FINAL

Columbia Pike Transit Corridor Study

PREPARED FOR

ARLINGTON
VIRGINIA

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Study Purpose

On November 18, 2014, the Arlington County Board voted to discontinue efforts to bring a streetcar to the Columbia Pike corridor. At the same time, the Board asked County staff to identify alternatives to improve transit options along the corridor. The purpose of this study is to review the existing and future transit needs of the Columbia Pike corridor, and identify strategies to enhance bus service and encourage ridership growth to support planned changes in land use and future growth.

Arlington County has invested a significant amount of time planning for the future of Columbia Pike, crafting a vision for the corridor that:

- Revitalizes Town Center and Neighborhood Centers
- Creates a pedestrian friendly "main street" served by high-quality transit
- Preserves the Pike's character, diversity, and affordability
- Invests in infrastructure for a more vibrant, sustainable community
- Manages growth

This vision is further supported and enacted through the County's form-based code adopted in 2003 for commercial districts and neighborhood districts in 2013. Additionally, the County's *Columbia Pike Multimodal Street Improvements* transportation study seeks to reimagine the Pike as a complete street that functions safely for all users and supports the vision for Columbia Pike.

The County saw public transportation as a vital piece of the larger puzzle; providing much needed capacity to a physically constrained corridor looking to grow; improving access and connectivity to area residents, workers and visitors; and supporting the continued development of the corridor.

Columbia Pike Plaza at Columbia Pike and S. Dinwiddie Street

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History and Development of Columbia Pike

Columbia Pike (Virginia State Route 244) is a major east-west transportation route stretching for approximately 3.5 miles across Arlington County from the border with Fairfax County in the west to the Pentagon in the east. The entirety of Columbia Pike extends further west through Fairfax County where it terminates at Little River Turnpike (Virginia State Route 236). The development along the corridor and surrounding area have historically been automobile-oriented. The County is currently focused on reimagining the corridor with a greater multimodal focus.

Initial development of Columbia Pike began in the early 20th century, as the S. Walter Reed Drive intersection emerged as a focal point for commercial development. During this time, buildings were located close to the roadway edge with retail space on the ground floor and office space or apartments on the upper floors. During the 1940s and 1950s, automobile-oriented retail increased along Columbia Pike with the construction of gas stations, service centers, automobile dealerships, and other auto-related businesses.

Arlington Cinema Draft House at Columbia Pike and S. Walter Reed

The majority of existing office space was constructed during the 1960s and early 1970s. The 1970s and 1980s saw an influx of car-oriented retail buildings with off-street parking.

Today, the corridor consists of a mix of single family detached homes, townhomes, garden and high-rise apartments and condominiums, retail, and office buildings. The corridor contains mixed-use development districts, containing retail, residential, and recreational facilities, and has been transitioning over the past decade into a more mixed-use corridor, in line with the county's vision.

Columbia Pike is a four-lane undivided arterial with multiple signalized intersections, and is a heavily-traveled roadway, with some segments carrying nearly 28,000 vehicles per day.[1] Ownership of Columbia Pike was transferred from the Virginia Department of Transportation (VDOT) to Arlington County in October 2010, with a commitment to maintain four general purpose lanes the length of the roadway in the county.

The first bus line on Columbia Pike to Washington, DC, began service in 1919. Today the Columbia Pike corridor carries approximately 17,000 passengers via bus.[2] WMATA offers multiple lines along the Columbia Pike corridor, but the primary service connects the western parts of the corridor to the Pentagon. Arlington Transit (ART) service connects the corridor to the urban villages of Shirlington, Rosslyn,

[1] Source: Arlington County Transportation. *Traffic Volumes*. Retrieved on April 14th, 2016, from https://transportation.arlingtonva.us/key-performance-measures/mobility/traffic-volumes.

[2] Source: *FY2017 Budget: Ridership and Revenue*. Washington Metropolitan Area Transit Authority: Finance & Administration Committee, October 2015.

Courthouse, and Ballston. Pike Ride was a branding effort initiated in September 2003 as a collaboration between Arlington and WMATA to highlight the frequent and convenient service along Columbia Pike.

Arlington and Fairfax Counties approved plans for a streetcar on Columbia Pike in 2006. In 2012, they adopted the streetcar as the "locally preferred alternative." In 2014, the Arlington County Board voted to cancel the streetcar program because of the impending election of Board members opposed to the streetcar program.[3] With the streetcar no longer an option, the focus to improve transit options and capacity for the Columbia Pike corridor shifted to developing alternate transportation strategies.

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[3] Source: Arlington County Newsroom. *Arlington Cancels Streetcar Program*. Retrieved on April 18th, 2016, from http://newsroom.arlingtonva.us/release/arlington-cancels-streetcar-program.

3

Current Conditions and Plans for Columbia Pike

The Columbia Pike corridor is expected to grow significantly by 2040. As of the 2010 census, the corridor is home to more than 36,000 people and is expected to add an additional 7,300 residents, 3,900 homes, 7,000 jobs, and 2.2 million square feet of new commercial space by 2040.

In the fall of 2015, data collection and analyses were conducted to get a better understanding of existing conditions along the Columbia Pike corridor. The data included observations of transit service, traffic operations, safety, and pedestrian access. Data were assembled by reviewing existing information and previous studies, walking and driving the corridor, riding the buses, and analyzing comments from public meetings.

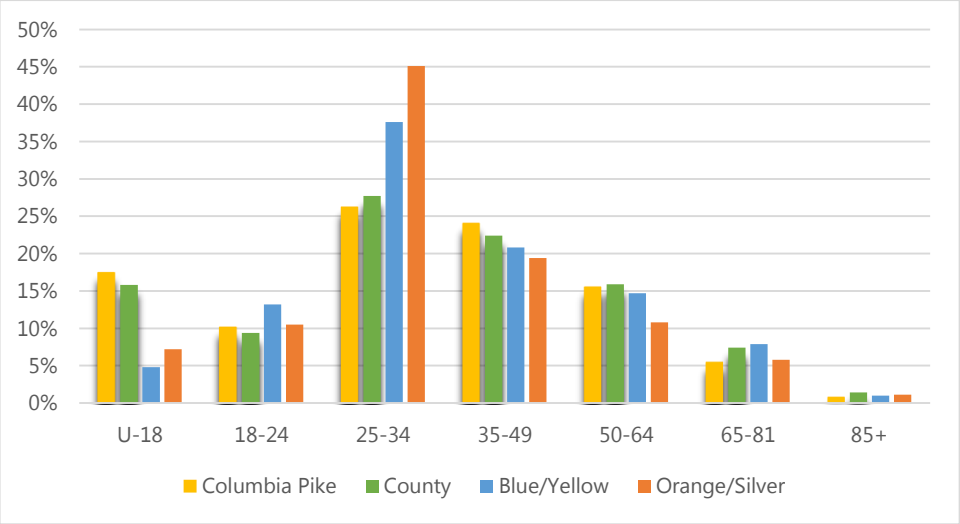
Pike 3400 building at Columbia Pike and S. Glebe Road is an example of new development along the corridor

3.1 Demographic Profile of the Columbia Pike Corridor

The Columbia Pike corridor contains more than 17% of the total population of Arlington County, in 10% of the Arlington land area. The corridor is quite diverse, with 65% of the population being non-white, compared to 36% countywide. Within the corridor are lower levels of home ownership, educational attainment, and income levels relative to the entire county.

Compared to the rest of the county, more people that live along Columbia Pike also work in Arlington County (38%). Three out of 10 commuters along Columbia Pike already use transit as opposed to a car to get to work. This transit use is greater than the county as a whole, but less than along either of the Metrorail corridors. While residents along other transit-focused corridors in the county tend to skew younger, Columbia Pike's population age distribution is more similar to the rest of Arlington County.[4]

Figure 3.1: Population by Age Distribution

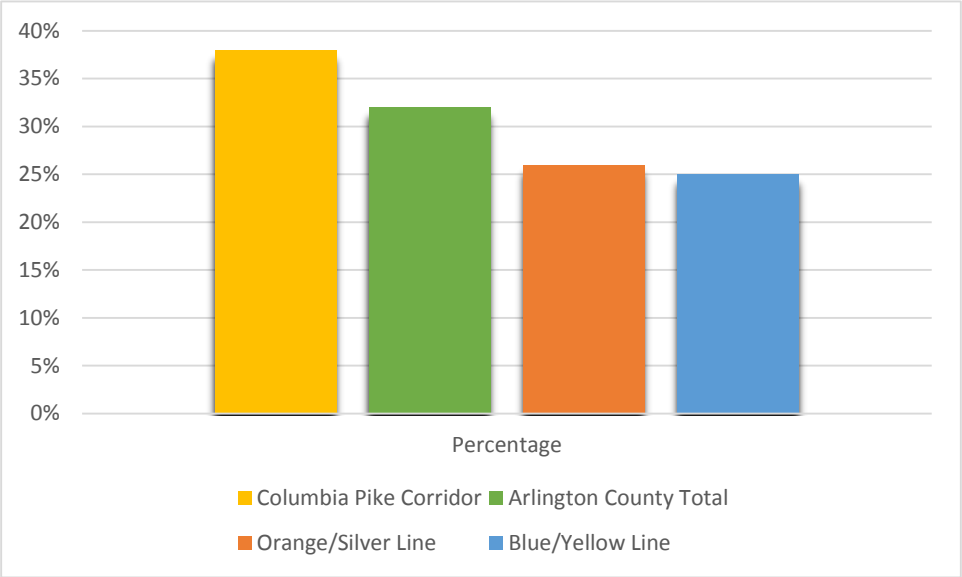


These demographic elements reveal a corridor densely made up of diverse individuals of working age, lower-than-Arlington-average income, working in Arlington, who already use transit at rates comparable to corridors with Metrorail. These suggest the presence of a population who would benefit from changes resulting in a higher quality transit experience along Columbia Pike.[5]

[4] Source: *Major Planning Corridors Demographic Trends*. 2008-2012 American Community Survey, July 2014.

[5] Source: Arlington County Projects & Planning. *Columbia Pike*. Retrieved on April 18th, 2016, from http://projects.arlingtonva.us/projects/columbia-pike.

Figure 3.2: Percentage of Residents that Work in Arlington



For the purpose of analyzing employment and residential population figures from the County's recent land use forecast, the corridor was divided into four segments:

- Columbia Heights/Columbia Forest between S. Four Mile Run Drive and S. Carlin Springs Rd
- Barcroft/Douglas Park/Alcova Height between S. Four Mile Run Drive and S. Glebe Road
- Arlington Heights/Penrose/Columbia Heights/Arlington Views between S. Glebe Road and Washington Boulevard
- Pentagon/Foxcroft Heights between Washington Boulevard and VA 110

The existing residential population is focused on the western end and in the middle of the corridor. There are a limited number of residences located east of Washington Boulevard, in the small neighborhood of Foxcroft Heights.

Conversely, the areas of the corridor that display the highest number of jobs are focused on the eastern end. The Pentagon, as one of the world's largest office buildings, skews the employment numbers. The segment of the corridor from S. Glebe Road to Washington Boulevard contains approximately 4,000 jobs. This is an older area of the corridor with the commercial center focused around S. Walter Reed Drive. A number of higher density redevelopment projects have also been constructed in this segment.

Figure 3.3: Arlington County Land Use Forecast Zones

Figure 3.4: Columbia Pike Population - 2015

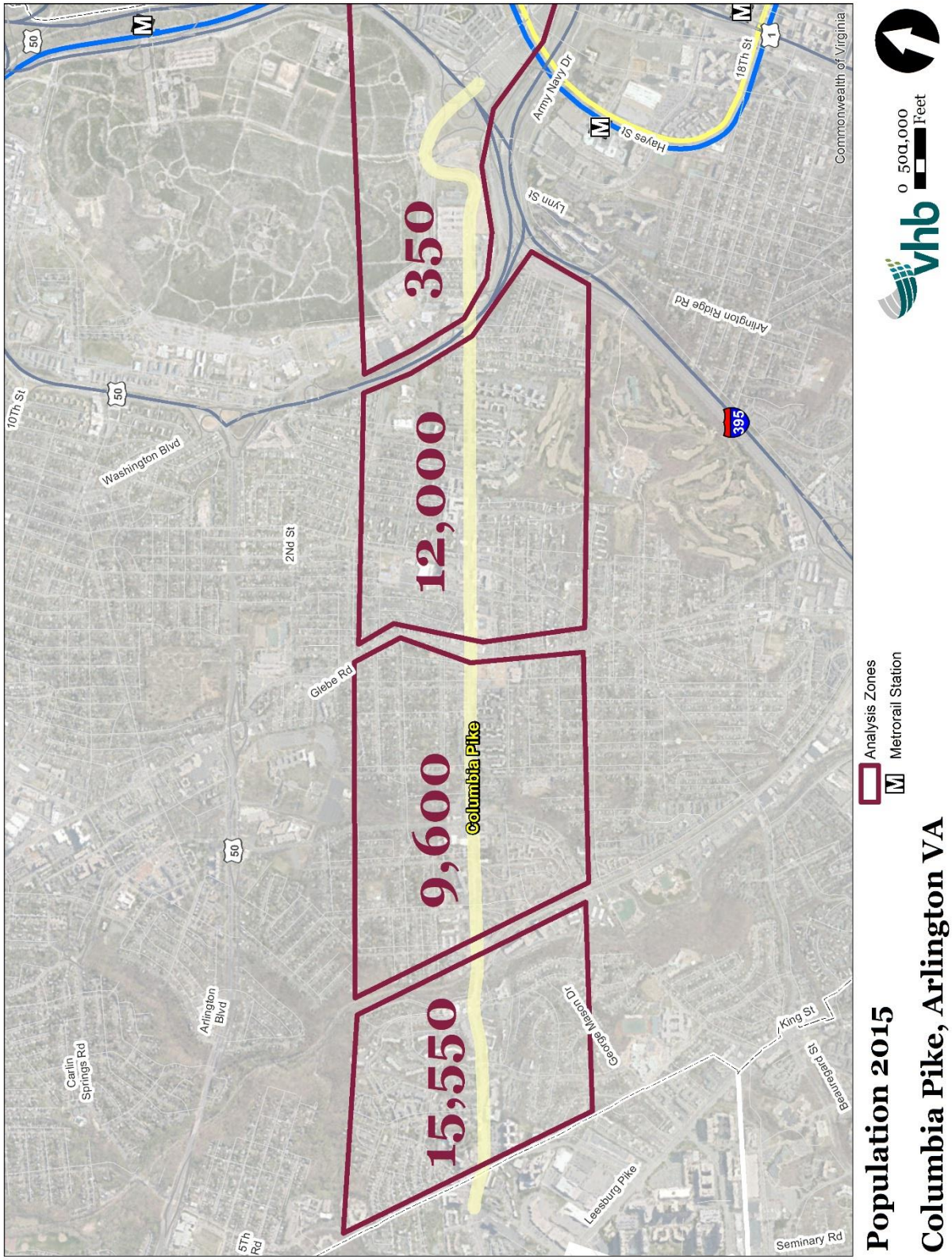


Figure 3.5: Columbia Pike Employment - 2015

3.2 Plans for Columbia Pike

In 2003, the County Board approved several policy documents to transform the Columbia Pike Corridor from an automobile-oriented roadway to a multimodal corridor supporting a variety of development types. Key elements of this vision included revitalizing town centers and neighborhood centers, creating a pedestrian-friendly Main Street served by high quality transit, preserving the Pike's character, diversity, and affordability, investing in infrastructure, and managing growth. The revitalization plan consists of a form-based code to create four major mixed-use development nodes connected by existing apartment and townhouse residential communities:[6]

- Town Center – area around S. Walter Reed Drive/Columbia Pike
- Village Center – area around S. George Mason Drive/Columbia Pike
- Neighborhood Center – area around S. Four Mile Run Drive/Columbia Pike
- Western Gateway – area along Columbia Pike between S. Jefferson and S. Greenbrier Streets

This commercial form-based code regulates the look and feel of the buildings that may be developed, providing specifications for buildings, frontage types, streetscape, parking, and historical preservation.[7]

The form-based code for residential development along Columbia Pike will help guide the next 30 or more years of redevelopment, and the addition of 9,500 housing units. This code sets standards for affordable housing requirements, transfer of development rights, green building standards, and conservation area standards. From west to east, there are five residential form-based code areas along Columbia Pike:

- The Columbia Heights West and Columbia Forest neighborhoods,
- South of Columbia Pike, east of S. Four Mile Run Drive, and west of S. George Mason Drive
- Between S. George Mason Drive and S. Glebe Road
- The large-scale apartment and condominium complexes between S. Walter Reed Drive and Washington Boulevard
- In Foxcroft Heights adjacent to the old Navy Annex site.[8]

[6] Source: Arlington Projects and Planning. "Columbia Pike Form Based Code – Commercial Centers." https://projects.arlingtonva.us/neighborhoods/commercial-form-based-code/

[7] Source: Arlington Projects and Planning. "Columbia Pike Form Based Code – Commercial Centers." https://projects.arlingtonva.us/neighborhoods/commercial-form-based-code/

[8] Source: Arlington Projects and Planning. "Columbia Pike Form Based Code – Neighborhoods." https://projects.arlingtonva.us/neighborhoods/neighborhoods-form-based-code/

3.3 Forecasted Growth

As Columbia Pike continues to transition and redevelop using the form-based codes, significant growth is forecasted. Over the next decade, population along Columbia Pike is expected to grow 17%, exceeding the countywide growth rate of 10% to 11%. The population is forecasted to reach 45,400, up from a 2015 level of 37,500.

While most of the corridor is expected to increase the resident population significantly, the center of the corridor is forecasted to see the most growth in the next 10 years. The area from S. Four Mile Run Drive to S. Glebe Road is forecasted to experience the greatest percent change, with many of the existing suburban commercial areas fronting Columbia Pike redeveloping into higher-density, mixed-use complexes that include residential units. A recent example of this is the new Pike 3400 development on the southwest corner of Columbia Pike and S. Glebe Road. No residential growth is expected to occur east of Washington Boulevard over the next 10 years.

Significant employment growth along the corridor is expected to occur over a longer period of time, with more growth observed beyond 2025. The areas east of Washington Boulevard and from S. Four Mile Run Drive to S. Glebe Road are not forecasted to grow. The areas just west of Washington Boulevard and at the western end of the corridor will see limited growth of only a few hundred jobs during the next 10 years.

Looking beyond the Columbia Pike corridor, Pentagon City and Crystal City are forecasted to add a significant number of jobs during the next 10 years. The Rosslyn-Ballston corridor is also forecasted to add jobs during the next 10 years.

Figure 3.6: Columbia Pike Population - 2025

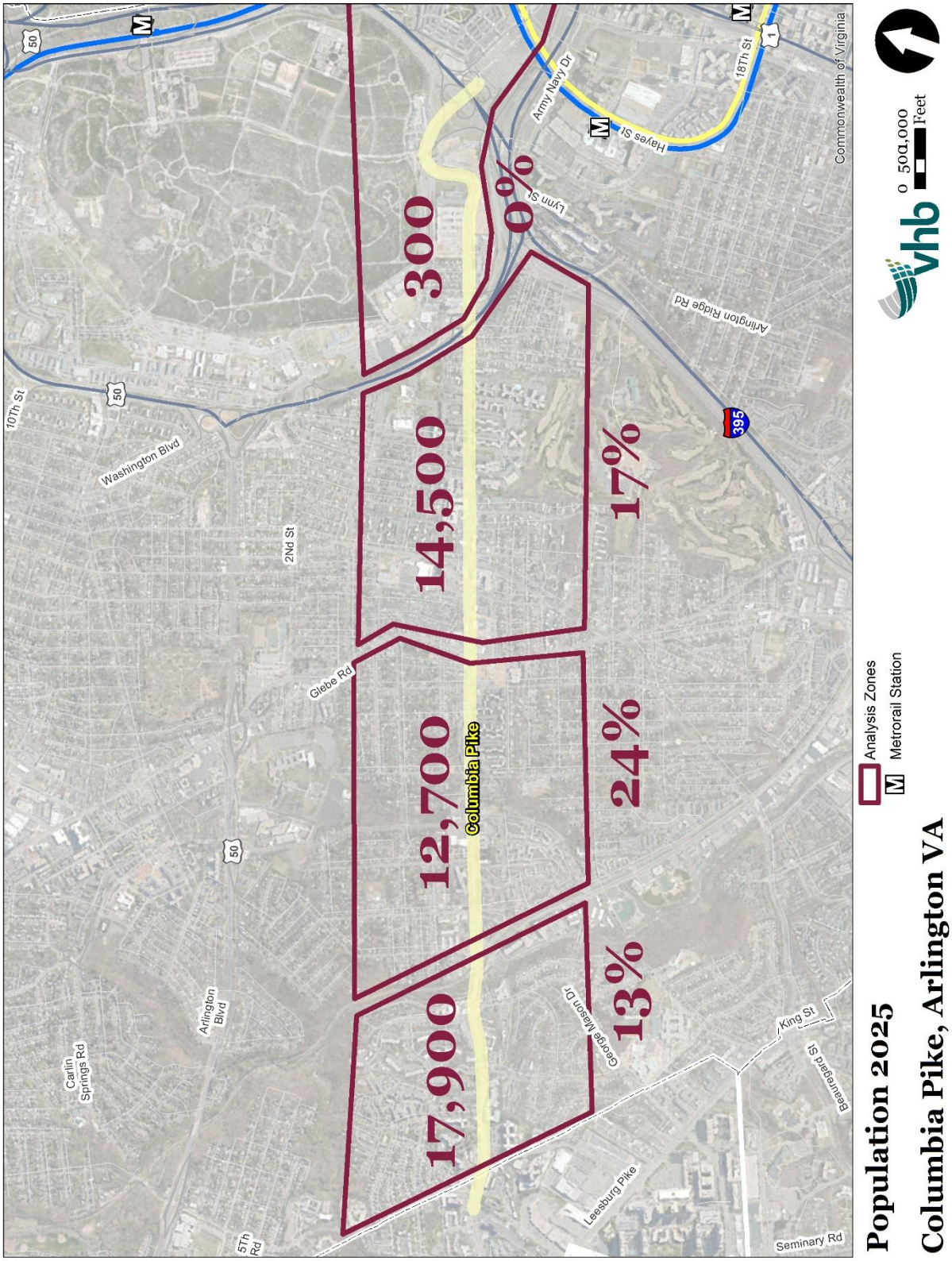
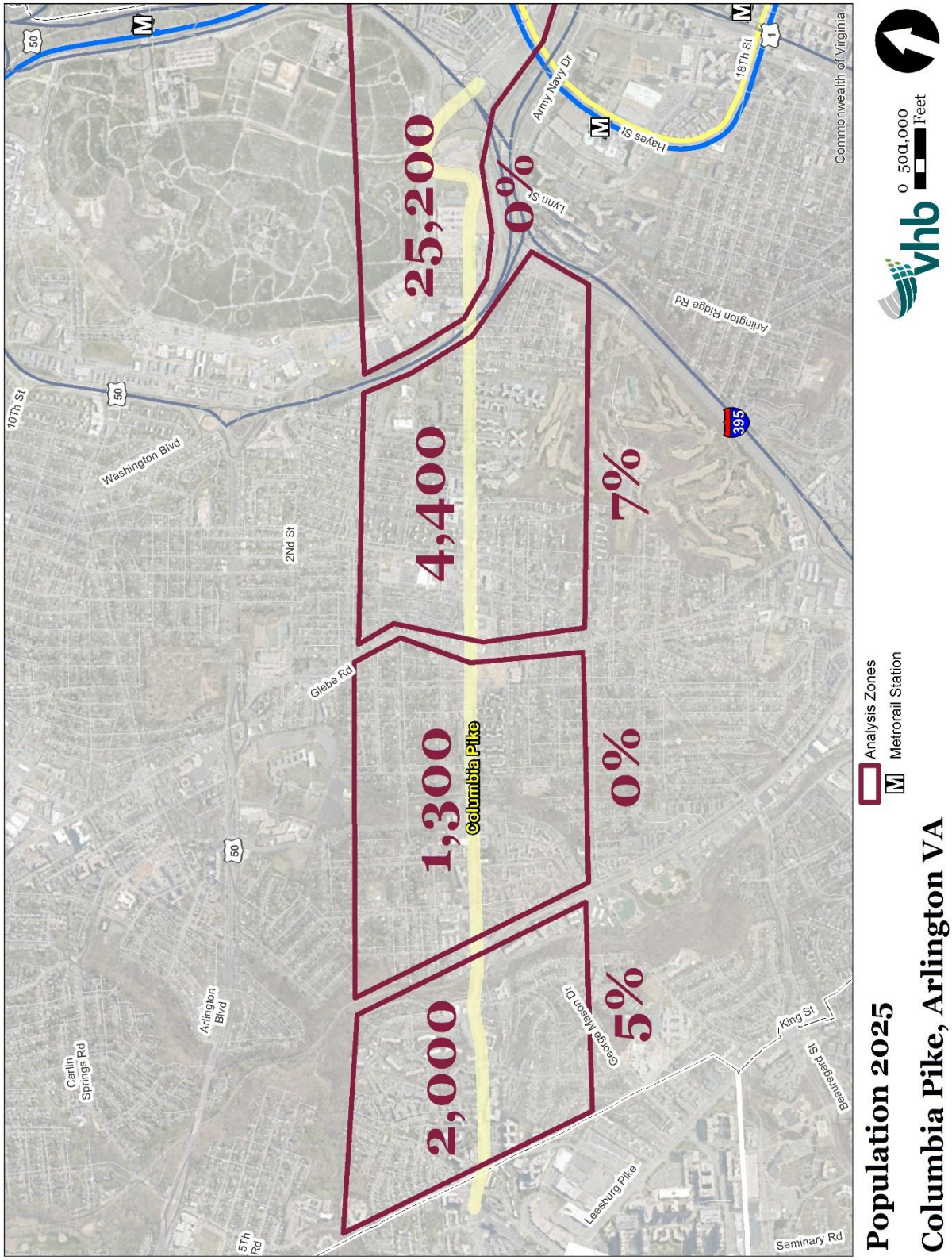


Figure 3.7: Columbia Pike Employment - 2025



Ensuring a strong connection between Columbia Pike and these areas will be critical to connecting people and jobs.

