Corridor travel patterns and can it relieve projected Metrorail passenger crowding?
- Does the alternative address the goals established for the project?
- Does the alternative serve areas with projected population and employment densities suitable for Metrorail service?
- Does the alternative consider potential stakeholder and public support and comments?

Each of these questions became screening steps. Screening narrowed the number of alternatives under consideration at each step, and only alternatives that passed each of the four screening steps were recommended for more detailed study and evaluation.

The No-Build Alternative was used as the baseline from which the alternatives were measured. The No-Build Alternative includes the existing regional transportation system, completion of the Silver Line Phase II (currently under construction), as well as other projects already included in WMATA's capital improvement program (CIP) and the National Capital Region (NCR) Transportation Planning Board (TPB)'s fiscally-constrained long-range transportation plan. The No-Build Alternative was not subjected to screening and will be advanced to more detailed evaluations – it will serve as the baseline for measuring the potential benefits of the “build” alternatives.

The results of the screening are presented in a matrix format that lists the universe of alternatives, the results of each step in the screening process, and which alternatives progressed to subsequent stages. This matrix can be found in **Table 4-15**. The alternatives that passed all screens successfully were advanced for more detailed study and evaluation of costs and benefits. Those detailed evaluations will provide the basis for recommending a Locally-Preferred Alternative (LPA) for consideration and potential approval by WMATA's General Manager and Board of Directors.

Two additional factors were considered when reviewing alternatives: estimated implementation time and construction cost. Neither factor was used to eliminate alternatives, although they may have impacted public/stakeholder opinion. Implementation timeframes were estimated at five years, 5-10 years, or 20-25 years. Construction cost could be low, medium, high, or very high.

4.1 Step 1: Serves the BOS Corridor and Travel Patterns

The first step assessed whether the potential alternative serves the BOS Corridor. Alternatives were evaluated to determine their potential to improve BOS Corridor operations by providing significant relief to passenger crowding in the core area between the Court House and Foggy Bottom stations.

Methodology

Step 1 assessed an alternative's ability to divert a significant amount of peak hour, peak direction trips from existing BOS lines to the new alternative connection to reduce the projected 2040 crowding on the existing BOS lines from between 108 and 119 passengers per railcar (PPC) to a more optimal level of 100 PPC. To achieve this needed reduction, an average of at least 2,500 passengers traveling in the peak hour and peak direction from the existing BOS lines would need to divert to a new Metrorail connection in the vicinity of the Rosslyn Station and Potomac River crossing. **Table 4-1** below shows the calculation of the number of peak hour and peak direction passenger trips needed to be diverted from existing BOS Line trains.

Table 4-1: Method for Estimating Number of Diverted Passenger Trips Needed to Reduce Crowding to Optimal Levels at Potomac River Crossing

Item	Value
A. 2040 forecast average PPC in peak hour and peak direction	108
B. Optimal average PPC (<i>Less than 100</i>)	97
C. Reduction in passenger trips per car to meet optimal level ($A - B$)	11
D. Cars per train (<i>assumes all eight-car trains</i>)	8
E. Reduction in passenger trips per train to meet optimal level ($C \times D$)	88
F. Maximum trains per hour (<i>WMATA Standard</i>)	26
G. Needed minimum passenger trip diversion from existing BOS trains ($E \times F$)	2,288
H. Needed minimum passenger trip diversion from existing BOS trains (<i>Rounded to nearest 500</i>)	2,500

The values shown in the table above represent crowding at the Potomac River crossing between Rosslyn and Foggy Bottom, which was used as a natural screen line location for this analysis since all three lines (Blue, Orange, and Silver) make this connection and can be used as a point of comparison for all the alternatives. However, the link between Court House and Rosslyn is forecast to include potentially higher levels of crowding than at the river crossing. The more detailed evaluations for the alternatives that pass this initial screening considers the ability to accommodate forecast ridership for this high-volume link.

To measure the ability of the alternatives to divert trips from the existing BOS Lines to a new Metrorail connection, the total forecast station to station trip table based on the 2040 Metropolitan Washington Council of Governments (MWCOC) travel demand model was used to identify all of the potential trip interchanges that may shift due to a shorter or more direct route via a new Metrorail connection. These trips were summed to determine the total number of trips that may be diverted from the crowded BOS segments to the new alternative connection.

An alternative was considered successful if it diverted at least 2,500 peak hour peak direction trips. Alternatives that did not divert 2,500 trips were removed from consideration.

Table 4-2: Step 1 Rating Thresholds

Rating	Threshold
	$\geq 2,500$ peak hour, peak direction trips diverted
	$< 2,500$ peak hour, peak direction trips diverted

Trip Diversions by Initial Alternative

To measure how many station-to-station trips would be diverted, it was assumed that any trips from the existing BOS Potomac River crossing would be diverted if there was a more direct route or shorter travel time via the proposed new Metrorail river crossing. For example, Alternative 3A proposes a new Potomac River crossing that would divert the Blue and Yellow Line trips crossing the river to Red (A) Line trains towards Shady Grove. It also assumed that trips destined to locations north of the Foggy Bottom, Farragut West, and McPherson Square Stations would be diverted because the new stations would be within a shorter walking distance than the existing stations. Detailed station-to-station origin-destination pair calculations and maps for each initial alternative are shown in Appendix A.

AM peak hour trips are currently about 18% of the total daily trips. This percentage is projected to increase to 21% by 2040. Based on the MWCOG 2040 travel demand model, the directional split of trips at the Potomac River crossing is projected to be 78% inbound and 22% outbound. To calculate the peak hour peak direction trips, the number of daily trips is multiplied by the percentage of peak hour trips as well as the directional split proportion. The formula and an example are depicted below, and the number of peak hour peak direction trips for each of the alternatives is displayed in **Table 4-3**.

$$\text{Total Trips} \times \text{Peak Hour Proportion} \times \text{Directional Split} = \text{Peak Hour Peak Direction Trips}$$

$$25,260 \times 0.21 \times 0.78 = \mathbf{4,100} \text{ (rounded)}$$

Table 4-3: Daily Trips and Peak Hour Peak Direction Trips Diverted at Potomac River crossing by Alternative Concept

Alternative	2040 Daily Trips Diverted	2040 Peak Hour Peak Direction Trips Diverted
1	-	-
2A	-	-
2B	-	-
3A	25,300	4,100
3B	5,600	900
3C	25,300	4,100
4	25,300	4,100
5A	28,500	4,700
5B	16,500	2,700
5C	7,800	1,300
5D	49,100	8,000
6A	4,200	700
6B	-	-
6C	7,600	1,200
6D	3,600	600
6E	-	-

Source: Station-to-station flows (trips) considered for this analysis are based on the 2040 Line Load data from WMATA, which projected the Metro ridership using WMATA short-term forecasts data and long-term forecasts from MWCOG model.

Step 1 Results

Alternatives 2B, 3B, 5C, 6A, 6B, 6C, 6D, and 6E were eliminated at the first screening stage as they did not divert at least the minimum number of trips. Alternatives 1 and 2A were also eliminated but are suggested for incorporation into a larger capital improvement plan as they may still have significant positive impacts with minimal cost/time investment.

Alternatives 1 and 2A are the short-term alternatives that are recommended as part of the study final recommendations. Alternatives 3A, 3C, 4, 5A, 5B, and 5D) were advanced to the second screening step.

Table 4-4: Step 1 Results

Alternative	Description	Diverted Trips
1	Optional Train Turnbacks	None
2A	Blue Line Terminus at Rosslyn II	None
2B	NoVA Circulator	None
3A	New Blue Line – Georgetown, Union Station, Bladensburg Rd to College Park	4,100 peak hour peak direction trips
3B	New Blue Line – Georgetown, Wisconsin Ave to Bethesda	900 peak hour peak direction trips
3C	New Blue Line – Georgetown, Union Station, Anacostia, National Harbor, and across Wilson Bridge to Franconia	4,100 peak hour peak direction trips
4	New Core Loop	4,100 peak hour peak direction trips
5A	New Silver Line – West Falls Church, Mid-City DC, Union Station to College Park	4,700 peak hour peak direction trips
5B	New Silver Line – McLean, Mid-City DC, Union Station to College Park	2,700 peak hour peak direction trips
5C	New Silver Line – McLean Friendship Heights, Rhode Island to College Park	1,300 peak hour peak direction trips
5D	New Silver Line – Rosslyn II, Mid-City DC, Cheverly to New Carrollton	8,000 peak hour peak direction trips
6A	New Silver Line – West Falls Church, Rt 7, Columbia Pike, SE DC and to Prince George’s County	7000 peak hour peak direction trips
6B	New Silver Line – West Falls Church, Rt 7, Columbia Pike, Pentagon and to National Airport	None
6C	New Silver Line – West Falls Church, Rt 7, Columbia Pike, SE DC and to Union Station	1,200 peak hour peak direction trips
6D	New Silver Line – West Falls Church, Rt 7, Columbia Pike, Farragut, 16 th St and to Silver Spring	600 peak hour peak direction trips
6E	New Silver Line – West Falls Church, Rt 7, King Street, National Harbor and to Union Station	None

 short-term alternatives

 alternatives advanced to next step

4.2 Step 2: Addresses Project Goals and Objectives

The six alternatives advanced from Step 1 were reviewed based on their support of the goals established for the project.

