Dulles Toll Road Comprehensive Traffic and Revenue Study 2018 Update

Final Report

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METROPOLITAN WASHINGTON AIRPORTS AUTHORITY

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Executive Summary

This report summarizes the results of an updated comprehensive traffic and toll revenue (T&R) study for the Dulles Toll Road (DTR) in Northern Virginia. The study builds on prior work performed by CDM Smith for the Metropolitan Washington Airports Authority (MWAA or Airports Authority) with the latest study being completed in March 2014. The purpose of the study is to develop updated T&R estimates from 2018-2054 in sufficient detail to support financial planning and/or project financing, if needed.

Dulles Toll Road Overview

The DTR was constructed by the Virginia Department of Transportation (VDOT) and opened to traffic in October 1984. It provides access to well-established and growing activity centers in the Northern Virginia region, such as Tysons Corner, the Reston-Herndon area, Dulles International Airport, and eastern Loudoun County.

The DTR is an eight lane (four in each direction) tolled roadway, approximately 13.4 miles in length, that extends from the Capital Beltway (Interstate 495) to beyond State Route (SR) 28 where it links directly to the Dulles Greenway, a privately-operated toll road. Toll collection is by means of cash and electronic toll collection (E-ZPass). The DTR is configured with one mainline toll plaza at the eastern end and a total of 19 ramp toll plazas at intermediate interchanges.

When opened in 1984, the DTR had two lanes in each direction and eight full interchanges. A ninth interchange and two partial interchanges were subsequently constructed to enhance local access. In response to strong demand, VDOT widened the DTR to six lanes in 1992 and again to eight lanes in 1998. Major improvements to the Capital Beltway ramps were made first in 2005 and more recently, with interchange improvements and reconfigurations associated with the 495 Express Lanes project, which opened in November 2012. The Dulles Corridor Metrorail Project, also known as the Silver Line, Phase 1 opened in 2014, extending rail service to the Wiehle-Reston East station; Phase 2, which extends the line further to Dulles International Airport and beyond, is expected to open in 2020.

Historical Traffic and Revenue

Initial DTR toll rates were 50 cents at the mainline toll plaza and 25 cents at ramp toll plazas, except for the 35-cent toll at SR 28. During the first 20 years of operation, there were no toll rate adjustments. In 2005, the Commonwealth Transportation Board increased toll rates to begin generating funds for transit improvements in the Dulles Corridor. The mainline toll rate for 2-axle vehicles was set at 75 cents in both directions, and all ramp tolls were established at a uniform 50 cents.

Responsibility for operating and maintaining the DTR was transferred to the Airports Authority in 2008. A series of toll increases took place between 2010 and 2014, ultimately increasing the mainline toll to $2.50 and the ramp toll to $1.00, where it remains as of 2018. The rate schedule for vehicles with three or more axles was also modified during this time to be more consistent with the policies for other toll facilities in the region; as of January 1, 2014, rates for multi-axle vehicles using the DTR

were equal to two times the rate for 2-axle vehicles, plus an additional charge per axle beyond two axles. This policy remains in place in 2018.

Historically, DTR demand has been sensitive, to a certain extent, to economic growth but has consistently rebounded after economic slowdowns, as illustrated in **Figure ES-1**. The figure also illustrates how the periodic widening of the DTR and toll rate adjustments in 2005, 2010, 2011, 2012, 2013, and 2014 resulted in increased toll revenue.

Study Approach Overview

This updated comprehensive T&R study is being conducted at a full "investment grade" level and is considered suitable for use in project financing. The study has benefited from the release of the Metropolitan Washington Council of Governments (MWCOG) revised travel demand model (Version 2.3.66 released in February 2017) and its revised socio-economic projections for the region (Round 9.0 Cooperative Forecast approved in March 2016). The model also reflects the most recently implemented and approved future transportation improvement plans, including the impacts of various high-occupancy toll (HOT) lanes projects and transit expansion projects.

The regional MWCOG travel demand model was the starting point for this T&R study. The model was updated and refined to better represent actual traffic conditions in the DTR corridor. Key components of the work effort included calibration of the model with existing travel data, an assessment of how much travelers in the DTR corridor may be willing to pay to save time, motorists' travel patterns and trip characteristics survey and an independent evaluation of the socioeconomic forecasts. Other key inputs were the assumed future toll rate adjustments provided by the Airports Authority's financial advisors.

Calibration of the MWCOG Travel Demand Model

To refine the MWCOG model, CDM Smith utilized significant data for the base model year 2017, including detailed traffic data collected at 26 locations and information related to travel characteristics collected in the DTR corridor. In addition to the detailed corridor reconnaissance, an origin-destination survey was also conducted during the same time frame; the survey asked roadway users a variety of questions, including the origin and destination of their most recent DTR trip, when it occurred, entry and exit interchanges, how long the total trip took to complete, and trip characteristics. A stated preference survey was also conducted to determine motorists' willingness to pay for travel time savings (also known as value of time). Three years of INRIX speed data at 5-minute intervals was used to understand the progressing levels of congestion and travel times in the study region. This data, along with plaza by plaza detailed transaction data, was used to calibrate the travel demand model to existing conditions.

Value of Time Calculations

Stated preference surveys conducted for this study were used as the basis for estimating toll impacts on the DTR. These surveys, conducted by CDM Smith over a six-week period as part of a comprehensive data collection program in fall 2017, provided useful estimates of travelers' willingness to pay for travel time savings in the DTR corridor, as well as motorists' preferences regarding toll collection options and other inputs. The surveys found values of time (VOT) generally in the range of $4.19 to $23.11 per hour, depending on trip purpose, travel time, and household income. The median VOT was $18.60 per hour for drivers operating 2-axle vehicles during peak hours. Off-peak VOT was calculated to be $17.40 per hour for drivers of 2-axle vehicles. Truck operator VOT

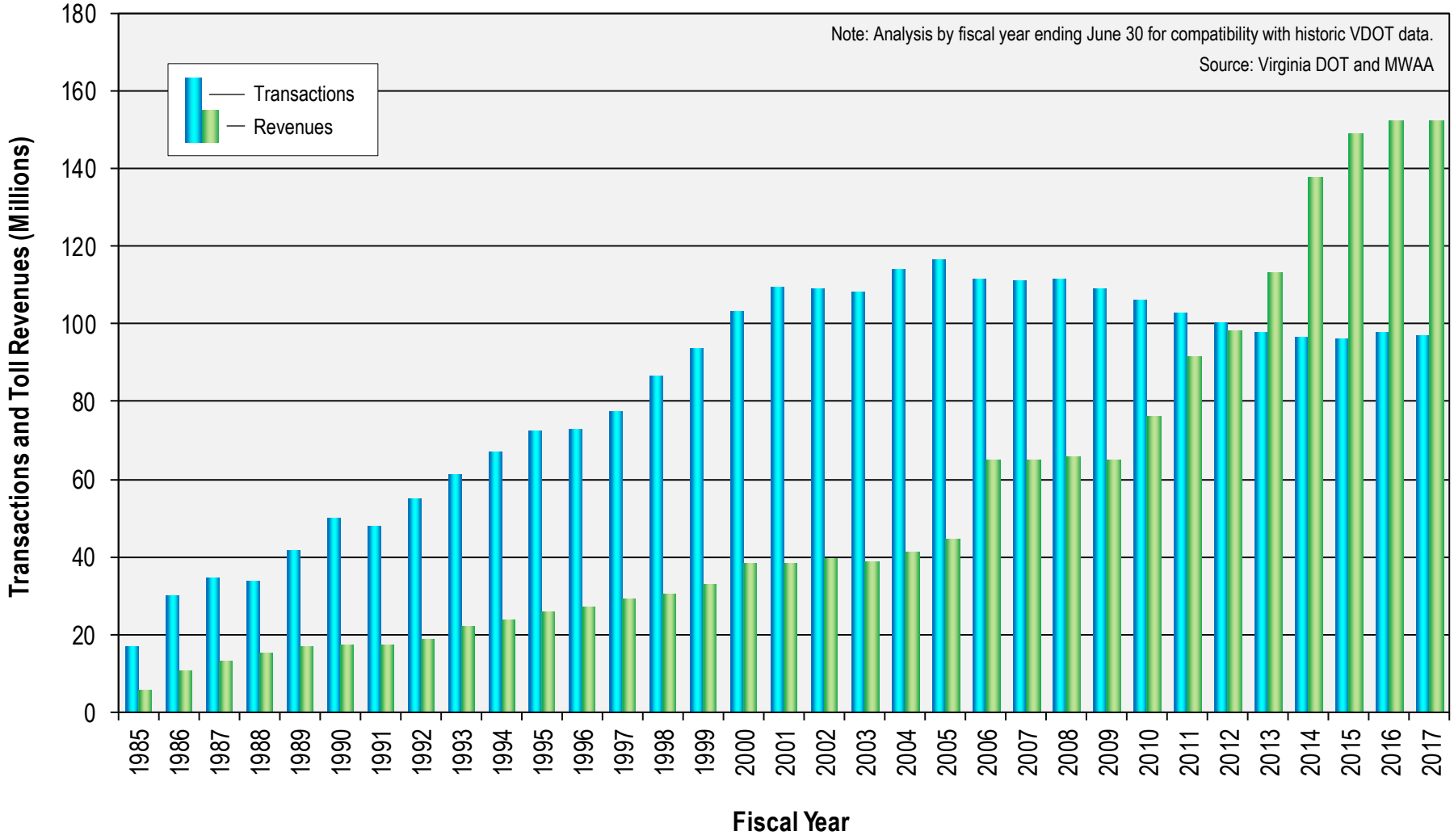


FIGURE ES-1: DTR TRANSACTIONS AND REVENUES FY 1985 - FY 2017

ranges from approximately $28.38 to $30.30 per hour. The VOT range for the DTR is relatively high compared with estimates calculated for other toll facilities in the country. However, median household incomes in Fairfax and Loudoun counties are also among the highest in the nation, and the results are consequently reasonable.

Review of Socioeconomic Projections

MWCOG's Round 9.0 socioeconomic forecasts formed the basis of the socioeconomic projections. An independent review of these projections was performed by Renaissance Planning Group (RPG). RPG's analysis included a reasonableness test of the traffic analysis zone (TAZ) level and countywide socioeconomic data relative to current economic conditions and trends, the availability of vacant and underutilized land, and the propensity for development and redevelopment in different parts of the region. Modifications to the MWCOG forecast based on the RPG review are discussed in **Chapter 4** and in their full report, which is included as an appendix to this study. The long-term economic and demographic outlook for the DTR corridor remains favorable with regional population growth of 0.9 percent compound annual growth rate (CAGR) and regional employment growth of 1.1 percent CAGR through 2040.

Future Toll Rate Adjustments

Prior to adjusting toll rates, the Airports Authority follows its process for promulgating regulations, including convening public hearings in the Dulles Corridor to provide opportunities for members of the public to become informed about, and express their views on, any proposed toll rate changes. The Airports Authority also consults with the Dulles Corridor Advisory Committee (DCAC) with respect to any proposed toll rate adjustments, but DCAC consent or approval of toll rate adjustments is not required under the agreements with the Commonwealth.

For the purposes of this study, future DTR toll rate adjustments are based on the Projected Toll Rate Schedule developed by the financial advisors to the Airports Authority for financial planning purposes. **Table ES-1** provides the assumed 2-axle toll rates through year 2054. A toll increase is assumed to occur in January 2019, with the toll rate for two-axle vehicles increasing by $0.75 at the mainline toll plaza (from the current rate of $2.50 to $3.25) and by $0.50 at tolled ramps (from $1.00 to $1.50). Beginning in 2023, and occurring every five years thereafter, there is an assumed increase of $0.75 at the mainline toll plaza and $0.50 at all ramp toll plazas, except for a $0.75 increase at all toll plazas in 2033.

Estimated Traffic and Toll Revenue

Base case traffic and toll revenue estimates were developed for the DTR, extending over a 37-year period, to 2054, using the Projected Toll Rate Schedule.

Detailed highway networks were prepared for the base model year (2017) and future years 2020, 2025, 2030, 2035, and 2040. Separate traffic assignments were run for morning peak, mid-day, afternoon peak, and night conditions in each model year.

Projected future toll rates in the Projected Toll Rate Schedule were then tested in selected years. No changes in toll collection methods were assumed at this stage. All traffic assignments listed above were also modeled with the previous period's toll rates to estimate toll impacts and to aid interpolation since toll rate increase years do not correspond with model years. Annual estimates were developed and re-based to the actual annual traffic and revenue observed through calendar year 2017 (CY2017).

Table ES-1
Projected Toll Rate Schedule

	Mainline		Ramps	
	Tolls	Change	Tolls	Change
1984-2005	$0.50	..	$0.35/$0.25	..
2005-2009	0.75	+ $ 0.25	0.50	+ $ 0.15
2010	1.00	+ $ 0.25	0.75	+ $ 0.25
2011	1.25	+ $ 0.25	0.75	..
2012	1.50	+ $ 0.25	0.75	..
2013	1.75	+ $ 0.25	1.00	+ $ 0.25
2014-2018	2.50	+ $ 0.75	1.00	..
2019-2022	3.25	+ $ 0.75	1.50	+ $ 0.50
2023-2027	4.00	+ $ 0.75	2.00	+ $ 0.50
2028-2032	4.75	+ $ 0.75	2.50	+ $ 0.50
2033-2037	5.50	+ $ 0.75	3.25	+ $ 0.75
2038-2042	6.25	+ $ 0.75	3.75	+ $ 0.50
2043-2047	7.00	+ $ 0.75	4.25	+ $ 0.50
2048-2054	7.75	+ $ 0.75	4.75	+ $ 0.50

Table ES-2 provides a summary of annual T&R estimates for the DTR under the Projected Toll Rate Schedule. In CY2017, total annual transactions that occurred on the DTR system amounted to approximately 97.1 million. This translated to annual toll revenue of approximately $152.1 million in CY2017.

Based on the toll rate increases in 2019 in the Projected Toll Rate Schedule, annual total transactions are estimated to decrease by 6.4 percent to approximately 91.7 million per year, producing almost $199 million in annual toll revenue, an increase of 29.6 percent over 2018 revenue. With toll rate increases occurring every five years, revenue is expected to grow significantly over the forecast horizon, while transactions are moderated due to the increases. By 2030, transactions are forecast to be almost 94.5 million, with $320.6 million in accompanying revenue. By 2050, transactions are estimated to be approximately 92.8 million with revenues of $550.9 million.

CDM Smith also performed a series of sensitivity tests to estimate the potential impacts on toll revenue in model years 2020 and 2040 associated with hypothetical changes in certain assumptions or basic study inputs. These tests cover a range of potential risk factors, such as alternative economic growth, lower VOTs, and fuel price increases.

Table ES-2
Dulles Toll Road Traffic and Toll Revenue Estimates 2017-2054

Forecast Year	Calendar Year	Main/Ramp[1] Tolls	Total[2] Transactions	% p.a.	Total[3] Revenue	% p.a.	Average[4] Revenue
0	**2017**	**$2.50 / $1.00**	**97,089,931**	-0.7%	**152,111,089**	**+0.3%**	**1.57**
1	2018	$2.50 / $1.00	97,960,000	+0.9%	153,289,000	+0.8%	1.56
2	2019	$3.25 / $1.50	91,653,000	-6.4%	198,650,000	+29.6%	2.17
3	**2020**	**$3.25 / $1.50**	**92,964,000**	**+1.4%**	**201,548,000**	**+1.5%**	**2.17**
4	2021	$3.25 / $1.50	94,488,000	+1.6%	204,838,000	+1.6%	2.17
5	2022	$3.25 / $1.50	96,037,000	+1.6%	208,182,000	+1.6%	2.17
6	2023	$4.00 / $2.00	88,345,000	-8.0%	245,109,000	+17.7%	2.77
7	2024	$4.00 / $2.00	89,793,000	+1.6%	249,111,000	+1.6%	2.77
8	**2025**	**$4.00 / $2.00**	**91,265,000**	**+1.6%**	**253,414,000**	**+1.7%**	**2.78**
9	2026	$4.00 / $2.00	93,483,000	+2.4%	259,702,000	+2.5%	2.78
10	2027	$4.00 / $2.00	95,754,000	+2.4%	266,145,000	+2.5%	2.78
11	2028	$4.75 / $2.50	90,053,000	-6.0%	305,290,000	+14.7%	3.39
12	2029	$4.75 / $2.50	92,241,000	+2.4%	312,864,000	+2.5%	3.39
13	**2030**	**$4.75 / $2.50**	**94,482,000**	**+2.4%**	**320,626,000**	**+2.5%**	**3.39**
14	2031	$4.75 / $2.50	96,705,000	+2.4%	328,064,000	+2.3%	3.39
15	2032	$4.75 / $2.50	98,981,000	+2.4%	335,675,000	+2.3%	3.39
16	2033	$5.50 / $3.25	92,297,000	-6.8%	385,498,000	+14.8%	4.18
17	2034	$5.50 / $3.25	94,468,000	+2.4%	394,440,000	+2.3%	4.18
18	**2035**	**$5.50 / $3.25**	**96,691,000**	**+2.4%**	**403,591,000**	**+2.3%**	**4.17**
19	2036	$5.50 / $3.25	98,666,000	+2.0%	411,647,000	+2.0%	4.17
20	2037	$5.50 / $3.25	100,680,000	+2.0%	419,863,000	+2.0%	4.17
21	2038	$6.25 / $3.75	89,474,000	-11.1%	425,965,000	+1.5%	4.76
22	2039	$6.25 / $3.75	91,301,000	+2.0%	434,468,000	+2.0%	4.76
23	**2040**	**$6.25 / $3.75**	**93,166,000**	**+2.0%**	**443,001,000**	**+2.0%**	**4.75**
24	2041	$6.25 / $3.75	94,117,000	+1.0%	447,422,000	+1.0%	4.75
25	2042	$6.25 / $3.75	95,078,000	+1.0%	451,887,000	+1.0%	4.75
26	2043	$7.00 / $4.25	91,547,000	-3.7%	489,384,000	+8.3%	5.35
27	2044	$7.00 / $4.25	92,482,000	+1.0%	494,268,000	+1.0%	5.34
28	2045	$7.00 / $4.25	93,426,000	+1.0%	499,201,000	+1.0%	5.34
29	2046	$7.00 / $4.25	93,903,000	+0.5%	501,692,000	+0.5%	5.34
30	2047	$7.00 / $4.25	94,382,000	+0.5%	504,196,000	+0.5%	5.34
31	2048	$7.75 / $4.75	91,900,000	-2.6%	545,422,000	+8.2%	5.93
32	2049	$7.75 / $4.75	92,369,000	+0.5%	548,144,000	+0.5%	5.93
33	2050	$7.75 / $4.75	92,841,000	+0.5%	550,879,000	+0.5%	5.93
34	2051	$7.75 / $4.75	93,315,000	+0.5%	553,628,000	+0.5%	5.93
35	2052	$7.75 / $4.75	93,791,000	+0.5%	556,391,000	+0.5%	5.93
36	2053	$7.75 / $4.75	94,270,000	+0.5%	559,167,000	+0.5%	5.93
37	2054	$7.75 / $4.75	94,751,000	+0.5%	561,958,000	+0.5%	5.93

[1] Historical and Projected Toll Rates per MWAA and Financial Advisor

[2] Total Transactions; revenue transactions, violations and non-revenue

[3] Total revenue including violation processing, fees and fines

[4] Average revenue per transaction.

Chapter 1
Introduction

CDM Smith has been selected as an independent consultant to provide a comprehensive Traffic and Toll Revenue (T&R) Study for the Metropolitan Washington Airports Authority (Airports Authority or MWAA). The purpose of this study is to develop updated T&R estimates from 2018-2054 in sufficient detail to support financial planning and/or project financing, if needed.

Pursuant to agreements with the Commonwealth of Virginia (the "Commonwealth"), the Airports Authority has been responsible for the operation and maintenance of the Dulles Toll Road (DTR) since 2008. The Airports Authority is also responsible for financing the construction of the Dulles Corridor Metrorail Project, also referred to as the Silver Line. Local partners (the Airports Authority, Fairfax County, and Loudoun County) are providing funding, along with the Commonwealth and the federal government. A significant portion of the funding for the Dulles Corridor Metrorail Project comes from proceeds of debt secured by DTR revenue.

This T&R study builds on several detailed studies commissioned by the Airports Authority with the latest completed in April 2014. It brings current assumptions up-to-date regarding the future toll rates, proposed highway and transit network improvements, the regional economic outlook, and actual T&R performance through CY 2017, including the impacts of toll adjustments on the DTR and nearby facilities. Background information regarding the DTR has also been updated through early 2018.

The study analysis is conducted at an investment-grade level and is considered suitable for use in project financing, if required. CDM Smith believes that all information from the original data, including socioeconomic forecasts, has been updated to make the conclusions set forth in this report current as of its date.

DTR Location

State Route (SR) 267 is the official designation of the route corridor on which the DTR is situated. **Figure 1-1** shows the roadway in a regional context. The DTR is the major artery of the transportation network in the Dulles Corridor, which is home to several of the Washington, D.C. metropolitan region's most dynamic activity centers, including Tysons Corner, Washington Dulles International Airport (IAD), and the emerging activity centers in Reston, Herndon, and eastern Loudoun County.

The eastern terminus of SR 267 connects with I-66 near the Fairfax County/Falls Church City border. While the portion east of the Capital Beltway is not tolled, a direct connection from the DTR to the 495 Express Toll Lanes opened in November 2012. The western terminus of the DTR connects to the Dulles Greenway (Greenway) toll road and IAD. SR 267 continues west as the Greenway until it intersects US 15/SR 7 in the Town of Leesburg, Virginia.

Figure 1-2 shows the DTR, the Greenway, and the surrounding major roadway network, including existing and future toll facilities in the Washington, D.C. region. Northern Virginia has become a densely populated, high-income area with a well-developed but congested roadway network. There are several parallel and intersecting roads that influence traffic on the DTR.

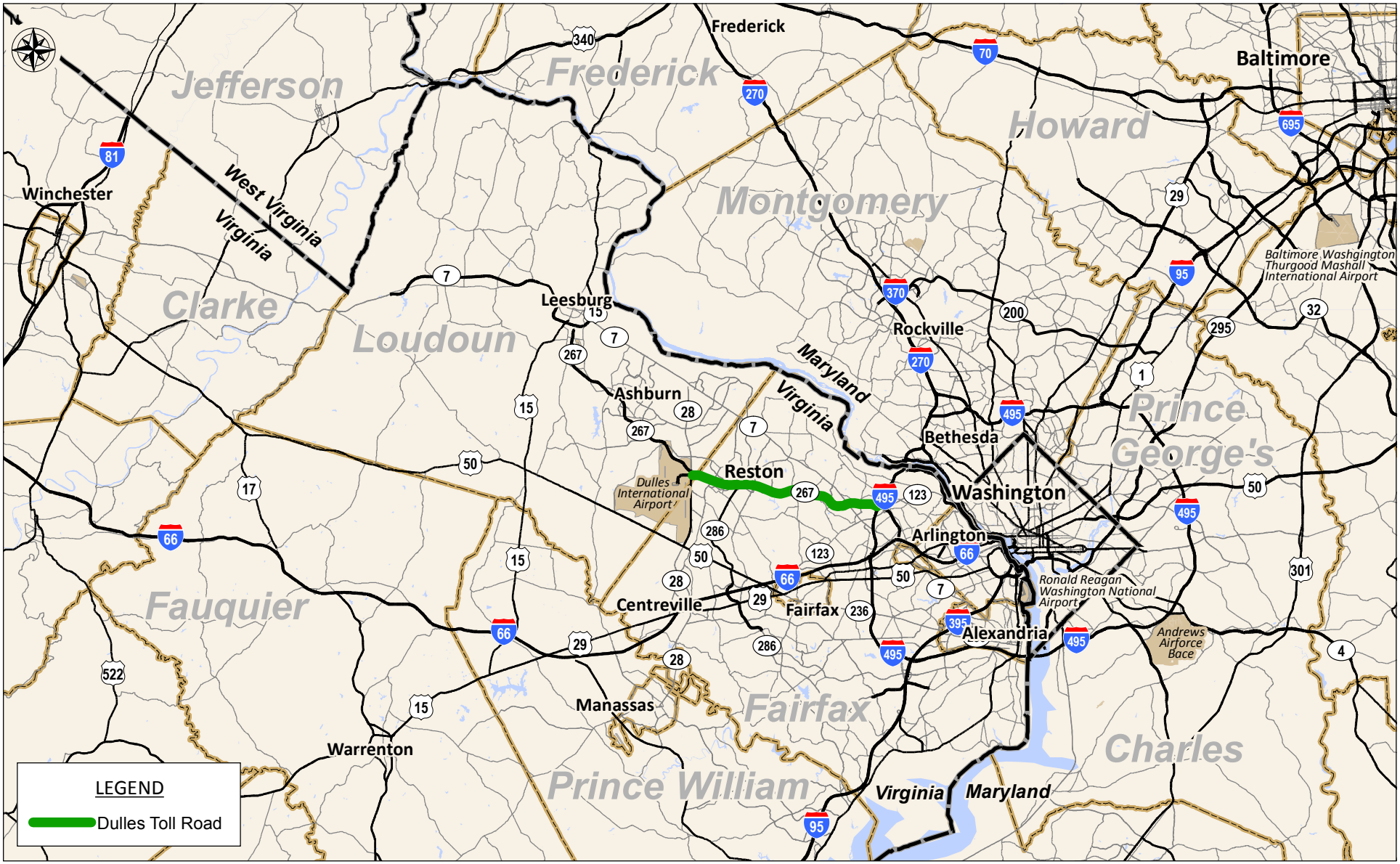


FIGURE 1-1: REGIONAL LOCATION MAP

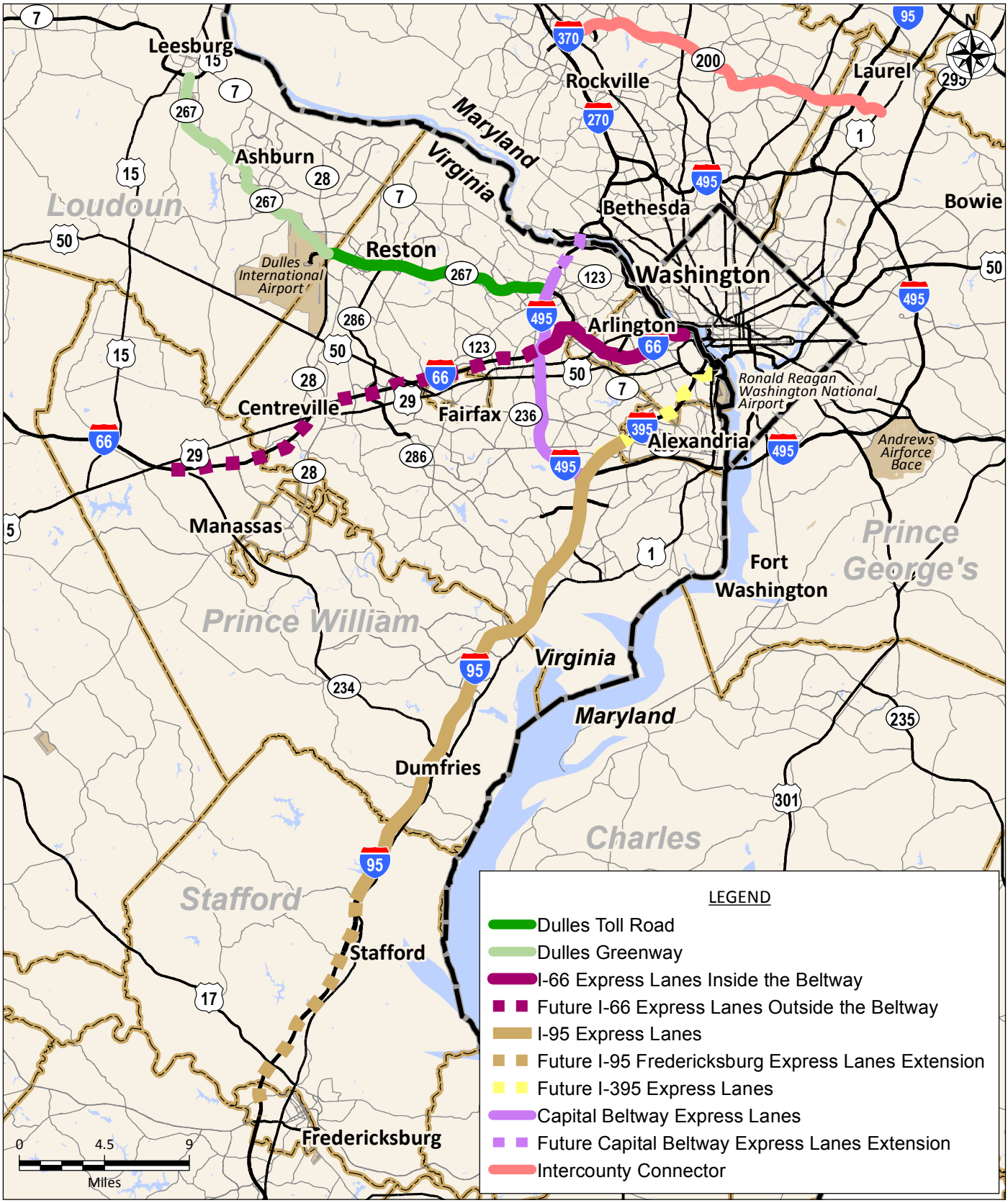


FIGURE 1-2: STUDY AREA MAJOR ROADWAY NETWORK

Nearby parallel toll-free roadways include:

- Interstate 66 (I-66 Outside the Beltway)
- US Route 29 (Lee Highway)
- US Route 50 (Lee-Jackson Memorial Highway / Arlington Boulevard)
- SR 7 (Leesburg Pike)

Intersecting roadways that act as complementary feeder routes to the DTR include:

- I-495 (Capital Beltway)
- 495 Express Lanes (dynamically-priced high-occupancy toll [HOT] lanes in the median of the Virginia side of the Capital Beltway)
- I-66 (Inside the Beltway, dynamically-priced HOT roadway between I-495 and US Route 29 in Rosslyn)
- SR 28 (Sully Road)
- SR 123 (Chain Bridge Road)
- SR 286 (Old Route 7100, Fairfax County Parkway)

Other major roadways with which DTR customers use to reach final destinations include:

- Dulles Greenway toll road
- I-95
- I-395
- George Washington Memorial Parkway (GW Parkway)
- I-270

It is important to note that during peak hours and in the peak direction, I-66 Inside the Beltway previously operated as HOV-2+ only, resulting in a significant portion of DTR traffic merging with the Capital Beltway to connect with non-HOV routes to/from Arlington and Washington, D.C. Beginning in December 2017, VDOT expanded the HOV-restricted hours and began allowing single-occupancy vehicles to utilize I-66 Inside the Beltway (during previously restricted hours) by paying a toll. Managed lanes are expected to be in operation on I-66 Outside the Beltway by 2022.

Additional future toll facility expansions include:

- I-66 Outside the Beltway, convert existing HOV lane and add second HOT lane extending from I-495 to University Boulevard, Gainesville (2022)
- I-395 Express Lanes from Eads Street to Duke Street (2019)
- I-95 Express Lanes Fredericksburg Extension from existing terminus to US 17 (2022)
- 495 Express Lanes Extension (I-495, Capital Beltway) from existing northern terminus to American Legion Memorial Bridge (2030)
- Express lanes on I-495 from American Legion Bridge to Woodrow Wilson Bridge and I-270 from I-495 to I-70 (Maryland). These are proposed Public Private Partnership projects sponsored by the Maryland Department of Transportation (MDOT). Schedule and funding are uncertain.

DTR History

The Dulles Corridor transportation network has several unique systems important to understanding its development history. The Dulles International Airport Access Highway (Access Highway), a limited-access highway subject to the Airports Authority's jurisdiction under its lease with the federal government, is the primary route to IAD. The Access Highway opened in 1962 when IAD began airport operations, and no tolls are collected on the roadway. Prior to the opening of the DTR, the Virginia Department of Transportation (VDOT) sold stickers to allow commuters to use the Access Highway, but this program was discontinued when the DTR opened. Currently, only vehicles with occupants on airport business and certain public buses may use the Access Highway; the Airports Authority police strictly enforce proper usage.

In the late 1970s, as development in Fairfax and Loudoun counties created the need for a general use highway providing direct access to employment centers inside the Capital Beltway, the Commonwealth of Virginia obtained permission from the Federal Aviation Administration (FAA) to build a toll road within the right-of-way acquired for the Access Highway. The DTR was constructed in the outer portions of the Access Highway right-of-way. The new roadway provided an access-controlled toll facility for travelers to and from points in Fairfax and Loudoun counties. The DTR was opened in 1984 with three lanes in each direction between SR 7 and the Capital Beltway and two lanes in each direction on the remainder of the toll facility. At the time, there were eight full interchanges on the DTR.

After the construction of Fairfax County Parkway (Old-SR 7100, current-SR 286), a north-south route intersecting the DTR, a ninth full interchange was built. Two additional interchanges, the tenth and eleventh overall, were constructed as partial interchanges. One provided DTR access for motorists using the Monroe Park & Ride lot with all movements except from the east and the other provided access to the Wolf Trap Performing Arts Center to and from the east.

Full expansion to six lanes was completed by 1992 and a fourth lane was added by VDOT in each direction in 1998, resulting in the 8-lane configuration seen today. The right-of-way for the DTR and subsequent improvements was granted by the federal government without charge to the Commonwealth.

Originally designed to be a commuter route from northern Fairfax County into Washington, D.C., the nature and characteristics of trips along the DTR changed as many residential and commercial developments were constructed in the Dulles corridor. The DTR now has significant peak-hour traffic in both directions. Activity centers such as Tysons Corner, the Reston-Herndon area, and eastern Loudoun County have all significantly benefited from the DTR becoming a multi-use highway.

Dulles Greenway Authorization

The Greenway was first conceived in the 1970s, when more and more regional residents were attracted to Loudoun County because of the relatively low housing costs. In 1988, the Virginia Highway Corporation Act was enacted to authorize the construction of new toll roads without the use of eminent domain under rates set by the Virginia Corporation Commission. Privately financed, construction of the Greenway started in 1993 and the facility opened to traffic in December 1995, extending SR 267 west of the DTR to Leesburg. The Greenway was initially built as a 4-lane facility with a speed limit of 55 miles per hour (mph). In 1997, the speed limit was increased to 65 mph to attract additional demand. In 2009, a third lane was added in each direction and the entire road

was resurfaced. An improved eastbound exit ramp to Dulles International Airport was also added in 2009.

Dulles Corridor Metrorail Project

The planning and construction of the Dulles Corridor Metrorail Project resulted from the need to provide rail service from IAD to the Washington, D.C. metro area and to meet the growing travel demand from population/employment centers in Fairfax and Loudoun counties. In July 2014, the Washington Metropolitan Area Transit Authority (WMATA) opened Phase 1 of the Dulles Corridor Metrorail Project, as part of the Silver Line. The Airports Authority was responsible for construction of Phase 1 and provided easement rights to WMATA within portions of the Access Highway median occupied by Phase 1 facilities. The five newly constructed stations added approximately 11.7 miles of track and are shown in **Figure 1-3**. They largely follow the corridor also served by the DTR. The western terminus of the current Silver Line is Wiehle-Reston East, which is served by a newly expanded Park & Ride center and provides access to Reston Town Center. The Silver Line shares existing Orange and Blue Line tracks from the East Falls Church station in Arlington, Virginia to the Stadium-Armory station in Washington, D.C. From that point, the Silver Line shares the Blue Line tracks to Largo, Maryland.

Phase 2 of the Dulles Corridor Metrorail Project will expand 11.5 miles westward from its current terminus at Wiehle-Reston East and is expected to open for riders by 2020 with the construction of six new metro stations, including a station at IAD. Phase 2 will continue to run within the median of SR 267, with the exception of the IAD station, and will extend to Ashburn, Virginia. All new stations are expected to include dedicated commuter parking, with the exception of the Reston Town Center and IAD stations.

Dulles Corridor Existing Conditions

DTR and Dulles Access Highway

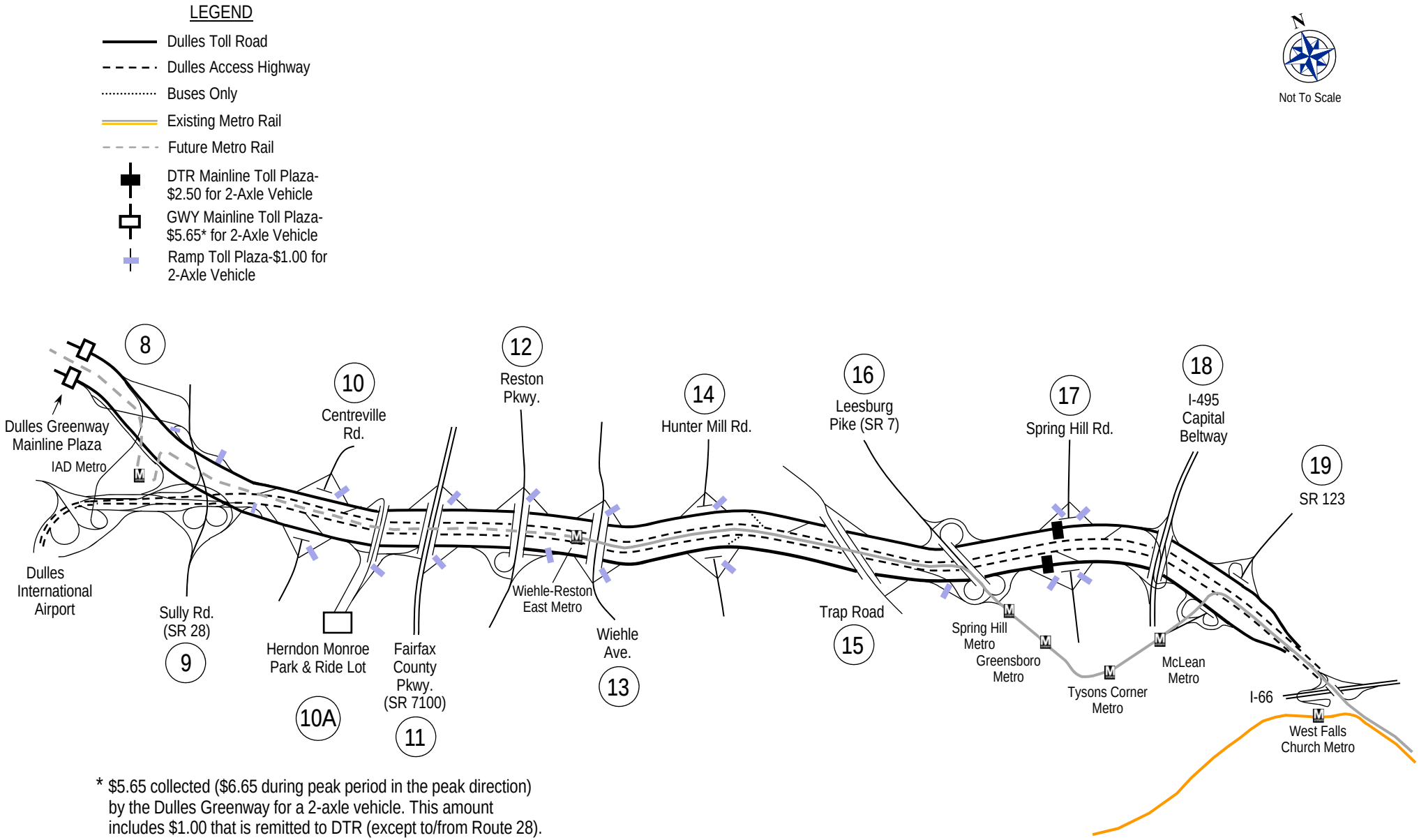
Figure 1-3 is a schematic of the Dulles Access Highway and DTR portions of the roadway, including interchange numbering.

The Access Highway is a 16.2-mile roadway that begins at I-66 and ends at IAD. Airport users may travel on this roadway at no cost. It consists of two lanes in each direction along its entire length.

The DTR is a 13.4-mile tolled roadway from the Capital Beltway to SR 28 built in the outer portions of the Access Highway right-of-way. The DTR lanes are separated from the Access Highway lanes by physical barriers. The DTR is four lanes in each direction along its entire length.

Several ramps allow access between the DTR and the Access Highway for travelers whose origin or destination is IAD. These travelers can travel toll-free to and from the airport by way of the Access Highway. Additionally, there are two barrier-controlled bus-only ramps, one in each direction.

In the westbound direction, ramps lead from the DTR to the Access Highway just west of the Capital Beltway, between Trap Road and Hunter Mill Road, just west of the Monroe Park & Ride lot westbound on-ramp, and west of Centreville Road. The bus-only ramp from the Access Highway to the DTR is located just east of Hunter Mill Road. In the eastbound direction, ramps lead from the Dulles Access Highway to the DTR just east of SR 28, just east of Centreville Road, and just west of Spring Hill Road.



* $5.65 collected ($6.65 during peak period in the peak direction) by the Dulles Greenway for a 2-axle vehicle. This amount includes $1.00 that is remitted to DTR (except to/from Route 28).

FIGURE 1-3: INTERCHANGES ON THE DTR

A ramp also leads from the Access Highway directly to SR 7. The bus-only ramp from the DTR to the Access Highway is located just east of Hunter Mill Road. The Access Highway diverges westbound and merges eastbound with the DTR just east of SR 123. From the merge to I-66, the Access Highway is two lanes in each direction.

During the peak periods, the left-most lane of the DTR west of the mainline toll plaza is reserved for HOV-2+ (two occupants or more) vehicles in the peak direction. The HOV lane is a general-purpose lane at all other times. At the toll plazas, motorists using the HOV lane pay the same toll as all other users of the DTR. However, the advantage for the HOV user is that peak travel speeds can be significantly faster because of peak travel period congestion in the general-purpose lanes. VDOT previously enforced its evening peak HOV restriction between the hours of 4:30 to 6:00 p.m. VDOT has since expanded that period to 4:00 to 6:30 p.m., adding a full hour to the evening peak period. This study assumes that HOV-2+ designation will continue and that all vehicles pay tolls.

The Greenway extends 12.5 miles of tolled roadway, continuing as SR 267 from the end of the DTR near SR 28 until it intersects with US 15/SR 7 in Leesburg. This roadway is owned and operated by a private corporation, Toll Road Investors Partnership II, and is three lanes in each direction.

DTR Toll Rates

In general, the DTR tolling plan consists of ramp toll collection to and from the east and mainline toll collection at the east end of the facility. Exceptions occur at the Spring Hill interchange where tolls are collected on ramps to and from the west and at the eastbound exit at SR 7. These exceptions ensure that toll revenue is collected from all through-traffic at the eastern end of the DTR facility and that the DTR mainline toll plaza cannot be easily evaded.

Figure 1-4 shows toll plaza locations on the DTR, the current toll rates in effect since January 2014, and previous toll rate changes that took effect in January 2013 and January 2012. In general, motorists traveling eastbound on the DTR will pay to enter the system, while motorists traveling westbound will pay to exit the system. For a 2-axle vehicle, the ramp tolls are currently $1.00 at each location, while at the mainline toll plaza, located between Leesburg Pike and Spring Hill Road, the toll for a 2-axle vehicle is $2.50 in each direction. There are eastbound exit tolls at two locations, Leesburg Pike and Spring Hill Road, and there is a westbound entrance toll at Spring Hill Road. These tolls are $1.00 for a 2-axle vehicle.

The schedule for multi-axle vehicles is also shown in Figure 1-4. A 3-axle vehicle pays double the amount of a 2-axle toll rate at all locations. Vehicles with additional axles pay an additional $1.25 per axle at the mainline toll plaza and $0.50 per axle at ramp toll plazas. The maximum toll (for a vehicle with six or more axles) is $8.75 at the mainline toll plaza and $3.50 at ramp toll plazas. The DTR is largely a commuter facility with relatively few multi-axle vehicles—less than 2.0 percent in transactions.

At the western end of the DTR, the Greenway has a mainline toll plaza that collects a toll in each direction of either $5.65 (base toll) or $6.65 (congestion management toll-eastbound from 6:30-9:00 a.m. and westbound from 4:00-6:30 p.m.) for a 2-axle vehicle coming from or going to the DTR. In addition to this amount collected, $1.00 is collected and remitted to the DTR as toll revenue. For vehicles with more than two axles, the appropriate multi-axle toll is collected by the Greenway and remitted to the DTR. The amount collected for the DTR by the Greenway at the Greenway mainline toll plaza is based on the prevailing DTR ramp toll schedule. The Greenway portion is determined by the

LEGEND

- Dulles Toll Road
- Dulles Access Highway
- Buses Only
- Mainline Toll Plaza-$2.50 for 2-Axle Vehicle
- Ramp Toll Plaza-$1.00 for 2-Axle Vehicle

2012 DTR Toll Rates

	Ramp Toll	Mainline Toll
2-axle vehicle	$0.75	$1.50
3-axle vehicle	$1.00	$1.75
4-axle vehicle	$1.25	$2.00
5-axle vehicle	$1.50	$2.25
6 or more axles	$1.75	$2.50

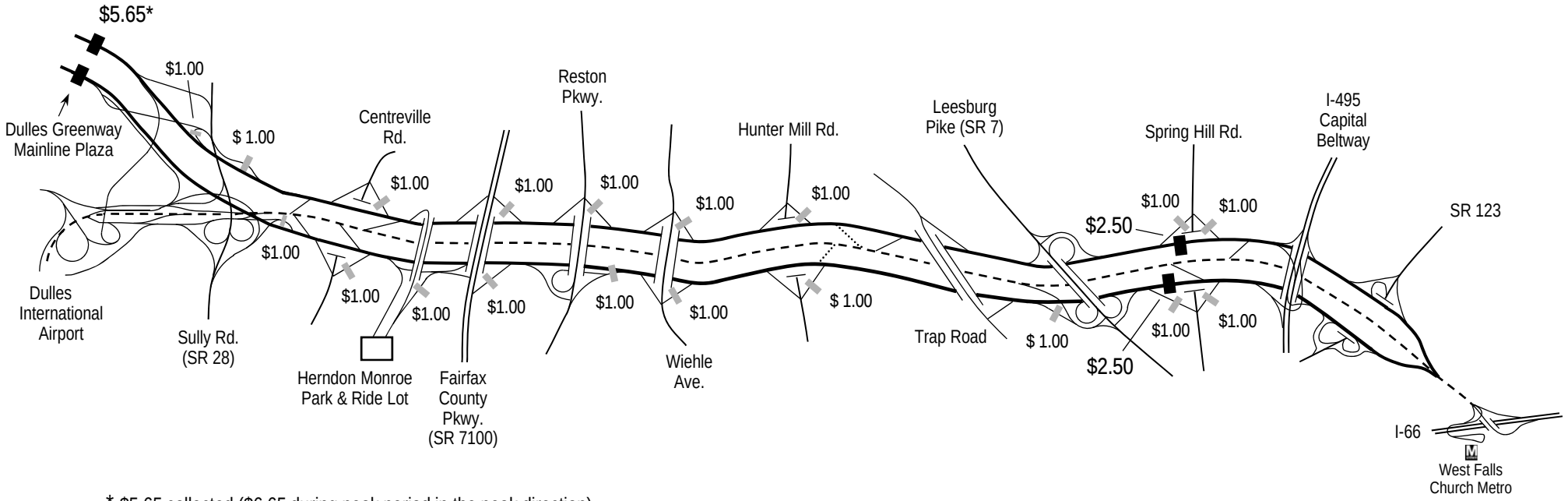
2013 DTR Toll Rates

	Ramp Toll	Mainline Toll
2-axle vehicle	$1.00	$1.75
3-axle vehicle	$2.00	$3.50
4-axle vehicle	$2.50	$4.50
5-axle vehicle	$3.00	$5.25
6 or more axles	$3.50	$6.25

2017 DTR Toll Rates

	Ramp Toll	Mainline Toll
2-axle vehicle	$1.00	$2.50
3-axle vehicle	$2.00	$5.00
4-axle vehicle	$2.50	$6.25
5-axle vehicle	$3.00	$7.50
6 or more axles	$3.50	$8.75

Not To Scale



* $5.65 collected ($6.65 during peak period in the peak direction) by the Dulles Greenway for a 2-axle vehicle. This amount includes $1.00 that is remitted to DTR (except to/from Route 28).

FIGURE 1-4: TOLL PLAZA LOCATIONS AND TOLL RATES ON THE DTR

Toll Road Investors Partnership II (TRIP II), the operator of the Greenway, and regulated by the Virginia State Corporation Commission (SCC).

Figure 1-5 shows the configuration and identification number of each DTR toll plaza, including a growing number of dedicated E-ZPass lanes. It should be noted that currently there is no differential toll rate for E-ZPass. Attended lanes at ramp toll plazas are not staffed between 9:30 p.m. and 5:30 a.m., requiring exact change during overnight hours. The Airports Authority completed its effort to convert 19 exact change lanes to E-ZPass only lanes in 2015. Currently, toll plazas exist at 19 ramps, as well as one bidirectional mainline and include 29 E-ZPass only lanes, 25 attended booths, and five unattended lanes.

As set forth in the DTR Permit and Operating Agreement between VDOT and the Airports Authority, the Airports Authority has the exclusive right to establish, charge, and collect tolls and other fees for the use of the DTR. Prior to establishing toll rates, the Airports Authority follows its regulatory process, which includes:

- Convening public hearings in the Dulles Corridor
- Reporting back to the Board of Directors on views collected during public hearings

The Airports Authority also consults with the Dulles Corridor Advisory Committee (DCAC) in accordance with the DTR Permit and Operating Agreement.

Dulles Greenway

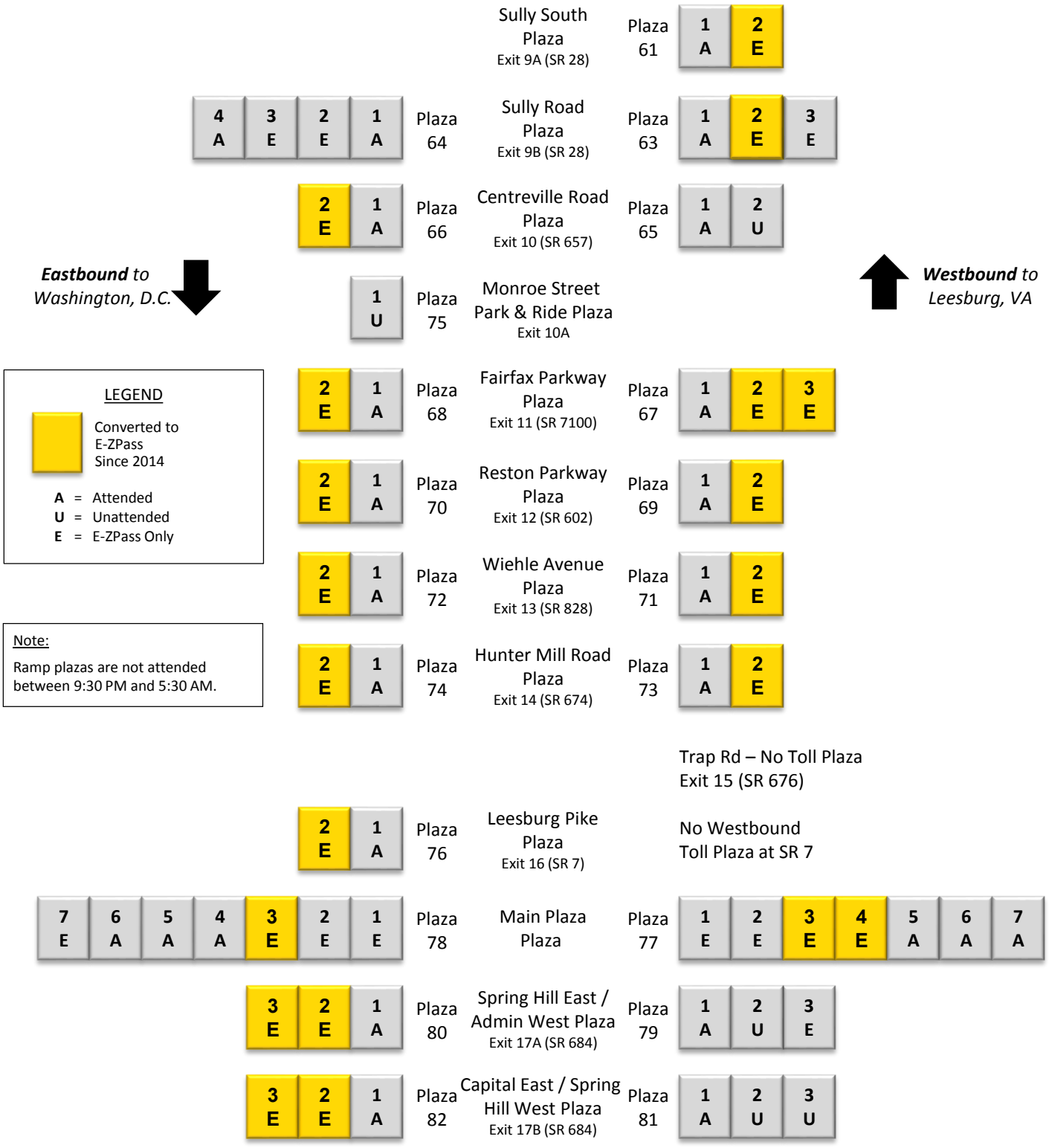
The Greenway connects with the DTR at the Greenway mainline toll plaza. In the westbound direction, the direct-access ramp from SR 28 northbound and IAD to the Greenway merge together before the mainline toll plaza and become the first westbound on-ramp. There are on-and off-ramps from and to SR 606, SR 607, SR 772, SR 901, SR 659, SR 653, and Battlefield Parkway. Completing the SR 267 corridor to Leesburg, the Greenway connects with US 15/SR 7 at the west end with an off-ramp to the north and a flyover direct connection to the south.

In the eastbound direction, the Greenway starts at the on-ramps from US 15/ SR 7. There are on-and off-ramps from and to Battlefield Parkway, SR 653, SR 659, SR 901, SR 772, SR 607, and SR 606. At the east end, the Greenway connects with the DTR at the mainline toll plaza. There are separate direct-access ramps from the Greenway to SR 28 south and to IAD.

Dulles Greenway Toll Rates

The Greenway opened to traffic on September 29, 1995, with a base toll of $1.75 for 2-axle vehicles and $3.50 for all other vehicles. **Figure 1-6** shows toll plaza locations on the Greenway and the current toll rates, which have been in effect since January 2018. The following list includes important dates in the roadway's cost structure made since opening (all toll amounts exclude the DTR portion):

- Effective September 13, 1999, the first E-ZPass discount was implemented on the roadway. A new tariff relationship between automobiles and trucks was implemented on October 1, 2007. Based on the new toll mechanism, 3-axle vehicles pay a multiplier of two times that of the 2-axle vehicle base toll, 4-axle vehicles pay 2.5 times, 5-axle vehicles pay 3.0 times, and 6-or-more-axle vehicles pay 3.5 times.
- A congestion management toll rate was first introduced on January 1, 2009. An additional $0.60 peak period, peak direction surcharge for 2-axle vehicles was implemented and was applied to trucks proportionally. This rate was increased to $1.00 in 2018.



19 Ramps, 29 E-ZPass Only, 25 Attended, 5 Unattended

Source: MWAA Operations (valid since March 28, 2018).

FIGURE 1-5: DTR TOLL COLLECTION LAYOUT

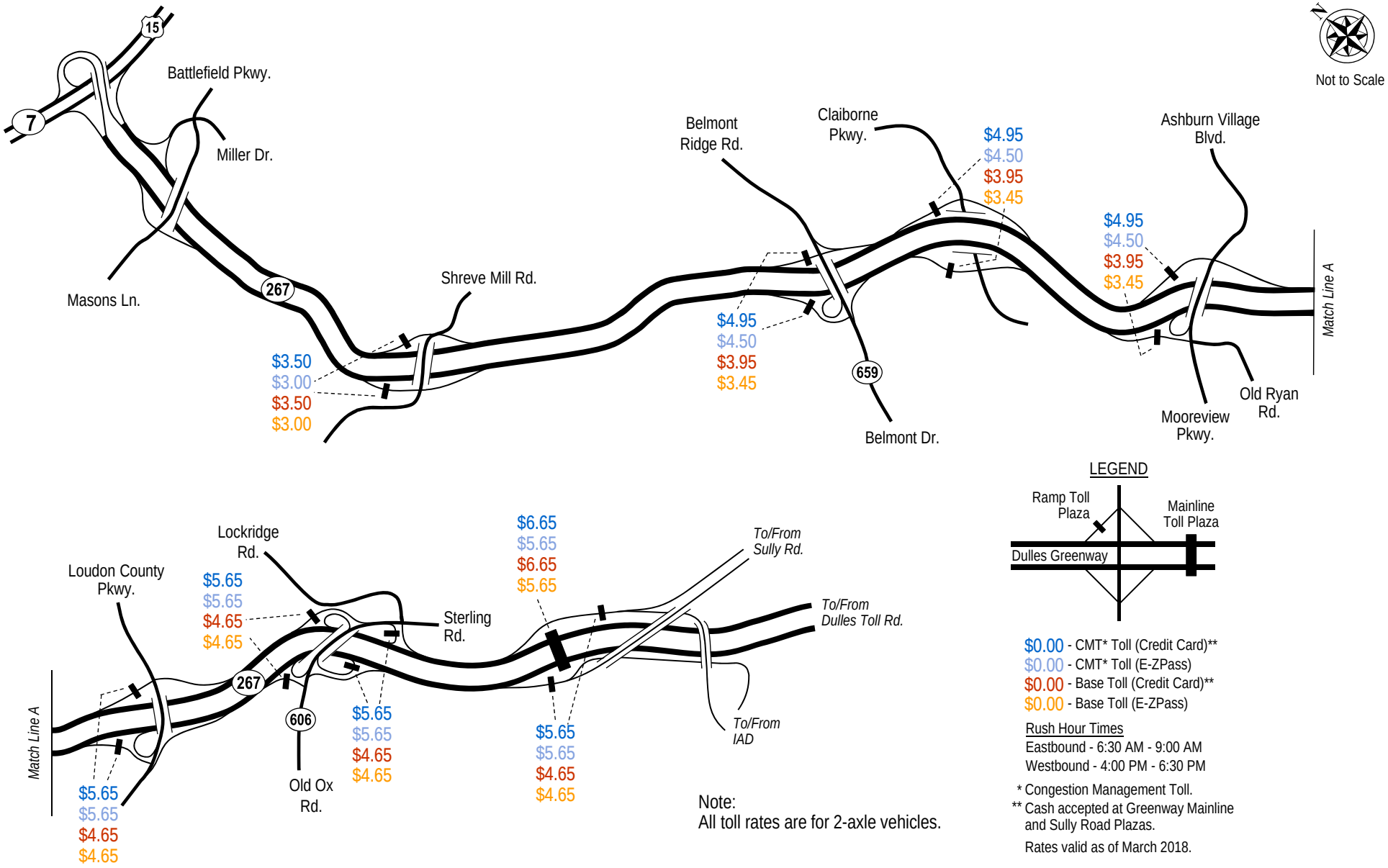


FIGURE 1-6: TOLL PLAZA LOCATIONS AND TOLL RATES ON DULLES GREENWAY

Under Virginia state law, the private operator of the Greenway is authorized to increase toll rates each year through 2020 by a percentage that is equal to the greater of the increase in the consumer price index plus 1.0 percent, real gross domestic product (GDP) growth, or 2.8 percent. An additional toll increase can be imposed to offset certain property tax increases. Annual toll increases in recent years have averaged approximately 3.0 percent.

495 Express Lanes

At the eastern end of the DTR, in the median of the I-495 Capital Beltway, motorists can access the 495 Express Lanes, a 14-mile facility with two HOT lanes in each direction that have end points just north of the DTR and west of the I-495 Springfield Interchange with I-95. The toll rate for the 495 Express Lanes is dynamically priced to manage traffic. Since opening in November 2012, demand and toll rates have simultaneously continued on an upward trend. For the quarter ending September 30, 2018, the average toll paid was $5.35.

66 Express Lanes - Inside the Beltway

In December 2017, I-66 east of I-495 (Inside the Beltway) to US 29 in Rosslyn (approximately 9 miles) was converted from an HOV2+ operation during peak direction/hours to allow single-occupancy vehicles access to the roadway by paying a toll that varies based on traffic volumes and travel times. As part of the transition, the HOV-restricted hours were extended by 90 minutes in the morning and evening, which means single-occupant vehicles are tolled on weekdays from 5:30 a.m. to 9:30 a.m. eastbound and 3:00 p.m. to 7:00 p.m. westbound. The lanes remain open to all users during off-peak periods and weekends.

Vehicles with two or more occupants (HOV2+) and vanpools can travel for free if they have an E-ZPass Flex transponder switched to HOV-mode. Buses, motorcycles and emergency response vehicles also travel for free. The I-66 Express Lanes will switch to HOV3+ when the I-66 Outside the Beltway Express Lanes open in mid-2022, matching the current HOV rules on I-495 and I-95 Express Lanes.

Single-occupant vehicles traveling to and from Dulles International Airport and those with a Clean Special Fuel License Plate are no longer permitted to use the I-66 HOV lanes during peak periods without paying applicable tolls.

66 Express Lanes - Outside the Beltway

I-66 continues as a free route outside the Beltway to I-81 in the Shenandoah Valley region of northwestern Virginia. One HOV-2 lane per direction is currently operational from Haymarket to I-495 in the eastbound travel direction from 5:30 a.m. to 9:30 a.m. and in the westbound travel direction from 3:00 p.m. to 7:00 p.m. Additionally, shoulder lanes are open for additional use eastbound from 5:30 a.m. to 11:00 a.m. and westbound from 2:00 p.m. to 8:00 p.m. HOV lanes act as general purpose travel lanes outside these restricted hours, while the shoulder lanes are fully closed to vehicular travel outside the noted hours of operation. Construction is underway to convert the HOV lanes to HOT lanes and add one additional high-occupancy travel lane per direction by August 2022. Final project designs present three general purpose lanes, two HOT-3+ lanes, plus a 14-foot shoulder per direction, with additional auxiliary lanes where needed.

Scope of Study

CDM Smith obtained and reviewed the latest Metropolitan Washington Council of Governments (MWCOG) travel demand model to create its modified study area model. In addition, the latest underlying socioeconomic forecasts for the Dulles corridor and the entire MWCOG model region were obtained, reviewed, and compared with multiple other forecasts from official and independent sources to refine the model.

During the fall of 2017, CDM Smith conducted a comprehensive data collection program, which focused on evaluating baseline operating conditions in the DTR corridor. This included an extensive traffic count program, as well as obtaining three years' worth of INRIX[1] speed data throughout the Dulles corridor. A series of surveys was undertaken to assess travel patterns, motorist characteristics and estimated values of time in the DTR corridor. Two surveys were performed: (1) a survey of cash customers on the system; and (2) a survey of E-ZPass customers who recently used the DTR. A full description of the surveys and their results is provided in **Chapter 3** of this report. The traffic model was updated to reflect the input of travel patterns, trip characteristics and values of times of DTR customers. The project configuration was coded, and the model was calibrated to more reasonably represent observed traffic volumes and speeds throughout the Dulles corridor for the model base year of 2017.

To bring these efforts more up to date, historical traffic trends were reviewed and current information on the latest Transportation Improvement Program (TIP) and Constrained Long Range Plan (CLRP) in the Washington Metropolitan region were obtained from MWCOG and reviewed.

Finally, detailed highway networks were prepared for the base model year 2017 and for future years 2020, 2025, 2030, 2035, and 2040. The future-year networks reflect changes envisioned by the TIP and the Constrained Long-Range Plan (CLRP), which contains projects that are expected to be constructed or implemented in the region, though subject to financial constraints. The projects identified either improve access to the DTR or improve alternate routes. Documentation of the type, scope and timing of these projects is provided in **Chapter 5**.

CDM Smith's traffic model assignments reflect tolls charged on the DTR by using proprietary toll diversion algorithms. As toll rates are adjusted, toll roads become more or less desirable relative to free roads. The extent to which one type of road is chosen over another is the subject of the toll diversion analysis. The toll algorithms used in this analysis have been applied successfully to a wide range of toll road projects—from new construction to existing facilities. The projections made using this approach have been accepted by toll road agencies and funding authorities throughout the United States and around the world.

After re-basing T&R to actual annual 2017 levels and by making the appropriate traffic model assignments in selected future years, likely volumes in intermediate years were estimated through interpolation. Multiplying volumes at plazas by tolls collected at each plaza yields the revenue at each location. The sum of all those revenue estimates is the basis for the annual toll revenue estimates for the DTR.

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[1] INRIX uses data collected from GPS devices, smartphones, cameras, and other devices to collect travel time information. INRIX data is collected on a 'roadway link' basis, with each link defined by entry/exit ramps and roadway intersections

Renaissance Planning Group (RPG), a firm that specializes in transportation, land use and urban planning, completed an independent evaluation of socioeconomic forecasts for the DTR corridor in October 2017. CDM Smith utilized revised population and employment forecasts provided by RPG to develop new travel demand forecasts from the MWCOG regional model.

For this update, a future-year toll rate schedule was tested based on assumptions provided by the financial advisors to the Airports Authority. Near-term projections take account of actual year-to-date T&R and a growth profile reflecting economic recovery. Beyond 2040, annual T&R is estimated using nominal assumed rates, traffic growth, and estimated toll diversion in the project corridor.

Order of Presentation

Following this introductory chapter, a summary of existing traffic and operating conditions in the DTR corridor is presented in **Chapter 2**, with T&R trends updated through CY 2017.

Chapter 3, Travel Patterns and Stated Preference Survey, summarizes the results of both the travel pattern and characteristic surveys conducted for the various recent studies performed for the Airports Authority.

Chapter 4, Corridor Growth Assessment, presents an overview of corridor economic trends and forecasts.

Chapter 5, Estimated Traffic and Toll Revenue, presents the results of the updated weekday and annual traffic and revenue analysis and discreet-year toll sensitivity analysis.

Chapter 6, Sensitivity Tests, presents the measure of sensitivity of annual transactions and revenue to changes in key study assumptions for discreet model years.

There are two appendices providing additional detail on several key aspects of the study:

- **Appendix A** summarizes the stated preference survey experiment design and methodology.
- **Appendix B** is a detailed report prepared by RPG on the economic analysis and socioeconomic forecast adjustments.

Chapter 2

Traffic and Toll Revenue Trends

This chapter presents historical and recent trends in transactions and toll revenue for the Dulles Toll Road (DTR). The statistics are presented on an annual, monthly, and daily historical basis, as provided by VDOT/MWAA through 2017. In addition, CDM Smith used an analysis of the typical daily and hourly traffic variations on the DTR to develop an average weekday travel profile for the base year models.

Annual Transaction and Revenue Trends

Figure 2-1 presents annual transactions and toll revenue trends on the DTR from fiscal year (FY)1985 though FY2017. Traffic and revenue data in this bar graph is presented by FY ending June 30 for compatibility with historical VDOT reporting. For recent years, detailed trends by toll plaza are provided for the period from calendar year (CY) 2009 through 2017 in further tabulations.

Table 2-1 shows annual transaction trends on the DTR by plaza and annual transactions for the entire system from calendar year CY2009 through CY2017. The total transactions include revenue transactions (i.e., each recorded toll payment, whether mainline or ramp), non-revenue transactions (such as police, emergency vehicles, military vehicles, and Airports Authority vehicles), and system-wide violations (i.e., each transaction where the full toll amount was not collected at the time of the transaction, whether due to avoidance or electronic misreading or otherwise, and where the amount was subsequently collected).

As evident from Table 2-1, the mainline toll plaza processes the most transactions in the system, approximately 35.2 percent of total revenue transactions in 2017. Total annual transactions have generally declined in recent years, predominantly due to toll increases and prevailing economic and financial conditions, leveling out at around 93 to 94 million transactions since 2014. The compound annual growth rate in transactions at the mainline toll plaza decreased by only 2.2 percent from 2009 to 2017, a period that saw the mainline toll rate increase from $0.75 to $2.50. Transactions at the Greenway toll plaza rose at an average rate of 0.3 percent per year from 2009 to 2017, the only location where transactions increased in this time frame, despite several toll rate increases.

The ramp toll plazas seeing the largest percent decline in transactions since the last toll rate increase in 2014 have been Centerville Road and Reston Parkway, with losses of 2.5 and 1.9 percent, respectively. This decline in transactions may be partially attributed to construction on both roadways near the Dulles Toll Road.

Violations and non-revenue transactions have changed by 6.5 percent and negative 1.8 percent annually since 2013, when data became available. Violations and non-revenue transactions represented 3.2 percent and 0.8 percent of total transactions in 2017, respectively.