These increases in employment and population along the corridor is expected to increase demand for transit. The need for service that allows existing and new residents to forego, or limit, car use will be critical to keeping Columbia Pike moving as it redevelops and grows.

Penrose Square at Columbia Pike and S. Adams Street is an example of the higher density, mixed-use development that will provide housing, retail space, and offices for the corridor's growing population.

4

Roadway Characteristics and Performance

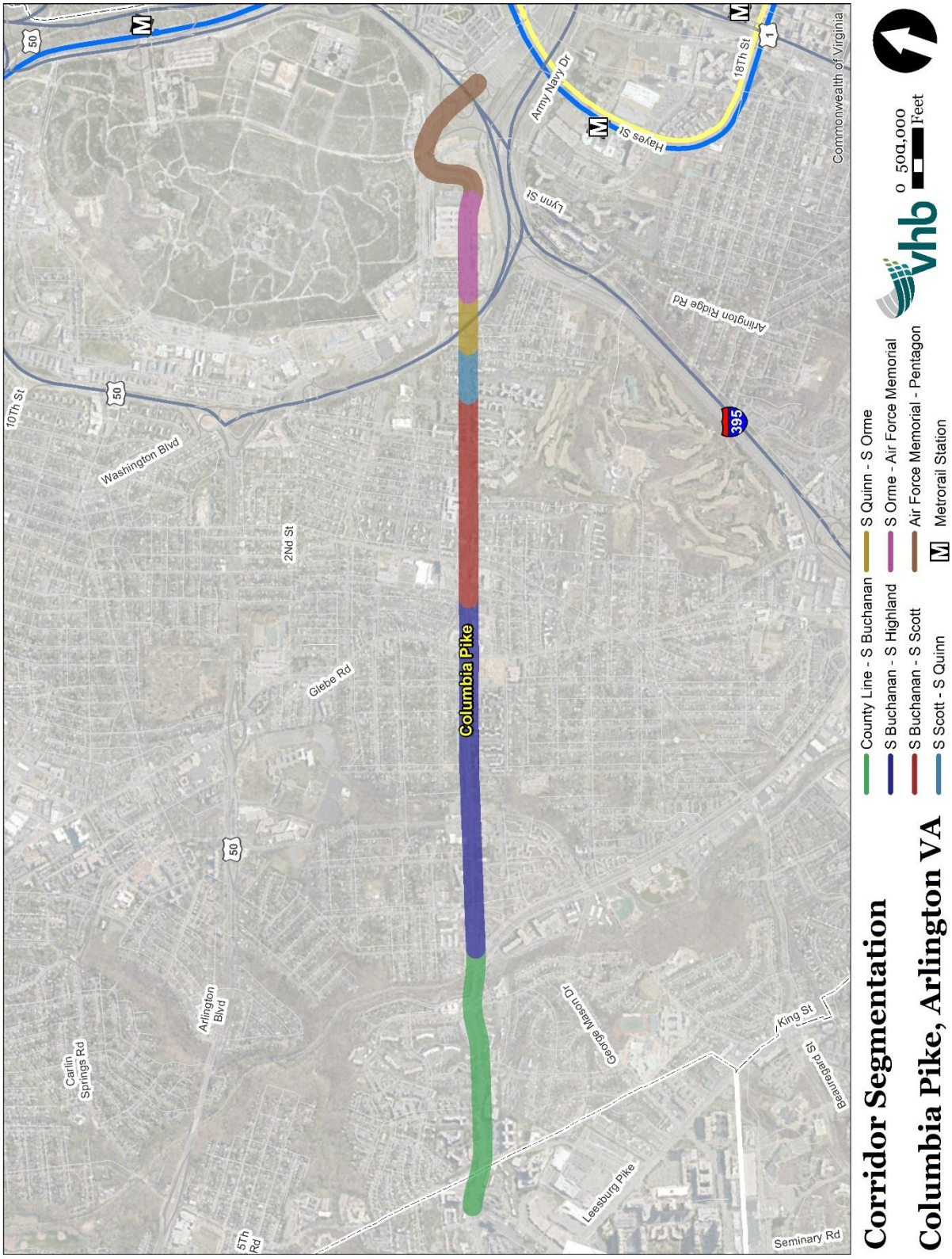
4.1 Physical Configuration

Within Arlington County, Columbia Pike is a 3.65-mile-long, multi-lane arterial with varying geometric characteristics. These geometric cross-sections along the corridor can be described using seven segmented sections of Columbia Pike. The seven segments described below were determined based on number of travel lanes, number of turn lanes, and whether the section was divided or undivided (Figure 4-1).

4.1.1 Columbia Pike from the Fairfax County/Arlington County Line to the S. Buchanan Street/S. Four Mile Run Intersection

The 0.72-mile segment of Columbia Pike from the Fairfax County/Arlington County line (west of S. Jefferson Street) to the east of S. Buchanan Street/S. Four Mile Run Drive intersection is generally a five-lane undivided cross-section; however, raised medians are located along the eastbound and westbound approaches to the S. Jefferson Street intersection. The roadway is typically 75 feet from curb to curb in this section, although portions are as narrow as 55 feet and one portion widens to 98 feet. Two travel lanes are provided in each direction with exclusive left-turn lanes located at most intersections. At the intersection with S. Frederick Street, an 8-foot-wide raised median is provided instead of left-turn lanes. Exclusive right-turn lanes

Figure 4.1: Columbia Pike Roadway Segments



are located eastbound approaching S. Greenbrier Street, eastbound approaching the Carlyle House entrance (5300 Columbia Pike), and westbound approaching driveways near 5353 Columbia Pike. A right-turn slip lane is located in the eastbound direction approaching S. Jefferson Street. Approximately 180 feet of on-street parking is provided along the westbound direction of Columbia Pike immediately downstream of the S. Greenbrier Street intersection. There are five signalized intersections in this segment:

- S. Jefferson Street
- S. Greenbrier Street
- S. Dinwiddie Street/S. Columbus Street
- S. Four Mile Run Drive
- S. Buchanan Street/S. Four Mile Run Drive

Existing morning and evening peak hour traffic volumes along both directions of Columbia Pike in this segment range from 1,940 to 2,290 vehicles.

4.1.2 Columbia Pike from the S. Buchanan Street/S. Four Mile Run Drive Intersection to S. Highland Street

The 1.13-mile segment of Columbia Pike east of S. Buchanan Street/S. Four Mile Run Drive to S. Highland Street is a four-lane undivided roadway. The roadway cross-section in this section is typically 48 feet; the cross-section increases to 64 feet in locations that have exclusive turn lanes and/or on-street parking. In this segment, the double-yellow centerline is painted wider in order to provide 1.5 to 5 feet of separation between the eastbound and westbound directions of traffic on Columbia Pike; however, this wider painted median is not provided approaching the S. George Mason Drive and S. Glebe Road intersections. At these intersections, exclusive left-turn lanes are provided for both directions of Columbia Pike. An exclusive right-turn lane is provided eastbound approaching S. George Mason Drive. On-street parking is located:

- Eastbound between S. Monroe Street and S. Glebe Road
- Westbound between S. Highland Street and S. Glebe Road
- Westbound between S. Oakland Street and S. Randolph Street

Columbia Pike looking east towards S. George Mason Drive

There are eight signalized intersections in this section:

- S. Wakefield Street
- S. Thomas Street
- S. Taylor Street
- S. George Mason Drive
- S. Quincy Street
- S. Monroe Street
- S. Glebe Road
- S. Highland Street

Existing morning and evening peak hour traffic volumes along both directions of Columbia Pike in this segment range from 1,740 to 2,010 vehicles.

4.1.3 Columbia Pike from S. Highland Street to S. Scott Street

Along the 0.65-mile segment between S. Highland Street (eastern, unsignalized intersection) and S. Scott Street, Columbia Pike consists of a five-lane undivided cross-section; however, a raised median is provided at the S. Scott Street intersection to provided median refuge for the pedestrian crosswalk. The roadway is typically 54 feet from curb to curb in this section. Two travel lanes are provided in each direction with exclusive left-turn lanes or a two-way left-turn lane in the median. The two-way left-turn lane is located along the eastern 0.14-mile portion of this segment. No right-turn lanes are provided in this section. A limited amount of on-street parking is located along the westbound direction of Columbia Pike between S. Wayne Street and 9th Road South/S. Barton Street. This section includes four signalized intersections:

- S. Walter Reed Drive
- S. Barton Street
- S. Wayne Street
- S. Courthouse Road

Existing morning and evening peak hour traffic volumes along both directions of Columbia Pike in this segment range from 1,800 to 2,460 vehicles.

Columbia Pike looking west at S. Walter Reed Drive

4.1.4 Columbia Pike from S. Scott Street to S. Quinn Street

Between S. Scott Street and S. Quinn Street (0.13-mile segment), Columbia Pike is a four-lane undivided roadway. The cross-section is 54 feet at the western end of this segment, as a painted median is provided in order to transition to the five-lane cross-section located west of S .Scott Street. The eastern end of this segment is 48 feet measured from face-of-curb to face-of-curb. No exclusive turn lanes or on-street parking is provided along this segment. There are no signalized intersections in this section of Columbia Pike. Existing traffic volumes along both directions of Columbia Pike at the S. Scott Street intersection were the highest along the corridor: 2,430 vehicles in the morning peak and 2,640 vehicles in the evening peak.

4.1.5 Columbia Pike from S. Quinn Street to S. Orme Street/the Ramp from Route 27 NB

The 0.17-mile segment from S. Quinn Street to east of the S. Orme Street/ramp from Route 27 NB (S. Washington Boulevard) is characterized primarily by the Route 27 (S. Washington Boulevard) western interchange. Columbia Pike is a four-lane raised median divided roadway in this segment with a varying cross-section width from 58 feet to 75 feet. In lieu of a raised median at S. Quinn Street, vertical flex-post delineators are installed in the median of Columbia Pike, which restrict northbound left-turns. There is a slip-lane from eastbound Columbia Pike to NB Route 27. An exclusive left-turn lane is provided westbound approaching S. Queen Street/the ramp to SB Route 27. A right-turn slip-lane is located eastbound approaching the ramp to SB Route 27, and an exclusive right-turn lane is provided along westbound Columbia Pike approaching the ramp to NB Route 27. Intelligent Transportation Systems (ITS) overhead signs dictate the lane-use along eastbound Columbia Pike approaching S. Queen Street/ramp to SB Route 27; during certain peak time periods, the right lane on Columbia Pike must turn right and the left lane is an optional through or right-turn lane. The other lane-use option along this eastbound approach utilizes the right lane as a traditional through-right lane and the left lane as a traditional through-only lane. This variable lane use condition results in buses needing to be in the leftmost lane to travel through the intersection when the lane use signs are illuminated to avoid conflicts with right-turning vehicles. There is no on-street parking in this section.

Columbia Pike and S. Orme Street looking west towards Washington Boulevard (Route 27)

There are three signalized intersections in this section:

- S. Queen Street/ramps to and from SB Route 27
- The ramps to and from Route 27 NB (westbound Columbia Pike only)
- S. Orme Street/ramps from Route 27 NB

This segment has the second lowest volumes along the corridor. The Columbia Pike volumes at the S. Orme Street/ramps from Interstate 395 SB and Route 27 SB (S. Washington Boulevard) intersection is only 1,280 vehicles during the morning peak and 1,690 vehicles during the evening peak.

4.1.6 Columbia Pike from S. Orme Street/the Ramp from Route 27 NB to Air Force Memorial Drive

Columbia Pike is a four-lane undivided roadway along the 0.30-mile segment beginning east of the S. Orme Street/ramps from Route 27 NB (S. Washington Boulevard) to Air Force Memorial Drive. The roadway cross-section is typically 40 feet in this segment. No exclusive turn lanes or on-street parking are provided along this segment. There are no signalized intersections in this section of Columbia Pike; however, a full-color signal controls the pedestrian crosswalk located adjacent to Virginia State Police/Virginia Department of Transportation (VDOT) facilities (midway between the S. Oak Street and Air Force Memorial Drive intersections).

4.1.7 Columbia Pike from Air Force Memorial Drive to the Pentagon Parking Lot

The 0.55-mile segment of Columbia Pike between Air Force Memorial Drive and the corridor's eastern terminus at the Pentagon parking lot is a four-lane divided roadway. Between Air Force Memorial Drive and Southgate Road/S. Joyce Street, Columbia Pike is typically 70 feet from curb to curb to accommodate a 20-foot-wide raised median. Between Southgate Road/S. Joyce Street and the Route 27 (S. Washington Boulevard) eastern interchange, the raised median widens to 50 feet, and narrows back down to only 4 feet wide at the eastern terminus of Columbia Pike. Exclusive left-turn lanes are provided in both directions of the Southgate Road/ S. Joyce Street intersection. An exclusive right-turn lane is provided in the westbound direction approaching the Air Force Memorial Drive intersection. Right-turn slip lanes are located eastbound approaching Southgate Road/S. Joyce Street, the Route 27 SB ramp, and the Route 27 NB ramp, as well as westbound for the Route 27 NB ramp, the Route 27 SB ramp, and at the Arlington National Cemetery service entrance. There is no on-street parking in this section. One signalized intersection (Southgate Road/S. Joyce Street) is located in this segment. Existing traffic volumes along both directions of Columbia Pike at the S. Joyce Street

intersection were the lowest along the corridor: 772 vehicles in the morning peak and 1,380 vehicles in the evening peak[9].

4.2 Roadway Connectivity

Four north-south roadways intersect the Columbia Pike corridor, serving as local commuter routes and Arlington County thoroughfares: S. Four Mile Run Drive, S. George Mason Drive, S. Glebe Road, and S. Walter Reed Drive. Three key characteristics differentiate these major corridors from other roadways intersecting the Columbia Pike corridor:

- These roadways have other major bus routes
- There is a high number of commercial properties along these roadways
- These roadways provide connections to the northern or southern areas of the county.

S. Four Mile Run Drive extends from Shirlington and Long Branch in the south to the Columbia Pike corridor. S. George Mason Drive provides connection between the Columbia Forest and Claremont neighborhoods in the south to Yorktown in the north. S. Glebe Road extends from Long Branch in the south and continues through Ballston all the way to the Chain Bridge located to the north of the George Washington Memorial Parkway. Finally, S. Walter Reed Drive connects Shirlington and Claremont in the south with Arlington Heights and the Route 50 corridor to the north, ultimately transitioning to S. Fillmore Street and continuing to Clarendon. S. Carlin Springs Road extends from Columbia Pike to N. Glebe Road in Ballston. Beyond the County is ties into Leesburg Pike (Route 7) at the southern end. The road provides similar connections to the other four, but is more of a major residential connector, and lacks commercial nodes except at either end.

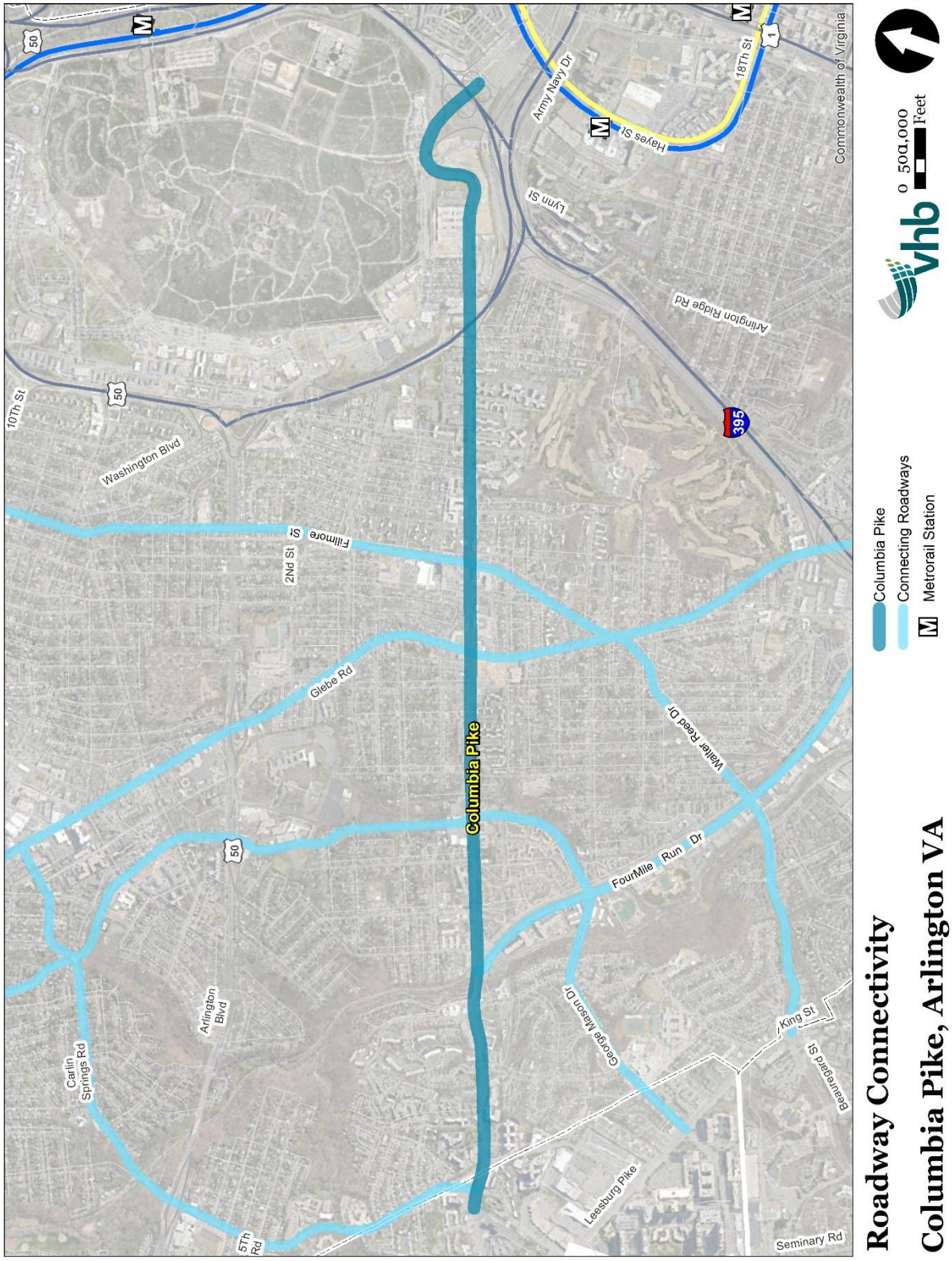
The remaining signalized and unsignalized intersections along Columbia Pike are generally considered to be local streets. Although some of these roadways provide connections within Arlington County, the majority of the local streets intersecting Columbia Pike help make up small networks of neighborhood streets. Additionally, the local streets predominantly have only residential land uses along the roadways.

In addition to providing local access within Arlington County, Columbia Pike serves as a regional link for the larger Washington, D.C. metropolitan area. Originating in Fairfax County, Columbia Pike connects east-west regional traffic from the Annandale and Bailey's Crossroads areas west of Arlington County directly to the

9 The description above is for the current Columbia Pike alignment. The County, the Department of the Army, and the Virginia Department of Transportation have been working towards a realignment of Columbia Pike that would provide additional land for Arlington Cemetery. The proposed realignment would have Columbia Pike continue due east at the Air Force Memorial instead of curving north. The realignment Columbia Pike would intersect with Joyce Street, and connect with the existing Columbia Pike as it enters the Pentagon near the ramps from Washington Boulevard. This realignment would not directly impact future transit operations. In fact, straightening Columbia Pike and improving the connection to Joyce Street could provide benefits to future transit along Columbia Pike.

Pentagon at the corridor's eastern terminus. Another major regional thoroughfare with connections to the Columbia Pike corridor is Route 27 (S. Washington Boulevard). This U-shaped limited access roadway intersects the eastern portion of Columbia Pike at two different grade-separated interchanges. The western segment of Route 27 links the study corridor with Fort Meyer, Lyon Park, and Clarendon. The eastern segment of Route 27 links the study corridor with Memorial Circle and Rosslyn. Both interchanges with Route 27 provide access to Interstate 395, connecting Arlington to downtown Washington D.C in the north and Alexandria and Crystal City in the south.

Figure 4.2: Columbia Pike Connecting Roadways



4.3 Travel Patterns

A review of the Metropolitan Washington Council of Government's Travel Demand Model, Version 2.3, also indicates that Columbia Pike is a local street for residents as well as a commuter corridor. People traveling on Columbia Pike are largely coming from four zones:

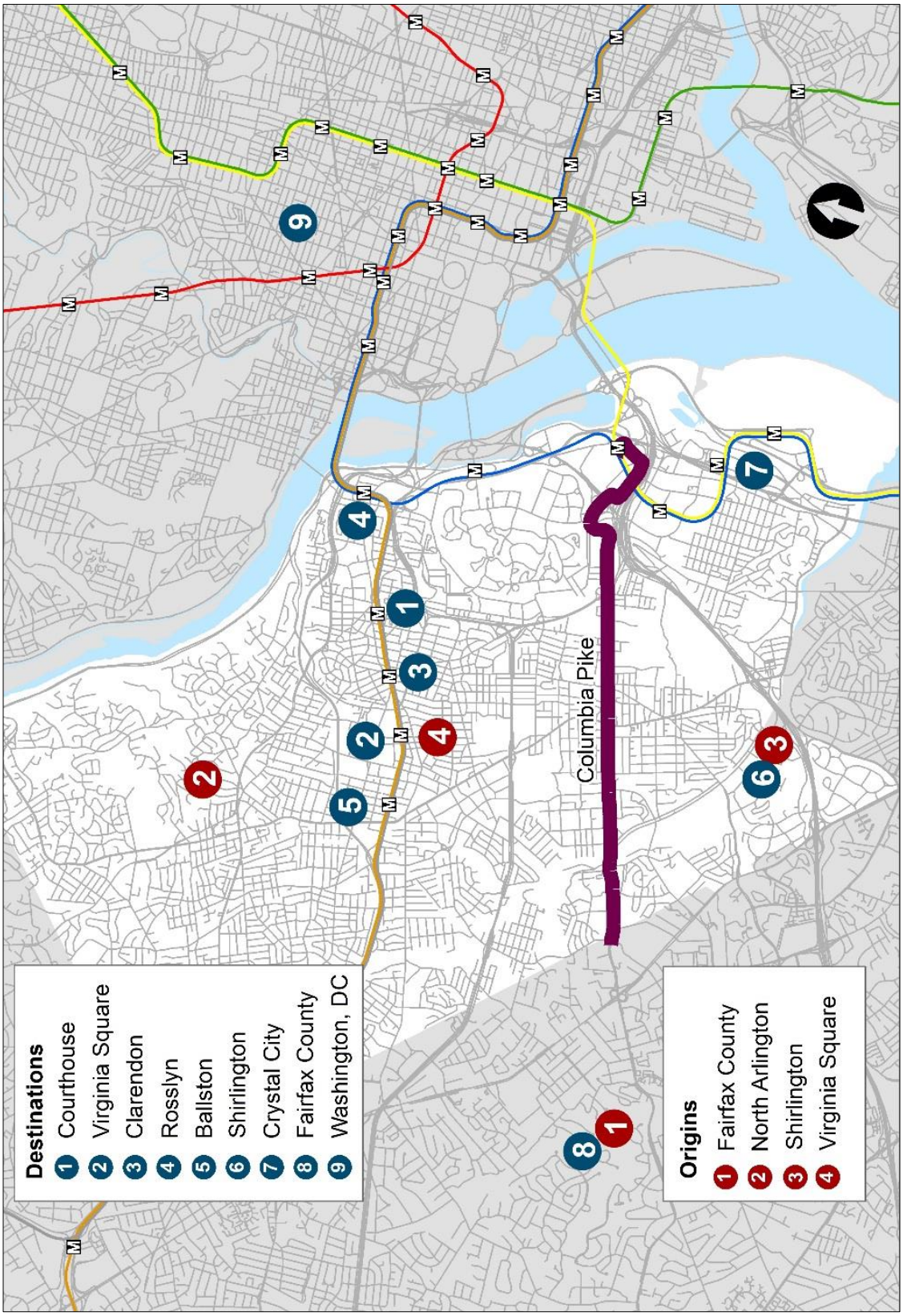
- Fairfax County
- North Arlington
- Shirlington
- Virginia Square

The destinations for these transit users include nine zones:

- Courthouse
- Rosslyn
- Ballston
- Shirlington
- Crystal City
- Fairfax County
- Washington, DC

While the Pentagon is a major destination for many people across the region, it was not a significant destination for people using the Columbia Pike corridor. This indicates that the Pentagon is not the ultimate destination specifically for transit users on Columbia Pike. Although Columbia Pike corridor transit users travel to the Pentagon, the Pentagon predominately serves as a significant transfer point for people traveling by transit along Columbia Pike rather than an endpoint.