- Goal 1: Provide sufficient rail capacity to serve ridership demand.
- Goal 2: Improve reliability and on-time performance.
- Goal 3: Improve operational flexibility and cost-efficiency.
- Goal 4: Provide transportation options that support sustainable development and expand access to opportunity.

The public demonstrated strong support for Goals 1 and 4 during open houses and online surveys, so these two goals were emphasized more heavily in the screening process.

Goal 1: Provide Sufficient Rail Capacity to Serve Ridership Demand

For Goal 1, the new Metrorail connections for the alternatives were modeled using the MWCOG 2040 travel demand forecasting model to determine the potential ridership at the key chokepoint in the corridor – the Rosslyn/Potomac River crossing. The screening considered how each alternative impacts net ridership changes, passenger carrying capacity across the river, and crowding at the river crossing. Alternatives that have the potential to increase Metro ridership, provide capacity to accommodate the forecasted ridership, and reduce the crowding on the existing BOS lines to less than 100 Passengers Per Car (PPC) were rated best for this goal.

Assumptions for the ridership and capacity analysis used in the screening process are described below. Ridership analysis for alternative screening was performed using a combination of the WMATA Line Load Application with short-term ridership forecasts, the recently adopted regional model, and population and employment growth forecasts.

WMATA Line Load Application

The Line Load Application is custom designed software that allows WMATA to estimate how crowded trains are based on origin-destination data, or where on the system passengers enter and exit. To develop an estimate for 2040, Line Load uses trip growth factors based on WMATA's Short-Term Ridership Forecast (July 2018). It adds trips for new Metrorail stations based on station-to-station forecasts generated by the MWCOG regional travel model. Line Load provides a baseline forecast of passengers by segment and indicates maximum load points, like the Potomac River crossing. The maximum load volume serves as the No-Build baseline.

Regional Travel Demand Model

The regional travel demand model used for the screening is the MWCOG TPB Version 2.3.75 Travel Demand Model. The model was used to forecast ridership for select alternatives, especially the load volume for the segment across Potomac River. The difference in the load volumes was computed by modeling the alternatives against the baseline to determine each alternative's anticipated effect on crowding. Due to time and resource constraints, the model runs were limited to Alternative 2A, 3A, 4A, 5A, and 6A. The remaining alternatives were evaluated by pivoting off these selected alternatives, using the population and employment growth forecasts in the alternative corridors.

The Version 2.3.75 Travel Demand Model was recently adopted and used in the Air Quality Conformity Determination of the 2018 Financially Constrained Long Range Transportation Plan (Visualize 2045) and FY 2019-2024 Transportation Improvement Program (TIP), reflecting the latest regional planning assumptions.

Two major inputs to the model include: 1) the transportation network that represents the long-range plan Visualize 2045 and FY 2019-2024 TIP, and 2) MWCOG Round 9.1 Cooperative Land Use Forecasts.

Capacity Assumptions

For the purposes of the capacity analysis, the AM peak hour capacity was calculated for the maximum load point between Rosslyn and Foggy Bottom. Capacity was calculated as the following:

- Peak hour trains = 60 minutes / peak headway
- Peak hour capacity = peak hour trains x 8 cars
- PPC = AM peak hour ridership (inbound) / peak hour capacity

Table 4-5 shows the forecasted 2040 AM peak hour ridership and assumed capacity for the Rosslyn-Foggy Bottom segment.

Table 4-5: Rosslyn-Foggy Bottom Ridership and Capacity, 2040

Line	From	To	Headways		Max. Load Points		AM Peak Ridership	
			Pk	OffPk	Pk Hr/Dir Trains	Pk Hr/Dir Cars	Total	PPC
Blue	Franconia	Largo	7.5	12	8	64	5,933	92.7
Orange	Vienna	New Carrollton	7.5	12	8	64	7,580	118.4
Silver	Ashburn	Largo	7.5	12	8	64	7,227	112.9
BOS Combined	Rosslyn	Foggy Bottom			24	192	20,740	108.0

For each of the initial alternatives, AM peak hour ridership and capacity for the Rosslyn-Foggy Bottom segment was projected. For alternatives that included a new Potomac River crossing between Rosslyn and Georgetown, the additional ridership and capacity for the new link was included in the totals. The rating of alternatives considers the following impacts.

- Change in Ridership
- Change in Capacity
- Change in Crowding

Rating thresholds for this goal are shown in Table 4-6.

Table 4-6: Step 2, Goal 1 Rating Thresholds

Rating	Threshold
	Increases Metrorail ridership and decreases crowding by more than 10%
	Increases Metrorail ridership and decreases crowding by less than 10%
	Results in a net loss in Metrorail ridership and/or no reduction in crowding

Alternatives 3A, 5A, 5B, and 5D performed well for this goal.

- Alternative 3A increases AM peak ridership by 31%, increases capacity by 50%, and reduces crowding by 13%. It potentially reduces ridership in the Rosslyn-Foggy Bottom to 95 PPC.
- Alternative 5A increases AM peak ridership by 17%, increases capacity by 83%, and decreases crowding by 36%. It potentially reduces ridership in the Rosslyn-Foggy Bottom to 69 PPC.
- Alternative 5B increases AM peak ridership by 17%, increases capacity by 67%, and reduces crowding by 30%. It potentially reduces ridership in the Rosslyn-Foggy Bottom to 76 PPC.
- Alternative 5D increases AM peak ridership by 6%, increases capacity by 50%, and decreases crowding by 29%. It potentially reduces ridership in the Rosslyn-Foggy Bottom to 77 PPC.

Alternatives 3C and 4 did not perform as well as the other alternatives. While they both increase ridership and capacity, they decrease crowding by less than 10%.

Goal 2: Improve Reliability and On-Time Performance

For Goal 2, initial alternatives were analyzed based on improving average travel times on existing Blue, Orange, and Silver Line routes, and increasing the single line (non-interlined) portion of the Corridor. Alternatives may provide opportunities for storage of eight-car disabled trains, shorten single-tracking within the study area, and/or allow for bypassing work zones. Average times that were within five minutes of existing travel times were rated best.

Table 4-7: Step 2, Goal 2 Rating Thresholds

Rating	Threshold
	Average travel time to core within 5 minutes of existing BOS lines, increases single line portion of corridor
	Average travel time to core between 6 and 9 minutes of existing BOS lines, increases single line portion of corridor
	No new connections to core or average travel time to core of 10 minutes or greater than existing BOS lines

Alternatives 3A, 5A, 5B, and 5D performed well for this goal.

- Alternative 3A provides new single line connections to the core with average travel time within three minutes of existing BOS travel times.
- Alternative 5A provides new single line connections with average travel times within one minute of existing BOS travel times.
- Alternative 5B provides new single line connections with average travel times within one minute of existing BOS travel times.
- Alternative 5D provides new single line connections with average travel times within three minutes of existing BOS travel times.

Alternatives 3C and 4 provide new single line connections but increase the average travel time.

Goal 3: Improve Operational Flexibility and Cost-Efficiency

Goal 3 considered whether the initial alternatives provide opportunities to incorporate features that improve flexibility in service patterns. This could include more crossovers, pocket tracks, storage tracks, or additional platforms. Alternatives could also provide new connections that allow for rerouting that is not currently possible. Alternatives were also evaluated for their relative capital costs and cost-efficiency, which was measured using the length of each Metrorail alignment.

Table 4-8: Step 2, Goal 3 Rating Thresholds

Rating	Threshold
	Opportunities to add new infrastructure to support flexible operations, < 15 miles in length
	Opportunities to add new infrastructure to support flexible operations, but 15 to 20 miles in length with higher cost or new connections that allow rerouting of BOS trains.
	No opportunities to add new infrastructure to support flexible operations and/or 15 to 20 miles in length with very high cost

Alternatives 3A and 5D performed well for this goal.

- Alternative 3A adds 13 miles of new Blue Line track with turnback opportunities.
- Alternative 5D adds 10 miles of new Silver Line track with turnback opportunities.

Alternatives 3C, 4, 5A, and 5B did not perform as well for Goal 3. Alternatives 3C, 5A, and 5B add more than 15 miles of service at a very high cost. Alternative 4 adds nine miles but provides additional interlining with the Blue and Yellow Lines.

Goal 4: Provide Transportation Options that Support Sustainable Development and Expand Access to Opportunity

BOS Corridor goals include supporting transit-oriented development (TOD) through connections to MWCOG-designated activity centers that are underserved by the current Metrorail system. Alternatives should promote higher density, transit-friendly development patterns where desired by local jurisdictions. The alternatives were also assessed based on ability to provide enhanced transit access to transit dependent and lower income communities; these areas are designated “Equity Emphasis Areas” (EEAs) by MWCOG.