Monthly Transaction and Revenue Trends

This section provides detailed trends in transactions and toll revenue by month by individual toll plaza. **Tables 2-2 and 2-3** present monthly transactions and toll revenue trends on the DTR from

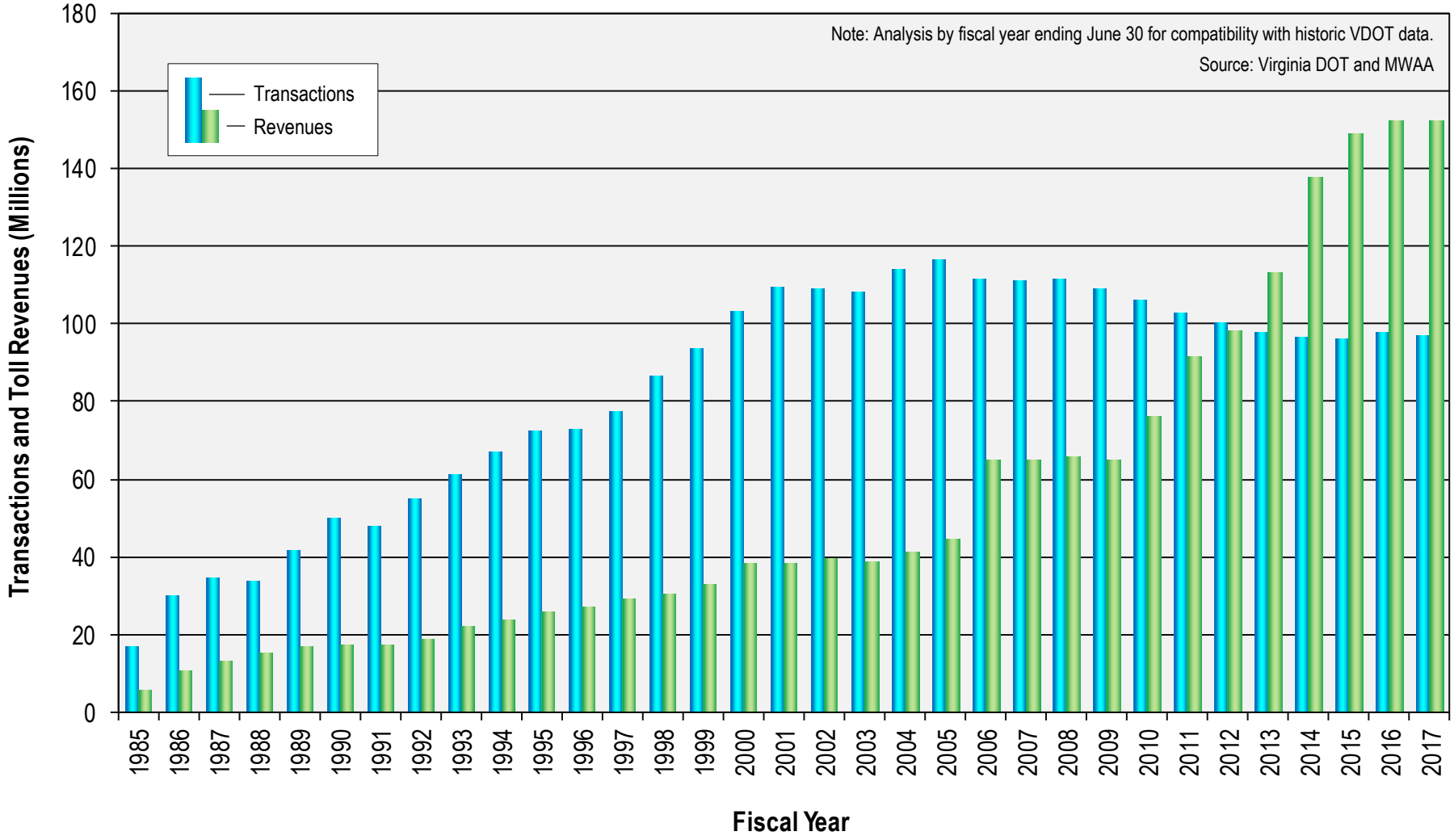


FIGURE 2-1: DTR TRANSACTIONS AND REVENUES FY 1985 - FY 2017

Table 2-1
Total Annual Transactions by Plaza, CY2009-CY2017
(in thousands)[1]

PLAZA	CY 2009	Change CY09-10	CY 2010	Change CY10-11	CY 2011	Change CY11-12	CY 2012[2]	Change CY12-13	CY 2013[2]	Change CY13-14	CY 2014[2]	Change CY14-15	CY 2015[2]	Change CY15-16	CY 2016[2]	Change CY16-17	CY 2017[2]	2009-2017[3] CAGR
Sully Rd	17,632	-1.6%	17,353	0.3%	17,402	-0.8%	17,269	-1.1%	17,077	-0.6%	16,977	3.4%	17,554	-4.0%	16,858	2.2%	17,230	-0.3%
Centreville Rd	7,524	-5.8%	7,087	-4.3%	6,782	-2.8%	6,593	-4.1%	6,320	-2.4%	6,167	0.6%	6,203	-2.8%	6,032	-5.2%	5,717	-3.4%
Fairfax Pkwy	6,975	-7.0%	6,489	-3.7%	6,251	-5.6%	5,899	0.2%	5,910	-2.0%	5,791	0.3%	5,806	-1.7%	5,708	-1.5%	5,624	-2.7%
Reston Pkwy	7,524	-5.9%	7,080	-3.6%	6,826	-1.6%	6,719	-4.5%	6,418	-2.8%	6,241	-1.6%	6,139	-0.9%	6,085	-3.1%	5,894	-3.0%
Wiehle Ave	4,182	-8.2%	3,838	-3.6%	3,701	-2.8%	3,597	-3.7%	3,462	-7.3%	3,209	-0.8%	3,184	-0.3%	3,175	-2.4%	3,101	-3.7%
Hunter Mill Rd	3,536	-6.9%	3,292	-6.1%	3,091	-4.4%	2,953	-2.5%	2,878	-5.1%	2,730	-0.7%	2,710	1.4%	2,748	-0.6%	2,731	-3.2%
Route 7, East	2,515	-10.9%	2,241	-4.1%	2,149	-3.6%	2,072	-6.7%	1,933	16.7%	2,257	0.8%	2,276	-2.3%	2,224	0.0%	2,223	-1.5%
Mainline	39,268	-4.0%	37,687	-4.9%	35,839	-2.3%	35,023	-0.6%	34,808	-5.9%	32,768	0.3%	32,877	0.5%	33,039	-0.6%	32,846	-2.2%
Spring Hill Rd	4,167	-1.0%	4,123	5.9%	4,367	-3.8%	4,200	-2.9%	4,079	-3.2%	3,951	1.5%	4,010	-0.8%	3,979	-1.9%	3,904	-0.8%
Capital Beltway	2,660	-9.2%	2,415	-3.3%	2,336	-6.6%	2,182	-6.7%	2,037	8.1%	2,201	5.0%	2,311	0.0%	2,312	-4.8%	2,200	-2.3%
Greenway[4]	11,473	-4.4%	10,965	-3.0%	10,633	1.5%	10,789	0.6%	10,848	2.3%	11,100	4.9%	11,645	2.7%	11,954	-1.9%	11,729	0.3%
Revenue Transactions	**107,457**	-4.5%	**102,571**	-3.1%	**99,376**	-2.0%	**97,417**	-1.5%	**95,939**	-2.5%	**93,549**	1.4%	**94,890**	-0.7%	**94,200**	-1.0%	**93,227**	-1.8%
Violations	-	-	-	-	-	-	-	-	1,888	15.2%	2,175	21.5%	2,644	6.8%	2,822	10.9%	3,129	-
Non-revenue	-	-	-	-	-	-	-	-	849	-7.8%	783	-9.7%	707	0.3%	709	3.5%	734	-
Violations & Non-revenue[5]	**1,261**	67.7%	**2,115**	2.1%	**2,159**	14.6%	**2,474**	10.6%	**2,737**	8.1%	**2,958**	13.3%	**3,351**	5.4%	**3,531**	9.4%	**3,863**	15.0%
Total Transactions	**108,718**	-3.7%	**104,686**	-3.0%	**101,535**	-1.6%	**99,891**	-1.2%	**98,676**	-2.2%	**96,507**	1.8%	**98,240**	-0.5%	**97,731**	-0.7%	**97,090**	-1.4%

Source: VDOT/MWAA reports through December 2017

[1] Violations not specified by plaza.

[2] Totals for CY 2012 and onward include transactions from Monroe Park & Ride.

[3] "CAGR" denotes compound annual growth rate.

[4] Violations and Non-revenue for the Greenway plaza included from 2010. This data for the Greenway plaza was not available prior to MWAA transfer from VDOT.

[5] Breakdown between Violations and Non-revenue not available prior to 2013.

Note: Toll rates adjusted in January 2010, January 2011, January 2012, January 2013, and January 2014.

Table 2-2
Monthly Transactions, CY2009-CY2017

	CY2009	% Change	CY2010	% Change	CY2011	% Change	CY2012	% Change	CY2013	% Change	CY2014	% Change	CY2015	% Change	CY2016	% Change	CY2017
January	8,412,824	-1.4%	8,299,024	-5.7%	7,824,547	2.5%	8,022,521	-1.3%	7,919,077	-4.9%	7,533,849	-1.5%	7,421,306	-8.3%	6,801,818	13.5%	7,720,943
February	8,366,392	-20.4%	6,657,821	16.6%	7,764,687	1.6%	7,889,749	-6.1%	7,409,382	-6.9%	6,897,287	0.8%	6,949,367	9.3%	7,597,218	-2.6%	7,397,887
March	9,234,614	1.2%	9,349,797	-3.5%	9,018,150	-3.7%	8,687,041	-8.1%	7,979,292	-2.1%	7,813,556	3.2%	8,067,467	5.9%	8,546,164	-1.7%	8,402,723
April	9,283,838	-0.9%	9,199,462	-7.8%	8,483,334	-3.6%	8,181,616	5.1%	8,596,720	-2.7%	8,366,358	2.0%	8,531,503	-1.8%	8,376,903	-4.6%	7,991,692
May	9,306,946	-2.1%	9,115,093	-3.1%	8,835,657	-1.3%	8,717,049	0.7%	8,773,942	-1.1%	8,677,032	-0.5%	8,630,483	-1.7%	8,486,112	1.5%	8,614,230
June	9,579,031	-2.0%	9,389,948	-4.7%	8,949,690	-2.5%	8,726,637	-3.9%	8,388,250	1.0%	8,475,065	3.4%	8,763,974	0.0%	8,761,470	-1.7%	8,608,525
July	9,462,994	-4.8%	9,011,255	-7.1%	8,375,850	0.5%	8,418,491	0.2%	8,437,968	-0.1%	8,425,436	2.3%	8,622,889	-5.4%	8,156,218	-2.8%	7,930,833
August	9,255,019	-2.6%	9,016,174	-3.7%	8,681,495	0.2%	8,700,231	-1.7%	8,550,839	-5.6%	8,074,295	3.4%	8,348,215	1.9%	8,502,760	-0.9%	8,427,385
September	9,126,570	-4.1%	8,748,923	-3.1%	8,476,912	-4.3%	8,113,485	2.2%	8,293,200	-1.4%	8,175,388	1.7%	8,316,546	-1.8%	8,166,102	-1.3%	8,063,784
October	9,524,392	-4.0%	9,140,399	-4.5%	8,724,624	-3.4%	8,428,482	3.4%	8,713,861	-0.5%	8,670,164	-0.1%	8,660,062	-0.9%	8,584,122	-0.2%	8,564,148
November	8,666,127	-2.8%	8,420,491	-3.0%	8,169,587	-0.1%	8,161,592	-2.7%	7,944,233	-5.5%	7,504,223	4.0%	7,806,575	1.1%	7,889,319	0.0%	7,888,215
December	8,499,460	-1.9%	8,337,797	-1.3%	8,230,422	-4.7%	7,844,178	-2.2%	7,669,453	2.9%	7,894,372	2.9%	8,122,250	-3.2%	7,862,834	-4.9%	7,479,566
Total	**108,718,207**	-3.7%	**104,686,184**	-3.0%	**101,534,955**	-1.6%	**99,891,072**	-1.2%	**98,676,217**	-2.2%	**96,507,025**	1.8%	**98,240,637**	-0.5%	**97,731,040**	-0.7%	**97,089,931**

Notes:
1) Toll rates were adjusted in January 2010, January 2011, January 2012, January 2013, and January 2014.
2) Transactions include violations and non-revenue transactions such as police, emergency vehicles, military vehicles, etc.
Source: VDOT/MWAA

Table 2-3
Monthly Toll Revenues, CY2009-CY2017

	CY2009	% Change	CY2010	% Change	CY2011	% Change	CY2012	% Change	CY2013	% Change	CY2014	% Change	CY2015	% Change	CY2016	% Change	CY2017
January	$5,026,089	38.1%	$6,943,140	4.5%	$7,252,137	12.8%	$8,178,917	22.9%	$ 10,053,324	15.7%	$ 11,628,573	-2.1%	$ 11,389,551	-7.4%	$ 10,543,515	14.1%	$ 12,029,155
February	4,967,856	11.3%	5,527,103	30.4%	7,207,088	11.8%	8,054,220	17.3%	9,443,886	12.8%	10,649,396	-0.1%	10,642,237	10.0%	11,704,668	-1.5%	11,530,241
March	5,478,538	44.7%	7,926,739	5.4%	8,357,690	5.5%	8,819,788	15.7%	10,204,385	17.8%	12,024,127	2.7%	12,344,215	6.7%	13,167,526	-3.3%	12,738,684
April	5,522,113	40.5%	7,758,413	1.8%	7,899,087	6.3%	8,398,229	29.0%	10,830,020	18.9%	12,881,743	1.6%	13,092,256	-1.5%	12,896,331	-1.2%	12,741,647
May	5,535,196	38.8%	7,682,533	7.0%	8,222,220	8.2%	8,900,082	28.2%	11,411,164	16.5%	13,288,581	0.3%	13,324,202	-1.6%	13,116,779	1.8%	13,351,053
June	5,703,716	38.2%	7,881,709	6.5%	8,395,804	5.8%	8,884,182	21.4%	10,787,616	22.1%	13,173,845	2.0%	13,442,996	0.1%	13,454,426	-0.3%	13,420,335
July	5,604,933	35.2%	7,576,203	4.2%	7,897,235	8.6%	8,579,991	26.1%	10,820,010	20.1%	12,991,259	2.3%	13,284,638	-4.3%	12,716,315	-1.7%	12,500,195
August	5,530,327	37.7%	7,615,869	6.5%	8,107,776	8.8%	8,824,605	25.9%	11,114,413	12.9%	12,548,064	3.5%	12,991,819	1.8%	13,221,979	0.2%	13,249,423
September	5,449,731	35.3%	7,374,258	7.4%	7,918,571	4.3%	8,255,318	30.6%	10,778,250	18.5%	12,777,532	1.1%	12,918,314	-1.0%	12,794,683	-0.6%	12,713,053
October	5,675,149	35.2%	7,673,235	6.2%	8,145,202	5.0%	8,549,445	34.6%	11,503,339	14.1%	13,127,022	1.9%	13,374,739	1.4%	13,558,343	-0.6%	13,481,517
November	5,161,461	39.3%	7,191,951	6.6%	7,665,907	7.4%	8,235,967	25.5%	10,339,310	11.5%	11,523,551	5.1%	12,114,303	1.8%	12,336,830	1.0%	12,456,183
December	5,050,039	36.4%	6,887,014	10.2%	7,590,822	4.3%	7,915,344	23.5%	9,774,125	23.2%	12,039,048	3.9%	12,512,489	-2.3%	12,219,638	-3.3%	11,811,178
Total	$64,705,148	36.1%	$88,038,167	7.5%	$94,659,539	7.3%	$101,596,089	25.1%	$ 127,059,842	17.0%	148,652,741	1.9%	151,431,759	0.2%	151,731,033	0.2%	152,022,664

Notes:
Toll rates were adjusted in January 2010, January 2011, January 2012, January 2013, and January 2014.
Source: VDOT/MWAA

CY2009 through CY2017. The total transaction data includes non-revenue transactions and violations.

Variations in Transactions

Mainline toll rates on the DTR increased $0.25 per year each year from CY2010 to CY2013, with ramp tolls also increasing $0.25 in CY2010 and CY2013 only. Mainline toll rates were raised by $0.75 in 2014, leading to the present-day toll rates of $2.50 at the mainline, and $1.00 for all ramp toll plazas. In conjunction with numerous adverse weather impacts, primarily during the winter months, total transactions declined every year in which a toll increase was instituted. Transaction declines were most pronounced in CY2010 and CY2014, when two of the largest toll increases were enforced, realizing a negative 3.7 percent and negative 2.2 percent, respectively.

With the first non-toll increase year since 2009, 2015 brought a 1.8 percent increase in annual transactions over the previous year. Especially harsh winter weather in January of 2015 attributed to a 1.5 percent decrease in transactions compared to January 2014, with May and October being the only other months seeing a decrease in transactions over 2014. August and November saw the largest increase in transactions at 3.4 percent and 4.0 percent, respectively.

2016 and 2017 both saw decreases in total transactions by less than 1 percent over their previous respective years. Adverse weather conditions in January 2016 accounted for the 8.3 percent decline in that month in 2016 and the 13.5 percent growth in 2017, while a leap year in February of 2016 is attributed to the 9.3 percent growth in 2016 and the 2.6 percent decline in 2017. Additional winter weather in March 2017 contributed to the 1.7 percent drop in transactions over 2016.

Variations in Revenue

Table 2-3 shows monthly DTR toll revenue since CY2009. Toll rates on the DTR were increased in every year from 2010 to 2014, with 2015 being the first year without a toll increase since 2009. These toll increases are reflected in consistent revenue increases over these years; revenue continues to increase at a lower rate as toll rates have been stable since 2014.

The mainline and ramp plaza toll rate adjustments beginning January 1, 2010 had significant positive impacts. January 2010 experienced a 38.1 percent increase in revenue compared to January 2009. Overall, CY2010 had a 36.1 percent increase in collected toll revenue, reaching a high of $88.0 million compared to $64.7 million in CY2009.

At the mainline toll plaza, the $0.25 toll rate adjustment of January 1, 2011 resulted in a 7.5 percent increase in toll revenue to $94.7 million. Although the winter months were affected by adverse weather conditions, monthly revenue was typically higher by 5.4 percent to 7.4 percent each month.

A further $0.25 toll rate adjustment to the mainline toll plaza became effective on January 1, 2012. For the month, this resulted in $8.2 million of toll revenue, 12.8 percent higher than revenue collected in January 2011. The month of February 2012 was also up 11.8 percent from February 2011. The rest of the months of CY2012 experienced an increase in toll revenue in the range of 4.3 percent to 8.8 percent when compared to respective months in CY2011. An annual total of $101.6 million in toll revenue was collected in 2012, resulting in a 7.3 percent increase from CY2011 toll revenue.

Toll increases in January 2013 at the mainline and ramp toll plazas yielded a significant increase in revenue very similar to the revenue realization that took place in 2010. January 2013 experienced a 22.9 percent increase in revenue compared to January 2012. Overall, CY2013 experienced a 25.1

percent increase in toll revenue, reaching $127.1 million, as compared to $101.6 million in the prior year.

The last toll increase occurred in January 2014. An increase of $0.75 at the mainline toll plaza attributed to a 15.7 percent increase over January 2013 and an overall increase of 17.0 percent over all of 2013, with total revenue reaching upward of $148 million.

In the first year without a toll increase since 2009, revenues in January and February of 2015 decreased over 2014, but showed an increase during the remaining months, adding up to an overall 1.9 percent increase over 2014.

While 2016 and 2017 both showed a slight decrease in overall transactions, a constant 0.2 percent growth in revenue was realized in both years. This disparity is possible because of plaza toll rate differentials and the addition of violation revenue.

Monthly Transaction Variations

Table 2-4 provides average daily total transactions on the DTR for each month for the period CY2011 through CY2017. To highlight the relatively small variation in monthly transactions throughout each year, an index has been calculated for each month.

This index is created by taking the average daily transactions for the month, dividing by the average daily transactions for the year, and multiplying by 100. This produces an index of 100 for any month that equals the annual average number of transactions. Months with an index greater than 100 have more than the annual average number of transactions, and months with an index less than 100 have less than the annual average number of transactions. The index provides the relative size of the demand for the month, in comparison to other months for the period CY2011 through CY2017.

As can be noted from Table 2-4, although there has been an overall decrease in average daily transactions throughout the period shown, only slight average daily variations have been observed in each month. Because of adverse weather conditions, November to February typically have index values lower than 100. March through October generally have average daily traffic at or above the annual daily average resulting in index values over 100.

A few exceptions have been observed (e.g. August 2014, July 2016, etc.), where average daily traffic has been observed below the year's average daily levels; this can occur in years when these months have one less weekday in that year as compared to other years.

Table 2-4
Monthly Variations in Average Daily Total Transactions, CY2011 - CY2017

Month	CY2011	*Index*	CY2012	*Index*	CY2013	*Index*	CY2014	*Index*	CY2015	*Index*	CY2016	*Index*	CY2017	*Index*
January	252,405	*90.7*	258,791	*94.8*	255,454	*94.5*	243,027	*91.9*	239,397	*88.9*	219,413	*82.2*	249,063	*93.6*
February	277,310	*99.7*	272,060	*99.7*	264,621	*97.9*	246,332	*93.2*	248,192	*92.2*	261,973	*98.1*	264,210	*99.3*
March	290,908	*104.6*	280,227	*102.7*	257,397	*95.2*	252,050	*95.3*	260,241	*96.7*	275,683	*103.2*	271,056	*101.9*
April	282,778	*101.7*	272,721	*99.9*	286,557	*106.0*	278,879	*105.5*	284,383	*105.7*	279,230	*104.6*	266,390	*100.1*
May	285,021	*102.5*	281,195	*103.0*	283,030	*104.7*	279,904	*105.9*	278,403	*103.4*	273,746	*102.5*	277,878	*104.5*
June	298,323	*107.2*	290,888	*106.6*	279,608	*103.4*	282,502	*106.8*	292,132	*108.5*	292,049	*109.4*	286,951	*107.9*
July	270,189	*97.1*	271,564	*99.5*	272,193	*100.7*	271,788	*102.8*	278,158	*103.3*	263,104	*98.5*	255,833	*96.2*
August	280,048	*100.7*	280,653	*102.8*	275,834	*102.0*	260,461	*98.5*	269,297	*100.1*	274,283	*102.7*	271,851	*102.2*
September	282,564	*101.6*	270,450	*99.1*	276,440	*102.3*	272,513	*103.1*	277,218	*103.0*	272,203	*101.9*	268,793	*101.0*
October	281,439	*101.2*	271,887	*99.6*	281,092	*104.0*	279,683	*105.8*	279,357	*103.8*	276,907	*103.7*	276,263	*103.9*
November	272,320	*97.9*	272,053	*99.7*	264,808	*98.0*	250,141	*94.6*	260,219	*96.7*	262,977	*98.5*	262,941	*98.8*
December	265,497	*95.4*	253,038	*92.7*	247,402	*91.5*	254,657	*96.3*	262,008	*97.3*	253,640	*95.0*	241,276	*90.7*
CY Average	278,178	-	272,926	-	270,346	-	264,403	-	269,152	-	267,025	-	266,000	-

Note: Total transactions include violations and non-revenue transactions.
Source: VDOT/MWAA, December 2017

Daily Traffic Trends

Table 2-5 provides average daily total transactions on the DTR for each day of the week for the period CY2011 through CY2017. The index value is calculated in a similar manner described in the section above for monthly variations. Average daily transactions by day of the week were compared against the average daily transactions of each entire year. As can be noted from Table 2-5, three mid-weekdays—Tuesday, Wednesday, and Thursday—usually experience the maximum average daily traffic.

Over the years, an overall decrease has been observed in average daily traffic, however index values across any day have kept relatively constant. Mondays tend to be the lowest weekday and maintain an index value in the range of 103.9 to 107.7, whereas Fridays are slightly higher between 111.1 and 115.3. Index values for Saturdays are typically around 70.0, whereas Sundays are usually lowest, with index values in the 57.2 to 58.3 range. Graphically, **Figure 2-2** presents these index values on a bar chart.

Table 2-5
Total Transactions by Day of Week[(1)], CY2011 - CY2017

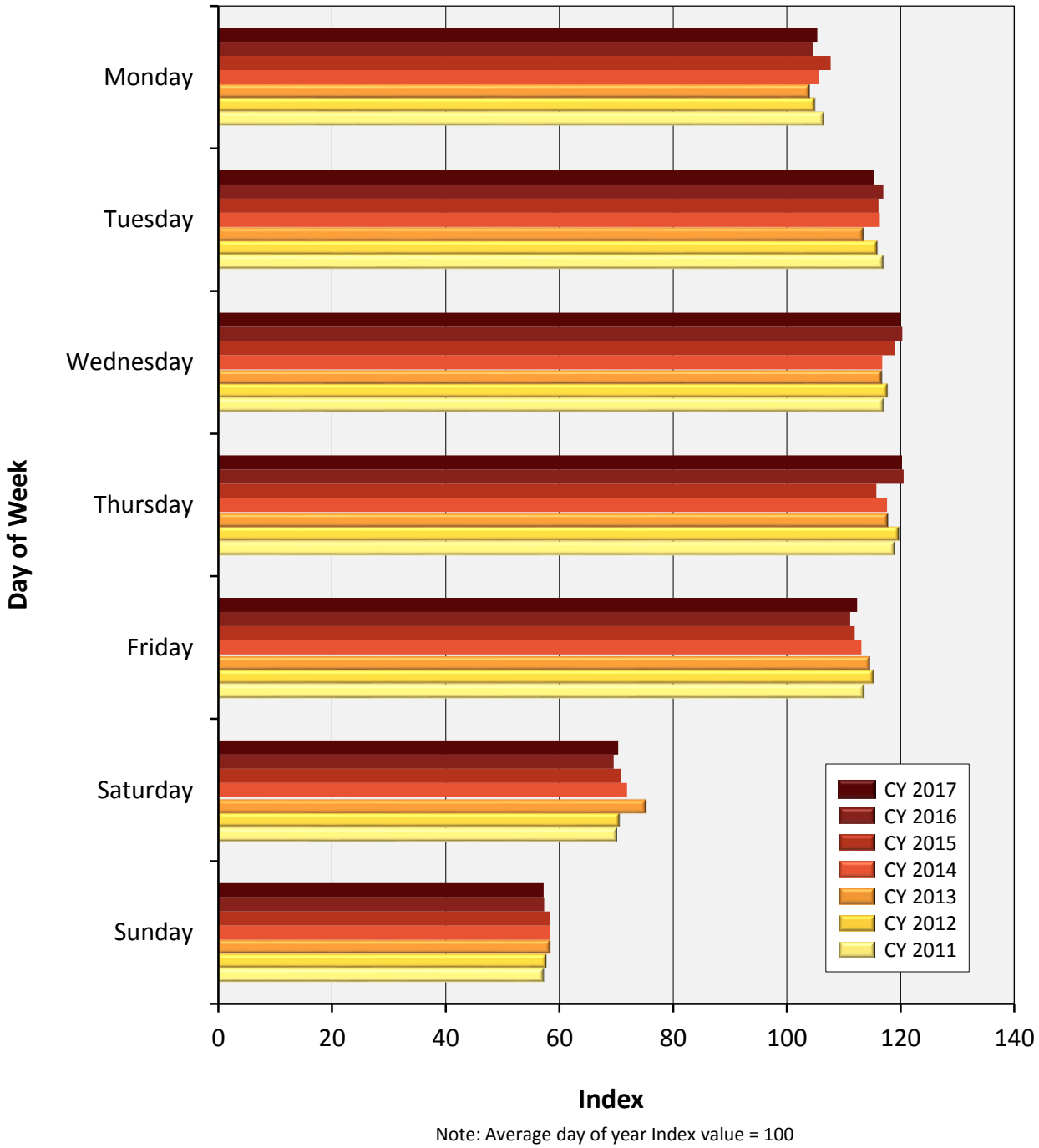
Day	CY2011	Index	CY2012	Index	CY2013	Index	CY2014	Index	CY2015	Index	CY2016	Index	CY2017	Index
Monday	296,329	*106.5*	284,055	*104.3*	281,041	*103.9*	279,200	*105.6*	289,835	*107.7*	279,190	*104.6*	280,290	*105.4*
Tuesday	325,396	*117.0*	315,722	*115.9*	306,959	*113.4*	307,661	*116.4*	312,551	*116.1*	312,307	*117.0*	306,716	*115.3*
Wednesday	325,470	*117.0*	320,829	*117.8*	315,810	*116.7*	308,775	*116.8*	320,469	*119.1*	321,241	*120.3*	319,275	*120.0*
Thursday	330,887	*119.0*	326,232	*119.8*	318,800	*117.8*	310,941	*117.6*	311,513	*115.7*	321,917	*120.6*	319,838	*120.2*
Friday	315,895	*113.6*	314,007	*115.3*	310,060	*114.6*	299,109	*113.1*	301,300	*111.9*	296,738	*111.1*	298,854	*112.4*
Saturday	195,300	*70.2*	191,886	*70.4*	203,072	*75.0*	190,031	*71.9*	190,599	*70.8*	185,694	*69.5*	187,044	*70.3*
Sunday	159,407	*57.3*	155,951	*57.3*	157,666	*58.3*	154,248	*58.3*	156,986	*58.3*	153,082	*57.3*	152,175	*57.2*
CY Average	278,178		272,926		270,346		264,403		269,152		267,025		266,000	

Source: MWAA daily transaction reports
[(1)]Includes violations and non-revenue transactions.
Note: Toll rates were adjusted January 2014.

Development of DTR Average Weekday Traffic Profile

CDM Smith undertook an extensive traffic count program in late 2017. These traffic counts were conducted to assist in the development of traffic profiles for the DTR and surrounding roadways.

CDM Smith partnered with MCV Associates Inc. (MCV) to conduct a 48-hour traffic count at most non-tolled ramps and one bi-directional mainline location along the DTR. **Figure 2-3** presents the locations where this 48-hour traffic data collection effort was carried out, by MCV, on October 11th and 12th and October 24th and 25th, 2017 with one additional count collected on November 8th and 9th, 2017. MCV collected this information using road tubes on all ramp locations and a "microwave radar unit" for the mainline locations. These radar units were set on existing poles along the toll road. As can be seen from the DTR schematics displayed in Figure 2-3, traffic data was collected at a total of 26 locations, including one bi-directional mainline location, all slip-ramps in and out of the Dulles Access Highway, and most ramps on the DTR interchanges. Ramps that were not recounted in 2017 were estimated from previously collected counts. This detailed information was used to develop a balanced traffic profile. Following this field effort, CDM Smith processed the 48-hour traffic count data to establish Average Annual Weekday Traffic (AAWDT) volumes, for use in base-year model calibration. CDM Smith also obtained hourly transactions from the DTR for all toll plazas on the system for a similar time frame in October 2017. This data was used in conjunction with 2017 annual total transactions to grow individual plaza data to an annualized average basis. **Figure 2-4** presents the



Note: Average day of year Index value = 100

FIGURE 2-2: DAILY VARIATION IN TOTAL DTR TRANSACTIONS CY2011 TO CY2017

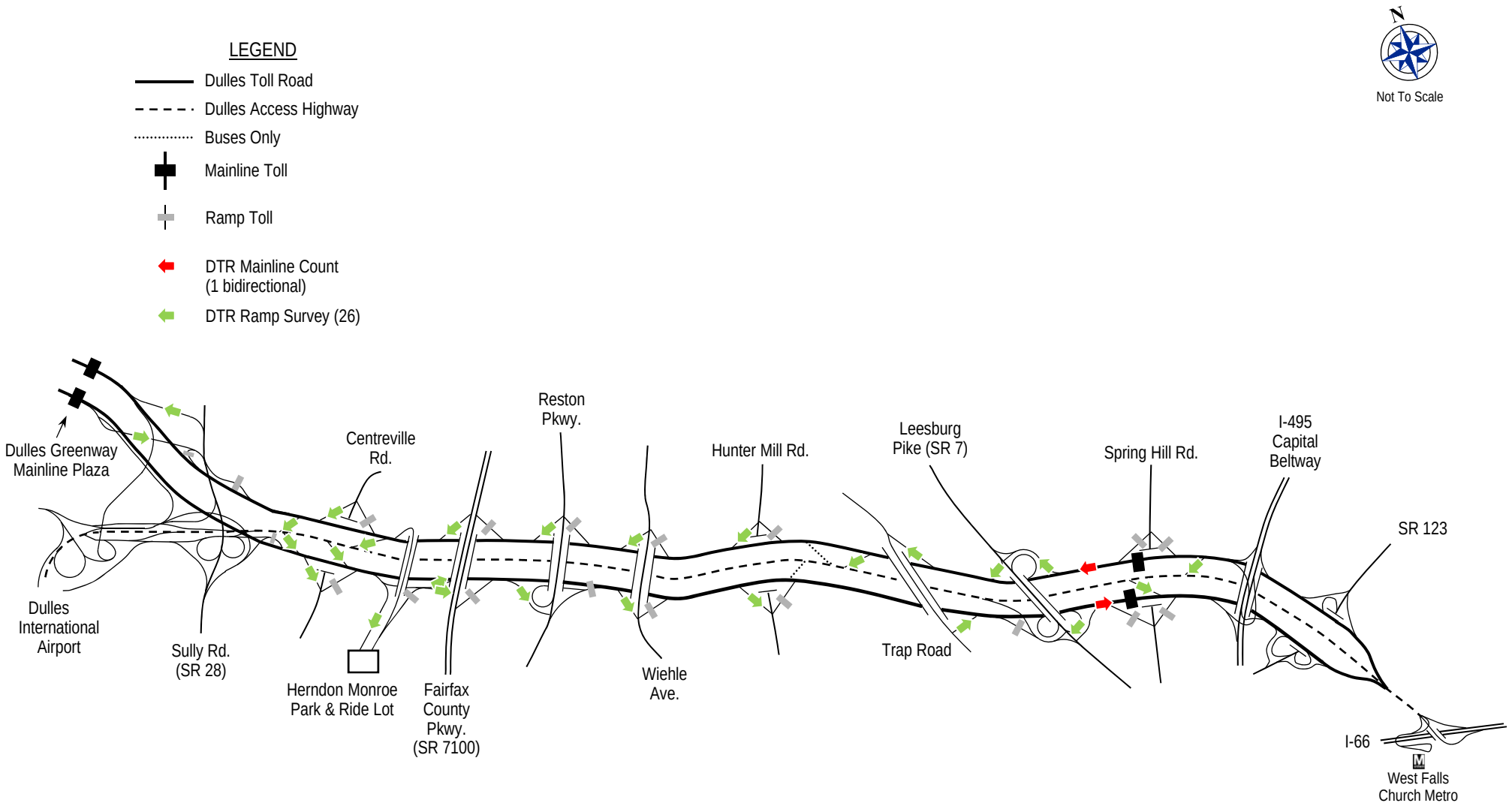


FIGURE 2-3: DTR 48 HOUR TRAFFIC COUNT DATA COLLECTION LOCATION MAP

resulting estimated daily traffic profile on a DTR schematic. Further utilization of this profile, along with other information, will be discussed in the model calibration section of **Chapter 5** in this report.

Hourly Traffic Variation

Figure 2-5 displays directional hourly traffic profiles on the DTR mainline toll plaza in the westbound and eastbound directions for an average weekday in 2017. Traffic on the DTR follows a typical double-peaking pattern with two distinct peaks in each travel direction. The eastbound travel direction experiences highest traffic in the AM peak, while the westbound travel direction sees its highest traffic during the PM peak period. This pattern coincides with the DTR's geographic location with respect to employment centers in the region, with many commuters using the facility to travel to and from work daily. **Figure 2-6** displays directional hourly profiles at all ramp locations.

Trends in ETC Utilization

DTR is part of the E-ZPass Interagency Group (IAG). The E-ZPass IAG began with only seven member toll agencies in three states in 1993 and has since grown to 29 toll agencies in 16 states with more than 35 million devices in circulation.

Table 2-6 presents a summary of total toll revenue collected by payment type for CY1998 through CY2017. Although no discount is given to electronic toll collection (ETC) transactions on the DTR, the percentage of revenue collected via E-ZPass increased from 32.6 percent in 1998 to 87.9 percent in 2017 and continues to increase annually. In CY2013, a total of $22.7 million in cash was collected, compared to over $100 million in E-ZPass payments, resulting in an ETC percentage of over 80 percent for the first time in the system's history. In CY2016, a total of $19.5 million in cash was collected, compared to $148.4 million in E-ZPass payments, resulting in an 85.9 percent penetration rate. This rate had climbed to 87.9 percent by the close of 2017.

Table 2-7 shows the number of total transactions at DTR plazas during CY2016 and CY2017. For each plaza, revenue transactions are shown by payment type (cash or E-ZPass). Violations and non-revenue transactions are also shown. Cash payment continues to decline and E-ZPass has increased to 83.4 percent on a transactional basis.

Traffic Volumes on Competing and Ancillary Routes

To prepare for base year model calibration, CDM Smith constructed daily traffic corridor screenlines as shown in **Figure 2-7**. These counts were obtained from VDOT, with additional counts collected by MCV associates. By utilizing screenlines in the calibration process, CDM Smith was able to accurately represent the traffic share along roadways running parallel to the DTR and also on perpendicular feeder routes that carry traffic to and from the roadway. Parallel routes of interest included: Sunrise Valley Drive, Sunset Hills Road, SR 7, US Route 50, US Route 29 and I-66, while notable feeder routes included any roadway that provided ramp access to the DTR or the Greenway.

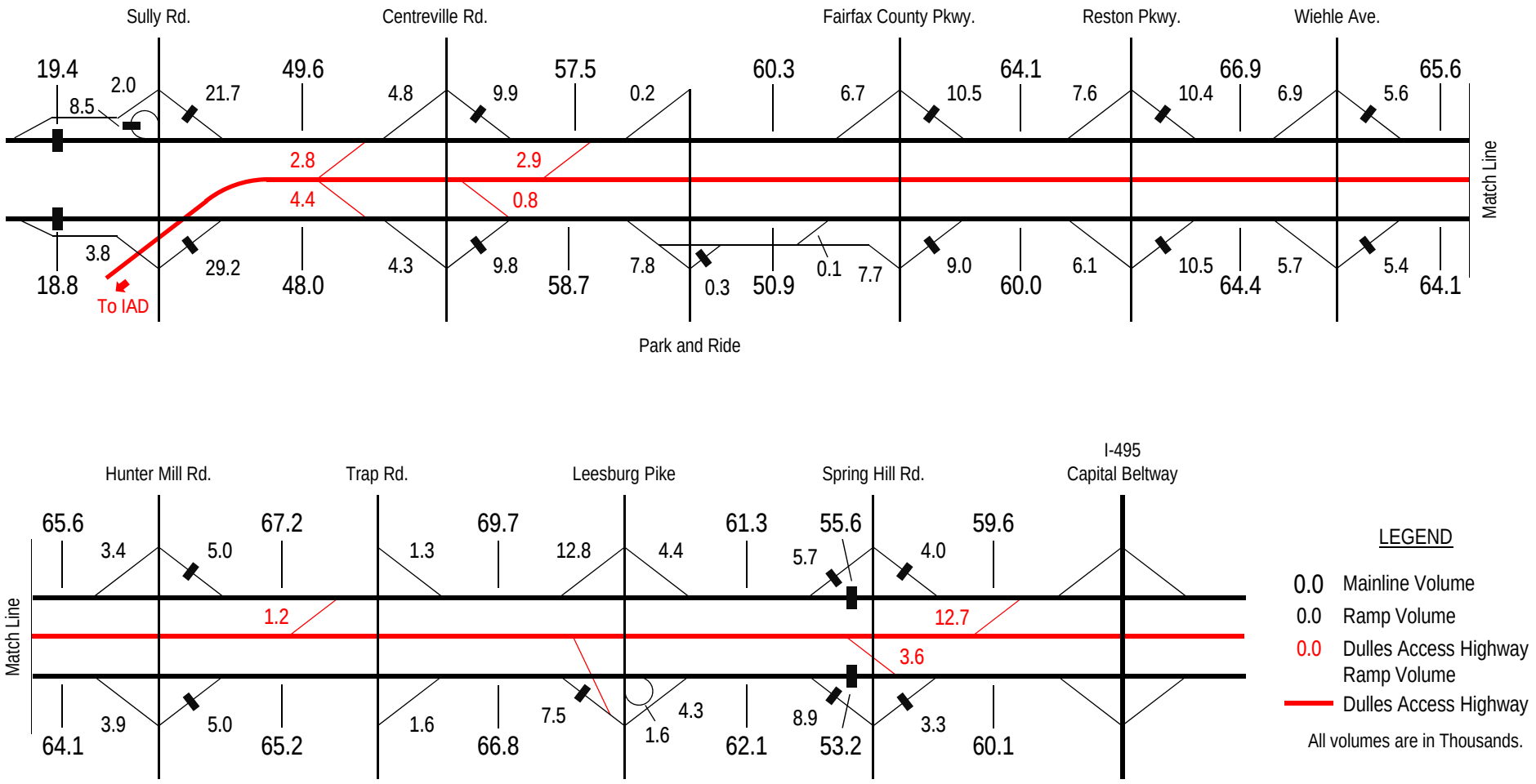


FIGURE 2-4: DTR 2017 WEEKDAY TRAFFIC PROFILE

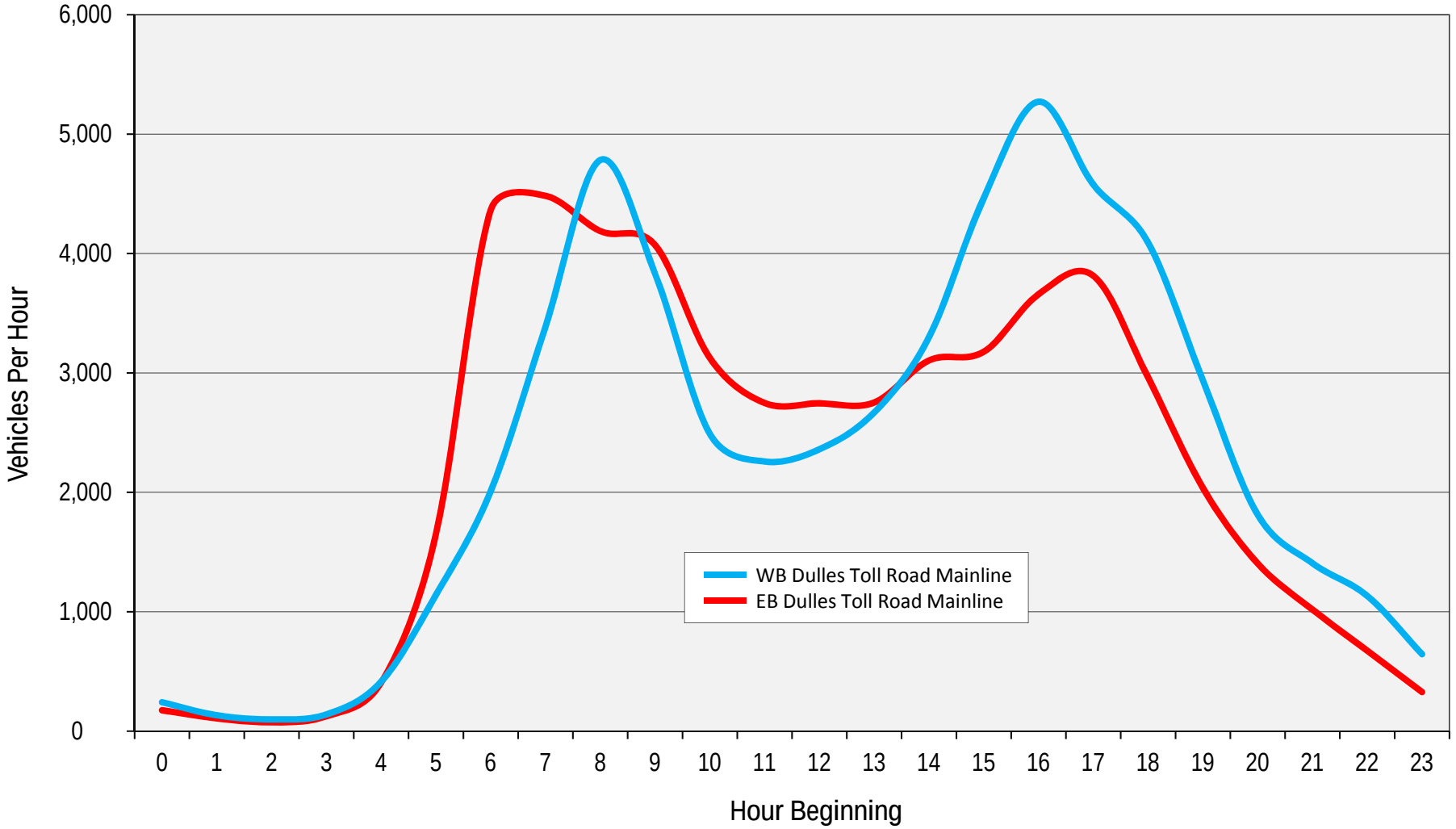
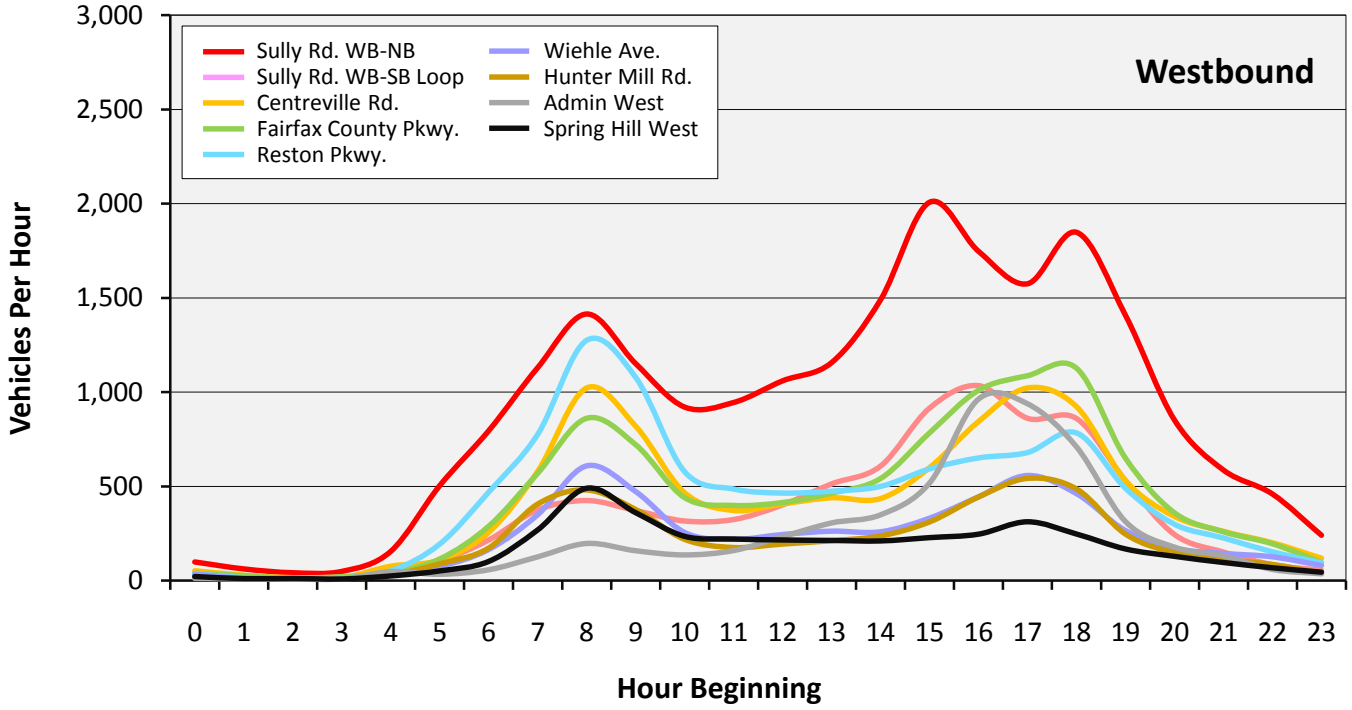


FIGURE 2-5: 2017 DTR AVERAGE ANNUAL WEEKDAY MAINLINE TOLL PLAZA HOURLY TRAFFIC VARIATIONS



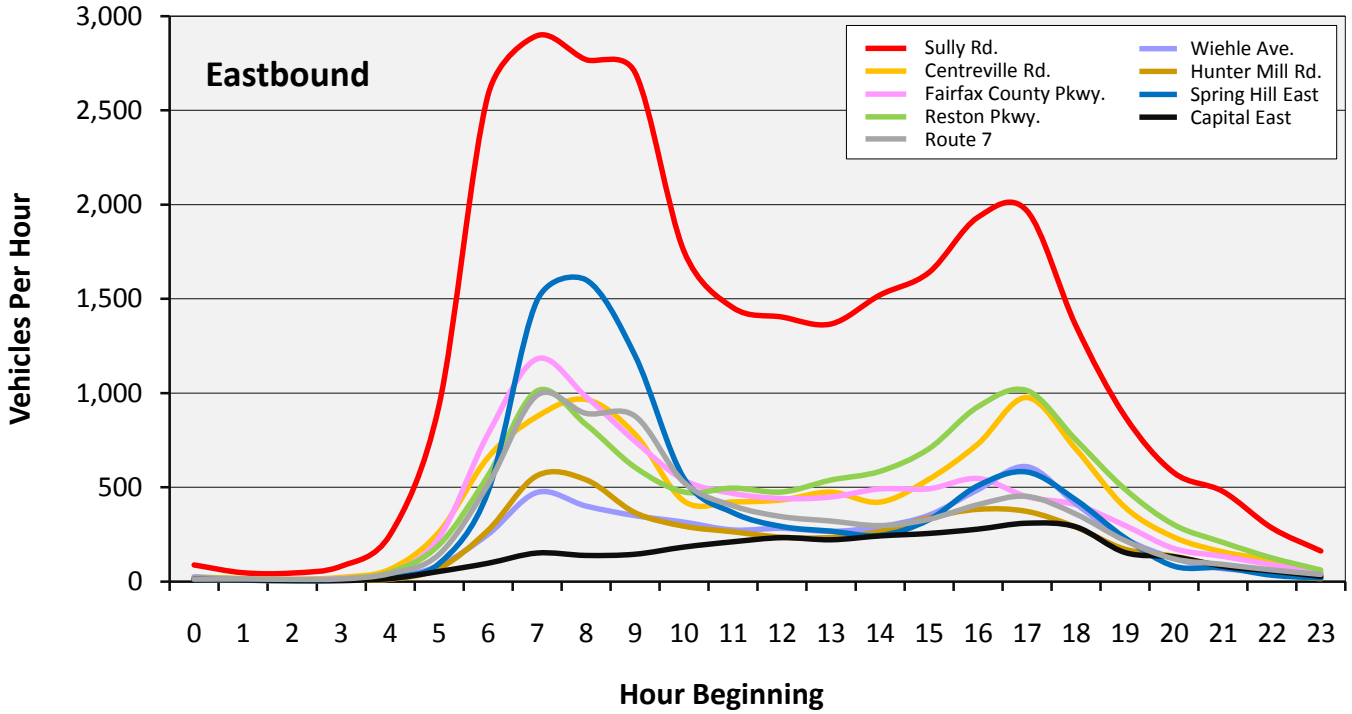


FIGURE 2-6: DTR RAMP PLAZAS HOURLY TRAFFIC VIOLATIONS

Table 2-6
Total Annual Toll Revenue by Payment Type, CY1998-CY2017

Calendar Year	Cash	E-ZPass	Total Toll Revenue	Percent E-ZPass
1998	$19,797,437	$9,573,897	$29,371,334	32.6%
1999	19,214,273	12,525,594	31,739,868	39.5%
2000	19,317,961	15,131,175	34,449,136	43.9%
2001	18,275,695	16,838,929	35,114,624	48.0%
2002	17,291,901	17,569,887	34,861,789	50.4%
2003	17,143,613	18,140,117	35,283,730	51.4%
2004	18,630,558	23,315,063	41,945,621	55.6%
2005	21,110,421	34,963,825	56,074,246	62.4%
2006	22,371,086	42,809,087	65,180,173	65.7%
2007	21,401,305	44,225,461	65,626,766	67.4%
2008	20,370,348	45,263,742	65,634,091	69.0%
2009	19,137,161	45,567,986	64,705,148	70.4%
2010	23,696,499	63,615,790	87,312,289	72.9%
2011	22,893,363	70,634,024	93,527,387	75.5%
2012	21,892,706	78,613,469	100,506,175	78.2%
2013	22,735,433	102,478,080	125,213,513	81.8%
2014	22,818,644	123,537,397	146,356,041	84.4%
2015	21,014,376	127,562,089	148,576,465	85.9%
2016	19,504,355	128,853,734	148,358,089	86.9%
2017	17,913,374	130,081,276	147,994,650	87.9%

Source: VDOT/MWAA, December 2017, excludes recovered violation revenues
Note: Toll rates adjusted in May 2005, Jan 2010, Jan 2011, Jan 2012, Jan 2013, and Jan 2014.

Table 2-7
Transactions[1] by Plaza and Payment Type

	CY2016					CY2017				
Plaza	Cash	E-ZPass	Violations	Non-Rev	Total	Cash	E-ZPass	Violations	Non-Rev	Total
Sully Rd	2,394,462	14,464,026	564,543	116,584	17,539,615	2,230,384	14,999,200	635,914	124,117	17,989,615
Centreville Rd	1,123,011	4,908,540	189,963	41,716	6,263,230	996,863	4,720,083	201,918	48,222	5,967,086
Monroe Park & Ride	6,969	78,247	12,903	66,481	164,600	4,877	23,797	11,025	68,690	108,389
Fairfax Pkwy	623,860	5,084,407	220,023	92,906	6,021,196	564,688	5,059,765	221,765	92,282	5,938,500
Reston Pkwy	755,059	5,330,007	194,410	42,769	6,322,245	675,099	5,219,064	218,590	44,402	6,157,155
Wiehle Ave	404,914	2,770,346	109,874	21,232	3,306,366	374,991	2,725,547	120,771	22,163	3,243,472
Hunter Mill Rd	237,386	2,510,902	74,972	15,813	2,839,073	214,019	2,516,593	84,947	17,088	2,832,647
Route 7, East	414,510	1,809,003	65,568	8,466	2,297,547	379,680	1,843,234	61,206	8,814	2,292,934
Main Line	4,324,245	28,714,423	1,078,719	85,802	34,203,189	4,003,321	28,842,456	1,217,683	95,843	34,159,303
Spring Hill Rd	413,845	3,565,523	110,815	54,772	4,144,955	356,922	3,547,402	122,366	52,663	4,079,353
Capital Beltway	572,753	1,739,040	124,135	19,280	2,455,208	476,951	1,723,205	144,616	20,364	2,365,136
Greenway	1,584,648	10,369,546	76,403	143,335	12,173,932	1,485,017	10,244,156	88,292	139,103	11,956,568
Total	**12,855,662**	**81,344,010**	**2,822,328**	**709,156**	**97,731,156**	**11,762,812**	**81,464,502**	**3,129,093**	**733,751**	**97,090,158**
% of total payments	13.2%	83.2%	2.9%	0.7%		12.0%	83.4%	3.2%	0.8%	

Source: MWAA Monthly T&R Reports through December 2017
[1]Includes unaudited figures.
Note: Toll rates adjusted in Jan 2014.

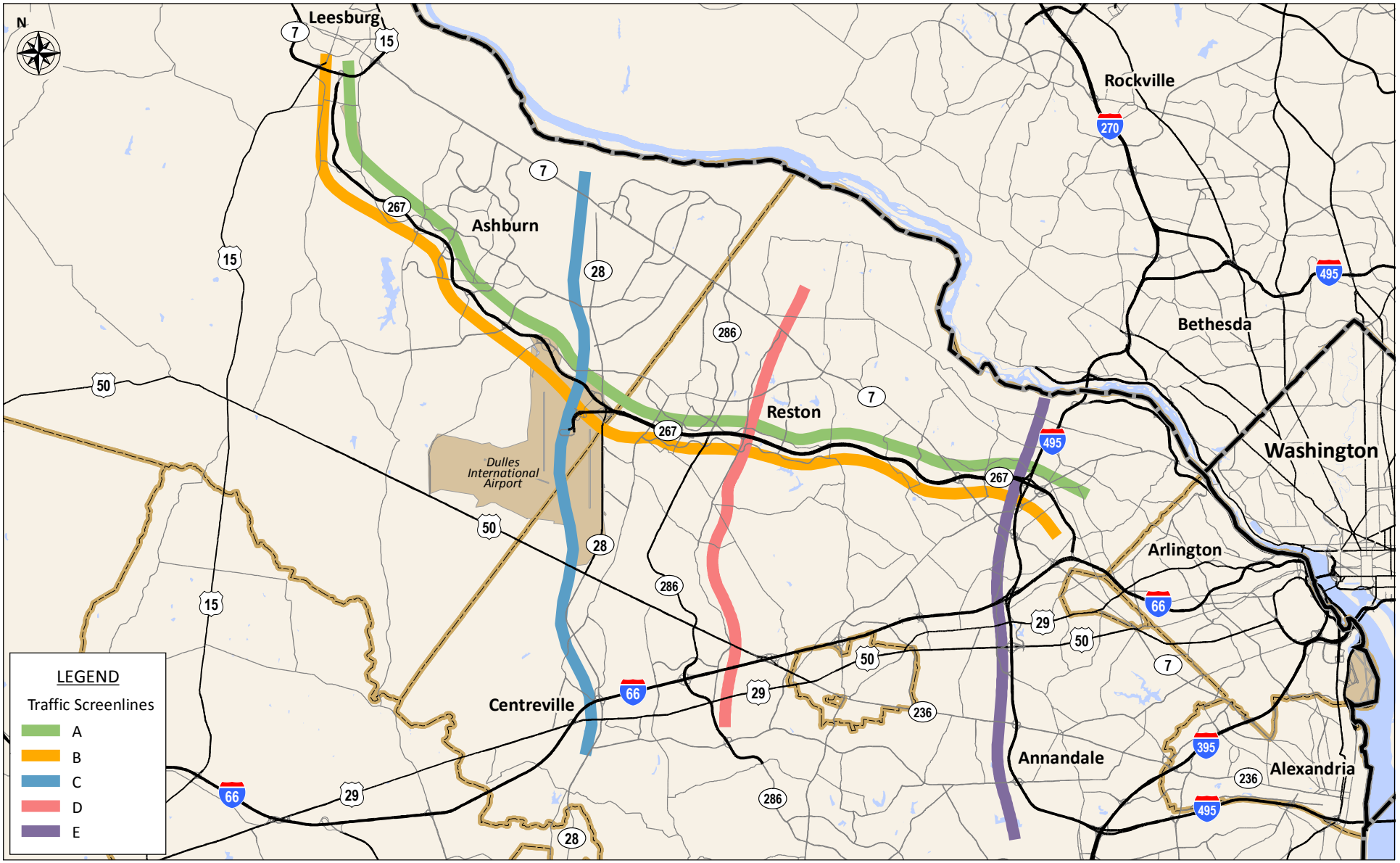


FIGURE 2-7: TRAFFIC SCREENLINES

Traffic Response to Recent Toll Increases

As part of this study, CDM Smith reviewed the impact, in terms of toll diversion, of all toll increases since 2010. **Table 2-8** presents the toll elasticities by toll-increase year in this time frame. A typical trip in this table is represented by the summation of one mainline toll and one ramp toll. The years that see the largest percentage increase in toll prices also see the largest decline in transactions from the previous year. Consequently, revenue changes from the previous year are also the greatest in years with large toll increases. Toll elasticity is calculated by the percent change in transactions divided by the percent change in price and is shown below. Overall, toll elasticities on the DTR have typically fallen between the range of -0.1 to -0.2, indicating toll customers on this facility are relatively inelastic to price changes, with the majority of U.S. urban/suburban toll roads ranging from -0.1 to -0.35.

Table 2-8
Toll Elasticity by Toll Increase Year

Year	Prior Toll Mainline	Prior Toll Ramp	Prior Toll Typical Trip	Current Toll Mainline	Current Toll Ramp	Current Toll Typical Trip	Transaction Change From Prior Year	Revenue Change From Prior Year	Toll Increase	Toll Elasticity
2005				$ 0.75	$ 0.50	$ 1.25				
2010	$ 0.75	$ 0.50	$ 1.25	$ 1.00	$ 0.75	$ 1.75	-3.7%	36.1%	40.0%	-0.09
2011	$ 1.00	$ 0.75	$ 1.75	$ 1.25	$ 0.75	$ 2.00	-3.0%	7.5%	14.3%	-0.21
2012	$ 1.25	$ 0.75	$ 2.00	$ 1.50	$ 0.75	$ 2.25	-1.6%	7.3%	12.5%	-0.13
2013	$ 1.50	$ 0.75	$ 2.25	$ 1.75	$ 1.00	$ 2.75	-1.2%	25.1%	22.2%	-0.05
2014	$ 1.75	$ 1.00	$ 2.75	$ 2.50	$ 1.00	$ 3.50	-2.2%	17.0%	27.3%	-0.08

Note: Assumes transactions change as a direct result of toll adjustment, ceteris paribus.

INRIX Speed Data

CDM Smith purchased three years of INRIX speed data at 5-minute intervals for important roadways in the DTR project area to understand the progressing levels of congestion in the Northern Virginia region. As it is imperative to replicate travel speeds on key roadways to properly present local roadway characteristics accurately in the modeling effort, this data was used in the calibration process of the base year 2017 model.

INRIX uses data collected from GPS devices, smartphones, cameras, and other devices to collect travel time information for a nationwide network. INRIX data is collected on a link basis, with a link defined by entry and exit ramps and roadway intersections. Data was summarized for the average internal weekday, not including holidays, for 2013, 2015, and 2017, as well as by model time periods. **Figures 2-8 and 2-9** present the average travel speeds by segment in 2017 in the a.m. and p.m. peak periods, respectively. **Figures 2-10 and 2-11** and **Figures 2-12 and 2-13** show the same speed diagrams for the average 2015 and 2013 weekday travel speeds, respectively.