Figure 4.3: Columbia Pike Origins and Destinations



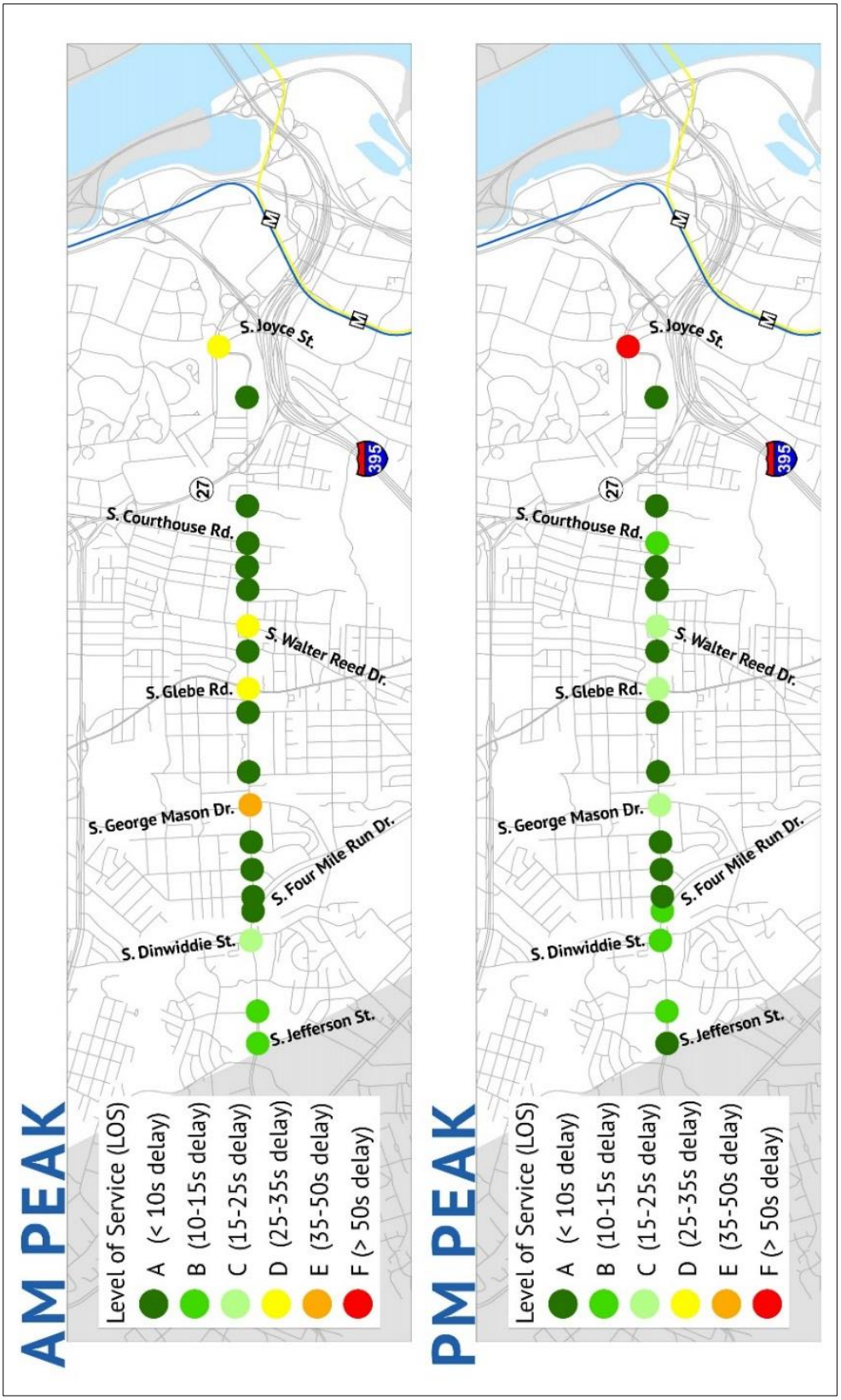
4.4 Traffic Performance

Congestion is a contributor to overall corridor delay and subsequently slower transit travel times. Intersections with a lower level of service (LOS) have the greatest impact (delay) on vehicles and buses. Overall, the intersection levels of service for Columbia Pike in the morning and evening peak periods are good; generally the signalized intersections along the corridor operate at LOS A through C. These levels of service indicate free flow or near free flow conditions. The side street volumes for the northbound and southbound approaches for these intersections range from 40 to 500 vehicles.

The intersections that do not operate at a LOS C or better include the major intersections of S. George Mason Drive (LOS E), S. Glebe Road (LOS D), and S. Walter Reed Drive (LOS D) during the morning peak periods. The lower levels of service indicate higher delay at these intersections. A key contributor to lower levels of service at these three intersections is the traffic volumes on the north-south approaches. These north-south routes carry 1,260 to 2,420 vehicles during the peak hour, which is significantly more volume when compared to the volumes of the remaining north-south roadways. Opportunities to reduce intersection delay at these three intersections could improve transit corridor speeds and overall congestion.

Also of note is the intersection of Southgate Road/S. Joyce Street, which currently operates at a LOS D during the morning peak and LOS F during the evening peak. Although this intersection has the lowest volumes on Columbia Pike during these peak periods, the northbound and southbound volumes equal or exceed the Columbia Pike volumes. Additionally, this intersection currently has the longest cycle length of any intersection on the corridor.

Figure 4.4: Columbia Pike Level of Service



4.5 Pedestrian and Bicycle Characteristics and Performance

Bicycling along Columbia Pike can be challenging and intimidating because of the existing travel lane widths and the high volume of traffic. Arlington County is focused on improving the experience for cyclists of all levels by expanding and completing their existing network of dedicated bicycle facilities. The County's Bicycle Element of the *Master Transportation Plan* includes recommendations for completing connections to the Columbia Pike corridor because of it continued growth as a key commercial corridor and activity center. To provide east-west connectivity along the corridor, the County proposes the development of bike boulevards on parallel streets.

4.5.1 Trails

Two major multi-use trails intersect Columbia Pike: the Four Mile Run Trail and the Washington & Old Dominion Trail. These trails both intersect Columbia Pike in the vicinity of S. Four Mile Run Drive and follow the course of Four Mile Run. The Four Mile Run Trail is approximately 7 miles long, running from the East Falls Church Metro Station in the west and the Mount Vernon Trail (near Ronald Reagan Washington National Airport) in the east. The Washington & Old Dominion Trail is approximately 45 miles long and runs from Purcellville (Loudoun County) in the west to I-395 in the east. These trails provide north-south connectivity for cyclists traveling to the corridor and more broadly to Arlington County and destinations beyond.

4.5.2 Bikeshare

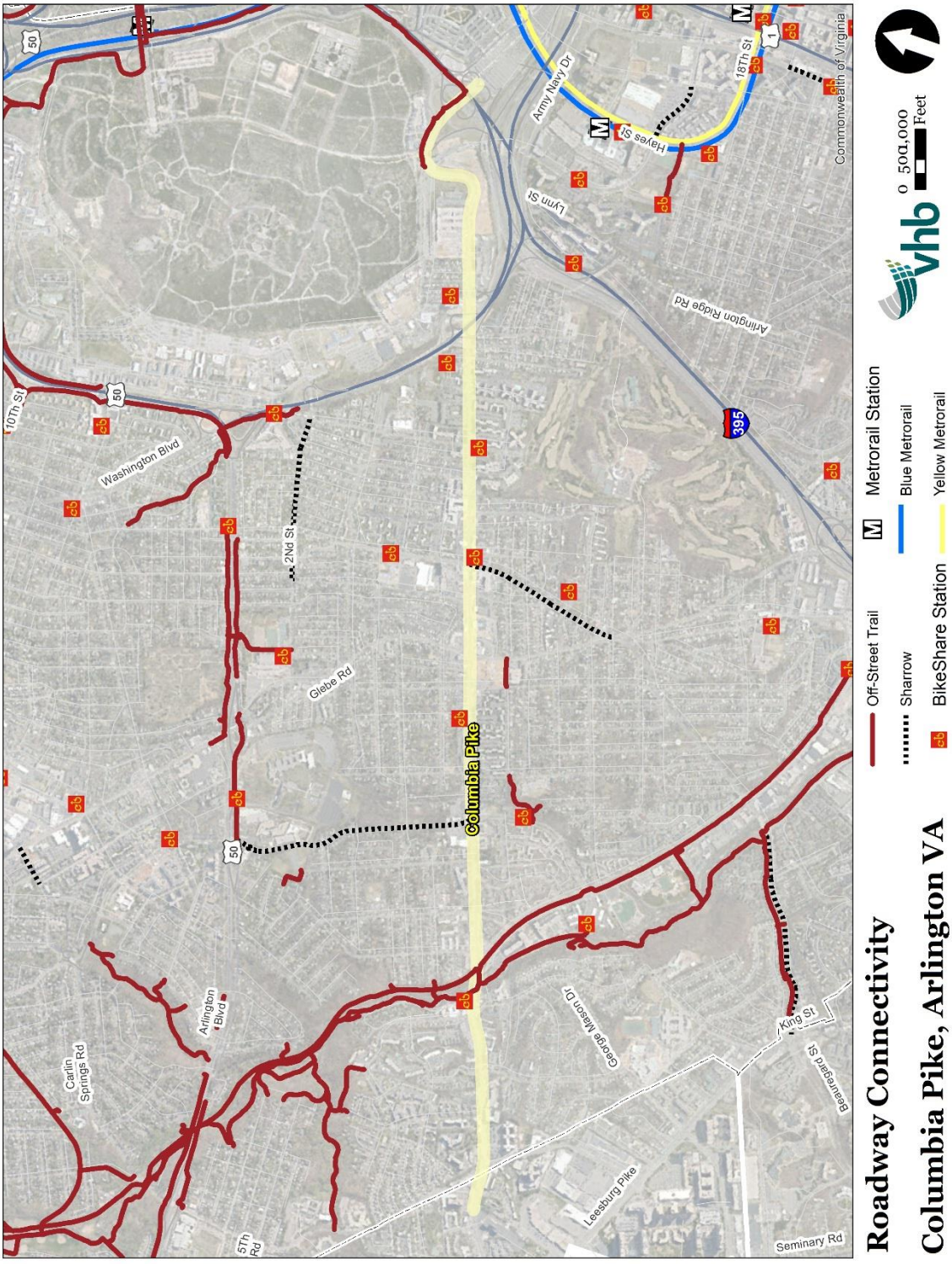
Capital Bikeshare provides a total of 74 potential docks for bikeshare bikes along the corridor in six different locations. From April to June 2015, these stations generated and attracted roughly 4,200 trips out of nearly one million total trips for the entire Washington DC region. The lack of bicycle infrastructure along Columbia Pike is likely a contributing factor to the low usage of the bikeshare facilities. The usage data shows that the origins and destinations of most users are within the corridor (corridor stations highlighted in bold) or between the corridor and nearby areas. Three of the top five locations were to nearby community centers.

Table 4.1: Columbia Pike Bikeshare Stations and Usage (April–June 2015)

Location	Bike Docks	Trips Starting at Station	Trips Ending at Station
Columbia Pike & S. Dinwiddie Street/ Arlington Mill Community Center	14	259	254
S. Oakland Street & Columbia Pike	11	75	97
Columbia Pike & S. Walter Reed Drive	12	577	551
Columbia Pike & S. Courthouse Road	15	613	533
Rolfe Street & 9th Street South	11	148	132
Columbia Pike & S. Orme Street	11	535	447

Source: Capital Bikeshare Trip History Data—Quarter 2, 2015.

Figure 4.5: Bicycle Network and Capital Bikeshare Stations



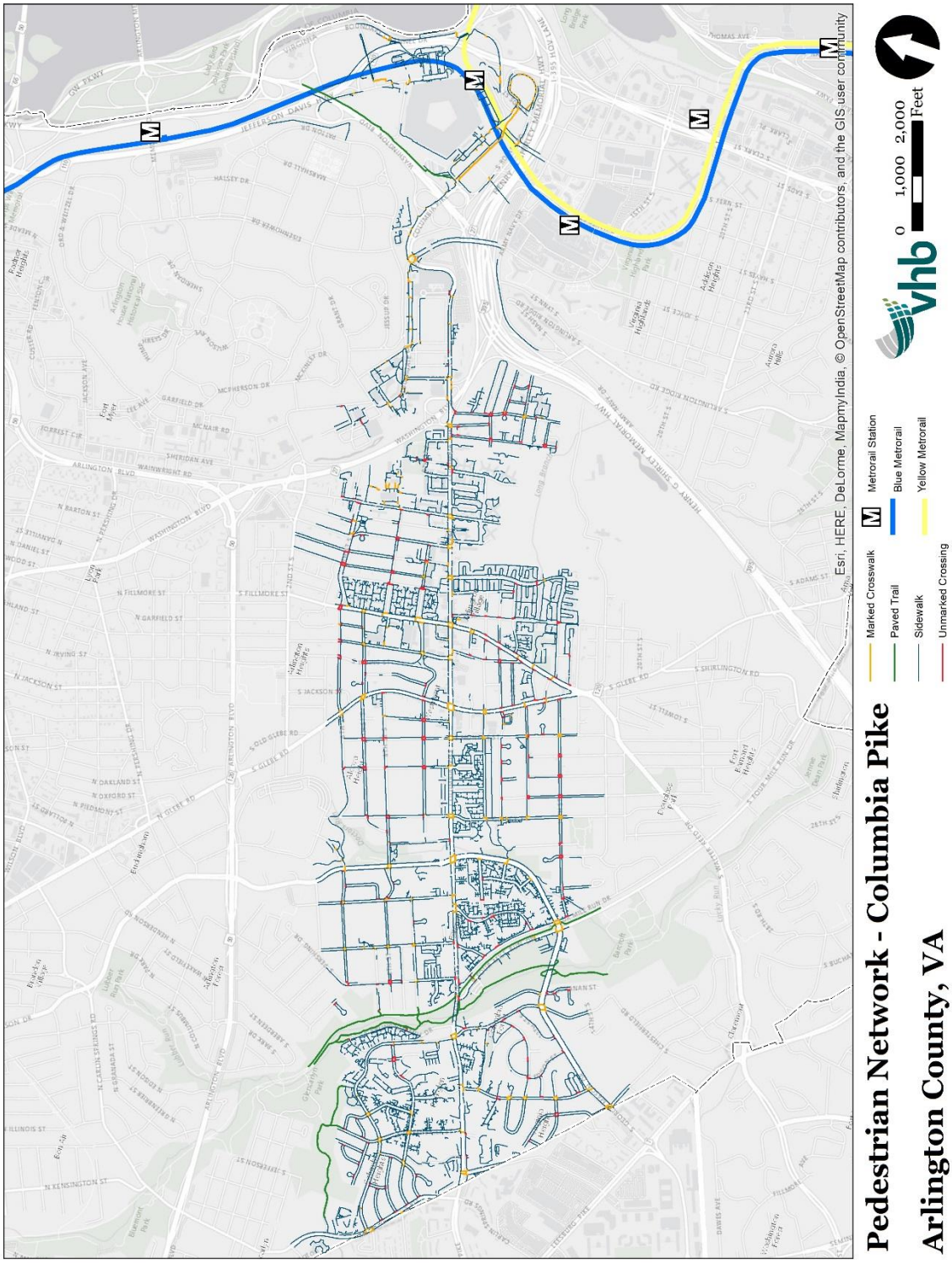
4.5.3 Pedestrian Infrastructure and Usage

The pedestrian network for the Columbia Pike corridor is mostly complete, providing sidewalks along most of Columbia Pike and the connecting side streets. Sidewalks vary in width and setback from the roadway, with wider sidewalks found along segments of the corridor where recent improvements have been made as part of new developments or the County's ongoing streetscape project.

Two types of crosswalk pavement markings are present: ladder style and standard parallel line markings. Crosswalks (signalized and unsignalized) are spaced throughout the corridor at least every 1,000 feet, with many segments providing crosswalks more frequently. The majority of crosswalks are signalized, with upgrades for curb ramps and accessibility being completed as part of larger projects along the corridor. Some crosswalks do not have curb ramps, especially at unsignalized intersections.

(Left) Example of sidewalk east of Courthouse Road. (Right) Example of sidewalk and crosswalk at S. Greenbrier Street.

Figure 4.6: Pedestrian Network



5

Transit Service Characteristics and Performance

Public transportation for the Columbia Pike corridor is provided through a combination of Metrobus and Arlington Transit (ART) routes. Metrobus routes provide regional connections between Fairfax and Arlington Counties, operating along the full length of the corridor. ART buses are designed to provide local connections, serving only segments of the corridor between residential and commercial centers within Arlington. Metrobus and ART collaborate on "Pike Ride," coordinating service between the two operators to provide frequent, convenient service along Columbia Pike.

The Columbia Pike corridor has the highest amount of bus service in the County. Twenty-three percent of the County's bus service hours are operated on Columbia Pike, reinforcing the importance of public transportation along the corridor. The service provided along Columbia Pike connects residents with key transit connections, commercial areas (including Columbia Pike), and job centers. The transit service also brings people onto the corridor for shopping and employment.

The following is a breakdown of the primary destinations served by the routes operating along Columbia Pike:

- The Pentagon: 27%
- Pentagon City: 28%
- Crystal City: 5%

- Washington, DC: 14%
- Rosslyn/Ballston Corridor: 25%

5.1 Transit Performance Objectives

As part of ART's update to their Transit Development Plan (TDP), an online survey was conducted to assess the public's desires for improvements to transit along Columbia Pike. The most frequently requested improvement was for more frequent service, followed by more service on evenings and weekends. Other common preferences requested were for improved transit information and faster boardings. Participants were also asked to list areas they would like to improved connections between. Common responses included Clarendon, Rosslyn, Ballston, Crystal City, Shirlington, and Washington, DC. Another commonly observed comment was related to crowding on buses, particularly the 16Y.

Objectives were developed to guide the assessment of the existing transit service and inform future improvements. The TDP recommends system-wide goals and objectives that are tied back to the County Transportation and Development Division's Key Performance Measures.[10] The goals are:

- Accessibility: Expand multimodal access and connectivity to destination both within and outside the County
- Mobility: Improve mobility for all users of the transportation system in Arlington County
- Safety and Security: Provide transportation infrastructure and an integrated transportation network that is safe and secure for all users and all modes of travel
- Managing Effectively and Efficiently: Construct and manage the transportation system, infrastructure, and operations effectively, efficiently, and transparently
- Environment, Energy, and Health Economy: Enrich the quality of life in Arlington County through sustainable transportation improvements and infrastructure

The TDP also includes targets against which to measure transit performance. The County has provided more specificity to particular targets based on defined service levels. For example, the Columbia Pike corridor has been identified as a Premium Transit Network (PrTN) corridor. A PrTN corridor is defined as a high-frequency (10-minute peak and 12-minute off-peak) enhanced bus service. The corridor will provide transit service for at least 18 hours a day, seven days a week.

[10] ArlingtonDES. "Key Performance Measures - Transportation." *Transportation*. N.p., n.d. Web.

Based on the existing goals and initial community feedback, the following objectives were identified for Columbia Pike:

- Provide sufficient capacity to meet existing and future demand
- Enhance connectivity and accessibility to the corridor and the larger transit network
- Improve transit travel time
- Improve reliability
- Support corridor development

5.2 Existing Transit Performance Assessment

The following section describes the assessment of factors that can influence transit performance. To address the objectives outlined above, it is necessary to understand the factors that are contributing positively and negatively to the performance of bus routes along Columbia Pike. Each subsection addresses a different aspect of bus performance that contributes to each rider's experience.

5.2.1 Columbia Pike Routes

Metrobus and ART routes operate along all or a portion of the Columbia Pike corridor in Arlington County. This planning effort primarily focuses on the Metrobus routes because they make up the greatest percentage of the service along Columbia Pike and serve the entire corridor from end to end. The ART routes are designed to connect Columbia Pike with other areas of the County, and tend to only operate along a segment of Columbia Pike before turning off the corridor.

This section describes the service characteristics of each bus route, areas served, the passenger loading patterns, and high ridership stops.

5.2.1.1 Metrobus Routes

Metrobus operates nine routes along the Columbia Pike corridor as part of the 16 line. The spine of this service operates between the Arlington/Fairfax County line and the Pentagon. On the western end of the corridor, many routes have different endpoints, as they provide connections to the corridor from major residential areas, many in Fairfax County. On the eastern end, some of the routes extend beyond the Pentagon, serving Pentagon City, Crystal City, and Washington, DC.

The service hours for the 16 line goes from as early as 4:30 a.m. to as late as 1:30 a.m. Monday through Thursday. Later night service is offered by the 16E on Fridays and Saturdays. Most other routes have shorter service hours on the weekends. Service frequencies range between 9 and 46 minutes during the weekday, with higher frequencies operated during the peak commuting hours. During the peak commuting periods, the combined frequency for the Metrobus 16 line routes can approach a bus arriving every 3 minutes. This changes during non-commuting

hours, with the combined frequency for the corridor only providing a bus roughly every 10 minutes. Weekend service frequencies decrease, with the highest being 60 minutes on the 16P on Sundays. Table 5.1 shows the service hours and frequency by route, as well as the combined frequencies by period.

Figure 5.1: Existing Metrobus 16 Line Routes

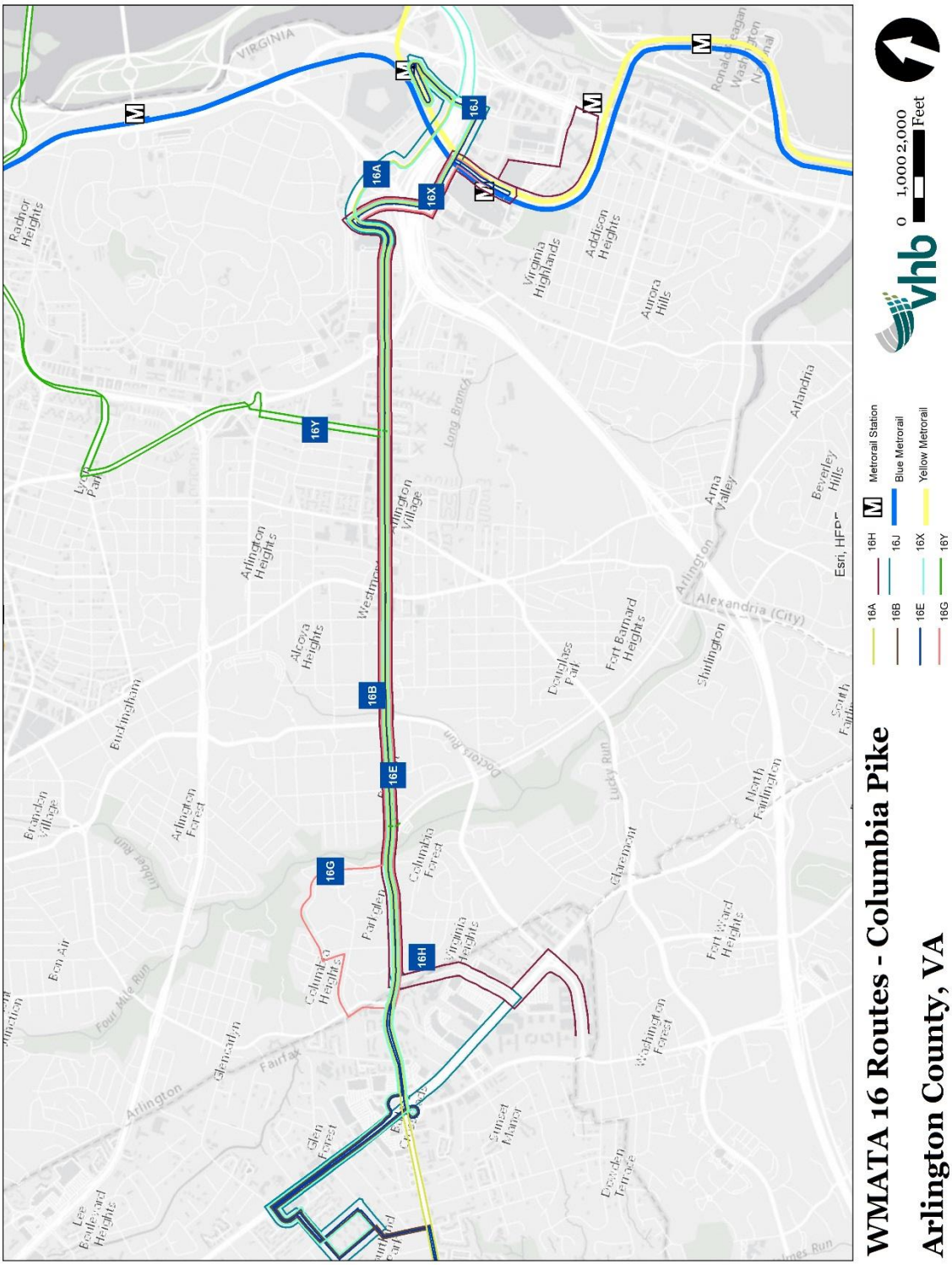


Table 5.1: Metrobus 16 Line Service Hours and Frequency

	Weekday						Saturday		Sunday	
		Frequency (Minutes)						Frequency (Minutes)		Frequency (Minutes)
Route	Span	Early	Peak	Midday	Evening	Late Night	Span		Span	
16A	4:33 am-11:02 pm	40	30	30	37					
16B	4:41 am-8:55am; 2:40 pm-12:14am	16	37		38	16	5:29am - 11:02pm	29	5:59am - 9:51pm	48
16E	10:47pm - 1:39am (Fri till 3:55am)					23	11:03pm - 3:55am	33	7:12pm - 1:01am	35
16G	4:35am - 11:57pm	11	12	15	15	20	7:17am - 11:15pm	16	7:20am - 10:15pm	30
16H	5:56am - 9:21am (EB only); 4:05pm - 7:15pm (WB only)		12							
16J	5:56am - 9:51pm		31	30	46		7:15am - 9:47pm	30		
16K							5:18am - 7:36pm	30	5:51am - 7:39pm	30
16P									9:09am - 8:05pm	60
16X	5:30am - 9:39am; 3:30pm - 7:53pm		15							
16Y	5:55am - 9:42am (EB only); 3:30pm - 7:54pm (WB only)		9							
	Combined Frequency	7	3	8	9	8		6		9

Source: WMATA Metrobus Public Timetables

The following is a brief description of each Metrobus 16 line route, documenting the end points of the route, service hours, frequency, run time, high ridership stops, and maximum load point for the route. A graphic showing the eastbound and westbound boarding and alighting data as well as passenger loading for each route can be found in the Appendix. Figure 5.2 and 5.3 show the aggregate load factor for the Metrobus 16 Line routes during the morning and evening peak respectively.