Table 4-9: Step 2, Goal 4 Rating Thresholds

Rating	Threshold
	Total number of currently unserved activity centers served by the alternative plus number of new stations serving EEAs ≥ 10
	Total number of currently unserved activity centers served by the alternative plus number of new stations serving EEAs between 5 and 9
	Total number of currently unserved activity centers served by the alternative and number of new stations serving EEAs < 5

Alternatives 3A, 5A, and 5B performed well for this goal. Total scores are the number of activity centers served plus the number of new stations.

- Alternative 3A supports TOD in four activity centers not currently served by Metrorail and provides six new stations in EEAs. *Total = 10*
- Alternative 5A supports TOD in three activity centers not currently served by Metrorail and provides six new stations in EEAs. *Total = 9*
- Alternative 5B supports TOD in four activity centers not currently served by Metrorail and provides six new stations in EEAs. *Total = 10*

Alternatives 3C and 5D met the minimum threshold for advancement. Alternative 3C supports TOD in three activity centers and four new stations in EEAs (total = 7). Alternative 5D supports two TOD centers and three new stations in EEAs (total = 5). Alternative 4 failed to advance—it serves no new activity centers and only a single EEA station.

Step 2 Results

Alternative 4 was eliminated during the second screening stage. It failed to meet Goal 4 and rated in the middle for Goals 1 – 3. Alternatives 3A, 3C, 5A, 5B, and 5D progressed to Step 3.

Table 4-10: Step 2 Results

Alternative	Goal 1	Goal 2	Goal 3	Goal 4
		✓	✓	—
		—	—	—
4	—	—	—	✗
		✓	—	✓
		✓	—	✓
		✓	✓	—

☐ alternatives advanced to next step

4.3 Step 3: Serves Densities Suitable for Metrorail

The next screening phase determined if the initial alternatives served combined population and employment densities that would be suitable for Metrorail. “Suitability” was measured by calculating the total projected population plus employment per acre for 2040 within one-half mile of new Metrorail stations outside of the urban core. The combined population and employment density per acre for the new Silver Line Phase 2 was used as a standard threshold for what could be suitable for Metrorail, which were generally in the range of 25-35 population plus employment per acre. The thresholds for Step 3 are shown in Table 4-11.

Table 4-11: Step 3 Rating Thresholds

Rati	old
✓	> 30 persons plus employees per acre
—	20 - 30 persons plus employees per acre
✗	< 20 persons plus employees per acre

Alternatives 3A, 3C, 5A, 5B, and 5D varied in their success.

- Alternative 3A stations serve areas with 22 persons plus employees per acre.
- Alternative 3C stations serve areas with 21 persons plus employees per acre.
- Alternative 5A stations serve areas with 22 persons plus employees per acre.
- Alternative 5B stations serve areas with 18 persons plus employees per acre.
- Alternative 5D stations serve areas with 35 persons plus employees per acre.

Step 3 Results

Alternatives 3A, 3C, 5A, and 5D proceeded to Step 4 and Alternative 5B was eliminated.

Table 4-12: Step 3 Results

Alternative	Rating
3A	
3C	
5A	
5B	
5D	

alternatives advanced to next step

4.4 Step 4: Reflects Public and Stakeholder Feedback/Comments

The fourth and final step considered the results of the stakeholder and public comments from the online survey, open houses, and stakeholder meetings. This included the percentage of respondents expressing support for a particular alternative and stated preference for one option over another option. The thresholds are based on the percentage of respondents that supported the alternative and are shown in

Table 4-14.

Solicitation of Public Comments/Feedback

The team engaged both stakeholders and the general public through online surveys, open houses, and the BOS Study website (www.wmata.com/BOSstudy). Four open houses were held in December 2019 in George Mason University’s Van Metre Hall in Arlington, Virginia (12/9); George Washington University’s Marvin Center in Washington, DC (12/10); St. Margaret’s Church in Capitol Heights, Maryland (12/12); and Courtyard by Marriott Tysons-McLean in Tysons, Virginia (12/17). More than 137 people attended the four public open houses and submitted 78 paper worksheets.

The team reviewed the demographics of respondents and found that most respondents were between 21 and 40 years of age, primarily identified as male and white, and typically rode Metrorail at least five days each week. Most respondents reported household income greater than \$150,000 per year.

Analysis of Public Comments

Stakeholders and the public were presented with six concepts to review. They were asked “Are you in favor of this concept?”, and potential responses included “Yes,” “No,” “Not Sure,” and “I don’t understand this concept.” Concepts 3 and 6 received the most support, and strong support was also expressed for Concept 4. Concept 1, 2, and 5 received the lowest levels of support.

Figure 4-1: Survey Respondent Demographics

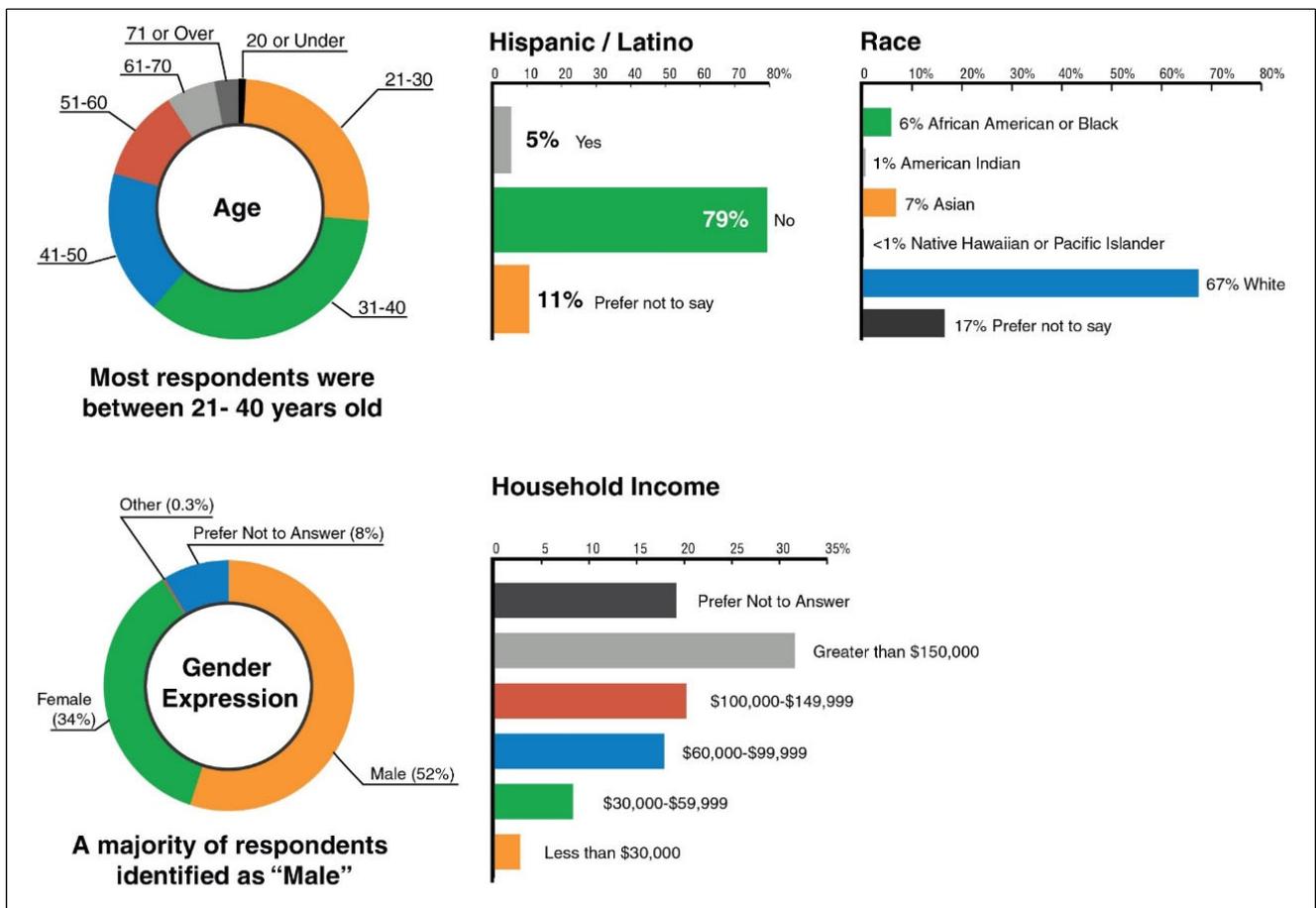


Table 4-13: Public Support for Concepts

Alternative	Description	Positive Feedback	Negative Feedback
Concept 1	Optional Train “Turnbacks”	41%	34%
Concept 2	NOVA Circulator	44%	35%
Concept 3	New Blue Line Regional Connections	61%	21%
Concept 4	New Core Loop	55%	25%
Concept 5	New Silver Line Connections North of I-66	42%	36%
Concept 6	New Silver Line Connections South of I-66	61%	24%

Step 4 Results

Feedback and comments were solicited for the six concepts, regardless of whether the alternative successfully completed Steps 1-3 of the screening process. Feedback was solicited on concepts as a whole and not the sub-concepts (such as 3A or 5C). Some concepts, like 1 and 4, had enough public support to advance in Step 4 but had been eliminated in previous steps. The four alternatives advanced to Step 4 (Alternatives 3A, 3C, 5A, and 5D) were successful at this screening stage and advanced for further consideration and development.