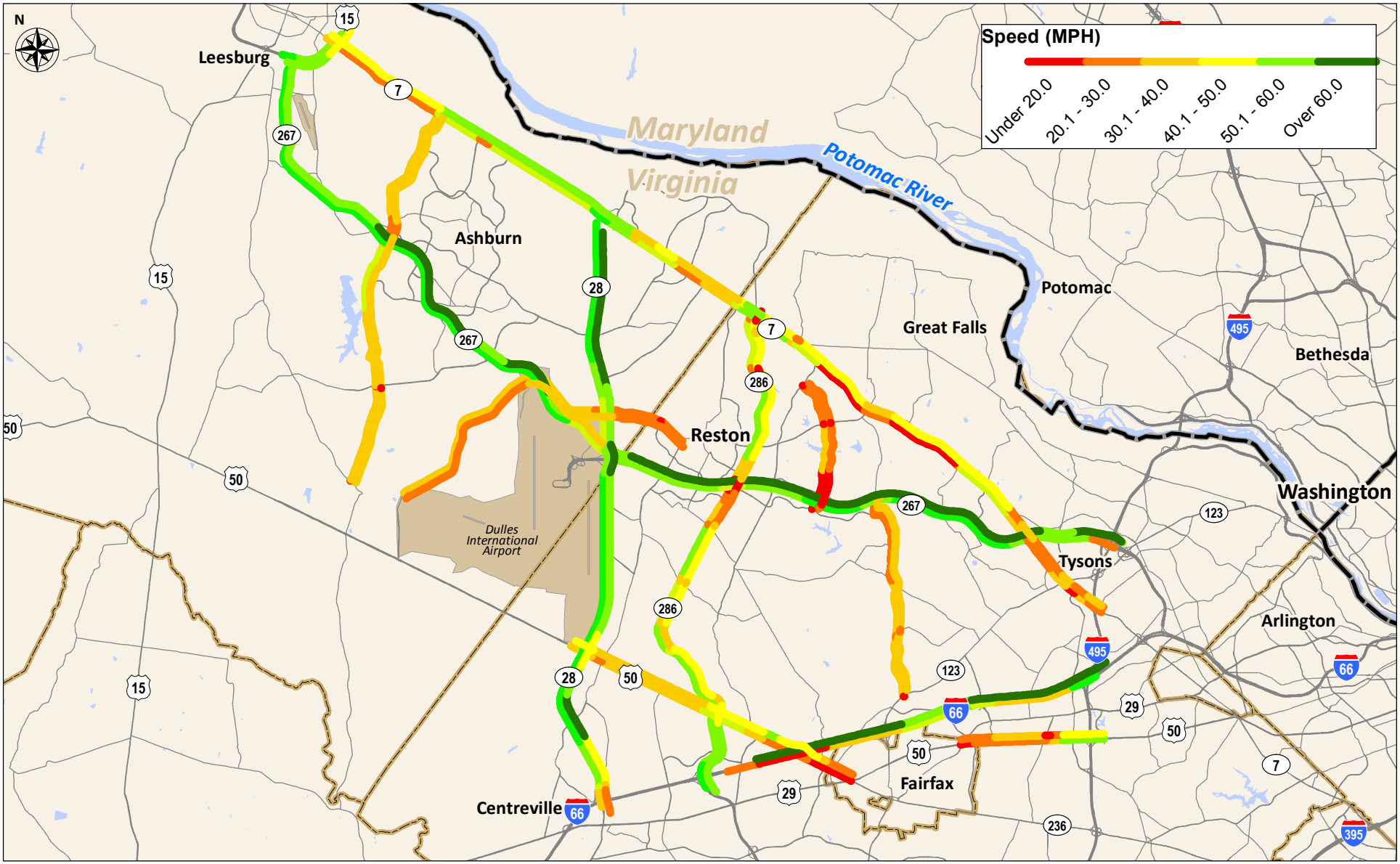


FIGURE 2-8: 2017 AVERAGE AM PEAK INRIX SPEEDS BY SEGMENT

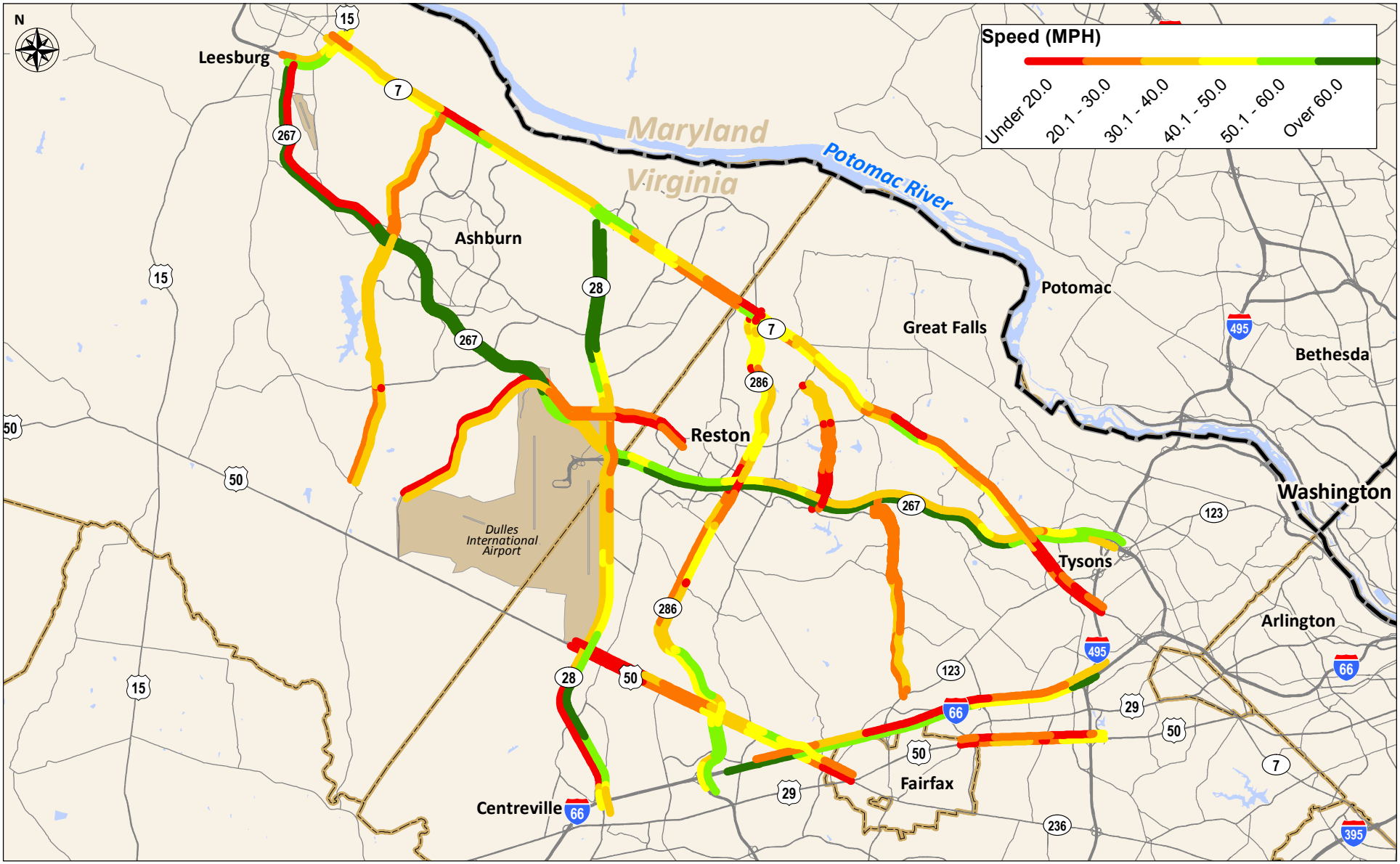


FIGURE 2-9: 2017 AVERAGE PM PEAK INRIX SPEEDS BY SEGMENT

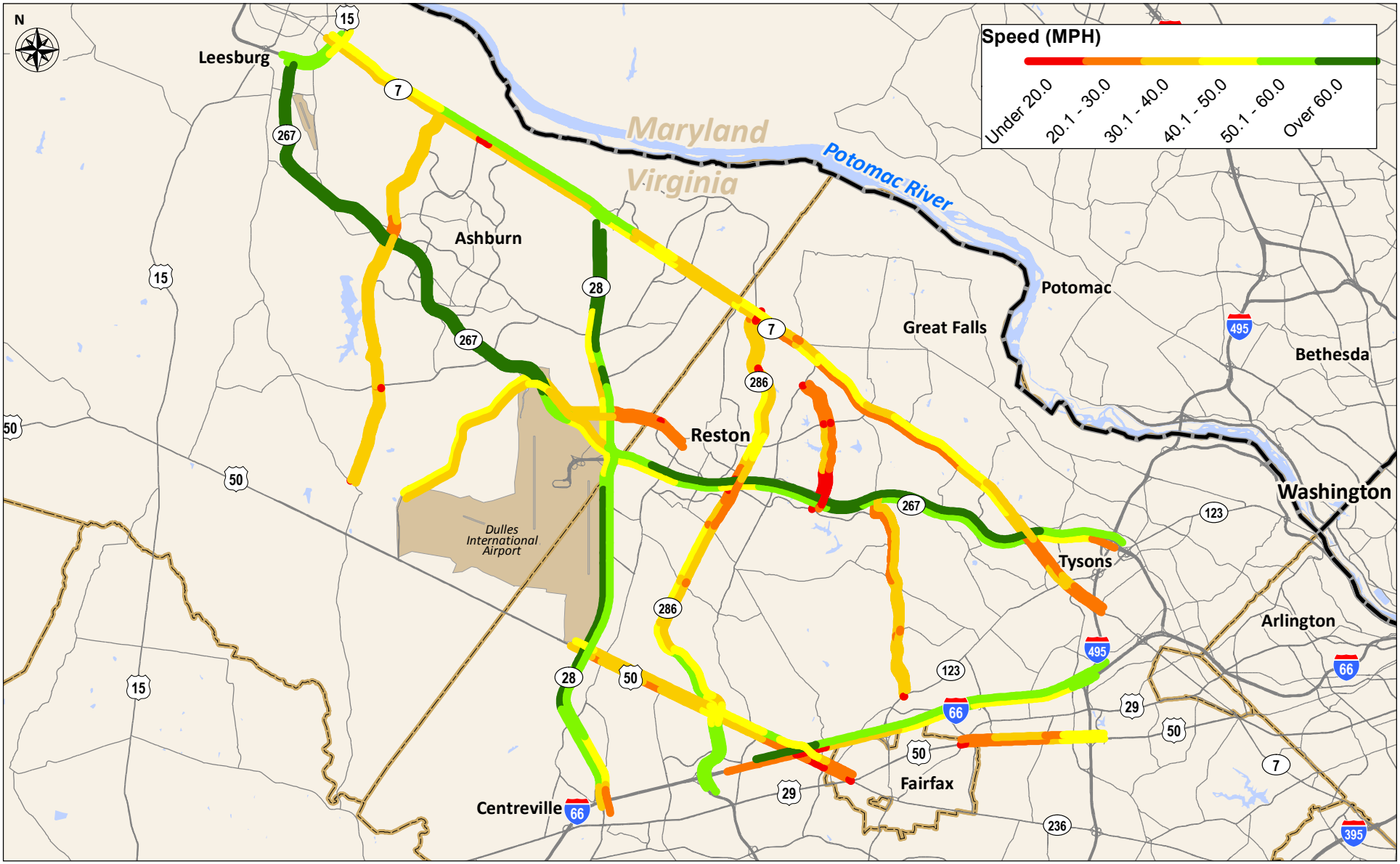


FIGURE 2-10: 2015 AVERAGE AM PEAK INRIX SPEEDS BY SEGMENT

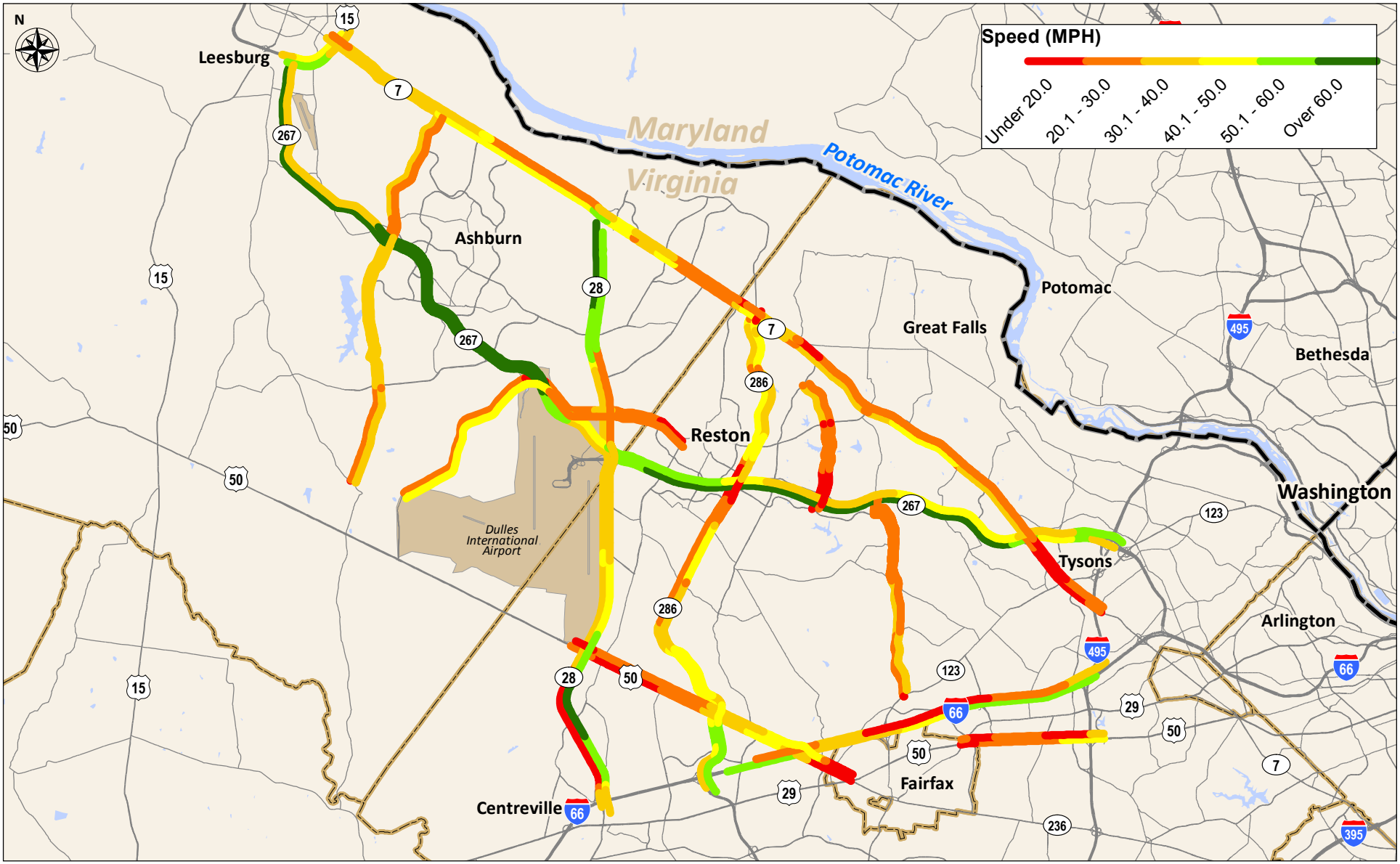


FIGURE 2-11: 2015 AVERAGE PM PEAK INRIX SPEEDS BY SEGMENT

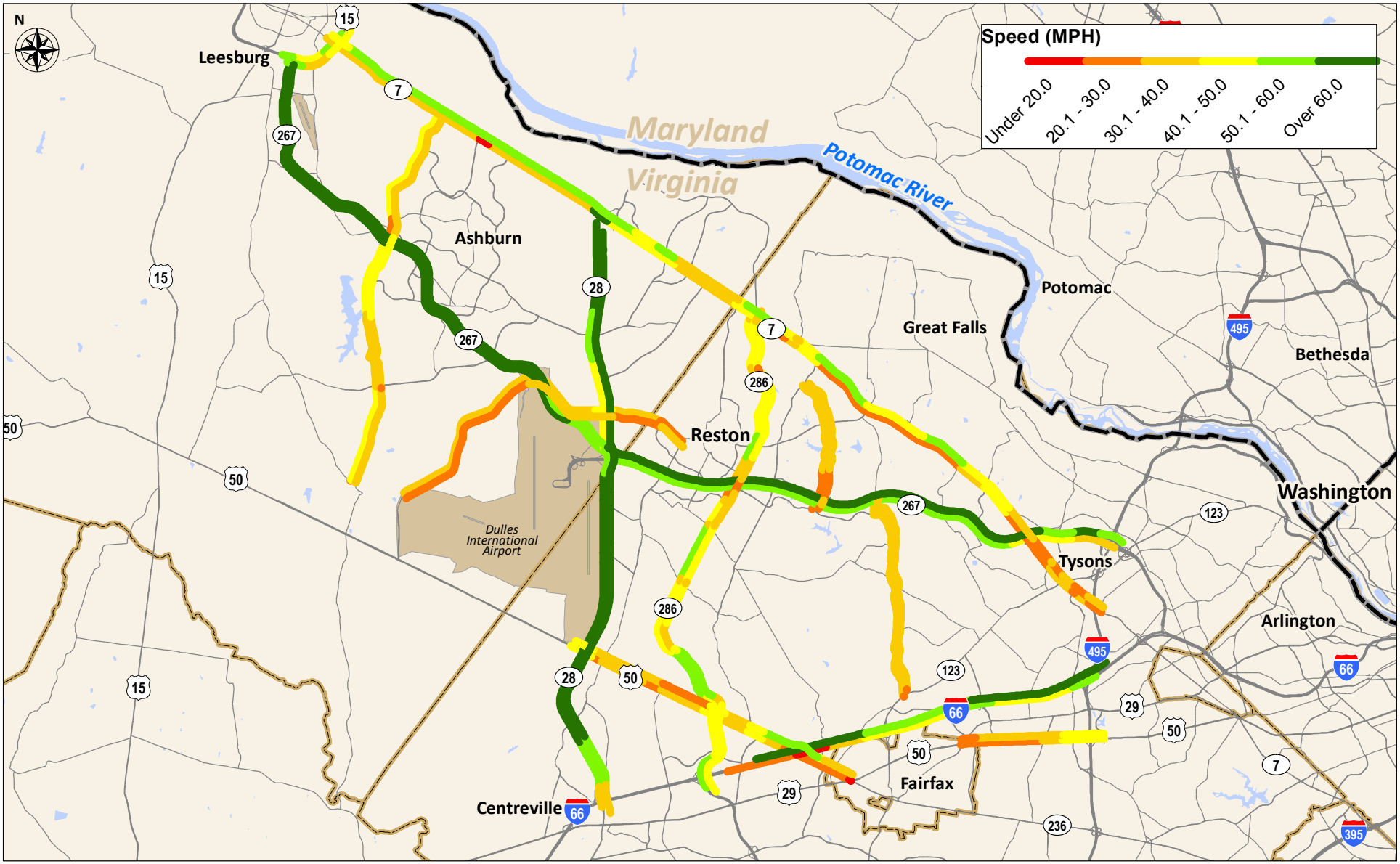


FIGURE 2-12: 2013 AVERAGE AM PEAK INRIX SPEEDS BY SEGMENT

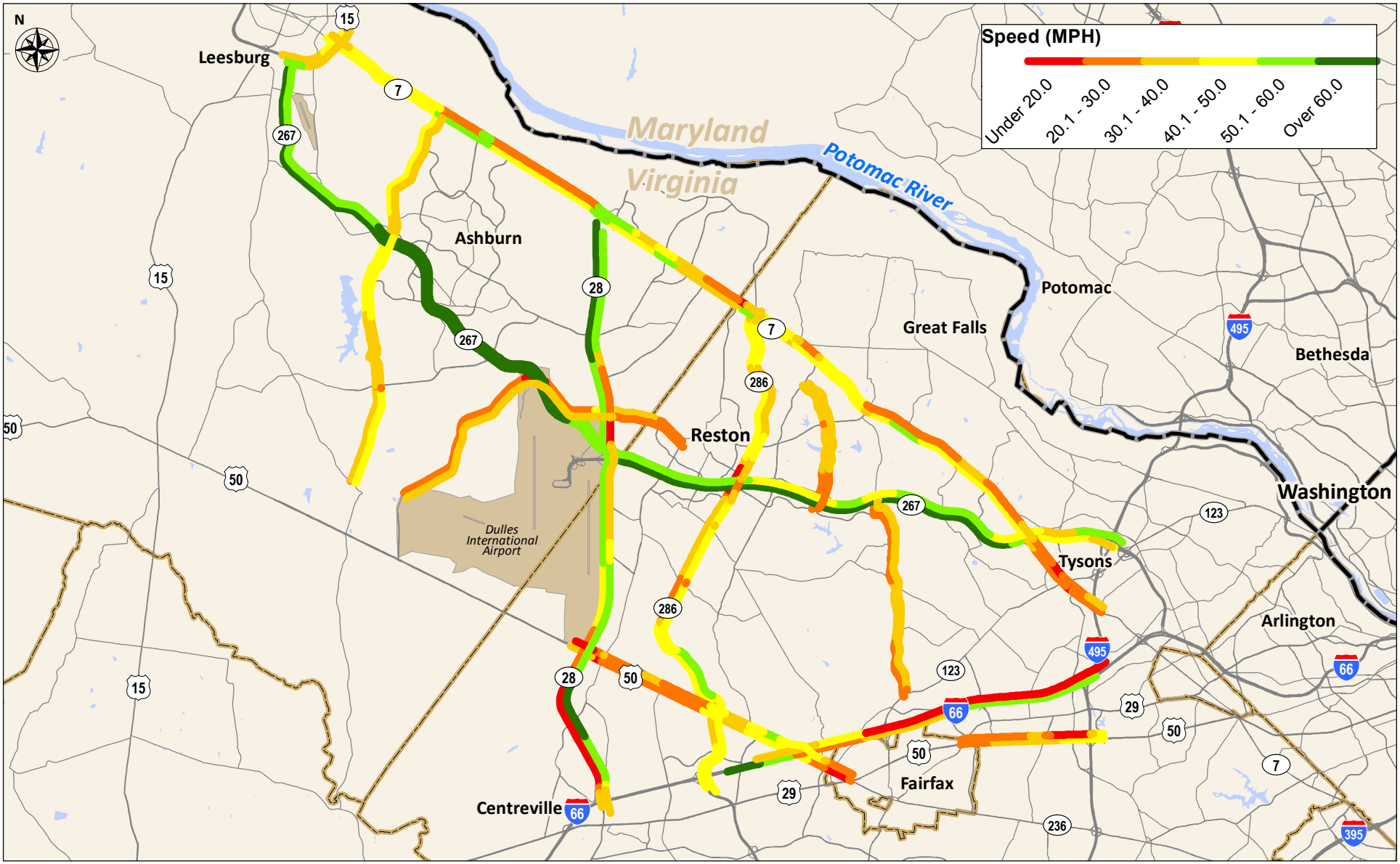


FIGURE 2-13: 2013 AVERAGE PM PEAK INRIX SPEEDS BY SEGMENT

Chapter 3

Travel Pattern and Stated Preference Survey

Travel pattern and stated preference (SP) surveys were conducted as part of the data collection efforts of this comprehensive traffic and revenue study. Surveys were administered online by CDM Smith from Wednesday, October 18, 2017 through Thursday, November 23, 2017. The survey work had two primary objectives:

- To collect information about the origin-destination patterns and trip characteristics of existing DTR E-ZPass customers, as well as travelers who pay cash to use the DTR
- To estimate the willingness to pay for travel time savings, or value of time (VOT), of DTR E-ZPass and cash customers

The estimated VOTs were incorporated into the travel demand model to support estimates of traffic and revenue. The survey questionnaire was designed to gather information from automobile travelers who recently made a trip using the DTR. The questionnaire collected data on respondents' current travel behaviors (also referred to as "revealed preferences") and used SP experiments to collect data that were used to estimate travelers' VOT.

Approach

The survey approach employed an online survey tool developed by CDM Smith. The SP survey instrument was customized for each respondent by presenting questions and modifying language based on respondents' previous answers. These dynamic survey features provided an accurate and efficient means of data collection and allowed the presentation of conditions that correspond with the respondents' reported experiences. The customized, proprietary software was programmed for online administration and targeted to DTR users.

The survey was administered, over the internet, to travelers recruited through e-mail distribution to E-ZPass customers who recently used Dulles Toll Road and through postcard handout invitations distributed to cash customers at DTR toll booths. Approximately 200,000 surveys were emailed to E-ZPass customers, and approximately 40,000 postcards were distributed to cash customers at plaza locations along the DTR.

Using these methods, a total of 26,664 customers completed the stated preference survey. Data from the survey was analyzed using accepted statistical techniques to estimate coefficients for a set of multinomial logit (MNL) models. The models were segmented into two trip-purpose segments (work/school/work-related business and non-work) and two time-of-day segments (peak and off-peak). The coefficients of the MNL models can be used to estimate travelers' VOT for each traveler market segment.

This chapter summarizes the development and administration of the survey questionnaire, presents the survey results, and presents VOT estimates for the surveyed population of DTR customers. The full set of survey screen captures from the online survey and a summary of the SP survey experiment design process and model estimation methodology are included in **Appendix A** of this report.

Survey Administration

The survey team designed the administration plan to produce a representative sample of DTR E-ZPass and cash customers. The sampling plan was designed to include a sufficient range of travelers and trip types to support the statistical estimation of choice model coefficients. By collecting data from a range of travelers and trip types, it became possible to identify the ways in which different characteristics affect route choice behavior. These differences could then be reflected in the structure and coefficients of the resulting choice model.

The survey instrument was administered online through CDM Smith's *dtrsurvey2017.com* (for E-ZPass customers) and *dtrtravelsurvey.com* (for cash customers) websites using two recruitment methods:

- Distribution of email invitations on October 18, 2017 to E-ZPass customers who recorded a transaction on the DTR between Sunday, September 3, 2017 and Saturday, September 30, 2017
- Postcard handout invitations to cash customers who used the DTR on Wednesday, October 18, 2017; Wednesday, October 25, 2017; and Thursday, October 26, 2017

The 4-week travel window from September 3, 2017 to September 30, 2017 and the postcard recruitment days in October were selected to generate a large population of DTR customers from a period with typical traffic volumes and travel patterns.

The survey administration process concluded with the closure of the survey websites on Thursday, November 23, 2017. All respondents who completed the survey during this window were given the opportunity to enter to win one of five $500 VISA e-gift cards. Winners were selected at random and notified within 6 weeks of the close of the survey.

Survey Questionnaire

CDM Smith worked closely with DTR staff to develop a questionnaire to help meet the primary objectives of this comprehensive T&R study.

The survey asked respondents to focus on their most recent weekday or weekend trip in the corridor while they answered a series of questions that were grouped into six main sections:

1. Introduction and Qualification Questions
2. Trip Characteristics and Travel Patterns Questions
3. Stated Preference Questions
4. Customer Service Questions
5. Demographic Questions
6. Survey Comments

Introduction and Qualification Questions

After being presented with basic instructions about how to navigate the online survey instrument and a brief introduction to the purpose of the study, respondents answered a qualification question to determine whether they had made a trip that met all the following conditions:

- Made within the past two months
- Used all or part of the DTR
- Took at least 10 minutes in total door-to-door travel time

Respondents who indicated that they did not meet these criteria were redirected to a survey exit question asking why they had not used the DTR recently. After answering this question, these respondents were thanked for their participation before exiting the survey.

Trip Characteristics and Travel Pattern Questions

Respondents who had made a trip on the DTR and met the qualifications were asked to focus on their most recent qualifying trip, referred to as the respondent's reference trip. Specifically, respondents were asked to think about their most recent trip and not a typical or average trip that they might make to ensure that the sample included a diverse range of trip types and travel characteristics. The reference trip formed the basis for questions in this section of the survey and provided a frame of reference for respondents when completing the stated preference scenarios in the next section of the survey.

Respondents were instructed to think of the one-way portion of their trip and were asked a series of questions regarding the specific characteristics of their reference trip, including:

- Time of day of travel
- Day of week of travel
- Reference trip frequency
- Vehicle type and number of axles
- Trip purpose
- Home-based or non-home-based
- Trip origin and destination
- DTR entrance and exit interchanges
- Travel time
- Travel delays due to traffic congestion, if any
- Other toll road usage
- Alternate routes for making the trip

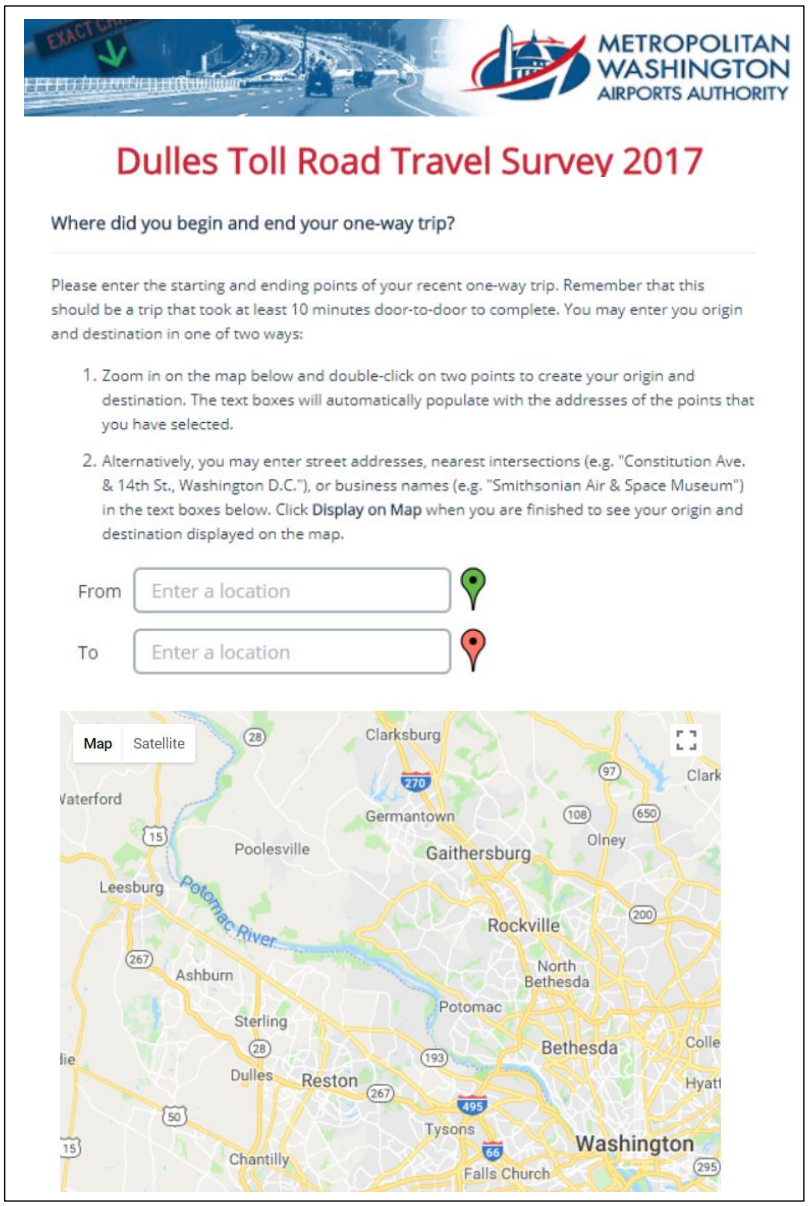
- Time savings on the DTR versus alternate routes
- Reason(s) for using the DTR rather than an alternate route

Respondents identified the specific location of their origin and destination by entering a business name, a street intersection, or a full address or by using an interactive map (**Figure 3-1**). The origin and destination locations were geocoded using a Google Maps application programming interface (API) to provide a latitude and longitude for both the trip origin and destination. The coordinates were used to verify that the trip began and ended in two different locations, i.e. was not a round-trip, and that the trip could have reasonably traveled through the study region. The geocoding application also was used to record the distance and Google-estimated travel time for the trip.

Next, respondents entered their trip start time and identified the interchanges they used to access and exit the DTR. A sample survey screen from this question is shown in **Figure 3-2**. All respondents then were asked to enter the time they spent traveling door-to-door between their origin and destination and if they encountered any delays on their trip. Reported travel times were compared to the travel time estimate obtained from the Google API. If a respondent's reported travel time differed significantly from the Google estimate, an average of the Google travel time and the respondent's travel time was used as the basis for the trade-off questions presented in the stated preference trade-off questions section of the survey.

To conclude this section of the survey, respondents were first asked how often they make the same trip between their selected origin and destination locations using the DTR. Then, they were asked about usage of nearby toll roads, including the Greenway and the 495/95 Express Lanes. The section concluded with questions about alternate routes available to the respondents in making their trip, other than the DTR, and about the perceived time saved by taking the DTR rather than those alternatives. The example alternate routes presented to users included SR 7, I-66, US 50, and the Metrorail Silver Line.

Figure 3-1 Trip Origin and Destination Sample Screen



Source: All figures in this chapter sourced from Dulles Toll Road Travel Survey

Stated Preference Questions

The stated preference questions were quantitative experiments to estimate travel preferences and behavioral responses under hypothetical conditions. The details of each respondent's reference trip were used to build a set of five stated preference scenarios. Each scenario alternative was described by both travel time and toll cost, which were varied across the five scenarios. Respondents were asked to select their preferred travel alternative under the conditions presented by selecting either the tolled alternative (the DTR) or the alternate toll-free route. **Figure 3-3** shows an example stated preference scenario with varying attribute values.

The attribute values presented in each scenario varied around the respondents estimated travel time and the toll cost of traveling between the respondent's entry and exit points on the DTR. By varying the travel time and toll cost shown in each experiment, the respondent was faced with different time savings for different costs, allowing them to demonstrate their travel preferences across a range of values of time.

Customer Service Questions

After completing the trade-off exercises, respondents were asked a series of customer service questions related to their experience using the DTR.

First, respondents were asked to express their level of satisfaction with various aspects of the DTR, including customer service

Figure 3-2 Trip Interchange Entry Sample Screen

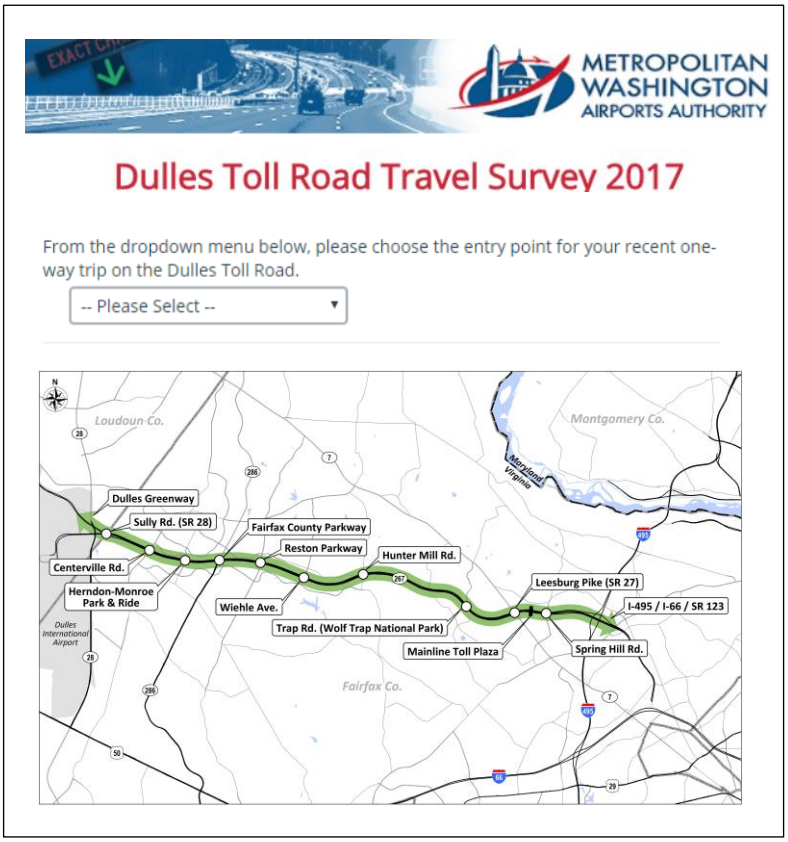


Figure 3-3 SP Survey Choice Sample Screen

provided by toll booth operators and the customer service center. Next, cash customer respondents were asked their reasons for paying with cash on the DTR and about their preferred payment method if cash were no longer an option.

Demographic Questions

The brief final section of the survey included two demographic questions asking for the user's home ZIP code and an estimate of annual household income before taxes. Responses to these questions were used to confirm that the sample contained a geographically diverse sample of drivers that travel in the study region.

Survey Comments

Respondents were given the opportunity to leave comments about the survey or the project. Over 8,600 respondents elected to provide comments on either the survey itself or their experiences with the DTR—too many to include in full in this report. However, a word frequency analysis was conducted on the comments, the results of which are summarized in **Table 3-1**. Overall, roughly 25 percent of respondents gave comments that were categorized as negative and included users' complaints and frustrations with toll roads in general and toll rates and toll rate increases on the DTR specifically. Four percent of respondents provided comments that were categorized as positive, detailing the benefits of the facility, such as safety, efficiency, and travel time savings. Another three percent of users offered suggestions for improving the facility. Many cash customers suggested accepting credit cards at the toll booths and instituting exact change toll lanes.

Table 3-1
Survey Comments

Classification	Percent
Negative	25%
Positive	4%
Suggestion for improvement	3%
No Comments	68%
Total	**100%**

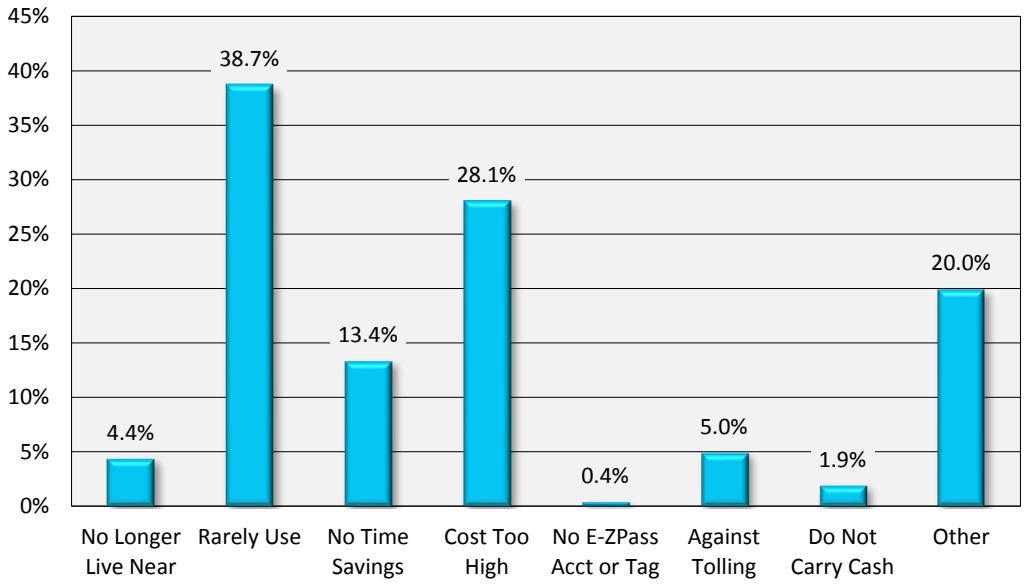
Survey Results

A total of 26,664 respondents completed the full survey, of which 26,478 (99 percent) were E-ZPass customers and 186 (1 percent) were cash customers.

An additional 1,252 customers attempted the survey but were directed to an exit question after failing to meet the qualification criteria. These customers were asked to select their reasons for not using the DTR within the past two months. The most common response, given by 39 percent of these customers, was that they rarely use the facility, followed by the 28 percent who said that costs on the toll road are too high. Of the 20 percent of users who selected "Other" as their reason for not using the facility, the most frequently cited reasons were that their most recent trip was less than 10 minutes, or that they had been a passenger rather than a driver on their most recent trip. The full range of responses is shown in **Figure 3-4**. Note that responders were able to select more than one answer to this question.

The descriptive analysis of the data presented here is based on the full sample of 26,664 completed survey responses, unless indicated otherwise, and is provided in five sections: trip characteristics, travel patterns, customer service, demographics, and stated preferences.

Figure 3-4 Reasons for Not Using Dulles Toll Road within Last Two Months



Note: This figure is based on responses from 1,252 customers who did not qualify for the survey. These customers had not completed a trip on the Dulles Toll Road within the past two months prior to attempting the survey.

Trip Characteristics

Figure 3-5 shows the percentage of trips by day of the week and time, as well as trip frequency. Nearly 80 percent of trips in the sample were made on a weekday, and nearly half (49 percent) of all sampled trips were made during the morning peak period. An additional 20 percent of respondents made their trip during the PM peak period. For the purposes of this chapter, a trip made during the peak period is defined as one that started between the hours of 6:00 a.m. and 9:59 a.m. or 3:00 p.m. and 6:59 p.m., while an off-peak trip is one that started during any other time.

In terms of facility frequency of use, a large percentage of survey respondents were infrequent customers. Only 25 percent of respondents reported making their reference trip four or more times per week, compared to 22 percent who reported making the trip between one and three times per month, and 31 percent who reported making the trip less than once per month.

The distribution method used to invite customers to participate in the survey accounts for the large sample of infrequent users who participated. One email invitation was sent to all E-ZPass customers who used the facility at least once during the 4-week period from September 3, 2017 to September 30, 2017, regardless of frequency of use. As a result, a regular commuter traveling to and from work five days per week for all four weeks of that period would have received a single invitation to the survey, the same as an individual who used the facility only once during that same period. To compensate for the large sample of infrequent users, a weighting factor was applied to the responses based on the more representative frequency distribution observed in the 2011 origin-destination survey of the DTR. The distribution from 2011 is also shown in Figure 3-5.

Figure 3-5 Day of Week, Time Period, and Trip Frequency

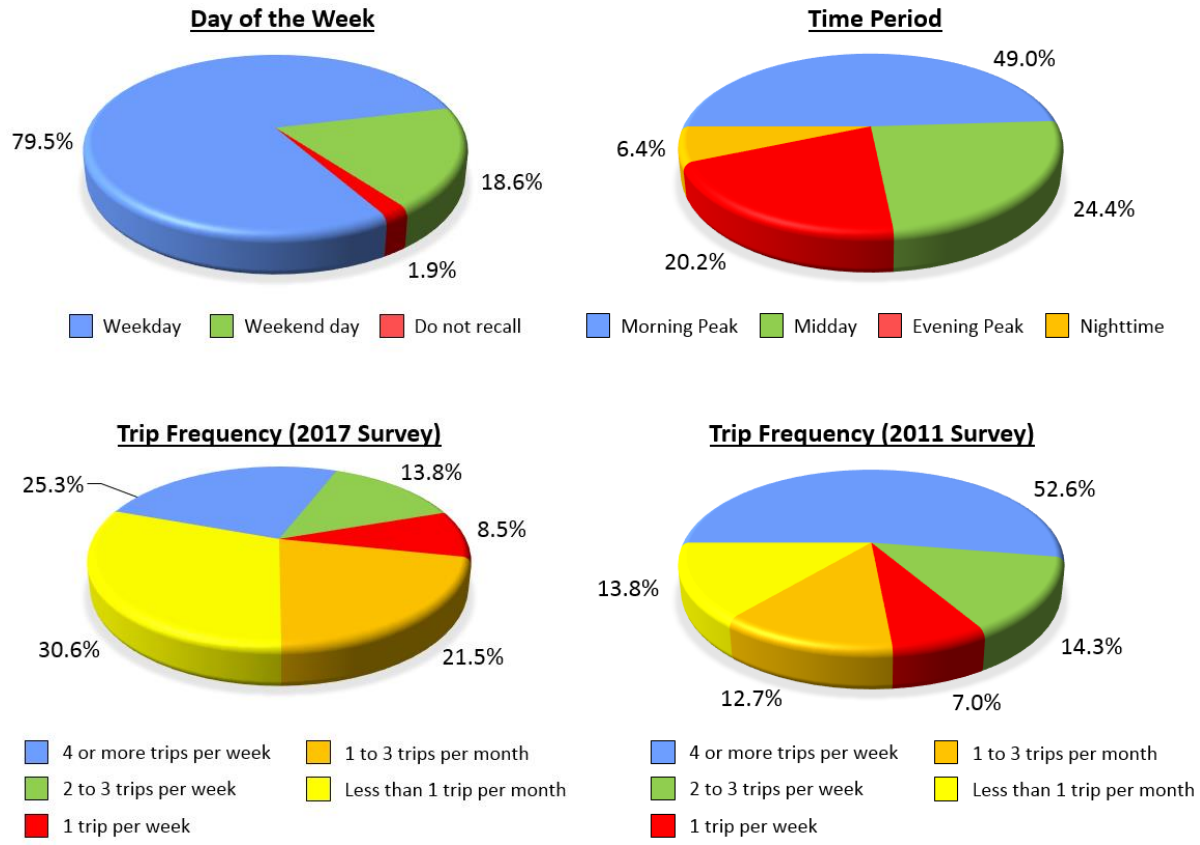
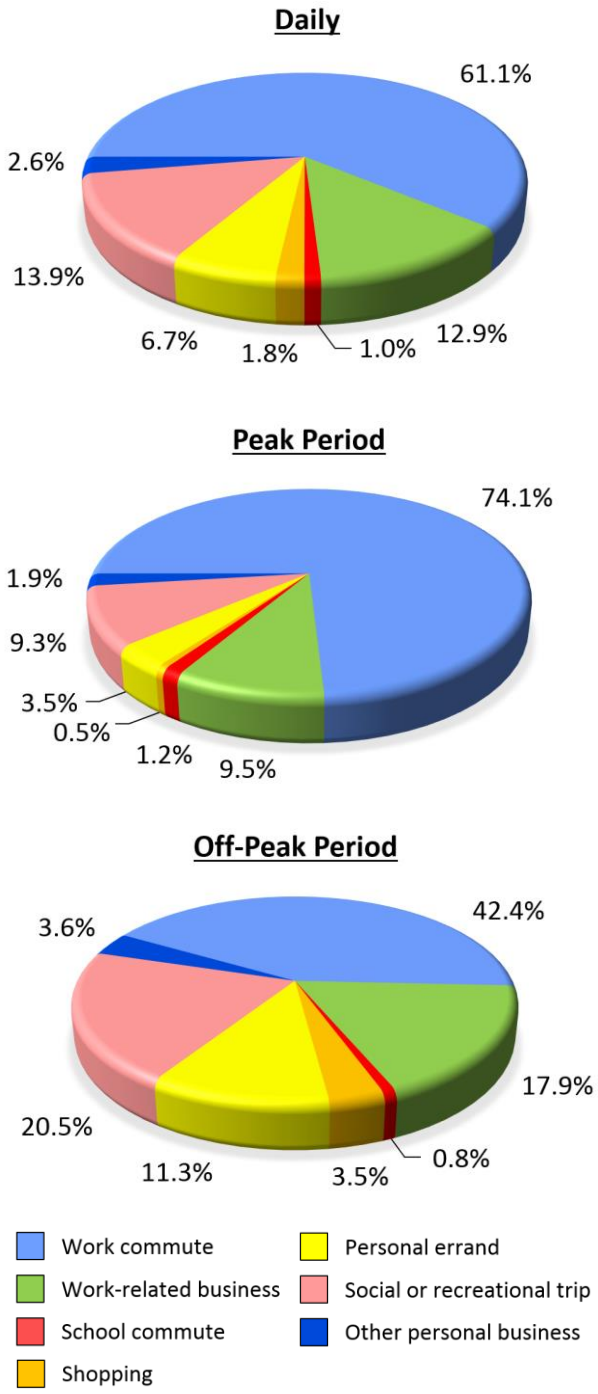


Figure 3-6 shows the breakdown of sampled trips by trip purpose, weighted according to the frequency distribution of the 2011 study. The first pie chart shows the full day breakdown of trip purposes, with the following two charts breaking out the sample into peak and off-peak time periods.

Work commutes were the most commonly cited trip purpose, at 61 percent for the full day and 74 percent during the peak period, followed by work-related business trips at 13 percent and 10 percent, respectively. In the off-peak period, the most common trip type outside of the work commute was the social or recreational trip, at 21 percent. Taken together, non-work trips accounted for nearly 40 percent of all off-peak trips.

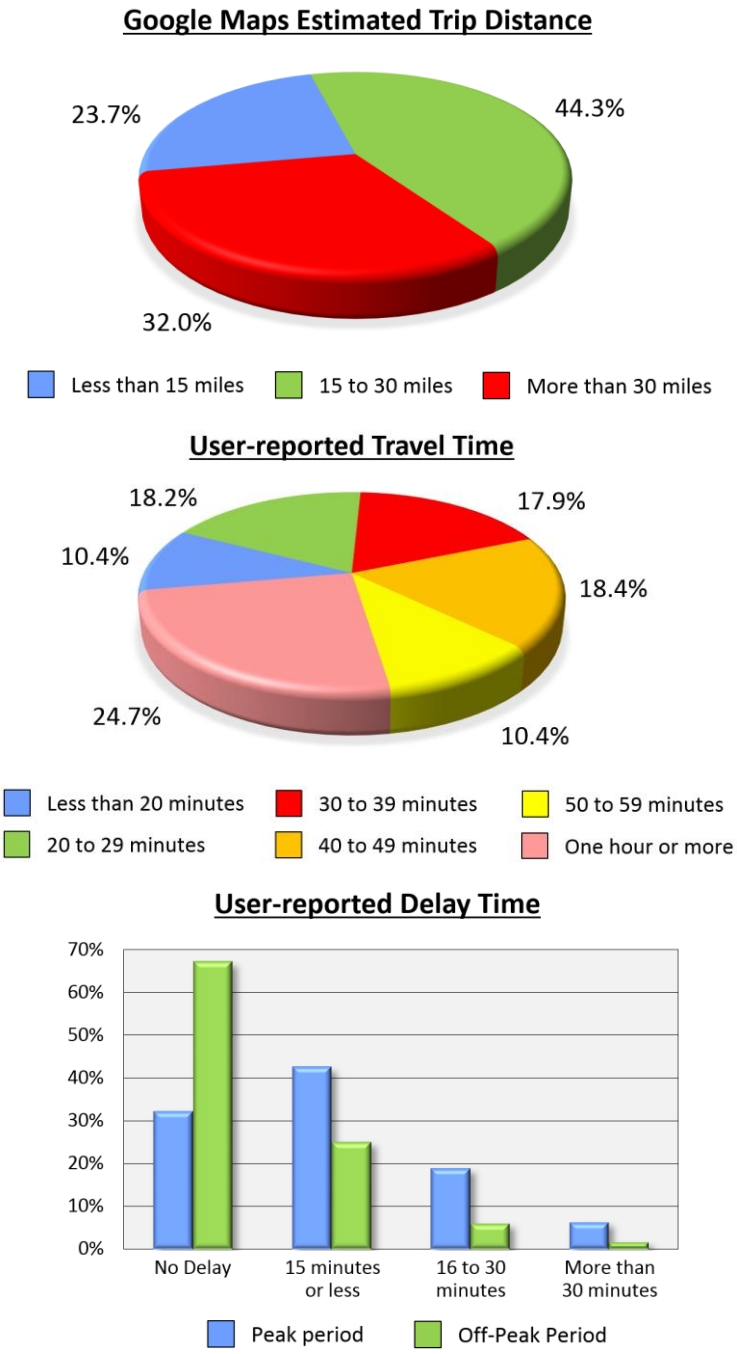
The latitude and longitude coordinates for each trip's origin-destination pair were used to calculate the trip distance using the Google Maps API. Google-estimated trip distances, as well as respondent-reported travel times, are displayed in **Figure 3-7**. Forty-four percent of respondents reported a trip of between 15 and 30 miles, and 55 percent of respondents estimated their travel time as being between 20 and 49 minutes.

Figure 3-6 Trip Purpose (Weighted to 2011 Trip Frequency Distribution)



Delays due to congestion experienced by respondents on any part of the reference trip are also shown in Figure 3-7. During the peak period, 43 percent of respondents reported experiencing a delay of less than 15 minutes, while 19 percent reported delays of between 16 and 30 minutes, and 6 percent reported delays of more than 30 minutes. The remaining 32 percent of peak hour respondents reported no delays. In the off-peak period, 67 percent of respondents reported no delays, while the majority of those experiencing a delay reported delays of less than 15 minutes.

Figure 3-7 Trip Distance, Travel Time, and Delay Time



Travel Patterns

Trip origins and destinations (also known as trip ends) were geocoded from the online survey Google Maps API. A sample of respondents' trip ends are displayed in **Figure 3-8.** The highest concentration of trip ends is located along the DTR corridor in the communities of Herndon, Reston, Tysons, and McLean. To the west, there are pockets of DTR users in Leesburg, Ashburn, and Sterling, and to the east, high concentrations of users are in Arlington and Washington, D.C. In Maryland, Silver Spring and Bethesda also account for a sizable number of trips.

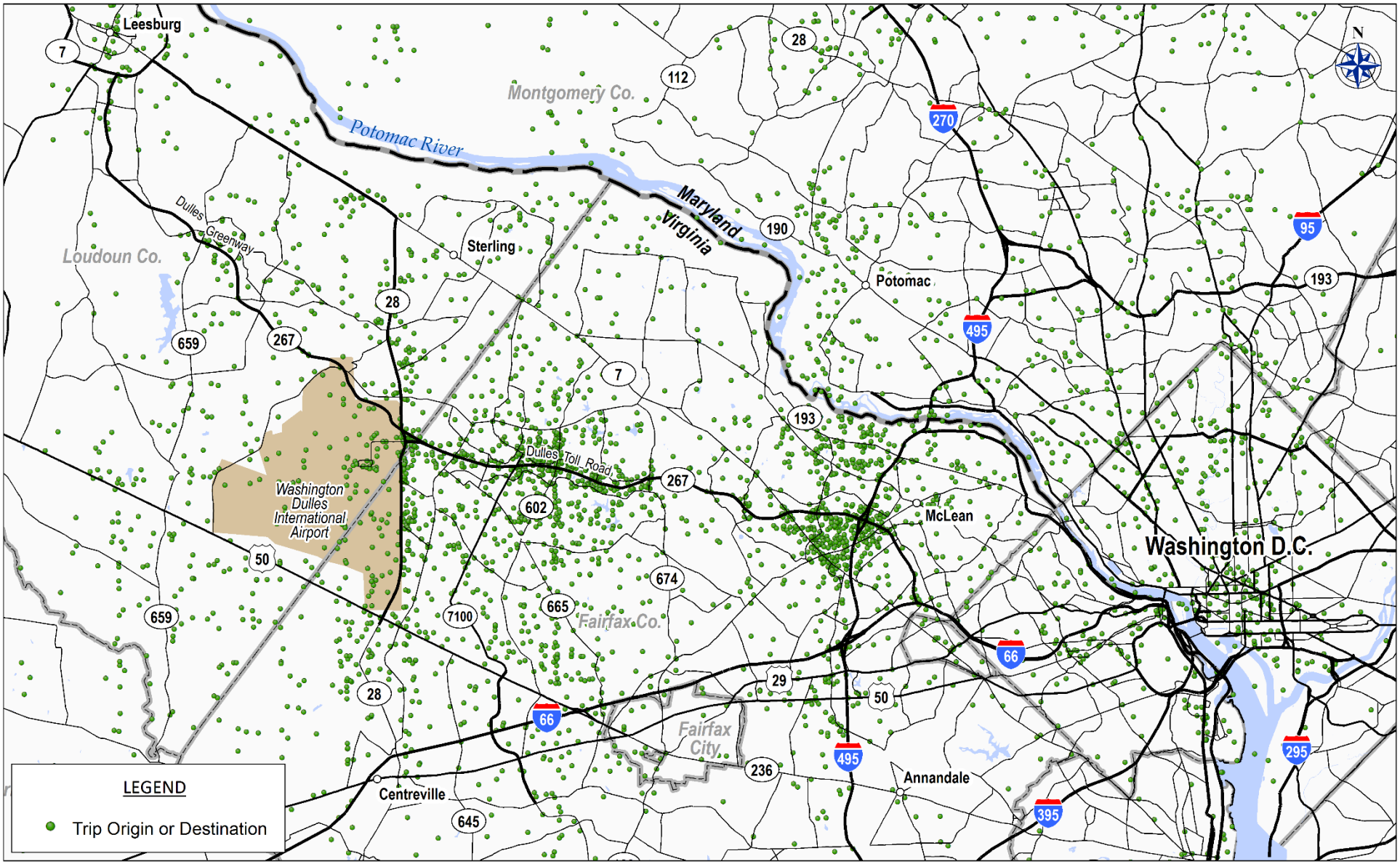
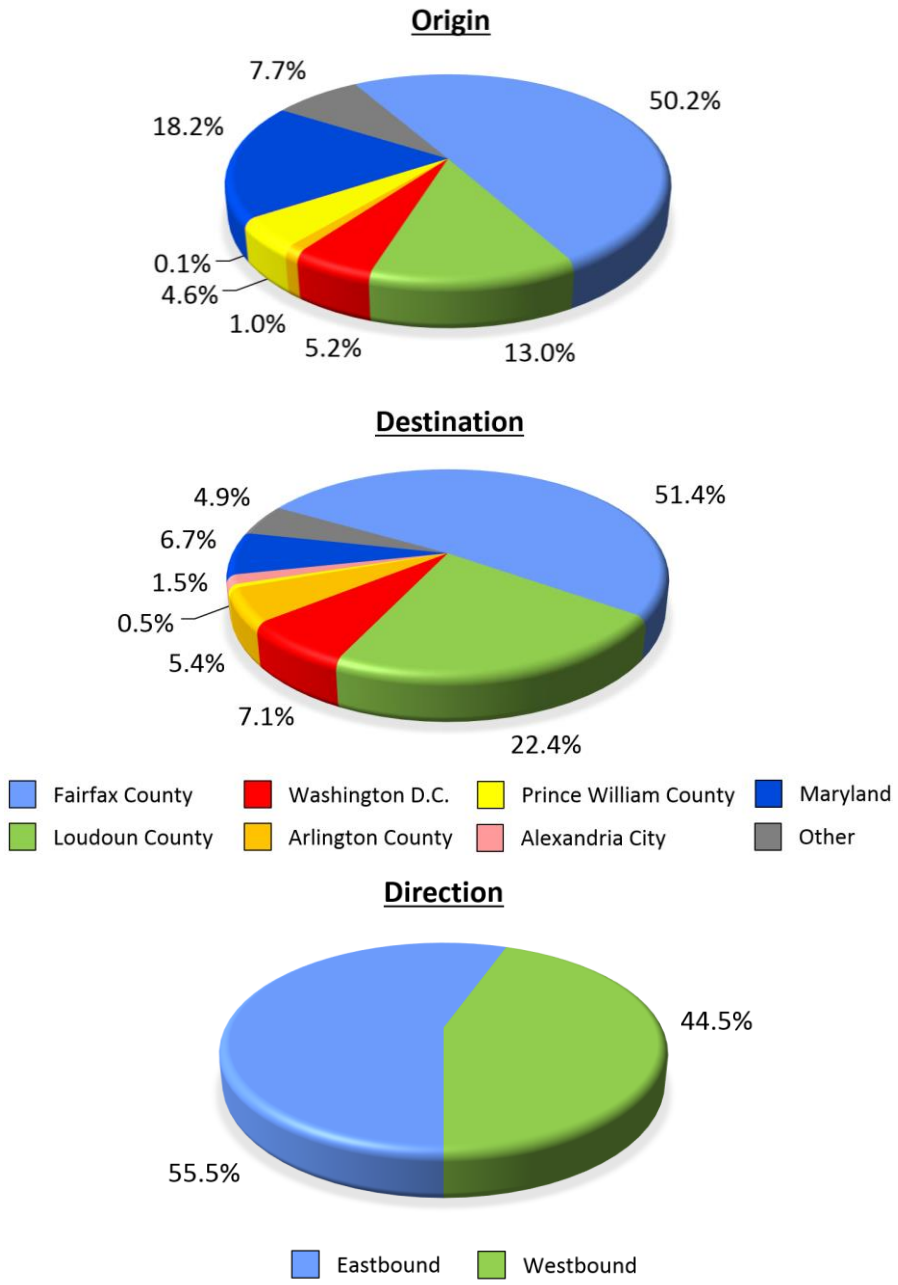


FIGURE 3-8: TRIP ORIGINS AND DESTINATIONS

Figure 3-9 Origin, Destination, and Direction of Travel of Survey Respondents

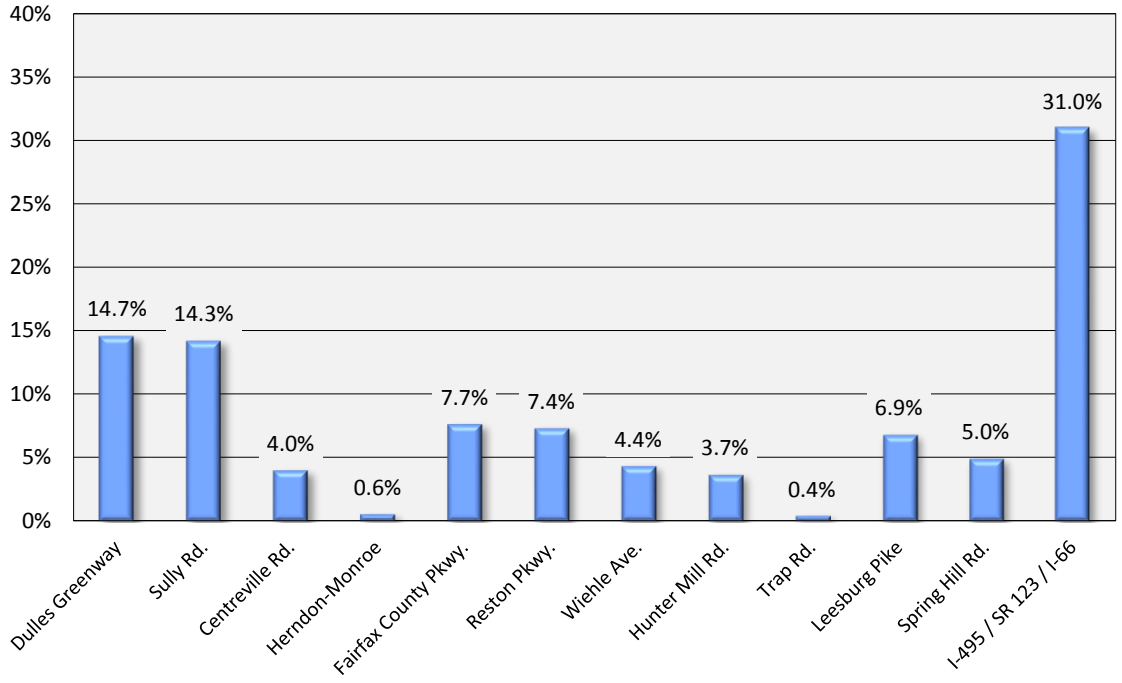


Breaking the trip ends down by jurisdiction, **Figure 3-9** shows that Fairfax County accounted for the largest share of DTR origins and destinations, at more than 50 percent in both cases. Loudoun County was the second largest source of trips, with 13 percent of the study sample origins and 22 percent of destinations. Maryland was the third largest, with 18 percent of origins and 7 percent of destinations, followed by Washington, D.C. with 5 percent and 7 percent, respectively.

Most trips (56 percent) were made in the eastbound direction, which was likely a function of sampling mostly morning peak hour trips with this survey. The peak direction on the DTR is eastbound in the mornings, as commuters head for employment centers and government facilities in and around Washington, D.C.

Respondents were asked to select the entry and exit points used on their reference trip on the DTR. The distribution of the most frequently reported on-ramps and off-ramps is presented in **Figure 3-10**. Thirty-one percent of respondents entered or exited the study corridor on the east end, using either I-495, SR 123, or I-66. On the west end, 14.7 percent of respondents entered or exited at the Greenway, and another 14.3 percent used the adjacent Sully Road interchange.

Figure 3-10 On-Ramp and Off-Ramp Usage



The complete breakdown of interchange-to-interchange movements is given in **Figure 3-11** on the following pages. Nearly half of all respondents, or 49 percent, entering from the Greenway drove the full length of the DTR to exit at I-495/SR 123/I-66, and more than half of respondents entering at all other points on the facility did the same. The pattern was similar in the reverse direction, as respondents traveling westbound tended to exit at either Sully Road or the Greenway, regardless of their entry point.

Most of survey respondents indicated that they did not use any other toll facilities on their trip, as shown in **Figure 3-12**. Of those that did, 26 percent reported using the Greenway at the western end of the DTR, and 17 percent used the 495/95 Express Lanes to the east and south.

Figure 3-11 Interchange to Interchange Movements

Daily - Eastbound

Entry \ Exit	1	2	3	4	5	6	7	8	9	10	11	12	Total
1 - Dulles Greenway	-	5.1%	2.8%	1.5%	8.2%	7.2%	5.4%	3.4%	-	9.2%	8.2%	49.0%	**100%**
2 - Sully Rd. (SR 28)		-	1.3%	0.6%	5.9%	6.3%	6.8%	4.0%	-	11.4%	11.8%	51.8%	**100%**
3 - Centreville Rd.			-	1.3%	2.1%	3.9%	4.8%	2.5%	-	16.8%	15.4%	53.2%	**100%**
4 - Herndon-Monroe Park & Ride				-	4.3%	5.5%	2.5%	1.8%	-	10.4%	11.7%	63.8%	**100%**
5 - Fairfax County Pkwy.					-	2.6%	2.1%	1.8%	-	12.7%	12.7%	68.2%	**100%**
6 - Reston Pkwy.						-	1.5%	1.5%	-	13.0%	13.9%	70.1%	**100%**
7 - Wiehle Ave.							-	0.9%	-	12.5%	11.4%	75.2%	**100%**
8 - Hunter Mill Rd.								-	-	12.8%	17.3%	69.9%	**100%**
9 - Trap Rd.									-	9.7%	10.8%	79.6%	**100%**
10 - Leesburg Pike (Rt. 7)										-	7.8%	92.2%	**100%**
11 - Spring Hill Rd.											-	100.0%	**100%**
12 - I-495 / SR 123 / I-66												-	**-**

Daily - Westbound

Entry \ Exit	1	2	3	4	5	6	7	8	9	10	11	12	Total
12 - I-495 / SR 123 / I-66	-	2.6%	5.7%	1.6%	5.2%	6.6%	14.3%	11.9%	-	6.9%	21.8%	23.4%	**100%**
11 - Spring Hill Rd.		-	4.0%	1.0%	6.1%	6.6%	15.5%	13.4%	-	10.0%	24.4%	19.0%	**100%**
10 - Leesburg Pike (Rt. 7)			-	0.8%	3.2%	6.4%	14.9%	14.4%	-	9.5%	29.6%	21.3%	**100%**
9 - Trap Rd.				-	-	-	-	-	-	-	-	-	**-**
8 - Hunter Mill Rd.					-	3.1%	10.6%	7.7%	-	9.2%	35.7%	33.8%	**100%**
7 - Wiehle Ave.						-	4.0%	6.4%	-	10.4%	46.5%	32.7%	**100%**
6 - Reston Pkwy.							-	9.5%	-	7.5%	39.2%	43.8%	**100%**
5 - Fairfax County Pkwy.								-	-	10.6%	34.7%	54.7%	**100%**
4 - Herndon-Monroe Park & Ride									-	21.7%	21.7%	56.5%	**100%**
3 - Centreville Rd.										-	44.3%	55.7%	**100%**
2 - Sully Rd. (SR 28)											-	100.0%	**100%**
1 - Dulles Greenway												-	**-**

AM Peak Period - Eastbound

Entry \ Exit	1	2	3	4	5	6	7	8	9	10	11	12	Total
1 - Dulles Greenway	-	5.0%	3.8%	2.0%	9.1%	8.9%	6.7%	3.4%	-	8.1%	9.4%	43.6%	**100%**
2 - Sully Rd. (SR 28)		-	1.2%	0.8%	5.5%	6.8%	7.3%	3.1%	-	13.1%	16.2%	46.0%	**100%**
3 - Centreville Rd.			-	1.2%	2.5%	2.5%	6.4%	1.5%	-	19.9%	19.7%	46.4%	**100%**
4 - Herndon-Monroe Park & Ride				-	5.4%	3.6%	1.8%	1.8%	-	8.9%	16.1%	62.5%	**100%**
5 - Fairfax County Pkwy.					-	2.3%	2.2%	1.4%	-	11.7%	15.6%	66.7%	**100%**
6 - Reston Pkwy.						-	1.1%	0.7%	-	12.8%	18.5%	67.0%	**100%**
7 - Wiehle Ave.							-	1.6%	-	12.6%	11.7%	74.1%	**100%**
8 - Hunter Mill Rd.								-	-	10.2%	19.9%	69.9%	**100%**
9 - Trap Rd.									-	11.4%	11.4%	77.3%	**100%**
10 - Leesburg Pike (Rt. 7)										-	10.1%	89.9%	**100%**
11 - Spring Hill Rd.											-	100.0%	**100%**
12 - I-495 / SR 123 / I-66												-	**-**

AM Peak Period - Westbound

Entry \ Exit	1	2	3	4	5	6	7	8	9	10	11	12	Total
12 - I-495 / SR 123 / I-66	-	4.0%	4.8%	0.8%	5.9%	8.8%	18.8%	12.5%	-	10.1%	17.6%	16.6%	**100%**
11 - Spring Hill Rd.		-	2.1%	-	7.0%	9.1%	18.9%	15.4%	-	14.7%	19.6%	13.3%	**100%**
10 - Leesburg Pike (Rt. 7)			-	0.4%	4.1%	7.9%	17.6%	14.6%	-	13.1%	27.7%	14.6%	**100%**
9 - Trap Rd.				-	-	-	-	-	-	-	-	-	**-**
8 - Hunter Mill Rd.					-	2.2%	15.8%	7.2%	-	11.5%	34.5%	28.8%	**100%**
7 - Wiehle Ave.						-	3.8%	5.0%	-	16.3%	58.8%	16.3%	**100%**
6 - Reston Pkwy.							-	10.6%	-	4.8%	52.9%	31.7%	**100%**
5 - Fairfax County Pkwy.								-	-	19.6%	41.3%	39.1%	**100%**
4 - Herndon-Monroe Park & Ride									-	50.0%	50.0%	-	**100%**
3 - Centreville Rd.										-	35.3%	64.7%	**100%**
2 - Sully Rd. (SR 28)											-	100.0%	**100%**
1 - Dulles Greenway												-	**-**

Figure 3-11 Interchange to Interchange Movements (Continued)

Midday Period - Eastbound

Entry \ Exit	1	2	3	4	5	6	7	8	9	10	11	12	Total
1 - Dulles Greenway	-	5.3%	2.9%	1.5%	8.0%	7.1%	3.6%	2.4%	-	11.2%	7.2%	50.8%	100%
2 - Sully Rd. (SR 28)		-	1.7%	0.7%	8.0%	5.6%	5.2%	4.3%	-	11.2%	6.9%	56.4%	100%
3 - Centreville Rd.			-	1.3%	3.9%	5.9%	3.3%	2.6%	-	17.0%	15.7%	50.3%	100%
4 - Herndon-Monroe Park & Ride				-	-	3.3%	6.7%	3.3%	-	16.7%	10.0%	60.0%	100%
5 - Fairfax County Pkwy.					-	4.1%	1.6%	1.3%	-	13.9%	11.7%	67.4%	100%
6 - Reston Pkwy.						-	2.7%	2.7%	-	14.2%	15.5%	64.8%	100%
7 - Wiehle Ave.							-	1.5%	-	16.8%	13.9%	67.9%	100%
8 - Hunter Mill Rd.								-	-	14.7%	12.7%	72.5%	100%
9 - Trap Rd.									-	9.1%	9.1%	81.8%	100%
10 - Leesburg Pike (Rt. 7)										-	6.3%	93.8%	100%
11 - Spring Hill Rd.											-	100.0%	100%
12 - I-495 / SR 123 / I-66												-	-

Midday Period - Westbound

Entry \ Exit	1	2	3	4	5	6	7	8	9	10	11	12	Total
12 - I-495 / SR 123 / I-66	-	2.2%	5.9%	1.0%	3.1%	5.8%	11.8%	10.9%	-	5.7%	23.6%	29.9%	100%
11 - Spring Hill Rd.		-	3.7%	0.6%	2.5%	5.6%	18.5%	14.8%	-	7.4%	28.4%	18.5%	100%
10 - Leesburg Pike (Rt. 7)			-	1.4%	3.7%	4.2%	16.7%	8.8%	-	7.4%	31.2%	26.5%	100%
9 - Trap Rd.				-	-	-	-	-	-	-	-	-	-
8 - Hunter Mill Rd.					-	4.0%	11.1%	7.9%	-	7.1%	37.3%	32.5%	100%
7 - Wiehle Ave.						-	5.4%	9.5%	-	2.7%	51.4%	31.1%	100%
6 - Reston Pkwy.							-	9.2%	-	8.0%	43.7%	39.1%	100%
5 - Fairfax County Pkwy.								-	-	8.9%	30.7%	60.4%	100%
4 - Herndon-Monroe Park & Ride									-	20.0%	20.0%	60.0%	100%
3 - Centreville Rd.										-	52.6%	47.4%	100%
2 - Sully Rd. (SR 28)											-	100.0%	100%
1 - Dulles Greenway												-	-

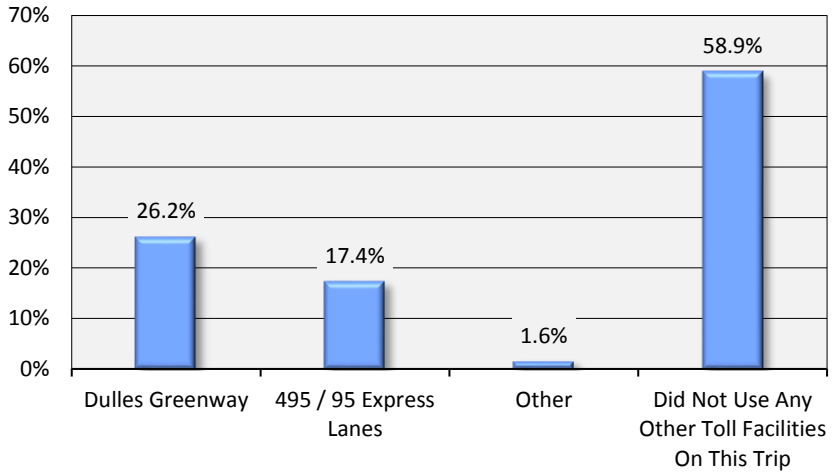
PM Peak Period - Eastbound

Entry \ Exit	1	2	3	4	5	6	7	8	9	10	11	12	Total
1 - Dulles Greenway	-	7.6%	1.1%	1.9%	8.2%	5.2%	4.3%	5.8%	-	10.8%	8.4%	46.5%	100%
2 - Sully Rd. (SR 28)		-	1.4%	0.3%	5.7%	7.9%	5.8%	7.2%	-	10.7%	8.2%	52.7%	100%
3 - Centreville Rd.			-	1.2%	1.2%	4.9%	3.1%	4.9%	-	12.3%	12.3%	59.9%	100%
4 - Herndon-Monroe Park & Ride				-	3.6%	7.1%	-	3.6%	-	3.6%	10.7%	71.4%	100%
5 - Fairfax County Pkwy.					-	2.8%	2.4%	3.3%	-	13.7%	9.5%	68.2%	100%
6 - Reston Pkwy.						-	2.7%	1.3%	-	11.7%	8.1%	76.2%	100%
7 - Wiehle Ave.							-	-	-	9.9%	10.9%	79.2%	100%
8 - Hunter Mill Rd.								-	-	13.8%	17.5%	68.8%	100%
9 - Trap Rd.									-	-	11.1%	88.9%	100%
10 - Leesburg Pike (Rt. 7)										-	9.8%	90.2%	100%
11 - Spring Hill Rd.											-	100.0%	100%
12 - I-495 / SR 123 / I-66												-	-

PM Peak Period - Westbound

Entry \ Exit	1	2	3	4	5	6	7	8	9	10	11	12	Total
12 - I-495 / SR 123 / I-66	-	1.7%	6.0%	3.7%	7.5%	5.6%	12.5%	12.6%	-	4.8%	23.3%	22.5%	100%
11 - Spring Hill Rd.		-	3.2%	2.1%	8.5%	5.3%	11.6%	11.1%	-	7.9%	24.9%	25.4%	100%
10 - Leesburg Pike (Rt. 7)			-	1.0%	2.2%	6.1%	11.2%	17.3%	-	8.0%	29.4%	24.9%	100%
9 - Trap Rd.				-	-	-	-	-	-	-	-	-	-
8 - Hunter Mill Rd.					-	1.0%	9.2%	8.2%	-	9.2%	27.6%	44.9%	100%
7 - Wiehle Ave.						-	1.9%	4.9%	-	9.7%	32.0%	51.5%	100%
6 - Reston Pkwy.							-	4.1%	-	7.4%	25.6%	62.8%	100%
5 - Fairfax County Pkwy.								-	-	7.3%	30.2%	62.5%	100%
4 - Herndon-Monroe Park & Ride									-	20.0%	20.0%	60.0%	100%
3 - Centreville Rd.										-	34.6%	65.4%	100%
2 - Sully Rd. (SR 28)											-	100.0%	100%
1 - Dulles Greenway												-	-

Figure 3-12 Use of Other Toll Roads

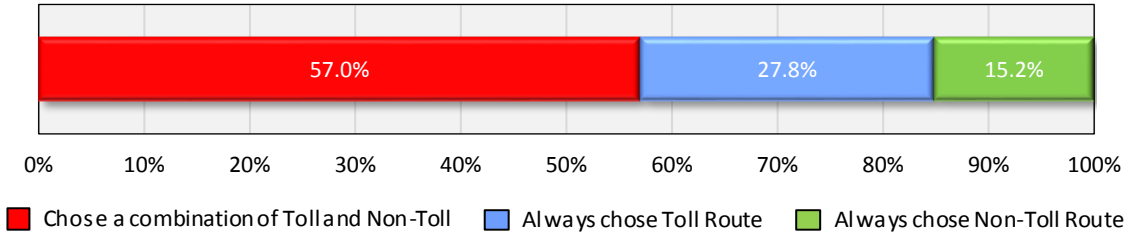


Stated Preferences

After completing the trip characteristics and travel pattern portion of the survey, respondents answered five stated preference trade-off exercises, each tailored to their reference trip.

As shown in **Figure 3-13**, 57 percent of the sample chose some combination of toll and non-toll routes during the five exercises, revealing their ability to make assessments about their own personal value of travel time savings while in a survey environment. Twenty-eight percent of respondents always chose the toll route option and 15 percent always chose the non-toll option, potentially revealing some bias either for or against toll roads.