Figure 5.2: Metrobus 16 Line AM Peak Load Factor

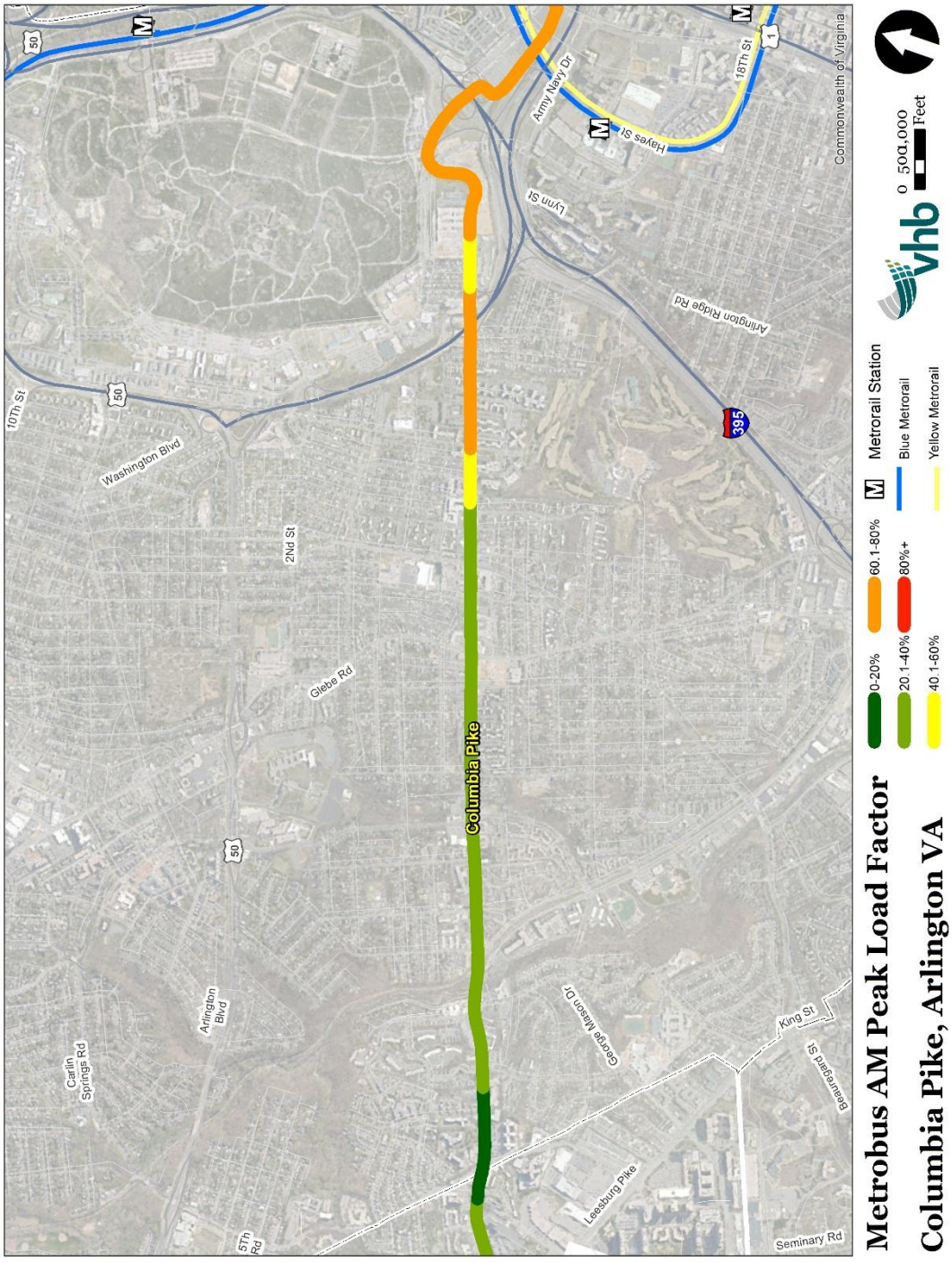
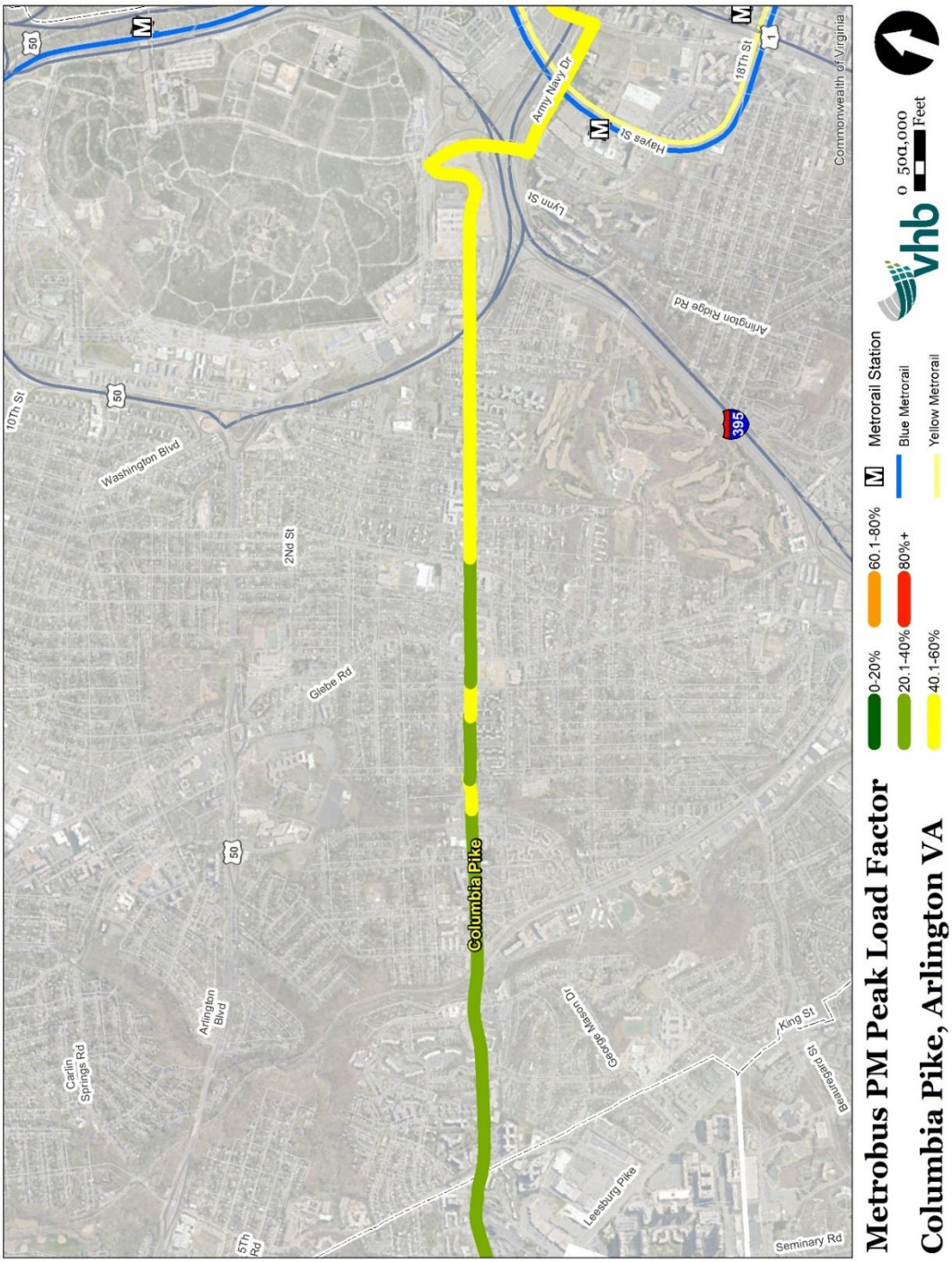


Figure 5.3: Metrobus 16 Line PM Peak Load Factor



Route 16A

Route 16A operates between Annandale in Fairfax County and the Pentagon Metro Station. The route operates from 4:33 a.m. and 12:24 a.m. on weekdays only. The route's end-to-end run-time is between 44 and 54 minutes, depending on direction and time of day. The route operates on 30-minute headways throughout the day. On Columbia Pike, during the morning peak, the passenger load on Route 16A is at its highest when entering Arlington County traveling eastbound. The load remains relatively consistent with a small decrease between Quincy and Monroe Streets, then increases again before reaching the Pentagon. Westbound evening trips show a reversed pattern—the load departing the Pentagon is high with slight fluctuations until reaching the county line, where it begins to decrease. In Arlington, eastbound during the morning peak period, boarding is highest at S. Courthouse Road and alighting is highest at S. Veitch Street. Westbound during the morning peak period, boarding is highest at S. Dinwiddie Street and alighting is highest at S. Veitch Street. Eastbound during the evening peak period, boarding is highest at the Windsor Towers stop, and alighting is highest at S. Edgewood Street. Westbound during the evening peak period, boarding is highest at S. Glebe Road and alighting is highest at S. Dinwiddie Street.

Route 16B

Route 16B operates between Annandale in Fairfax County and the Pentagon Metro Station. The route operates from 4:41 a.m. and 12:14 a.m. on weekdays, between 5:29 a.m. and 12:28 a.m. on Saturdays, and between 5:59 a.m. and 1:01 a.m. on Sundays. On weekdays, the route's end-to end run-time is between 21 and 38 minutes. The route's end-to-end run-time extends to between 42 and 59 minutes on Saturdays and Sundays. On weekdays, the route operates on a 30-minute headway in the mornings and evenings. The route operates on an hourly headway all-day Saturday and Sunday.

Along Columbia Pike, during morning peak eastbound travel, the passenger load is relatively small at the Fairfax County/Arlington County line and gradually increases as the route travel through the corridor. The load finally drops at the Pentagon Metro Station. During the evening peak westbound trips, this pattern is generally reversed, with a significant dip in passenger load between Barton Street and Highland Street. Along the Columbia Pike corridor during eastbound morning peak travel, boarding is highest at Scott Street and alighting is highest at the Glebe Road. During westbound morning travel, boarding is highest at Thomas Street and alighting is highest at S. Veitch Street. During eastbound evening travel, boarding is highest at Windsor Towers and alighting is highest at S. Edgewood Street. For westbound evening travel, boarding is highest at Glebe Road and alighting is highest at Dinwiddie Street

Route 16E (Late Night)

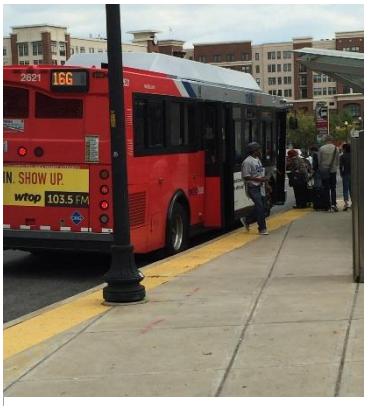
Route 16E operates between Annandale in Fairfax County and the Pentagon Metro Station. The route operates weekdays, Saturdays, and Sundays in the evenings and

late nights only. The route operates from 10:47 p.m. and 1:10 a.m. Monday to Thursday, and until 3:59 a.m. on Fridays. On Saturdays, service hours are between 11:03 p.m. and 3:55 a.m. On Sundays, the route operates from 7:12 p.m. to 1:01 a.m. The route operates on a 20- to 30-minute headway before 1:00 a.m. and then on a 30- to 60-minute headway after 1:00 a.m. On Columbia Pike, the passenger load on eastbound trips is highest at the entry into the County and remains generally constant until Glen Carlyn and Vista, where the load experiences a drop. The passenger load then remains steady until the route approaches the Pentagon Metro Station. In Arlington, during the eastbound travel, boarding is highest at Columbia Pike and Carlin Springs and alighting is highest at S. Hayes and 12th Streets. During westbound travel, boarding is highest at S. Hayes and 12th Streets and alighting is highest at Thomas Street.

Route 16G

Route 16G operates between the western end of the Columbia Pike corridor and the Pentagon City Metro Station. The route is in service between 4:53 a.m. and 11:57 p.m. on weekdays, between 5:18 a.m. and 11:15 p.m. on Saturdays, and between 5:51 a.m. and 10:15 p.m. on Sundays. On weekdays, the route's end-to-end run-time is between 14 and 31 minutes. On Saturdays and Sundays, the route's end-to-end run-time is between 15 and 24 minutes. On weekdays and weekends, the route operates on a 30-minute headway. In Arlington, passenger load on the eastbound Route 16G during the morning peak is relatively low at the start of the route in Columbia Pike. The passenger load gradually increases and peaks at Scott Street, where it generally remains constant until the route reaches the Pentagon City neighborhood. During the evening peak westbound trips, the passenger load experiences many fluctuations. The passenger load from Pentagon City to Buchanan Street is high and encounters drops at Orme, Barton, and Glebe. The load begins to decline after Buchanan Street, with large alighting occurring at Dinwiddie, Windsor Towers, and Carlin Springs.

On Columbia Pike, as the route travels eastbound during the morning peak period, boarding is highest at S. Courthouse Road, and alighting is highest at S. Highland Street. During morning westbound travel, boarding is highest at S. Highland Street and alighting is highest at S. Glebe Road. During evening eastbound service, boarding and alighting are highest at the S. Edgewood Street. During evening westbound service, boarding is highest at S. Glebe Road and alighting is are highest at S. Dinwiddie Street.



Metrobus 16G stopped at Columbia Pike and S. Walter Reed Drive

Route 16H

Route 16H operates between the Skyline area and the Pentagon City Metro Station. The route operates eastbound service only during weekday mornings (between 5:56 a.m. and 9:21 a.m.), and westbound service only during weekday evenings (between 4:05 p.m. and 7:15 p.m.). The route's end-to end run-time is between 24 and 32 minutes, and its headways are 12 minutes. Route 16H's passenger load during morning eastbound service steadily increases from the county line near Carlin Springs Road until South Hayes Street and 12th Street, where many passengers alight. During evening westbound service, the passenger load is the highest leaving Pentagon City and gradually decreases approaching Skyline, with a slightly more pronounced dip around S. Courthouse Road. During morning eastbound service, boarding is highest along the Columbia Pike corridor at Windsor Towers and Courthouse Road. During evening westbound service, boarding is highest in the corridor at the Pentagon City Metro.

Route 16J

Route 16J operates between the Skyline area and the Pentagon Metro Station. The route operates from 5:42 a.m. to 9:51 p.m. on weekdays, and from 7:15 a.m. to 9:47 p.m. on Saturdays. The route does not operate on Sundays. On weekdays, the route's end-to end run-time is between 28 and 39 minutes. On Saturdays, the route's end-to-end run-time is between 28 and 42 minutes. The route operates on a 30-minute headway. In Arlington, passenger load on the eastbound Route 16J during the morning is low entering the County and gradually climbs as the route travels east towards the Pentagon. The passenger load reaches a peak at Scott Street and remains relatively constant until the Pentagon Metro Station stop. The westbound 16J during the evening peak period has the reverse trend, with a noticeable decrease in load between Scott Street and Highland, and a more continued decrease beginning at Thomas Street through the County line.

During morning eastbound trips along the Columbia Pike corridor, boarding is highest at Courthouse Road and alighting is highest at George Mason Drive. Westbound during the morning peak period, boarding is highest at S. Dinwiddie Street and alighting is highest at S. Veitch Street. For eastbound trips during the evening peak period, boarding is highest at S. Barton Street and alighting is highest at S. Edgewood Street. For westbound trips during the same time period, boarding is highest at the Pentagon and alighting is highest at S. Veitch Street.

Route 16K (weekend only)

Route 16K operates between the western edge of the Columbia Pike corridor and the Pentagon Metro Station. The route is an early-morning, weekend-only service operating from 5:18 a.m. to 7:36 a.m. on Saturdays and from 5:51 a.m. to 7:39 a.m. on Sundays. On Saturdays, the route's end-to-end run-time is between 22 and 32 minutes. On Sundays, the route's end-to-end run-time is 26 minutes. The route operates four round-trips on Saturday and three round-trips on Sunday, with 30-minute headways.

On Saturday and Sunday eastbound trips towards the Pentagon, the passenger load typically peaks at Oakland Street, declines between Monroe Street and Edgewood Street (where several passengers alight), increases again at Scott Street, and remains high until the route ends at the Pentagon Metro Station. On Saturday and Sunday westbound trips, the passenger load is relatively high at the start of the route (Pentagon Metro Station) due to the many passengers boarding at that stop. The load increases incrementally as the route travels west to Carlin Springs Road, where the passenger load experiences a drop.

During eastbound Saturday service, boarding along Columbia Pike is highest at Thomas Street and alighting is highest at Glebe Road. During westbound Saturday service, boarding is highest at the Pentagon Metro Station and alighting is highest at Carlin Springs Road. On eastbound Sunday service, boarding along Columbia Pike is highest at Four Mile Run and alighting is highest at Glebe Road. During westbound Sunday service, boarding along the Columbia Pike corridor is highest at Highland Street and alighting is highest at Carlin Springs Road.

Route 16P (weekend only)

Route 16P operates between the Culmore neighborhood in Fairfax County and the Pentagon City Metro Station. The route operates from 9:09 a.m. to 8:05 p.m. on Sundays only. The route's end-to-end running time is between 37 and 43 minutes. The route operates on a 60-minute headway.

During eastbound trips along Columbia Pike, the passenger load remains relatively constant until Highland Street, where it experiences a decline until Courthouse Road, and Hayes and 12th Street South, where most passengers alight. During westbound trips, the passenger load along Columbia Pike remains relatively static until Jefferson Street, where the passenger load begins to decline until the end of the route. During eastbound service, boarding along the Columbia Pike corridor is highest at Windsor Towers and alighting is highest at Glebe Road. During westbound service, boarding and alighting along Columbia Pike are highest at Thomas Street.

Route 16X (Express)

Route 16X is a MetroExtra service that operates between Culmore neighborhood in Fairfax County and Federal Triangle in Washington, DC. Route 16X makes limited stops along Columbia Pike, serving only the following locations (on Columbia Pike):

- All stops between Glen Carlyn & Vista Drives and Baileys Crossroads
- Columbia Pike and S. Carlin Springs Road
- Columbia Pike and S. Greenbrier Street
- Columbia Pike and S. Columbus Street/S. Dinwiddie Street
- Columbia Pike and S. Four Mile Run Drive/S. Buchanan Street
- Columbia Pike and S. George Mason Drive
- Columbia Pike and S. Oakland Street
- Columbia Pike and S. Glebe Road

- Columbia Pike and S. Walter Reed Drive
- Columbia Pike and S. Barton Street
- Columbia Pike and S. Court House Road
- Columbia Pike and S. Orme Street
- Pentagon Transit Center

The route operates during weekday morning and evening peak hours only (from 5:30 a.m. to 9:39 a.m. and from 3:30 p.m. to 7: 53 p.m.). Service operates the full length of the line in the peak period/peak direction only. During the a.m. peak there is westbound service between the Pentagon and Federal Triangle, and during the p.m. peak there is eastbound service between Federal Triangle and the Pentagon. The route's end-to-end running time is between 43 and 55 minutes. The route operates on 11- to 19-minute headways in the morning peak, and 12- to 30-minute headways in the evening peak.

On Columbia Pike, the passenger load on Route 16X traveling eastbound during the morning peak steadily increases as the route travels east. It reaches its maximum passenger load around Courthouse Road and remains high until the Pentagon Metro Station, where many passengers alight. The passenger load then continues to further decline as the bus approaches Federal Triangle. The passenger load traveling westbound during the evening peak has two peaks. From Federal Triangle to Pentagon Metro Station, the passenger load peaks from Independence Avenue to the Pentagon Mero Station, where many passengers alight. The passenger load then re-balances at Pentagon Metro Station, where many passengers board, and the load remains high until Veitch Street, where it begins to descend again.

During the eastbound morning peak period, boarding is highest (excluding the Pentagon) at S. Courthouse Road, and alighting is highest at the Pentagon. During the westbound evening peak period, boarding is highest at the Pentagon and alighting is highest at S. Veitch Street.

Route 16Y (Express)

Like Route 16X, Route 16Y is a MetroExtra service that operates between the Barcroft area along Columbia Pike and McPherson Square in Washington, DC. Route 16Y makes limited stops along Columbia Pike, serving only the following locations (on Columbia Pike):

- Columbia Pike and S. Four Mile Run Drive/S. Buchanan Street
- Columbia Pike and S. George Mason Drive
- Columbia Pike and S. Oakland Street
- Columbia Pike and S. Glebe Road
- Columbia Pike and S. Walter Reed Drive
- Columbia Pike and S. Barton Street

The route operates eastbound service during the morning peak period (from 5:55 a.m. and 9:42 a.m.) and westbound service only during the evening period

(from 3:30 p.m. and 7:54 p.m.). The route operates during weekdays only. The route's end-to-end running time is between 31 and 42 minutes, and it has 6- to 10-minute headways. On Columbia Pike during morning eastbound travel, the passenger load is relatively low at the start of the route in Barcroft and gradually increases as the route travels east, with the highest passenger load at S. Courthouse Road. For westbound travel, the passenger load follows a similar pattern, with the highest passenger load along the corridor occurring at S. Courthouse Road and gradually declining as the bus approaches Four Mile Run Drive. During eastbound morning service, boarding is highest along Columbia Pike at S. Courthouse Road and alighting is minimal along the corridor. During westbound evening service, boarding is minimal along the corridor and alighting is highest at S. Courthouse Road.

5.2.1.2 ART Routes

ART operates four routes on portions of the Columbia Pike corridor. Each route circulates through the adjoining neighborhoods and then provides service on a section of the corridor. Table 5.2 shows ART's service hours and frequency along Columbia Pike. Figure 5.4 shows the ART routes.

Route 41

ART Route 41 has the highest ridership among all ART routes. Route 41 operates between the Court House Metro Station and Columbia Pike and S. Dinwiddie Street. Route 41 operates along Columbia Pike between South Glebe Road and South Greenbrier Street. On weekdays, the route operates from 5:30 a.m. to 1:10 a.m. On Saturdays, the route operates from 6:10 a.m. to 1:57 a.m. On Sundays, the route operates from 6:55 a.m. to 10:10 p.m. On weekdays, the route's end-to-end running time is between 24 and 40 minutes. On Saturdays, the route's end-to-end running time is between 27 and 30 minutes. The route operates on a 15- to 20-minute headway seven days a week.

On Columbia Pike, the passenger load on Route 41 during morning peak eastbound travel is relatively low at the county line near S. Dinwiddie St and steadily increases until it peaks at S. Glebe Road. The route then turns off the corridor to continue to North Arlington. Along the Pike, during morning eastbound travel, boarding is highest at S. Dinwiddie Street (beginning of the line) and alighting is highest at S. Glebe Road. During morning westbound travel, boarding is highest at S. Greenbrier Street and alighting is highest at S. Dinwiddie Street (end of the line). During evening eastbound travel, boarding is highest at S. Dinwiddie Street (beginning of the line) and alighting is highest at S. Glebe Road. During evening westbound travel, boarding is highest at S. Glebe Road and alighting is highest at S. Dinwiddie Street (end of the line).

Route 42

Route 42 operates between the Pentagon Metro Station and the Ballston-MU Metro Station. Route 42 operates along Columbia Pike between South Courthouse Road and South Joyce Street. On weekdays, the route operates from 6:00 a.m. to 8:10 p.m.

On Saturdays, the route operates from 6:30 a.m. to 7:52 p.m. The route does not operate on Sundays. On weekdays, the route's end-to-end running time is between 27 and 34 minutes. On Saturdays, the route's end-to-end running time is between 27 and 30 minutes. The route operates on 20- to 40-minute headways on weekdays, and a 60-minute headway on Saturdays.

During eastbound travel, Route 42's passenger load is highest on Columbia Pike at S. Joyce Street. During westbound travel, its highest passenger load in the corridor occurs at S. Scott Street. During morning eastbound travel, boarding and alighting is highest along Columbia Pike at S. Scott Street. For westbound travel during the morning peak period, boarding and alighting is highest at S. Courthouse Road. During evening eastbound travel, boarding along the corridor is highest at S. Scott Street and alighting is highest at S. Courthouse Road. For evening westbound travel, boarding and alighting is highest at S. Courthouse Road.

Route 45

ART Route 45 has the third highest ridership among all ART routes. Route 45 operates between Columbia Pike and S. Dinwiddie Street and the Rosslyn Metro Station or between South Greenbrier and Columbia Pike and the Rosslyn Metro Station. Route 45 operates along Columbia Pike between South Courthouse Road and South George Mason Drive and between South Four Mile Run Drive and Carlin Springs Road. On weekdays, the route operates from 5:45 a.m. to 11:00 p.m. The route does not operate on Saturdays or Sundays. The route's end-to-end running time is between 38 and 42 minutes. The route operates on a 30-minute headway.

During eastbound morning travel on Columbia Pike, Route 45's passenger load begins to increase at Four Mile Run and peaks at S. Courthouse Road. During westbound evening travel along the corridor, the passenger load trend reverses with the load highest at S. Courthouse Road and declining as it approaches Four Mile Run. During the morning eastbound travel, boarding is highest at S. Courthouse Road and alighting is highest at S. Glebe Road. For westbound travel during the morning peak period, boarding is highest at S. Jefferson Street and alighting is highest at S. Dinwiddie Street (end of the line). For eastbound travel during the evening peak period, boarding is highest at S. Dinwiddie Street (beginning of the line) and alighting is highest at S. Walter Reed Drive. During westbound evening travel, boarding is highest at S. Dinwiddie Street and alighting is highest at S. Courthouse Road.

Route 74

Route 74 operates between Arlington Village (Halstead – Walter Reed & Columbia Pike) and the Pentagon City Metro Station. Route 74 operates along Columbia Pike between South Quinn Street and South Barton Street. The route operates on weekdays only, providing peak period/peak direction service. During the weekday morning, service operates from 5:53 a.m. to 9:11 p.m. in the eastbound direction only. During the weekday evening, Route 74 operates from 3:35 p.m. to 7:55 p.m. in

the westbound direction only. The route's end-to-end running time is 20 minutes, and it has a 30-minute headway.