Table 4-14: Step 4 Rating Thresholds

Rating	Threshold
	> 50% support
	<50% support
	< 50% plus stated preferences for another alternative instead of the alternative being screened

4.5 Initial Alternatives Screening Matrix

The results of the screening process were consolidated into a single matrix. Each alternative has a row on the matrix. Columns provide the alternative identifier and description, estimated implementation timeframe, construction cost, results of each screening step, and whether the alternative advances to further refinement.

The results of the screening step are explained within each cell and provide clarification as to why an alternative succeeds or fails. The same icons displayed within this report are used in the matrix. The checkmark icon (blue) indicates that the alternative surpassed the minimum threshold and proceeds to the next screening step. A minus sign icon (orange) indicates that the alternative met the minimum threshold and advances to the next screening. The X icon (red) indicates that the alternative failed to meet the minimum threshold and that the alternative did not progress for further screening.

While Alternatives 1 and 2A show stop signs at the first screening step, they are recommended for further refinement. Neither of the alternatives will effect significant change by itself; however, they are low/medium cost and could provide operational or capacity improvements in the near term (within 10 years). This will improve the system while bigger BOS corridor capital projects are constructed.

Alternatives 2B, 3B, and 5C did not advance past the first screening stage, which tested how well the alternative served the BOS corridor and affected travel plans. All of the options related to Alternative 6 (A, B, C, D, and E) were also rejected as they did not divert the minimum trips required.

Step 2 evaluated each alternative against the project goals and objectives. Only Alternative 4 was eliminated during this screening step. Alternative 4 did not advance transportation options that reduced environmental impacts or advanced transit-oriented development.

Alternative 5B was removed at Step 3, as it did not serve areas with densities suitable for Metrorail.

The matrix may show information in Step 4 for alternatives that failed earlier steps. The public was invited to comment on all of the alternatives, so any feedback received is consolidated here.

Alternative 4 received positive feedback from the public, but it was not moved forward for refinement since it failed Step 2.

Table 4-15: Initial Alternatives Screening Matrix.

Initial Alternative No.	Initial Alternative Name	Estimated Implementation Timeframe	Construction Cost	Step 1: Serves the BOS Corridor Study and Travel Patterns?	Step 2: Addresses the Project Goals and Objectives?				Step 3: Does it Serve Densities Suitable for Metrorail?	Step 4: Public and Stakeholder Feedback/ Comments	POTENTIAL INITIAL ALTERNATIVE ADVANCES TO FURTHER REFINEMENT	Initial Alternative No.
					Goal 1: Provide Sufficient Rail Capacity to Serve Ridership Demand (Public Priorities Emphasized this Goal)	Goal 2: Improve Reliability and On-Time Performance	Goal 3: Improve Operational Flexibility and Cost-Efficiency	Goal 4: Provide Transportation Options that Support Sustainable Development and Expand Access to Opportunity (Public Priorities Emphasized this)				
1	Optional Train "Turnbacks"	5 Years	Low	✗	✗	—	✓	✗	N/A	—	SHORT TERM	1
2A	Blue Line Terminus at Rosslyn II Station	5 - 10 Years	Medium	✗	✗	—	—	✗	N/A	✗	SHORT TERM	2A
2B	NoVA Circulator	5 - 10 Years	Medium	✗	✗	✗	—	✗	N/A	—	NO	2B
3A	New Blue Line – Georgetown, Union Station, Bladensburg Rd to College Park	20 - 25 Years	High	✓	✓	✓	✓	✓	—	✓	YES	3A
3B	New Blue Line – Georgetown, Wisconsin Ave, to Bethesda	20 - 25 Years	High	✗	✗	—	✓	✗	✓	—	NO	3B
3C	New Blue Line – Georgetown, Union Station, Anacostia, National Harbor and across Wilson Bridge to Franconia	20 - 25 Years	Very High	✓	—	—	—	—	—	—	YES	3C
4	New Core Loop	20 - 25 Years	High	✓	—	—	—	✗	✓	✓	NO	4
5A	New Silver Line – West Falls Church, Mid-City DC, Union Station and to College Park	20 - 25 Years	Very High	✓	✓	✓	—	—	—	—	YES	5A
5B	New Silver Line – McLean, Mid-City DC, Union Station and to College Park	20 - 25 Years	Very High	✓	✓	✓	—	✓	✗	✗	NO	5B
5C	New Silver Line – McLean Friendship Heights, Rhode Island and to College Park	20 - 25 Years	Very High	✗	✓	—	—	—	✗	✗	NO	5C
5D	New Silver Line – Rosslyn II, Mid-City DC, Cheverly and to New Carrollton	20 - 25 Years	High	✓	✓	✓	✓	—	✓	N/A	YES	5D
6A	New Silver Line - West Falls Church, Rt 7, Columbia Pike, Southeast DC and to Prince George's County	20 - 25 Years	Very High	✗	✗	✗	—	✓	—	✓	NO	6A
6B	New Silver Line - West Falls Church, Rt 7, Columbia Pike, Pentagon, and to National Airport	20 - 25 Years	High	✗	✗	✗	✓	✓	✓	—	NO	6B
6C	New Silver Line - West Falls Church, Rt 7, Columbia Pike, Southeast DC and to Union Station	20 - 25 Years	High	✗	✗	✗	—	✓	✓	N/A	NO	6C
6D	New Silver Line - West Falls Church, Rt 7, Columbia Pike, Farragut, 16 th St, and to Silver Spring	20 - 25 Years	Very High	✗	✗	✓	—	✓	✓	N/A	NO	6D
6E	New Silver Line - West Falls Church, Rt 7, King Street, National Harbor, Anacostia and to Union Station	20 - 25 Years	Very High	✗	✗	✗	—	✓	—	N/A	NO	6E

Meets the criteria
 Partially meets criteria
 Does not meet the criteria

5.0 ALTERNATIVES EVALUATED

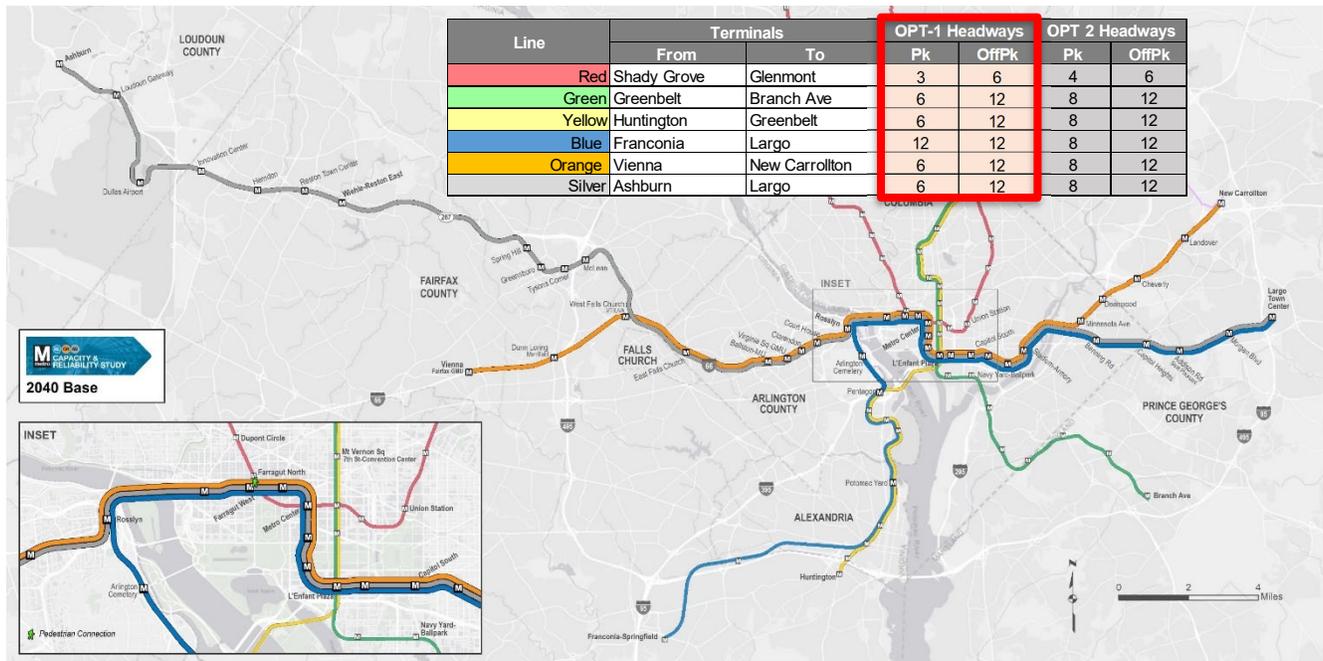
Four alternatives (3A, 3C, 5A, and 5D) successfully passed the screening steps and were evaluated along with the No-Build Alternative and Lower Capital Cost Alternative. These six alternatives are described in this section.