Figure 3-13 Stated Preference Toll Choices

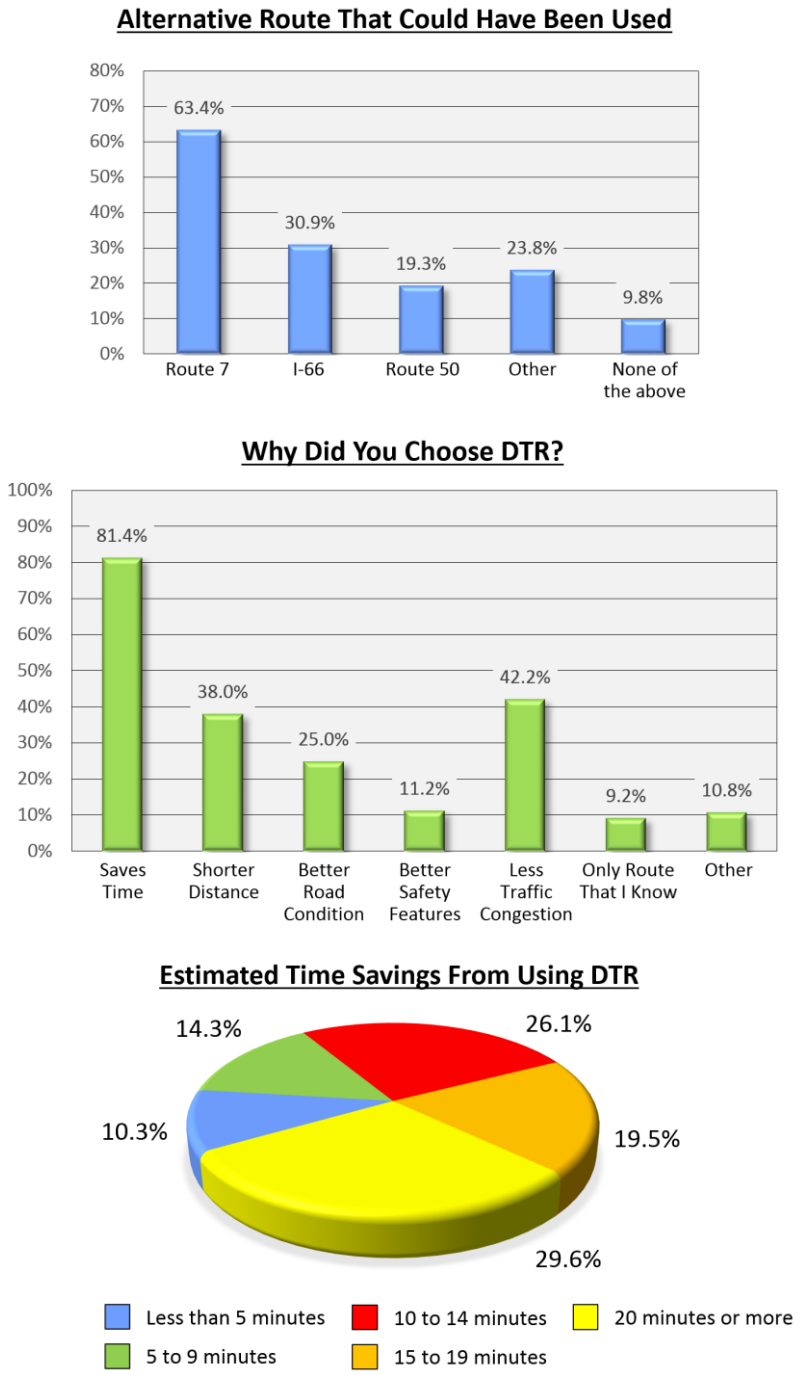


Customer Service

Respondents were asked to identify alternative routes that could have been used to make their trip, and why they chose to use the DTR instead of these alternatives. Responses to these questions are shown in **Figure 3-14**. Leesburg Pike (Route 7), being a straight route from Leesburg to Tysons Corner, was the most selected alternative to DTR at 63 percent. I-66 and a combination of other unspecified routes and local roadways were selected as the next best DTR alternatives, at 31 percent and 24 percent respectively.

In response to the question of why users chose the DTR, 81 percent cited the time savings, and 42 percent cited reduced traffic congestion. (Note that respondents could select more than one reason for this question.)

Figure 3-14 User Alternatives and Time Savings



Respondents' estimates of time savings provided by the DTR is also shown in Figure 3-14, with nearly 30 percent estimating time savings of 20 minutes or more. Combining several categories reveals more than 75 percent of respondents believe that the DTR saves them at least 10 minutes over their next preferred route. Estimated travel time savings are broken out by peak and off-peak time of day of travel in **Table 3-2**, which shows that the perception of time savings is consistently high, regardless of whether the user was describing a trip during a typically congested period or not.

Table 3-2
User Estimate of Time Saved by Using the DTR

	E-ZPass		Cash		Total	
	Count	Percent	Count	Percent	Count	Percent
No time savings	1,629	6.2%	15	8.1%	1,644	6.2%
Less than 5 minutes	1,093	4.1%	1	0.5%	1,094	4.1%
5 to 9 minutes	3,797	14.3%	24	12.9%	3,821	14.3%
10 to 14 minutes	6,902	26.1%	47	25.3%	6,949	26.1%
15 to 19 minutes	5,167	19.5%	36	19.4%	5,203	19.5%
20 minutes or more	7,840	29.6%	52	28.0%	7,892	29.6%
No Response	50	0.2%	11	5.9%	61	0.2%
Grand Total	**26,478**	**100.0%**	**186**	**100.0%**	**26,664**	**100.0%**

In addition to the time savings provided by the DTR, survey respondents also gave high overall satisfaction ratings of DTR facilities. **Figure 3-15** presents the results of the customer satisfaction questions asked of cash and E-ZPass users. In all but one category, ratings were positive. For seven of the eight questions, between 80 and 96 percent of respondents rated conditions either Satisfactory or Very Satisfactory. The time savings benefit gained by using a transponder was the most frequently cited source of satisfaction, with 61 percent giving a rating of Very Satisfied and an additional 35 percent rating Satisfied.

Two cash-customer targeted questions were geared toward determining their reasons for paying cash rather than using an E-ZPass transponder, and to discover what payment methods these customers might prefer if paying cash were no longer an option. Forty-nine percent of cash customers chose the self-service credit/debit machines as their preferred alternative method of payment in the absence of a cash option, followed by E-ZPass (40 percent) and Pay Later (Bill by Mail) (26 percent). Only 16 percent of respondents stated that they would no longer use the DTR if cash was no longer an option. (Note that respondents could select more than one answer to this question.)

Figure 3-15 reveals that the largest share of cash respondents (37 percent) pointed to the lack of a toll discount offered to E-ZPass customers as a reason to continue paying with cash. Another sizable group (26 percent) offered another financial reason for paying cash instead of opening an E-ZPass account: avoidance of pre-paying tolls. Other reasons included infrequency of use (32 percent) and privacy concerns (20 percent). Of the 29 percent who selected the "Other," over one-quarter explained they were actually E-ZPass customers who had forgotten their transponder on that particular trip. (Note that respondents could select more than one answer to this question.)

Demographics

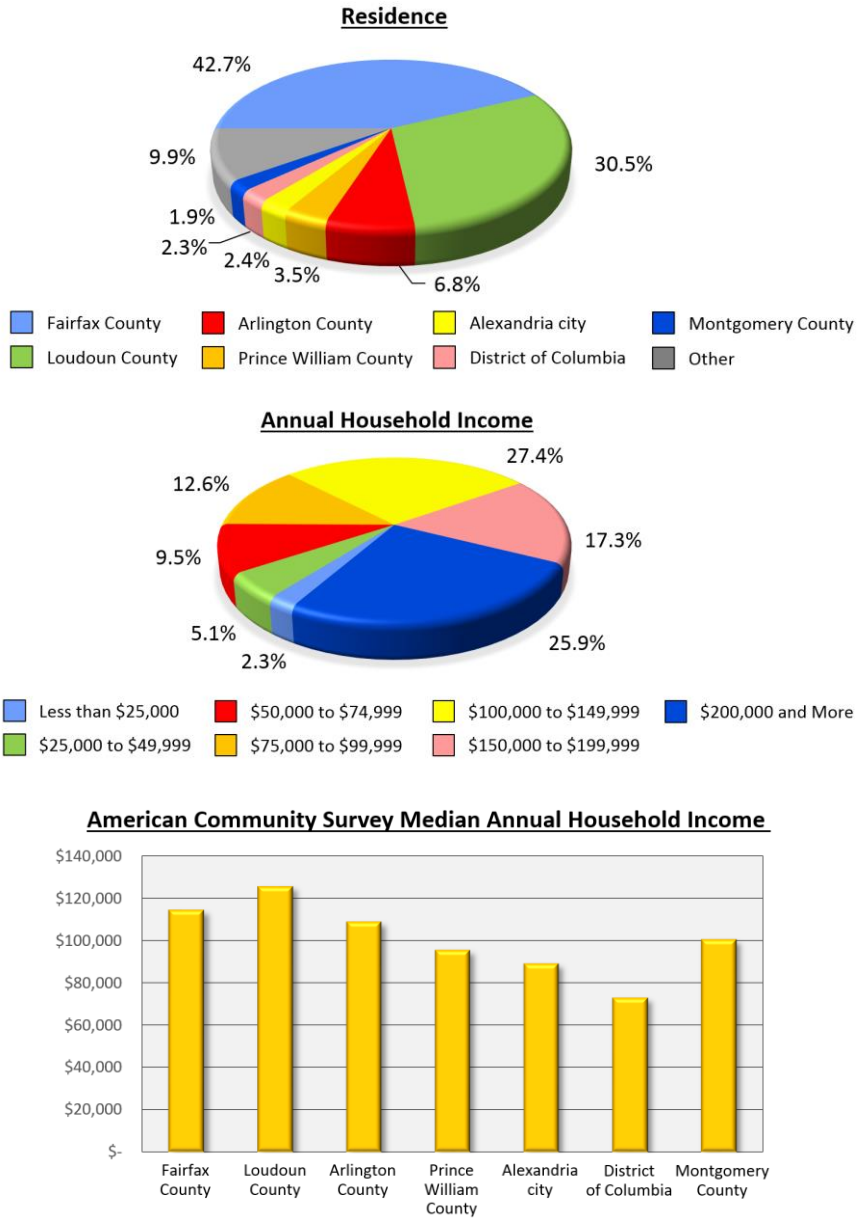
To conclude the survey, respondents were asked to provide their home ZIP code and an estimate of their annual household income before taxes. Using this data, it is possible to get an idea of the market area of the DTR and to compare the household incomes of sampled toll road customers with other residents of the community. **Figure 3-16** includes charts showing the breakdown of survey respondents by home county, as well as user-provided household incomes. Fairfax County is home to

Figure 3-15 Toll Road Opinion Questions Results

the largest percentage of survey respondents, at 43 percent, followed by Loudoun County at 31 percent. Arlington, Prince William, City of Alexandria, and Washington, D.C. together account for 15 percent of respondents, and Montgomery County, Maryland accounts for 2 percent.

The U.S. Census American Community Survey estimates for median annual household incomes for each of these counties are also given in Figure 3-16. They range from a low of $73,000 in Washington, D.C. to a high of $126,000 in Loudoun County, with Montgomery County in the middle at $100,000.

Figure 3-16 Survey Respondent Demographics



Source: Dulles Toll Road Travel Survey, CDM Smith; 2012-2016 American Community Survey, U.S. Census

The survey area therefore represents a relatively high-income market area. The subset of residents within the market who can afford to use the toll roads have higher incomes still, as evidenced by the reported annual household incomes of survey respondents. Over 70 percent of survey respondents estimate their household income at more than $100,000. In fact, $200,000 annual household income was the second largest single income group from the survey, at 26 percent. It is important to note these elevated incomes when considering the VOT estimates generated by the multinomial choice model, discussed in the following section.

Model Estimation

One of the objectives of the stated preference surveys was to estimate reliable VOTs for automobile travelers who use the toll road. These VOT estimates supported estimates of traffic and revenue for this project.

Statistical analysis and discrete choice model estimation were carried out using the stated preference survey data. The statistical estimation and specification testing were completed using a conventional maximum likelihood procedure that estimated a set of coefficients for a multinomial logit model. The experiment design and model estimation process are explained in detail in **Appendix A** of this report.

Willingness to Pay for Travel Time Savings (Value of Time)

The expression for calculating willingness to pay for travel time savings, or VOT, is shown below. VOT is calculated by dividing the travel time coefficient from the multinomial model by the toll cost coefficient and then multiplying by 60 to convert from dollars per minute to dollars per hour. If an income-based log transformation was applied to the toll cost attribute prior to model specification, then the same transformation is applied to the toll cost coefficient when calculating VOT. In this case, toll cost was transformed by the natural log of household income, in ten thousands.

$$VOT = 60 * {\beta Time} \Big/ \left(\frac{\beta Cost}{LN(income/10{,}000)}\right)$$

The aggregate VOT for the full sample, at the survey sample median income level of $137,500, was calculated as $19.38 per hour. The values of time evaluated at each income category midpoint by market segment and by customer type are shown in **Table 3-3**.

Table 3-3
Value of Time

		Peak Period		Off-Peak Period	
Household Income	**Full Sample**	**Work**	**Non-Work**	**Work**	**Non-Work**
$20,000 and Less	$5.13	$5.14	$4.89	$4.57	$4.19
$30,000	$8.12	$8.15	$7.75	$7.24	$6.64
$42,500	$10.70	$10.74	$10.20	$9.53	$8.75
$62,500	$13.55	$13.60	$12.92	$12.07	$11.08
$87,500	$16.04	$16.10	$15.29	$14.29	$13.11
*$112,500	$17.90	$17.96	$17.07	$15.95	$14.63
**$137,500	$19.38	$19.45	$18.48	$17.27	$15.85
$175,000	$21.17	$21.24	$20.18	$18.86	$17.30
$200,000 and More	$23.03	$23.11	$21.95	$20.51	$18.82

**Fairfax County median income: $114,000*
***Survey sample median income: $137,500*

These values are consistent with USDOT guidelines for valuation of travel time[1], which suggest a plausible range for value of travel time savings as being between 35 and 60 percent of average regional person hour earnings for local trips. According to data from the 2016 American Community Survey[2], the average hourly wages of Fairfax and Loudoun counties—the home counties of 73.2 percent of all respondents in this survey—were $42.85 and $44.69, respectively, suggesting a value of time for a representative household as being between $15.00 and $26.26 per hour.

Summary and Conclusion

A successfully developed and implemented origin-destination and stated preference survey questionnaire gathered information from 26,664 current DTR travelers. The purpose of the survey was to measure the VOT of travelers within the DTR market area. The questionnaire collected data on current travel behavior and engaged the travelers in a series of stated preference experiments to measure their propensity to use the toll road under a variety of travel time and toll cost conditions.

Cash user participation in the survey was limited, owing to the relative difficulty of encouraging users to seek out and manually enter the URL address of a survey website from a postcard handout compared with E-ZPass customers, who were able to follow a hyperlink provided in the email invitation. However, E-ZPass usage is high on the facility and growing, so the low levels of cash user response are not of major concern.

Choice models were developed to produce estimates of VOT for travelers in the region. The magnitude and signs of the sensitivity estimates are reasonable and intuitively correct, and the VOTs that were estimated are consistent with what would be expected given the demographic and trip characteristics of the sampled travelers. As would be expected, travelers commuting to and from work during the peak period were found to have the highest VOTs. Overall, customer VOTs were estimated to range from $4.19 to $23.11 per hour, depending on trip purpose, travel time, and household income. These estimates of VOTs and propensity to use the DTR have been incorporated into the travel demand model to support estimates of traffic and revenue as discussed in **Chapter 5: Traffic and Revenue Analysis**.

[1] U.S. Dept. of Transportation. *Revised Departmental Guidance on Valuation of Travel Time in Economic Analysis*. 2016.
[2] U.S. Census Bureau American FactFinder. "S2303: Work Status in the Past 12 Months." 2012 – 2016 American Community Survey.

Chapter 4
Corridor Growth Assessment

Regional growth of population, households, and employment are key inputs for the trip generation step in building travel demand model trip tables. These trip tables serve as the foundation of model forecasting; therefore, significant resources were devoted to reviewing underlying demographic assumptions. The regional socioeconomic forecasts used in the travel demand modeling process were prepared for the Washington, D.C. metropolitan area and for the Dulles Corridor in detail. The forecasts consider regional agency forecasts, independent third-party forecasts, and specialized analysis by an independent economic firm to resolve differences and account for localized development projects.

The Metropolitan Washington Council of Governments, known as MWCOG, was established in 1957 as an independent non-profit association to help develop regional solutions to such issues as transportation, the environment, affordable housing, growth and development, public health, child welfare, public safety, and homeland security. MWCOG's Cooperative Forecasting Program, established in 1975, is a joint effort with the federal government and local governments of the region to produce a consistent set of long-range economic and demographic forecasts for use in metropolitan and local planning programs. This process provides common assumptions about future growth and development in the region and results in forecasts of employment, households, and population by 5-year increments for the entire MWCOG region, individual member jurisdictions, and small-area traffic zones within each jurisdiction. The latest MWCOG regional zone system is comprised of a total of 3,722 geographic areas (Traffic Analysis Zones or "TAZ") in the Washington region. The current socioeconomic cooperative forecasts prepared for the total TAZ system, released in March 2016, is referred to as the 'Round 9.0 Cooperative Forecast.'

Independent third party socioeconomic estimates and forecasts used include Moody's Analytics and Woods & Poole Economics, which are generated by sector for counties across the country.

As part of this study, Renaissance Planning Group (RPG) was retained to conduct an independent validity analysis of the MWCOG Round 9.0 socioeconomic data. A separate report by RPG has been prepared and is included in **Appendix B**. Key features of that report are included here.

This chapter begins by describing historical socioeconomic trends in the region, generally based on data from Woods & Poole Economics, Inc. and the Bureau of Labor Statistics. This data is provided for historic growth context and is not a direct input to the refined CDM Smith travel demand model. The remainder of the chapter provides a summary of long-term demographic and economic forecasts from a variety of sources, as well as RPG's findings and adjusted socioeconomic forecast for the Washington, D.C. metropolitan area and Dulles Corridor, which is used as a direct input to the CDM Smith model.

Historical Population Growth by Jurisdiction

Table 4-1 shows the historical population trends for major jurisdictions in the Washington, D.C. metropolitan area. The total population of these jurisdictions has observed a steady annual growth rate of 1.3 percent from 1970 to 2017, adding nearly 2.5 million additional residents during that time.

Table 4-1
Historical Population Growth by Jurisdiction
(thousands)

County	1970	CAGR	1980	CAGR	1990	CAGR	2000	CAGR	2010	CAGR	2015	CAGR	2017	1970-2017 CAGR
District of Columbia	755.4	-1.7%	637.2	-0.5%	605.3	-0.6%	572.0	0.6%	605.1	2.1%	672.2	0.6%	679.7	-0.2%
Fairfax County, VA [1]	489.6	2.6%	631.4	3.0%	851.1	1.7%	1,007.5	1.1%	1,121.9	1.0%	1,180.1	1.8%	1,222.1	2.0%
Arlington County, VA	174.3	-1.3%	153.3	1.1%	171.2	1.0%	189.2	1.0%	209.4	1.8%	229.2	0.6%	231.8	0.6%
Alexandria City, VA	110.8	-0.7%	103.6	0.7%	111.5	1.5%	129.2	0.9%	140.8	1.7%	153.5	0.7%	155.6	0.7%
Prince William County, VA [2]	112.7	4.1%	168.6	4.1%	251.6	2.7%	329.8	3.4%	459.1	2.1%	509.2	1.8%	528.1	3.3%
Loudoun County, VA	37.4	4.4%	57.8	4.2%	87.2	7.1%	173.9	6.1%	315.6	3.5%	375.6	2.8%	396.9	5.2%
Montgomery County, MD	525.1	1.0%	581.9	2.8%	765.5	1.4%	877.5	1.1%	976.2	1.3%	1,040.1	0.9%	1,059.9	1.5%
Prince George's County, MD	666.9	0.0%	665.6	0.9%	725.9	1.0%	803.1	0.8%	865.9	1.0%	909.5	0.8%	923.8	0.7%
Frederick County, MD	85.4	3.1%	115.8	2.7%	151.3	2.6%	196.6	1.8%	234.2	0.9%	245.3	1.3%	251.6	2.3%
Total	**2,957.6**	**0.5%**	**3,115.1**	**1.8%**	**3,720.6**	**1.4%**	**4,278.8**	**1.4%**	**4,928.2**	**1.5%**	**5,314.9**	**1.3%**	**5,449.5**	**1.3%**

Source: Population data from Woods & Poole Economics, Inc. (W&P) CEDDS 2017 publication.

[1] Fairfax County + Fairfax City + Falls Church.

[2] Prince William County + Manassas + Manassas Park.

Between 1970 and 1980, the region's population grew at an annual rate of 0.5 percent, adding about 157,600 residents. Loudoun and Prince William counties grew most, exceeding 4.0 percent per year. Fairfax County grew at 2.6 percent annually in this period.

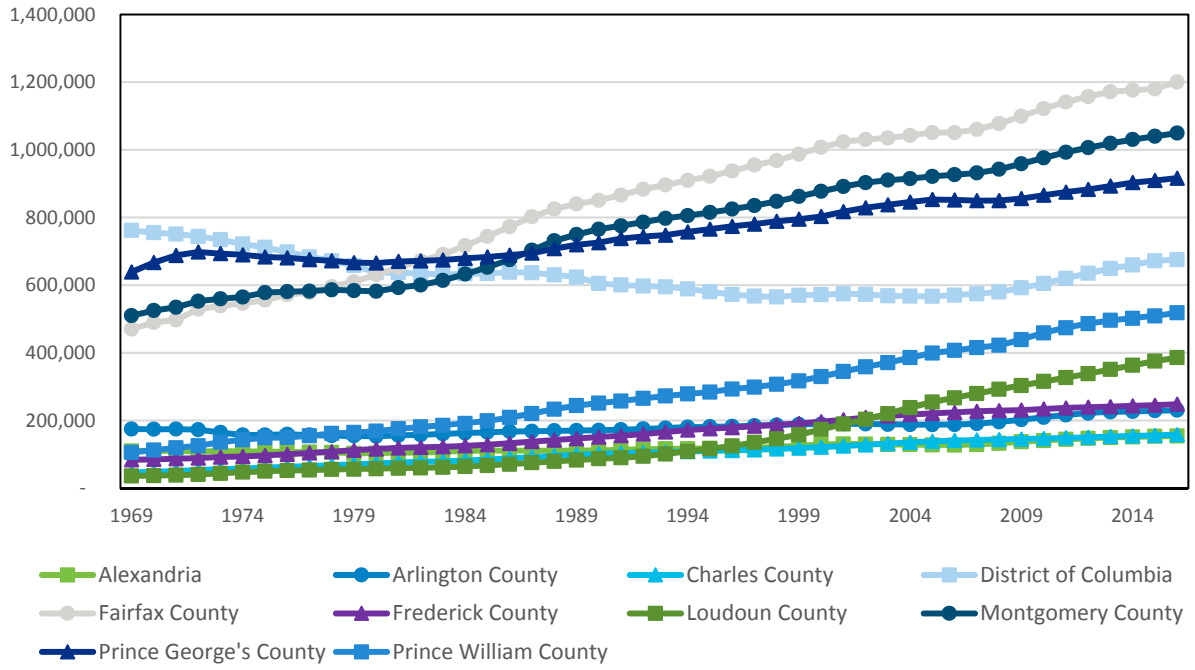
Between 1980 and 1990, the regional population annual growth rate increased to approximately 1.8 percent, with Loudoun, Prince William and Fairfax again experiencing the highest growth rates. Population growth continued to 2000, with 7.1 percent growth in Loudoun County since 1990. In these 3 decades (1970 to 2000) Washington, D.C.'s population fell from over three quarters of a million residents to approximately 570,000.

Between 2000 and 2017, strong population growth continued despite the economic slowdown beginning in 2008. Counties immediately west and north of the District showed particularly strong growth. In absolute terms, Loudoun, Fairfax, Prince William, and Montgomery (MD) counties saw the highest population increases, adding approximately 223,000, 215,000, 198,000, and 182,000 residents, respectively, during this period for a total of an 818,000 increase. The remainder of the region grew by a total of just 352,000.

Overall, Loudoun and Prince William counties have led regional growth in the past 47-year period, with annual average growth rates of 5.2 percent and 3.3 percent, respectively. Fairfax County has shown lower growth rates than these counties but started from a higher benchmark and is now the most populous jurisdiction in the region.

Figure 4-1 illustrates long term population trends by jurisdiction. In this graphic it is easy to see the rise of the suburban counties, while Washington, D.C. lost population during the first three decades of DTR operation. The counties of Fairfax, Montgomery, Prince William, and Loudon, along with Prince George's to a lesser extent, led regional growth. Beginning around 2000, population growth in Washington, D.C. began to rebound, while the five counties continued already strong growth patterns.

Figure 4-1 Historical Changes in Jurisdictional Population



Source: RPG interpretation of Woods & Poole Economics

Historical Employment Growth by Jurisdiction

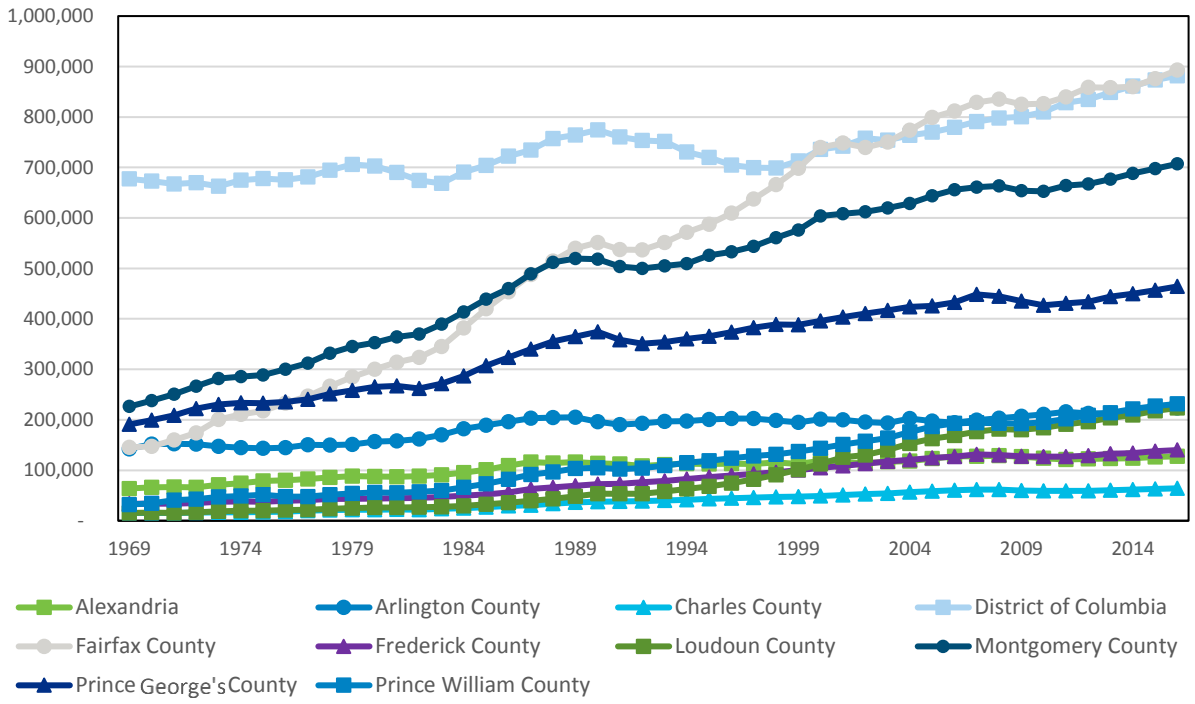
The historical employment trend in the region by jurisdiction is shown in **Table 4-2**. Total employment in the nine jurisdictions has increased by nearly 2.4 million in the 47 years shown. This equates to a compound annual growth rate of 2.0 percent, with a high 3.3 percent in the decade of 1980-1990. Again, the counties of Fairfax, Loudoun, and Prince William maintained high growth rates compared to other jurisdictions.

Employment levels fell about 0.1 percent between 2008 and 2010 because of the economic downturn, but the regional job market has since rebounded successfully. Since 2010, the nine-jurisdiction area gained approximately 394,000 jobs, reflecting a growth rate of 1.5 percent.

Figure 4-2 illustrates these long-term employment trends by jurisdiction. During the first three decades of DTR operation, employment growth was very strong in Fairfax, Montgomery, and Prince George's counties. Washington, D.C. employment was flat, with some variations through the 1980s. From 2000 onward, Washington, D.C., Prince William County, and Loudon County showed significantly stronger growth than prior years, while growth in the City of Alexandria (Virginia) and Montgomery and Prince George's counties (Maryland) has tapered.

Taking a close look at impacts on the Washington, D.C. metropolitan region's employment in recent years, **Figure 4-3** presents the nationwide; statewide; Washington-Arlington-Alexandria; Washington, D.C.-Virginia-Maryland-West Virginia Metropolitan Statistical Area (MSA) monthly unemployment rates since the year 2000. Unemployment rates presented are not seasonally adjusted. From the general trend, it can be observed that the Washington, D.C. metropolitan area withstood the recession considerably better than the rest of nation. The unemployment rates of the MSA have generally remained 2.0 to 4.0 percent lower than the national average over the past decade. Washington, D.C., however, has seen consistently higher unemployment than the national average.

Figure 4-2 Historical Changes in Jurisdictional Employment



Source: RPG interpretation of Woods & Poole Economics

Table 4-2
Historical Employment Growth by Jurisdiction
(thousands)

County	1970	CAGR	1980	CAGR	1990	CAGR	2000	CAGR	2010	CAGR	2015	CAGR	2017	1970-2017 CAGR
District of Columbia	673.0	0.4%	702.5	1.0%	774.5	-0.5%	735.9	1.0%	809.9	1.5%	873.1	1.0%	890.3	0.6%
Fairfax County, VA [1]	147.6	7.4%	300.0	6.3%	550.9	3.0%	739.3	1.1%	826.4	1.2%	876.0	1.9%	910.1	3.9%
Arlington County, VA	151.5	0.3%	156.7	2.3%	195.9	0.3%	201.1	0.5%	210.6	1.0%	221.2	0.9%	225.1	0.8%
Alexandria City, VA	66.0	2.9%	87.8	2.6%	113.7	0.5%	119.0	0.4%	123.7	0.5%	126.5	1.0%	129.1	1.4%
Prince William County, VA [2]	34.6	4.9%	56.0	6.5%	104.6	3.2%	143.4	3.1%	194.7	3.1%	226.9	2.0%	236.0	4.2%
Loudoun County, VA	15.9	5.0%	25.9	7.5%	53.6	7.7%	112.4	5.1%	184.0	3.4%	217.7	2.6%	229.3	5.8%
Montgomery County, MD	237.7	4.0%	352.8	3.9%	518.2	1.5%	604.0	0.8%	652.4	1.4%	697.8	1.3%	716.1	2.4%
Prince George's County, MD	199.5	2.9%	265.0	3.5%	374.1	0.6%	396.0	0.8%	427.2	1.4%	457.0	1.6%	471.4	1.8%
Frederick County, MD	33.6	2.8%	44.2	5.1%	72.5	3.8%	104.9	1.9%	127.2	1.6%	137.6	1.7%	142.4	3.1%
Total	**1,559.4**	**2.5%**	**1,990.8**	**3.3%**	**2,757.9**	**1.4%**	**3,156.0**	**1.2%**	**3,556.1**	**1.5%**	**3,833.8**	**1.5%**	**3,949.7**	**2.0%**

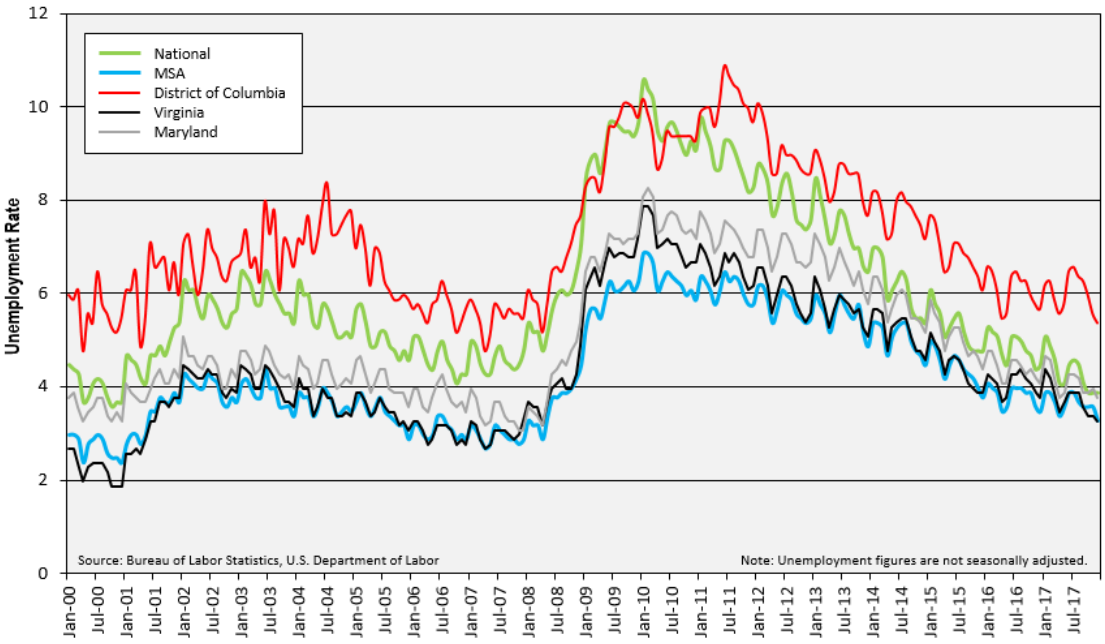
Source: Employment data from Woods & Poole Economics, Inc. (W&P) CEDDS 2017 publication.
Note: Woods & Poole data may be higher than that from other sources because more kinds of employment are measured. The Woods & Poole employment database includes a complete measure of the number of full- and part-time jobs, including wage and salary workers, proprietors, private household employees, and miscellaneous workers. A person holding two part-time jobs, for instance, would be counted twice in the Woods & Poole estimate. [3]

[1] Fairfax County + Fairfax City + Falls Church.

[2] Prince William County + Manassas + Manassas Park.

[3] *Methodology Notes for 2014 Projections* . Woods & Poole Economics, Inc. Sage Busines Stats. http://data.sagepub.com/sagestats/html/public/WP Methodology.pdf

Figure 4-3 Regional and National Unemployment Rates



As can be noted from Figure 4-3, the Washington, D.C. MSA unemployment rate largely mirrored the national unemployment rate pattern from mid-2007 through early-2009. The MSA rebounded earlier than the national employment rate and the gap between the region and the nation increased to 3.7 percent when the national unemployment rate reached its peak of 10.6 percent in January 2010. Since early 2010, the MSA unemployment rate has continued a steady decline, reaching a low of 3.3 percent at the end of 2017.

Table 4-3 shows the historical non-farm employment levels in the Washington, D.C. MSA since 2008. Annual average employment has increased by about 261,000 jobs, rising to approximately 3.3 million jobs in 2017. The MSA lost a total of 50,000 non-farm jobs in 2009 but subsequently gained a total of 311,000 jobs by 2017, for an overall increase of 10.5 percent.

Historical Median Income by Jurisdiction

Travel demand on a toll facility is sensitive to, among other things, the amount of disposable income available in a household. An indicator of an individual's propensity to pay tolls instead of taking a toll-free alternative is his/her personal income. This income is a key input into the assessment of the VOT for a motorist, as there is typically a strong correlation between VOT, income, and the motorist's willingness to pay.

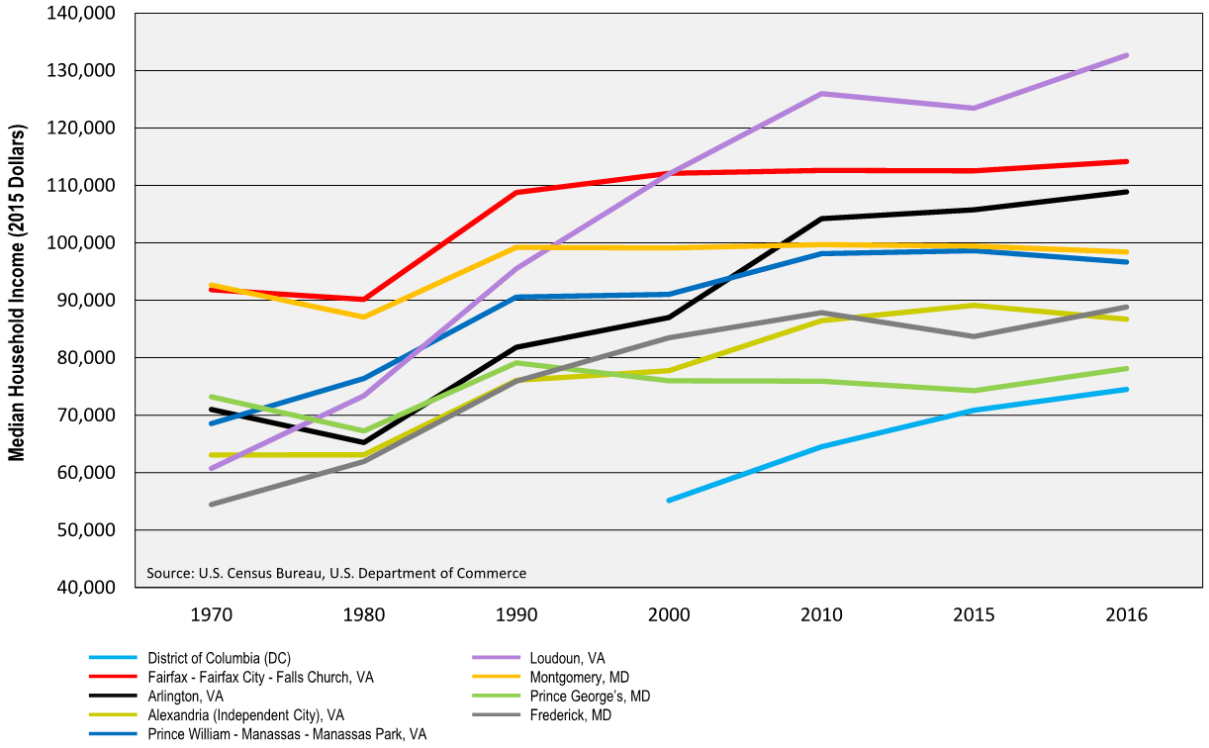
The historical regional household income trend by jurisdiction is shown in **Figure 4-4**. Area household income has increased steadily in the last few decades in several study area jurisdictions, with the largest growth since 2000 occurring in Loudoun County, Arlington County, and Washington, D.C. Household income growth is noticeably lower in the remainder of the region.

Table 4-3
Trends in Washington-Arlington-Alexandria, DC-VA-MD-WV MSA Employment Levels
Total Nonfarm Not Seasonally Adjusted (thousands)

Month	2008	Percent Change	2009	Percent Change	2010	Percent Change	2011	Percent Change	2012	Percent Change	2013	Percent Change	2014	Percent Change	2015	Percent Change	2016	Percent Change	2017
January	2,979.6	-0.7%	2,958.1	-1.3%	2,920.5	0.2%	2,968.8	1.1%	3,001.6	1.6%	3,050.3	4.6%	3,054.3	3.5%	3,103.6	1.9%	3,162.6	1.8%	3,218.2
February	2,989.9	-1.1%	2,957.7	-2.0%	2,898.7	0.3%	2,979.3	1.3%	3,016.9	1.6%	3,064.9	5.7%	3,062.6	3.6%	3,116.0	1.9%	3,174.1	2.1%	3,240.0
March	3,008.6	-1.4%	2,966.8	-0.7%	2,945.4	0.3%	3,001.9	1.4%	3,044.8	1.2%	3,081.3	4.6%	3,080.9	3.7%	3,124.1	2.3%	3,194.5	1.6%	3,246.4
April	3,027.9	-2.0%	2,967.2	0.5%	2,982.8	0.9%	3,028.2	1.0%	3,059.0	1.2%	3,096.9	4.2%	3,108.3	3.9%	3,155.4	2.4%	3,230.3	1.1%	3,266.0
May	3,044.6	-2.0%	2,982.4	0.8%	3,007.6	0.4%	3,029.2	1.5%	3,073.4	1.2%	3,108.9	4.1%	3,131.3	3.5%	3,178.3	1.9%	3,240.0	1.4%	3,285.0
June	3,050.6	-1.9%	2,992.0	0.9%	3,019.5	0.4%	3,045.6	1.4%	3,088.6	0.8%	3,112.1	4.0%	3,140.6	3.4%	3,190.0	1.8%	3,246.9	2.0%	3,312.6
July	3,048.1	-1.9%	2,988.7	1.0%	3,017.2	1.0%	3,052.6	0.8%	3,077.9	1.0%	3,107.3	3.5%	3,123.4	3.7%	3,189.6	1.5%	3,238.4	2.6%	3,323.4
August	3,036.5	-2.2%	2,969.4	0.5%	2,984.8	0.5%	3,026.6	1.3%	3,066.3	0.9%	3,092.7	4.2%	3,110.8	3.7%	3,170.9	1.8%	3,227.3	2.1%	3,294.4
September	3,026.8	-2.4%	2,955.4	1.2%	2,991.0	1.2%	3,044.7	1.1%	3,078.8	0.8%	3,102.4	4.6%	3,128.1	3.6%	3,187.4	1.7%	3,241.5	1.6%	3,293.4
October	3,029.1	-1.7%	2,976.7	1.2%	3,012.2	0.7%	3,050.4	1.6%	3,100.1	0.2%	3,106.3	4.3%	3,143.1	3.7%	3,212.7	1.5%	3,260.0	1.5%	3,307.3
November	3,030.2	-1.3%	2,989.5	1.1%	3,023.5	0.7%	3,060.9	1.7%	3,113.6	0.4%	3,127.1	4.4%	3,155.5	3.6%	3,226.8	1.3%	3,267.8	1.6%	3,320.0
December	3,028.8	-1.2%	2,991.9	1.3%	3,029.4	0.5%	3,065.4	1.5%	3,112.3	0.2%	3,119.8	4.1%	3,154.1	3.7%	3,230.9	1.2%	3,269.8	1.7%	3,324.8
Annual Average	**3,025.1**	**-1.7%**	**2,974.7**	**0.4%**	**2,986.1**	**0.6%**	**3,029.5**	**1.3%**	**3,069.4**	**0.9%**	**3,097.5**	**4.4%**	**3,116.1**	**3.6%**	**3,173.8**	**1.8%**	**3,229.4**	**1.8%**	**3,286.0**

Source: Bureau of Labor Statistics; data retrieved March, 2018

Figure 4-4 Historical Median Household Income by Jurisdiction



Long-Term Regional Socioeconomic Forecasts

CDM Smith retained RPG to conduct an independent economic growth analysis based on socioeconomic projections generated by MWCOG, other sources, and RPG's own analysis. RPG's analysis includes a reasonableness test of the TAZ level and countywide socioeconomic data relative to current economic conditions and trends, the availability of vacant and underutilized land, and the propensity for development and redevelopment in different parts of the region. The economic analysis and socioeconomic forecast adjustments prepared by RPG were utilized as an integral part of the toll forecasting model. A detailed report prepared by RPG has been included as **Appendix B** of this report. Below is a summary of RPG's approach, analysis, and findings.

Approach of the Independent Economist

RPG collected countywide population and employment data for 2015 and 2017 and prepared forecasts for 2017, 2020, 2025, 2030, 2035, and 2040 for the core and suburban counties of the Washington, D.C. metropolitan area including: Arlington, Fairfax, Loudoun, and Prince William Counties in Virginia; Frederick, Montgomery, and Prince George's counties in Maryland; and Washington, D.C. The forecasts have been generated considering 2010 and prior U.S. Decennial Census results, public and private forecasts, and the Round 9.0 forecasts created by MWCOG.

RPG identified a DTR Primary Market Area based on a critical mass of origin-destination information obtained from prior DTR patron surveys. They then reviewed the interagency and intergovernmental coordination to understand the MWCOG forecasting methods. RPG compared the MWCOG forecasts against several alternative private and public sources. A macroeconomic assessment of past trends, present conditions, and near-term prospects for development absorption and job creation within the regional was prepared. Using this information and the macroeconomic factors of population and

employment, a jurisdiction level forecast for 2020 through 2040 was prepared to guide final adjusted forecasts. Following this, RPG conducted a detailed parcel level evaluation of the existing conditions and supply side factors to validate micro-level MWCOG forecasts in the Primary Market Area. Final TAZ, jurisdiction, and Primary Market Area forecasts were developed based on adjusted 2010 population and employment, supply analysis, macroeconomic guidance, and forecasting model based on MWCOG assumptions.

Independent Economist Socioeconomic Forecasts Adjustments

In terms of the macroeconomic analysis, it was found that the metropolitan area had key attributes which affect its economic viability over the long term. Strengths included:

- A competitive advantage nationally due to positive trends in population, employment, and the economy
- A growing population, complemented by a high-quality job market and a strong, albeit consolidated, traded sector
- The individual jurisdictions within the region continue to grow "together"

Weaknesses included:

- Some elements that strengthen the MWCOG region also expose it to economic volatility, such as a high reliance on the professional, scientific, and technical services sectors.
- Due to its attractiveness, the region has a relatively high cost of living that is not commensurate with slow income growth and which may be attributed to stagnating federal job growth.
- In the long-term, the region is susceptible to changes in federal spending, but long-term federal job loss has not impeded regional growth to date.
- The private sector remains heavily dependent on public contracts.

The results of the macroeconomic analysis and subsequent population forecast adjustments are summarized below.

- Macroeconomic trends suggest slightly higher population growth than the MWCOG forecast.
- The MWCOG forecast for Washington, D.C. was dramatically higher than outside forecasts, as well as what is suggested by the macroeconomic finding of a region likely to experience less differentiation in growth patterns.
- The MWCOG forecast for Loudoun County was dramatically lower than outside forecasts after 2025, in response to a policy-based expectation of long-term growth management. However, a regional evaluation of land availability and much higher outside forecasts led to upward adjustments in the applied forecast.
- Fairfax County and Montgomery County were adjusted upward in the applied forecast, in response to outside forecasters' higher growth expectations and macroeconomic trends.

- Prince George's County was adjusted upward in the applied forecast, with the expectation that long-term regional growth pressures and strong regional access to jobs and amenities in the county will encourage growth

Similarly, adjustments for employment are summarized below.

- Overall, employment was nearly identical at the regional scale between MWCOG and the applied forecast. The allocations to the associated jurisdictions have some differences.
- The MWCOG forecast for Washington, D.C. employment was notably higher than outside forecasts. The employment forecast for the jurisdiction was adjusted down.
- The MWCOG forecast for Loudoun County was viewed as too low, due to an overemphasis on existing growth management intentions and was thus adjusted upward.
- Prince George's County employment was viewed as too low, though by a smaller proportion than population due to the expectation that population demand will be the primary driver of county growth.

Tables 4-4 through **4-7** present the final jurisdiction level adjusted forecasts for population and employment for the study region and compare them to the MWCOG baseline. Table 4-4 indicates the nine-jurisdiction region is expected to add approximately 1.2 million residents from 2017 to 2040, 60 percent of which is expected in Fairfax, Loudoun, Montgomery, and Prince William counties. With this forecast, projected annual average population growth through 2040 is 0.9 percent per year.

Table 4-4
Population Growth by Jurisdiction
(thousands)

County	2015	CAGR	2017	CAGR	2020	CAGR	2025	CAGR	2030	CAGR	2035	CAGR	2040	2015-2040 CAGR
District of Columbia	670	1.2%	687	1.2%	711	0.9%	744	1.1%	785	0.9%	819	1.0%	860	1.0%
Fairfax County, VA [1]	1,175	0.7%	1,192	0.7%	1,216	0.8%	1,263	0.9%	1,321	0.7%	1,371	0.8%	1,430	0.8%
Arlington County, VA	228	1.1%	233	1.0%	240	0.9%	251	1.0%	263	0.7%	273	0.9%	285	0.9%
Alexandria City, VA	153	1.1%	157	1.1%	162	0.9%	169	0.9%	178	0.7%	184	1.0%	193	0.9%
Loudoun County, VA	375	2.6%	394	2.2%	421	1.8%	460	1.4%	494	1.0%	519	0.9%	542	1.5%
Prince William County, VA [2]	488	1.3%	501	1.3%	520	1.0%	546	1.2%	578	0.9%	605	1.1%	639	1.1%
Montgomery County, MD	1,015	1.0%	1,035	0.9%	1,064	0.7%	1,102	0.8%	1,150	0.6%	1,187	0.8%	1,234	0.8%
Prince George's County, MD	904	0.8%	918	0.7%	939	0.6%	969	0.7%	1,003	0.6%	1,034	0.6%	1,067	0.7%
Frederick County, MD	247	1.3%	253	1.3%	263	1.0%	276	1.0%	290	0.9%	304	1.0%	319	1.0%
Total	**5,256**	**1.1%**	**5,369**	**1.0%**	**5,537**	**0.9%**	**5,781**	**1.0%**	**6,062**	**0.8%**	**6,294**	**0.9%**	**6,569**	**0.9%**

Source: MWCOG Round 9.0 forecast adjusted by RPG.
[1] Fairfax County + Fairfax City + Falls Church.
[2] Prince William County + Manassas + Manassas Park.

Table 4-5
Difference of Final Population Forecast and MWCOG Round 9.0
(thousands)

County	2015		2017		2020		2025		2030		2035		2040	
	Abs Diff	%Diff	Abs Diff	%Diff	Abs Diff	%Diff	Abs Diff	%Diff	Abs Diff	%Diff	Abs Diff	%Diff	Abs Diff	%Diff
District of Columbia	-1.9	-0.3%	-8.6	-1.3%	-18.2	-2.6%	-43.0	-5.8%	-57.6	-7.3%	-75.2	-9.2%	-80.9	-9.4%
Fairfax County, VA [1]	12.0	1.0%	12.8	1.1%	13.6	1.1%	8.2	0.6%	13.2	1.0%	12.1	0.9%	22.1	1.5%
Arlington County, VA	7.4	3.2%	7.6	3.3%	7.7	3.2%	6.2	2.5%	7.2	2.7%	6.8	2.5%	7.1	2.5%
Alexandria City, VA	5.5	3.6%	4.2	2.7%	2.7	1.7%	1.8	1.1%	4.7	2.6%	3.7	2.0%	2.4	1.2%
Loudoun County, VA	11.0	2.9%	10.2	2.6%	6.7	1.6%	9.1	2.0%	22.8	4.6%	34.5	6.6%	49.3	9.1%
Prince William County, VA [2]	0.0	0.0%	-1.7	-0.3%	-4.2	-0.8%	-12.2	-2.2%	-6.2	-1.1%	-2.1	-0.3%	13.4	2.1%
Montgomery County, MD	0.0	0.0%	4.8	0.5%	12.0	1.1%	15.1	1.4%	21.1	1.8%	19.0	1.6%	37.3	3.0%
Prince George's County, MD	0.0	0.0%	6.3	0.7%	15.7	1.7%	31.1	3.2%	50.2	5.0%	65.7	6.4%	84.4	7.9%
Frederick County, MD	0.0	0.0%	-2.0	-0.8%	-5.0	-1.9%	-12.9	-4.7%	-13.2	-4.5%	-15.8	-5.2%	-13.5	-4.2%
Total	**34.0**	**0.6%**	**33.6**	**0.6%**	**31.0**	**0.6%**	**3.4**	**0.1%**	**42.2**	**0.7%**	**48.7**	**0.8%**	**121.6**	**1.9%**

Source: MWCOG Round 9.0 forecast and RPG-adjusted forecast.
[1] Fairfax County + Fairfax City + Falls Church.
[2] Prince William County + Manassas + Manassas Park.

Table 4-6
Employment Growth by Jurisdiction
(thousands)

County	2015	CAGR	2017	CAGR	2020	CAGR	2025	CAGR	2030	CAGR	2035	CAGR	2040	2015-2040 CAGR
District of Columbia	798	0.8%	812	1.0%	835	0.7%	864	0.8%	899	0.6%	928	0.7%	962	0.7%
Fairfax County, VA [1]	687	1.8%	711	1.6%	747	1.2%	794	1.3%	846	0.9%	885	1.0%	930	1.2%
Arlington County, VA	214	0.6%	217	1.0%	223	0.6%	230	0.8%	239	0.7%	247	0.5%	253	0.7%
Alexandria City, VA	106	2.0%	110	2.5%	119	1.0%	125	1.1%	132	0.9%	138	0.3%	140	1.1%
Loudoun County, VA	164	2.9%	174	2.8%	189	2.4%	213	2.6%	242	2.1%	269	2.0%	297	2.4%
Prince William County, VA [2]	175	2.1%	182	2.0%	193	1.5%	209	1.8%	228	1.4%	245	1.6%	265	1.7%
Montgomery County, MD	520	1.0%	531	1.0%	547	0.8%	568	1.0%	595	0.7%	617	0.9%	644	0.9%
Prince George's County, MD	339	1.0%	345	1.0%	355	0.8%	371	0.9%	388	0.8%	404	0.9%	422	0.9%
Frederick County, MD	106	1.4%	109	1.4%	114	1.2%	120	1.3%	128	1.1%	136	1.2%	144	1.2%
Total	**3,110**	**1.3%**	**3,191**	**1.3%**	**3,322**	**1.0%**	**3,492**	**1.1%**	**3,697**	**0.9%**	**3,868**	**1.0%**	**4,057**	**1.1%**

Source: MWCOG Round 9.0 forecast adjusted by RPG.
[1] Fairfax County + Fairfax City + Falls Church.
[2] Prince William County + Manassas + Manassas Park.

Table 4-7
Difference of Final Employment Forecast and MWCOG Round 9.0
(thousands)

County	2015		2017		2020		2025		2030		2035		2040	
	Abs Diff	%Diff	Abs Diff	%Diff	Abs Diff	%Diff	Abs Diff	%Diff	Abs Diff	%Diff	Abs Diff	%Diff	Abs Diff	%Diff
District of Columbia	0.0	0.0%	-5.9	-0.7%	-11.2	-1.3%	-31.6	-3.7%	-39.2	-4.4%	-50.4	-5.4%	-49.7	-5.2%
Fairfax County, VA [1]	0.0	0.0%	3.7	0.5%	8.0	1.1%	5.4	0.7%	13.8	1.6%	14.8	1.7%	21.3	2.3%
Arlington County, VA	4.4	2.1%	5.6	2.6%	9.9	4.4%	4.4	1.9%	-3.3	-1.4%	-8.9	-3.6%	-14.2	-5.6%
Alexandria City, VA	0.0	0.0%	2.6	2.4%	8.8	7.4%	3.4	2.7%	4.8	3.6%	3.0	2.2%	-2.7	-1.9%
Loudoun County, VA	0.0	0.0%	0.2	0.1%	0.7	0.4%	1.8	0.8%	6.4	2.6%	13.1	4.9%	23.1	7.8%
Prince William County, VA [2]	0.0	0.0%	-1.2	-0.7%	-3.2	-1.7%	-8.9	-4.3%	-9.9	-4.3%	-13.1	-5.4%	-15.1	-5.7%
Montgomery County, MD	0.0	0.0%	1.1	0.2%	3.1	0.6%	-4.9	-0.9%	-9.3	-1.6%	-10.6	-1.7%	-10.3	-1.6%
Prince George's County, MD	0.0	0.0%	2.4	0.7%	6.3	1.8%	4.2	1.1%	12.4	3.2%	18.3	4.5%	28.8	6.8%
Frederick County, MD	0.0	0.0%	1.2	1.1%	3.1	2.7%	4.8	4.0%	7.1	5.5%	7.8	5.7%	9.8	6.8%
Total	**4.4**	**0.1%**	**9.7**	**0.3%**	**25.5**	**0.8%**	**-21.4**	**-0.6%**	**-17.2**	**-0.5%**	**-26.0**	**-0.7%**	**-9.0**	**-0.2%**

Source: MWCOG Round 9.0 forecast and RPG-adjusted forecast.
[1] Fairfax County + Fairfax City + Falls Church.
[2] Prince William County + Manassas + Manassas Park.

Table 4-6 indicates the nine-jurisdiction region is expected to add about 866,000 jobs from 2017 to 2040, of which Fairfax County is expected to add 219,000 jobs. Overall, RPG expects an employment growth rate of 1.1 percent per year through 2040. Loudoun County leads the way among the regional counties with an expected annual employment growth rate of 2.4 percent through 2040.

Figures 4-5 and **4-6** illustrate the difference between the final RPG forecasts, the MWCOG baseline, and additional forecasts from Woods & Poole Economics, Inc. and Moody's Economy.com.

Figures 4-7 through **4-9** show thematic maps of the adjusted number of expected residents at TAZ levels from 2015 through 2025, 2025 through 2040, and from 2015 through 2040, respectively. These figures graphically expand on what is presented in the population forecast tables above with TAZ-level spatial detail. The three figures depict growth mainly along the Dulles Corridor and in parts of Loudoun County over the next 25 years, with additional pockets of growth in Fairfax County, Washington, D.C., and in nearby Montgomery County, Maryland.

Figures 4-10 through **4-12** map the RPG-adjusted projections of growth in TAZ level employment. The Dulles Corridor is expected to experience very favorable employment growth conditions throughout the forecast horizon. Similar to population projections, the largest employment growth is projected for Loudoun County. A more detailed socioeconomic discussion is provided in RPG's report in **Appendix B** of this document.