Route 74's passenger load along the corridor is the highest at S. Courthouse Road for both eastbound and westbound travel. During the eastbound morning peak period, boarding and alighting is highest at S. Barton Street. During the westbound evening peak period, boarding and alighting is highest at S. Courthouse Road.

Figure 5.4: Existing ART Routes

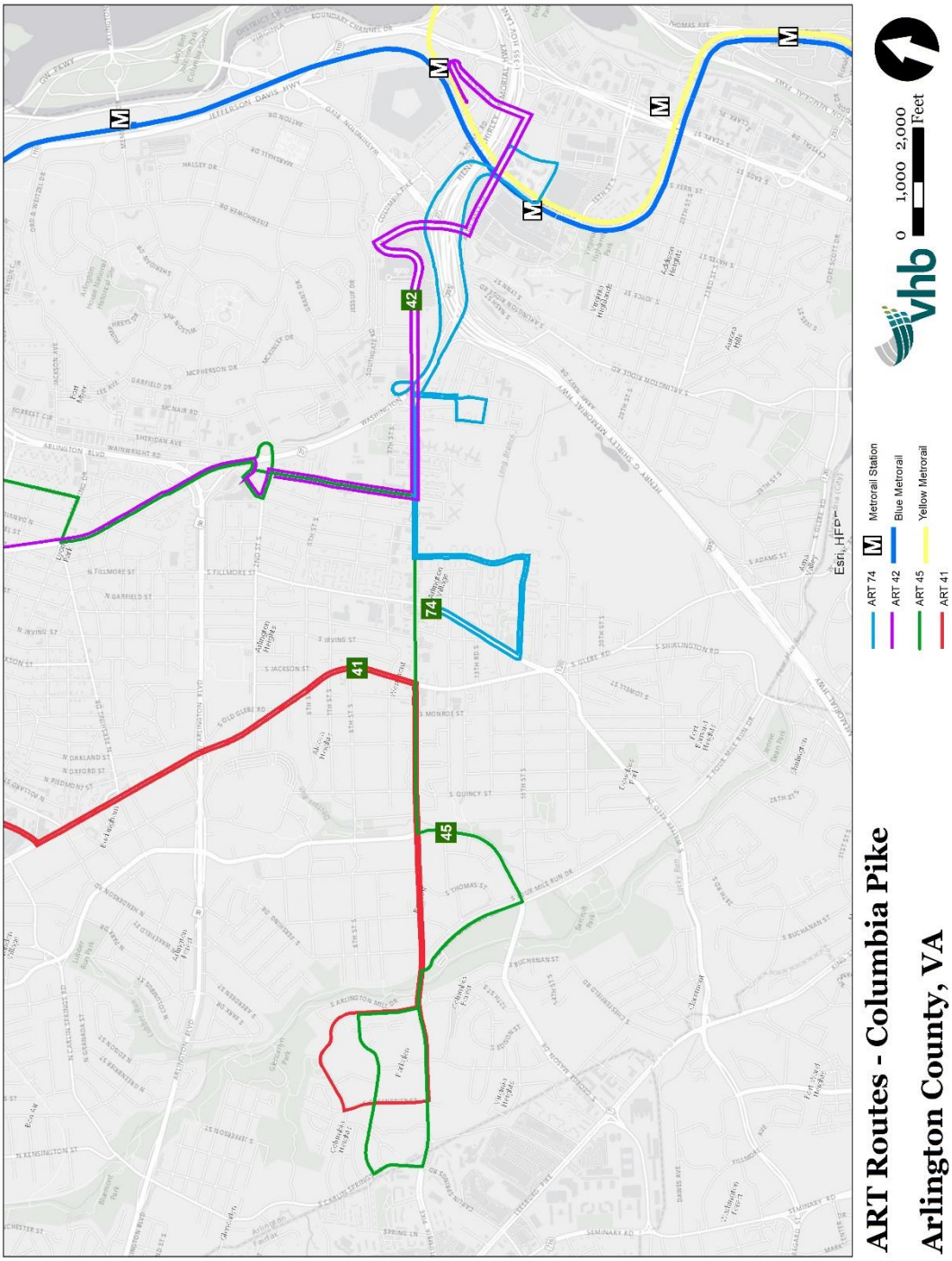


Table 5.2: ART Columbia Pike Service Hours and Frequency

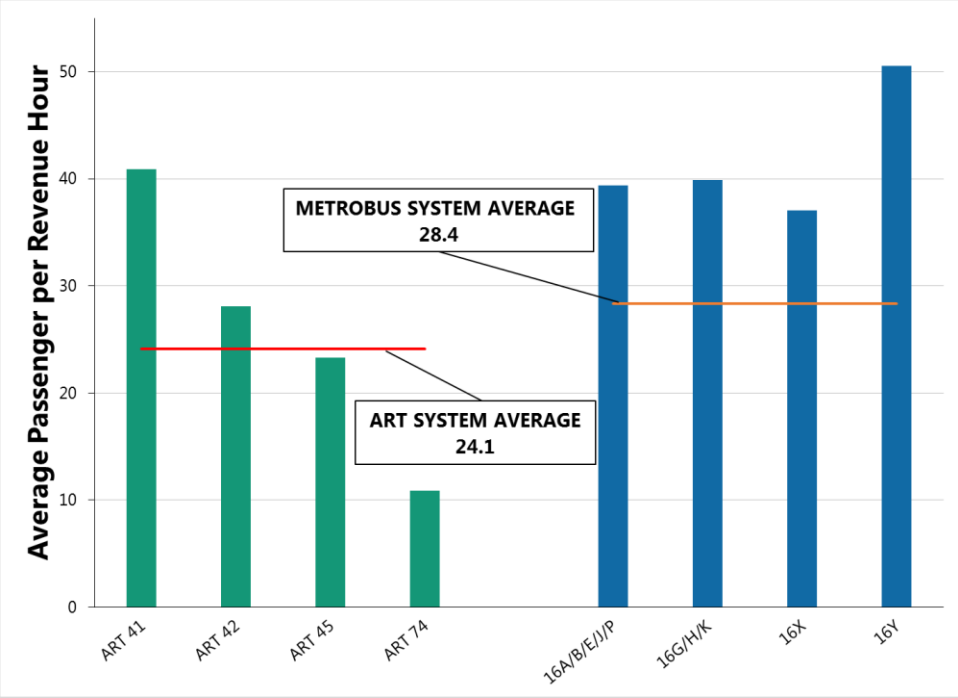
Route	Weekday						Saturday		Sunday	
	Span	Frequency (Minutes)					Span	Frequency (Minutes)	Span	Frequency (Minutes)
		Early	Peak	Midday	Evening	Late Night				
41	5:30 am - 1:10 am	20	15	15	20	25	6:10 am - 1:57 am	15	6:55 am - 10:10 pm	15
42	6:00 am - 8:24 pm		19	36	17		6:45 am - 8:15 pm	35	7:00 am - 7:22 pm	35
45	5:40 am - 11:23 pm	25	25	30	30		7:50 am - 12:15 am	30	6:50 am - 7:45 pm	30
74	5:53 am - 9:11 am; 3:35 pm - 7:55 pm	30	30		30					

Source: Arlington Transit Public Timetables

5.2.2 Ridership

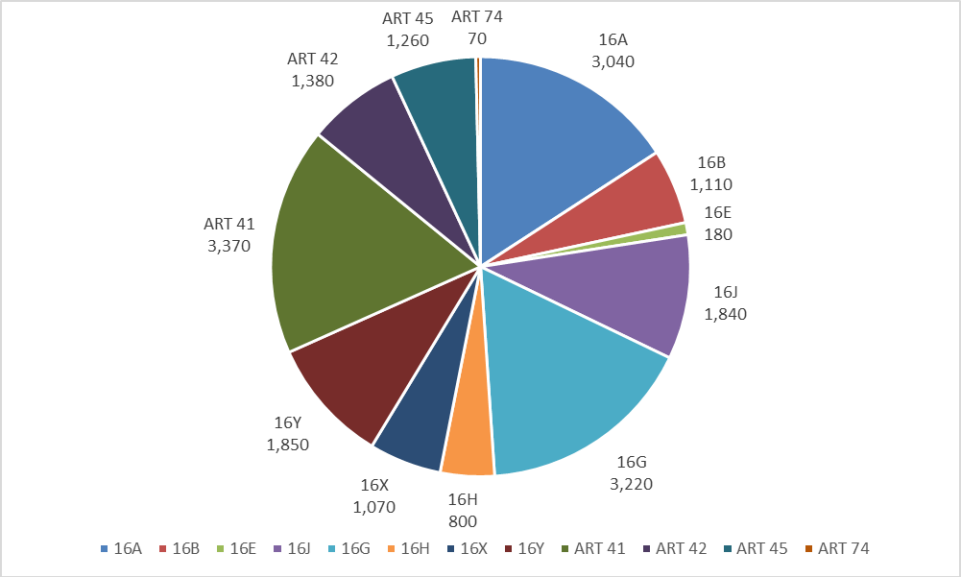
The Columbia Pike corridor is the highest ridership bus corridor in Arlington County and the Commonwealth of Virginia, carrying over 17,000 weekday riders. Many of these routes are some of the most productive in the County, performing better that the system average for riders per trip.

Figure 5.1: Columbia Pike Route Productivity



An examination of the existing transit ridership demand and capacity along Columbia Pike show that the existing ridership levels are being met by the bus service currently being operated, except on a few routes (16A and 16Y) and during specific trips (peak periods). Based on 2015 ridership figures, the routes traveling Columbia Pike carry approximately 17,700 riders a day. The majority of this ridership is associated with the Metrobus 16 Line.

Figure 5.2: Columbia Pike Average Daily Ridership (2015)



An impact of the success of some of the routes is crowding on certain trips. This was a comment relayed by riders and observed in the ridership data provided. Figure 5.3 and Figure 5.4 show the maximum observed passenger load for each route during different time periods of the day. This data indicates that some of the trips on the 16A and 16Y exceed the seated capacity in the eastbound direction. The 16Y actually had some trips that exceeded the standard set by WMATA for bus capacity during the morning peak in the eastbound direction. In the westbound direction, the 16X and 16Y were the only routes that had trips that exceeded the seated capacity. The 16Y again exceeded the standard for bus capacity. The average load for all routes during the morning and evening peak was about 70% in the eastbound direction and 60% in the westbound. The average load during off-peak times was around 50% in both the eastbound and westbound directions.

Figure 5.3: Passenger Loading (Eastbound)

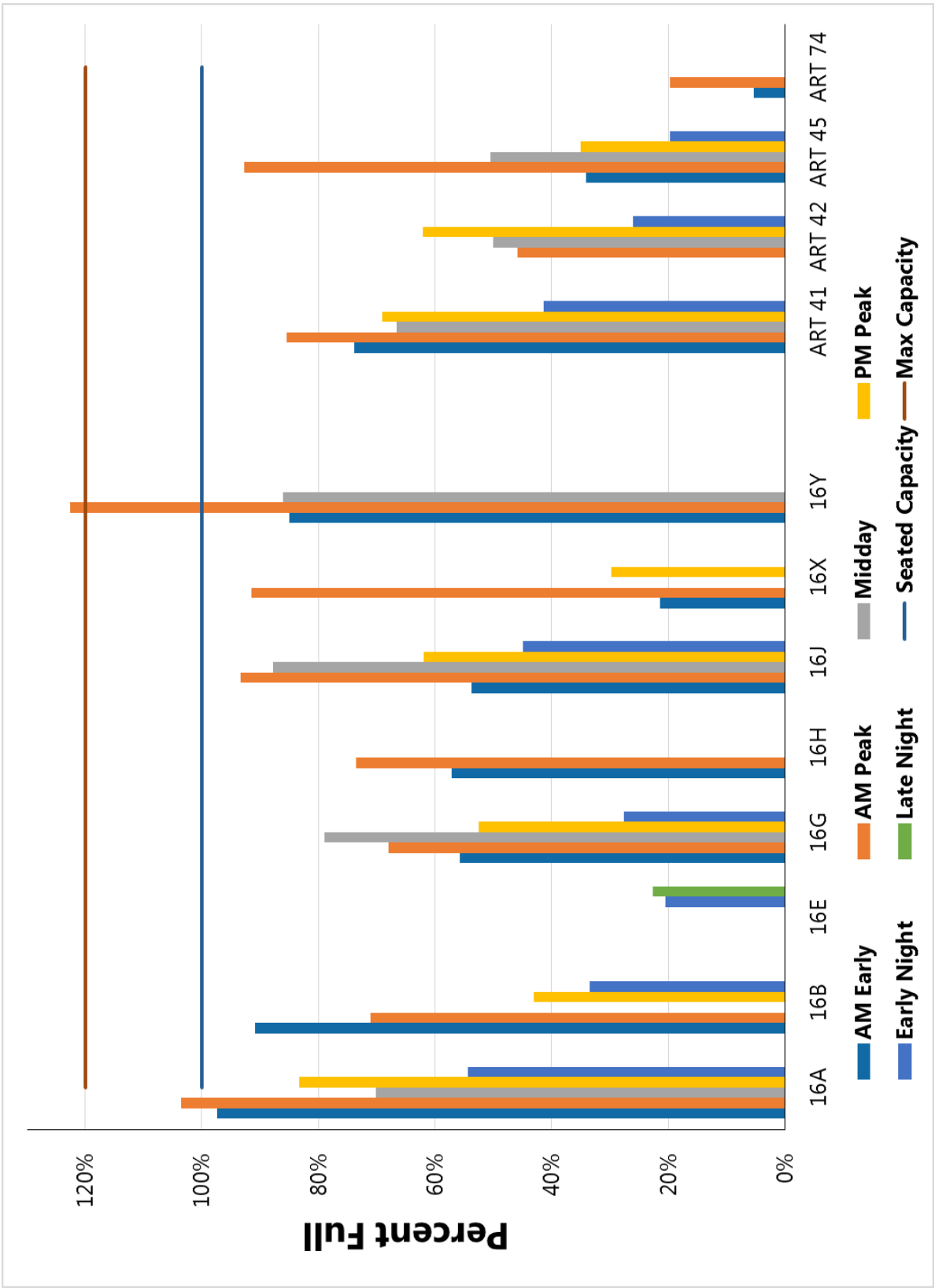
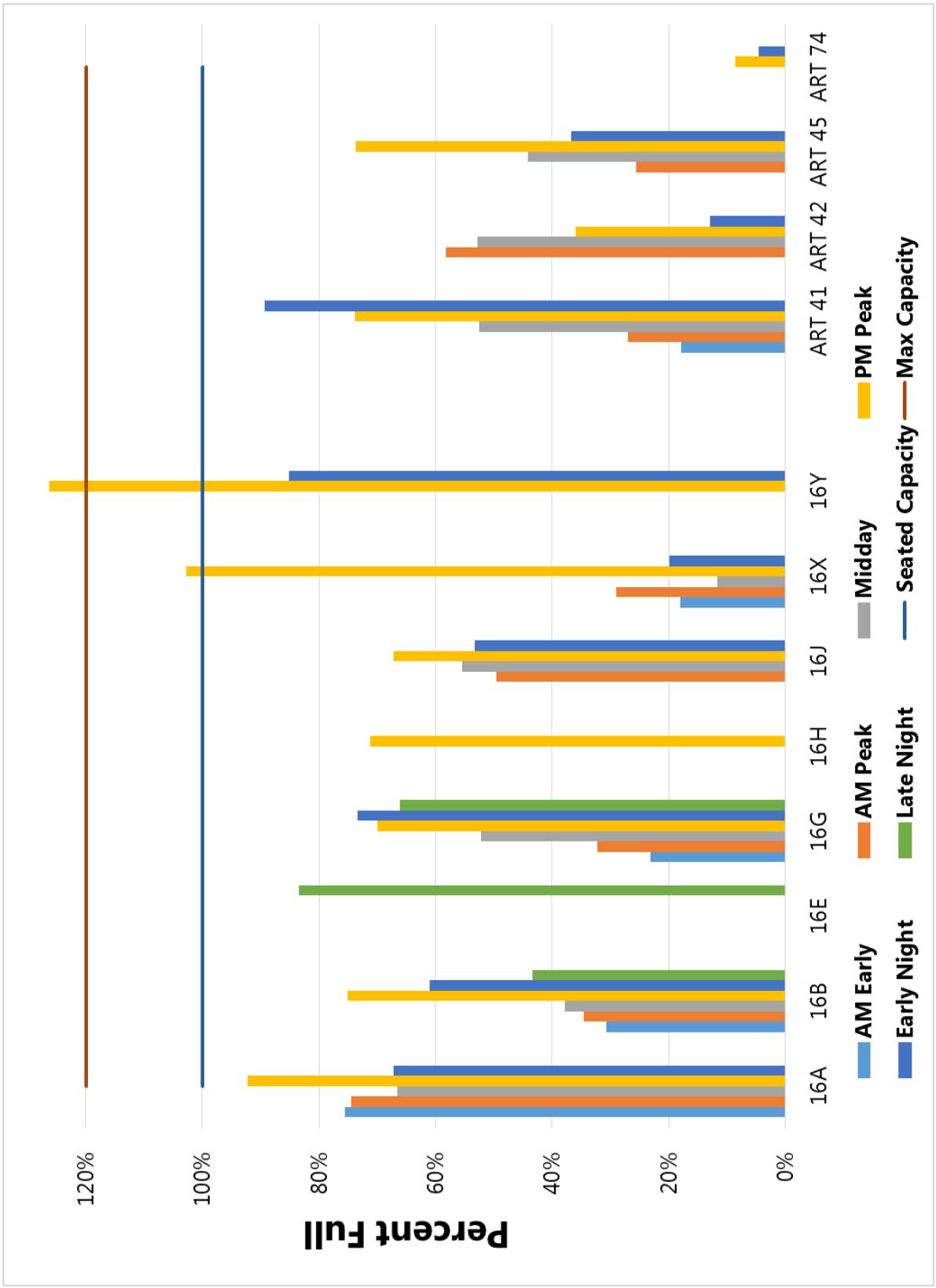


Figure 5.4: Passenger Loading (Westbound)



A review of the existing passenger load data by trip for each route identified six routes that have trips that exceed 75% of the seats being occupied, meaning that it may be time to consider adding capacity. In addition, three routes have trips that exceed 100%, meaning that on average there are people standing. Most transit agencies allow for some level of standing passengers on local bus routes, typically between 20% and 50% above seated capacity. WMATA's current standard for bus capacity is 20% above seated capacity. The 16Y displayed trips above this threshold; according to regular riders, this is a common occurrence. Overall, the 16Y showed the greatest number of trips above 75 percent (42), with 16 trips carrying standing passengers. These trips tend to be concentrated around the peak travel times of 7 a.m. to 8 a.m. and 5 p.m. to 6 p.m.

Table 5.3: Metrobus 16 Line Passenger Loads (by Trip)

Route	Trips over 75% Seated Capacity	Trips over 100% Seated Capacity	Trips over 120% Seated Capacity
16A	14	2	0
16B	2	0	0
16E	0	0	0
16G	1	0	0
16H	0	0	0
16J	2	0	0
16X	9	1	0
16Y	42	16	2

Examining the corridor at a stop level reveals that the stops with the highest ridership (boardings and alightings) are located near major activity centers and transfer points. The Pentagon is the stop with the highest observed boardings and alightings. This is not surprising, considering its role as a major transfer point for both bus and Metrorail. Other major stops include S. George Mason Drive, S. Walter Reed Drive, and S. Barton Street. These stops provide opportunities for transfer to other routes traveling north to the Rosslyn/Ballston corridor, a major destination for many traveling the corridor.

5.2.3 Transfers

The corridor offers several opportunities for bus transfers along Columbia Pike. These include transfers between Metrobus and ART, Metrobus to Metrobus, ART to ART, and transfers from both services to Metrorail and other bus routes.

The highest number of weekday transfers occur between buses and Metrorail. Riders on the 16A, 16B, 16E, and 16J routes transfer to Metrorail at the Pentagon, while riders on the 16G and 16H routes transfer to Metrorail at the Pentagon City station. A small number of riders transfer from the 16X to Metrorail at the Pentagon. ART

riders access rail at the Pentagon City, Pentagon, Clarendon, Ballston, Court House, and Virginia Square/GMU stations at various levels.

Bus-to-bus transfers are common between the various 16 Line routes and the other routes intersecting the Columbia Pike corridor. Popular route transfers from the ART routes occur with the 16 Line routes as well as some other Metrobus routes such as the 38B; 23A, 23B, and 23T; and the 1A, 1B, 1E, and 1Z. Other common transfers involve ART-to-ART transfers, including the 51 and 77.

Table 5.4: Columbia Pike Average Weekday Bus to Rail Transfers

From	To	Average Weekday Transfers
16A, 16B, 16E, 16J	Pentagon	1,460
	Pentagon City	50
16G, 16H	Pentagon City	1,450
16X	Pentagon	170
41	Clarendon	80
	Ballston	70
	Court House	60
	Virginia Square GMU	30
42	Pentagon	140
	Clarendon	100%
	Ballston	30%
	Pentagon City	20
45	Rosslyn	40
	Court House	40
74	Pentagon City	160

Table 5.5: Columbia Pike Average Weekday Bus to Bus Transfers

From	To	Average Weekday Transfers
16A,B,E,J	16G,H	220
	28A	180
	ART 41	160
	23A,B,T	70
16G,H	16A,B,E,J	220
	ART 41	110
	23A,B,T	70
	16Y	60
16X	16A,B,E,J	50
	7A,F,Y	20
	7C,H,P,W,X	20
	17G,H,K,L	20
	9A	20
16Y	16G,H	60
	16A,B,E,J	60
41	45	50
	42	30
	51	30
	16A,B,E,J	160
	16G,H	110
	38B	100
	23A,B,T	80
42	41	30
	45	20
	51	20
	77	20
	1A,B,E,Z	30
	38B	30
	2A	20
	16G,H	20

From	To	Average Weekday Transfers
45	41	50
	77	20
	42	20
	16A,B,E,J	60
	16G,H	40
	38B	30

5.2.4 Bus Dwell Time

Bus dwell time is the amount of time a bus spends sitting stopped at a bus stop. Many factors can contribute to a longer dwell. Ridership is one of these factors. Stops that have a higher number of boardings and/or alightings will sit stopped at a bus stop longer while this activity occurs. Both WMATA and ART have buses with two doors. This allows alighting passengers to get off the bus using the rear door, removing conflicts between those boarding and those alighting. However, the largest amount of time associated with boarding the bus is the time spent paying a passenger's fare. Most agencies, WMATA and ART included, provide a single farebox at the front door for passengers to pay. This results in all boarding passengers having to enter the bus at a single location, and for each passenger to pay their fare one after the other. Improvements in farebox technology and fare media have resulted in faster transaction times. The SmarTrip® card is a 2.5-second transaction compared to a 6-second transaction when paying with cash. This small difference can add up when boarding a larger number of riders. Both WMATA and ART currently allow riders to add cash value to their SmarTrip® card. This type of transaction averages 20 seconds. Transit agencies such as DASH in Alexandria have enacted policies eliminating this activity in an effort to reduce bus dwell time and improve travel time.

WMATA and ART provided information on how many people pay by cash or reload their SmarTrip® card on the various bus routes operating along Columbia Pike. Table 5.6 shows the percentage of riders who pay by cash or reload their SmarTrip® card. It also calculates the time spent processing all the cash and SmarTrip® reloading transactions for an average day. On a given day the total time spent processing cash fares and card reloading is around 10 hours. If all those transactions could be converted to SmarTrip® taps alone, the daily savings would amount to about 8 hours.

Table 5.6: Time Spent Processing Cash and SmarTrip® Reloading Transactions[11]

Route	Daily Ridership	% Riders paying Cash	% Riders Reloading	Processing Time (minutes)
16A	3,040	7.2%	9.4%	117
16B	1,110	7.2%	7.4%	35
16E	180	7.2%	6.8%	5
16J	1,840	7.2%	8.4%	65
16G	3,220	5%	6.3%	84
16H	800	5%	4.6%	16
16X	1,070	0.9%	3.1%	12
16Y	1,850	1.4%	2.9%	20
41	1,100	12.2%	13.4%	192
45	500	8.8%	10.0%	53

5.2.5 Bus Stop Spacing and Design

The number and design of the bus stops along a particular corridor have an impact on bus operations. Corridors with a large number of stops, spaced closely together, can impact bus travel times and speeds because of frequently stopping and starting. Bus stops are the access point for riders entering the system. Spacing stops too far apart reduces accessibility while improving bus travel times. Spacing stops too close together improves accessibility while increasing bus travel times. Determining the appropriate bus stop spacing is a delicate exercise, balancing accessibility and route performance. Consideration must be given to locations with higher concentrations of riders, key destinations, opportunities for transfers, and consideration for those with limited mobility.

WMATA has established guidelines for bus stop spacing. The Transit Cooperative Research Program (TCRP) also provides guidance on stop spacing based on industry-wide practice. Arlington County's previous TDP (2010) also established some standards. Based on these sources, stop spacing distances for Columbia Pike should range from 750 feet to 1,320 feet for local service, and from 1,760 feet to 2,640 feet for MetroExtra service. A quarter of a mile (1,320 feet) is the industry-accepted distance most riders are willing to walk to access local bus service.

There are currently 38 total bus stops along Columbia Pike with an average spacing of approximately 850 feet between stop. As part of previous planning efforts undertaken by Arlington County, the current 38 bus stops are proposed to be consolidated to 24 transit stations. Each station will include a larger shelter, with

[11] The ART 42 and 74 were excluded from this analysis because of the limited amount of time they spend on the Columbia Pike corridor.

modular seating, allowing it to be scaled to the ridership. The stations will also include a raised curb and platform to facilitate near-level boarding, improving passenger loading and decreasing dwell time. They will provide real-time passenger information, lighting, and off-board fare collection. The County is still working through the design phase of this project; plans for construction of the first stations are scheduled for 2018. This plan assumes the 24 station locations and features as part of any proposed recommendations.