No-Build Alternative

The study considers a No-Build Alternative, which essentially measures whether land use changes and transportation investments that are already planned and funded are sufficient to meet the four goals and identified Purpose and Need for transit in the BOS corridor. This includes the regional land use and population forecasts provided by the region’s jurisdictions and approved by the MWCOG, in this case Cooperative Forecasts Round 9.1. The No-Build Alternative also includes all transportation investments planned and programmed for funding by the region, as listed in the *Visualize 2045 Regional Long-Range Transportation Plan* and Metro’s FY 2021-2026 Capital Improvement Program (CIP). The No-Build Alternative includes the existing rail and bus network plus completion of Silver Line Phase 2, the Potomac Yard Metrorail Station, and all of the State-of-Good-Repair and modernization projects included in Metro’s CIP. It also includes jurisdictional transit projects such as the State of Maryland’s Purple Line light rail and various bus rapid transit (BRT) lines.

While the No-Build Alternative was modeled with two headway options, all results are based on the Option 1 headways shown in **Figure 5-1**. This was considered the most likely scenario for 2040.

Figure 5-1: No-Build Alternative and assumed headways.



Because it represents the future transportation network as it is planned and funded today, the No-Build Alternative was used as the baseline from which to compare the potential benefits and costs of the other alternatives. Those other alternatives include the Lower Capital Cost (LCC) Alternative and four potential realignments and extensions of Metrorail lines.

Lower Capital Cost Alternative

The Lower Capital Cost Alternative attempts to attain the four BOS corridor goals at a lower cost than the rail build alternatives. It includes a network of enhanced commuter and BRT services, targeted rail capital investments, and operational strategies. The Lower Capital Cost Alternative includes the following components, which are described in detail in a separate report titled *BOS Study: Lower Capital Cost Alternative*:

- Enhanced bus service (6 bus rapid transit lines and 54 commuter routes – see **Figure 5-2**)
- Rail operations strategies: these include scheduling service to more accurately reflect varying run times during the day and to reduce conflicts at junctions, which will reduce delay and increase schedule/headway adherence.
- New or improved rail junction infrastructure (crossovers and pocket tracks) at West Falls Church and the D&G Junction – see **Figure 5-3**): this infrastructure will allow operational flexibility for short turns and other service options that focus capacity where it is most needed. Pocket tracks can be used to deploy variable service patterns; to reduce the geographic extent and customer impacts of single-tracking events; to remove malfunctioning trains from revenue service tracks; and to insert relief trains in order to recover scheduled service during disruptions.
- Potential railcar passenger carrying capacity enhancements: changes—such as open gangways or flip-up seats—to railcars to increase standing area so more passengers can be carried at peak load times.
- Core station capacity improvements: improvements to increase station capacity at Ballston, Farragut West, Metro Center, and L’Enfant Plaza.
- Customer convenience-focused enhancements: improved real-time messaging related to delays and alternative routing to allow passengers to avoid delays.

The enhanced bus network was designed to be capable of attaining the corridor’s capacity goal by reducing peak-period crowding on the BOS rail lines. It could do so by providing adequate bus capacity for the number of peak-hour customers that would need to be diverted from the BOS lines, by providing an attractive transit alternative that offers direct connections between major BOS origin-destination points with bus prioritization strategies. This alternative is designed to meet the minimum BOS capacity and crowding needs in 2040, but would create no new rail capacity; requires substantial jurisdictional investments in bus prioritization infrastructure; and would rely on thousands of peak-period rail customers voluntarily shifting to competitive bus services.

**Figure 5-2: Bus routes included in the Lower Capital Cost alternative.
BRT routes originating in Virginia**

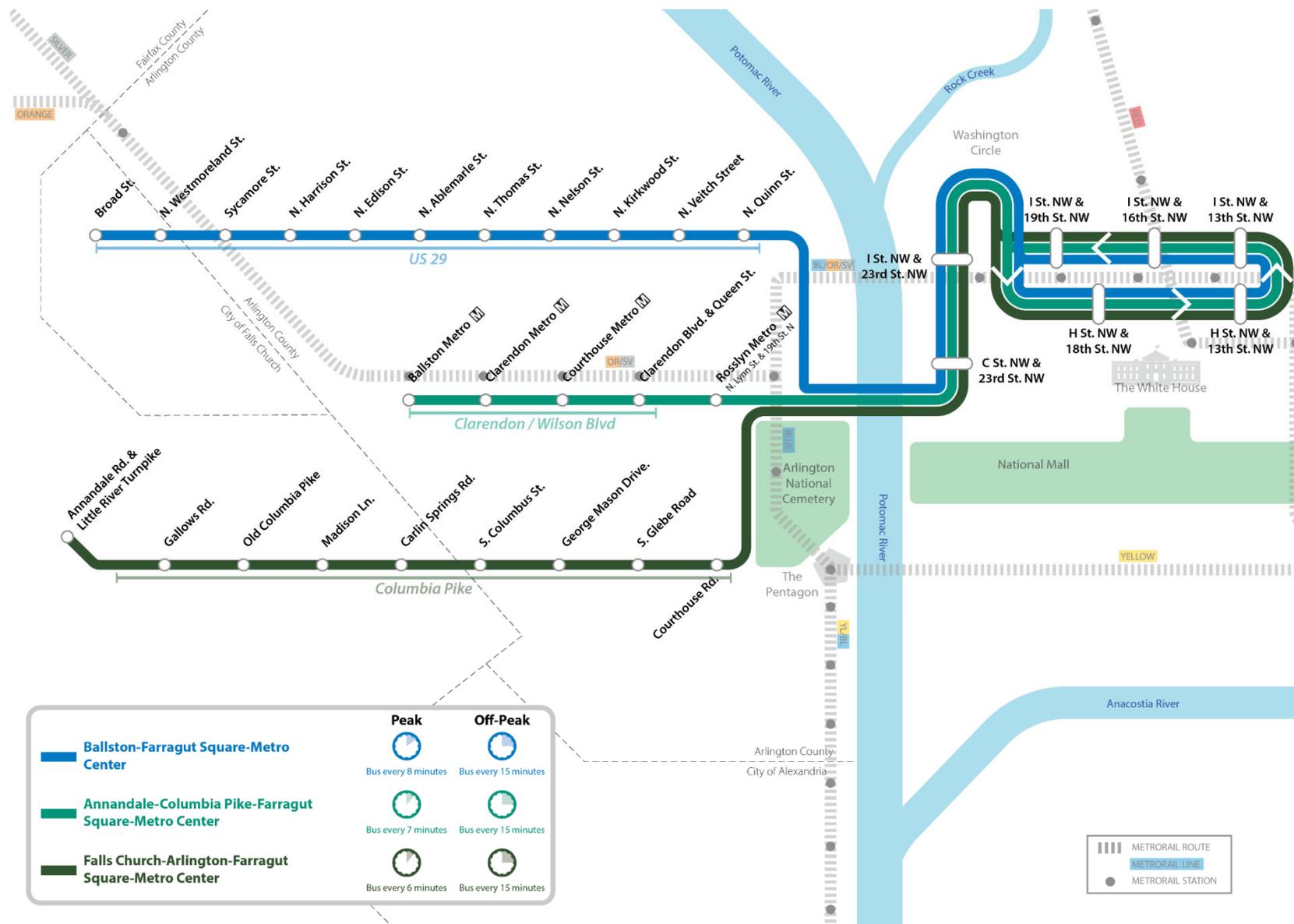




Figure: Bus routes included in the Lower Capital Cost alternative (cont.) – BRT routes originating in Maryland