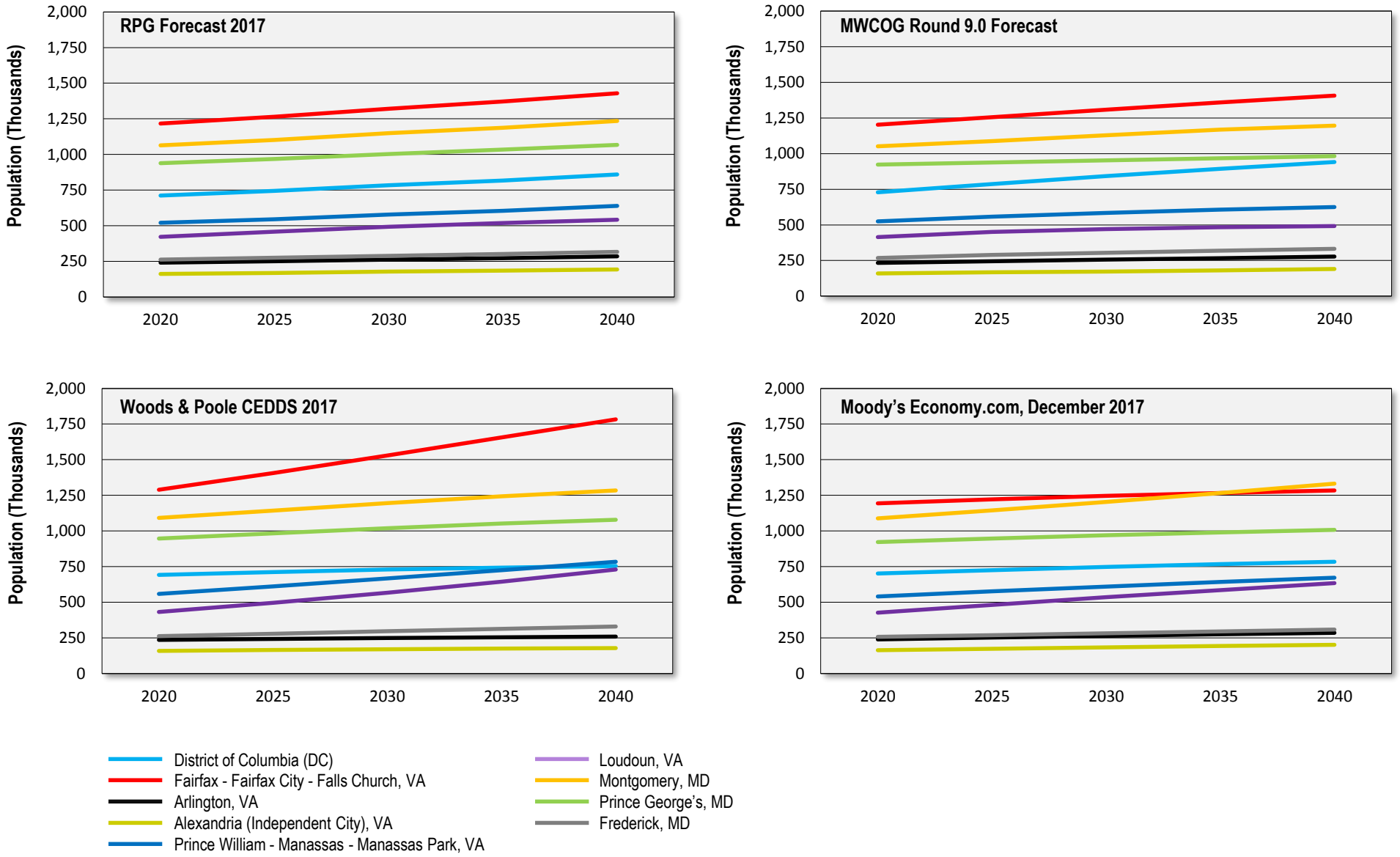


FIGURE 4-5: POPULATION FORECASTS FROM VARIOUS SOURCES

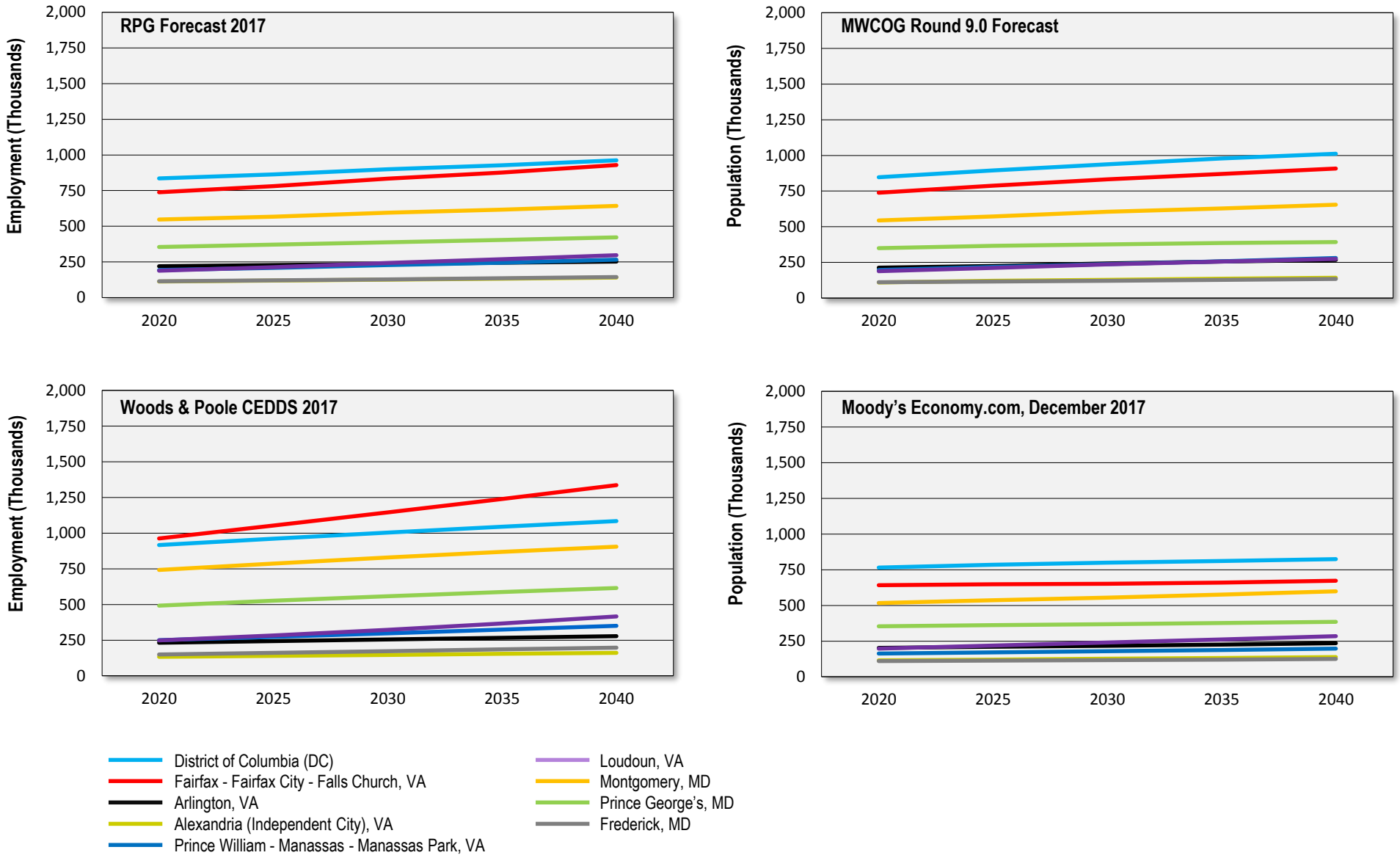


FIGURE 4-6: EMPLOYMENT FORECASTS FROM VARIOUS SOURCES

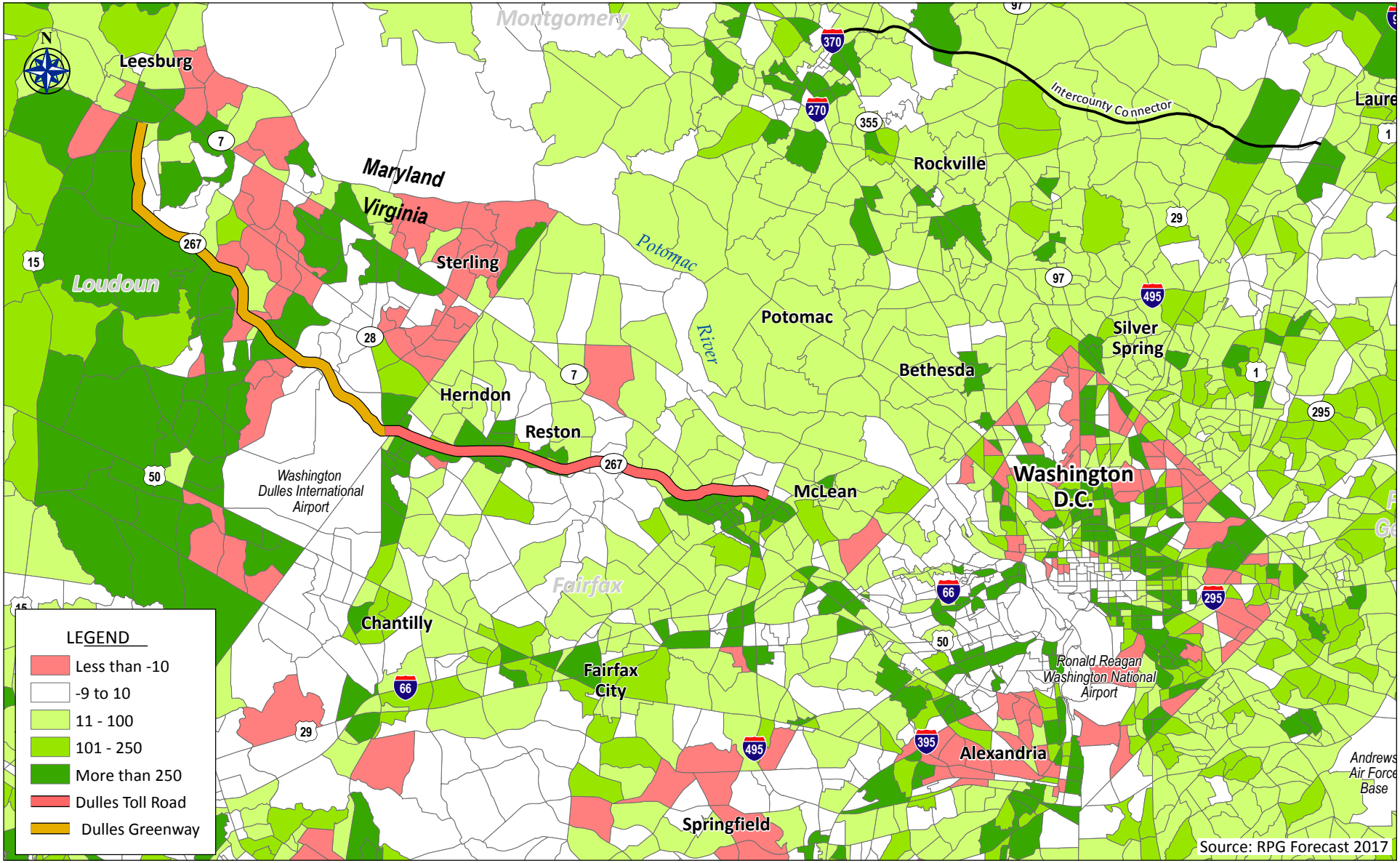


FIGURE 4-7: TOTAL GROWTH IN POPULATION, 2015-2025

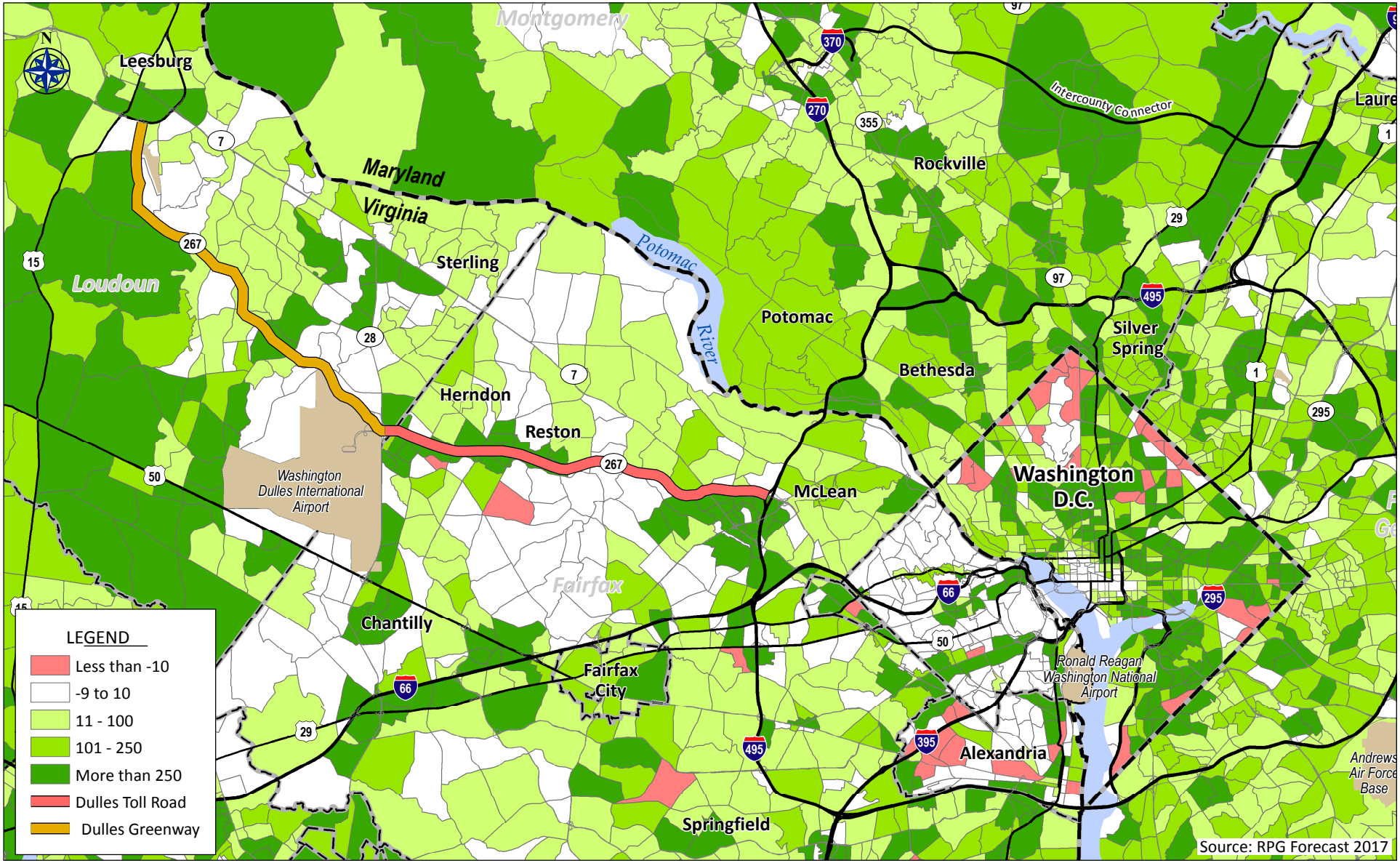


FIGURE 4-8: TOTAL GROWTH IN POPULATION, 2025-2040

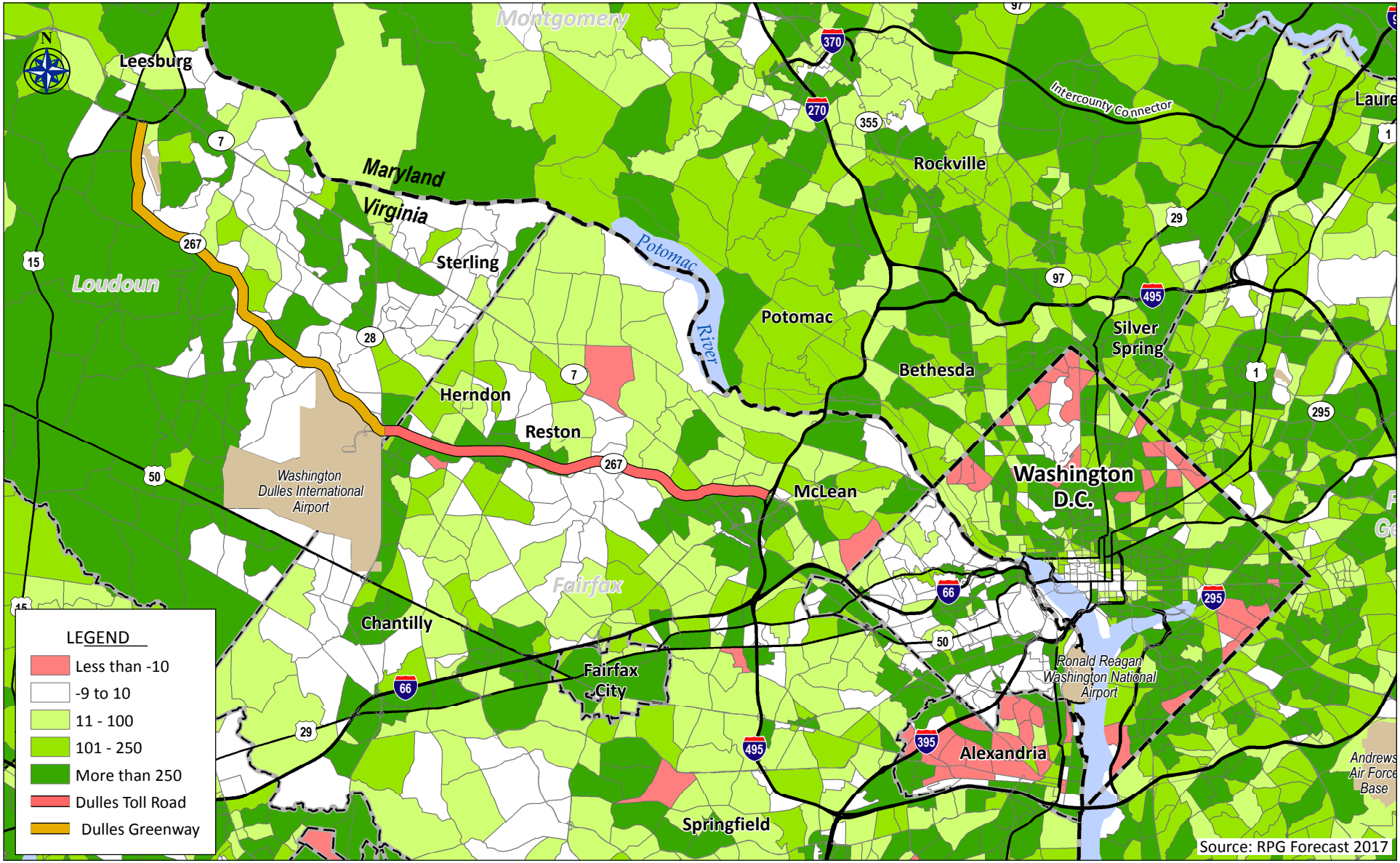


FIGURE 4-9: TOTAL GROWTH IN POPULATION, 2015-2040

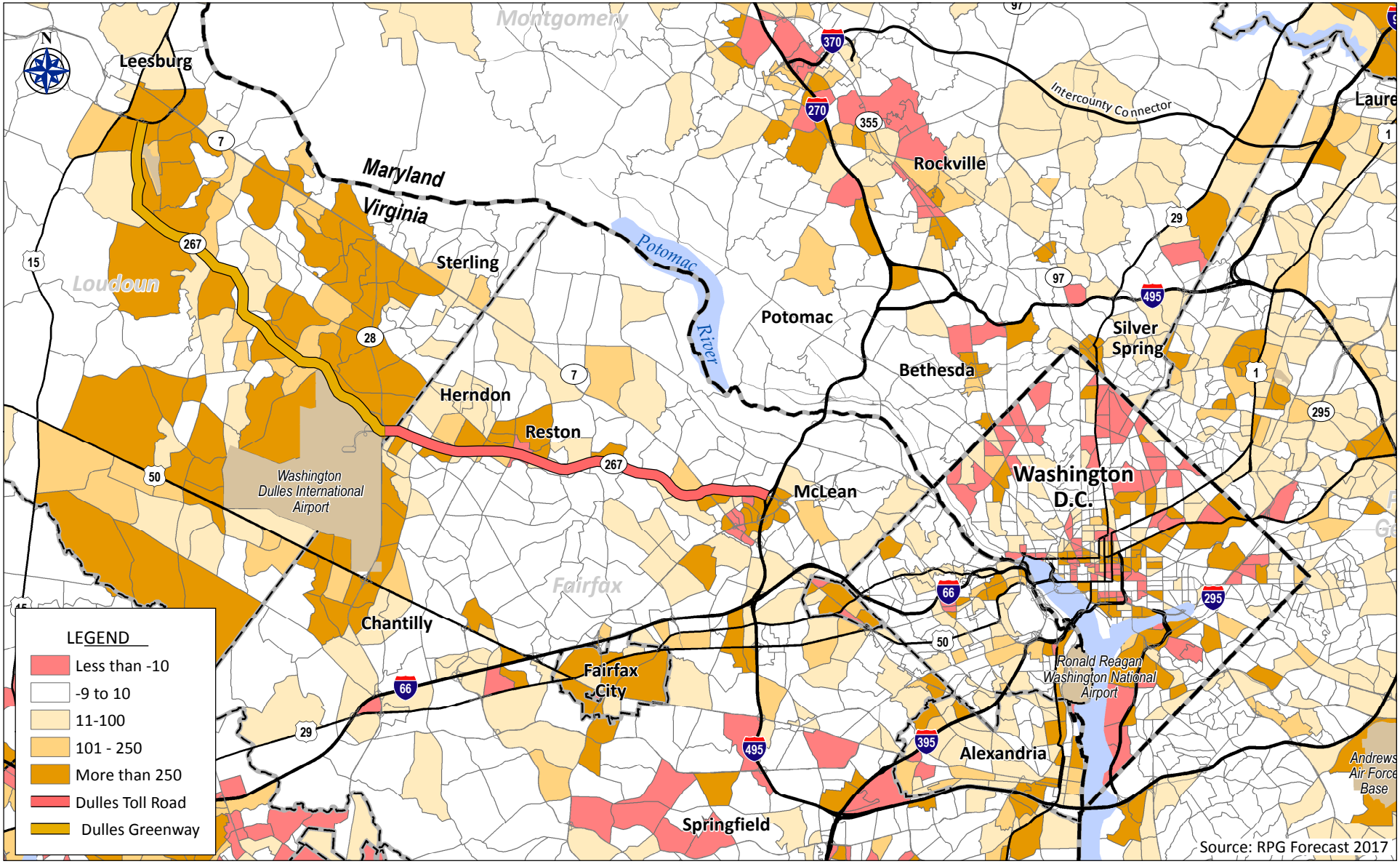


FIGURE 4-10: TOTAL GROWTH IN EMPLOYMENT, 2015-2025

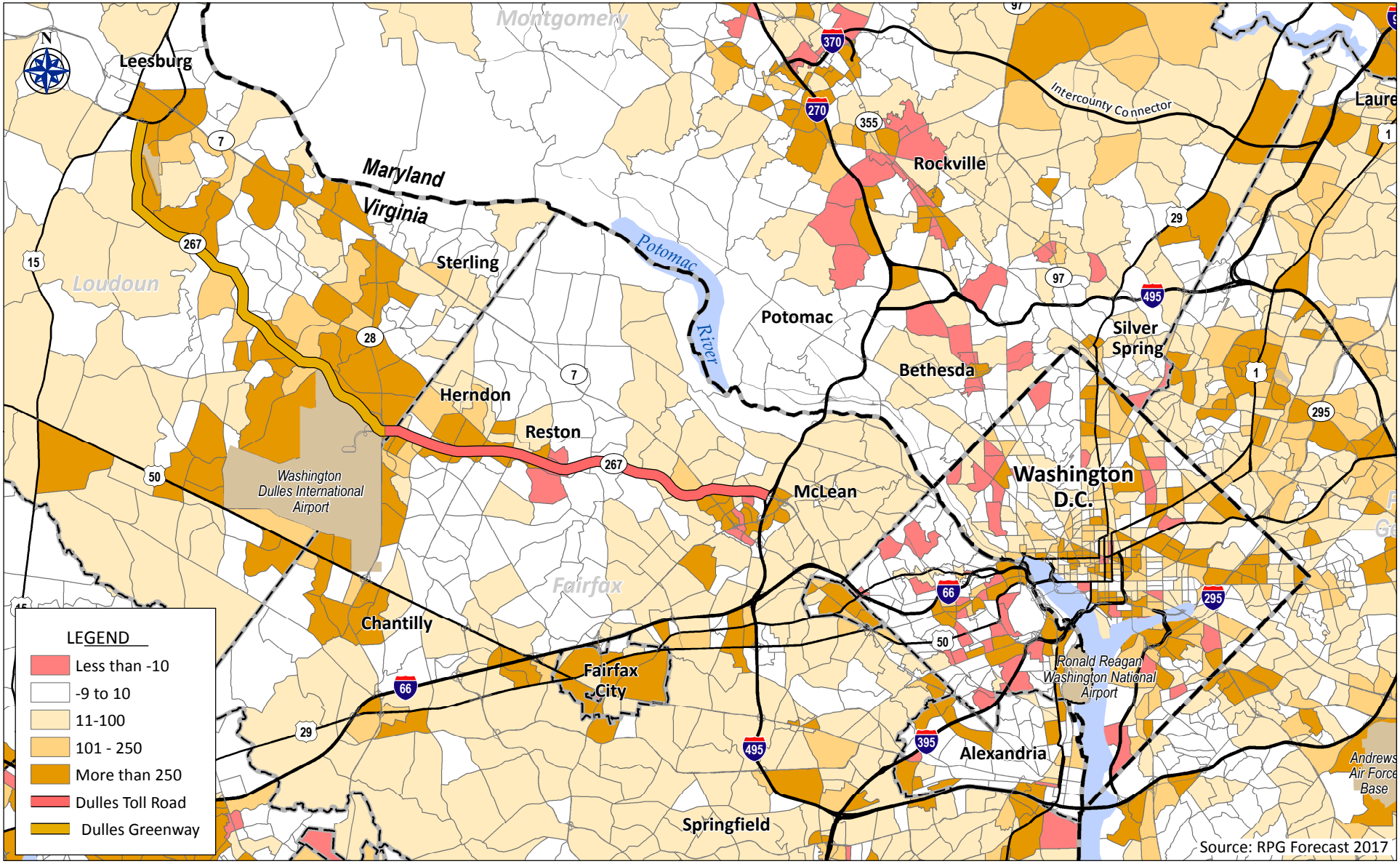


FIGURE 4-11: TOTAL GROWTH IN EMPLOYMENT, 2025-2040

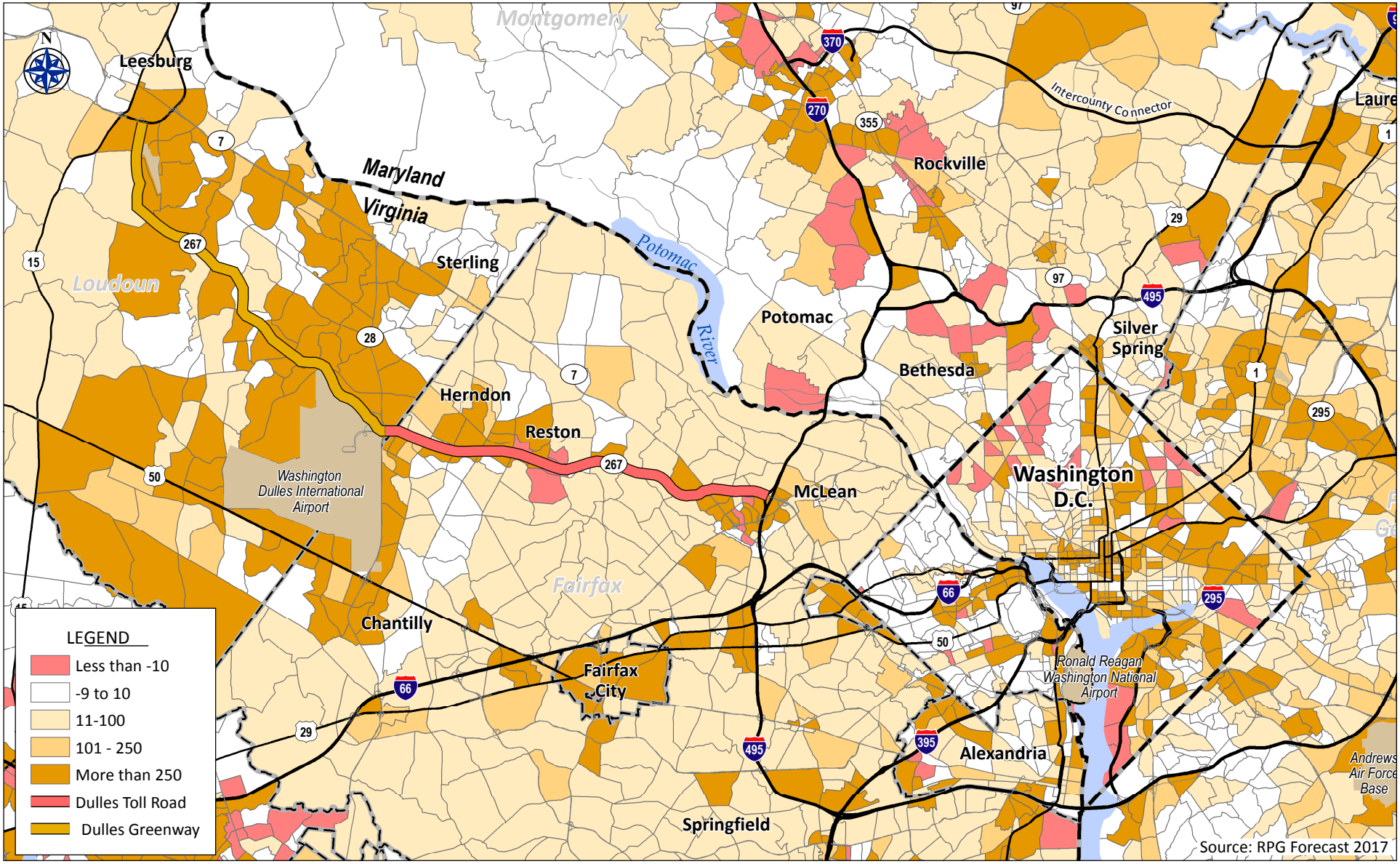


FIGURE 4-12: TOTAL GROWTH IN EMPLOYMENT, 2015-2040

Chapter 5

Estimated Transactions and Toll Revenue

This chapter outlines the basic assumptions and key inputs to the travel demand model that CDM Smith used to develop annual traffic and toll revenue estimates for the Dulles Toll Road. It also describes the modeling methodology and analytic process for generating those estimates.

In developing the DTR toll revenue estimates, CDM Smith used a regional travel demand forecasting model provided by the MWCOG (Version 2.3.66, adopted in February 2017). The MWCOG model was refined and enhanced based on the professional experience and judgment of CDM Smith. Key components of that work included calibrating the MWCOG model with existing travel data for the Dulles Corridor, incorporating CDM Smith toll diversion algorithms, and conducting an independent evaluation of the MWCOG socioeconomic forecasts.

Presented at the end of this chapter are the estimated annual toll revenue and toll transactions for the DTR from 2018 through 2054 using a toll rate schedule developed by MWAA and its financial advisors for financial planning purposes. The assumed toll rates are subject to change. Following the traffic and revenue estimates, this chapter also presents a toll sensitivity analysis that was performed for estimated transactions and toll revenue for the base year 2017.

This report also includes a series of sensitivity tests in Chapter 6, to test the potential impacts on toll revenue associated with hypothetical changes in certain assumptions or basic study inputs, such as alternative economic growth, lower values of time and higher fuel prices.

Basic Assumptions

Traffic and toll revenue estimates for the DTR are predicated on the following basic assumptions, all of which are considered reasonable for purposes of this comprehensive traffic and toll revenue study:

1. The DTR is assumed to provide four travel lanes in each direction, for a total of eight lanes, over its entire length. No expansion of the DTR is expected or assumed in the forecast period. The long-range transportation plan for the region does assume a two-lane untolled frontage road will be constructed along the DTR in both directions from Wiehle Avenue to Interstate 495 by 2040.

2. The physical configuration of the DTR, will remain broadly unchanged throughout the forecast period.

3. Future toll rates assumed in this study were developed for financial planning purposes by MWAA and its financial advisors. No dynamic, variable or peak congestion pricing options have been investigated at this stage. Toll rates on the DTR facility are in future year dollars as set forth subsequently in this chapter. Commercial vehicle rates will continue to be incrementally higher than passenger cars based on the current multipliers.

4. No change in toll collection technology or method of payment has been assumed. Toll collection operations are assumed to continue to be actively monitored and strictly enforced to minimize potential revenue losses due to toll evasion and/or system failure.

5. An average annual inflation rate of 2.3 percent has been assumed for the purposes of escalating values of time and for input in calculating vehicle operating costs for future year dollars. Annual toll revenue estimates and toll rates are expressed in future year dollars.

6. Future toll increases on the Greenway will be implemented per the maximum toll schedule set by the Virginia State Corporation Commission through 2020 as described in Chapter 1. Post 2020, toll rate increases are assumed to continue in line with guidelines set for 2013 through 2020. Future toll increases on other regional toll facilities have been estimated per assumed future toll rate policies and objectives of the other agencies/operators.

7. No adjustments have been made to annual toll revenue estimates included in this report to reflect the impacts associated with changes in future enforcement, changes in toll evasion, or other forms of uncollectible tolls. Changes in these topic areas may affect actual toll revenue. It is assumed that enforcement and public relations programs will be undertaken by the Airports Authority to ensure customer satisfaction and minimum diversion as necessary.

8. Annual transactions and toll revenue have not been adjusted to reflect any "ramp-up" characteristics as the DTR is a mature toll road facility.

9. Only those highway improvements that are committed in the following documents during the study area and time frame are assumed:

    - FY 2017-2022 Transportation Improvement Program (TIP) for the National Capital Region, Adopted November 16, 2016
    - Financially Constrained Long-Range Transportation Plan (CLRP) for the National Capital Region 2016 Amendment, Adopted November 16, 2016
    - Northern Virginia Transportation Authority (NVTA) TransAction Plan, Adopted October 2017

    Specific improvements assumed in future year networks are described in the following sections of this Chapter. MWCOG's 4-step travel demand model was used as the basis to assess mode choice effects between highway and transit modes. Diversion to the Dulles Corridor Metrorail is represented by the adjustments made in the MWCOG highway trip tables generated through the 4-step travel demand modeling process. Fares were assumed as given in the MWCOG model. No other competing or feeder bus line service or service frequency has been assumed along the DTR corridor, other than outlined in the TIP, CLRP and MWCOG plans.

10. Only airport traffic and transit buses will be eligible to use the Dulles Airport Access Highway. It is assumed that active monitoring, rigorous airport traffic enforcement and administrative adjudication processes will be implemented to avoid potential misuse of the Dulles Access Highway for toll evasion and to minimize potential revenue losses.

11. Regional and corridor socioeconomic growth is generally in accordance with forecasts provided by MWCOG, as reviewed and adjusted by the independent consultant, Renaissance Planning Group (RPG).

12. Travel demand modeling was performed by estimating average interior weekdays of Tuesday through Thursday travel on the DTR and study area. For purposes of annualization of

transactions and revenue, it was assumed that the existing base relationship between weekday and annual trips observed at each toll plaza will remain constant in the future, including violations and non-revenue transactions-examples such as police, emergency vehicles, and military vehicles.

13. The DTR will continue to be well-maintained, efficiently-operated and effectively signed and promoted to encourage maximum usage. It is assumed that there will be no interruptions in availability of lanes for use by patrons, other than for routine maintenance and average number of incidents.

14. Motor fuel will remain in adequate supply and its price will not increase significantly in real terms; the rate of price increases will not significantly exceed the overall rate of inflation. The base case forecast reflects an assumption of $2.70 per gallon increasing with general prices. Fuel cost sensitivity tests are provided in **Chapter 6**.

15. No local, regional or national emergency will arise which would abnormally restrict the use of motor vehicle, or substantially alter economic activity or freedom of mobility.

Any significant departure from the above basic assumptions could materially affect the estimates for traffic and toll revenue on the DTR presented in this report.

Key Model Inputs

Infrastructure Improvements

The most recent regional transportation improvement plan documents were obtained and reviewed to identify any committed improvements which could potentially impact traffic and revenue on the DTR. As necessary, corresponding adjustments were made to the regional transportation model as refined by CDM Smith.

Figure 5-1A and **Figure 5-1B** present a map and accompanying list of major roadway capacity and operational improvements assumed to be carried out in future years throughout the study area. Also pictured is the route of the Silver Line Extension to IAD and beyond to Ashburn. Phase 2 is scheduled to be operational by 2020. Further transit improvements have been assumed to be in line with those specified in the 'transit improvements' portion of the CLRP.

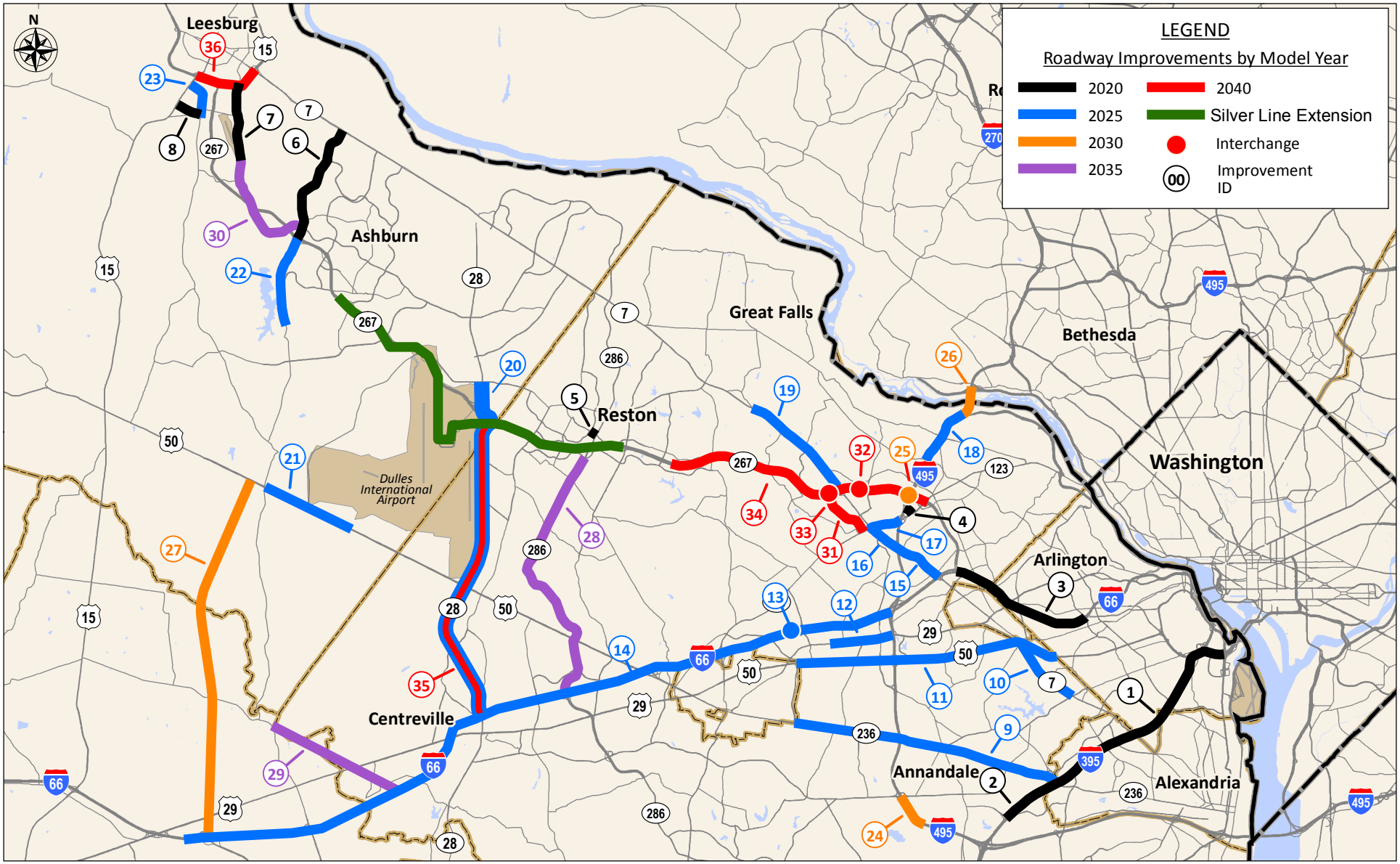


FIGURE 5-1A: HIGHWAY IMPROVEMENT PLAN

2020

1. **I-395 Express Lanes –** Convert existing reversible lanes from HOV to HOT, add third lane
2. **I-395 SB Widen –** Add fourth southbound lane between north of Duke Street and south of Edsall Road
3. **I-66 Widen –** Widen I-66 1 lane from Dulles Connector to Fairfax Drive.
4. **Jones Branch Drive Connector –** Build connection between SR 123 and I-495 Express Lanes
5. **Spring Street Widen –** Widen Spring Street to 6 lanes from Herndon Parkway to Fairfax County Parkway
6. **Belmont Ridge Road Widen –** Widen Belmont Ridge Road to 4 lanes from Dulles Toll Road to SR 7
7. **Sycolin Road Widen –** Widen Sycolin Road to 4 lanes from SR 7/US 15 Bypass to Leesburg Town Line
8. **Battlefield Parkway Construction –** Construct new 4 lane parkway from US 15 to Dulles Greenway

2025

9. **SR 236 Reconstruct, Widen –** Widen Little River Turnpike to 6 lanes from Pickett Road to I-395
10. **SR 7 Widen –** Widen Leesburg Pike to 6 lanes from Seven Corners to Baily's Crossing
11. **US 50 Widen –** Widen Arlington Boulevard to 6 lanes from Fairfax City Line to Arlington County Line
12. **US 29 Widen –** Widen Lee Highway to 6 lanes from Espana Court to I-495
13. **I-66 HOV Access to Vienna Metro Station –** Provide direct connection access from HOV/HOT to Vienna Metro Station

2025 (Cont'd)

14. **I-66 Outside the Beltway –** Convert existing HOV to HOT, add second HOT lane from University Boulevard to I-495
15. **SR 7 Widen –** Widen Leesburg Pike to 6 lanes from I-495 to I-66
16. **SR 7 Widen –** Widen Leesburg Pike to 6, 8 lanes from Chain Bridge Road to I-395
17. **SR 123 Widen –** Widen Chain Bridge Road to 8 lanes from Leesburg Pike to I-495
18. **I-495 HOT Expansion –** Expand existing HOT system from Old Dominion Road to George Washington Parkway
19. **SR 7 Widen –** Widen Leesburg Pike to 6 lanes from Dulles Toll Road to SR 743
20. **SR 28 Widen –** Widen Sully Road to 8 lanes from Sterling Boulevard to I-66
21. **US 50 Widen –** Widen Lee Jackson Memorial Highway 6 lanes from SR 659 to Poland Road
22. **SR 659 Widen –** Widen Belmont Ridge Road from 2 to 4 lanes from Croson Lane Dulles Greenway
23. **Evergreen Mill Road Widen –** Widen Evergreen Mill Road from 2 to 4 lanes from King Street to Leesburg Town Line

2030

24. **Capital Beltway Auxiliary Lanes –** Construct 2 auxiliary lanes on I-495 in both directions from N of Hemming Avenue Underpass to Braddock Road
25. **I-495 / Dulles Access Road Interchange Construction –** Construct new ramp from I-495 southbound general purpose to westbound Dulles Airport Access Road

2030 (Cont'd)

26. **I-495 HOT Expansion –** Expand existing HOT system from George Washington Parkway to American Legion Bridge
27. **Manassas Battlefield Bypass –** Construct 4 lane bypass from US 50 to I-66

2035

28. **Fairfax County Parkway Expansion –** Widen SR 286 to 6 lanes from I-66 to Sunrise Valley Drive, 1 lane HOV per direction during peak period
29. **Manassas Battlefield Bypass –** Construct 4 lane bypass from SR 234 to US 29, close portions of roadway
30. **Sycolin Road Widen –** Widen Sycolin Road from 2 to 4 lanes from Leesburg Town Line to Crosstrails Boulevard

2040

31. **Boone Boulevard Extension –** Extend Boone Boulevard as 4 lane roadway from SR 123 to Dulles Toll Road
32. **Greensboro Drive Interchange –** New Dulles Toll Road access at Greensboro Drive
33. **Boone Boulevard Interchange –** New Dulles Toll Road access at Boone Boulevard Extension
34. **Dulles Toll Road Frontage Road –** Construct 2 lane frontage road system, both directions, from Wiehle Avenue to I-495
35. **SR 28 HOV Conversion –** Convert 1 lane per direction Sully Road to HOV from I-66 to Dulles Toll Road
36. **SR 7 / US 15 Widen–** Widen Harry Byrd Highway to 6 lanes from South King Street to East Market Street

CDM Smith

FIGURE 5-1B: HIGHWAY IMPROVEMENT PLAN

Toll Rate Schedule

Table 5-1 is the projected 2-axle toll rate schedule provided by the Airports Authority and its financial advisors for estimating traffic and revenue for the DTR.

Table 5-1
Projected Toll Rate Schedule

	Mainline		Ramps	
	Tolls	Change	Tolls	Change
1984-2005	$0.50	..	$0.35/$0.25	..
2005-2009	0.75	+ $ 0.25	0.50	+ $ 0.15
2010	1.00	+ $ 0.25	0.75	+ $ 0.25
2011	1.25	+ $ 0.25	0.75	..
2012	1.50	+ $ 0.25	0.75	..
2013	1.75	+ $ 0.25	1.00	+ $ 0.25
2014-2018	2.50	+ $ 0.75	1.00	..
2019-2022	3.25	+ $ 0.75	1.50	+ $ 0.50
2023-2027	4.00	+ $ 0.75	2.00	+ $ 0.50
2028-2032	4.75	+ $ 0.75	2.50	+ $ 0.50
2033-2037	5.50	+ $ 0.75	3.25	+ $ 0.75
2038-2042	6.25	+ $ 0.75	3.75	+ $ 0.50
2043-2047	7.00	+ $ 0.75	4.25	+ $ 0.50
2048-2054	7.75	+ $ 0.75	4.75	+ $ 0.50

For purposes of this study, the next toll increase is assumed to occur in 2019, with 2-axle users at the mainline toll plaza paying an additional $0.75 and a $0.50 increase at all ramp toll plazas. Beginning in 2023, and occurring every five years thereafter, there is an assumed periodic increase of $0.75 at the mainline toll plaza. Tolls at ramp toll plazas are also assumed to be adjusted every five years, beginning in 2023, generally by $0.50, except for the $0.75 increase in 2033. The last assumed toll increase is scheduled for 2048. For the purposes of this study truck toll rates are assumed to increase on the same schedule and based on the multiplier between 2-axle and multi-axle rates currently in use.

Modeling Methodology

The National Capital Region Transportation Planning Board (TPB) is the federally designated Metropolitan Planning Organization (MPO) for the region. The MWCOG model inputs obtained by CDM Smith were used as the basis for the current estimates of traffic and revenue. Critical inputs to the models are the socioeconomic data at the traffic analysis zone (TAZ) level which were reviewed by an independent consultant.

The following sections discuss the modeling framework, review of key model inputs, and the development of highway networks and trip tables. Also provided is an overview of the parameters and traffic assignment and toll diversion process used in this study.

MWCOG Model Framework

The MWCOG regional transportation model is a computer-based traffic forecasting model designed to forecast traffic volumes in the Washington, D.C. region, which includes parts of Maryland, West Virginia, and Virginia as well as the District. The MWCOG regional model version 2.3.66 includes the latest underlying socioeconomic forecasts of MWCOG. The MWCOG model includes all inputs and

application files required to execute the travel demand model for the MWCOG base year of 2015 and horizon year 2040 as released by MWCOG in 2016.

Mode-Choice and Potential Diversion to Rail

The regional model has a sequential procedure for generating trips based on the traditional four-step transportation demand modeling process (trip generation, trip distribution, mode choice, and highway assignment) with several loop-back steps to take congestion levels into account. Trip tables representing a.m. peak period, p.m. peak period, midday, and overnight travel are developed in the MWCOG model using factors from regional household surveys.

The model predicts mode choice based on the relative costs of each mode. In relative terms, the expected diversion from highway to rail, because of the Dulles Corridor Metrorail Project Phase 2, is considered to be low, similar to the actual experience of Phase 1. Prior testing of the model confirmed that the transit share of travel mode choice is low and insensitive to other factors such as tolls.

The passenger capacity of the Dulles Corridor Metrorail Project is small relative to the hundreds of thousands of commuters that travel on the Dulles Corridor and competing highway routes on a daily basis. Current DTR customers have very diverse travel patterns that are not conveniently served by the Dulles Corridor Metrorail Project.

Socio-economic Assumptions

As described in Chapter 4, CDM Smith retained RPG as an independent economist to develop socioeconomic forecasts to be used in the trip table generation process deployed by CDM Smith. As part of their analysis, RPG reviewed the latest MWCOG Round 9.0 socioeconomic forecasts and applied certain adjustments to the regional and primary market area numbers. Results of their detailed assessment were summarized in Chapter 4 and a report is attached as **Appendix B**. New trip tables for each of the forecast years (2017, 2020, 2025, 2030, 2035 and 2040) were generated using the RPG adjusted socioeconomic forecasts for the region and the DTR primary market area.

Highway Network Assumptions

The MWCOG model contains highway networks for a base year 2015 and horizon year 2040 representing the highways, arterials and local streets and transit infrastructure of the region. The year 2015 network was then reviewed against the transportation improvements through 2017 to develop new base model networks for year 2017 specifically for this study. The year 2017 roadway network was then reviewed and corrected based on posted speed limits and the type and number of roadway lanes. The year 2017 roadway network, in combination with 2017 traffic assignments, was reviewed and adjusted based on average weekday traffic volume and current travel speed observations. The future year networks were then reviewed against the highway improvements list noted above to confirm that committed and funded improvements had been included.

Trip Table Adjustments to Reflect DTR Travel Patterns

CDM Smith ran a series of 2017 traffic assignments initially using trips generated solely by the MWCOG model to understand the underlying model. Adjustments were made in order to obtain a better fit between the ground counts at multiple screen line locations and traffic volumes assigned by the model.

The 2017 trip tables were then adjusted to better reflect actual transaction counts at each tolling point on the roadway. In addition, a comparison was made of actual ramp-to-ramp movements on the DTR

and adjusted to match the entry/exit trip pattern from the survey. This ensures that the adjusted trip tables are a better reflection of actual trip patterns and trip lengths observed on the DTR corridor.

Overview of Toll Diversion Assignment Process

A series of tolled diversion assignments in the years 2017, 2020, 2025, 2030, 2035 and 2040 were run for the toll rate schedule assumed for the DTR.

Trip tables were divided into market segments based on different trip purposes including airport trips, passenger car SOV, passenger car HOV-2, passenger car HOV-3, and commercial vehicle traffic. These market segments were assigned to the network using a modified version of a multi-class user equilibrium assignment process. Appropriate toll rates and fees were used for each of these categories of vehicles.

The MWCOG model was updated to include CDM Smith tolling algorithms designed to estimate the share of traffic for each travel movement which would be expected to choose the tolled route at each toll rate. This is specifically designed to assess motorists' willingness to pay tolls at varying toll levels and congestion conditions. The process builds two sets of minimum time paths for each origin-destination zone pair: one using the DTR where appropriate and the other using competing toll-free facilities. A proportion of the total trips moving between the zones is assigned to each network path based on the relative total cost between the two paths considering travel time costs, distance cost and tolls. The travel time cost is equal to the time spent traveling between two zones, multiplied by the value-of-time. The distance cost for each of the two paths is equal to the vehicle operating cost multiplied by the distance traveled for each path. The toll cost is the toll that would be paid on the tolled route. As the cost of the tolled route increases compared to the competing toll-free route, the estimated share of traffic using the DTR decreases, and vice versa.

Values-of-Time and Vehicle Operating Costs

Traffic and revenue on a toll facility is dependent on motorists' willingness to pay a toll for benefits received in using the toll facility. These benefits can include mileage savings, improved quality of travel, safety, and reduced congestion. The motorist's value–of-time, vehicle operating cost, and toll charges are the three key elements in determining the cost of making a particular trip and, therefore, determine the share of traffic assigned to tolled vs. toll-free paths for each origin-destination pair.

The overall average value-of-time (VOT) for trips in the corridor was calculated to be $0.31 per minute ($18.60/hr) for drivers operating passenger cars and traveling during peak travel times (2017 values). VOT for passenger car trips occurring in off-peak times was calculated at $0.29 per minute ($17.40/hr). The value of time estimates are relatively high compared with other areas of the United States, reflective of the high incomes in the corridor. These VOTs were assumed to inflate 2.3 percent each year through the forecast period. A full summary of future year value-of-time estimates can be found in **Table 5-2.**

Vehicle operating costs used in the analysis were calculated by taking into account the average per-mile costs of gasoline and oil, and to a lesser extent, maintenance, and wear and tear of tires. In addition, future year estimates of vehicle operating costs considered assumed increases in vehicle fuel efficiency, changes in car fleet compositions, estimates of future fuel prices, and CPI. **Table 5-3** presents vehicle operating costs used in the analysis.

Table 5-2
Value of Time in Future Year Dollars (Per Minute)

Year	Peak Period		Off-Peak Period	
	Passenger Cars	Trucks	Passenger Cars	Trucks
2017	$0.310	$0.505	$0.290	$0.473
2020	$0.332	$0.541	$0.311	$0.506
2025	$0.372	$0.606	$0.348	$0.567
2030	$0.417	$0.679	$0.390	$0.635
2035	$0.467	$0.761	$0.437	$0.712
2040	$0.523	$0.852	$0.489	$0.797

Table 5-3
Vehicle Operating Costs in Future Year Dollars (Per Mile)

Year	Passenger Cars	Trucks
2017	$0.182	$0.547
2020	$0.197	$0.623
2025	$0.197	$0.727
2030	$0.206	$0.804
2035	$0.221	$0.895
2040	$0.243	$1.002

Sources:
(1) AAA, Your Driving Costs, 2016 Edition
(2) Washington-Baltimore Area Gasoline Prices, 2017
(3) Energy Prices by Sector and Source, U.S. Energy Information Administration

Assumed ETC Market Shares

It was assumed for this study that there will continue to be no difference in toll rates for ETC and cash collection. The model also assumes the currently observed E-ZPass participation rates will continue.

Toll Differential Assumptions

It was assumed that the toll rate differential between passenger cars and multi-axle vehicles will continue to be based on the multipliers currently in use.

Traffic Assignment Process

Traffic assignments were run using trip table information supplied by MWCOG and modified for this study by CDM Smith. Since assumed toll rate increases are not generally aligned with the base and forecast years in the model, traffic assignments were run using toll rates expected at and between model years. Using interpolation, toll traffic and revenue estimates were generated at each forecast year at each expected toll rate.

The assignment results were reviewed for reasonableness, using both select link and screen line corridor share analyses. In the screen line review, special attention was paid to the overall level of growth in traffic throughout the projection period, and the relative share of total screen line demand expected to be accommodated by the DTR.

The traffic assignment process utilized the projected toll rate schedule for the DTR in Table 5-1.

Estimated Annual Transactions and Toll Revenue

T&R Estimates

Estimates of annual toll revenue for the DTR under the projected toll rate schedule are presented in **Table 5-4**. Total revenue for the DTR is presented from 2017 through 2054. In CY2017 annual transactions on the DTR system totaled approximately 97.1 million per year, translating to annual toll revenue of about $152.1 million.

With a mainline toll adjustment in 2019, total transactions are estimated to decrease to approximately 91.7 million. These transactions would produce about $199 million in annual toll revenue, an increase of 29.6 percent over the prior year forecast. Transactions are expected to rebound and climb until 2023, with the introduction of the next assumed toll increase. Annual transactions are expected to drop to 88.3 million per year, while annual toll revenues are expected to hit approximately $245.1 million.

Transactions typically increase in all years where no toll increase is incurred, while revenue is expected to grow each year. Years in which toll increases occur are expected to see a reduction in transactions but are anticipated to begin to recover the following year.

Toll Sensitivity Analysis

A toll sensitivity analysis is helpful in assessing the reasonableness of assumed future toll rates for the DTR. Future year toll sensitivity curves are based on changes in traffic characteristics in the corridor including increasing congestion, value of time, competing facilities, and inflationary trends. These curves are essential in estimating the viability of future toll rate increases.

In general, the toll sensitivity curve suggests that when the toll rate increases, a portion of travelers will leave the toll facility in favor of other routes. Therefore, as the toll rate increases, transactions will decrease. However, as the toll rate increases, the toll revenue increases until it reaches the highest revenue point where an additional toll rate increment will generate a decrease in revenue.

CDM Smith conducted a toll sensitivity analysis for the model base year 2017. The toll sensitivity analysis indicates that the assumed future toll rates of DTR are well below the estimated theoretical revenue maximization point. This demonstrates that there would be considerable potential for revenue enhancement through toll increases above current rates. Using this analysis, revenue-maximizing mainline tolls are estimated to be in the range of $6.00 to $7.00 in 2017, more than the current $2.50 mainline toll.

Figure 5-2 illustrates the average weekday toll sensitivity curves for the model base year 2017. Mainline toll rates, in nominal year dollars, ranging from $1.00 to $7.00 were analyzed.

Table 5-4
Dulles Toll Road Traffic and Toll Revenue Estimates 2017-2054

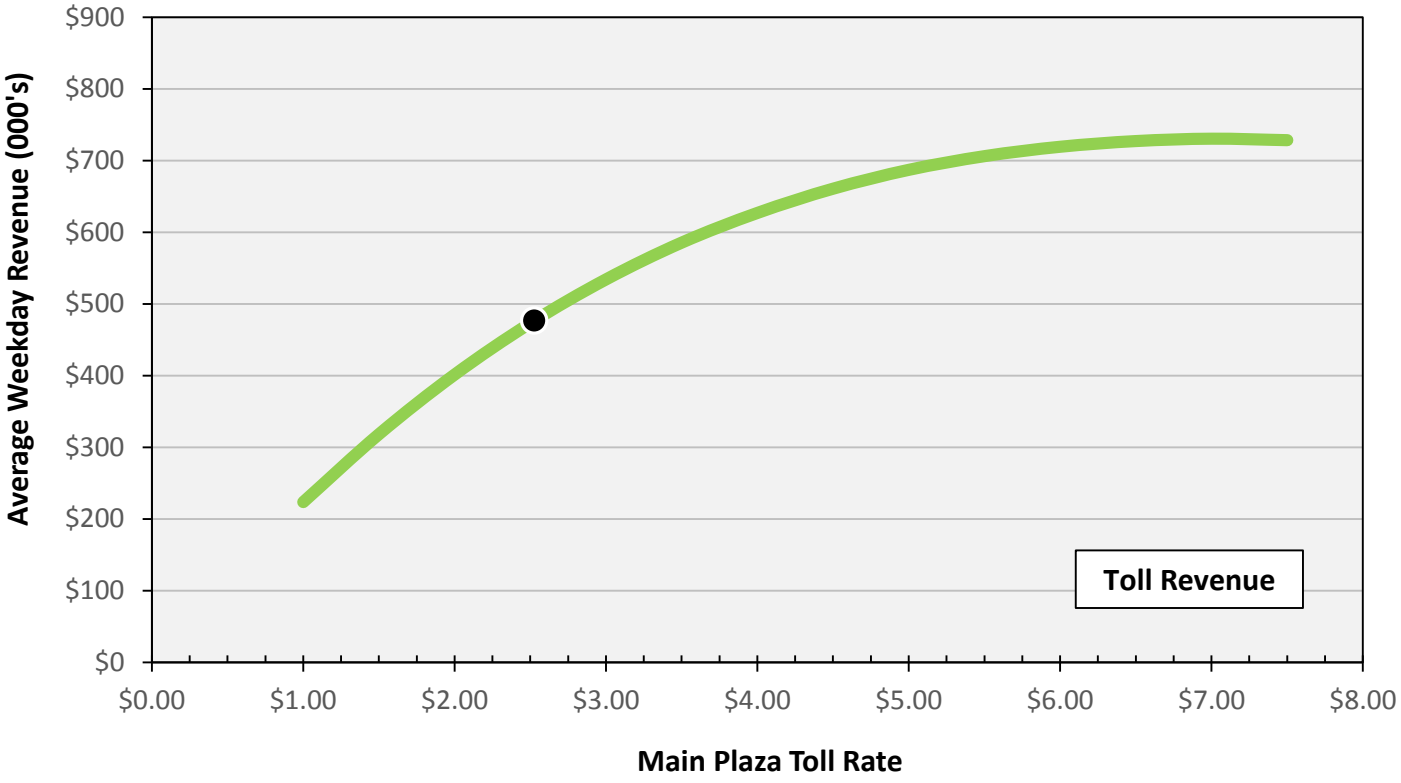
Forecast Year	Calendar Year	Main/Ramp[1] Tolls	Total[2] Transactions	% p.a.	Total[3] Revenue	% p.a.	Average[4] Revenue
0	**2017**	**$2.50 / $1.00**	**97,089,931**	-0.7%	**152,111,089**	**+0.3%**	**1.57**
1	2018	$2.50 / $1.00	97,960,000	+0.9%	153,289,000	+0.8%	1.56
2	2019	$3.25 / $1.50	91,653,000	-6.4%	198,650,000	+29.6%	2.17
3	**2020**	**$3.25 / $1.50**	**92,964,000**	**+1.4%**	**201,548,000**	**+1.5%**	**2.17**
4	2021	$3.25 / $1.50	94,488,000	+1.6%	204,838,000	+1.6%	2.17
5	2022	$3.25 / $1.50	96,037,000	+1.6%	208,182,000	+1.6%	2.17
6	2023	$4.00 / $2.00	88,345,000	-8.0%	245,109,000	+17.7%	2.77
7	2024	$4.00 / $2.00	89,793,000	+1.6%	249,111,000	+1.6%	2.77
8	**2025**	**$4.00 / $2.00**	**91,265,000**	**+1.6%**	**253,414,000**	**+1.7%**	**2.78**
9	2026	$4.00 / $2.00	93,483,000	+2.4%	259,702,000	+2.5%	2.78
10	2027	$4.00 / $2.00	95,754,000	+2.4%	266,145,000	+2.5%	2.78
11	2028	$4.75 / $2.50	90,053,000	-6.0%	305,290,000	+14.7%	3.39
12	2029	$4.75 / $2.50	92,241,000	+2.4%	312,864,000	+2.5%	3.39
13	**2030**	**$4.75 / $2.50**	**94,482,000**	**+2.4%**	**320,626,000**	**+2.5%**	**3.39**
14	2031	$4.75 / $2.50	96,705,000	+2.4%	328,064,000	+2.3%	3.39
15	2032	$4.75 / $2.50	98,981,000	+2.4%	335,675,000	+2.3%	3.39
16	2033	$5.50 / $3.25	92,297,000	-6.8%	385,498,000	+14.8%	4.18
17	2034	$5.50 / $3.25	94,468,000	+2.4%	394,440,000	+2.3%	4.18
18	**2035**	**$5.50 / $3.25**	**96,691,000**	**+2.4%**	**403,591,000**	**+2.3%**	**4.17**
19	2036	$5.50 / $3.25	98,666,000	+2.0%	411,647,000	+2.0%	4.17
20	2037	$5.50 / $3.25	100,680,000	+2.0%	419,863,000	+2.0%	4.17
21	2038	$6.25 / $3.75	89,474,000	-11.1%	425,965,000	+1.5%	4.76
22	2039	$6.25 / $3.75	91,301,000	+2.0%	434,468,000	+2.0%	4.76
23	**2040**	**$6.25 / $3.75**	**93,166,000**	**+2.0%**	**443,001,000**	**+2.0%**	**4.75**
24	2041	$6.25 / $3.75	94,117,000	+1.0%	447,422,000	+1.0%	4.75
25	2042	$6.25 / $3.75	95,078,000	+1.0%	451,887,000	+1.0%	4.75
26	2043	$7.00 / $4.25	91,547,000	-3.7%	489,384,000	+8.3%	5.35
27	2044	$7.00 / $4.25	92,482,000	+1.0%	494,268,000	+1.0%	5.34
28	2045	$7.00 / $4.25	93,426,000	+1.0%	499,201,000	+1.0%	5.34
29	2046	$7.00 / $4.25	93,903,000	+0.5%	501,692,000	+0.5%	5.34
30	2047	$7.00 / $4.25	94,382,000	+0.5%	504,196,000	+0.5%	5.34
31	2048	$7.75 / $4.75	91,900,000	-2.6%	545,422,000	+8.2%	5.93
32	2049	$7.75 / $4.75	92,369,000	+0.5%	548,144,000	+0.5%	5.93
33	2050	$7.75 / $4.75	92,841,000	+0.5%	550,879,000	+0.5%	5.93
34	2051	$7.75 / $4.75	93,315,000	+0.5%	553,628,000	+0.5%	5.93
35	2052	$7.75 / $4.75	93,791,000	+0.5%	556,391,000	+0.5%	5.93
36	2053	$7.75 / $4.75	94,270,000	+0.5%	559,167,000	+0.5%	5.93
37	2054	$7.75 / $4.75	94,751,000	+0.5%	561,958,000	+0.5%	5.93

[1] Historical and Projected Toll Rates per MWAA and Financial Advisor

[2] Total Transactions; revenue transactions, violations and non-revenue

[3] Total revenue including violation processing, fees and fines

[4] Average revenue per transaction.



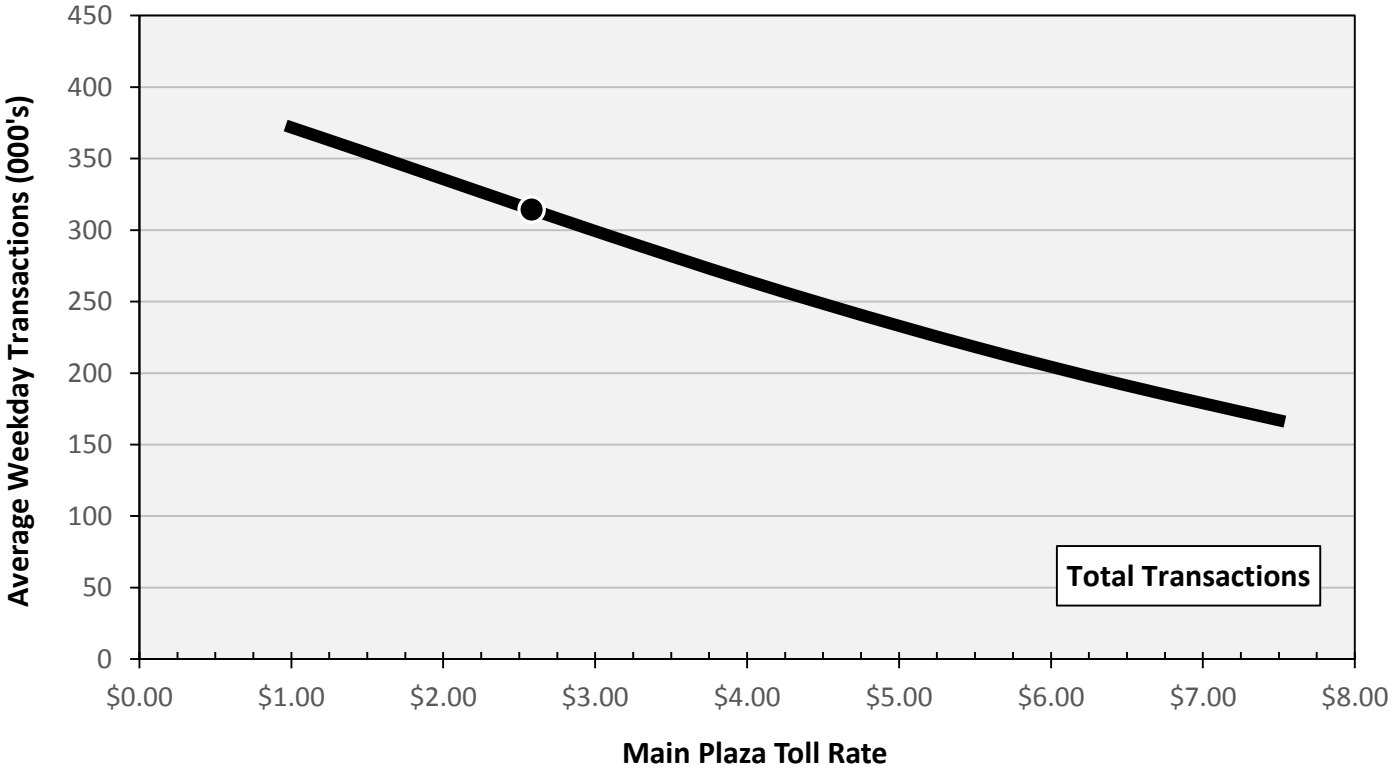


FIGURE 5-2: TOLL SENSITIVITY CURVES (2017)

Disclaimer

CDM Smith used currently-accepted professional practices and procedures in the development of traffic and revenue estimates. However, as with any forecast, differences between forecasted and actual results may occur, as caused by events and circumstances beyond the control of the forecasters. In formulating the estimates, CDM Smith reasonably relied upon the accuracy and completeness of information provided (both written and oral) by Metropolitan Washington Airports Authority (Airports Authority or MWAA) and Renaissance Planning Group. CDM Smith also relied upon the reasonable assurances of independent parties and is not aware of any material facts that would make such information misleading.

CDM Smith made qualitative judgments related to several key variables in the development and analysis of the traffic and revenue estimates that must be considered as a whole; therefore, selecting portions of any individual result without consideration of the intent of the whole may create a misleading or incomplete view of the results and the underlying methodologies used to obtain the results. CDM Smith gives no opinion as to the value or merit of partial information extracted from this report.

All estimates and projections reported herein are based on CDM Smith's experience and judgment and on a review of information obtained from multiple agencies, including the Airports Authority. These estimates and projections may not be indicative of actual or future values and are therefore subject to substantial uncertainty. Future developments, economic conditions, and impacts related to advances in automotive technology cannot be predicted with certainty and may affect the estimates or projections expressed in this report, such that CDM Smith does not specifically guarantee or warrant any estimate or projection contained within this report.

While CDM Smith believes that the projections and other forward-looking statements contained within the report are based on reasonable assumptions as of the date of the report, such forward-looking statements involve risks and uncertainties that may cause actual results to differ materially from the results predicted. Therefore, following the date of this report, CDM Smith will take no responsibility or assume any obligation to advise of changes that may affect its assumptions contained within the report, as they pertain to socioeconomic and demographic forecasts, proposed residential or commercial land use development projects and/or potential improvements to the regional transportation network.

CDM Smith is not, and has not been, a municipal advisor as defined in Federal law (the Dodd Frank Bill) to the Airports Authority and does not owe a fiduciary duty pursuant to Section 15B of the Exchange Act to MWAA with respect to the information and material contained in this report. CDM Smith is not recommending and has not recommended any action to the Airports Authority. The Airports Authority should discuss the information and material contained in this report with any and all internal and external advisors that it deems appropriate before acting on this information.

Chapter 6
Sensitivity Tests

The base case T&R forecast for the DTR shown in **Chapter 5** is based on certain assumptions of future economic growth, gasoline prices, VOT, and other factors. As noted, any forecast of the future is subject to considerable uncertainty. Consequently, T&R forecasts used in support of project financing typically include sensitivity tests; these are intended to provide a general measure of the potential impact on the base case forecasts associated with hypothetical changes in certain basic assumptions.

A series of sensitivity tests (described below) was conducted and compared with base case revenue forecasts. These sensitivity tests were run for 2020 and 2040 analysis years. The assumed base mainline and ramp toll rates of $3.25|$1.50 and $6.25|$3.75, in 2020 and 2040 respectively, were used in all sensitivity tests presented in this chapter.

A summary of the sensitivity test results is shown in **Table 6-1**. The first line in the table shows base case transactions and revenue forecast at near-year and out-year levels. For each of the sensitivity test scenarios described below, an alternative revenue forecast is shown, together with a calculation of the net impact on annual transactions and toll revenue and the percentage impact.

Lower Long-Term Economic Growth

The base case forecasts were predicated upon the regional socioeconomic growth forecasts incorporated in the regional travel model as updated and refined by CDM Smith. These socioeconomic forecasts were reviewed for reasonableness and adjusted by the independent economist RPG as previously described. However, CDM Smith also tested alternative economic growth scenarios by lowering the socio-economic growth rate. Two hypothetical scenarios were simulated by changing the rate of annual growth between the base year 2017 and future year 2020 and 2040 trip tables. In the first economic test, it was assumed that no trip growth would occur beyond the base year. In the second, overall growth rates were reduced by 25 percent from the base case trip growth obtained from RPG and future year 2020 and 2040 trip tables were adjusted accordingly.

As shown in Table 6-1, the assumption of no economic growth in the region results in an estimated 4.9 percent reduction in DTR transactions in 2020 and an estimated 30.9 percent reduction in 2040. Without economic growth, congestion on alternative toll-free routes will not increase, which reduces the relative time savings offered by the DTR. Toll revenue in the no growth scenario is estimated to be 4.8 percent and 30.6 percent lower for 2020 and 2040, respectively.

A decrease of 25 percent in the underlying trip table growth rate was tested, which resulted in a reduction of annual base transactions by an estimated 1.1 percent in 2020 and 8.4 percent in 2040. Toll revenue would be expected to be lower by approximately 1.1 percent in 2020 and 8.3 percent in 2040.

Table 6-1
Sensitivity Test Results
Annual Transactions and Toll Revenue (thousands)

Scenario	Total Transactions 2020	Total Transactions 2040	Toll Revenue 2020	Toll Revenue 2040
Base Case	92,960	93,170	$201,550	$443,000
No Economic Growth[1]	88,440	64,360	$191,870	$307,550
Difference	*(4,520)*	*(28,810)*	*(9,680)*	*(135,460)*
Percent Difference	*-4.9%*	*-30.9%*	*-4.8%*	*-30.6%*
Lower Economic Growth - Reduce 25%[2]	91,940	85,320	$199,370	$406,180
Difference	*(1,020)*	*(7,850)*	*(2,180)*	*(36,820)*
Percent Difference	*-1.1%*	*-8.4%*	*-1.1%*	*-8.3%*
Higher Economic Growth - Increase 25%[3]	94,090	101,570	$203,970	$482,540
Difference	*+1,130*	*+8,400*	*+2,420*	*+39,540*
Percent Difference	*+1.2%*	*+9.0%*	*+1.2%*	*+8.9%*
Lower Value of Time - Decrease by 25%[4]	74,660	78,950	$160,470	$376,390
Difference	*(18,300)*	*(14,210)*	*(41,070)*	*(66,610)*
Percent Difference	*-19.7%*	*-15.3%*	*-20.4%*	*-15.0%*
Higher Gasoline Prices[5]	87,780	88,750	$190,640	$422,850
Difference	*(5,180)*	*(4,420)*	*(10,900)*	*(20,150)*
Percent Difference	*-5.6%*	*-4.7%*	*-5.4%*	*-4.5%*

[1] Assumes no future growth in trips.
[2] Assumes decrease of 25 precent over base trip table growth.
[3] Assumes increase of 25 percent over base trip table growth.
[4] Assumes decrease of 25 percent over base value of time.
[5] Assumes gasoline prices increase to $5/gallon; reduce total regional trips by 4 percent.

Higher Long-Term Economic Growth

Regional trip growth in this sensitivity test was obtained by increasing the base case annual growth rate between the base year 2017 and future year trip tables by 25 percent. As a result, annual transactions and revenue would be expected to increase by an estimated 1.2 percent in 2020 and by approximately 9.0 percent in 2040.

Lower Value of Time

CDM Smith estimated VOT from the updated stated preference surveys of DTR customers. However, the VOT can be difficult to predict into the future. Consequently, a sensitivity test was performed considering the potential impact on the DTR traffic of a 25 percent lower VOT than assumed in the base case.

Traffic assignments were conducted for 2020 and 2040 calendar years using a lower VOT but retaining the toll rates in the base assignments. As noted from Table 6-1, a decrease of 25 percent in the underlying VOT would lower the annual transactions and revenue by an estimated 20 percent in 2020 and by 15 percent in 2040.

Higher Gasoline Prices

The base case forecast reflects an assumption of gasoline prices remaining at the 2017 fuel price average—i.e., approximately $2.70 per gallon initially—and then increasing in proportion to general prices thereafter.

A sensitivity test was performed, assuming gasoline prices increase to $5.00 per gallon in real terms in 2020 and 2040. Vehicle operating cost factors, of which a component is fuel costs, were adjusted accordingly. More significantly, it was assumed that gasoline prices at $5.00 per gallon would also result in a reduction in total regional travel of approximately 4.0 percent for purposes of this test.

Under this scenario, total annual transactions would be approximately 5.6 percent lower for 2020 and about 4.7 percent lower for 2040. Revenue would be 5.4 percent lower in 2020 and 4.5 percent lower in 2040.

Appendix A

Online SP Survey Experiment Design and Model Estimation Methodology

A main objective of the stated preference (SP) survey conducted for the Dulles Toll Road Comprehensive Traffic and Revenue Study was to estimate DTR customers' willingness to pay for travel time savings, or value of time (VOT). The VOTs estimated from the survey data were incorporated into the travel demand model to support estimates of traffic and revenue. This report details the SP survey experiment design and model estimation methodology used to produce those VOT estimates.

This appendix also includes the full set of survey screen captures from the online survey for reference.

Stated Preference Questions

The SP survey questionnaire was administered online by CDM Smith from Wednesday, October 18, 2017 through Thursday, November 23, 2017. The survey was designed to gather travel behavior information from automobile travelers who recently made a trip using the DTR. The questionnaire collected data on respondents' current travel behaviors (also referred as "revealed preferences") and used SP experiments to collect data that were used to estimate travelers' VOT.

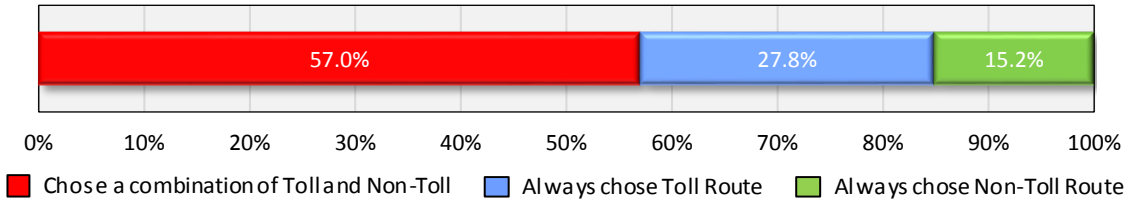
The stated preference questions were quantitative experiments designed to estimate travel preferences and behavioral responses under hypothetical conditions. The details of each respondent's reference trip were used to build a set of five stated preference scenarios. Each scenario alternative was described by both travel time and toll cost, which were varied across the five scenarios around the respondent's estimated travel time and the toll cost of traveling between the respondent's selected entry and exit points on the DTR. By varying the travel time and toll cost shown in each experiment, the respondent was faced with different time savings for different costs, allowing them to demonstrate their travel preferences across a range of values of time.

Figure B-1 SP Choice Survey Screen Sample

Respondents were asked to select their preferred travel alternative under the conditions presented by selecting either the tolled alternative (the DTR) or the alternate toll-free route. **Figure B-1** shows an example stated preference scenario with varying attribute values.

As shown in **Figure B-2**, 57 percent of the sample chose some combination of toll and non-toll routes during the five exercises, revealing their ability to make assessments about their own personal value of travel time savings even in the survey environment. Twenty-eight percent of respondents always chose the toll route option and 15 percent always chose the non-toll option, potentially revealing some bias either for or against toll roads.

Figure B-2 Stated Preference Toll Choices



Experiment Design

Two separate attribute level tables were developed for this study: one for respondents who had selected the Dulles Greenway mainline toll gantry as either their entry or exit point, and one for those who did not use the Dulles Greenway. The toll currently charged at the Dulles Greenway mainline plaza is significantly higher than any toll charged on the DTR, so the hypothetical toll costs shown to respondents during the stated preference trade-off questions had to be calculated differently for Greenway respondents compared with non-Greenway respondents.

In addition to differentiating between Greenway and non-Greenway survey respondents, the survey also presented slightly different travel time savings and penalty values to respondents based on the start time of their reference trip. Separate peak period and off-peak period values were developed for both the Greenway and non-Greenway choice experiments, and these levels are displayed in **Table B-1**.

After an analysis of average speeds and commuting times in the peak and off-peak periods, non-toll route delay penalties between 2 and 6 minutes were chosen as the levels to be added to the user's base travel time in the non-Greenway experiment. To calculate the hypothetical toll route travel time, a toll route time savings value of between zero and 4 minutes was then subtracted from the user's base travel time. These travel time penalties and savings values were also subject to a multiplication factor based on the toll distance of the user's reference trip. Non-Greenway respondents were placed in one of two groups based on their distance traveled on the DTR, with those traveling less than 7 miles on the toll road having their attribute values multiplied by one, and those traveling between 7 and 15 miles being multiplied by two.

Respondents who entered or exited from the Greenway mainline were shown route delay penalties of between 6 and 14 minutes and time savings of between zero and 11 minutes. Trips of between 7 and 15 toll road miles that used both the DTR and the Greenway were assigned a multiplication factor of 1, and trips greater than 15 miles used a factor of 1.5.

The specific levels used in each stated preference experiment were determined by using an orthogonal experimental design. The experimental design used to generate the stated preference experiments in the survey included 72 total experiments, from which five were randomly selected using a Latin Hypercube sampling technique. Orthogonal designs are used commonly in SP survey modeling to ensure that the attribute values vary independently and to minimize correlation between attribute values.

Table B-1 Stated Preference Experiments Time Savings and Penalties Ranges

Non-Greenway		Peak Travel Time		Off-Peak Travel Time			
Attribute	Level	Alternative 1: Non-toll Route	Alternative 2: Toll Route	Alternative 1: Non-toll Route	Alternative 2: Toll Route	Toll Distance Group	Multiplier
Travel Time:	1	+ 5.33 min	- 0.00 min	+ 6.00 min	- 0.00 min	< 7.0 miles	x1.0
Level value	2	+ 4.50 min	- 1.00 min	+ 4.75 min	- 1.00 min	7.0 to 14.9 miles	x2.0
added/subtracted	3	+ 3.66 min	- 1.50 min	+ 3.00 min	- 1.66 min		
from user-reported	4	+ 2.50 min	- 2.25 min	+ 2.75 min	- 2.33 min		
travel time.	5	+ 2.33 min	- 3.00 min	+ 2.50 min	- 3.50 min		
	6	+ 2.00 min	- 3.75 min	+ 2.00 min	- 4.00 min		
Toll Cost:	1		100%		100%		
Level value multiplied	2		121%		121%		
by user-reported toll	3		153%		153%		
cost.	4		174%		174%		

Greenway		Peak Travel Time		Off-Peak Travel Time			
Attribute	Level	Alternative 1: Non-toll Route	Alternative 2: Toll Route	Alternative 1: Non-toll Route	Alternative 2: Toll Route	Toll Distance Group	Multiplier
Travel Time:	1	+ 13.00 min	- 0.00 min	+ 14.00 min	- 0.00 min	7.0 to 14.9 miles	x1.0
Level value	2	+ 12.00 min	- 3.00 min	+ 12.25 min	- 3.00 min	>= 15.0 miles	x1.5
added/subtracted	3	+ 11.00 min	- 4.50 min	+ 9.00 min	- 5.00 min		
from user-reported	4	+ 8.00 min	- 7.50 min	+ 8.25 min	- 7.00 min		
travel time.	5	+ 7.00 min	- 8.50 min	+ 7.50 min	- 8.00 min		
	6	+ 6.00 min	- 11.00 min	+ 6.00 min	- 11.00 min		
Toll Cost:	1		100%		100%		
Level value multiplied	2		110%		110%		
by user-reported toll	3		120%		120%		
cost.	4		125%		125%		

Model Estimation

Statistical analysis and discrete choice model estimation were carried out using the stated preference survey data. The statistical estimation and specification testing were completed using a conventional maximum likelihood procedure that estimated a set of coefficients for a multinomial logit model.

Methodology and Alternatives

In each stated preference experiment, respondents who used the DTR for their reference trip were presented with two alternatives: make their trip using the toll road, or make their trip using an alternate, non-toll route. The five choice observations for each respondent were compiled into a dataset with a total of 67,585 observations, after removing outlier responses.

Data Cleaning and Identification of Outliers

The final dataset included only weekday travelers and 2-axle vehicles and rental cars and excluded commercial trucks and cash customers due to low sample size. Infrequent users (less than one trip per month) were also removed due to oversampling in the email distribution of survey invitations. The choice data then was screened to ensure that all observations included in the model estimation represented realistic trips and reasonable trade-offs, and that respondents made a genuine effort to take the time to read and respond to the questions honestly. Responses from individuals completing the survey in less than seven minutes were removed, for example.