An aspect that should be considered as part of the transit station project is the location and length of the bus stop. The length of the bus stop impacts how many buses can be at a stop at one time. The high volume of buses traveling the corridor results in times where more than one bus is at the same stop. If the stop is not long enough to accommodate both buses, there are impacts to traffic and/or bus operations. Having a bus block part of an intersection because it is stopped behind another bus can impact the ability for cross-street traffic to advance. If both buses cannot pull up to the curb with both sets of doors, the lagging bus cannot let passenger board or alight. This results in the second bus's dwell time being a combination of the first and the second.

Typical stop length should be around 90 feet for a standard 40-foot bus. Eighteen of the current 38 bus stops have a length of 90 feet or less. The stop should be 20 feet longer if the bus is articulated. A stop should be increased in length by 50 feet to accommodate a second standard 40-foot bus, or 70 feet to accommodate a second articulated bus.[12] Based on these figures, most of the bus stops along Columbia Pike should be around 140 feet long to accommodate at least two standard 40-foot buses.

Table 5.7: Columbia Pike Bus Stop Length

Stop Location	Eastbound Length (feet)	Westbound Length (feet)
S. Jefferson Street	140 feet	55 feet
S. Greenbrier Street	140 feet	170 feet
S. Frederick Street	80 feet	95 feet
S. Dinwiddie Street/S. Columbia Street	75 feet	100 feet
S. Four Mile Run Drive	55 feet	125 feet
S. Buchannan Street/S. Four Mile Run Drive	500 feet	115 feet
S. Thomas Street	90 feet	140 feet
S. George Mason Drive	150 feet	50 feet
S. Quincy Street	280 feet	80 feet
S. Oakland Street	80 feet	40 feet

[12] Texas Transportation Institute. TCRP Report 19: *Guidelines for the Location and Design of Bus Stops*. Washington, D.C.: National Academy, 1996. Print.

Stop Location	Eastbound Length (feet)	Westbound Length (feet)
S. Monroe Street	80 feet	90 feet
S. Glebe Road	90 feet	80 feet
S. Highland Street	95 feet	100 feet
S. Walter Reed Drive	120 feet	70 feet
S. Barton Street	60 feet	100 feet
S. Courthouse Road	150 feet	70 feet
S. Scott Street	60 feet	185 feet
S. Rolfe Street	130 feet	180 feet
S. Orme Street	140 feet	55 feet

5.2.6 Bus Bunching

Reports of bus bunching—buses being closely spaced, followed by longer gaps—were received during meetings with the public. These reports were verified through field observations during both the peak and off-peak travel times. Bus bunching is problematic because the platooning of the buses results in bus frequencies not being evenly spaced. If there are 10 buses traveling a corridor every hour, they would provide a 6-minute frequency if they were evenly spaced. If every second bus tails the preceding bus, you have effectively halved your frequency. While not all of the buses traveling the corridor are headed to the same destination, many of them are destined for the Pentagon. If two buses headed to the Pentagon are grouped together, the first will pick up all the passengers and the second will operate near empty, decreasing service productivity. Currently, WMATA and ART resolve bus bunching by having dispatchers and on-street supervisors manually hold buses to correct the bus bunching. While effective, this does not address every situation.

5.2.7 Bus Speeds

Travel speeds were measured along select WMATA buses during morning peak (6:00 a.m. to 9:00 a.m.), evening peak (4:00 p.m. to 7:00 p.m.), and off-peak hours. Speed was captured using GPS-enabled tablets while on-board the bus. The tablets captured location points in 1-second intervals. Average speeds including waiting time were calculated by direction for the three time periods. Those data are displayed in Table 5.8. The limited sample size collected likely introduces some variability in the data, but overall the non-peak direction was faster than the peak direction and the off-peak time of day was typically faster than the peak travel times. This confirms that the higher volumes of traffic during peak commuting times and in the peak direction have an impact on bus operations.

Table 5.8: Metrobus 16 Line Travel Speeds

Route	AM Peak Average Speed (mph)	PM Peak Average Speed (mph)	Off-Peak Average Speed (mph)
16A Eastbound	12.1	11.0	13.0
16A Westbound	10.4	10.9	13.7
16B Eastbound	8.0	10.6	-
16B Westbound	10.2	9.7	8.5
16J Eastbound	10.2	10.6	11.8
16J Westbound	12.3	9.1	9.8
16G Eastbound	10.6	-	-
16G Westbound	-	8.4	-
16H Eastbound	10.4	10.7	10.0
16H Westbound	9.5	10.9	9.5
16X Eastbound	-	9.9	-
16X Westbound	12.3	-	-
16Y Eastbound	10.4	-	-
16Y Westbound	10.0	7.0	7.6

*Route speeds were not collected along the 16E route because of its hours of operation.

Mapping the collected data shows that other than when stopping to pick up passengers at stops, the bus encounters slowdowns around the more congested intersections of S. George Mason, S. Glebe, and S. Walter Reed. Targeting improvements that prioritize the bus at the intersections could be beneficial to improving bus travel times (Figure 5.5).

Figure 5.5: Metrobus 16J AM Travel Speed (Eastbound)

5.3 Summary of Critical Issues

The preceding sections highlighted the traffic and transit operational challenges to providing frequent and reliable bus transit to the Columbia Pike corridor. With multiple service patterns operating along Columbia Pike and actual bus trip times running longer than scheduled trip times, buses are often unreliable and unpredictable. Five identified issues contribute to delays:

- Traffic congestion delays buses at key intersections
- Frequent bus stop spacing lowers bus average speeds
- Short bus stop design can only accommodate one bus, when two buses often arrive at the same time, delaying boarding and alighting
- The current methods of fare payment delay the boarding process
- Bus bunching on Columbia Pike decreases service productivity

Columbia Pike is the most used bus corridor in Virginia, with nearly 65 percent of passengers alighting at either the Pentagon or Pentagon City. Currently some buses are at or near capacity during weekday rush hours. Ten percent of weekday trips had a load greater than 85% of the seated capacity. The 16Y consistently has riders standing, and in some cases has to wait for another bus due to issues with overcrowding. Stops with the highest boarding and alightings are S. Four Mile Run Drive, S. George Mason Drive, S. Glebe Road, S. Walter Reed Drive, S. Barton Street, S. Courthouse Road, and the Pentagon. These stops provide riders with the opportunity to transfer to other bus lines or Metrorail.

Buses experience traffic-related delays along Columbia Pike during the a.m. and p.m. peak periods. Congestion along the corridor, especially at the S. George Mason Drive, S. Glebe Road, and S. Walter Reed Drive intersections, increases the travel time of buses through the corridor. During the peak periods, it can take buses several minutes to proceed through these intersections.

Columbia Pike's bus stop spacing creates bus delays as the bus has to slow down, stop, and dwell frequently to service the 38 bus stops along the corridor. These stops have an average spacing of 0.16 miles. Bus stops spaced farther apart than in the existing arrangement could improve bus speed and reliability; however, the need for improving travel time must be balanced with accessibility. The County has already proposed a plan that would consolidate the existing 38 stops down to 24 transit stations.

Bus stop design also negatively affects bus performance along the corridor. The guidelines for a bus stop design suggest a length of 90 feet to accommodate one standard 40-foot bus; 18 of the 38 stops along Columbia Pike have stop areas of 90 feet or shorter—however, the frequency of service along Columbia Pike often results in two buses needing to occupy a single stop at once. This space constraint creates operational challenges and results in delays to passengers boarding and alighting the buses.

Methods of on-board fare payment causes delays for buses. Approximately 6% of riders pay a cash fare. Generally, it takes 6 seconds per boarding for cash payment, compared to 2.5 seconds with a SmarTrip® card. Metrobus and ART buses also allow passengers to add value to SmarTrip® cards aboard the bus; approximately 7% of riders use this feature. The average rider spends 20 seconds reloading a SmarTrip® card on the bus, further increasing the dwell time and creating additional bus delays. Eliminating on-board cash loading and creating opportunities for bus customers to load their SmarTrip® cards prior to boarding the bus would eliminate this time-consuming transaction. Additionally, having riders pay their fare prior to boarding would further decrease the time associated with passengers boarding. Quicker loading at each stop would reduce dwell times and raise average bus speeds.

The next chapter of this report will outline strategies that could be implemented by the County and WMATA to improve transit service and address the critical issues outlined above.

6

Transit Improvement Strategies

The following chapter discusses various strategies for improving transit along the Columbia Pike corridor. The strategies were assessed to determine their benefits and impacts, highlighting any logistics or considerations associated with their implementation. Based on the assessment, recommendations were proposed.

6.1 Toolbox of Transit Improvement Elements

A number of strategies can be implemented along the Columbia Pike corridor to address the issues previously highlighted and respond to the objectives for transit service along Columbia Pike.

6.1.1 Provide sufficient capacity to meet existing and future demand

Additional capacity can be provided by increasing the frequency the service currently provides, or by increasing the number of seats available by providing a larger vehicle.

Service Frequency

Increasing service frequency is a relatively simple method for providing additional transit capacity to a corridor. If the current route operates every 15 minutes and uses a standard 40-seat bus, then there are 160 seats available every hour. Doubling the frequency of the buses to operate every 7.5 minutes would result in twice as many seats (320) in a given hour. The ability to increase service frequency is limited by the number of buses available for service, the budget available to pay for service, and

the capacity of the corridor. The first two are straightforward, but the latter is dependent on a number of additional factors. The current volume of service operating along Columbia Pike provides an aggregate headway between 2 and 3 minutes. Buses are currently bunching along the corridor, so increasing the aggregate frequency will require additional operational management.

Vehicle Size

Providing larger vehicles can increase corridor capacity without increasing service frequency. This can be beneficial in corridors where there is limited capacity to increase service frequency. WMATA currently operated articulated buses on selected Metrobus routes. These buses can carry 61 seated riders and up to 54 standees. A current 40-passenger bus can carry 40 seated passengers and up to 20 standees. An articulated bus can carry nearly two times as many people as a standard bus can carry. Articulated buses typically cost around $1 million compared to $560,000 for a standard 40-foot bus.

WMATA currently operates articulated buses in DC and Maryland; however, there are challenges to assigning articulated buses to routes in Virginia. Currently, there is no maintenance or storage space for articulated buses at any of the garages in Virginia. The Four Mile Run Garage has space that could be converted to a maintenance bay for articulated buses, but this would only provide minimal capacity. The Cinder Bed Road Bus Operations and Maintenance Facility in Lorton, VA, could support articulated buses, but would add considerable deadhead miles to any routes in Arlington. The future heavy maintenance facility being planned by Arlington could also support some level of articulated bus maintenance.

Another consideration for providing articulated buses, especially on MetroExtra routes like the 16Y, is the deadhead mileage associated with the general route operations. The 16Y does not operate in revenue service outbound in the morning and inbound in the evening. The cost to operate an articulated bus is more than a standard bus, resulting in added costs where passenger revenue is not being collected. The question of whether it is an effective use of resources needs to be answered.

Double-decker buses are another type of bus that can provide additional passenger capacity. A double-decker bus can carry around 80 seated passengers and up to 10 standees. The seating configuration and addition of stairs to access the second level limit the space for riders to stand. A double-decker bus costs about the same as an articulated bus ($1 million).

Some of the disadvantages of a double-decker bus include concerns over safety and accessibility. Accessing the seats on the second level require walking up stairs. Consideration must be given to the height of overpasses and signal mast arms in relation to the taller bus height, although there are no concerns along Columbia Pike. The addition of double-decker buses to either the Metrobus or ART fleet would require a special maintenance facility to accommodate taller vehicles. Double-decker buses would introduce a longer dwell time because of the additional time associated

with riders ascending the stairs to reach their seat. For this reason, current use of double-decker buses in America is limited to longer-haul commuter routes. Currently, there is no American manufacturer of double-decker buses. This would present a challenge when attempting to purchase buses with federal funds. For these reasons, double-decker buses are not seen as a viable option to increasing corridor capacity for Columbia Pike.

6.1.2 Enhance connectivity and accessibility to the corridor and the larger transit network

The previous chapter highlighted the current travel patterns associated with Columbia Pike. Current commuters are traveling to Columbia Pike from Fairfax County, northern Arlington, Shirlington, and the Virginia Square area. The existing routes providing these connections should continue and be looked at for improvements.

Route Modifications

Residents along Columbia Pike are traveling to various destinations along the Rosslyn-Ballston corridor, Shirlington, Fairfax County, Crystal City, and Washington, DC. Many of these destination are currently served by bus routes; however, improving the connection between Columbia Pike and Crystal City should be considered as these two areas would have been connected by the streetcar. Columbia Pike and Crystal City are currently connected by the 16H, but the service is only inbound in the morning peak and outbound during the evening peak, with no midday or late night service. The forecasted growth for Columbia Pike and Crystal City warrants consideration for more service to connect two changing activity centers for Arlington County. Additional connections to Washington, DC, would provide redundancy to an already taxed Metrorail system. Comments received from focus groups with Columbia Pike residents and stakeholders affirmed the challenges of accessing Crystal City from Columbia Pike, and mentioned destinations such as Navy Yard in the District. The stronger transit connection between Columbia Pike and Pentagon City/Crystal City was mirrored by residents in those areas seeking easier access to Columbia Pike.

Transfers and Multimodal Access

Any enhancement in service should continue to consider the location along the corridor that facilities transfers. These locations include the stops at S. George Mason Drive, S. Glebe Road, and S. Walter Reed Drive as well as the Pentagon and Pentagon City Metrorail stations. Bus schedules must facilitate easy transfers and stop location and design must be able to accommodate multiple buses. It is also

important to consider the location of stops in relation to each other when examining transfer activity to provide for safe crossing of an intersection.

Bike share station in Crystal City near Metroway route

Connections between other modes of travel should also be considered. Arlington County currently has five Capital Bikeshare stations along Columbia Pike. These locations are already currently accessible from both existing bus stops and the future transit stations. As new bikeshare stations come online, they should be sited to facilitate easy access for transit riders. Many travelers use bikeshare as a means to complete the first or last mile of their trip. Consideration should be given to developing multimodal nodes or stations that provide easy access to transit, bikeshare, or carshare services like ZipCar or Car2Go.

6.1.3 Improve transit travel time

Strategies that can improve bus speeds and travel times are focused on reducing the delay encountered as the bus travels along Columbia Pike. This can be accomplished by reducing the time a bus sits stopped at a traffic signal, allowing the bus to avoid areas of heavy traffic congestion, reducing the time a bus spends stopped at a bus stop, or reducing the number of times a bus stops.

Transit Signal Priority

Transit signal priority (TSP) is a technology that allows the bus to communicate with the traffic signal to request a green signal so that the bus does not get stopped. This is accomplished through extending an already green signal or providing an early green. TSP is designed to reduce the time a bus spends stopped in traffic. TSP does not preempt the signal, like a fire engine or ambulance does, but allows the bus to request the signal to grant additional seconds to the traffic traveling with the bus.

Research indicates that TSP can result in a time savings of 2% to 8%. The Columbia Pike corridor is 3.4 miles long. A bus that travels an average of 10 mph could save between 30 seconds and 1.5 minutes in travel time on a 20-minute trip.

Arlington County's signal system is currently equipped to accommodate TSP. WMATA has been piloting TSP along State Route 7 in Virginia and in the City of Alexandria. The current challenge with implementing TSP in Arlington is that the County would prefer to use a different technology to communicate between the bus and signal equipment than WMATA has selected. The County and WMATA are continuing to work on ways to implement TSP.

Queue Jumps

There are two strategies the County could consider for helping buses avoid traffic congestion delays: queue jumps and dedicated bus lanes. Queue jumps allow a bus to bypass and jump in front of long queues of traffic. This can be provided by allowing a bus to use an existing right-turn lane to travel through an intersection or by constructing a bus-only queue jump lane. The bus will enter the queue jump lane and then receive a special bus-only green signal that allows it to advance in front of the stopped traffic. The time savings will vary depending on the length of the queue being avoided, current travel speeds, the space between pockets of congestion, and signal timing.

The locations along Columbia Pike where congestion creates a delay for both vehicles and buses are S. George Mason Drive, S. Glebe Road, and S. Walter Reed Drive. S. Walter Reed Drive could not accommodate a queue jump because the existing roadway cross-section is four travel lanes and a center left-turn lane. There is no existing dedicated right-turn lane, and the current location of the sidewalk and adjacent buildings would not accommodate adding one. Queue jumps lanes could be accommodated at both S. George Mason Drive and S. Glebe Road, but would require the elimination of a parking lane or expansion of the roadway cross-section. Expanding the roadway cross-section would require the County Board of Supervisors to approve a modification to the form-based code. The code currently defines the street cross-section as 54 feet face-of-curb to face-of-curb at intersections and 56 feet mid-block. This width accommodates four through travel lanes and a center median or left-turn lane. The County would need to acquire additional right-of-way to construct queue jumps, and adding right-turn lanes goes against the County's efforts to eliminate right-turn lanes to shorten crossing distances.

A traffic analysis to evaluate the operations and design requirements of potential queue jumps lanes on Columbia Pike at S. George Mason Drive and S. Glebe Road showed that there was potential for transit travel time savings, but in most cases the eastbound queue jump lane would need to extend beyond a full block length to allow the bus to bypass the queue at peak travel times. The total time savings per bus in the eastbound morning peak is up to 124 seconds and in the westbound evening peak 60 seconds. Ultimately, peak congestion spillback may limit the realized time savings.

Table 6.1: Bus Queue Jump Time Savings

Intersection	Approach/ Movement	AM Bus Time Savings (seconds)	PM Bus Time Savings (seconds)	Minimum Queue Jump Length (feet)
S. George Mason Drive	Eastbound	78.2	5.1	660
	Westbound	5.2	21.5	420
S. Glebe Road	Eastbound	45.7	6.8	650
	Westbound	27.1	38.9	400

Dedicated Bus Lanes

Another way to potentially alleviate the impacts caused by general traffic is through the creation of a bus-only lane. Bus-only lanes give priority to transit vehicles, improving travel times by removing conflicts with other traffic. The lanes can be located along the curb or in the median, with different benefits to each design. Adding bus-only lanes to Columbia Pike by expanding the existing roadway is likely too cost prohibitive. While some segments of the corridor still have deep setbacks of buildings, all of the new construction along the corridor and existing buildings east of S. Glebe Road are not set back from the road edge to accommodate expansion of the right-of-way without significant property impacts.

The only other way to accommodate bus-only lanes would be through repurposing some portion of the existing roadway; however, when VDOT transferred Columbia Pike to Arlington County, a memorandum of understanding was put in place that requires the County to maintain four general purpose lanes or pay a financial penalty. Regardless of the challenges associated with the agreement, the current volume of traffic along Columbia Pike make the conversion of general purpose lanes to bus-only operationally challenged.

A traffic analysis of two lane repurposing scenarios shows that the level of service (LOS) at the S. George Mason Drive, S. Glebe Road, and S. Walter Reed Drive all increase to unacceptable levels. The LOS at other intersections would likely degrade to similar levels, indicating that the repurposing of a single lane of Columbia Pike is likely infeasible due to the resulting traffic impacts. Scenario One would repurpose the outside through lane in the peak direction for bus-only. Scenario Two would require a redesign of the existing cross-section to include five total lanes, removing the median and left-turn lanes. Columbia Pike would still maintain four general purpose travel lanes (two in each direction), but add a bus-only lane in the curb lane of the peak direction. This lane would switch from the eastbound curb lane in the a.m. peak period to the westbound curb lane during the p.m. peak period, requiring the center lane to be reversible. Left-turning traffic would have to share a lane with through traffic, requiring split phasing of the signal and delaying through traffic. The implementation and operation of a reversible center lane would also require additional overhead signage and signaling, adding to the cost.

To assess how much traffic would need to be removed from Columbia Pike to make considering lane repurposing feasible, a critical lane volume (CLV) assessment was used to perform a sensitivity analysis of various traffic reduction scenarios. The analysis indicated that at least 30% of the east-west traffic traveling Columbia Pike would need to be removed from the roadway to make it operate at a level of service not considered failing. Removing 40% of vehicles would allow the three critical intersections to operate at a LOS of D or better. S. George Mason Drive, for example, currently processes nearly 2,000 vehicles in the morning peak hour—to accommodate lane repurposing, 600 to 800 vehicles would have to find an alternate route. This is a challenge for Columbia Pike because of the limited number of east-

west parallel routes. At this time, lane repurposing does not appear to be a viable strategy for improving bus travel times.

Off-board Fare Collection

Transit agencies have two main strategies available to help reduce the dwell time for buses traveling along a corridor: off-board fare collection and mobile device payment.

Off-board fare collection allows the rider to pay their fare prior to boarding the bus, removing the time associated with fare transactions from the bus entirely. This can be accomplished by requiring riders to purchase a ticket prior to boarding, using kiosks at each transit stop. This removes the need to insert cash or fare card when boarding the bus. Fares are then validated on board the vehicle through random fare inspections or fare validation machines. This type of application requires the installation of ticket kiosks at all stops to allow riders to purchase fare tickets.

Another payment technology that is being piloted is using mobile devices to pay a fare. Smartphones have access to the internet, and many businesses are providing mobile payment platforms. The mobile device payment could be validated using a validation machine on the bus.

Off-board fare collection machine in Tucson, Arizona

Although WMATA was pursing the next generation of fare payment technology, which would have likely included mobile payment, this project has been suspended, with no clear indication on its future schedule. This leaves some uncertainty in the future fare payment technology, but there are steps that could be taken in the interim to advance off-board fare payment. Installing kiosks at the transit stations along Columbia Pike would allow riders to pay their fare or reload their SmarTrip® card prior to boarding the bus. Upon boarding, payment could be validated at the farebox or a new fare validation approach could be considered. WMATA has considered installing a second fare device at the rear door to facilitate all-door boarding. Eliminating fare reloading and cash payment has the potential to save minutes on each trip.

One approach that could be taken without adding costs would be to eliminate on-bus SmarTrip® card reloading. This is the most time-consuming transaction. The City of Alexandria has already taken this step on DASH buses. Cards can currently be reloaded online, at commuter stores, and in CVS and Giant stores. Expanding

opportunities through other retail partnerships could eliminate the need for SmartTrip® reloading to occur on the bus.

Stop Design

Whether a bus stop is capable of handling the demand placed upon it can impact dwell time and ultimately travel time. A number of stops along Columbia Pike are not long enough to meet the guidance for a single bus or multiple buses. During peak travel times, there are often situations where more than one bus will occupy a single stop. If the stop is not long enough to accommodate the second bus, the second bus must sit and wait before it can open its doors to boarding and alighting passengers, resulting in wasted time. As Columbia Pike implements projects as part of the multimodal transportation plan and overall corridor redevelopment, the County should look for opportunities to extend bus stops. This could involve shifting a stop, closing a driveway, or relocating the stop to another intersection.

Stop Consolidation

The more times a bus has to stop, the slower the average bus speed and longer the travel time. Bus stop spacing is a delicate balance of providing enough stops to promote accessibility for riders, but not providing so many the bus is constantly starting and stopping. The County has already proposed a plan to reduce the number of stops from 38 to 24 as part of the upgrade to transit stations. These plans should continue to advance, with some adjustments based on feedback from the public.

6.1.4 Improve reliability

Improving reliability starts by making transit travel more predictable by removing the variability in travel times caused by congestion, heavy passenger loads, or vehicle maintenance. Many of the strategies discussed as part of improving travel time have a direct impact on reliability—for example, reducing the impact of traffic congestion through TSP or queue jumps would provide greater adherence to existing schedules. In addition, ensuring that bus schedules and timed transfers are coordinated to facilitate timely transfers is important.

Providing riders with accurate and current information about the status of the system can help eliminate a rider's uncertainty when something doesn't go as planned. Providing real-time information and updates that can be viewed at stops or from a computer or mobile device allow users to make informed decisions on how to proceed with their trip. To strengthen the service, information could be integrated from different service providers and even different modes into a single platform. The County has done this at their commuter stores, in County buildings, and at other locations throughout the County. The displays show bus arrivals, Metrorail train arrivals, bikeshare availability, carshare availability, and service alerts. This gives the rider a single source of information that allows them to make an informed decision about how they complete their trip. The County is doing a study that will assess the

best methods for sharing real-time information with transit riders, which could inform future plans.

6.1.5 Support corridor development

The Columbia Pike corridor is forecasted to grow and needs a transit solution that can accommodate that growth. This is more than just providing enough system capacity to support the demand. It is also about providing a service that connects key destinations and allows residents, employees, and visitors to easily make trips using service that is understandable and easy to navigate. The service should be frequent to facilitate all types of trips, not just planned trips—it shouldn't vanish during non-peak periods. For transit to be a preferred mode of travel, it has to be available in the middle of the day and in the evening.

Transit also should be highly visible. A distinctive service catches people's attention and encourages them to ride. This can be accomplished through using unique vehicles and special branding, and by providing a highly visible and inviting "front door." The stops and stations should be comfortable, provide useful amenities, and be designed as an attractive part of the streetscape.

6.2 Corridor Options and Performance

Based on the initial evaluation of the corridor, the following needs/deficiencies were identified:

- Reduced bus speeds due to overall roadway congestion at specific locations
- Multiple route variants that are difficult to understand
- Mismatch between service levels and route ridership
- Bus congestion due to multiple routes along the corridor
- Inability to make certain connections via transit
- Significant amount of dwell time spent reloading SmarTrip® cards at the farebox

6.2.1 Initial Concept

A recommendation was proposed that added a new premium service to the Columbia Pike corridor from Skyline to Crystal City. There were other prior options that carried the premium service all the way to Potomac Yard, but concerns about the length of the route and ability to maintain headways resulted in the route stopping at Crystal City. This route could overlap with the existing Metroway service. The specific details of whether the overlap would be utilized to provide more frequent service or certain trips would be short-turned from either route based on future ridership demand would need to be decided as the service was implemented. Future technology improvements may be developed to facilitate the extension to Potomac Yard and still provide for headway-based management.