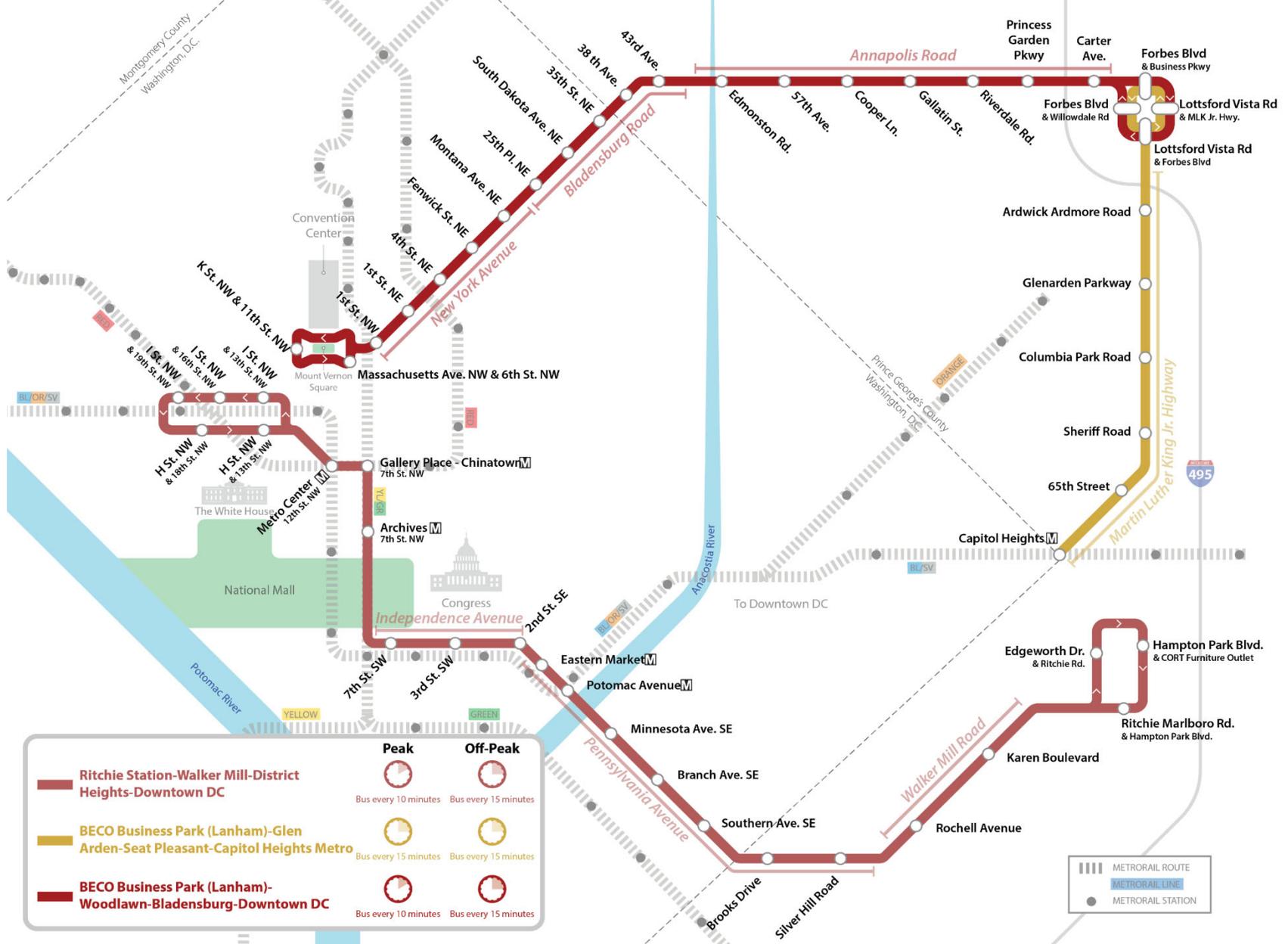


Figure: Bus routes included in the Lower Capital Cost alternative (cont.) – commuter bus routes originating in Fairfax and Loudoun Counties

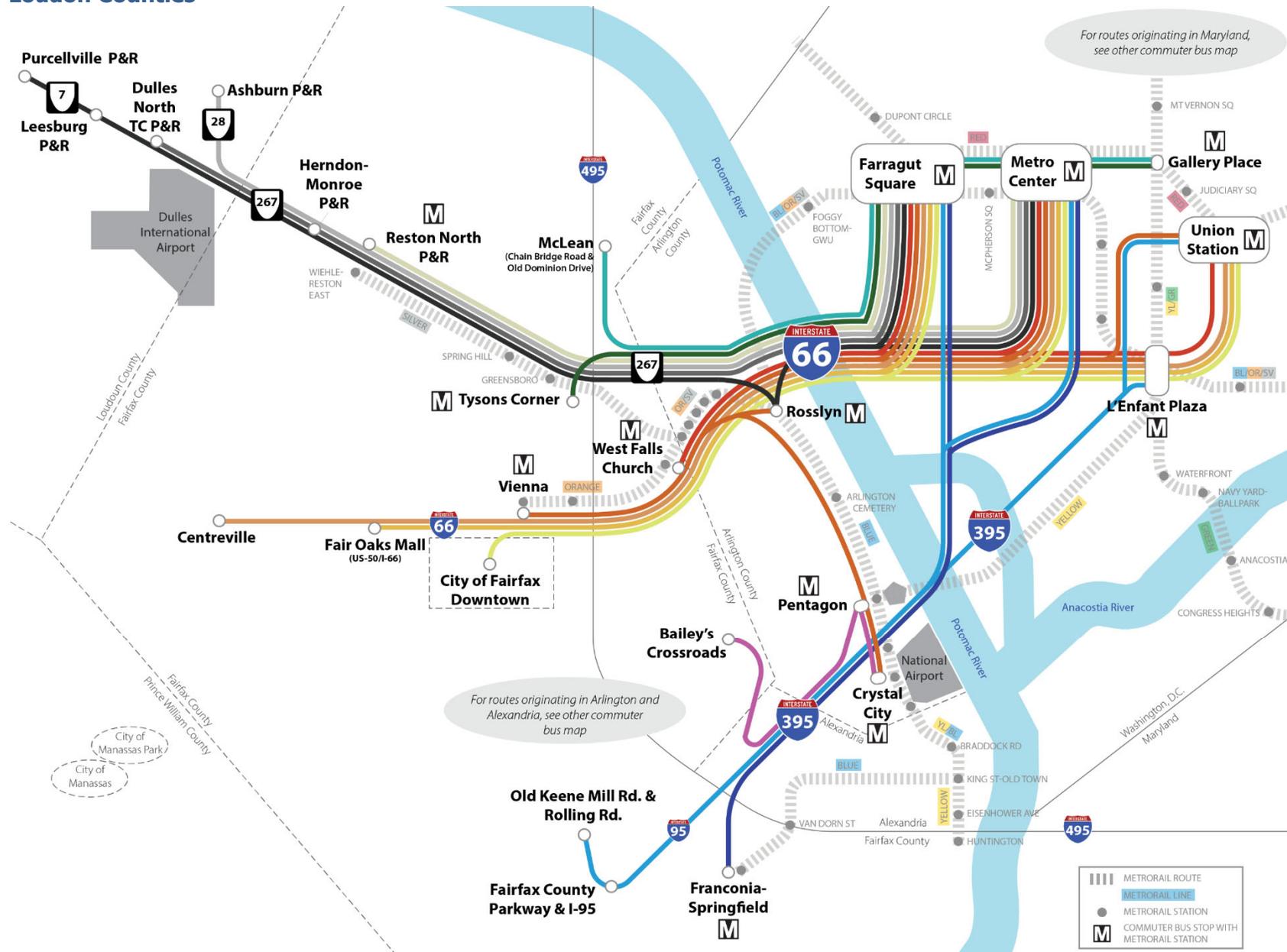




Figure: Bus routes included in the Lower Capital Cost alternative (cont.) – commuter bus routes originating in Arlington, Alexandria, and Maryland