Segmentation

In addition to aggregate models, segmented models were estimated for the following four different traveler groups based on trip purpose and the reported trip departure time:

- Peak period work and school
- Peak period non-work
- Off-peak period work and school
- Off-peak period non-work

By segmenting the models in this way, the behavioral differences between the segments can be identified and applied separately in the travel forecasting model. This final segmentation scheme was chosen based on the behavioral differences observed between the segments, expected application of the choice models, and the reasonableness and intuitiveness of the segmented results. In other words, the modeling results showed respondents in each of these categories behaved similar to others within their category and whose choices were statistically different than those in the other segments.

Model Specification

The multinomial logit model estimates a choice probability for each alternative presented in the stated preference trade-off exercises. The alternatives are represented in the model by observed utility equations of the form given below, where each *X* represents a variable (such as travel time), each β represents that variable's associated coefficient, which is estimated by the model, and ε represents the error term. These coefficients reflect respondents' sensitivity to changes in the corresponding variable.

$$U_i = \beta_1 * X_1 + \beta_2 * X_2 + \cdots + \beta_n * X_n + \varepsilon$$

Multinomial Logit Model Coefficient Estimates

The results of the final model specifications are presented below in **Table B-2** and **Table B-3** and include coefficients for the aggregate sample as well as the four market segments. The coefficient values, robust standard errors, robust t-statistics, and general model statistics for the full sample are included**.**

The standard error is a measure of error around the mean coefficient estimate. The t-statistic is the coefficient estimate divided by the standard error, which can be used to evaluate statistical significance. A t-statistic greater than or less than ±1.96 indicates that the coefficient is statistically significantly different from zero (unless otherwise reported) at the 95 percent level.

Table B-2 Choice Model Overall Fit

		Coefficient Values		
Coefficient	**Units**	**Value**	**Robust Std Error**	**Robust t-stat**
Travel Time	Minutes	-0.1590	0.00186	-85.89
Toll Cost	Dollars	-1.29	0.022	-58.98
DTR Route Constant	(0,1)	0.00	(fixed)	
Non-Toll Route Constant	(0,1)	1.08	0.0189	57.23

Model Statistics	
Number of estimated parameters	3
Number of observations	67,585
Number of individuals	13,517
Initial log-likelihood	-46,846.4
Final log-likelihood	-41,050.8
Rho-square	0.124
Adjusted rho-squre	0.124

Table B-3 Choice Model Segment Coefficients

		Coefficient Values		
Coefficient	**Units**	**Value**	**Robust Std Error**	**Robust t-stat**
Travel Time - Peak Work	Minutes	-0.1670	0.00296	-56.26
Travel Time - Peak Non-Work	Minutes	-0.1610	0.00718	-22.48
Travel Time - Off-Peak Work	Minutes	-0.1450	0.00360	-40.39
Travel Time - Off-Peak Non-Work	Minutes	-0.1660	0.00577	-28.77
Toll Cost* - Peak Work	Dollars	-1.3500	0.03500	-38.59
Toll Cost* - Peak Non-Work	Dollars	-1.3700	0.08410	-16.27
Toll Cost* - Off-Peak Work	Dollars	-1.1200	0.04460	-25.20
Toll Cost* - Off-Peak Non-Work	Dollars	-1.3700	0.0679	-20.19

** Toll cost is transformed by the natural log of user-reported household income, in ten thousands*

The model fit statistics that are presented include the number of observations, the number of estimated parameters, the initial log-likelihood, the log-likelihood at convergence, rho-squared, and adjusted rho- squared. The log-likelihood is a model fit measure that indicates how well the model predicts the choices observed in the data. The null log-likelihood is the measure of the model fit with coefficient values of zero. The final log-likelihood is the measure of model fit with the final coefficient values at model convergence. A value closer to zero indicates better model fit. The log-likelihood cannot be evaluated independently, as it is a function of the number of observations, the number of alternatives, and the number of parameters in the choice model. The rho-square model fit measure accounts for this to some degree by evaluating the difference between the null log-likelihood and the final log likelihood at convergence. The adjusted rho-square value takes into account the number of parameters estimated in the model.

The coefficient values are the values estimated by the choice model that represent the relative importance of each of the variables. It should be noted that these values are unit-specific, and the units must be accounted for when comparing coefficients. The sign of the coefficient indicates a positive or negative relationship between utility and the associated variable. For example, a negative travel time coefficient implies that utility for a given travel alternative will decrease as the travel time associated with that alternative increases.

Willingness to Pay for Travel Time Savings (Value of Time)

The expression for calculating willingness to pay for travel time savings, or VOT, is shown below. VOT is calculated by dividing the travel time coefficient by the toll cost coefficient and then multiplying by 60 to convert from dollars per minute to dollars per hour. If an income-based log transformation was applied to the toll cost attribute prior to model specification, then the same transformation is applied to the toll cost coefficient when calculating VOT. In this case, toll cost was transformed by the natural log of household income, in ten thousands.

$$VOT = 60 * {}^{\beta Time}\Big/\left(\frac{\beta Cost}{LN(income/10{,}000)}\right)$$

The aggregate VOT for the full sample, at the survey sample median income level of $137,500, was calculated as $19.38 per hour. The values of time evaluated at each income category midpoint by market segment and by customer type are shown in **Table B-4**.

Table B-4 Value of Time

		Peak Period		Off-Peak Period	
Household Income	**Full Sample**	**Work**	**Non-Work**	**Work**	**Non-Work**
$20,000 and Less	$5.13	$5.14	$4.89	$4.57	$4.19
$30,000	$8.12	$8.15	$7.75	$7.24	$6.64
$42,500	$10.70	$10.74	$10.20	$9.53	$8.75
$62,500	$13.55	$13.60	$12.92	$12.07	$11.08
$87,500	$16.04	$16.10	$15.29	$14.29	$13.11
*$112,500	$17.90	$17.96	$17.07	$15.95	$14.63
**$137,500	$19.38	$19.45	$18.48	$17.27	$15.85
$175,000	$21.17	$21.24	$20.18	$18.86	$17.30
$200,000 and More	$23.03	$23.11	$21.95	$20.51	$18.82

**Fairfax County median income: $114,000*
***Survey sample median income: $137,500*

These values are consistent with USDOT guidelines for valuation of travel time[1], which suggest a plausible range for value of travel time savings as being between 35 and 60 percent of average regional person hour earnings for local trips. According to data from the 2016 American Community Survey[2], the average hourly wages of Fairfax and Loudoun counties—the home counties of 73.2 percent of all respondents in this survey—were $42.85 and $44.69, respectively, suggesting a value of time for a representative household as being between $15.00 and $26.26 per hour.

[1] U.S. Dept. of Transportation. *Revised Departmental Guidance on Valuation of Travel Time in Economic Analysis*. 2016.
[2] U.S. Census Bureau American FactFinder. "S2303: Work Status in the Past 12 Months." 2012 – 2016 American Community Survey.

Online Survey Screenshots

The full set of survey screen captures from the online survey are included below.

Dulles Toll Road Travel Survey 2017

Welcome to the Dulles Toll Road Travel Survey!

Please click the Next button below to begin the survey.

Dulles Toll Road Travel Survey 2017

Welcome to the Dulles Toll Road Travel Survey!

We need your input! The Metropolitan Washington Airports Authority is conducting this anonymous 15-minute survey to help improve the travel experience for all Dulles Toll Road customers.

Qualifying participants who complete the survey will be eligible to enter into a drawing to win **one of five $500 VISA gift cards***!

THANK YOU for taking the time to share your thoughts and feelings about the Dulles Toll Road! If you have any questions, or would like additional information about the survey, please email DTRsurvey2017@gmail.com.

** Void where prohibited by law. Entrant must be 18 years or older. The survey must be filled out in its entirety and electronically postmarked by November 22, 2017. No facsimiles of the information will be accepted. Employees of VDOT, MWAA, its consultants, concessionaires, contract employees, their spouses and children are not eligible. Winners of the $500 American Express gift cards will be selected in a random drawing and need not be present to win. Notification will be by email. Winners unable to be contacted within 30 days after the drawing and those not indicating acceptance and eligibility within 30 days of notification will forfeit the right to a prize. Alternate winners will then be drawn from the pool of applicants. All decisions will be final. The odds of winning are determined by the number of entries.*

Dulles Toll Road Travel Survey 2017

Section One

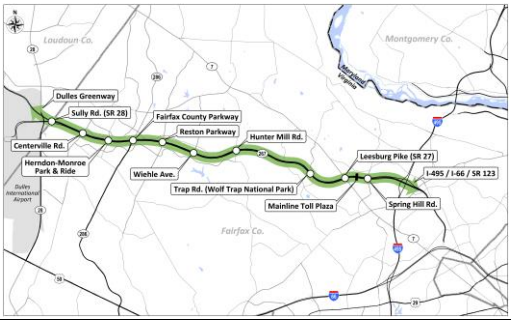
*Note: Please use the **Next** and **Back** buttons at the bottom of this page to navigate this survey, rather than your web browser's "forward" and "back" buttons.*

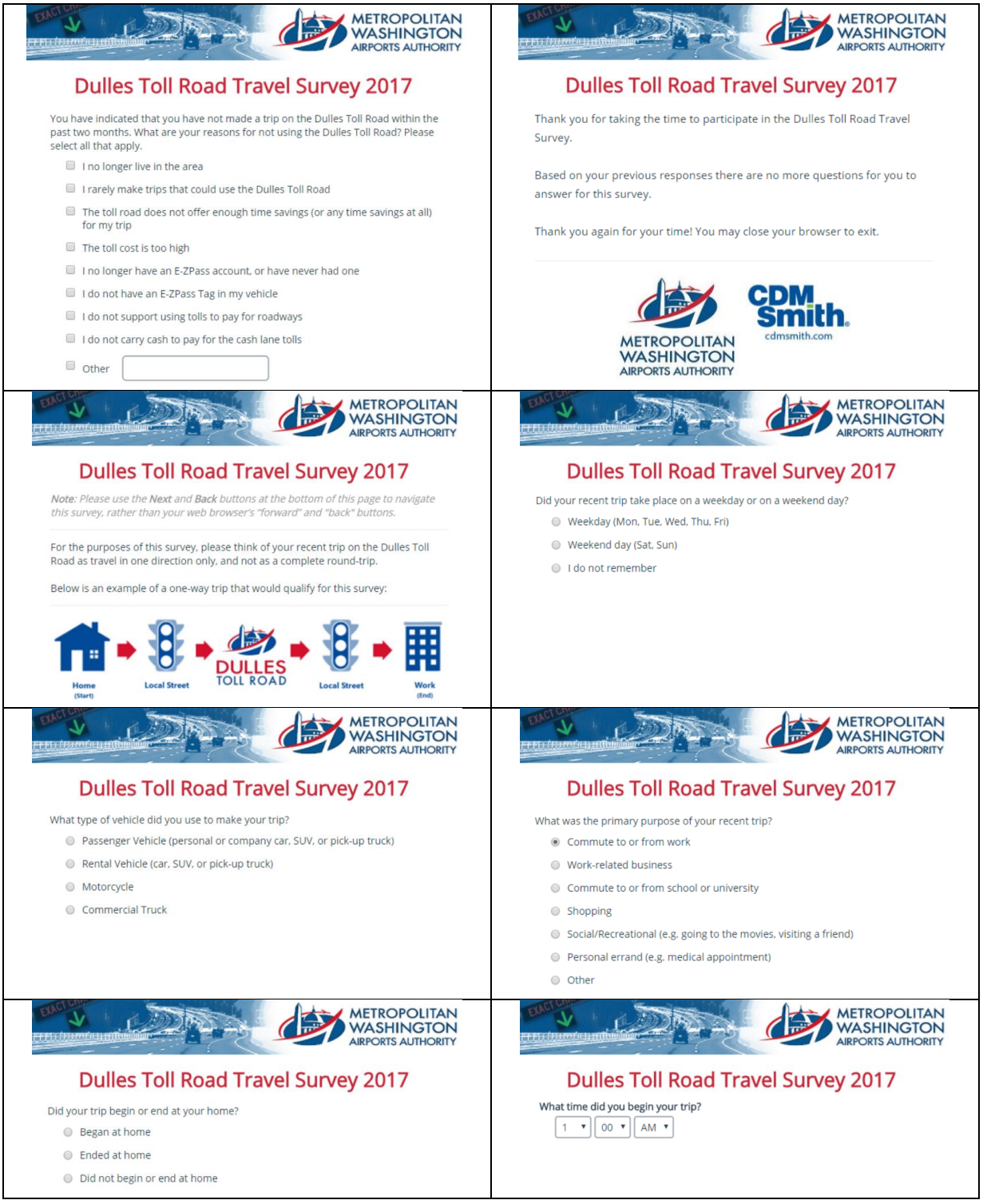
This survey is divided into three sections. In this first section, you will be asked to describe a recent trip that you made using the Dulles Toll Road.

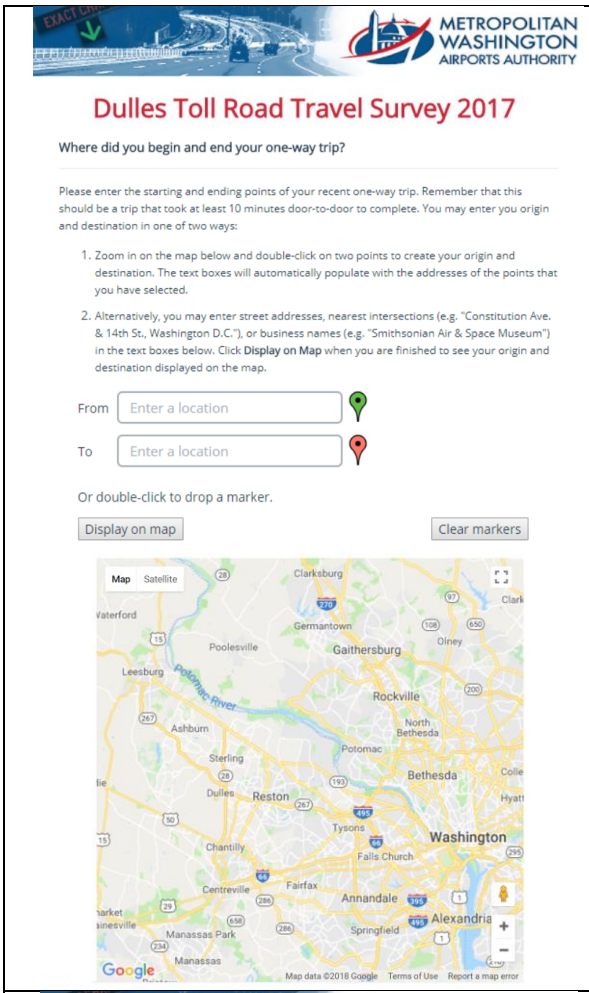
Dulles Toll Road Travel Survey 2017

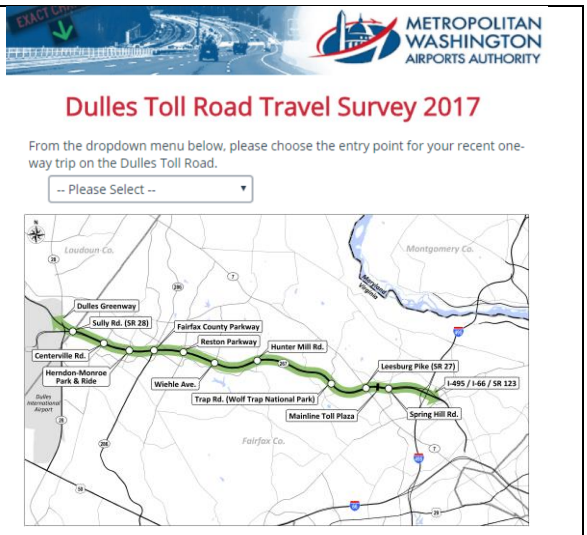
From the dropdown menu below, please choose the entry point for your recent one-way trip on the Dulles Toll Road.

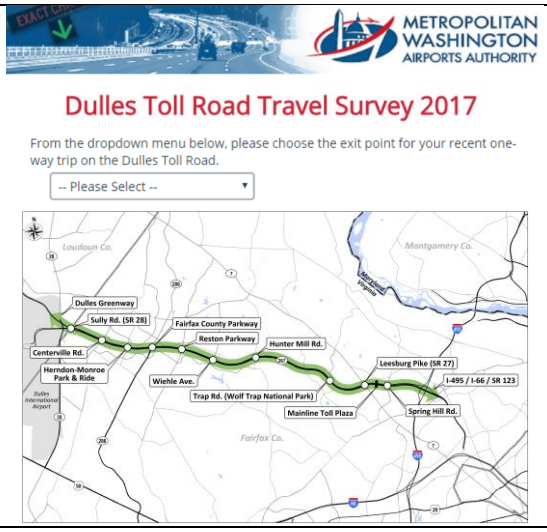
-- Please Select --

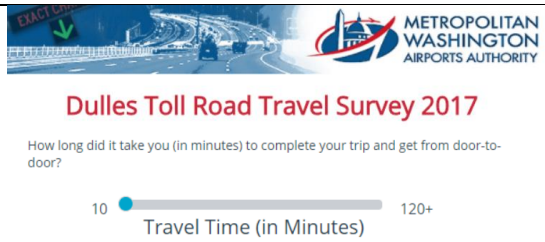


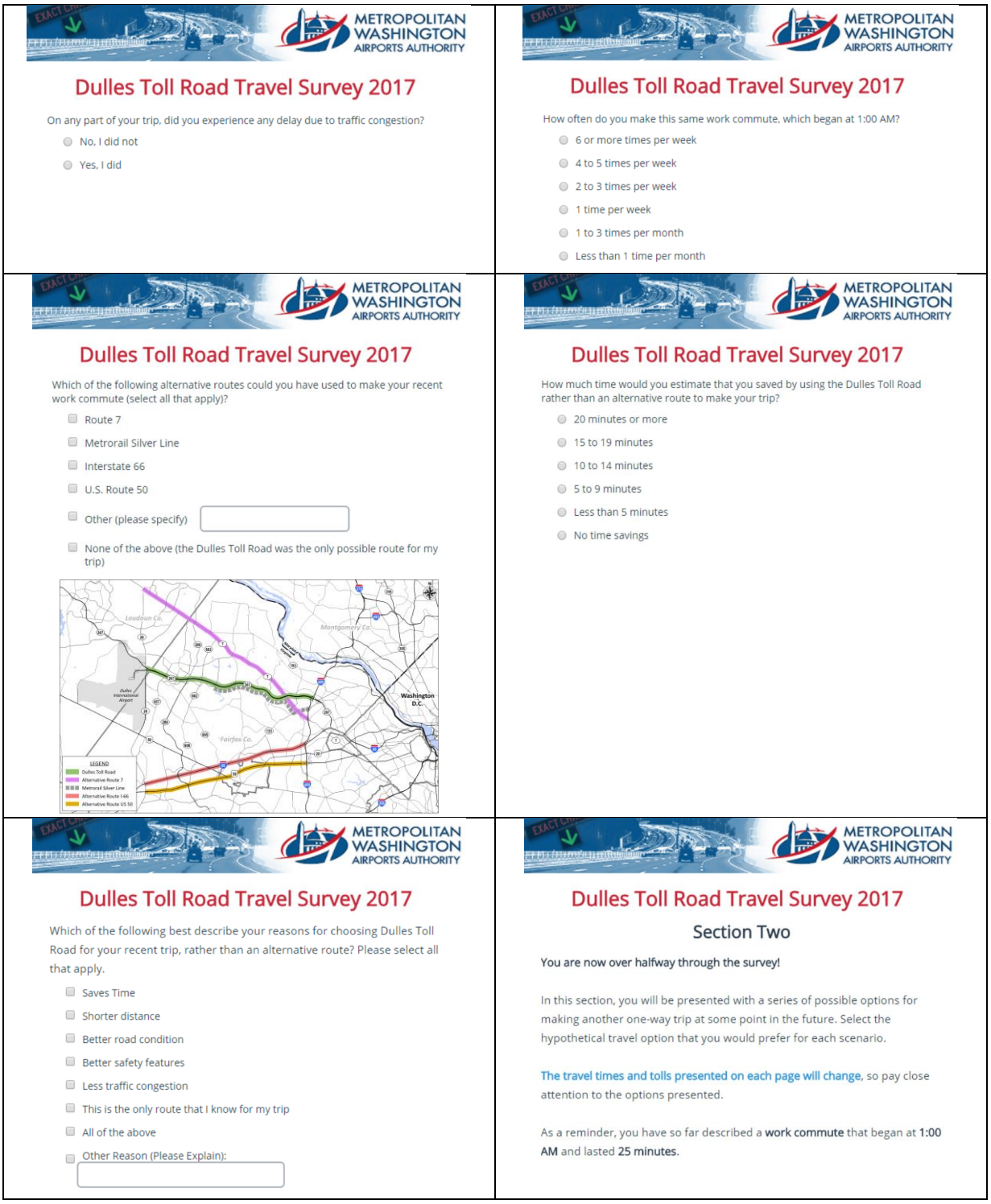

METROPOLITAN WASHINGTON AIRPORTS AUTHORITY
Dulles Toll Road Travel Survey 2017
You have indicated that you have not made a trip on the Dulles Toll Road within the past two months. What are your reasons for not using the Dulles Toll Road? Please select all that apply.
I no longer live in the area
I rarely make trips that could use the Dulles Toll Road
The toll road does not offer enough time savings (or any time savings at all) for my trip
The toll cost is too high
I no longer have an E-ZPass account, or have never had one
I do not have an E-ZPass Tag in my vehicle
I do not support using tolls to pay for roadways
I do not carry cash to pay for the cash lane tolls
Other
METROPOLITAN WASHINGTON AIRPORTS AUTHORITY
Dulles Toll Road Travel Survey 2017
Thank you for taking the time to participate in the Dulles Toll Road Travel Survey.
Based on your previous responses there are no more questions for you to answer for this survey.
Thank you again for your time! You may close your browser to exit.
METROPOLITAN WASHINGTON AIRPORTS AUTHORITY
CDM Smith
cdmsmith.com
METROPOLITAN WASHINGTON AIRPORTS AUTHORITY
Dulles Toll Road Travel Survey 2017
Note: Please use the Next and Back buttons at the bottom of this page to navigate this survey, rather than your web browser's "forward" and "back" buttons.
For the purposes of this survey, please think of your recent trip on the Dulles Toll Road as travel in one direction only, and not as a complete round-trip.
Below is an example of a one-way trip that would qualify for this survey:
Home (Start)
Local Street
DULLES TOLL ROAD
Local Street
Work (End)
METROPOLITAN WASHINGTON AIRPORTS AUTHORITY
Dulles Toll Road Travel Survey 2017
Did your recent trip take place on a weekday or on a weekend day?
Weekday (Mon, Tue, Wed, Thu, Fri)
Weekend day (Sat, Sun)
I do not remember
METROPOLITAN WASHINGTON AIRPORTS AUTHORITY
Dulles Toll Road Travel Survey 2017
What type of vehicle did you use to make your trip?
Passenger Vehicle (personal or company car, SUV, or pick-up truck)
Rental Vehicle (car, SUV, or pick-up truck)
Motorcycle
Commercial Truck
METROPOLITAN WASHINGTON AIRPORTS AUTHORITY
Dulles Toll Road Travel Survey 2017
What was the primary purpose of your recent trip?
Commute to or from work
Work-related business
Commute to or from school or university
Shopping
Social/Recreational (e.g. going to the movies, visiting a friend)
Personal errand (e.g. medical appointment)
Other
METROPOLITAN WASHINGTON AIRPORTS AUTHORITY
Dulles Toll Road Travel Survey 2017
Did your trip begin or end at your home?
Began at home
Ended at home
Did not begin or end at home
METROPOLITAN WASHINGTON AIRPORTS AUTHORITY
Dulles Toll Road Travel Survey 2017
What time did you begin your trip?
1
00
AM

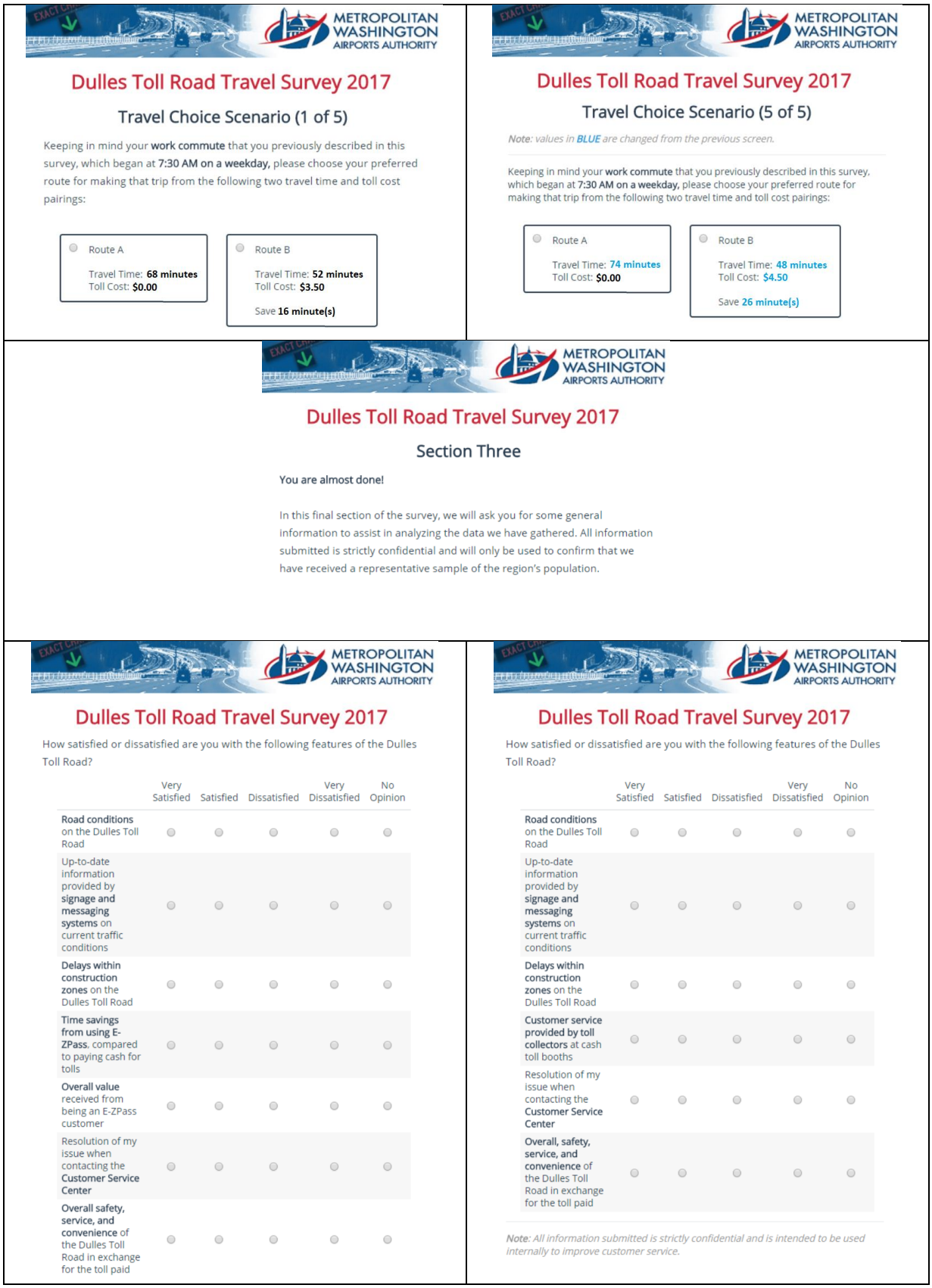

METROPOLITAN WASHINGTON AIRPORTS AUTHORITY
Dulles Toll Road Travel Survey 2017
Where did you begin and end your one-way trip?
Please enter the starting and ending points of your recent one-way trip. Remember that this should be a trip that took at least 10 minutes door-to-door to complete. You may enter you origin and destination in one of two ways:
1. Zoom in on the map below and double-click on two points to create your origin and destination. The text boxes will automatically populate with the addresses of the points that you have selected.
2. Alternatively, you may enter street addresses, nearest intersections (e.g. "Constitution Ave. & 14th St., Washington D.C."), or business names (e.g. "Smithsonian Air & Space Museum") in the text boxes below. Click Display on Map when you are finished to see your origin and destination displayed on the map.
From
Enter a location
To
Enter a location
Or double-click to drop a marker.
Display on map
Clear markers
Map
Satellite
Clarksburg
Germantown
Gaithersburg
Olney
Poolesville
Leesburg
Potomac River
Rockville
Ashburn
North Bethesda
Potomac
Sterling
Bethesda
Dulles
Reston
Tysons
Washington
Chantilly
Falls Church
Centreville
Fairfax
Annandale
Alexandria
Springfield
Manassas Park
Manassas
Google
Map data ©2018 Google
Terms of Use
Report a map error


METROPOLITAN WASHINGTON AIRPORTS AUTHORITY
Dulles Toll Road Travel Survey 2017
From the dropdown menu below, please choose the entry point for your recent one-way trip on the Dulles Toll Road.
-- Please Select --
Loudoun Co.
Montgomery Co.
Fairfax Co.
Dulles Greenway
Sully Rd. (SR 28)
Fairfax County Parkway
Reston Parkway
Hunter Mill Rd.
Centerville Rd.
Herndon-Monroe Park & Ride
Wiehle Ave.
Leesburg Pike (SR 27)
I-495 / I-66 / SR 123
Trap Rd. (Wolf Trap National Park)
Mainline Toll Plaza
Spring Hill Rd.


METROPOLITAN WASHINGTON AIRPORTS AUTHORITY
Dulles Toll Road Travel Survey 2017
From the dropdown menu below, please choose the exit point for your recent one-way trip on the Dulles Toll Road.
-- Please Select --
Loudoun Co.
Montgomery Co.
Fairfax Co.
Dulles Greenway
Sully Rd. (SR 28)
Fairfax County Parkway
Reston Parkway
Hunter Mill Rd.
Centerville Rd.
Herndon-Monroe Park & Ride
Wiehle Ave.
Leesburg Pike (SR 27)
I-495 / I-66 / SR 123
Trap Rd. (Wolf Trap National Park)
Mainline Toll Plaza
Spring Hill Rd.


METROPOLITAN WASHINGTON AIRPORTS AUTHORITY
Dulles Toll Road Travel Survey 2017
How long did it take you (in minutes) to complete your trip and get from door-to-door?
10
120+
Travel Time (in Minutes)


METROPOLITAN WASHINGTON AIRPORTS AUTHORITY
Dulles Toll Road Travel Survey 2017
On any part of your trip, did you experience any delay due to traffic congestion?
No, I did not
Yes, I did
Dulles Toll Road Travel Survey 2017
How often do you make this same work commute, which began at 1:00 AM?
6 or more times per week
4 to 5 times per week
2 to 3 times per week
1 time per week
1 to 3 times per month
Less than 1 time per month
Dulles Toll Road Travel Survey 2017
Which of the following alternative routes could you have used to make your recent work commute (select all that apply)?
Route 7
Metrorail Silver Line
Interstate 66
U.S. Route 50
Other (please specify)
None of the above (the Dulles Toll Road was the only possible route for my trip)
Loudoun Co.
Montgomery Co.
Fairfax Co.
Washington D.C.
LEGEND
Dulles Toll Road
Alternative Route 7
Metrorail Silver Line
Alternative Route I-66
Alternative Route US 50
Dulles Toll Road Travel Survey 2017
How much time would you estimate that you saved by using the Dulles Toll Road rather than an alternative route to make your trip?
20 minutes or more
15 to 19 minutes
10 to 14 minutes
5 to 9 minutes
Less than 5 minutes
No time savings
Dulles Toll Road Travel Survey 2017
Which of the following best describe your reasons for choosing Dulles Toll Road for your recent trip, rather than an alternative route? Please select all that apply.
Saves Time
Shorter distance
Better road condition
Better safety features
Less traffic congestion
This is the only route that I know for my trip
All of the above
Other Reason (Please Explain):
Dulles Toll Road Travel Survey 2017
Section Two
You are now over halfway through the survey!
In this section, you will be presented with a series of possible options for making another one-way trip at some point in the future. Select the hypothetical travel option that you would prefer for each scenario.
The travel times and tolls presented on each page will change, so pay close attention to the options presented.
As a reminder, you have so far described a work commute that began at 1:00 AM and lasted 25 minutes.



Dulles Toll Road Travel Survey 2017

Travel Choice Scenario (1 of 5)

Keeping in mind your **work commute** that you previously described in this survey, which began at **7:30 AM on a weekday,** please choose your preferred route for making that trip from the following two travel time and toll cost pairings:

Route A
Travel Time: **68 minutes**
Toll Cost: **$0.00**

Route B
Travel Time: **52 minutes**
Toll Cost: **$3.50**
Save **16 minute(s)**

Dulles Toll Road Travel Survey 2017

Travel Choice Scenario (5 of 5)

*Note: values in **BLUE** are changed from the previous screen.*

Keeping in mind your **work commute** that you previously described in this survey, which began at **7:30 AM on a weekday,** please choose your preferred route for making that trip from the following two travel time and toll cost pairings:

Route A
Travel Time: **74 minutes**
Toll Cost: **$0.00**

Route B
Travel Time: **48 minutes**
Toll Cost: **$4.50**
Save **26 minute(s)**

Dulles Toll Road Travel Survey 2017

Section Three

You are almost done!

In this final section of the survey, we will ask you for some general information to assist in analyzing the data we have gathered. All information submitted is strictly confidential and will only be used to confirm that we have received a representative sample of the region's population.

Dulles Toll Road Travel Survey 2017

How satisfied or dissatisfied are you with the following features of the Dulles Toll Road?

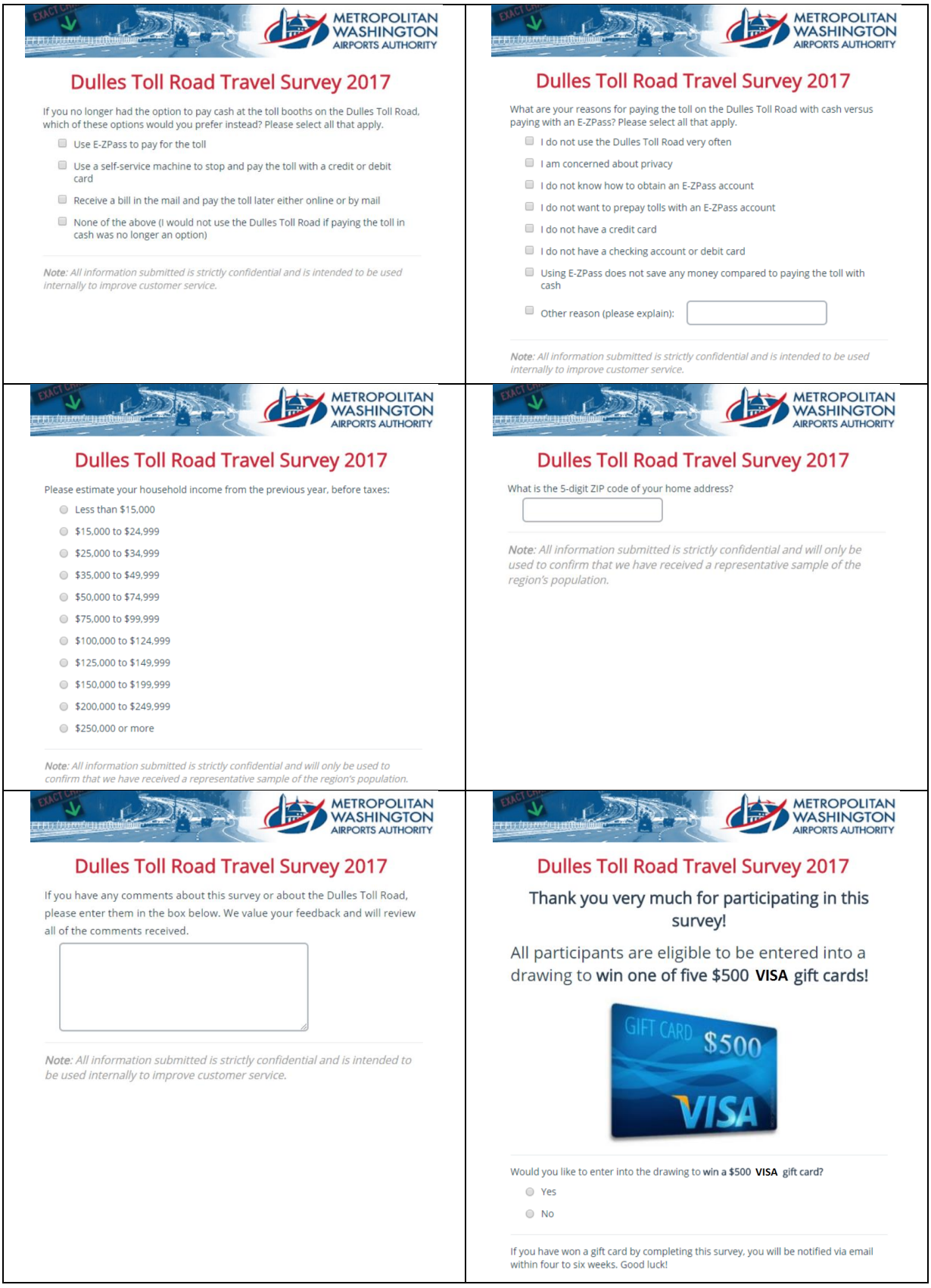
	Very Satisfied	Satisfied	Dissatisfied	Very Dissatisfied	No Opinion
Road conditions on the Dulles Toll Road					
Up-to-date information provided by **signage and messaging systems** on current traffic conditions					
Delays within construction zones on the Dulles Toll Road					
Time savings from using E-ZPass, compared to paying cash for tolls					
Overall value received from being an E-ZPass customer					
Resolution of my issue when contacting the **Customer Service Center**					
Overall safety, service, and convenience of the Dulles Toll Road in exchange for the toll paid					

Dulles Toll Road Travel Survey 2017

How satisfied or dissatisfied are you with the following features of the Dulles Toll Road?

	Very Satisfied	Satisfied	Dissatisfied	Very Dissatisfied	No Opinion
Road conditions on the Dulles Toll Road					
Up-to-date information provided by **signage and messaging systems** on current traffic conditions					
Delays within construction zones on the Dulles Toll Road					
Customer service provided by toll collectors at cash toll booths					
Resolution of my issue when contacting the **Customer Service Center**					
Overall, safety, service, and convenience of the Dulles Toll Road in exchange for the toll paid					

Note: All information submitted is strictly confidential and is intended to be used internally to improve customer service.



Dulles Toll Road Travel Survey 2017

If you no longer had the option to pay cash at the toll booths on the Dulles Toll Road, which of these options would you prefer instead? Please select all that apply.

- Use E-ZPass to pay for the toll
- Use a self-service machine to stop and pay the toll with a credit or debit card
- Receive a bill in the mail and pay the toll later either online or by mail
- None of the above (I would not use the Dulles Toll Road if paying the toll in cash was no longer an option)

Note: All information submitted is strictly confidential and is intended to be used internally to improve customer service.

Dulles Toll Road Travel Survey 2017

What are your reasons for paying the toll on the Dulles Toll Road with cash versus paying with an E-ZPass? Please select all that apply.

- I do not use the Dulles Toll Road very often
- I am concerned about privacy
- I do not know how to obtain an E-ZPass account
- I do not want to prepay tolls with an E-ZPass account
- I do not have a credit card
- I do not have a checking account or debit card
- Using E-ZPass does not save any money compared to paying the toll with cash
- Other reason (please explain):

Note: All information submitted is strictly confidential and is intended to be used internally to improve customer service.

Dulles Toll Road Travel Survey 2017

Please estimate your household income from the previous year, before taxes:

- Less than $15,000
- $15,000 to $24,999
- $25,000 to $34,999
- $35,000 to $49,999
- $50,000 to $74,999
- $75,000 to $99,999
- $100,000 to $124,999
- $125,000 to $149,999
- $150,000 to $199,999
- $200,000 to $249,999
- $250,000 or more

Note: All information submitted is strictly confidential and will only be used to confirm that we have received a representative sample of the region's population.

Dulles Toll Road Travel Survey 2017

What is the 5-digit ZIP code of your home address?

Note: All information submitted is strictly confidential and will only be used to confirm that we have received a representative sample of the region's population.

Dulles Toll Road Travel Survey 2017

If you have any comments about this survey or about the Dulles Toll Road, please enter them in the box below. We value your feedback and will review all of the comments received.

Note: All information submitted is strictly confidential and is intended to be used internally to improve customer service.

Dulles Toll Road Travel Survey 2017

Thank you very much for participating in this survey!

All participants are eligible to be entered into a drawing to **win one of five $500 VISA gift cards!**

Would you like to enter into the drawing to **win a $500 VISA gift card?**

- Yes
- No

If you have won a gift card by completing this survey, you will be notified via email within four to six weeks. Good luck!

Dulles Toll Road Travel Survey 2017

The survey is now complete.

Thank you very much for your participation!

You may now exit the survey.

If you have any questions, please send inquiries to DTRsurvey2017@gmail.com.

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Appendix B

RPG Socio-Economic Growth Update

Renaissance Planning Group (RPG) was retained to conduct an independent validity analysis of the MWCOG Round 9.0 socioeconomic data. The report by RPG is included in full in the following pages.

DULLES TOLL ROAD INDEPENDENT ECONOMIC ASSESSMENT

FALL 2017 UPDATE

FEBRUARY 21, 2018

Prepared By: Renaissance Planning Group
Prepared For: Metropolitan Washington Airports Authority

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EXECUTIVE SUMMARY

This report describes the independent economic analysis of the land use trends and forecasts affecting potential travel demand for a traffic and revenue study for the Dulles Toll Road in Fairfax County, Virginia. The study is prepared for input to travel demand forecasts using the travel model maintained by the Metropolitan Washington Council of Governments (MWCOG) staff. The independent economic analysis therefore utilizes the data structure of the MWCOG travel demand model in terms of traffic analysis zone (TAZ) forecasts for residential and employment in the region. The independent economic analysis uses both local and national data sources to develop a new set of TAZ forecasts for a series of near-term to long-term analysis years. The report describes both the process and key findings of the independent economic analysis.

INTRODUCTION

Renaissance Planning Group (Renaissance or RPG) has conducted this independent economic analysis of the validity of the socioeconomic data that is used in conjunction with the Metropolitan Washington Transportation Planning Board travel demand forecasting model to forecast future travel demand in the Washington D.C. Metropolitan Area. The analysis includes a reasonability test of traffic analysis zone (TAZ) and countywide socioeconomic data relative to current economic conditions and trends, the availability of vacant and underutilized land, and the propensity for development and redevelopment. This analysis has been conducted in support of a traffic and revenue study issued by the Metropolitan Washington Airports Authority (MWAA) for the Dulles Toll Road project in Fairfax County, Virginia. The economic analysis and socioeconomic data validation and adjustment will be utilized in the study, undertaken by CDM Smith, Inc. The findings of the analysis will be used by CDM Smith to forecast future vehicle traffic and toll revenue of the Dulles Toll Road project.

Renaissance has prepared countywide population and employment estimates for 2015 and 2017, and forecasts for 2020, 2025, 2030, 2035 and 2040 for the core and suburban jurisdictions within the Washington D.C. metropolitan area: Alexandria, Arlington, Fairfax, Loudoun and Prince William Counties in Virginia; Charles, Frederick, Montgomery and Prince George's Counties in Maryland; and the District of Columbia. These forecasts were generated considering 2010 and prior U.S. Decennial Census results, public and private forecasts from several sources, as well as MWCOG forecasts of the purposes of long range regional land use and transportation planning. Additionally, a detailed evaluation of market conditions and socioeconomics forecasts was conducted for the primary market area of the Dulles Toll Road, comprising portions of Loudoun County, Fairfax County, Arlington County, and the District of Columbia. This was accomplished by compiling and refining parcel level data from various sources, deploying a land use allocation model, and identifying TAZs where our findings indicate revisions to the adopted forecasts may be warranted.

This report updates the forecasts developed in spring 2014, as summarized in Appendix C to the Dulles Toll Road Comprehensive Traffic and Revenue Study 2014 Update from CDM Smith. The 2017 update utilizes the latest available TAZ-level forecasts adopted by the MWCOG, referred to as Round 9.0. The purpose of this report is to document the analysis undertaken by Renaissance Planning Group and present the resulting jurisdictional and TAZ level adjustments to the adopted population and employment forecasts for the Washington D.C. Metropolitan Area.

APPROACH

Renaissance assembled a project team of professional land use planners, development specialists, transportation planners, and geographic information systems (GIS) analysts. The project team evaluated economic conditions, local market dynamics, land use patterns, land availability and infrastructure investments that affect the long-term population and employment growth in the Washington, D.C. Metropolitan Area. The RPG approach included:

- Testing and adjusting regionwide and jurisdiction level population and employment control totals;
- Analyzing the capacity for residential and non-residential development;
- A macroeconomic assessment of the opportunities for short and long-term growth; and
- A forecasting tool that integrates predictive variables to analyze and adjust forecasts at the TAZ level.

The approach to analyzing and refining the data for the region includes several steps as first documented in the 2014 report and as summarized below:

I. Definition of a Dulles Toll Road Primary Market Area (PMA) based on a critical mass of origins and destinations for Dulles Toll Road patrons;
II. Interagency and intergovernmental coordination to understand perspectives on MWCOG methods and forecasts;
III. Evaluation and documentation of MWCOG jurisdiction-level population and employment forecasts, as well as a comparison of those forecasts to several public and private sources;
IV. Macroeconomic assessment of past trends, present conditions and near-term prospects for development absorption and job creation within the metropolitan region;
V. A forecast for 2020 through 2040 based on macroeconomic factors of population and employment at the jurisdictional level to be used as guidance in preparing the final adjusted forecast;
VI. Detailed local area evaluation of existing conditions and land supply side factors for the jurisdictions in the Primary Market Area;

VII. Methodology for modeling and testing the validity of TAZ-level MWCOG forecasts for the District of Columbia, the Cities of Alexandria and Arlington, and Arlington, Fairfax, and Loudoun Counties in Virginia;
VIII. Final TAZ, jurisdiction, and Primary Market Area forecasts based on adjusted 2010 population and employment, supply analysis, macroeconomic guidance and forecasting model based on MWCOG assumptions.

The development of TAZ-level forecasts reflects information and knowledge regarding localized planning, zoning, and market research affecting development patterns within the Primary Market Area. The Primary Market Area includes several key activity centers that are referenced throughout the report and detailed in Section I.

I. DULLES TOLL ROAD PRIMARY MARKET AREA

The results of a 2007 Travel Pattern Survey for the Dulles Toll Road were used to identify the Primary Market Area for our analysis. The survey was conducted by CDM Smith (formerly Wilbur Smith Associates) on behalf of MWAA and VDOT. The survey contained data points for 8,674 trip origins and 8,574 trip destinations within the COG model TAZs. These origin and destination points were mapped and analyzed by normalized density per acre, as well as total per TAZ. The Primary Market Area is defined by TAZ boundaries. TAZs with the highest concentration of both origins and destinations were manually selected to comprise the Primary Market Area. Wherever possible, TAZs were selected to form a cohesive study area, avoiding holes and rough edges. Prior analyses for other transportation facilities in the Washington region have demonstrated that a cohesive study area boundary can usually be defined by a “travel-shed” encompassing 85% of total facility origins and destinations (a point beyond which the remaining users are too dispersed to be cohesive). The selection process continued until the percent of total origins and destinations were both greater than 85%. The Primary Market Area and origins and destinations by TAZ are depicted in Figure 1. The area includes all or portions of Loudoun County, Fairfax County, Arlington County, the District of Columbia, and the cities of Alexandria and Arlington.

Figure 1 | Primary Market Area (PMA)

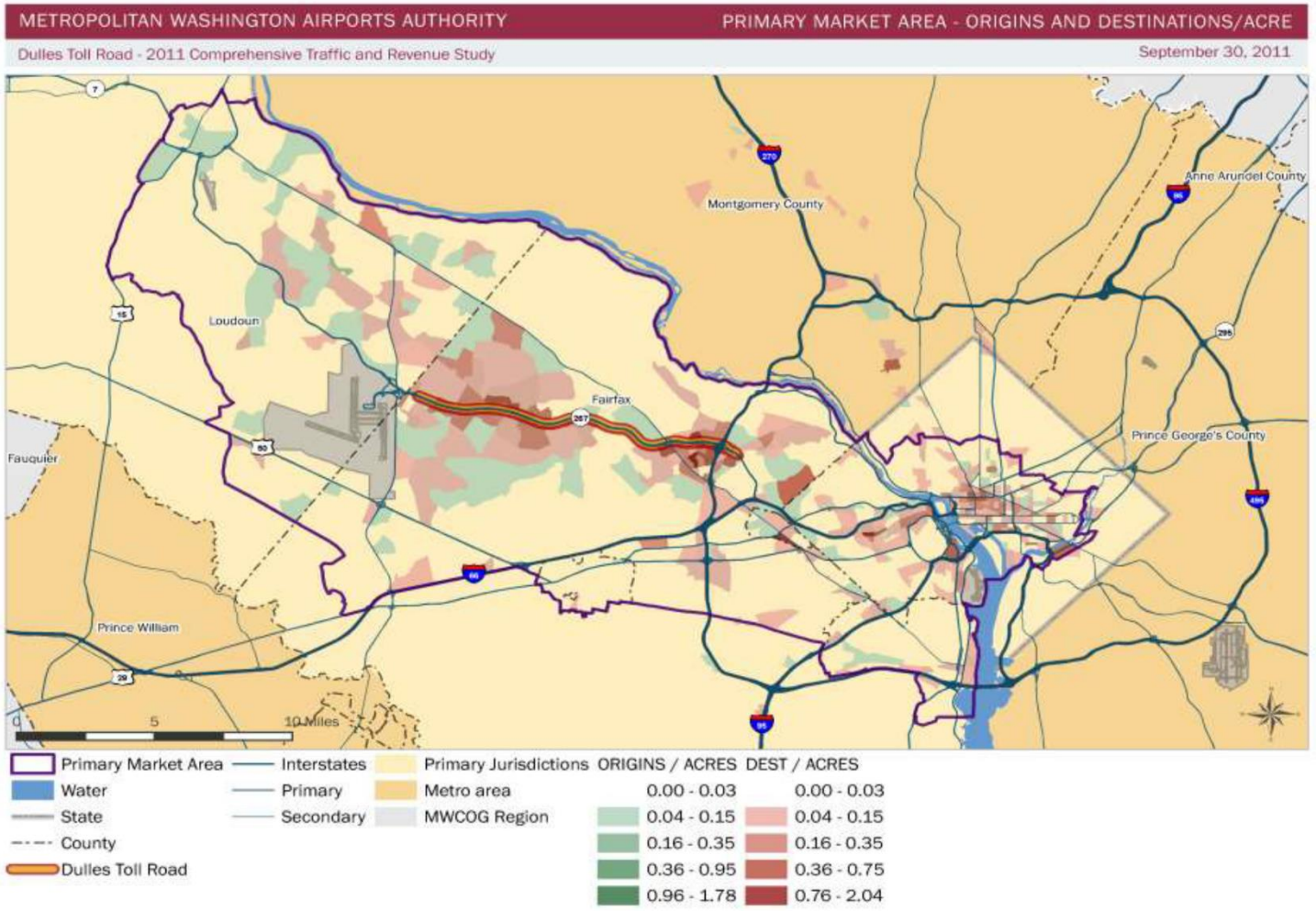
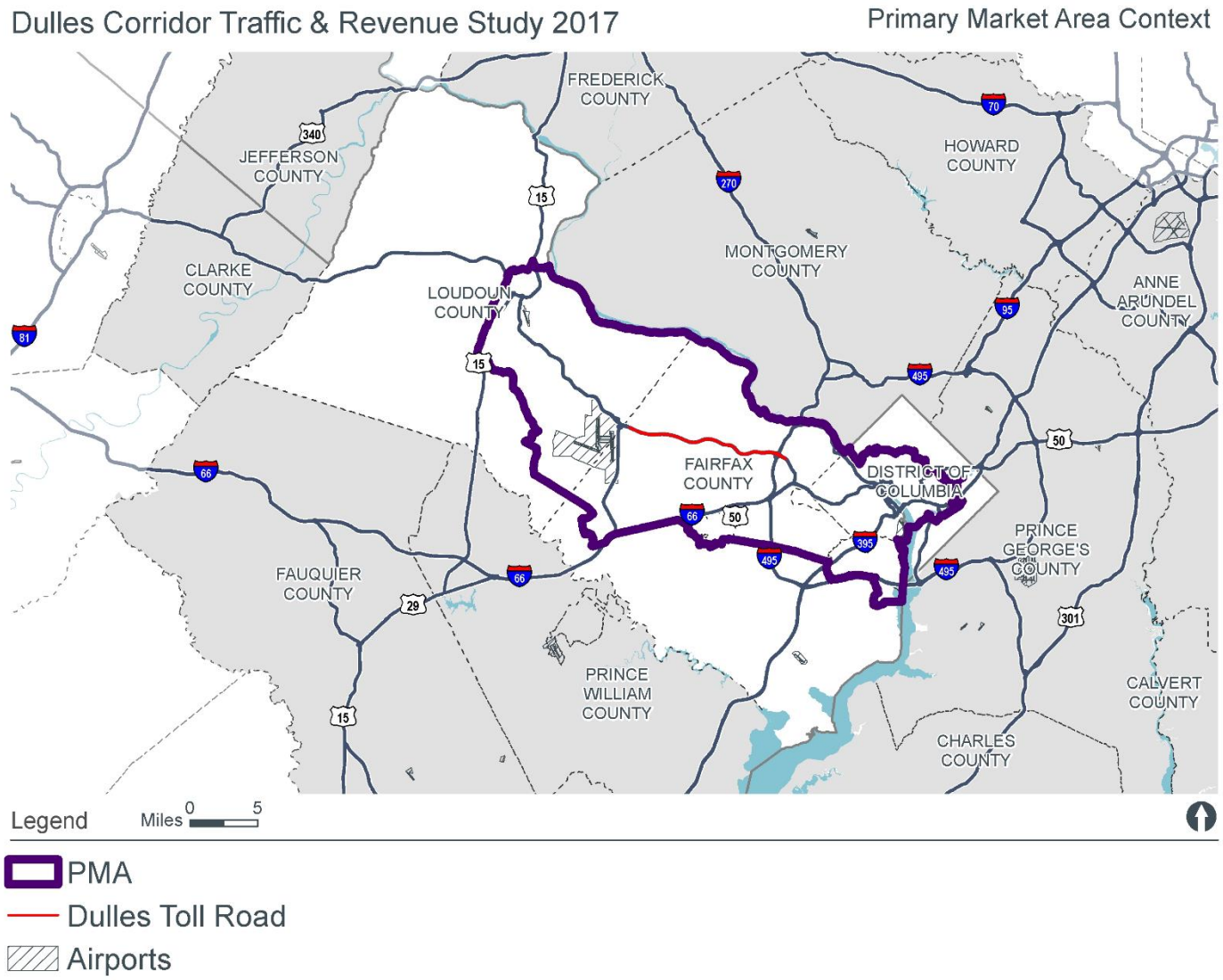


Figure 2 | Primary Market Area Context



The MWCOG has a cooperative land use forecasting process in which local jurisdictions regularly provide TAZ-level forecasts to the regional planners in a coordinated process that reflects regional econometric forecasts with established growth control totals based on market conditions. These forecasts are generally produced on an annual cycle, with each year's forecasts described as a "round" of forecasts. Each round provides employment, population, and household forecasts by five-year increments, covering a period of 20 to 30 years. MWCOG has most recently completed Round 9.0 forecasts meaning the ninth substantive regional forecast. Note that the term "Round 9.0" forecasts are for the full MWCOG model region, which includes (in addition to the PMA) Frederick, Stafford, Montgomery, Prince William, Prince George's, and Charles Counties.

II. INTERAGENCY AND INTERGOVERNMENTAL COORDINATION

For the 2012, 2014 and 2017 forecasts, Renaissance contacted several government agencies responsible for land use planning, zoning, and transportation planning within the PMA to collect information and interview key staff. The interviews and meetings helped us gain perspective on trends and conditions in the housing and commercial development markets and hear their perspective on the MWCOG forecasts. The following is a list of those who were consulted for inputs on the 2017 update:

- Arlington County Department of Community Housing and Development
- Fairfax County Department of Planning and Zoning
- Loudoun County Department of Planning
- Metropolitan Washington Council of Governments

III. JURISDICTION-LEVEL ANALYSIS

One component of the economic analysis is to conduct an evaluation of population and employment historic data and forecasts at the jurisdictional level. This section summarizes the data sources used and presents graphs comparing historic trends and forecasts for a select number of jurisdictions within the metropolitan region. For this level of analysis, we have cast a wide net to include jurisdictions that do not have a significant impact on the Dulles Toll Road. The purpose is to ensure we understand the regional dynamics of job formation, population growth, and general trends and preferences that affect the long-term prospects for change in the region and within the Primary Market Area for the Dulles Toll Road.

In 1970, Washington D.C. was the center of the regional economy, and had the highest number of jobs and residents. Starting in the 1970s, the region's suburbs began to grow in population and employment at a higher rate than Washington D.C. The next 30 years saw continual population decline and general employment stagnation in the District of Columbia, alongside explosive growth in the outer suburbs of Fairfax. Alexandria and Arlington County also exhibited robust growth, though at slower rates than the outer suburbs.

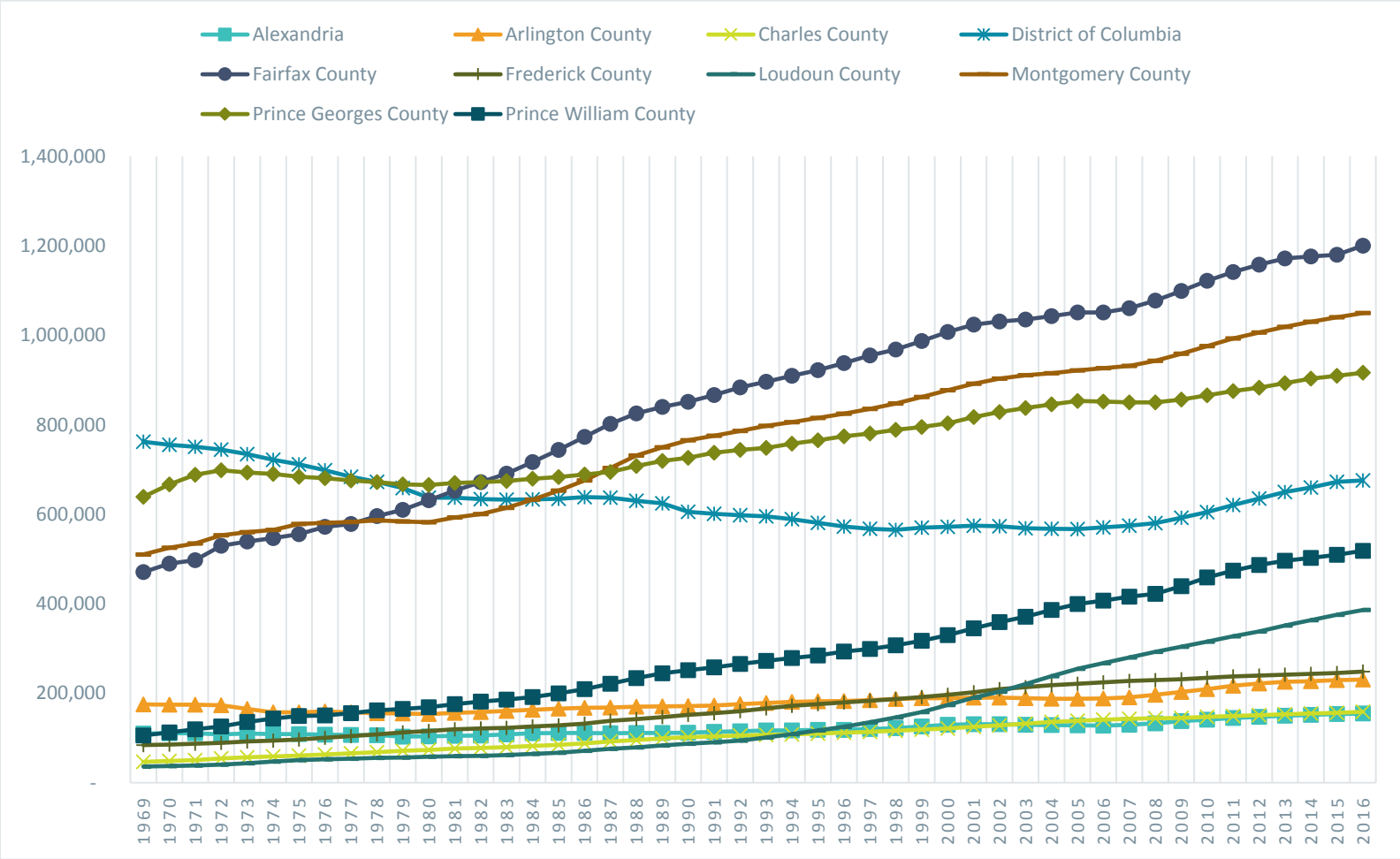
Figure 3 and Figure 15 illustrate that over the past fifty years, the primary jurisdictions have demonstrated the evolution of first-tier suburban growth typical of metropolitan areas along the eastern seaboard. In these metropolitan areas the central cities are landlocked and cannot expand through annexation and have gone through a cycle of disinvestment and rebirth.

This trend of urban disinvestment and exurban growth began to shift at the turn of the century. As seen in Figure 4 and Figure 16, the percent changes in population and employment by jurisdiction began to align across the region. This has been particularly true for employment over the past half-decade. All jurisdictions have seen nearly identical percent changes in employment. In fact, Fairfax has joined D.C. as a regional employment leader, with Montgomery County close behind. Relative growth in population and employment is starting to align across the region, demonstrating a trend of "growing together", with Loudoun County as an outlier.

Population History and Forecasts

Historic population estimates and trends, illustrated in Figure 3 and Figure 4, were obtained from Woods & Poole Economics. Population forecasts were obtained from four sources, two from the public sector and two from the private sector. The public-sector sources were the state government data center for Maryland and Virginia, depending on the jurisdiction's location, and MWCOG Round 9.0 Cooperative Forecast. No public-sector source was identified for the District of Columbia. The State of Maryland forecast was available in five-year increments extending to 2040. The State of Virginia forecast was only available in ten-year increments, extending to 2030: for ease of comparison, Renaissance interpolated five-year forecasts using the CAGR of Virginia ten-year forecasts. The two private sources were Moody's Analytics and Woods & Poole Economics. All available forecasts from 2020 through 2040 are visualized for each jurisdiction in Figure 5 through Figure 14 below.