Extension of this service further on the western end was reviewed and found not to make sense at this time. The locations considered were the Alexandria Campus of Northern Virginia Community College (NVCC) and the Mark Center. As future developments and transportation improvements occur, service to these additional western termini may warrant further consideration.

Considerations for an extension would involve development and redevelopment around NVCC as well as improvements to the existing street network. An extension to the Mark Center may make sense because of its importance as a major job center and connections to the West End Transitway; however, this would require an expanded transit terminal at Mark Center and improvements in technology to maintain headways.

Construction of a bus transfer facility on or near the Columbia Pike corridor is proposed near the western terminus to facilitate easier transfers between other routes. The location of this transfer center has yet to be determined, but would presumably be located near the Arlington/Fairfax County Line. Possible locations that have been discussed include S. Jefferson Street near Route 7, the Skyline property, and other neighboring properties along Route 7.

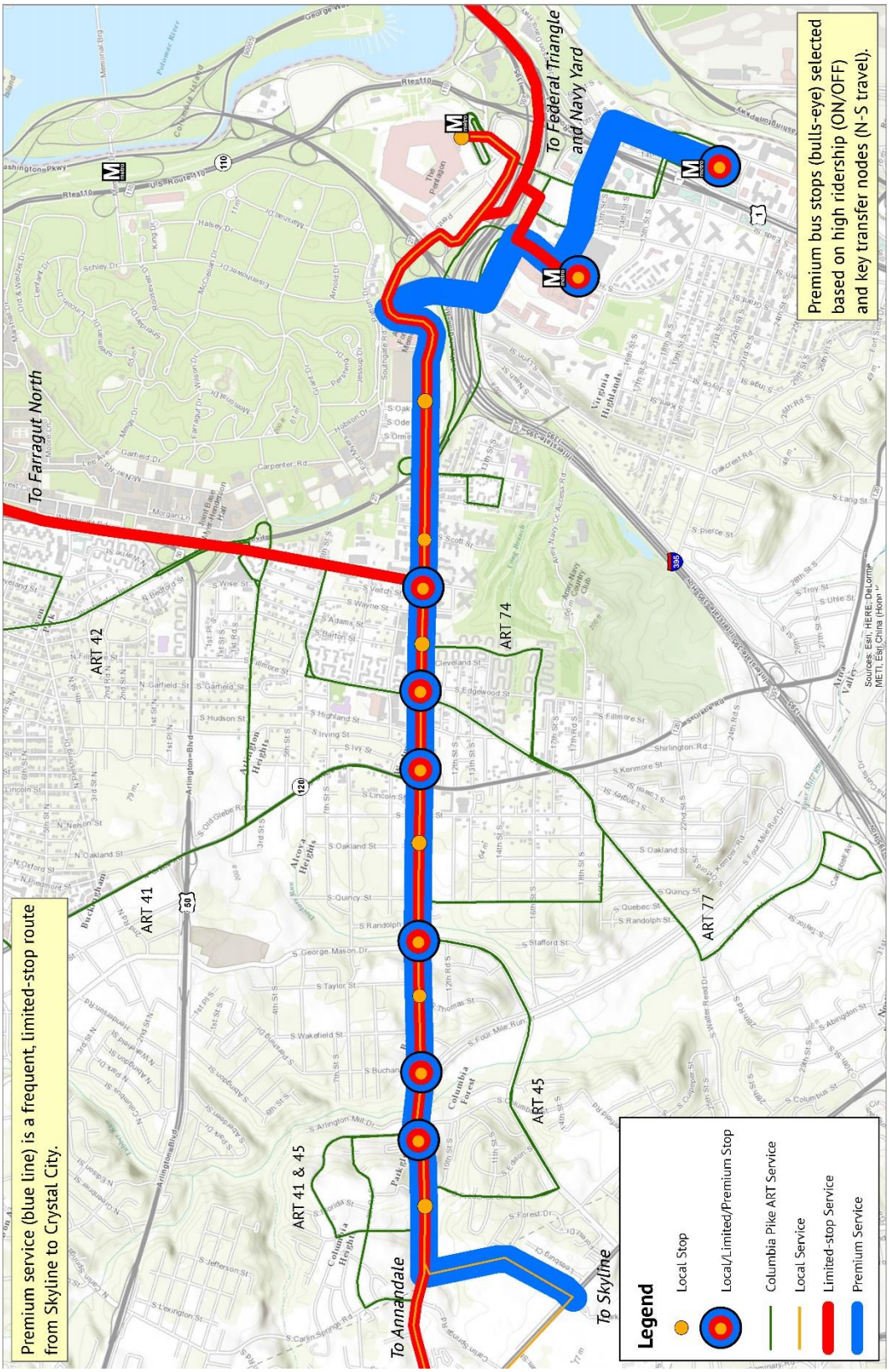
The proposed premium service would be branded differently than the current services operated along Columbia Pike. Physical upgrades to the corridor would be included as part of this service including transit signal priority, upgraded and consolidated station locations, off-board fare reloading/collection, and potentially transit-only lanes.

Operating in concert with this premium service would be limited-stop service—service focused on quickly moving people to major destinations in the region—and local service. The combination of these services will provide a more user-friendly service model for Columbia Pike.

The limited stop routes would provide a connection between the corridor and various destinations in Washington, DC (Farragut North, Federal Triangle, and Navy Yard). These routes would stop only at the stops indicated in the graphic below, and would primarily provide peak period service. The 16X would expand to provide late night service in line with a recommendation from WMATA's recent late-night service study.

Local service would be consolidated into ART service and two Metrobus routes. The ART routes would provide increased frequency service to the surrounding neighborhoods, and the two Metrobus routes would provide all-stop service from Annandale and Culmore to the Pentagon. Service eliminated on other Metrobus routes would be consolidated into these two local routes and the new, frequent premium service.

Figure 6.1: Columbia Pike Initial Route Concept



6.2.2 Public Feedback

The initial service option described above was shared with the public through a combination of outreach events at key activity centers and workshops along with other service recommendations associated with the larger TDP. Feedback received included:

- Concerns about fewer buses going to the Pentagon and Pentagon City
- Concerns about losing the late night bus service
- Requests to not eliminate the 16G
- A desire to see more 16X and 16Y service (midday, weekends, late night)
- Concerns about the crowding on 16Y buses
- Support for the new service to Navy Yard
- Concerns about eliminating or stopping at fewer stops for most of the route recommendations
- Support for the new high frequency premium service, but concerns about capacity and increased fares
- Concerns that this plan does not do enough to serve the demand
- Requests for more environmentally friendly buses

6.2.3 Recommendations

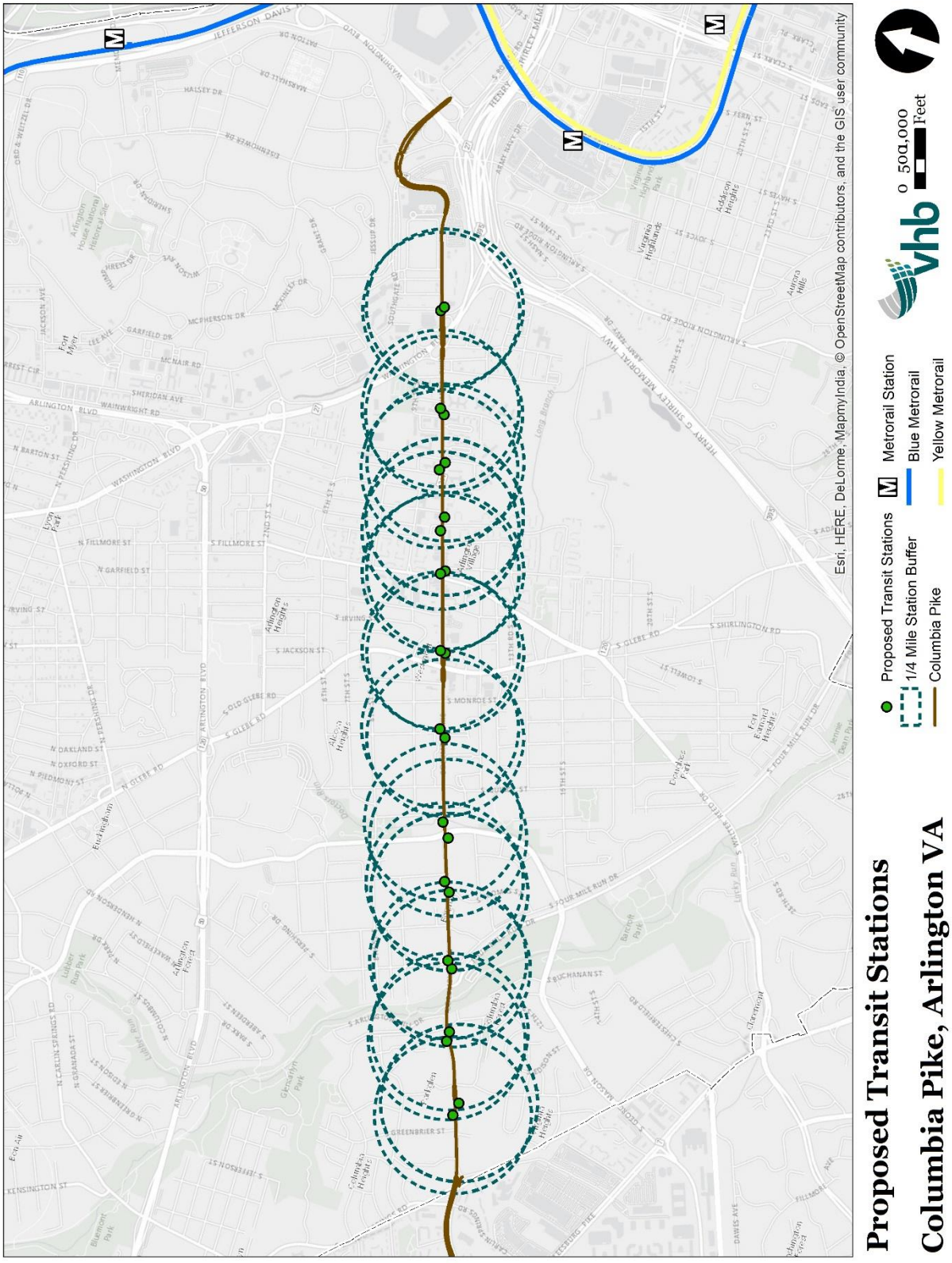
Based on the feedback received during public outreach events and workshops, and through meetings with County and WMATA staff, the initial concept for route revisions to Columbia Pike was revised to reflect the public's input and respond to concerns from staff and County officials.

6.2.4 Transit Stations

The County has proposed consolidating the 38 existing bus stops along the corridor into 24 enhanced transit stations, providing near-level boarding, shelters, seating, real-time passenger information, and space for off-board fare collection. These recommendations were shared with public as part of the initial service concept. Overall, there was support for the consolidation and an understanding of the benefits this project would provide. One common comment received was a request not to eliminate the stop at S. Orme Street.

Based on this feedback, the following locations are proposed for the enhanced transit stations:

Figure 6.2: Proposed Columbia Pike Transit Stations



- S. Greenbrier Street
- S. Dinwiddie Street/S. Columbus Street
- S. Buchannan Street/S. Four Mile Run Drive
- S. Taylor Street/S. Thomas Street
- S. George Mason Drive
- S. Oakland Street
- S. Glebe Road
- S. Walter Reed Drive
- S. Barton Street
- S. Courthouse Road
- S. Scott Street
- S. Orme Street

The County will continue to advance this project. The design of the enhanced stations is currently under review; once complete, the stations will move into final design and ultimately construction.

6.2.5 Stop Consolidation

The initial concept idea of stopping at fewer stops with the limited-stop routes and the premium service was not well received by the public. Concerns about accessibility were voiced as well as a strong belief that the premium service should stop at every stop to provide a frequent service for moving up and down the corridor. Based on the large amount of feedback received, the premium service was switched to stop at all transit stations, and the 16A was converted to a limited-stop service. The proposal to eliminate the 16Y stops was not advanced, and only one stop on the 16X (S. Oakland Street) will be eliminated due to ridership.

6.2.6 Routes

The initial three-tiered concept of local service, limited-stop service, and premium service was carried forward. This simplified service concept provides connections from the neighborhoods to Columbia Pike and other major activity centers (local), provides faster connections between the corridor and major job centers (limited-stop), and provides a premium frequent, all-day bus route that connects major destination in Fairfax County, along Columbia Pike, and to Pentagon City and Crystal City.

The service will be easy to use because there are fewer routes, making a rider's choice simpler. The three levels of service will be branded appropriately and allow riders to easily identify and select the route that best meets their needs. The three-tiered concept would provide new and improved connections not currently available: additional service to Pentagon City and Crystal City, new service to the Navy Yard, and increased service to Skyline, which would provide a connection to the proposed

Route 7 bus rapid transit (BRT). Passengers would access the routes through enhanced stations that provide real-time route information as well as comfortable and attractive amenities.

The existing routes would be restructured as described below.

Local Routes

Local route recommendations were developed as part of the larger TDP; because of their importance to the service concept for Columbia Pike, they are highlighted here.

- ART 41 will increase service frequency from 15-minute peak service to 10-minute peak service starting in FY2018. This increase in frequency will provide additional service to the Arlington Mill neighborhood as the 16G and 16K are eliminated.
- ART 42 will increase frequency during peak periods from 19 minutes to 15 minutes beginning in FY 2025. There is also a proposed extension to Crystal City on the weekends to serve a more active location.
- ART 45 will be realigned to not travel along Columbia Pike between S. Dinwiddie Street and S. Four Mile Run Drive, instead providing more neighborhood coverage. The routes frequency will increase from 25 minutes in the peak period to 20 minutes in FY 2018. Another frequency increase to 15-minute peak period headways will occur in FY 2024. This increase in frequency will provide additional service to the Arlington Mill neighborhood as the 16G and 16K are eliminated.
- ART 74 will be realigned to service the Douglas Park neighborhood and the Pentagon, eliminating service to Pentagon City. Service frequencies will be increased to 25 minutes with afternoon service beginning earlier (3:00 p.m.)

Limited-Stop Routes

- 16A will be converted to a limited-stop route in Arlington County. The route will continue to operate as it currently does in Fairfax County. Starting in FY 2018, the route will only stop at S. Four Mile Run Drive, S. George Mason Drive, S. Glebe Road, and S. Walter Reed Drive to facilitate transfers. The route will also provide service seven days a week, and start providing some late-night service on weekdays.
- 16X will increase service frequency to the Pentagon from 15 minutes to 10 minutes during the peak period in response to elimination of the 16B and 16J[13]. Service to Federal Triangle will be every 15 minutes (with every other bus). The service span will be increased to operate from 4:30 a.m. until 1:00 a.m. weekdays, 5:30 a.m. to 3:30 a.m. on Friday and Saturday, and 6:00 a.m. to 11:00 p.m. on Sundays. These changes will occur in FY 2018. Starting in FY

[13] This is a change from the recommendation shown in the Arlington Transit FY 2017-2026 Transit Development Plan (TDP). The TDP proposed a frequency of 7.5 minutes to the Pentagon during the peak period.

2021, the 16Z will begin splitting service between Culmore and the Pentagon.

- 16Y will not see any immediate changes. The County and WMATA are looking into providing additional buses for select trips to accommodate the demand. The County and WMATA are also examining the feasibility of adding articulated buses in the longer term.
- 16Z is a new route that will begin in FY 2021 by converting select Metrobus 16X trips. Both routes will continue to serve the Pentagon, but the 16Z buses will then continue into Washington, DC, to connect to the Navy Yard. Service will operate every 30 minutes from 6:00 a.m. to midnight Monday through Saturday and 6:00 a.m. to 11:00 p.m. on Sundays.

Premium Transit

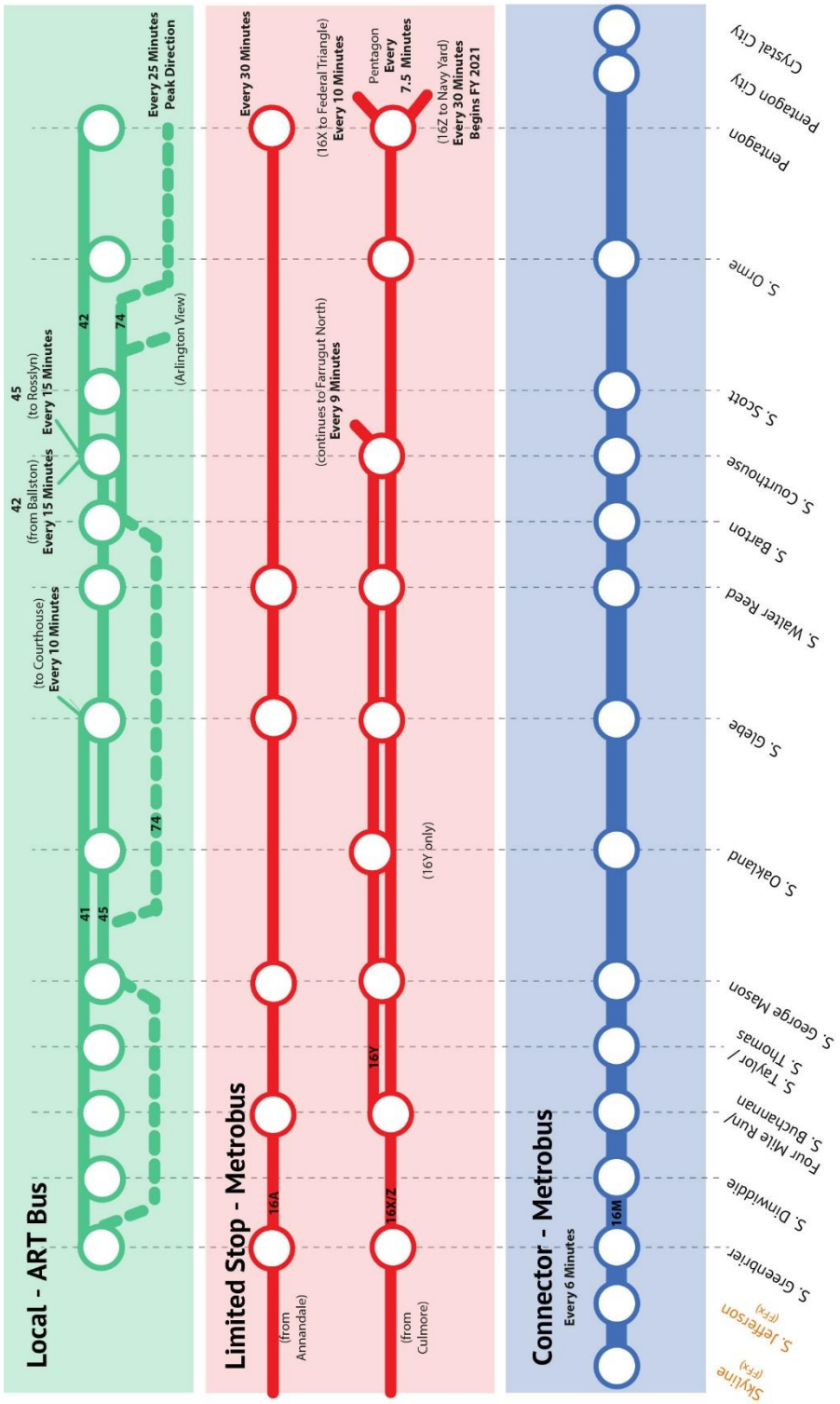
- 16M will begin service in FY 2018 as a new premium transit service. The route will operate from Skyline in Fairfax County to Crystal City in Arlington. The route will serve all 24 of the new Columbia Pike transit stations with additional stops near Skyline, along Jefferson Street, Pentagon City, and Crystal City. The route will utilize transit signal priority, off-board fare collection, near-level boarding, and other station amenities to improve the rider's experience. The service will also be specially branded, similar to Metroway. Service will operate seven days a week with peak period frequencies at 6 minutes, off-peak at 12 minutes, and late night and weekend service at 15 minutes.

Eliminated

The following routes are proposed for elimination as part of the Columbia Pike service concept. The service supplied by these routes will be reallocated into the increased service of many of the routes described above.

- 16B
- 16E
- 16G
- 16H
- 16J
- 16K
- 16P

Figure 6.3: Columbia Pike Route Concept (Revised)



6.2.7 Transit Signal Priority

The County continues with plans to implement TSP on its fleet and in its signal cabinets. While the benefits of TSP are not as much of a windfall as some of the other strategies reviewed, the ability to grant green time to buses running behind schedule can be a huge benefit to providing a reliable service for customers. Additionally, there are other corridors in the County where TSP is a likely candidate for improving service and may provide a greater benefit due to the conditions along those particular corridors. The County should continue to explore ways for their signal equipment to communicate with WMATA's on-board equipment.

6.2.8 Vehicles

Questions about vehicle size and fuel technology were raised during the course of this study. The challenges of providing articulated buses were documented above. The lack of a location to store and maintain them in Virginia would result in money being spent to drive empty buses long distances to operate on Columbia Pike. Both WMATA and the County are exploring ways to accommodate articulated buses at garage locations in Virginia. In the long term, articulated buses may become a viable option to adding capacity to the corridor, specifically for the new 16M service. The challenge of operating articulated buses on the 16Y is the lack of two-way service and the costs associated with operating a larger vehicle. There may become a time when two-way service between the District and Columbia Pike becomes necessary, making articulated buses more viable.

There are currently three predominant fuel types for transit vehicles: liquid (diesel), gaseous (compressed natural gas [CNG]), and electric (trolley bus and battery). There are also hybrid versions that combine liquid or gaseous fuel sources with an electric fuel source. Alternative vehicle fuel technologies are constantly being improved and commercialized. The current Arlington fleet is powered entirely by CNG. Arlington County has three CNG-electric hybrid buses that are being retired due to issues with reliability and maintenance.

Both types of electric buses (trolley and battery) currently cost more than a standard CNG bus. Arlington is currently replacing 40-foot CNG buses for $560,000, while a battery electric bus costs nearly $750,000. This does not account for the charging infrastructure required to keep the batteries charged, maintenance upgrades, and costs to replace batteries when they reach their end of life. Trolley buses can cost nearly $900,000, and require significant infrastructure costs because of the overhead catenary wires needed to power the bus. The wires can also have negative impacts on streetscapes. Trolley buses often have an auxiliary power unit to allow the bus to come off the wire and continue to operate in the case of an emergency or if the catenary network is not fully developed. Both electric and trolley buses operated with zero emissions, although the electricity to power the catenary wires and charging stations are likely still utilizing fossil fuels to generate the power. One benefit of trolley buses is the longer useful life. A typical bus had a 12-year useful life that can be extended by four years with a mid-life rehab. A trolley bus can have a

useful life between 15 to 20 years. There is also the potential to access fixed guideway funding from the federal government to pay for the capital costs of electrifying a corridor.

Arlington County has invested in CNG technology. The County is in the process of constructing a CNG fueling facility off of S. Eads Street. Because of this recent investment, it is unlikely the County will abandon CNG as their fuel of choice for the foreseeable future. It is also important to consider fleet mix when examining agency maintenance practices and parts purchasing.

Battery powered buses are a relatively young technology that are likely to continue to advance in coming years. Battery technologies are continuing to improve, adding range and capability. As these technologies improve, the prices will also begin to decrease. In the long term, Arlington County should consider transitioning to zero emissions fleet as the technology becomes more proven and costs begin to decrease.

7

Performance Analysis

Once the recommendations were made a number of questions were raised by staff and elected officials, specifically about the capacity of the proposed recommendations to meet the forecasted demand. There were continued calls for bus-only lanes as well as requests for comparisons of the proposed improvements to the former streetcar plan. This chapter presents the demand forecast for Columbia Pike and assesses how well the proposed plan accommodates it. An assessment of the benefits and impacts of the different recommendations was completed using microsimulation. This chapter also compares the proposed plan's performance to the proposed performance of the streetcar.

7.1 Assessment of Proposed Transit Services

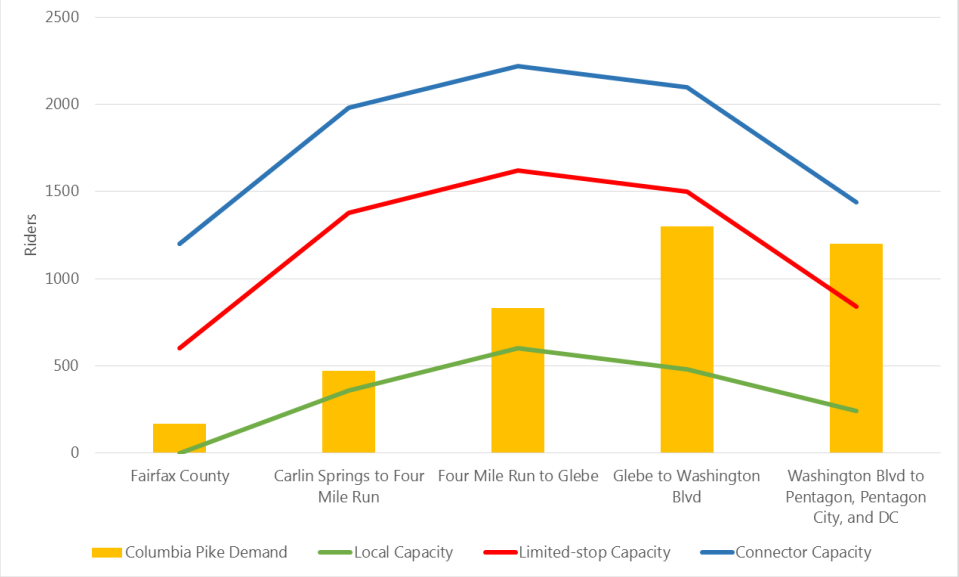
7.1.1 Ridership Forecast

A transit demand estimate was developed for Columbia Pike based on the updated forecast for population and job growth provided by the Arlington County Department of Community Planning, Housing and Development. The updated figures forecasted an average 21% growth in population and a 4% growth in jobs along Columbia Pike over the next 10 years. A pivot-point model was applied to the existing Columbia Pike average daily ridership to develop a forecasted 10-year demand. The 10-year growth rates for each of six zones was applied to the aggregated ridership from each zone for each route. The percentage growth in population was applied to the boardings and the percentage growth for jobs was applied to the alightings. Ridership associated with routes proposed for elimination

was reassigned to the route(s) proposed to be the eliminated route's replacement. Daily ridership was then factored to provide a peak hour ridership for the corridor.