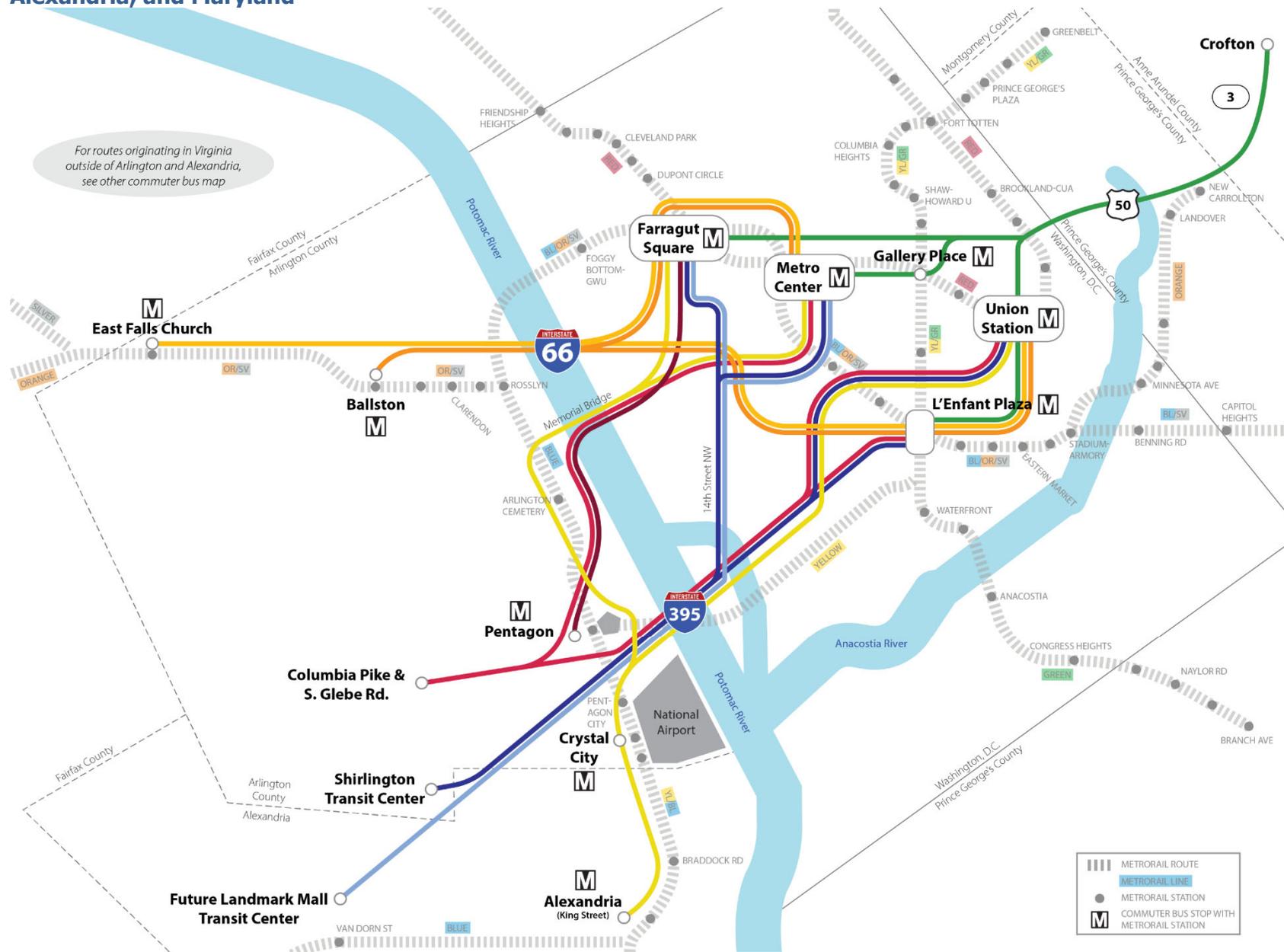
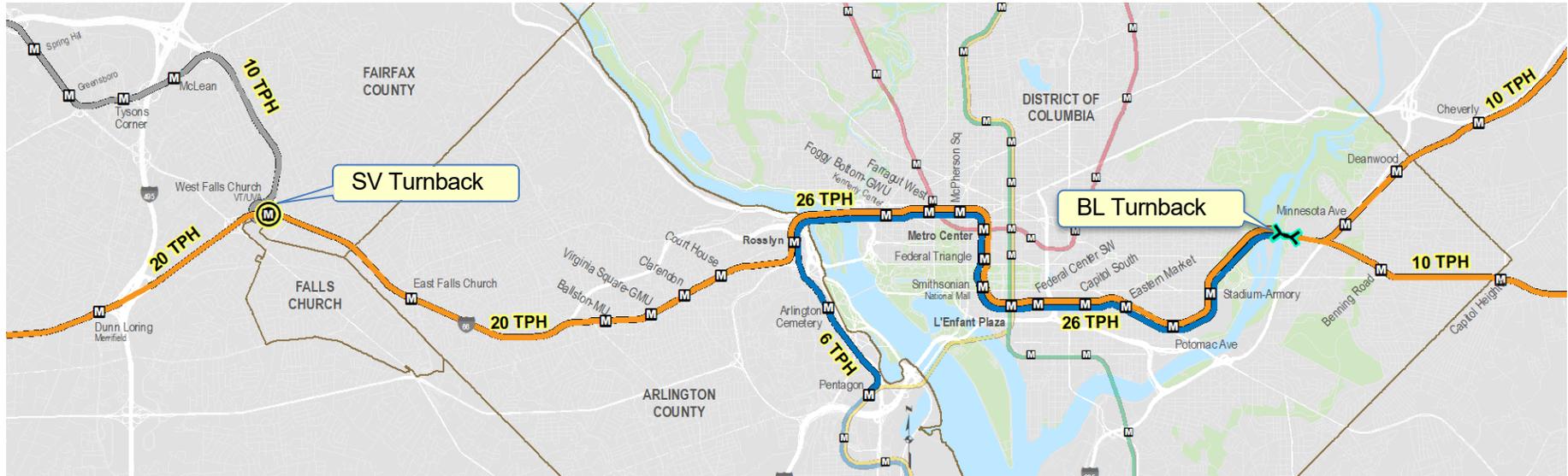


Figure 5-3: Turnback infrastructure included in the Lower Capital Cost alternative.

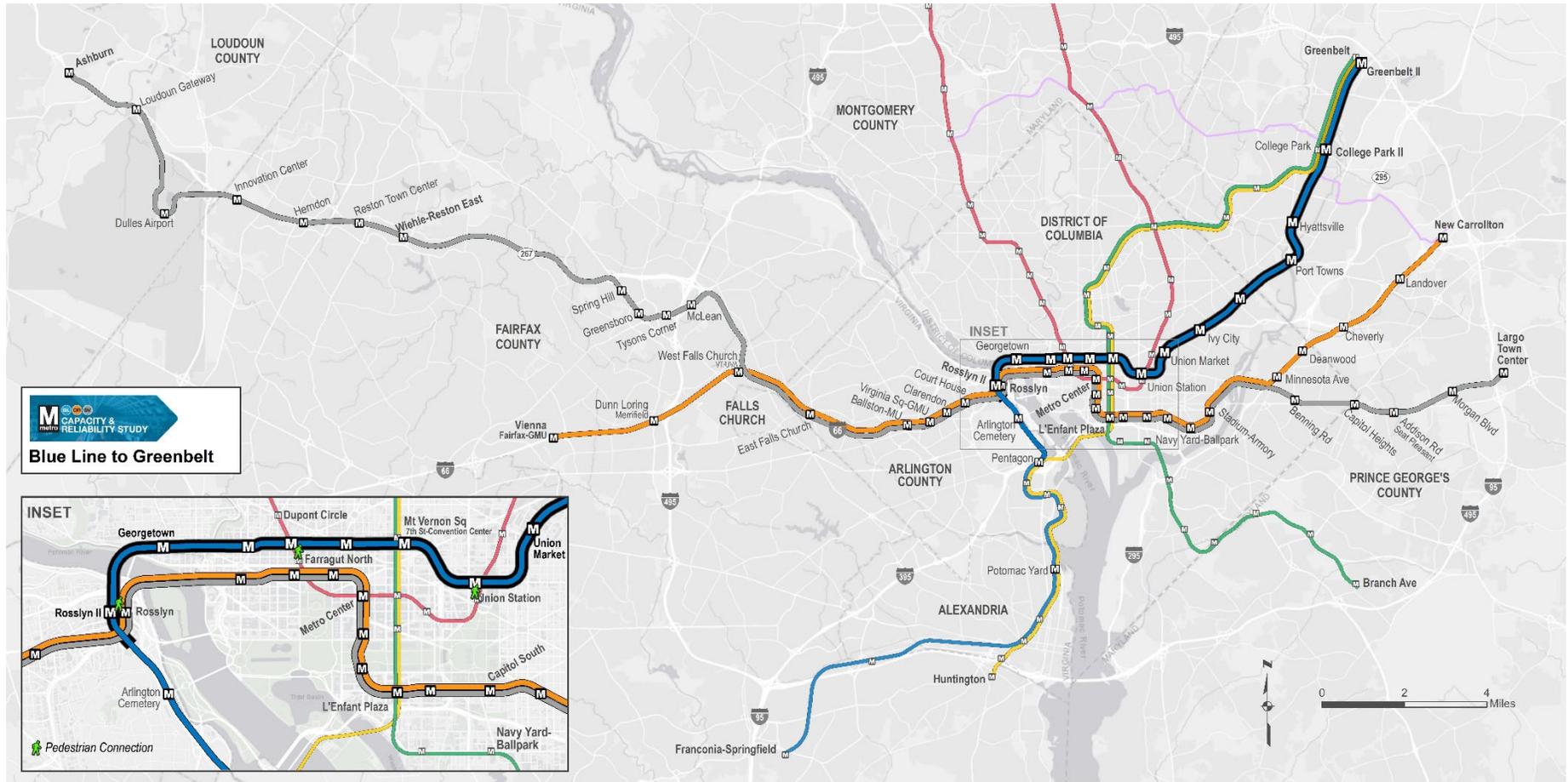


Metrorail Build Alternatives

The four Metrorail build alternatives selected for more detailed analysis are described in the following pages.