Figure 3 | Historic Changes in Jurisdictional Population, 1969-2016[1]



[1] Source: Woods & Poole Economics. NOTE: 2016 numbers for population and employment trends are Woods & Poole forecasts

Figure 4 | Annual Percent Change in Population by Jurisdiction, 1970-2016

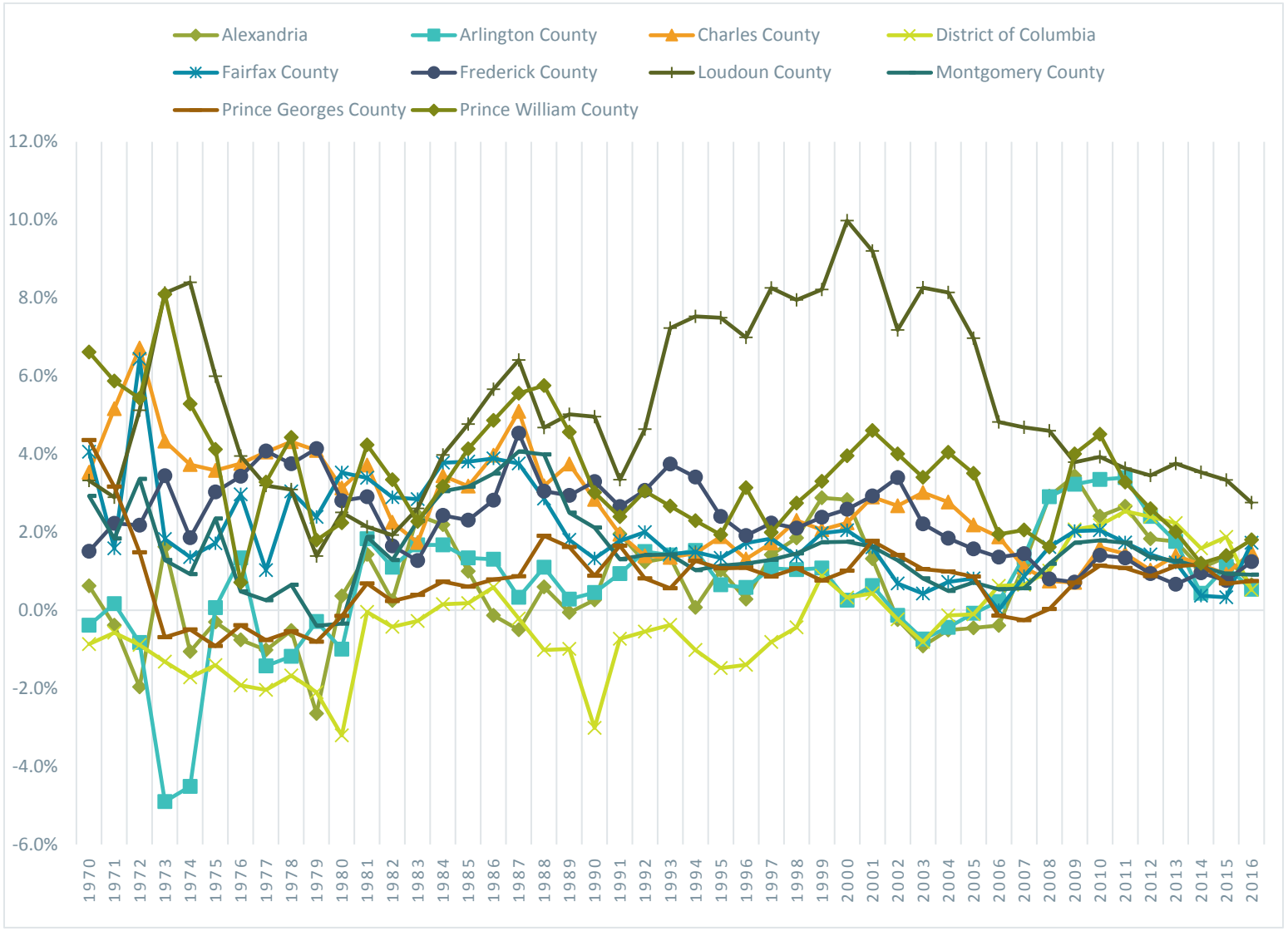


Figure 5 | Alexandria Population Forecasts, 2020-2040

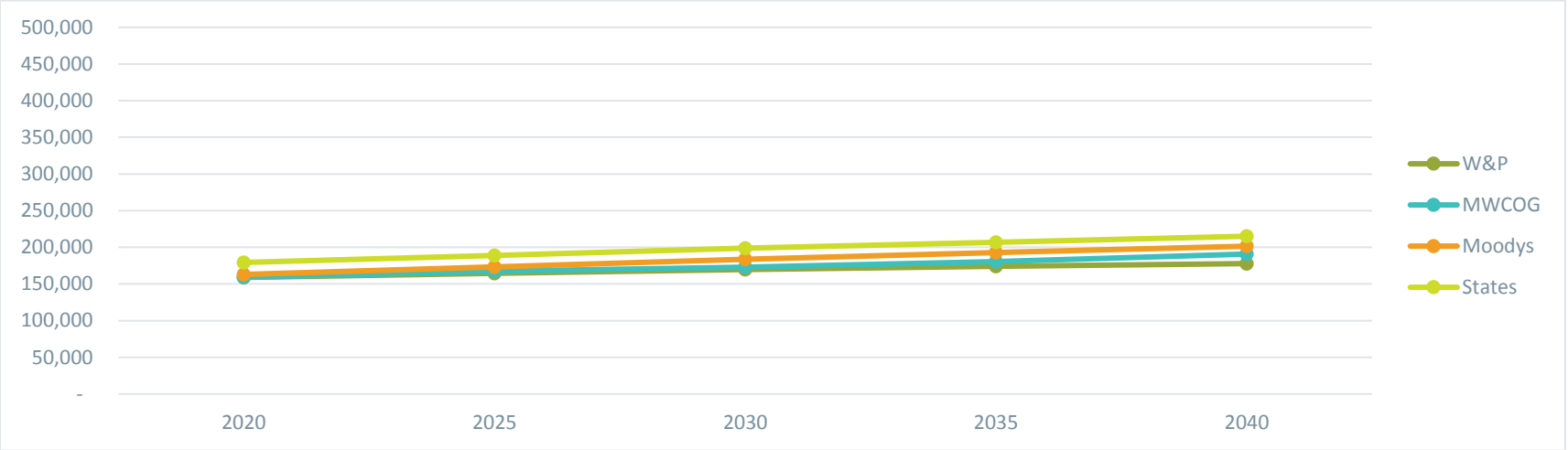


Figure 6 | Arlington County Population Forecasts, 2020-2040

Figure 7 | Charles County Population Forecasts, 2020-2040

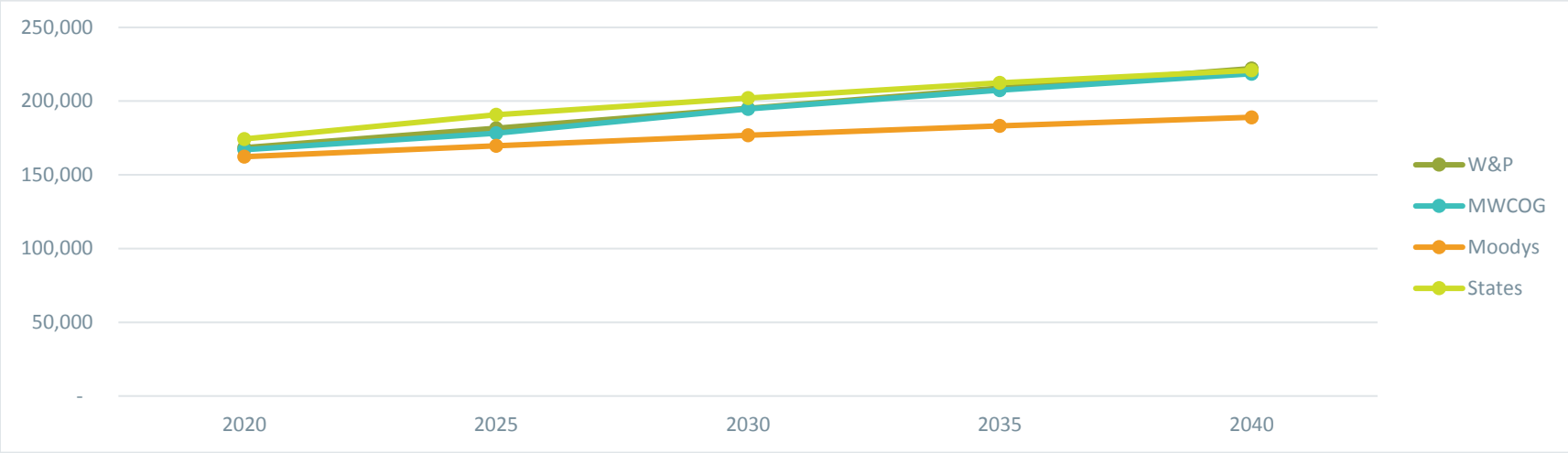


Figure 8 | District of Columbia Population Forecasts, 2020-2040

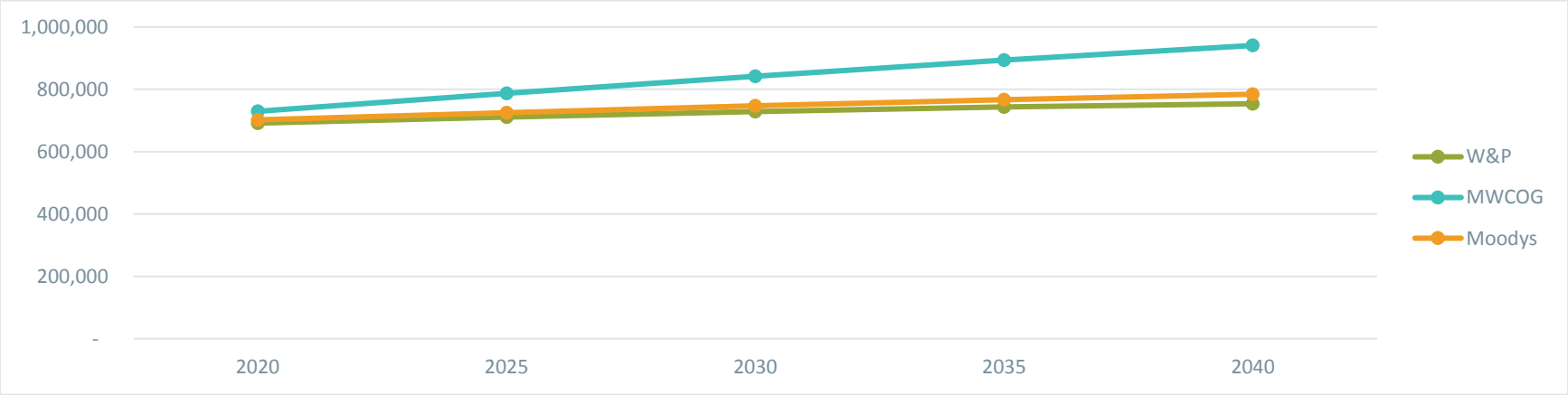


Figure 9 | Fairfax County Population Forecasts, 2020-2040

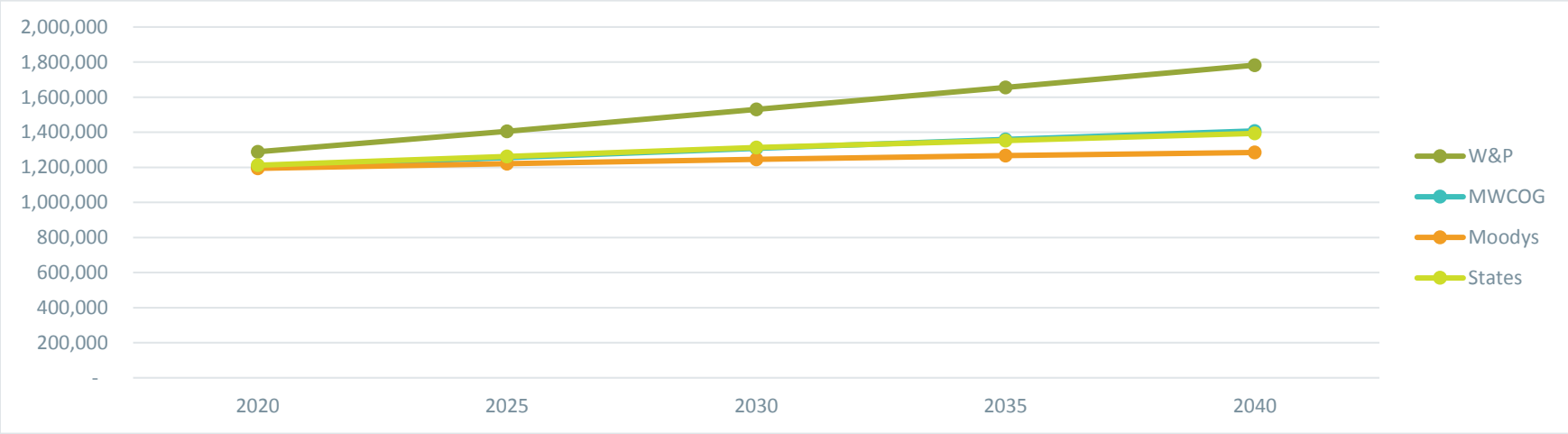


Figure 10 | Frederick County Population Forecasts, 2020-2040

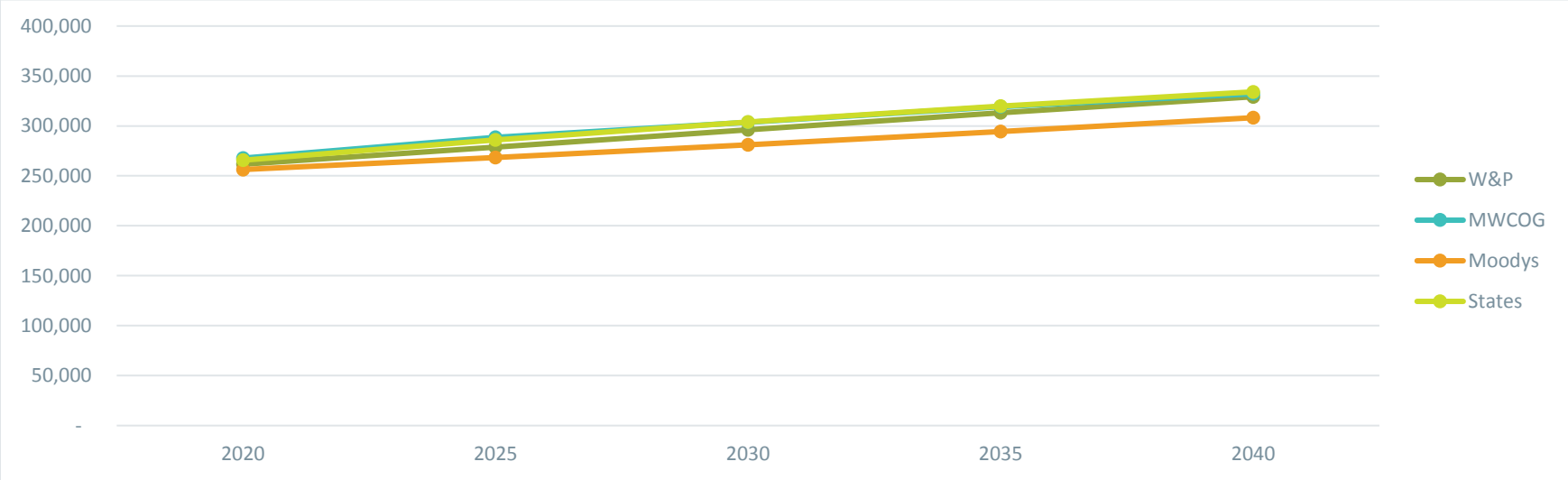


Figure 11 | Loudoun County Population Forecasts, 2020-2040

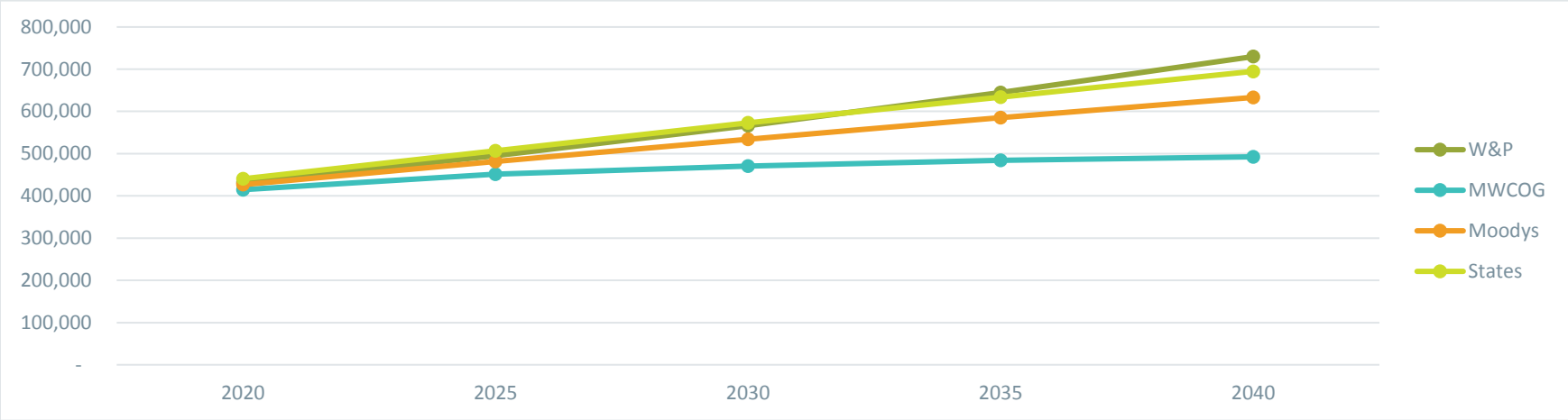


Figure 12 | Montgomery County Population Forecasts, 2020-2040

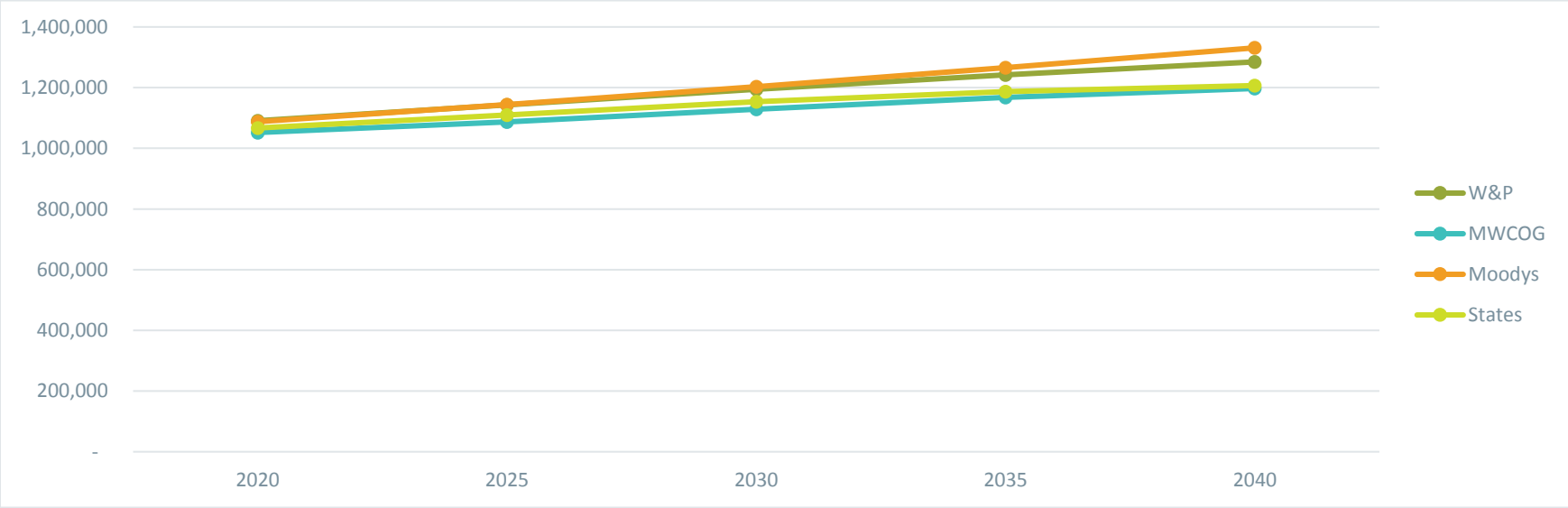


Figure 13 | Prince Georges County Population Forecasts, 2020-2040

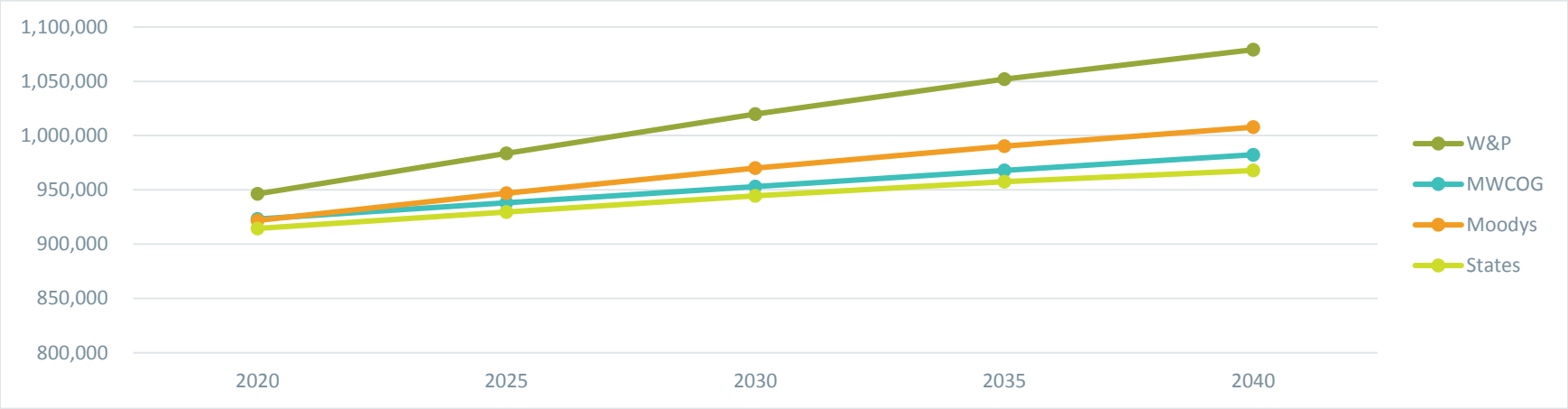
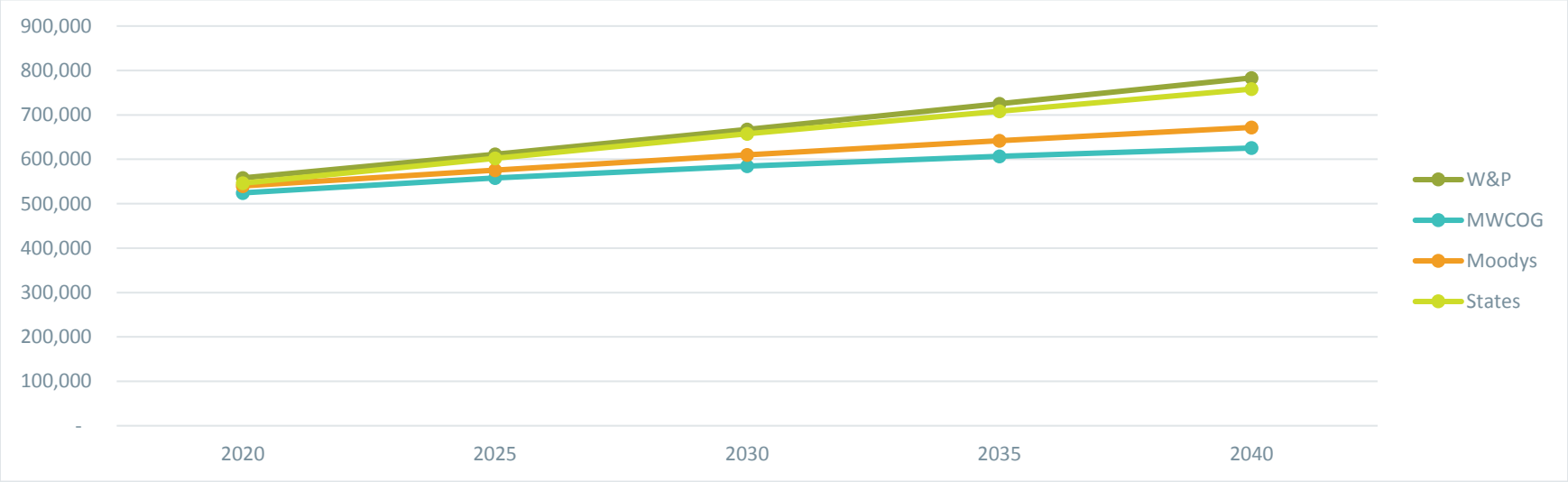


Figure 14 | Prince William County Population Forecasts, 2020-2040



Overall, the Round 9.0 forecast projects slightly lower population growth than outside forecasts. However, the outside forecasts comparison identified two outliers: District of Columbia and Loudoun County. The Round 9.0 forecast for the District of Columbia was dramatically higher than the outside forecasts, whereas the Round 9.0 forecast for Loudoun County was dramatically lower than the outside forecasts after 2025. Among the jurisdictions analyzed, The District of Columbia and Loudoun are both projected to see the greatest percent change in population in the 30-year period from 2010 to 2040, as highlighted in Table 1.

Table 1 | Round 9.0 MWCOG Historic and Forecast Population by Jurisdiction

	2010	2015	2020	2025	2030	2035	2040	2010-40 Change	2010-40 Change
Alexandria	140,012	147,646	159,169	167,515	172,781	180,463	190,824	50,812	36%
Arlington County	207,627	220,523	232,702	244,782	256,013	266,302	278,055	70,428	34%
Charles County	146,550	150,781	167,036	178,238	194,671	207,519	218,575	72,025	49%
District of Columbia	601,764	672,230	729,501	787,116	842,154	893,898	940,687	338,923	56%
Fairfax County	1,116,549	1,163,161	1,202,687	1,255,119	1,308,017	1,358,679	1,407,629	291,080	26%
Frederick County	233,383	246,499	267,782	288,690	303,583	319,361	332,151	98,768	42%
Loudoun County	312,310	363,519	414,699	451,119	470,695	484,410	492,517	180,207	58%
Montgomery County	971,713	1,015,273	1,052,023	1,087,259	1,128,823	1,167,709	1,197,131	225,418	23%
Prince George's County	863,420	904,430	923,144	938,023	952,955	967,842	982,385	118,965	14%
Prince William County	459,520	487,970	524,367	558,090	584,602	606,821	625,376	165,856	36%

Employment History and Forecasts

Historic employment estimates and trends, illustrated in Figure 15 and Figure 16, were derived from Woods & Poole Economics. Employment forecasts were derived from both public and private sources. The public-sector forecast includes the Maryland state data center and MWCOG Round 9.0 Cooperative Forecast. Jurisdiction level forecasts were not available for either the State of Virginia or the District of Columbia. Private forecast sources were Moody's Analytics and Woods & Poole Economics. All available forecasts from 2020 through 2040 are visualized for each jurisdiction in Figure 17 through Figure 26 below.

Figure 15 | Historic Changes in Jurisdictional Employment, 1969-2016

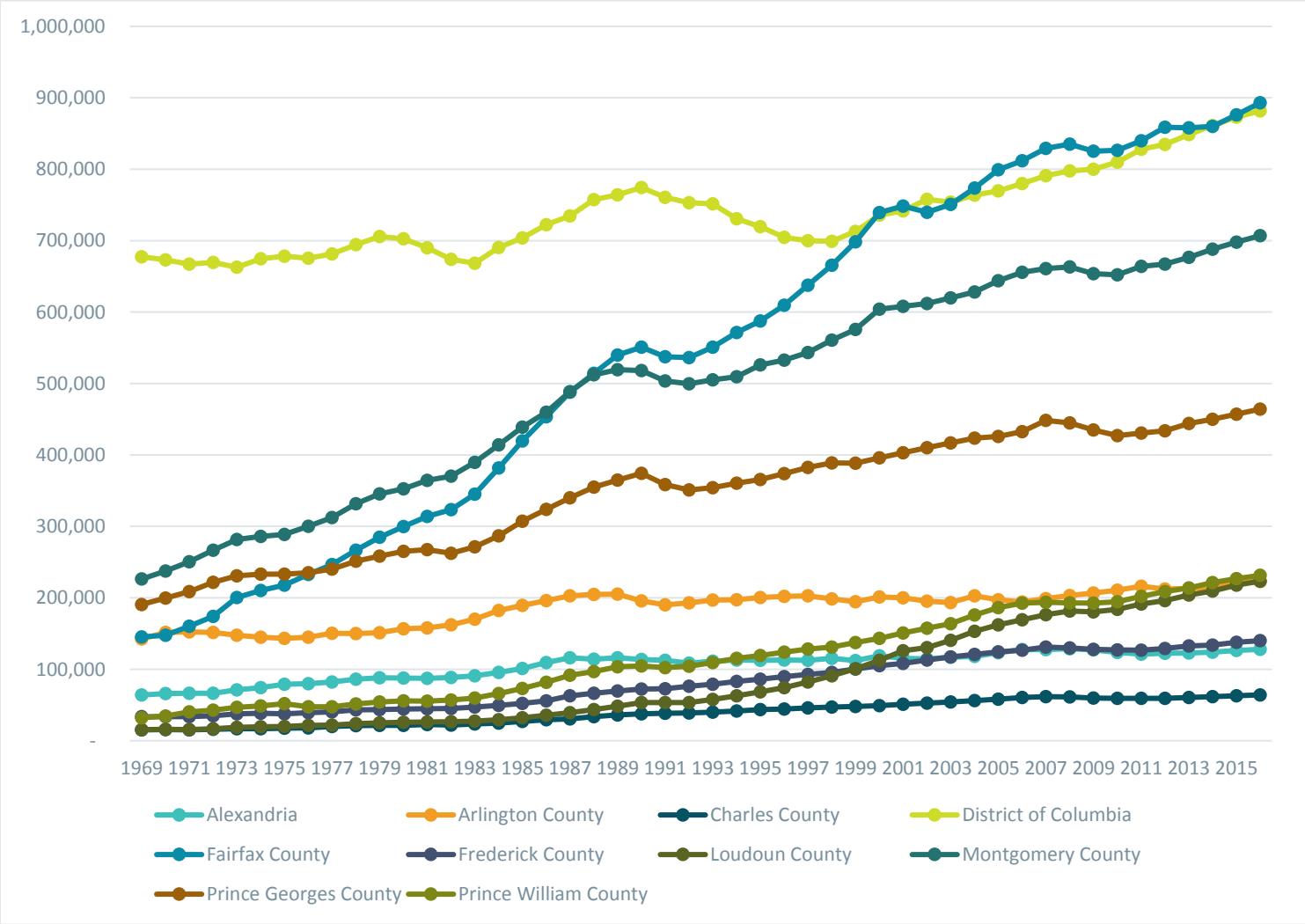


Figure 16 | Annual Percent Change in Employment by Jurisdiction, 1970-2016

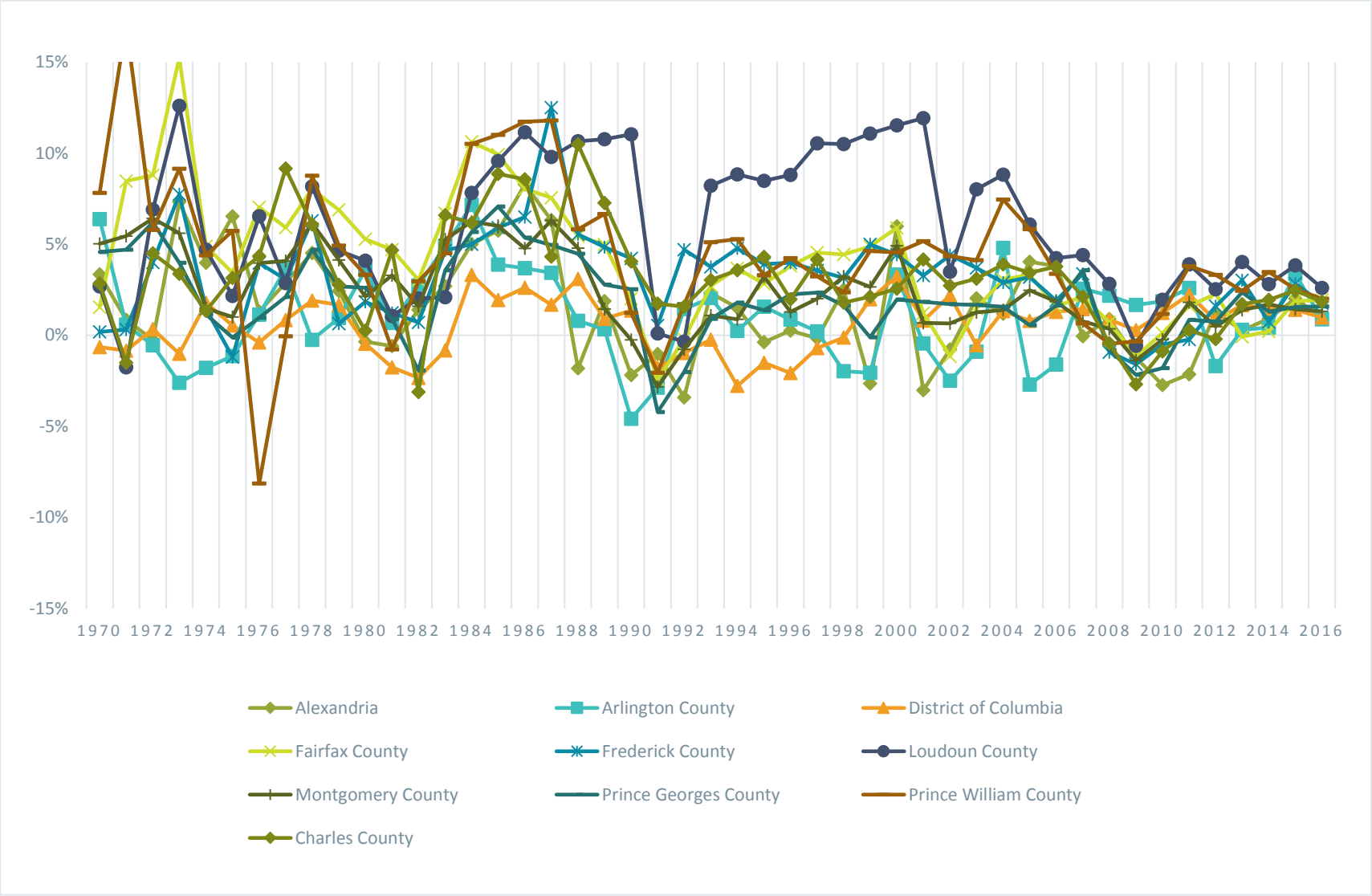


Figure 17 | Alexandria Employment Forecasts, 2020-2040

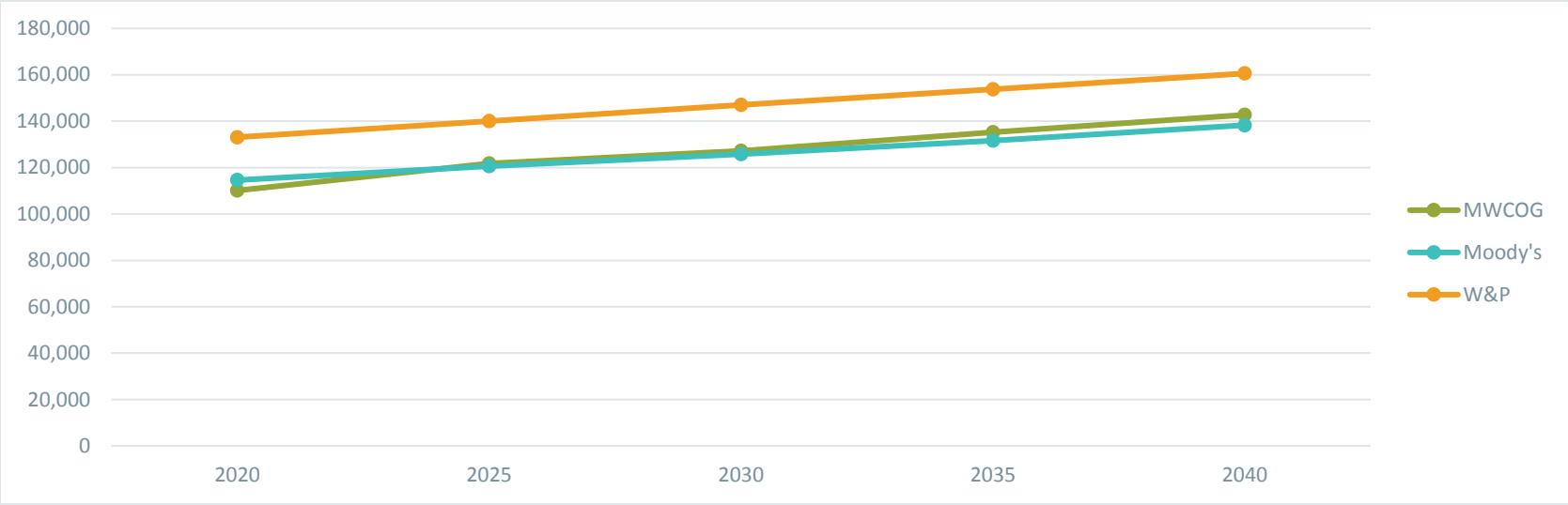


Figure 18 | Arlington County Employment Forecasts, 2020-2040

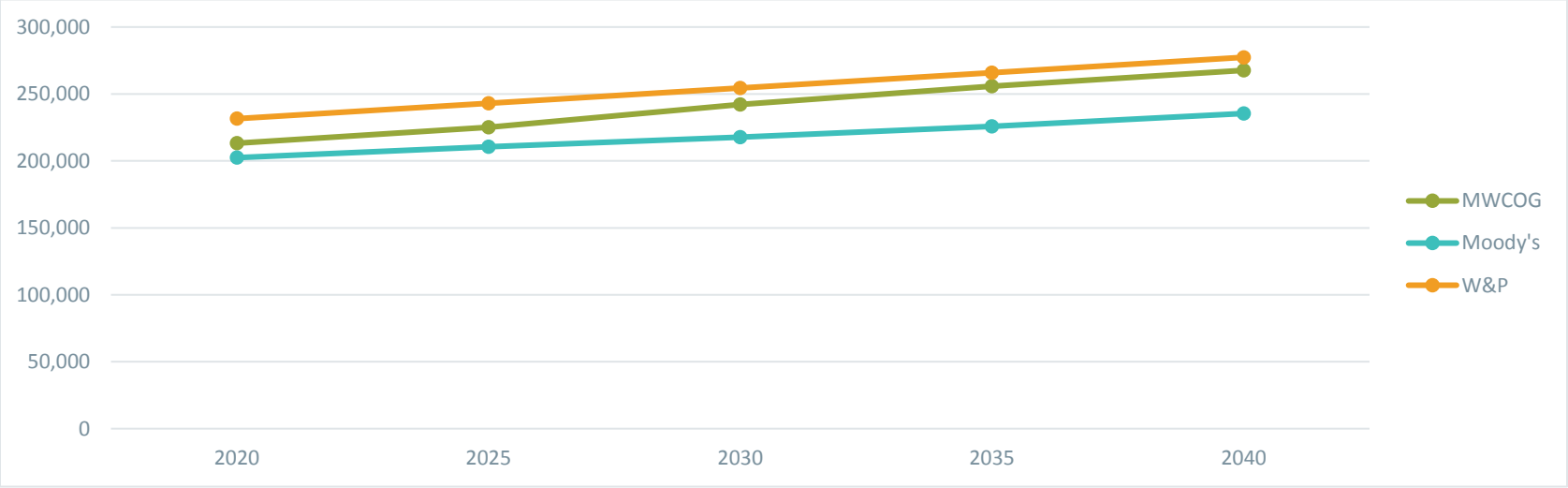


Figure 19 | Charles County Employment Forecasts, 2020-2040

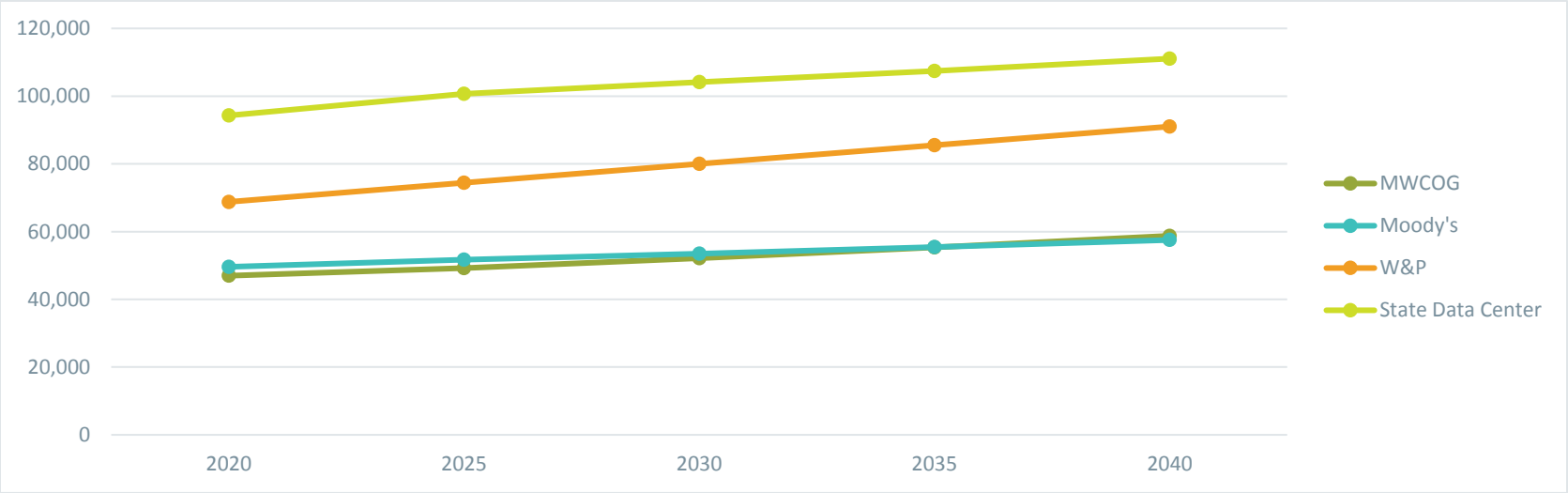


Figure 20 | District of Columbia Employment Forecasts, 2020-2040

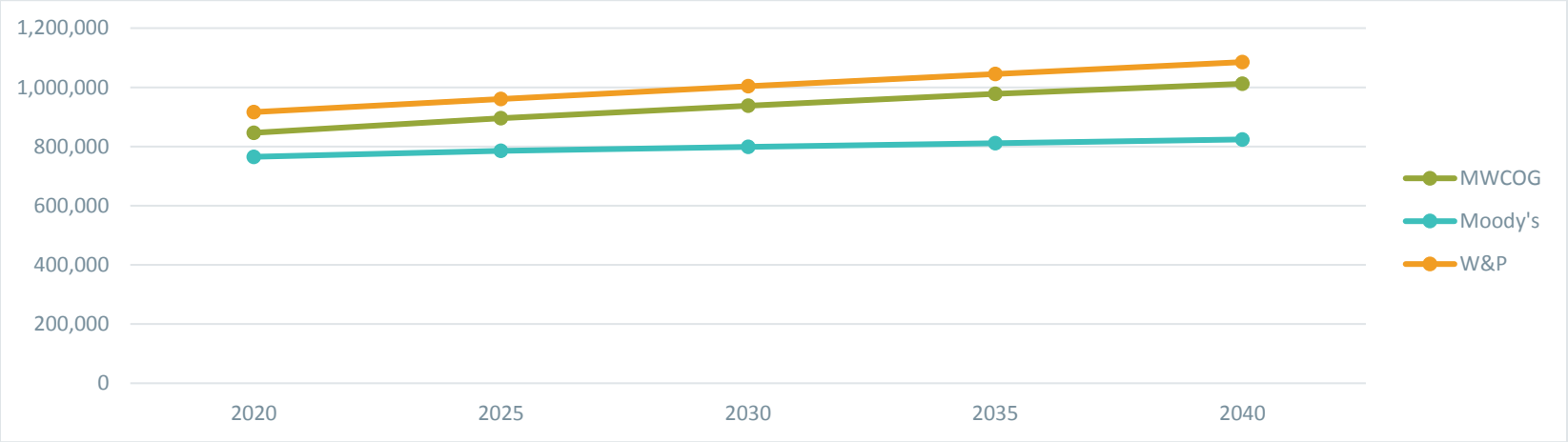


Figure 21 | Fairfax County Employment Forecasts, 2020-2040

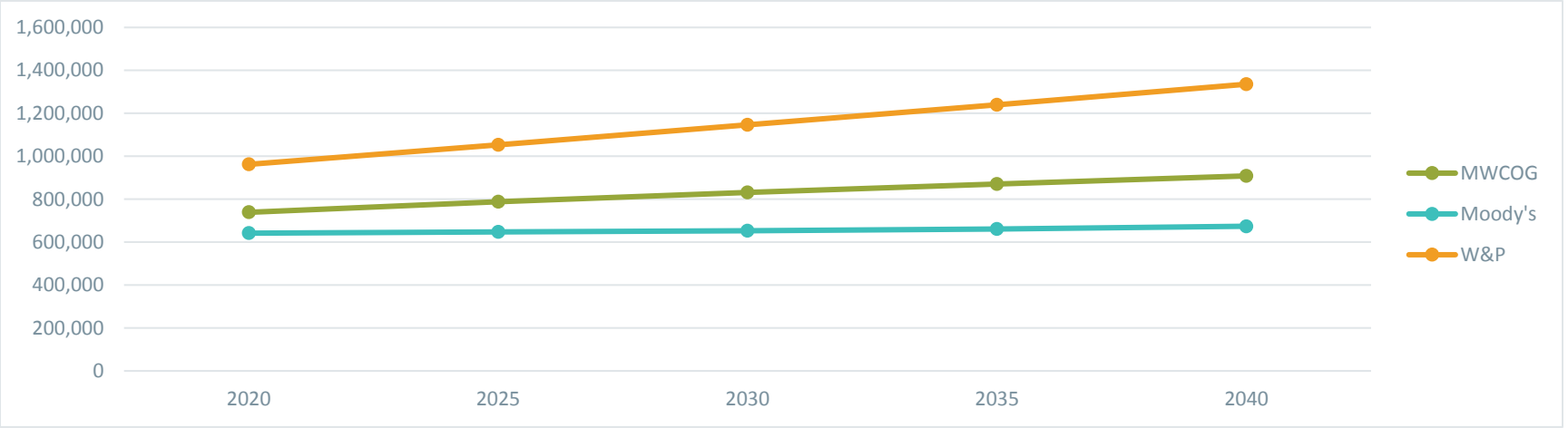


Figure 22 | Frederick County Employment Forecasts, 2020-2040

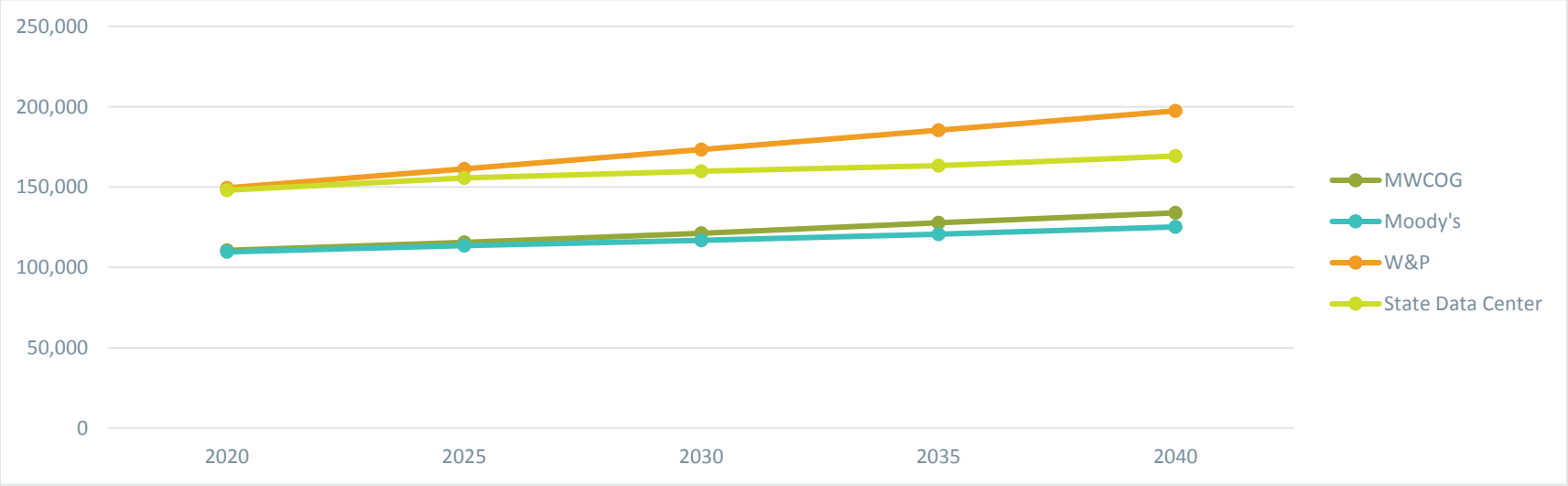


Figure 23 | Loudoun County Employment Forecasts, 2020-2040

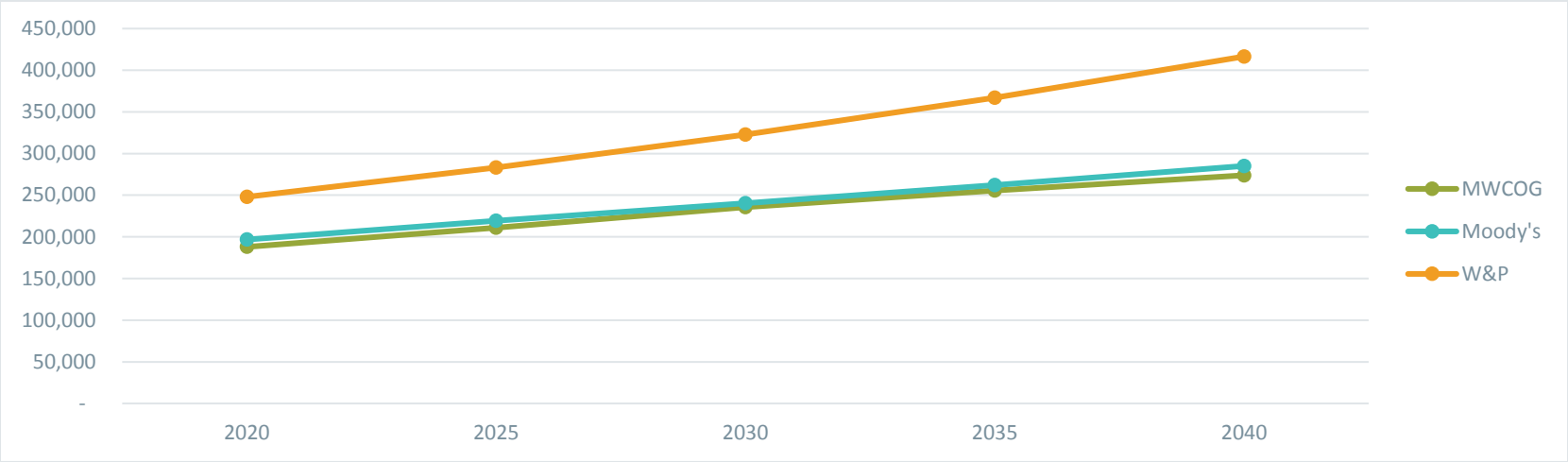


Figure 24 | Montgomery County Employment Forecasts, 2020-2040

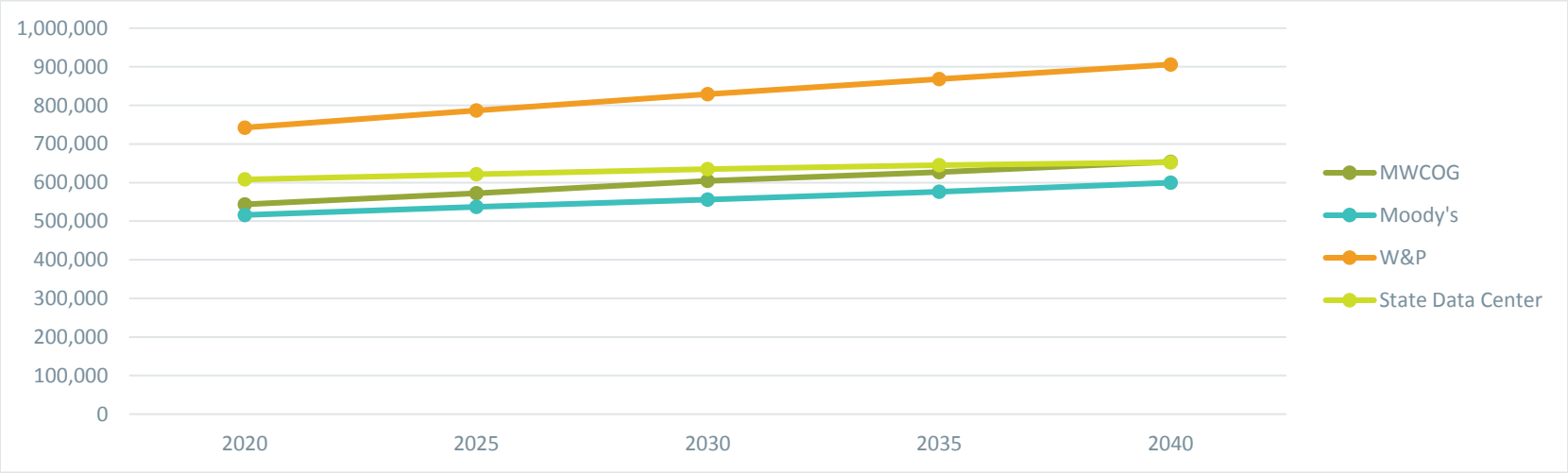


Figure 25 | Prince Georges County Employment Forecasts, 2020-2040

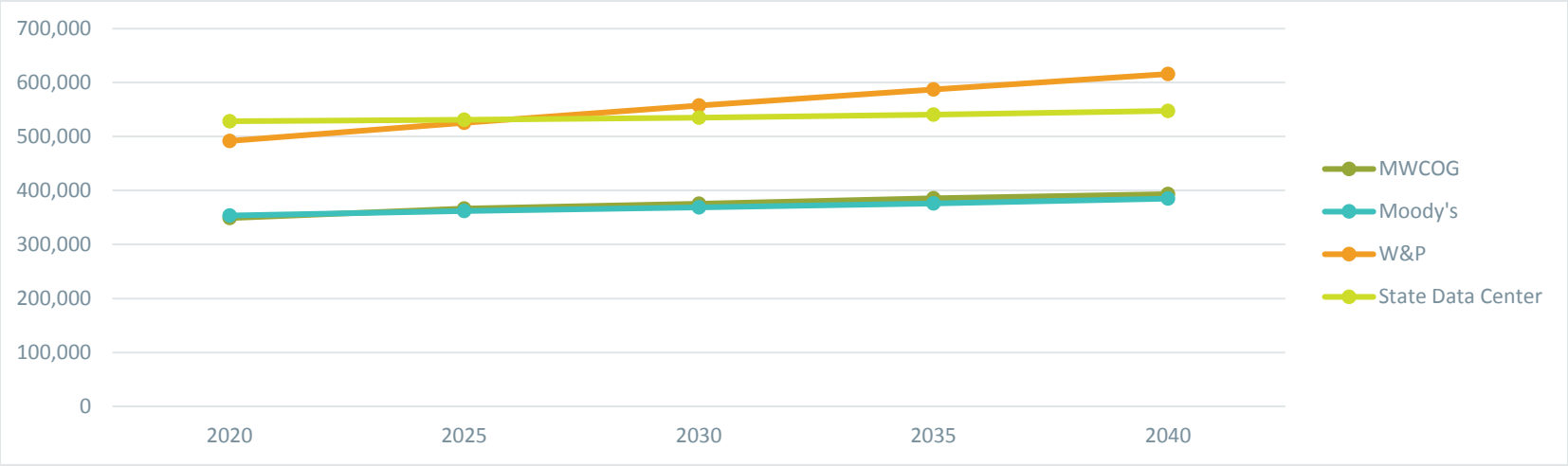
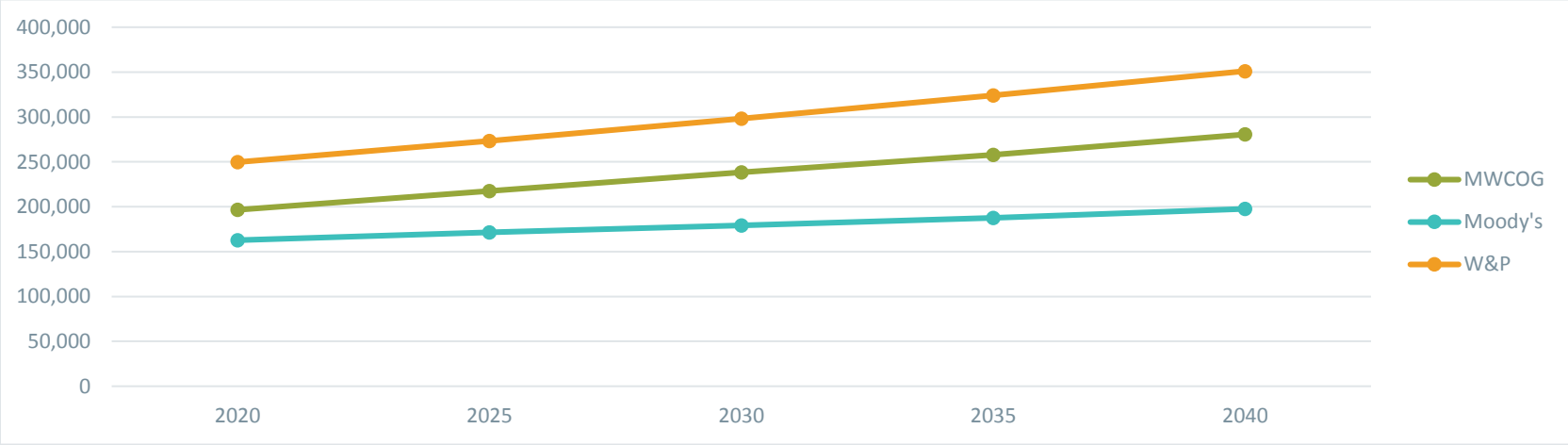


Figure 26 | Prince William County Employment Forecasts, 2020-2040



Overall, Round 9.0 employment forecast is either on par or slightly above other outside forecasts. The same outlier issues persist in the employment forecasts for both District of Columbia and Loudoun County. The Round 9.0 forecast for District of Columbia employment is notably higher than outside forecasts and the forecast for Loudoun County employment is slightly lower than outside forecasts.

Table 2 | Round 9.0 MWCOG Forecast by Jurisdiction – Employment Forecast

	2010	2015	2020	2025	2030	2035	2040	2010-40 Change	2010-40 Change
Alexandria	102,895	106,238	110,119	121,772	127,266	135,254	142,735	39,840	39%
Arlington County	222,319	209,604	213,202	225,194	242,136	255,750	267,641	45,322	20%
Charles County	45,863	46,606	46,988	49,227	52,196	55,378	58,762	12,899	28%
District of Columbia	746,235	798,271	846,280	895,120	937,854	978,223	1,011,806	265,571	36%
Fairfax County	657,546	686,865	738,777	788,281	831,913	870,451	908,430	250,884	38%
Frederick County	102,375	106,202	110,572	115,618	121,283	127,810	133,934	31,559	31%
Loudoun County	142,596	164,210	187,959	211,000	235,476	255,633	273,910	131,314	92%
Montgomery County	493,454	520,160	543,542	572,521	604,491	627,350	653,917	160,463	33%
Prince George's County	333,942	338,565	349,048	366,326	375,741	385,510	393,336	59,394	18%
Prince William County	150,518	174,958	196,555	217,510	238,297	257,686	280,546	130,028	86%

Land Use Diversity

The diversity of land use is commonly expressed in either jobs to household (J/HH) ratios or jobs to population (J/P) ratios. These ratios provide an indicator of total economic activity when compared to household and employment forecasts. The J/P ratio is a common measure used to gain perspective on the type of growth (e.g., suburban residential, mixed suburban and employment center, aging urban, new urban) given knowledge of what is happening on the ground in jurisdictions and sub-markets. A high J/P ratio for a given geography is indicative of a commercial center that typically has high levels of entering traffic during morning peak periods and high levels of traffic leaving during evening peak periods (particularly if the jobs are heavily concentrated in office or industrial uses as contrasted with retail uses). A low J/P ratio is indicative of a more residential community that tends to have traffic leaving during the morning commute peak and returning during the evening peak. Balanced J/P ratios indicate a mix of residents and employees that increase the propensity for recurring travel to be made by walking, bicycling, or shorter auto trips. The appropriate balance between jobs and households varies slightly depending on regional demographics and the state of the economy,

but most practitioners generally agree that a P/J ratio of about 0.55 to 0.60 indicates a fairly balanced mix of jobs and housing (because on a regional basis, that range reflects the number of employed residents per household). Generally, the MWCOG jurisdictions each have policies promoting more balanced J/HH ratios both within commercial activity centers where infill development is promoted as well as jurisdiction-wide. Table 3 presents the change in MWCOG J/P ratios over time, again highlighting and contrasting the District of Columbia and Loudoun County. The District of Columbia is the regional core employment center with a J/P ratio over 1.0 and Loudoun County is in the process of shedding the "bedroom community" label with J/P ratios under 0.6, but MWCOG forecasts both jurisdictions to move toward a more balanced J/P ratio.

Table 3 | Round 9.0 MWCOG Forecast by Jurisdiction – Jobs to Population Ratio

	2010	2015	2020	2025	2030	2035	2040	2010-40 Change	2010-40 Change
Alexandria	0.73	0.72	0.69	0.73	0.74	0.75	0.75	0.02	3%
Arlington County	1.07	0.95	0.92	0.92	0.95	0.96	0.96	-0.11	-10%
Charles County	0.31	0.31	0.28	0.28	0.27	0.27	0.27	-0.04	-13%
District of Columbia	1.24	1.19	1.16	1.14	1.11	1.09	1.08	-0.16	-13%
Fairfax County	0.59	0.59	0.61	0.63	0.64	0.64	0.65	0.06	10%
Frederick County	0.44	0.43	0.41	0.40	0.40	0.40	0.40	-0.04	-9%
Loudoun County	0.46	0.45	0.45	0.47	0.50	0.53	0.56	0.10	22%
Montgomery County	0.51	0.51	0.52	0.53	0.54	0.54	0.55	0.04	8%
Prince George's County	0.39	0.37	0.38	0.39	0.39	0.40	0.40	0.01	3%
Prince William County	0.33	0.36	0.37	0.39	0.41	0.42	0.45	0.12	36%

IV. MACROECONOMIC ASSESSMENT

The Washington D.C. Metropolitan Area is perhaps unique among the nation's most populous metropolitan areas due to its function as a national capital, providing a rich employment base of federal agency headquarters and the types of goods and services they attract. The linkage between the Washington region's unique economic base and its transportation system extends even to the (often negative) connotations of terms such as "K-Street lobbyist" and "Beltway bandit", describing private sector industries that are associated with federal government activities and contracts. The relative consistency of federal government activities, as contrasted with private sector economic cycles, helped the Washington region through the Great Recession of 2007-2009 with less volatility than many other regions nationwide.

However, in subsequent years the metropolitan economy has weakened somewhat due to federal cutbacks, many mandated or influenced by sequestration, a reduction in the federal workforce. Within the Metropolitan Area the inner core has seen milder swings between the high and low growth periods. This section presents a summary of additional demographic, economic, and real estate trends taking place at the national, regional, and local levels that are likely to influence the course of development in and around the Primary Market Area.

Historic Regional Growth Trends

Regional Economic Trends

The Washington Metro region's economy is dominated by two primary sectors: federal jobs and private professional and technical services jobs. Table 4 summarizes jobs by industry sector in 2016. The table shows how strongly the regional economy depends on a narrow band of knowledge sector jobs for economic growth. Table 5 provides an estimate of the jobs that would be categorized as traded sector (i.e. jobs that export goods or services to customers outside the region). Professional, Scientific and Tech Services is the dominant industry in the region as well as the dominant traded sector, with fewer, high-paying traded sector jobs in other industries.

Table 6 summarizes the proportion of employment by industry sector in 1969 and 2016. The table shows that office jobs have become the dominant industry type over the last 50 years, replacing "other" (government, administrative, and support services). Additionally, it also demonstrates that retail and industrial job totals have remained steady, despite popular narratives suggesting otherwise.

Figure 27 demonstrates the proportional change in employment by industry type over that same interval of time, further illustrating the growth of office jobs in the region.

Table 4 | Washington Metro Area Jobs by Industry, 2016

Industry	Private	Public	Total
Professional, Scientific, and Technical Services	504,683	758	505,441
Health Care and Social Assistance	306,685	9,095	315,780
Retail Trade	282,354	1	282,355
Accommodation and Food Services	280,219	0	280,219
Educational Services	89,245	164,450	253,695
Administrative, Support, Waste Management, and Remediation Services	202,830	2,156	204,986
Other Services (except Public Administration)	175,435	1,066	176,501
Construction	156,564	1,917	158,481
Finance and Insurance	93,555	0	93,555
Public Administration	-	91,098	91,098
Information	74,405	2,885	77,290
Transportation and Warehousing	53,790	18,301	72,091
Wholesale Trade	60,642	0	60,642
Arts, Entertainment, and Recreation	52,130	5,382	57,512
Manufacturing	53,480	8	53,488
Real Estate and Rental and Leasing	53,090	2	53,092
Management of Companies and Enterprises	40,543	0	40,543
Utilities	8,027	2,460	10,487
Agriculture, Forestry, Fishing and Hunting	2,619	0	2,619
Mining, Quarrying, and Oil and Gas Extraction	941	0	941

Source: US Census Longitudinal Employer-Household Dynamics (LEHD) 2016 Q3, Washington DC/VA/MD/WV MSA

Table 5 | Washington Metro Area Jobs by Industry Percent Traded Sector, 2016

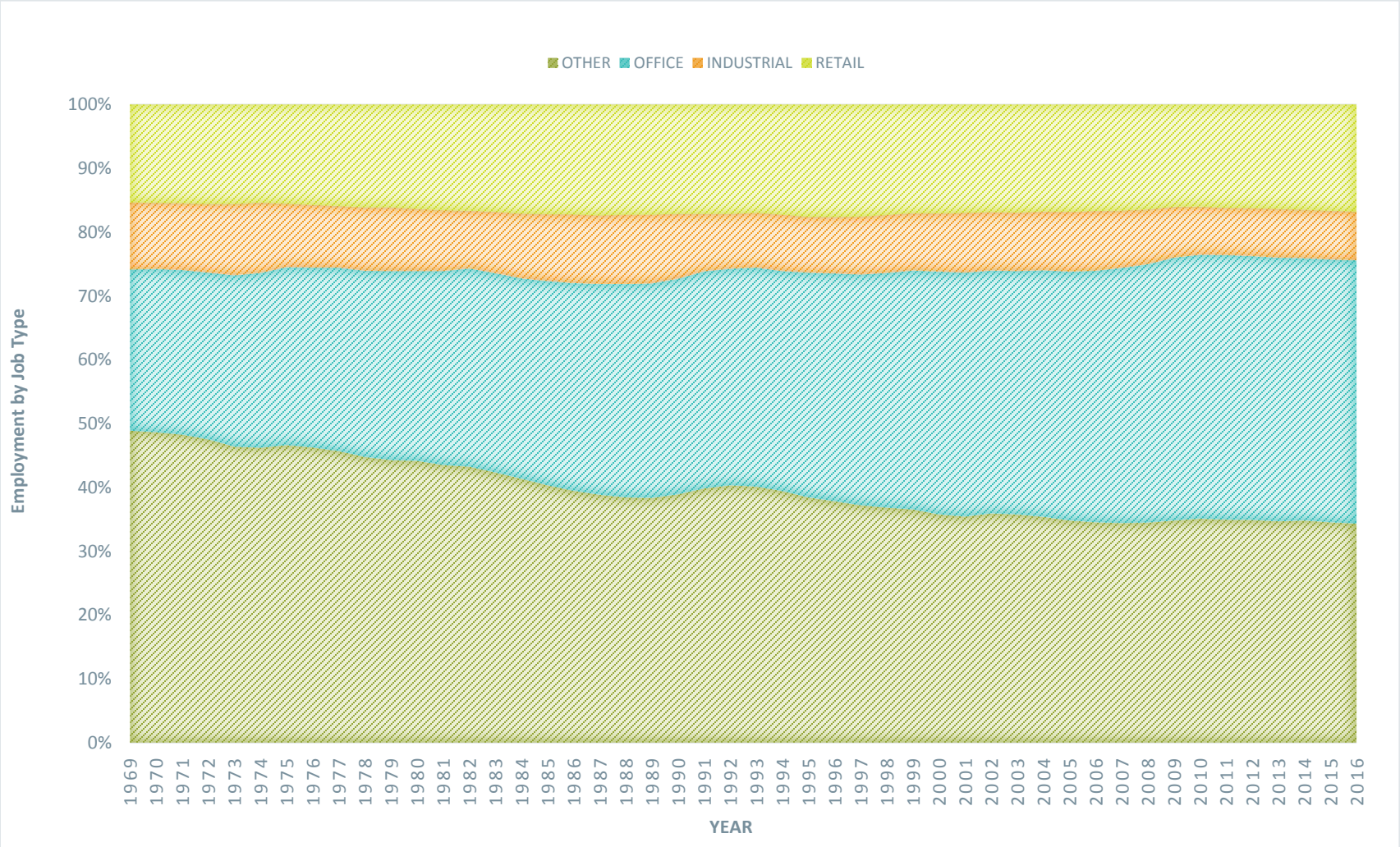
Industry	Total	Percent Traded Sector
Professional, Scientific, and Technical Services	505,441	86%
Health Care and Social Assistance	315,780	2%
Retail Trade	282,355	7%
Accommodation and Food Services	280,219	13%
Educational Services	253,695	1%
Administrative, Support, Waste Management, and Remediation Services	204,986	40%
Other Services (except Public Administration)	176,501	15%
Construction	158,481	0%
Finance and Insurance	93,555	66%
Public Administration	91,098	29%
Information	77,290	64%
Transportation and Warehousing	72,091	59%
Wholesale Trade	60,642	43%
Arts, Entertainment, and Recreation	57,512	36%
Manufacturing	53,488	93%
Real Estate and Rental and Leasing	53,092	94%
Management of Companies and Enterprises	40,543	100%
Utilities	10,487	20%
Agriculture, Forestry, Fishing and Hunting	2,619	100%
Mining, Quarrying, and Oil and Gas Extraction	941	100%

Note: Traded sector jobs are those involved in exporting goods or services outside the region.

Table 6 | Proportion of Employment by Job Type, 1969 and 2016

	Year	
Job Type	***1969***	***2016***
Industrial	11%	8%
Retail	15%	17%
Office	25%	41%
Other	49%	34%

Figure 27 | Washington Metro Area Employment by Job Type, 1969-2016



While the growth in private sector jobs is a positive sign for the economic health of the region, there are some concerns worth noting. One such concern is the dominance of local sector jobs in the region. Figure 29 displays the proportion of local and traded sector job clusters in the region. An economy heavily dependent on local clusters, with only 37% of jobs in the traded sector, has insulated the region from national economic and employment downward trends. Another concern is that the private sector is still quite homogenous. Business services and education are the two largest job clusters, as indicated in Figure 28.

Figure 30 and Figure 31 display the ten largest traded sectors in the region as a proportion of employment. A comparison of the two figures indicate that the private sector in the region may be becoming less diverse. Business services and education grew substantially between 2005 and 2016, accounting for more than 60% of the top 10 largest clusters. This homogeneity can lead to more uncertainty in future projections.

Figure 28 | Washington Metro Area Top Ten Clusters by Employment, 2015

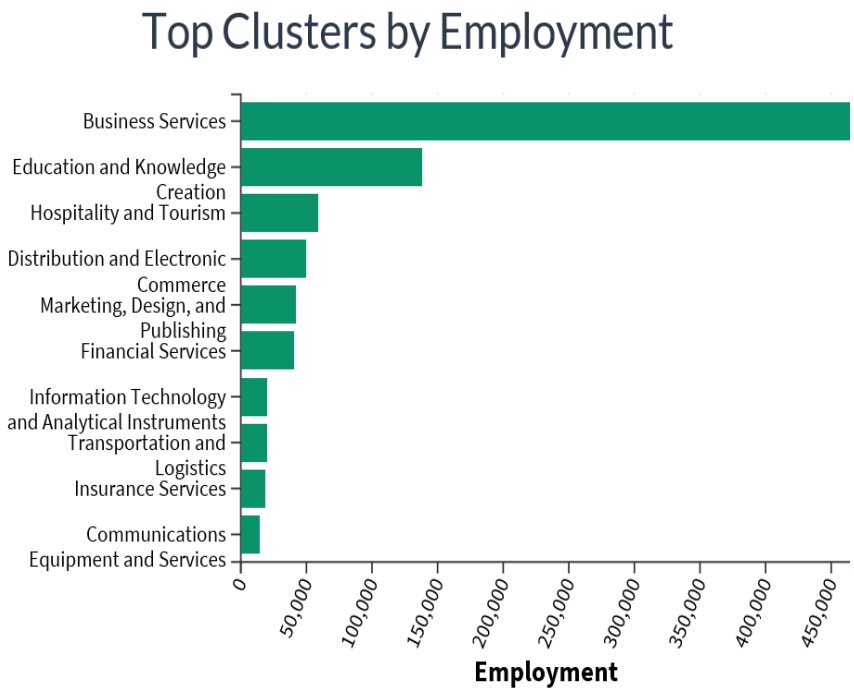


Figure 29 | Washington Metro Area Traded and Local Employment Clusters, 2015

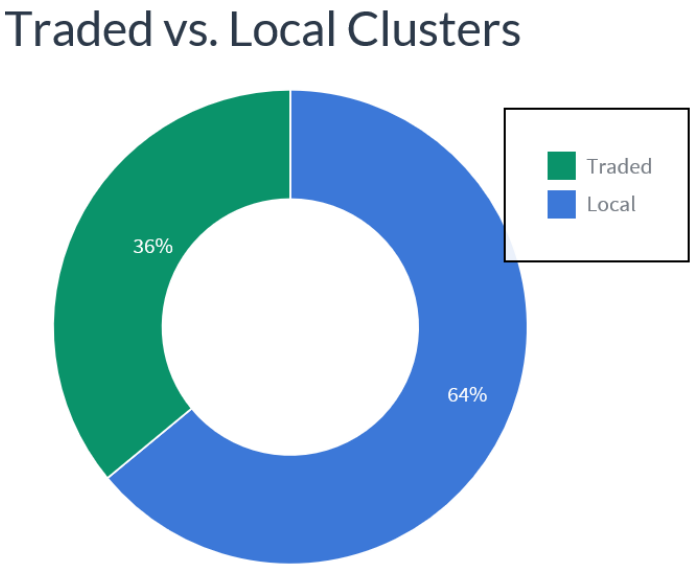
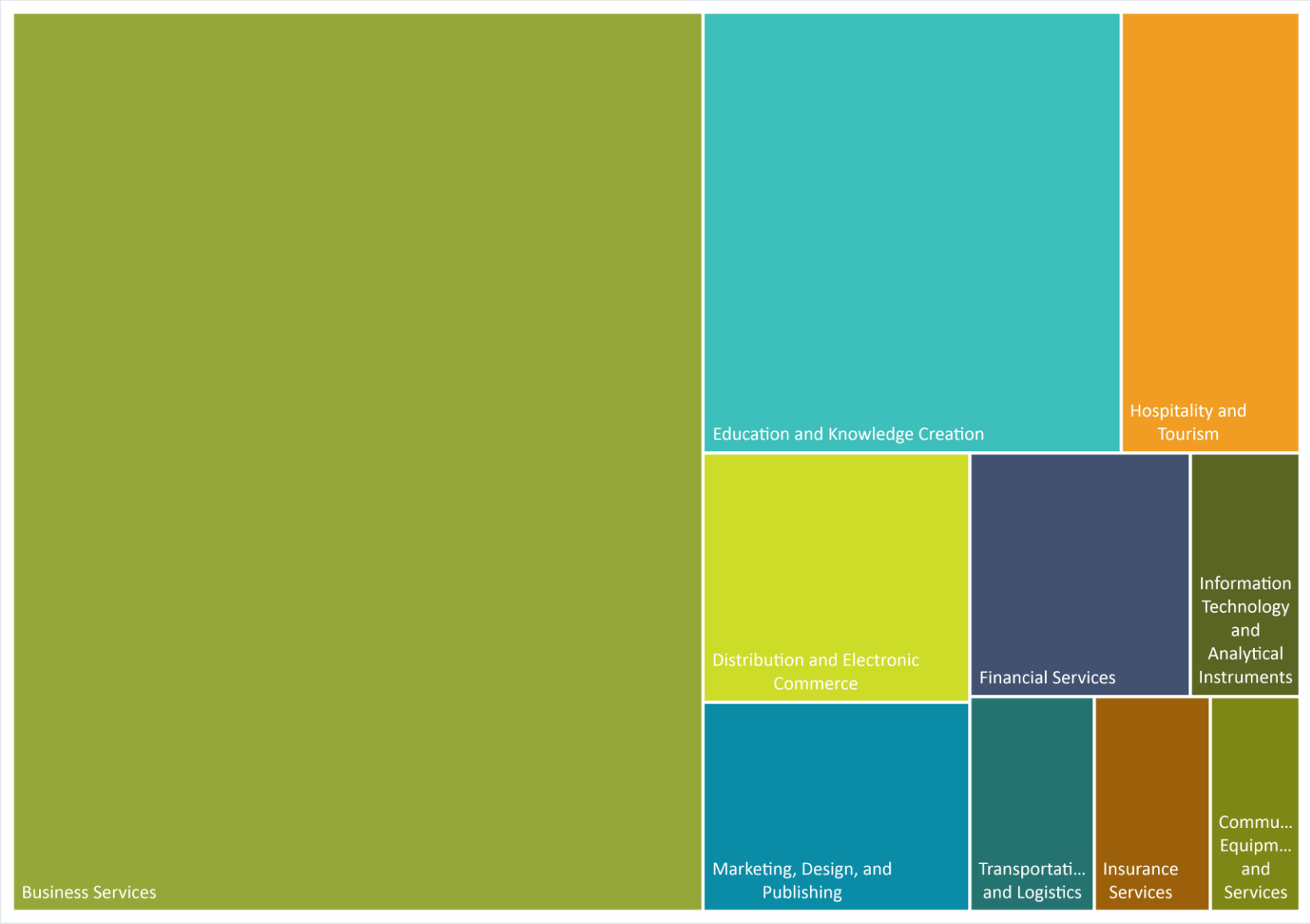


Figure 30 | Diversity of Ten Largest Traded Sector Job Clusters, 2005

Figure 31 | Diversity of Ten Largest Traded Sector Job Clusters, 2015



Federal jobs, which are part of several industry sectors, have had limited growth in the past two decades, as seen in Figure 32. Jobs are still concentrated in the District of Columbia, but all jurisdictions contain some federal employment. While growth has been limited, the jobs themselves have spread out geographically. Figure 33 shows that over the past 50 years the proportion of total jobs that are with Federal agencies is declining nearly everywhere, except Alexandria, which experienced a sharp increase in 2004 that stabilized around 2007 and has continued to trend upwards since.