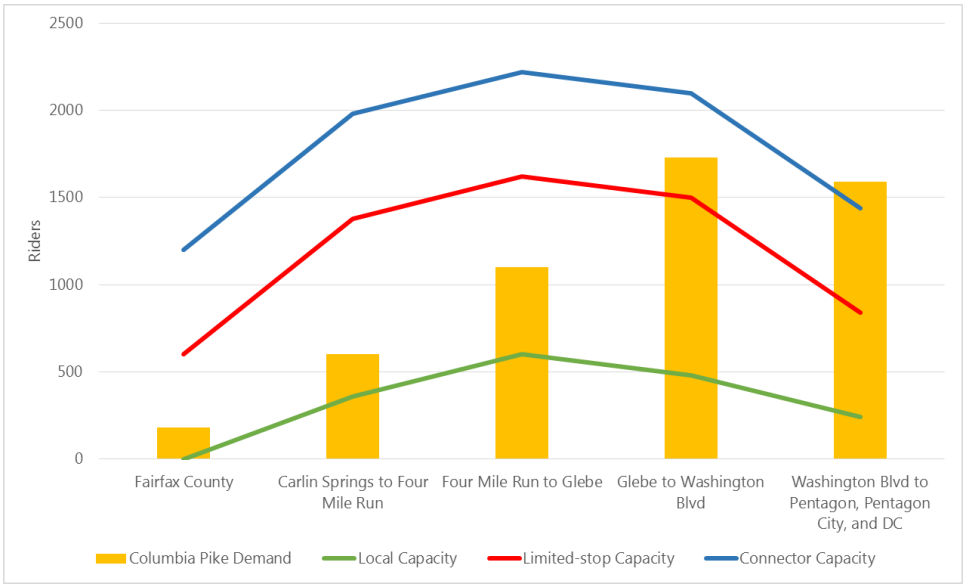
The average daily ridership is forecasted to increase to 19,200 riders over the next 10 years. This results in a peak-hour ridership of roughly 3,500 riders, compared to 2,700 currently. The 2026 peak hour ridership results in a volume to capacity ratio (v/c) of 0.87, assuming that all the peak hour demand is riding in the corridor at the same time and within the same segment. The figure below shows the passenger loads (ONs minus OFFs) for a given segment against the capacity for that segment. This capacity assumes all standard vehicles lengths, peak hour headways, and a load factor of 150%.

Figure 7.1: Columbia Pike 2026 Peak Hour Direction Demand and Capacity (Existing Mode Split)



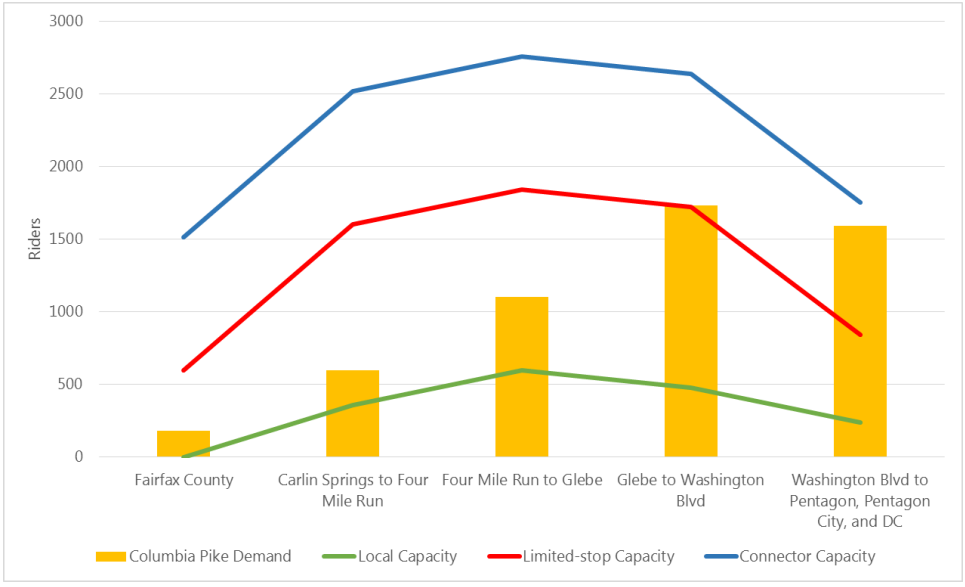
The demand estimate above assumes that the mode split (25%) for Columbia Pike will not change. This mode split is approximately equal to the County-wide mode split. As the corridor transitions to a more mixed-use, transit-oriented development pattern with higher densities, the County will want to increase the number of people choosing alternative modes of travel instead of driving. In fact, the County will need new residents moving to the corridor to choose alternatives to driving because Columbia Pike cannot be widened further. The County's Transit Element of the Master Transportation Plan (2009) seeks to achieve a County-wide mode split of 33% by 2030 for transit. Acknowledging that the mode split for Columbia Pike is in line with the County's mode split, a second demand forecast was developed applying an increase in the mode split. Under this scenario, the 10-year transit capacity begins to show difficulty accommodating the demand, especially at the eastern end of the corridor.

Figure 7.2: Columbia Pike 2026 Peak Hour Direction Demand and Capacity (33% Transit Mode Split)



As redevelopment occurs along Columbia Pike, and assuming the County is successful in achieving its goal of increasing the transit mode split, it may be necessary to consider larger vehicles to provide additional capacity. Adding articulated buses (61 seated + 54 standing) will almost double the capacity from a standard bus (40 seated + 20 standing). Assuming a more reasonable standing capacity of 150% for articulated buses on the 16M and 16Y increases the corridor passenger capacity to almost 3,000 where service is the heaviest. This increase would cover the demand increase associated with a 33% increase in transit mode split.

Figure 7.3: Columbia Pike 2026 Peak Hour Direction Demand and Capacity (33% Transit Mode Split and Articulated Buses - 16M and 16Y)



7.1.2 Columbia Pike Simulation

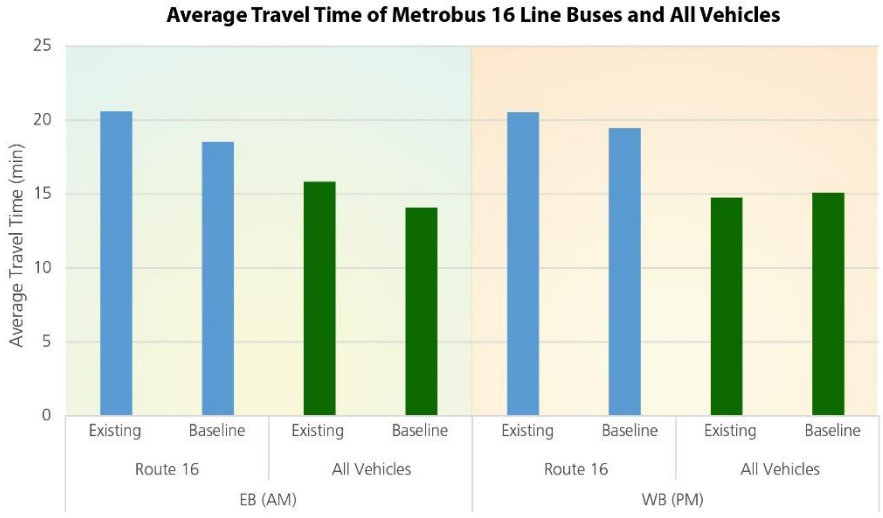
Following the development of the recommendations, County staff were still being asked about the potential for dedicated bus lanes along Columbia Pike. In order to fully assess the impacts of lane repurposing, the proposed route recommendations and corridor treatments were modeled to more clearly identify the benefits and understand the impacts of various bus priority treatments. A secondary purpose of this study was to assess whether adjustments to traffic operations could be made to allow a lane to be dedicated to buses only. A more detailed description of the simulation methodology, model development, and discussion of the results is included as an appendix.

Five scenarios were modeled to assess the additive impacts of the route modifications and various strategy improvements:

- Scenario 1 - Existing Conditions
- Scenario 2 - Baseline (TDP Route recommendations)
- Scenario 3 - Baseline with TSP and Off-board Fare Collection
- Scenario 4 - Baseline with TSP, Off-board Fare Collection, and Queue Jumps
- Scenario 5 - Baseline with TDP, Off-board Fare Collection, and Dedicated Transit Lanes

Modeling the TDP route recommendations with the County's planned stop consolidation resulted in a 10% travel time savings for the Metrobus 16 Line during the morning peak hour and 5% in the evening peak hour compared to the existing conditions. During the morning peak hour, east-west traffic showed an 11% travel time savings.

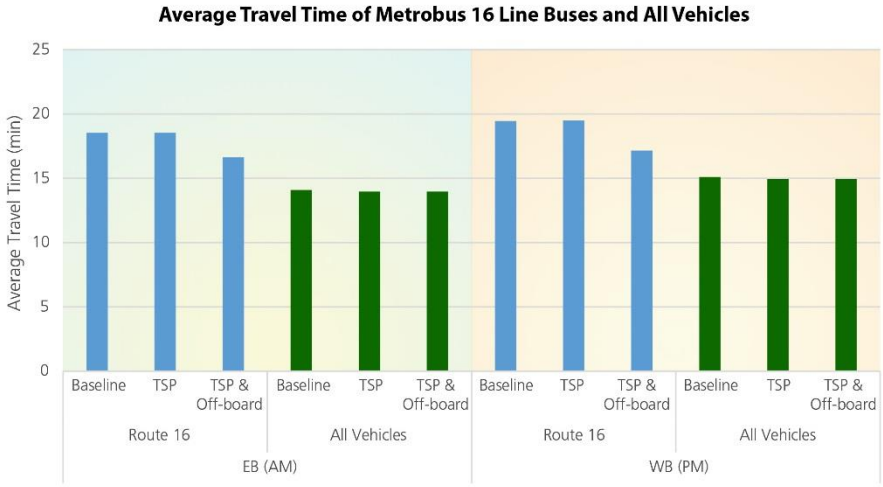
Figure 7.4: Average Travel Time of Metrobus 16 Line and All Vehicles (Baseline)



Scenario 3 was initially modelled with TSP applied to all the intersections, but significant delays were observed at S. George Mason Drive, S. Glebe Road, and

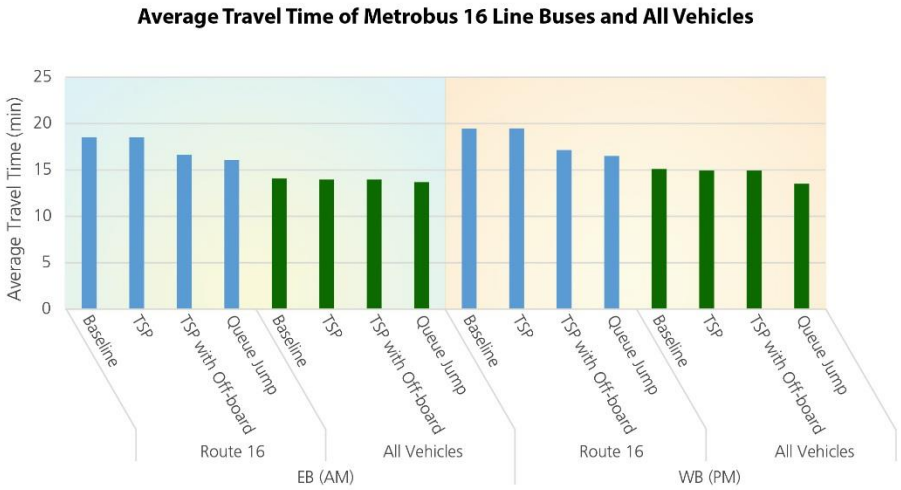
S. Walter Reed Drive. TSP was removed from these three intersections and the benefit in travel time savings was negligible. The conclusion that can be drawn is that these three intersections are the locations of delay for transit in the corridor, but, due to the high volume of cross-street traffic, adjusting the signal timings to benefit Columbia Pike results in poor levels of service. However, the addition of off-board fare collection in Scenario 3 resulted in a noticeable 10% to 12% travel time savings on top of the existing benefits observed from Scenario 2.

Figure 7.5: Average Travel Time of Metrobus 16 Line and All Vehicles (Baseline with TSP and Off-board Fare Collection)



In Scenario 4, a queue jump was placed at S. George Mason Drive and S. Glebe Road. This resulted in an additional 3% in travel time savings for transit as well as travel time improvements for general traffic. The impact to the cross-street traffic was minimal.

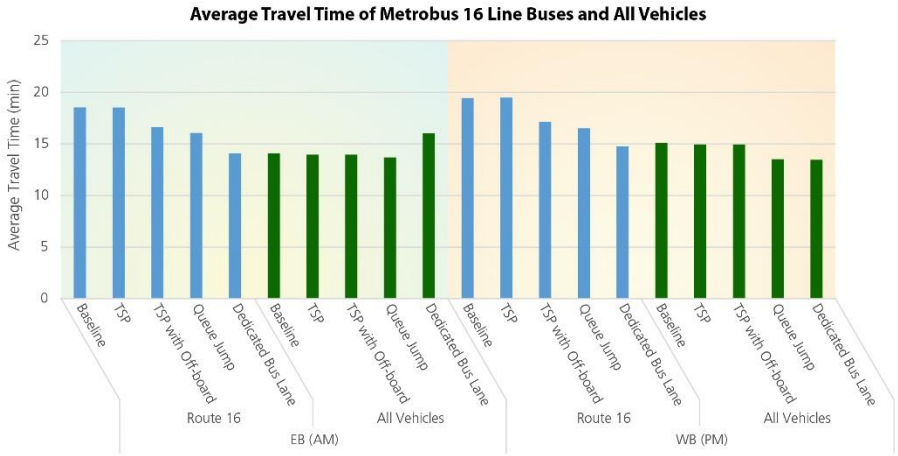
Figure 7.6: Average Travel Time of Metrobus 16 Line and All Vehicles (Baseline with TSP, Off-board Fare Collection, and Queue Jump)



Scenario 5 repurposed the curb lane as a bus- and right-turn-only lane between S. Greenbrier Street and S. Courthouse Road. The bus-only lane was not continued east of S. Courthouse due to operational issues associated with a bus lane and the Washington Boulevard interchange. The model could not process 100% of the traffic in this scenario, indicating the delays encountered by drivers were too great.

An alternative Scenario 5 was modeled with a reallocation of 10 seconds of green time from the side streets to Columbia Pike. The reallocation was an attempt to see if traffic could be held on the side streets, allowing the mainline to operate. The model was not able to process all the traffic at 100%. When 30% of the traffic was removed from the model, it was able to process all the vehicles, but not at a desirable level of service. The 16 Line buses did observe a 25% improvement in travel time savings, but general traffic on the mainline and cross streets had large impacts. Left-turning vehicles from Columbia Pike were observed to have a difficult time finding a sufficient gap to complete the turning movement, resulting in queuing along the mainline.

Figure 7.7: Average Travel Time of Metrobus 16 Line and All Vehicles (Baseline with TSP, Off-board Fare Collection, and Dedicated Transit Lanes)



A conversion to person-time savings was done to determine whether the impacts to vehicles were worth the benefit to transit riders. While the person time savings for scenarios 3 and 4 showed positive person-time savings, the impact of the bus-only lane was significant.

Figure 7.8: Morning Peak Hour Eastbound Total Year Person-hour Savings

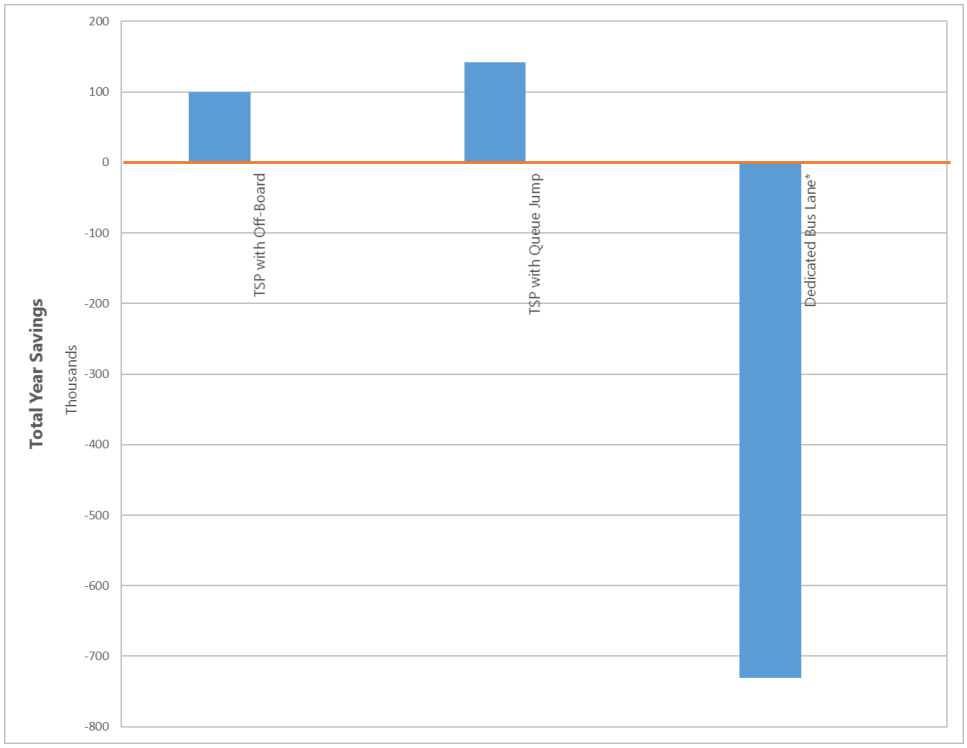
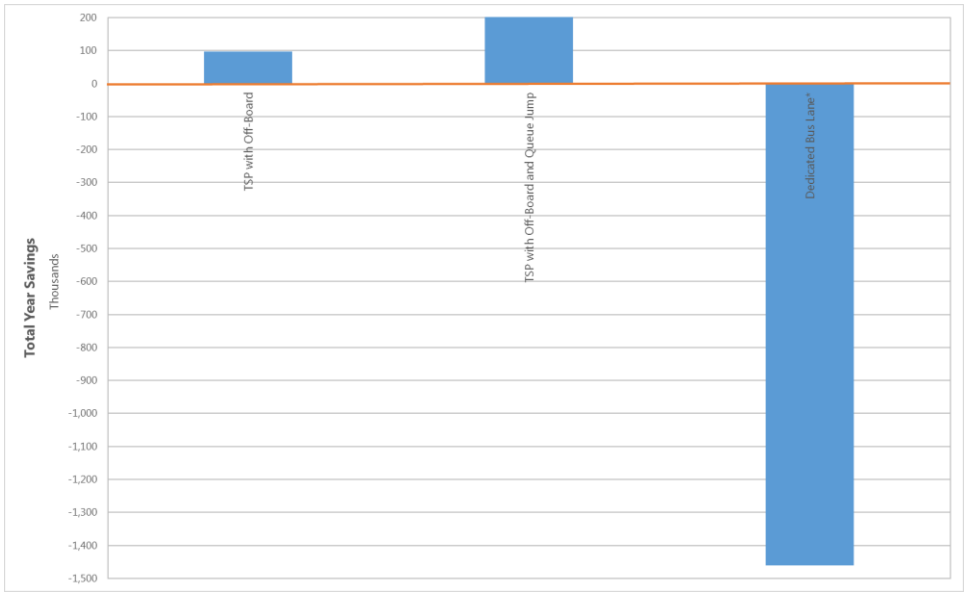


Figure 7.9: Morning Peak Hour Westbound Total Year Person-hour Savings



The results of the microsimulation show that implementation of the TDP route recommendations, stop consolidation, TSP, and off-board fare collection would all have positive impacts on travel time savings for transit and minimal impacts to general traffic. The queue jumps shows a modest (3%) increase in travel time savings

for transit with minimal impacts, but the County will need to decide if departing from the consistent cross section of Columbia Pike and widening a pedestrian crossing at two of the corridor's busiest intersections is worth the benefit to transit riders. The dedicated lane scenario shows that while the benefits to transit could be great, the impact to existing traffic that would need to find an alternative route in addition to the remaining traffic still experiencing significant delays appears to exceed the transit benefits. Focusing improvements only on the mainline operations of Columbia Pike at the expense of side street operations seems to run counter to the vision for Columbia Pike as a multimodal corridor.

7.1.3 Comparison of Proposed Recommendations to Streetcar

The 2012 Alternative Analysis/Environmental Assessment (AA/EA) for the Columbia Pike streetcar assumed a 67-foot vehicle with a capacity of 115 passengers (seated and standing). This capacity is almost double the total capacity of a standard 40-foot bus. As part of the streetcar planning effort, an updated ridership forecast was completed in 2014, which showed that the assumed streetcar capacity of 115 passengers per car would not meet the forecasted 2035 demand. A recommendation was made to select a longer streetcar (79 feet) with a capacity of 155 passengers.

The streetcar plan proposed eliminating the 16G and 16H routes, and modifying the 16J to serve Pentagon City. Assuming a 6-minute frequency for the streetcar and existing peak hour buses for the not-eliminated 16 Line and ART routes results in an estimated capacity of 5,100 passengers (3,100 streetcar alone). The streetcar ridership update completed in 2014 forecasted 25,000 riders in 2015, and 38,700 in 2035. Ridership values for a streetcar alternative connecting to Crystal City forecasted 27,500 riders in 2015 and 42,800 in 2035.

The TDP proposes some significant changes to service levels and routes along Columbia Pike. It is important to understand how the changes impact capacity, and ultimately how the service levels respond to forecasted changes in demand along the corridor. The following table shows how the peak hour capacity increases with the Columbia Pike service changes compared to today's service levels. The proposed TDP increases the number of seats along the corridor by approximately 700. This assumes 40-foot buses for all routes. The total capacity (seats and standing) increases by approximately 1,000.

Table 7.1: Comparison of Columbia Peak Transit Capacity 2015 vs 2026[14]

	2015			2026		
Route	**Peak Hour Buses**	**Seats**	**Total Capacity**	**Peak Hour Buses**	**Seats**	**Total Capacity**
16A	4	160	240	4	160	240
16B	4	160	240	0	0	0
16J	4	160	240	0	0	0
16G	10	400	600	0	0	0
16H	6	240	360	0	0	0
16X	6	240	360	12	480	720
16Y	6	240	360	7	280	420
16Z	0	0	0	4	160	240
16M	0	0	0	20	800	1,200
41	8	320	480	12	480	720
45	4	160	240	8	320	480
TOTAL	**50**	**2,080**	**3,120**	**67**	**2,680**	**4,020**

Table 7.2 tries to compare the peak hour demand and capacity figures forecasted for Columbia Pike as part of this planning effort to those produced for the streetcar study. It is important to note that the land use assumptions used to forecast ridership as part of this study have changed since the figures for the streetcar were forecasted. This study did not follow the same forecasting methodology as the streetcar study; Table 7.2 attempts to compare similar figures from this study to the streetcar study to provide a comparison. It shows that the bus plan, even using smaller vehicles, provides a comparable capacity to the proposed streetcar plan. All the scenarios provide enough capacity to meet the forecasted demand.

[14] The ART 42 is not shown in this table because the route is only on Columbia Pike between Courthouse Road and the Pentagon. Other routes (41, 45, and 16Y) are no longer on the corridor, so the peak capacity is not impacted by the addition of the ART 42.

Table 7.2: Comparison of Columbia Peak Bus Capacity to Streetcar

Current (2015)		2026 (25% Mode Share)		2026 (33% Mode Share)		2035 Streetcar	
Peak Load		Peak Load		Peak Load		Peak Load	
900		1,300		1,700		2,200	
Capacity (Bus)		Proposed Capacity (40' Bus)		Proposed Capacity (Articulated Bus)		Capacity (Streetcar)	
Seated	Seated + Stand	Seated	Seated + Stand	Seated	Seated + Stand	Streetcar Only	Streetcar + Bus
2,000	3,000	2,700	4,000	3,200	4,900	3,100	5,100

7.1.4 Addressing Long-term Transit Needs

This planning study focused on addressing the needs for transit in the Columbia Pike corridor over the next 10 years. The recommended plan is able to accommodate the forecasted growth in ridership. The plan does require the transition to larger vehicles if the County is successful in shifting more travelers to using transit, but beyond 10 years, the ability to continuously serve demand is not known. There are many variables to be considered, like how quickly the Columbia Pike corridor will develop, whether the growth will follow a linear trend, and how much growth can be expected beyond 10 years.

If Columbia Pike continues to grow substantially beyond the growth that is forecasted over the next 10 years, the proposed transit recommendations will likely fail, assuming current trends and travel preferences. The longer-term solution for transit along Columbia Pike may require a more dramatic solution to meet future demands. This could involve a complete restructuring of transit routes to focus on a single spine with numerous feeder routes, which would force more transfers, but eliminate some of the overlap that currently occurs. The longer-term solution may require a transit technology that is separated from Columbia Pike. This will likely be cost prohibitive. Another solution could be that the County revises its land use plans and forecast to more closely match the capabilities of the transportation system. This is unlikely due to development pressures. Another solution may be that a technology is developed in the next 10 to 20 years that revolutionizes the transportation industry. Technology is changing rapidly and there are many ideas, such as driverless cars, that are showing the potential to become reality. While these technologies could improve overall traffic operations, they are unlikely to replace the need for public transportation. Driverless cars do not offer a practical solution to handle the volume of transit riders on Columbia Pike. Additionally, emerging technologies and trends have no data that currently allows a model or forecast to predict how they will impact demand. In these disruptive times, the best thing Arlington County can do is to continue to collect data, make observations, and adapt to changing trends.