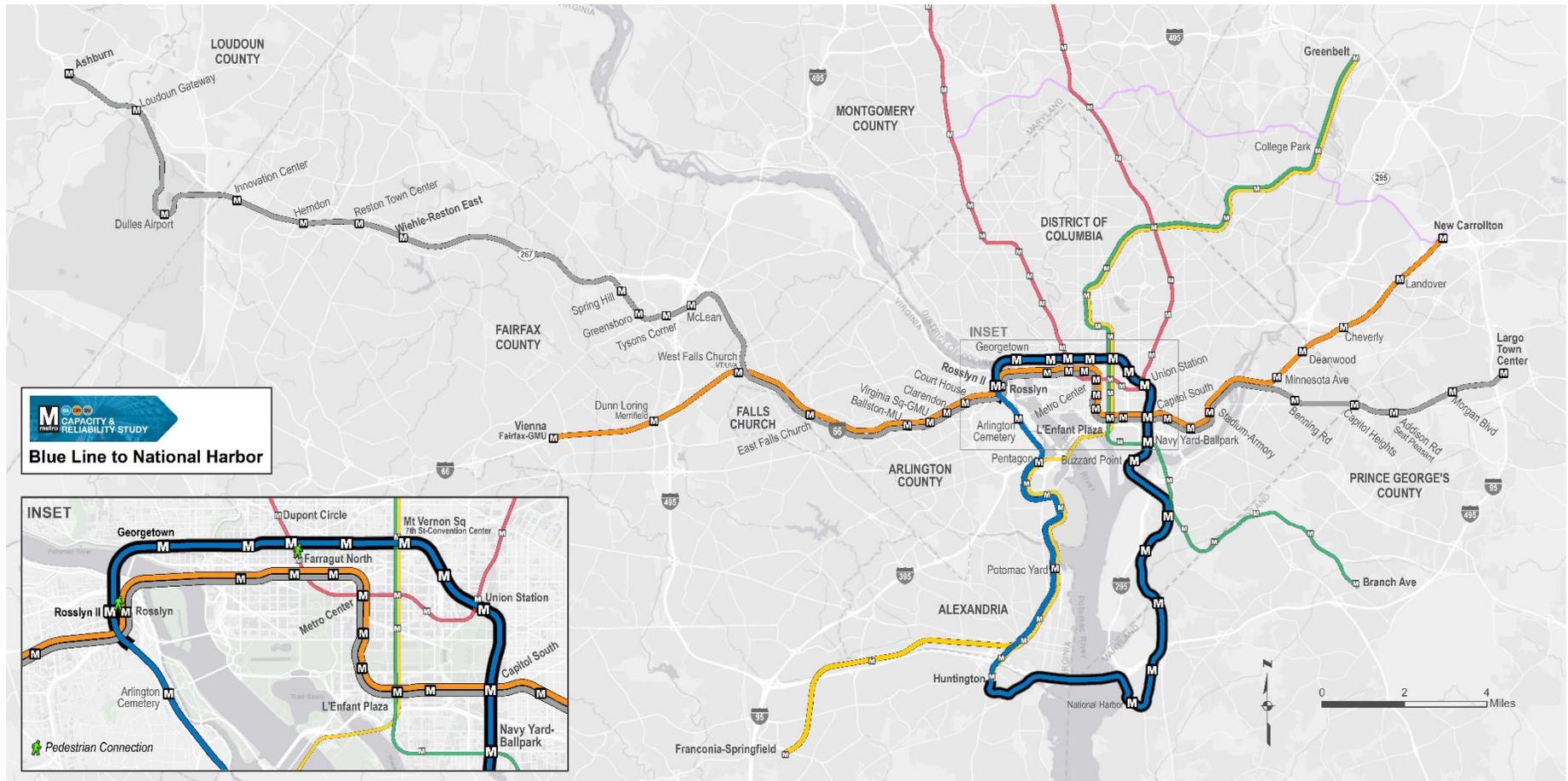
Metrorail Build Alternative 3A - Blue Line to Greenbelt: This alternative would realign the existing Blue Line from the Arlington Cemetery Station to a new Rosslyn II station, which would offer a direct pedestrian connection to the existing Rosslyn Station. From there it would run through a separate tunnel into Georgetown, along M Street, through the District’s downtown to Union Station, then northeast through Union Market, Ivy City, Port Towns, Hyattsville, and College Park to Greenbelt. It would operate on separate tracks from the existing Green and Yellow Lines in order to avoid re-interlining. This alternative would create net new rail capacity of 16 TPH per direction.

Figure 5-4: Alternative 3A - Blue Line to Greenbelt



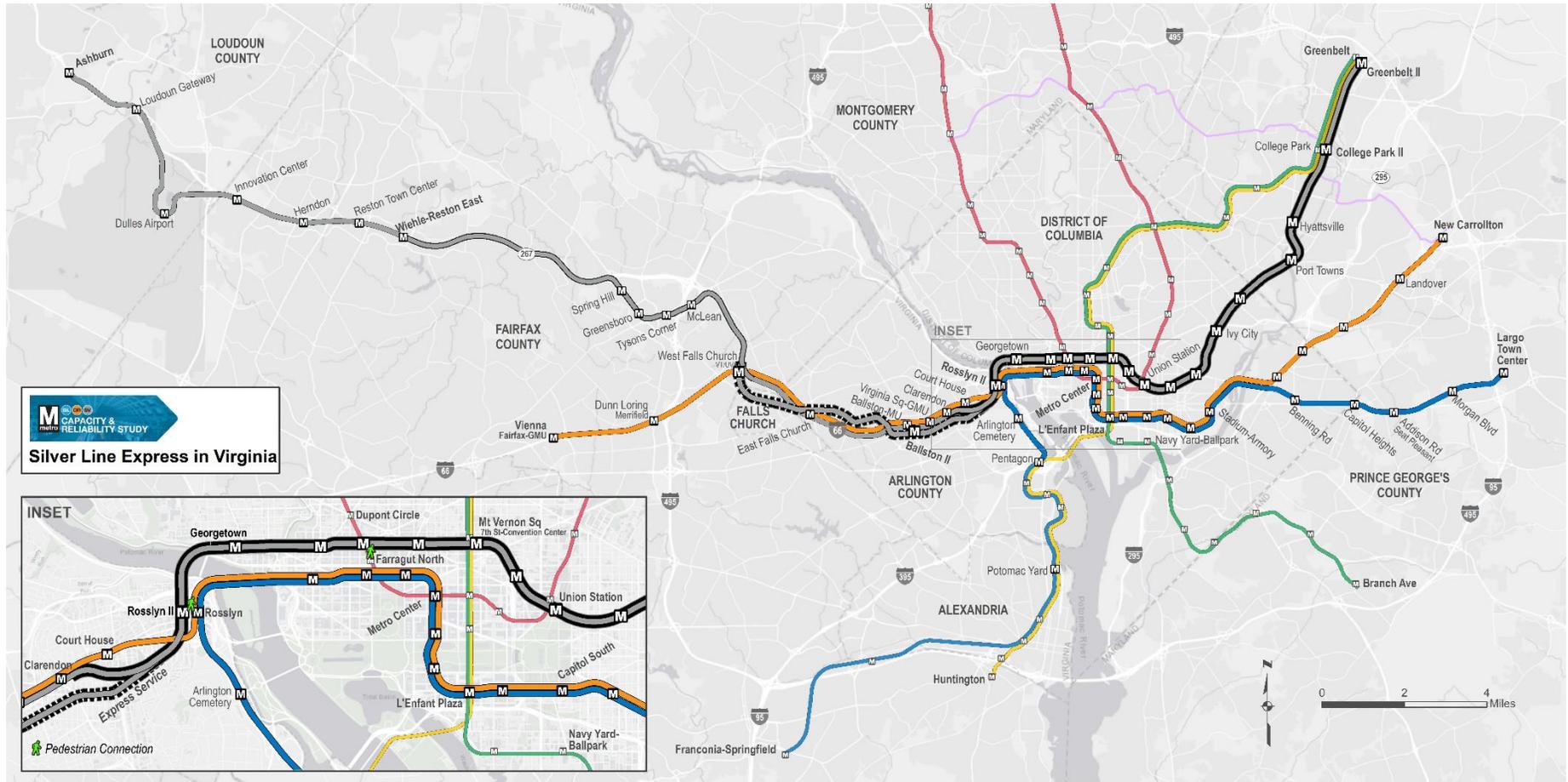
Metrorail Build Alternative 3C - Blue Line to National Harbor: This alternative would also realign the existing Blue Line from Arlington Cemetery Station to a new Rosslyn II station, continuing through Georgetown and along M Street to Union Station. From Union Station it would turn south, providing new north-south service in Waterfront and Navy Yard and creating new rail access in areas targeted for development, such as Buzzard Point, St. Elizabeth's, and National Harbor, before crossing the Potomac River to Alexandria. This alternative would create net new rail capacity of 16 TPH per direction.

Figure 5-5: Alternative 3C - Blue Line to National Harbor



Metrorail Build Alternative 5A - Silver Line Express in Virginia: This alternative would create a separate tunnel and tracks for the Silver Line, starting at West Falls Church Station. From WFC to the new Rosslyn II station, the new tunnel could support express service, local service, or a mix of express and local service. From the new Rosslyn II station, the Silver Line would travel through Georgetown along M Street to Union Station, then through Capitol Hill, Ivy City, Port Towns, Hyattsville, and College Park to Greenbelt. This alternative would create net new rail capacity of 26 TPH per direction.

Figure 5-6: Alternative 5A - Silver Line Express in Virginia



Metrorail Build Alternative 5D - Silver Line to New Carrollton: This alternative would separate the Silver Line from the Orange Line at Clarendon Station, creating a new connection at a new Rosslyn II station before continuing through Georgetown to Union Station. From Union Station, the new tunnel would turn north and east to serve Ivy City and Port Towns, then run along the Annapolis Road/MD 450 corridor to New Carrollton Station. This alternative would create net new rail capacity of 16 TPH per direction.

Figure 5-7: Alternative 5D - Silver Line to New Carrollton.