Figure 32 | Federal Employment by Jurisdiction, 1997-2016

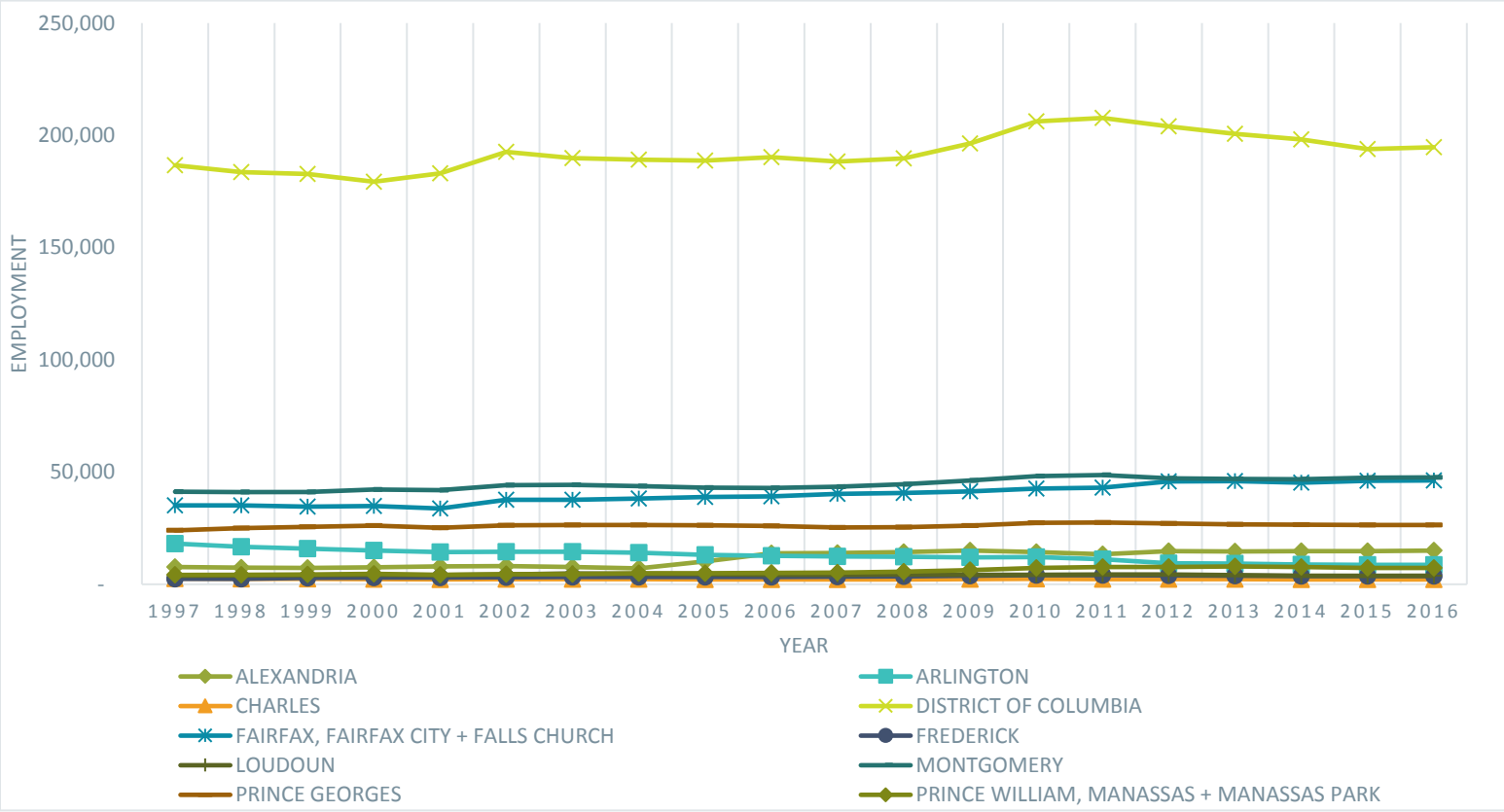
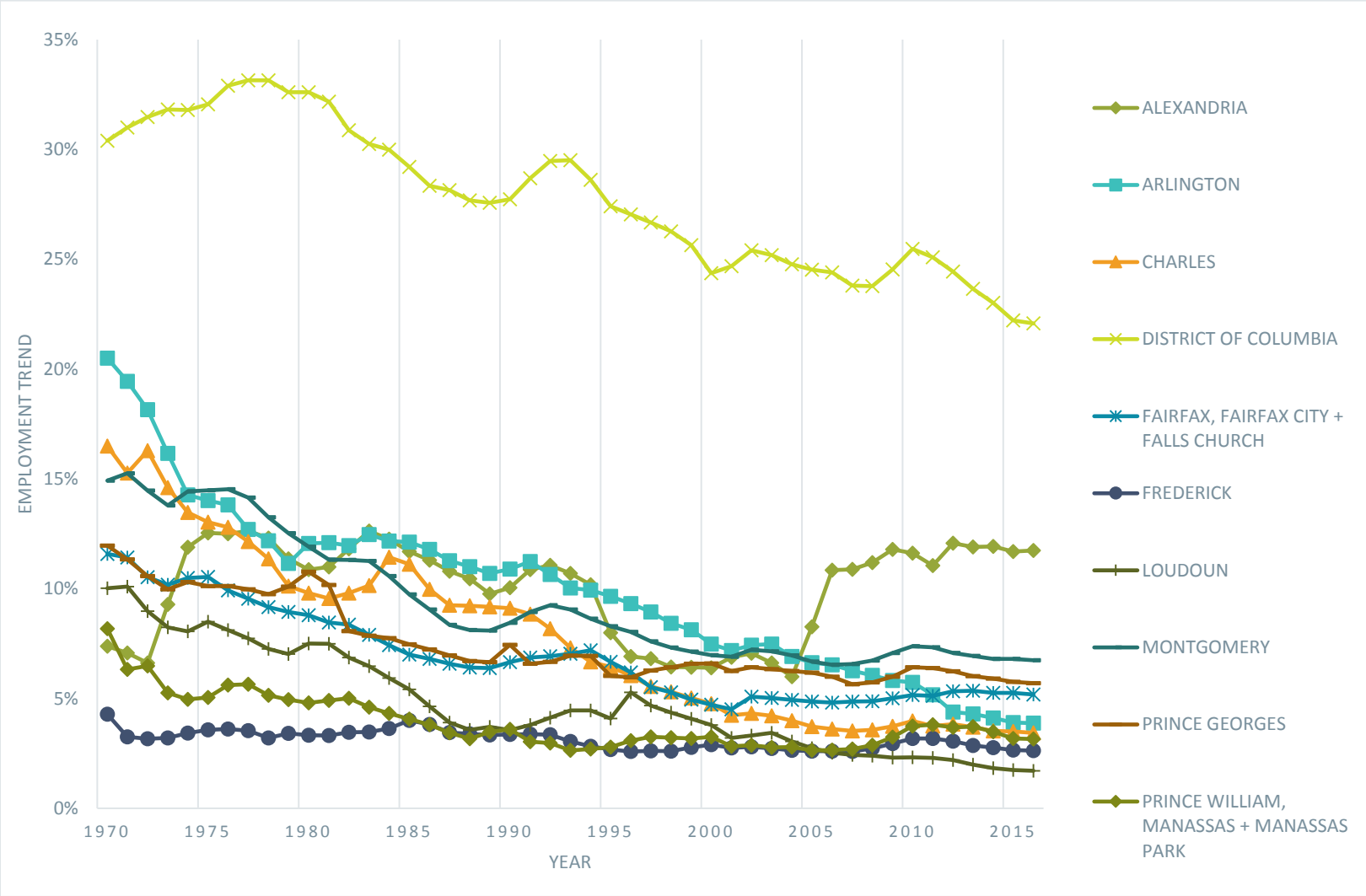


Figure 33 | Federal Employment as Share of Total Employment by Jurisdiction, 1970-2015



Annual employment data provided by the U. S. Bureau of Labor Statistics since 2000 are shown for Professional, Scientific, and Technical Services Employment in Figure 34. The professional services sector in Fairfax shows a peak in 2012, with a dip downwards until 2014, and then upward movement again. In the District, professional services have been on an upward trajectory since 2011. Arlington has shown a slight increase and Alexandria has remained mostly flat during the period examined. Recent growth in this sector has started to align across jurisdictions and on average growth is slowing, as demonstrated in Figure 35.

Figure 34 | Number of Professional Services Jobs by Jurisdiction, 2000-2016

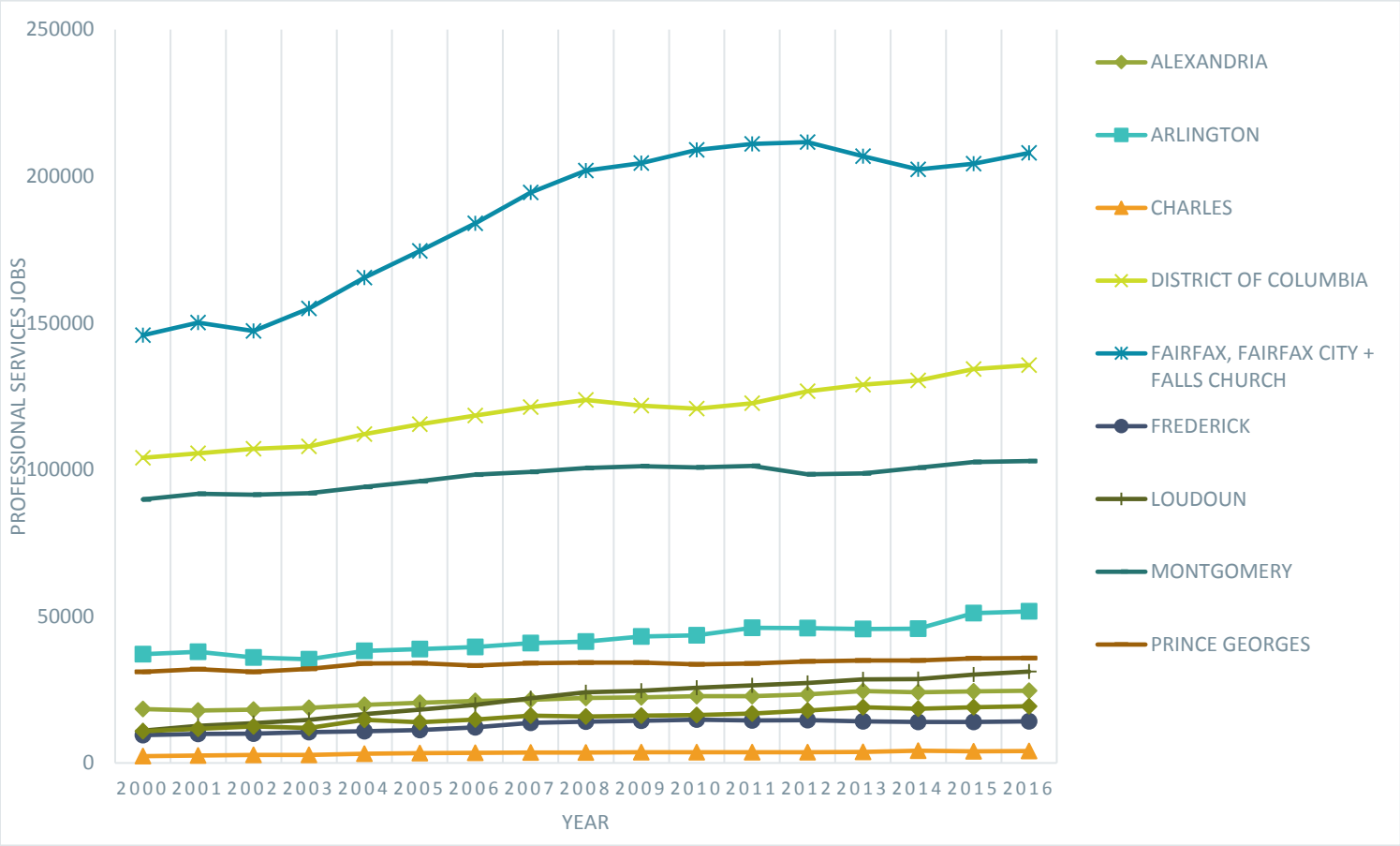
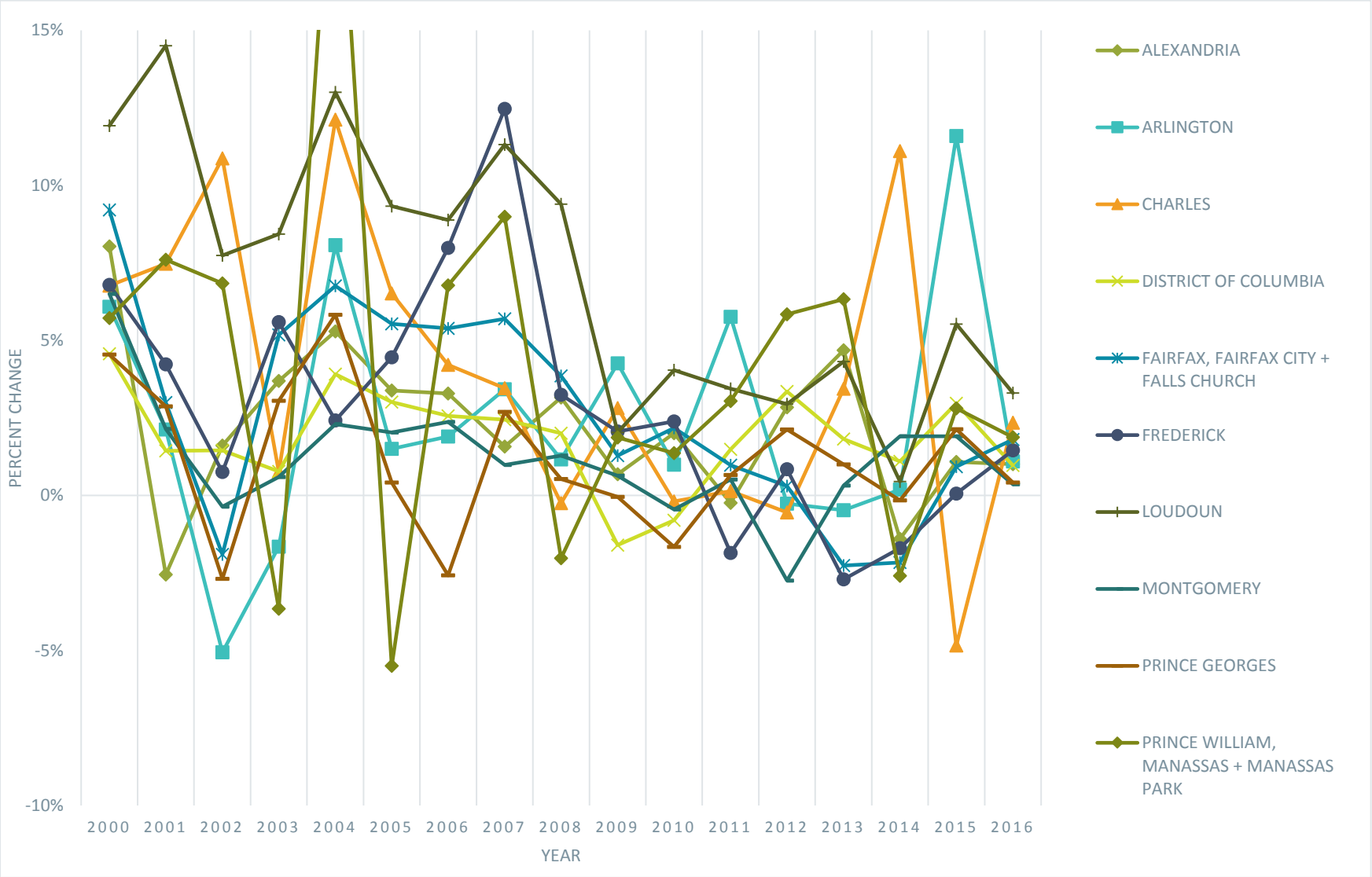


Figure 35 | Annual Percent Change in Professional Services Jobs by Jurisdiction, 2000-2016.



In addition to this employment homogeneity, it seems that the private sector is still heavily dependent upon federal expenditures. Figure 36 shows the total amount of federal contract awards by jurisdiction from 2008 to 2015. Award amounts remain at or above 2008 levels for most jurisdictions, and particularly so for the largest two federal beneficiaries, District of Columbia, and Fairfax County. However, Fairfax experienced a recent downward trend in contract awards. Figure 37 illustrates the amount of federal contract awards and federal jobs from 2008 to 2015 in Fairfax. The recent downward trend in contract awards appears to correlate with an upward trend in federal jobs.

Figure 36 | Federal Contract Awards by Jurisdiction, 2008-2015

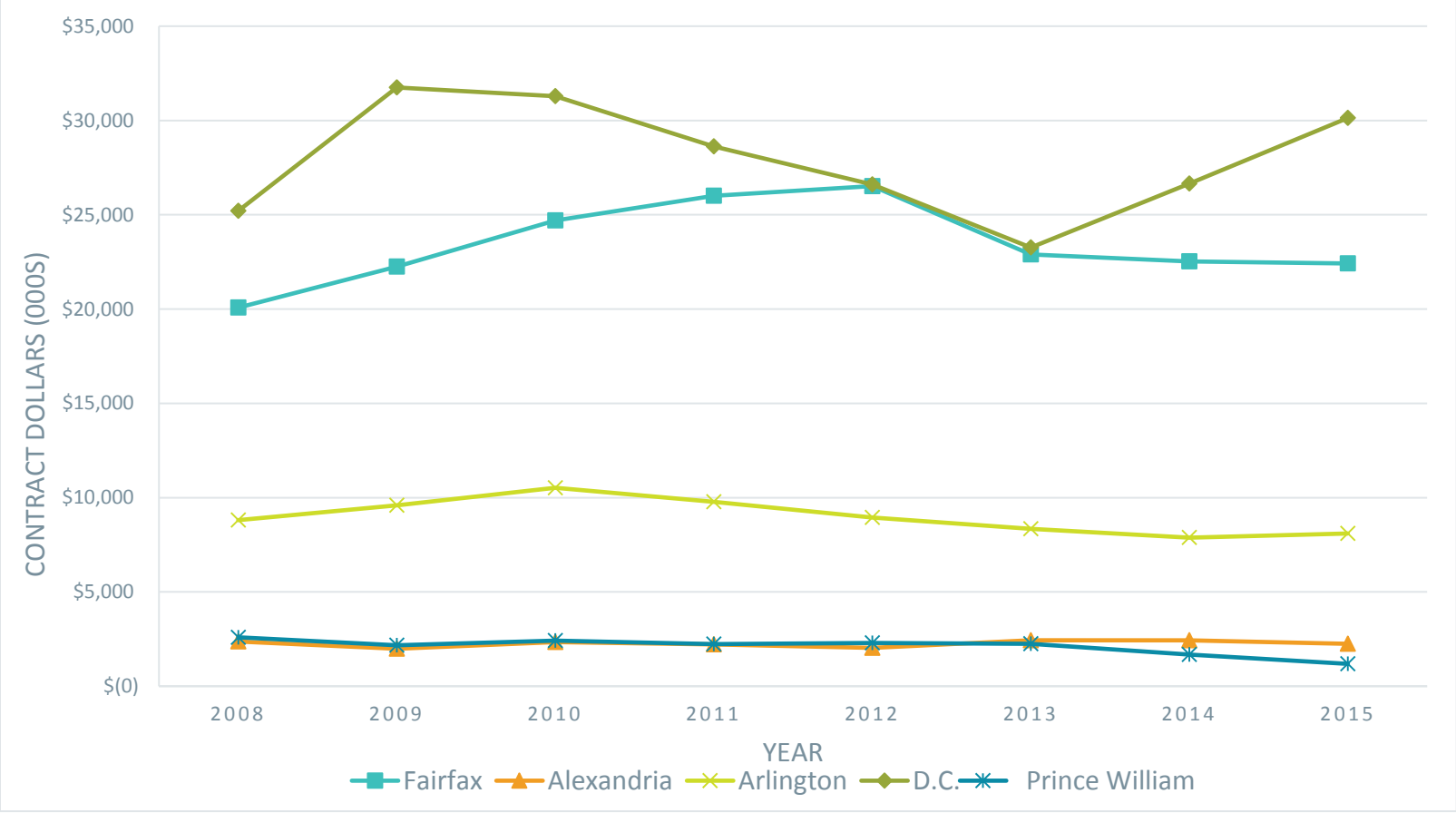
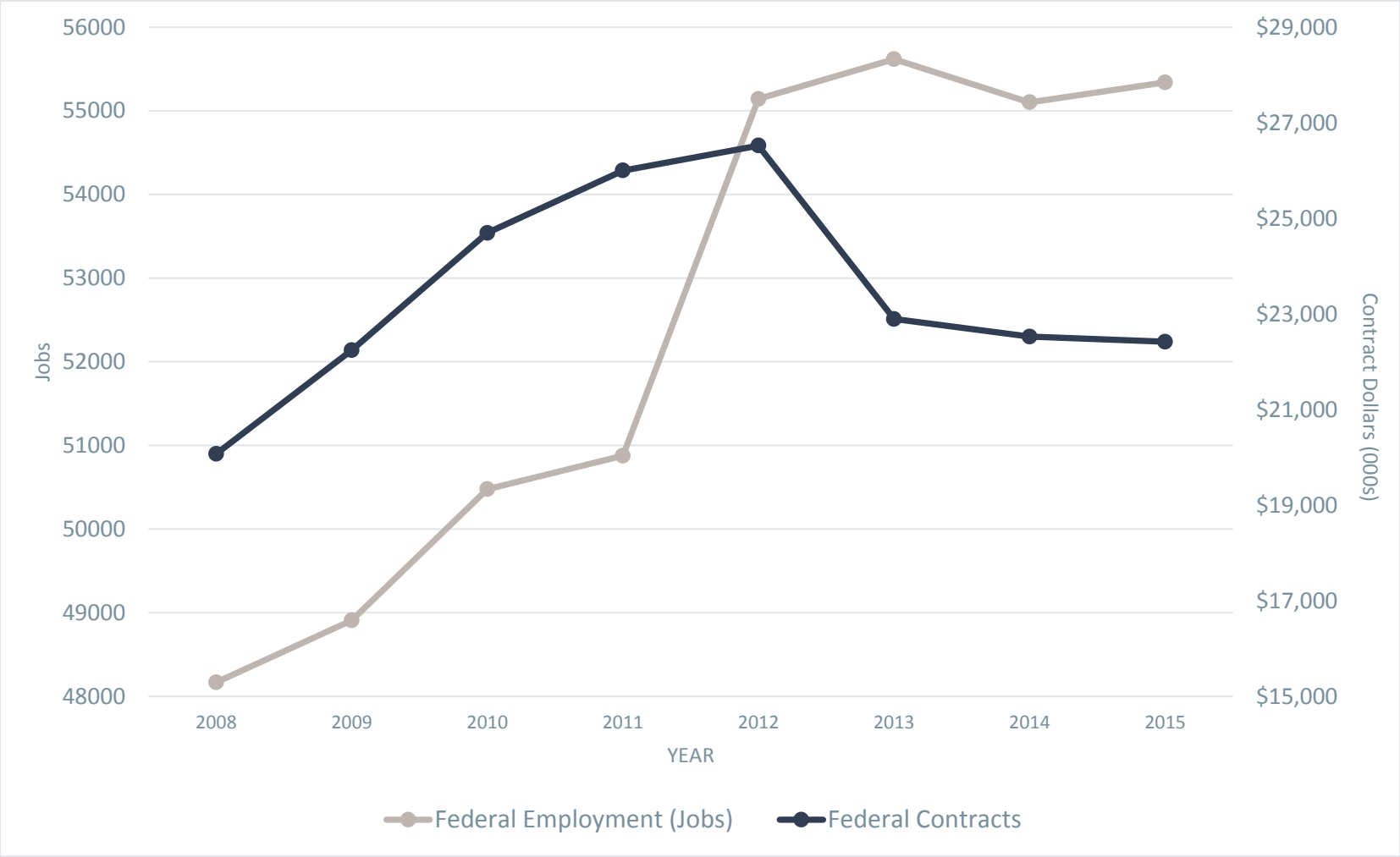


Figure 37 | Federal Employment and Contracts for Fairfax County, 2008-2015



Outside observers are noting many of the same trends. George Mason University's Center for Regional Analysis provides annual observations of economic conditions in the Washington, D.C. region[2]. Their most recent presentation on current trends and conditions in the regional economy are summarized in the following bullets:

- This post-recession recovery is the slowest of any in the last 40 years, and that trend of slow growth has been felt in the region. Growth Domestic Product trends in Washington D.C. have outpaced the nation since 2000, though much of that is due to the region weathering the economic recession better than most. However, as compared to many big regions, Washington growth has lagged. In 2015, Washington had the smallest percent increase in GDP of any of the 15 largest regions in the U.S.
- Population has grown steadily since 2000. However, the source of that growth has been changing in recent years. In both 2014 and 2015, domestic migration was negative after being positive the year before, while international migration grew by over 10,000 to mitigate some of that domestic loss.
- Employment growth stalled between 2006 and 2010 but is now increasing again. Among the 15 largest regions, Washington's increase of nearly 100,000 jobs in the 12-month period ending July 2016 was 4th highest, trailing only New York, Los Angeles, and Dallas.
- Private sector job growth has been strong since 2010. Professional and business services is becoming a strong part of the regional economy.
- In their "What's Next for the Regional Economy?" summary, they see less federal dependency on job creation, with focuses on key opportunities in professional services and tourism. But they also note that the region remains vulnerable to federal sequestration and BRAC, and that the region is challenged in retaining talent due to quality of life concerns such as high cost of housing and long commuting.

Overall, these trends point to a region that should continue a strong economic position relative to the nation, but expectations of robust growth should be balanced against concerns that a lack of employment heterogeneity does create additional long-term uncertainty.

[2] http://cra.gmu.edu/wp-content/uploads/2016/03/Committee-for-Dulles-Virginia-Presentation-1.pdf

Population, Housing, and Cost of Living Trends

Cost of living has been a growing concern in the region and can have implications for short- and medium-term population projections. The U.S. Bureau of Economic Analysis publishes state and regional cost of living comparison metrics known as regional price parities for goods, services, and rents (a proxy for all housing costs), where the regional price parity number represents the percentile relative to the national average (i.e. 100 equals the national average and 110 equals 110% of the national average). As Figure 38 shows, the housing costs in the District have increased considerably since 2008, while the larger metro region has seen slower but still steady increases relative to the nation as a whole[3]. Interestingly, while D.C. home values trend higher than regional home values, D.C. rents trend lower than regional rents. Meanwhile, the cost of goods and services in both areas stayed steady and similar, with D.C. goods and services costs trending slightly higher than the region, emphasizing that cost of living concerns are really cost of housing concerns. Confirming the BEA findings on rent, the real estate website Zillow reports that home values in the District are up 29 percent and rents are up 13 percent since 2011. A study by the U.S. Bureau of Labor Statistics found that the Washington, D.C. metro area had the highest average annual housing costs in U.S. for 2011-2012 – even more than New York City and San Francisco – and they are still rising.[4]

Rising housing costs are generally mitigated either through income increases or population changes. As seen in Figure 39, relative per capita income mirrors housing cost changes in the District of Columbia, with sharp increases particularly during the recession years, when much of the country suffered losses in per capita income. The region has begun to see a drop in relative per capita income despite slow increases in housing costs, suggesting that short to medium term growth may contract. Additionally, the Washington D.C. region is characterized by multiple jurisdictions competing for growth, resulting in an inverse relationship between price increases and population increases at the jurisdictional level, otherwise observed as a cyclical growth pattern. Periods of sustained housing cost increases lead to drops in population growth as people choose alternative living quarters in nearby jurisdictions. This begins to lower prices. At some point, the lower prices are once again competitive relative to nearby jurisdictions, thus bringing new population growth, and eventually new housing cost increases. As seen in Figure 40, it should be expected that the District will struggle in the short term to attract growth relative to the more attractive neighboring jurisdictions. When compared to the District, the home values and population have a weaker relationship in the region, as demonstrated in Figure 41.

[3] Regional Price Parities data, Bureau of Economic Analysis. District of Columbia (Metropolitan Portion) and Washington-Arlington-Alexandria, DC-VA-MD-WV MSA: http://www.bea.gov/itable/iTable.cfm?ReqID=70&step=1#reqid=70&step=25&isuri=1&7022=101&7023=8&7024=non-industry&7001=8101&7029=101&7090=70

[4] Wiener, Aaron. "D.C. Area Housing Costs Are the Highest in America." *Washington CityPaper.* September 8, 2014. http://www.washingtoncitypaper.com/blogs/housingcomplex/2014/09/08/d-c-housing-costs-are-the-highest-in-america

Figure 38 | Cost of Living Comparison by Jurisdiction, 2008-2015

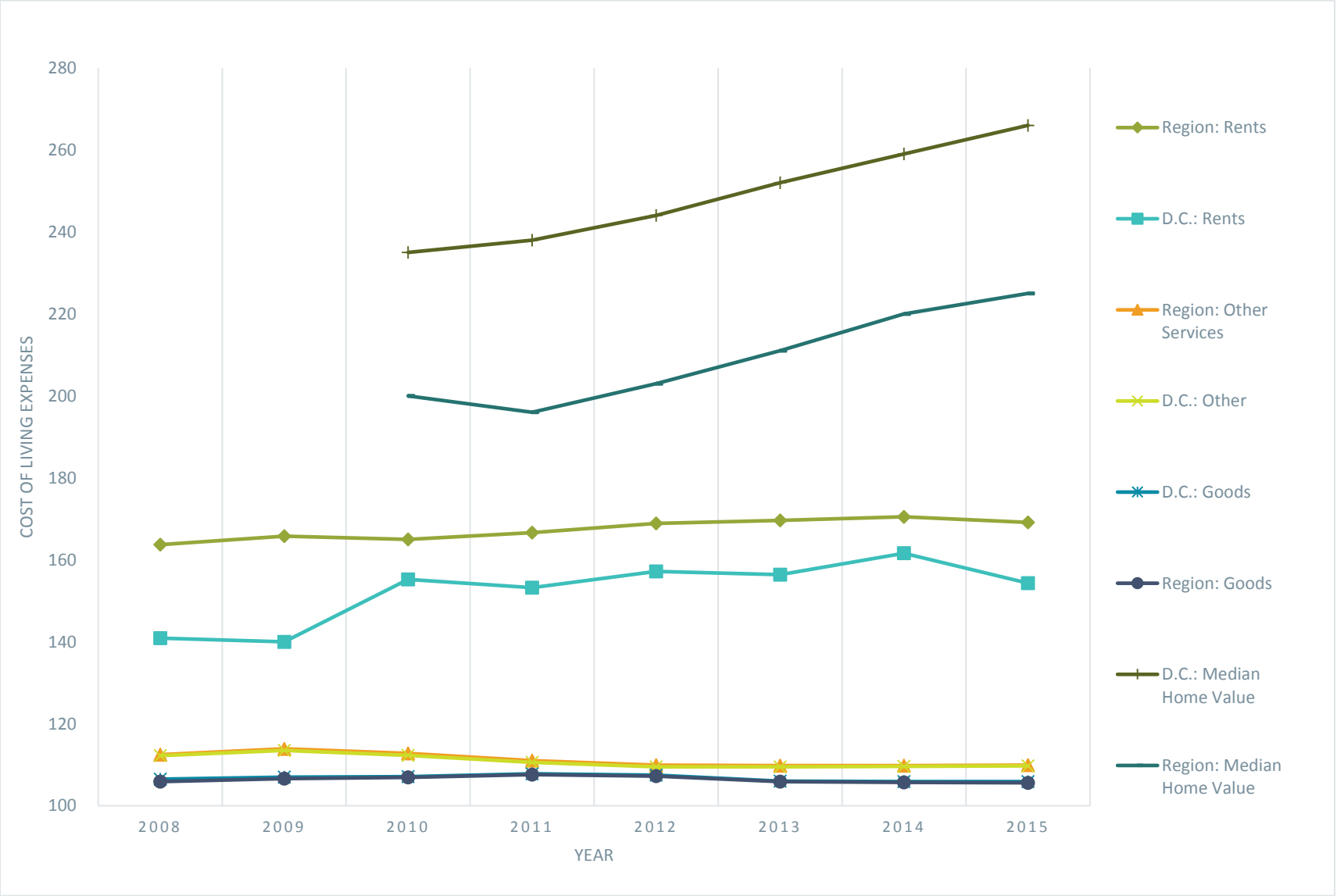


Figure 39 | Regional Relative Per Capita Income, 2005-2015

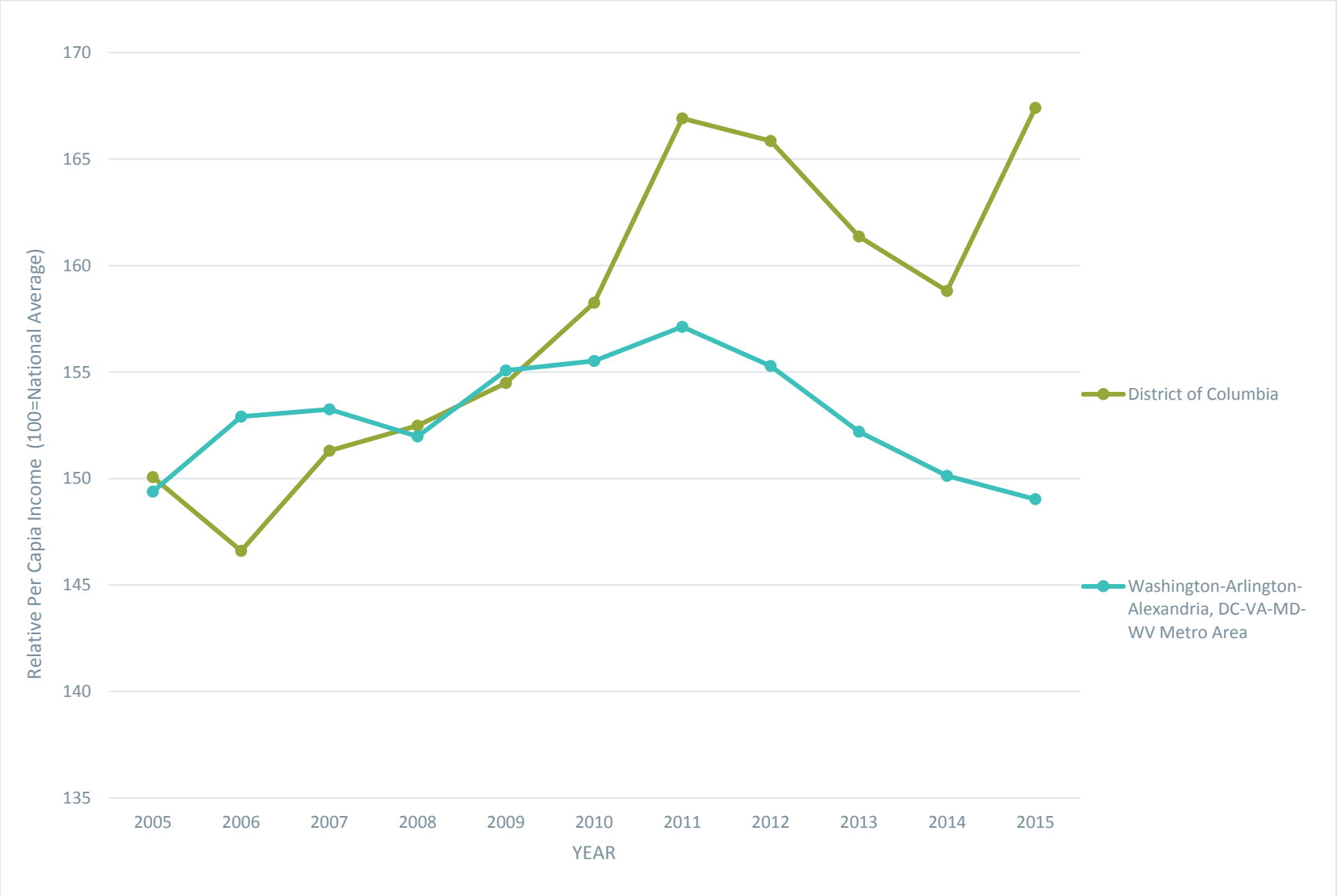
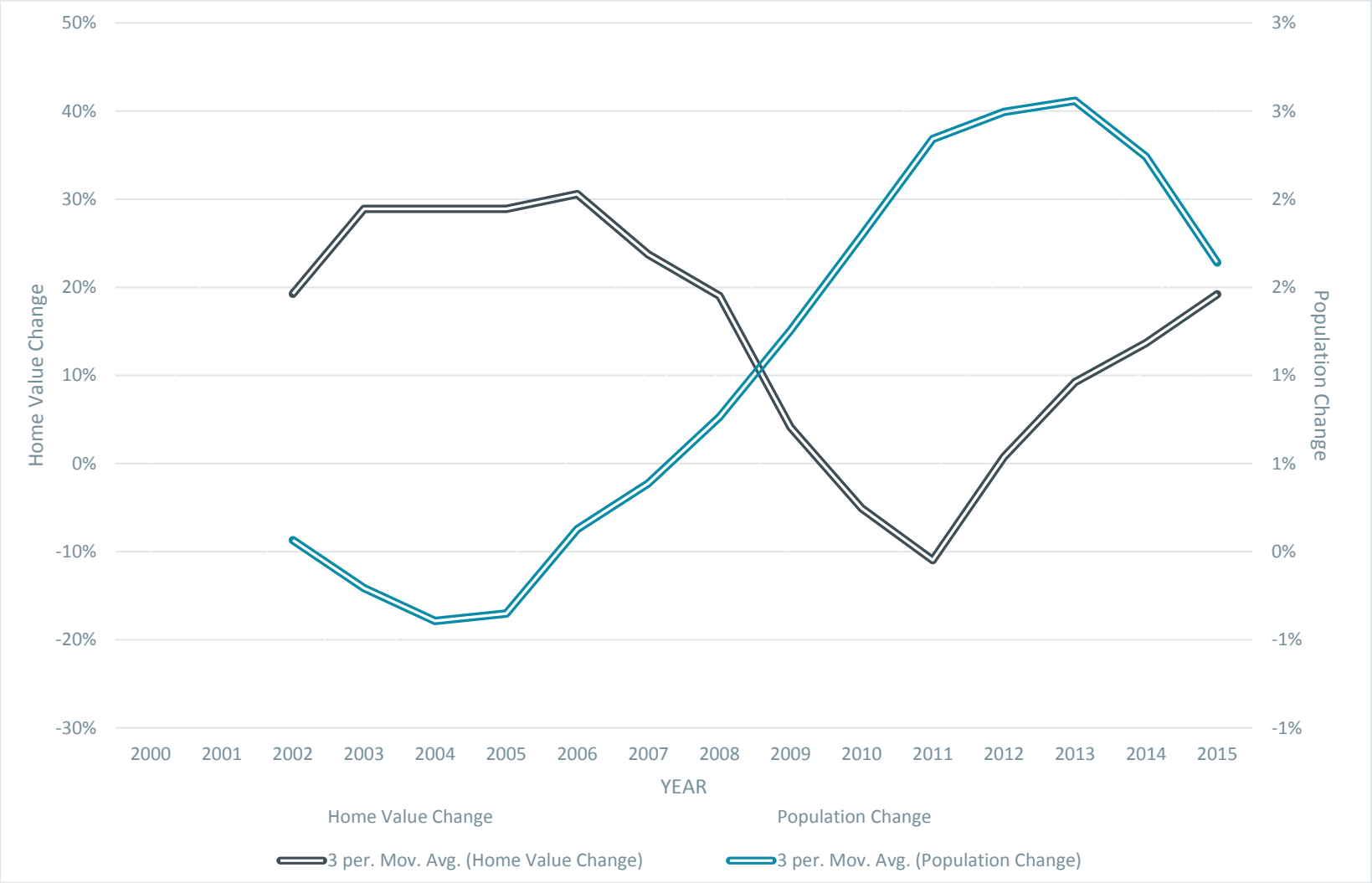
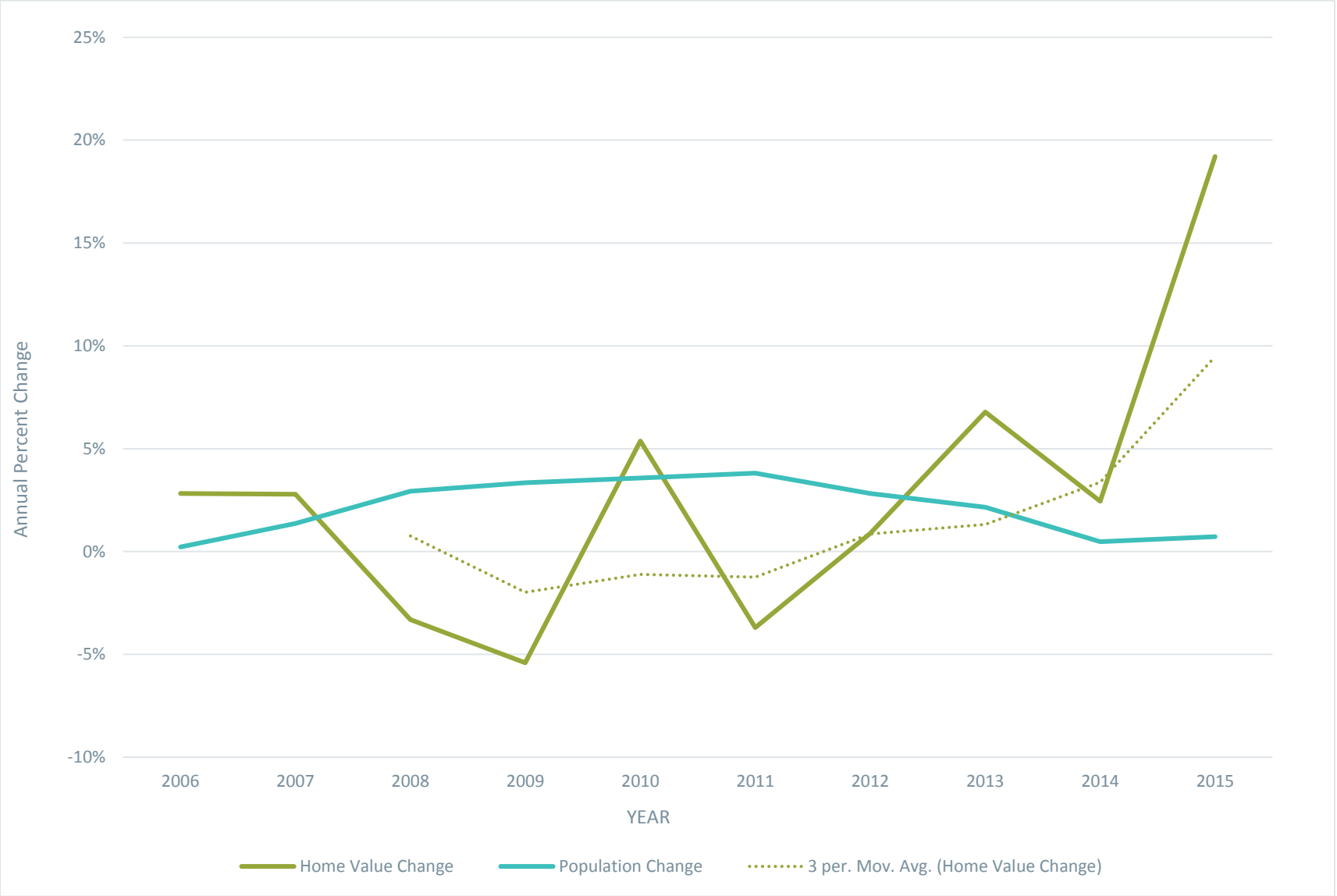


Figure 40 | D.C. Home Value and Population Change Comparison, 2000-2015



SOURCE: Home Value Data - US Census American Community Survey (2005-2015), US Census Decennial Census (2000), Renaissance Planning Group estimates (2001-2005). Population Data - U.S. Census Bureau via Woods & Poole

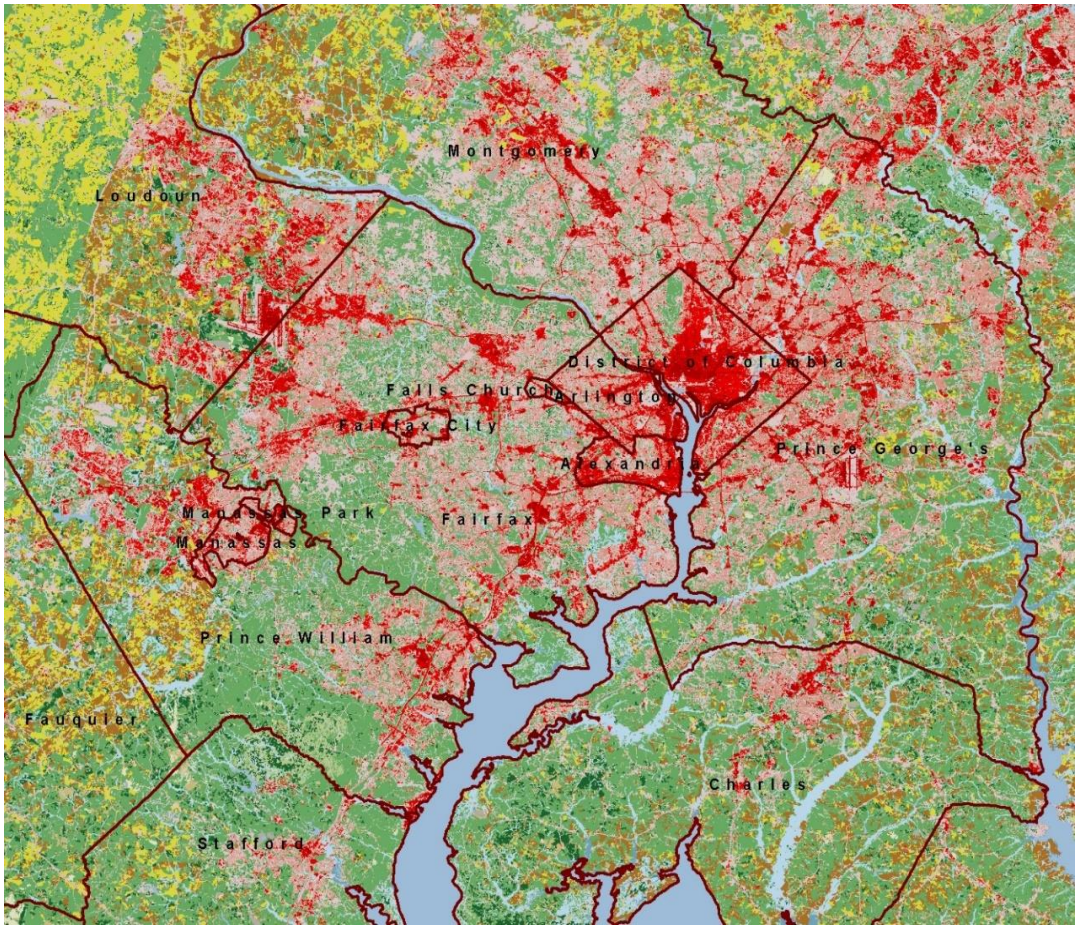
Figure 41 | Regional Home Value and Population Change Comparison, 2005-2015



Place-based Trends

Suburban Growth

Figure 42 | Development Patterns, 2011[1]



Suburban growth prospects are dependent upon both supply of suburban land and demand for suburban residential and non-residential products. Looking first at supply, the region is not in danger of running out of either greenfield or infill development opportunities in the near term. Figure 42 shows recent development intensity (though note that this most recently available data is now five years old). Areas of dark red are intensely developed areas that have little room for infill, though could always accommodate increased density on already-developed land. Areas of light red and green are places that have little to no existing development with no known growth restrictions. The outer ring suburbs of Washington D.C. still have plenty of available land, though there are also pockets of highly intensive developments in all jurisdictions. In the long-term, there is a potential supply problem for land in suburban counties.

Population growth in the District of Columbia and real estate demand and development in walkable centers around the region are suggesting that urban and urban-style places are the future of regional growth. But the suburbs still have strong prospects and not all growth is likely to come from city-dwelling Millennials. In fact, new census data suggests that suburbs and exurbs have both recently grown faster than the urban core. The most recent Census data shows that for the approximately 50 metro areas of at least 1 million, the primary city saw slower growth than did its suburban counterparts. This slower growth rate for primary cities was the first of the decade. It is worth noting, however,

that this trend is most pronounced in the smaller (though still 1 million and above) southern, southwestern, and Midwestern regions; additionally, the D.C. region itself had higher population growth in the city (1.5%) than the suburbs (0.8%). ULI's recent publication, "Housing in the Evolving American Suburb", makes the case that suburban housing markets are poised to maintain their relevance and predominance. Per this report, "Although the ascendancy of American suburbs starting after World War II came largely at the expense of cities, the recent revitalization of urban centers is in many cases complementary to the continued strength of their suburbs. In fact, the main message of this report is that healthy regions and fully functioning housing markets require a range of housing choices for households of different backgrounds, means, desires, and stages of life. In practical terms, this means a variety of city and suburban housing options." Overall, these various findings suggest the need to consider increased suburban growth prospects, particularly as compared to the more urban portions of the MWCOG region.

Office Space

Suburban office markets that were hit hard by the recession are starting to bounce back.[5] This recovery is focused on the best locations, so many secondary and lower-tier suburban markets are either struggling or stagnant. The location and density of future employment in the Primary Market Area could be influenced by trends in office space usage. Specifically, the average square footage of building space per worker influences individual firm location decisions based on the amount and characteristics of available space.

The guide for analysts and brokers has been 200 or 250 square feet per worker, but there have been several commentators and analysts in recent years forecasting that corporate office space usage will decline significantly to 150 square feet or even less per worker. This potentially dramatic reduction in office space demand could significantly change build-

Figure 43 | Average Office Lease Size by Class Type, 2004-2014

[5] Drummer, Randy. "Once Left for Dead, Suburban Office Making a Comeback." *CoStar News.* November 12, 2013. http://www.costar.com/News/Article/Once-Left-for-Dead-Suburban-Office-Making-a-Comeback/154320

out assumptions in some developing areas. In contrast, a 2012 paper by Professor Norm G. Miller of the University of San Diego found that the traditional rule of thumb is most likely underestimating the true amount of office space companies are occupying per worker.[6] Miller argues that, rather than 200 or 250 square feet per worker, the true figure may be more like 340 square feet per worker. From that adjusted starting point, Miller posits that most companies will not be able to dramatically reduce their office space usage due to the practicalities of fluctuating personnel counts, inefficiencies in space configurations, and the influence on recruitment of new employees.

Figure 44 | Average Office Lease Size by Industry Type, 2004-2014

Square feet per employee is clearly in long-term decline nationally, with the average size of new leases declining by 8 percent from 2005 to 2015[7]. However, this trend is not consistent among all types of office space. Figure 44 illustrates that square feet per employee in Class A office space has increased while space in Class B and C has dropped precipitously. Additionally, Figure 44 shows that office space changes are not consistent across all industry types. Interestingly, two of the larger industries in the Washington D.C. area are on opposite ends of this spectrum, with computer and data processing locations getting larger per employee, and federal jobs getting smaller.

[6] Miller, Norm G. "Estimating Office Space per Worker: Implications for Future Office Space Demand." September 17, 2012. http://www.costar.com/Webimages/Webinars/EstOfficeNMiller.pdf

[7] http://www.naiop.org/en/Magazine/2015/Spring-2015/Business-Trends/Trends-in-Square-Feet-per-Office-Employee.aspx

Millennial Trends

The Millennial generation is poised to have as much of an impact on economic and social trends as the Baby Boom generation did before it. Also known as Gen Y, it makes up one-fourth of the U.S. population and is expected to increase in size since many immigrants come to the U.S. at an early age. Early thought on the emerging and future influence of this generation centered on its role in an urban renaissance, and the Urban Land Institute commissioned two surveys in the past few years to evaluate its current and future housing and shopping preferences. The findings point to a more nuanced set of settlement patterns and preferences.

Contrary to the narrative of millennials greatly preferring downtown living, most millennials live on the urban fringe. Only 13% of millennials live in or near downtowns. Notably, in a recent ULI report nearly 2 in 5 surveyed described themselves as "city people", so there does still appear to be a mismatch between locational preference and current living situation. This finding likely stems from several sources, but the biggest looks to be cost. One recent survey found that 'cost of housing' was the most important characteristic of any future residential choice by millennials, far surpassing features like safety, proximity to work, or quality of schools[8].

Average earnings in the two major employment sectors of federal government and professional services are both high (though they have declined slightly since 2008). High home prices and rents will not stop all young professional growth because of the financial resources many will have available. A more relevant question for the long term is whether the current Millennial cohort remain in the District as the people get older and start families. The District CFO has documented the fact that once households have their first child they are more likely to leave the District within four years. Middle income households are more likely to leave than low and high-income households, suggesting that cost is a factor for residents in the middle of the income scale.[9] Other findings from the research indicate that the District population is transient: only 23 percent of people living there in 2004 were still there in 2012. Single people were more likely to leave the District, while people who got married during the analysis timeframe were more likely to stay. Having multiple children in the household tended to make people stay, and higher income households tended to stay. [10]

In its December 2014 revenue letter, the District CFO stated that the District population cannot be assumed to grow as fast in the future as it has recently.[11] We expect continuing in-migration of young urban professionals to help the District continue the population

[8] UDR/Lachman Associates Survey, November 2014
[9] Moored, Ginger and Lori Metcalf. "D.C. Parenthood: Who Stays and Who Leaves?" District of Columbia Government, Office of the Chief Financial Officer. January 15, 2015. http://cfo.dc.gov/publication/dc-parenthood-who-stays-and-who-leaves
[10] Taylor, Yesim Sayin. "Who Stays in the District? Who Leaves? Preliminary Findings from DC Tax Filers from 2004." District of Columbia Government, Office of the Chief Financial Officer. January 28, 2015. http://cfo.dc.gov/publication/who-stays-district-who-leaves-preliminary-findings-dc-tax-filers-2004
[11] DeWitt, Jeffrey S. "December 2014 Revenue Estimates." District of Columbia Government, Office of the Chief Financial Officer. December 30, 2014. http://cfo.dc.gov/sites/default/files/dc/sites/ocfo/publication/attachments/Revenue%20Certification%20Letter_Dec%202014.pdf

growth increase over the next several decades. However, the cost of living concerns and tendency for aging Millennial generation families to leave the District suggests that the population growth forecasts in Round 9.0 may be somewhat optimistic and that those in the Round 8.4 forecasts are more likely supportable.

Emerging Preferences for Cities and Walkability

To capitalize on the qualities of city living at more reasonable costs, many seem to be choosing non-downtown city neighborhoods or more walkable suburbs. While many have a vision of younger people and retirees flooding back into cities, it may not actually be the urbanity that is pulling them in but the accessibility that is nearly guaranteed in an urban location. Almost regardless of geographic preference for living- urban or suburban- what people want is the ability to be within walking distance of a variety of opportunities- restaurants, shops, jobs, parks, and more. Looking more specifically at the D.C. Metro region, ULI's 2015 'Millennials Inside the Beltway' report found that participants expressed a consistent interest in living in walkable places with good transit access. Over two-thirds of respondents say that walkability is the best attribute and 65% of respondents said Metro access is among their top three reasons for selecting or staying in their current location.

The walkability of urban areas and "urban-like" areas is seen as one of the key factors in their appeal, to Millennials and others alike. A national survey found that 60% of respondents "favor a mix of houses and stores that are easy to walk to"[12]. Real estate analyst and longtime Washington, D.C. market observer Christopher Leinberger has published research showing that the region leads the nation in major walkable centers, most of the region's recent development has happened in these centers, and real estate in these centers has a major price/value premium over other suburban development.[13] It appears that walkability is increasingly driving the commercial real estate market in the region, and most of the walkable places are in or near the urban core or along Metrorail lines. Of the 43 walkable centers identified by Leinberger, 21 are in the District.

Research at a national level published by the National Association of Industrial and Office Properties (NAIOP) found similar preferences by office tenants and higher values for walkable, mixed-use places. Across the U.S. "vibrant suburban centers" compete evenly with regional central business districts for office tenants, but they have beaten out conventional suburban locations.[14] Finally, ULI's Emerging Trends in Real Estate 2016 report included walkable secondary markets (i.e. medium-sized cities) in their list of Expected Best Bets for real estate investment. Overall, this suggests that much of the MWCOG region will be a desirable place to live, as all counties in the PMA have elements of urbanity and walkability. Moreover, there are many different examples of urban,

[12] National Association of Realtors, 2013 Community Preference Survey.
[13] Leinberger, Christopher B. *DC: The WalkUP Wake-Up Call.* The George Washington University School of Business. 2012. http://business.gwu.edu/dc-the-walkup-wake-up-call
[14] Malizia, Emil. *Preferred Office Locations.* NAIOP Research Foundation. 2014. http://www.naiop.org/preferredofficelocations

walkable places, increasing the potential attractiveness as a place to raise families and retire, thus decreasing the jobs-to-person ratio seen currently in the region.

Retail Industry Trends

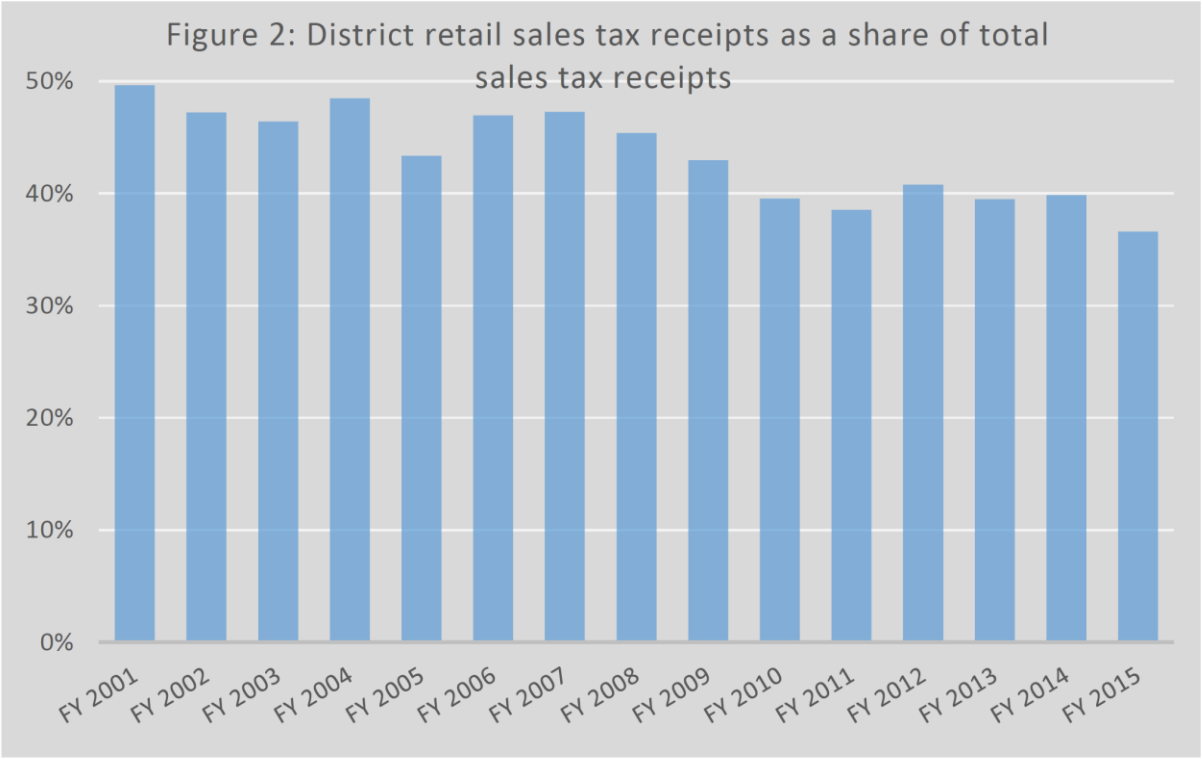
The retail industry is in flux because of the aftermath of the Great Recession, the continuing rise of e-commerce, the knock-on effects of mobile technology, and Generation Y preferences beginning to supersede those of the Baby Boomers, which have driven the market for so long. Many commentators and analysts have weighed in on this subject, and it is complex because it reflects a wide range of cultural and economic influences. While there are slight changes every year, recent years have seen a consistent set of key trends:

1. The U.S. urban population increase has been outpacing the nation's overall growth rate for over a decade, and new construction in suburban areas is increasingly more urban in feel, with a mix of development types and transportation options located nearby.[15]
2. Washington will continue to be bolstered by international capital. "Global economic and political uncertainty continues to drive capital to a "safe haven" in the United States. The U.S. property market is the most stable and transparent in the world, making it an easy investment choice."
3. Dramatic shifts in the retail market will only continue. The "de-massification" of retail continues to occur; mass markets are disappearing and fragmenting, and along with that are many big malls, shopping centers, and retailers. The retail in demand now is either driven by experience (upscale) or need/convenience (downscale). The convenience and choice of online shopping fits with the desires of current shoppers, so getting them out to physical locations calls for prime locations and compelling experiences/products.[16]
4. In 2015 online purchasing outpaced in-store purchasing for the first time, and major retailers have been adjusting to this new way of doing business. The rise of mixed spaces (i.e. both virtual and physical space used by retailers), entertainment-themed space, and "showroom" style spaces are all expected to increase in prominence. These types of spaces are well suited to urban and denser suburban spaces, where space is not available for large inventories.
5. Fluctuations in oil prices may be masking other trends in real estate and purchasing patterns. Oil prices dropped to a decade-long level, creating short-term windfalls for households and businesses. This windfall is often quickly spent on retail goods (by households) and in capital investments (by businesses). These actions are generally associated with an improving economy but can dry up quickly if oil prices reverse their downward trend.

[15] Urban Land Institute. *Emerging Trends in Real Estate, United States and Canada*. 2016.
[16] Lewis, Robin. "The Great Retail Demassification, Part 1." *Forbes.* March 24, 2014. http://www.forbes.com/sites/robinlewis/2014/03/24/the-great-retail-demassification-part-1

The D.C. CFO reviewed retail trends in their March 2017 'District Retail Sector: Past, Present, and (Possible) Future' report, and noted a significant downward trend in retail sales receipts as a share of total sales tax receipts, from half of all receipts in 2001 to 35% in 2015.

Figure 45 District Retail Sales from CFO report



They note that this could be due to e-commerce, which only recently has been taxed. Additionally, it seems that post-recession sales tax growth has only occurred for the largest retailers, while the smaller retailers have been stagnant. The report also notes that current plans for cuts to federal nondefense spending could further reduce retail sales tax growth.

ULI provides interesting insights about retail, particularly by land use context. They note continuing investor concern about retail in general, but not about retail in urban or "high street" settings or among neighborhood and lifestyle centers common within high density suburban areas. Furthermore, they show that interest has been steadily growing since the end of the recession, which suggests this is not a recent short-term trend. As such, national retail concerns need to be tempered by the land use context.

Based on these trends, it is unlikely for retail to grow dramatically in the region, but the number and strength of walkable, mixed-use places in the Washington, D.C. region that was mentioned earlier suggests that the region is at the leading edge in the evolution of the retail industry and the locations and real estate that it occupies. Combined with the emerging preference for urban living on the part of Millennials and the District population boom, the expansion of retail development following an expansion of population may slow or be redirected to more intensely developed centers than has been the case in the past.

Summary of Regional Trends

Strengths

The MWCOG region has a competitive advantage due to positive trends in population, employment and the economy. The population is growing, complemented by a high-quality job market and a strong, albeit consolidated, traded sector. Additionally, the individual jurisdictions with the region continue to grow "together". A continuation of this trend would require cooperation towards increased diversity and attractive as both a population and employment center.

Weaknesses

Some of the elements that strengthen the MWCOG region also expose it to economic volatility. Due to its attractiveness, the region has been characterized by a relative high-cost of living that is not commensurate with slow income growth. This slow income growth could be attributed to stagnating federal job growth, as federal jobs continue to be the dominant industry. In the long-term, the region is susceptible to changes in federal spending, but long-term federal job loss hasn't impeded regional growth to date. Changes in federal jobs growth have direct and indirect impacts on employment in other sectors. Specifically, the private sector remains heavily dependent on public contracts and could feel the effects of stagnant federal jobs growth.

Historic National Growth Trends

Figure 46 shows the D.C. region outpaced national population growth and has been doing so more quickly in the past two decades. The US population continues to grow, yet the rate of increase is slowing, indicated in Figure 47. The US Census Bureau forecasts a continued drop in relative population increases, following the patterns of the last few decades, as illustrated in Figure 48. Historically, regional and national employment trends are in-sync, as demonstrated in Figure 49, although the region did not experience as much of an employment drop as the rest of the nation during the Great Recession. The influence of the federal jobs sector helped the region survive economic downturn, evidenced in Figure 50, but has also limited growth afterwards.

Figure 46 | Historic Regional and National Population, 1970-2016

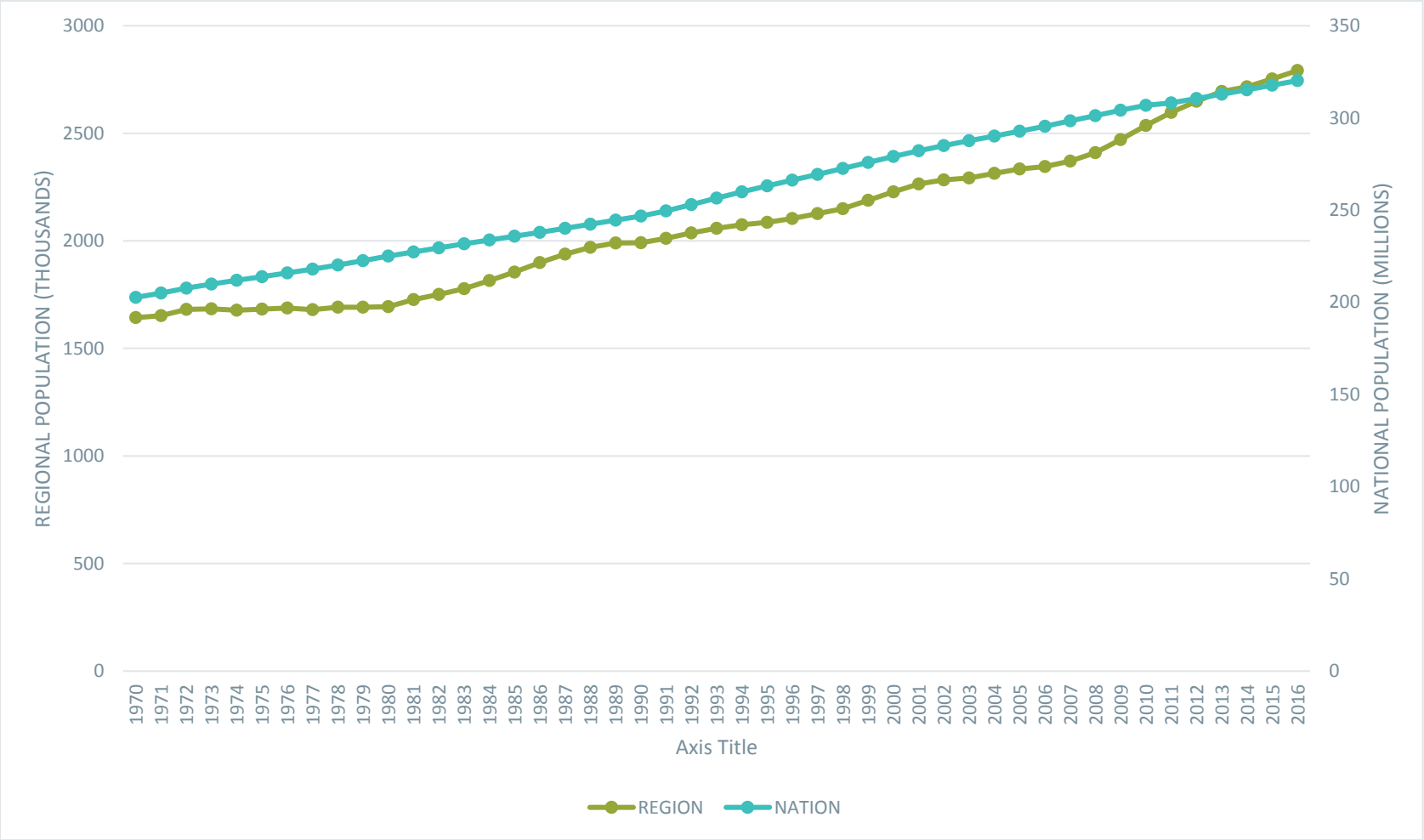


Figure 47 | Year-to-Year Percent Change in National and Regional Population, 1970-2015

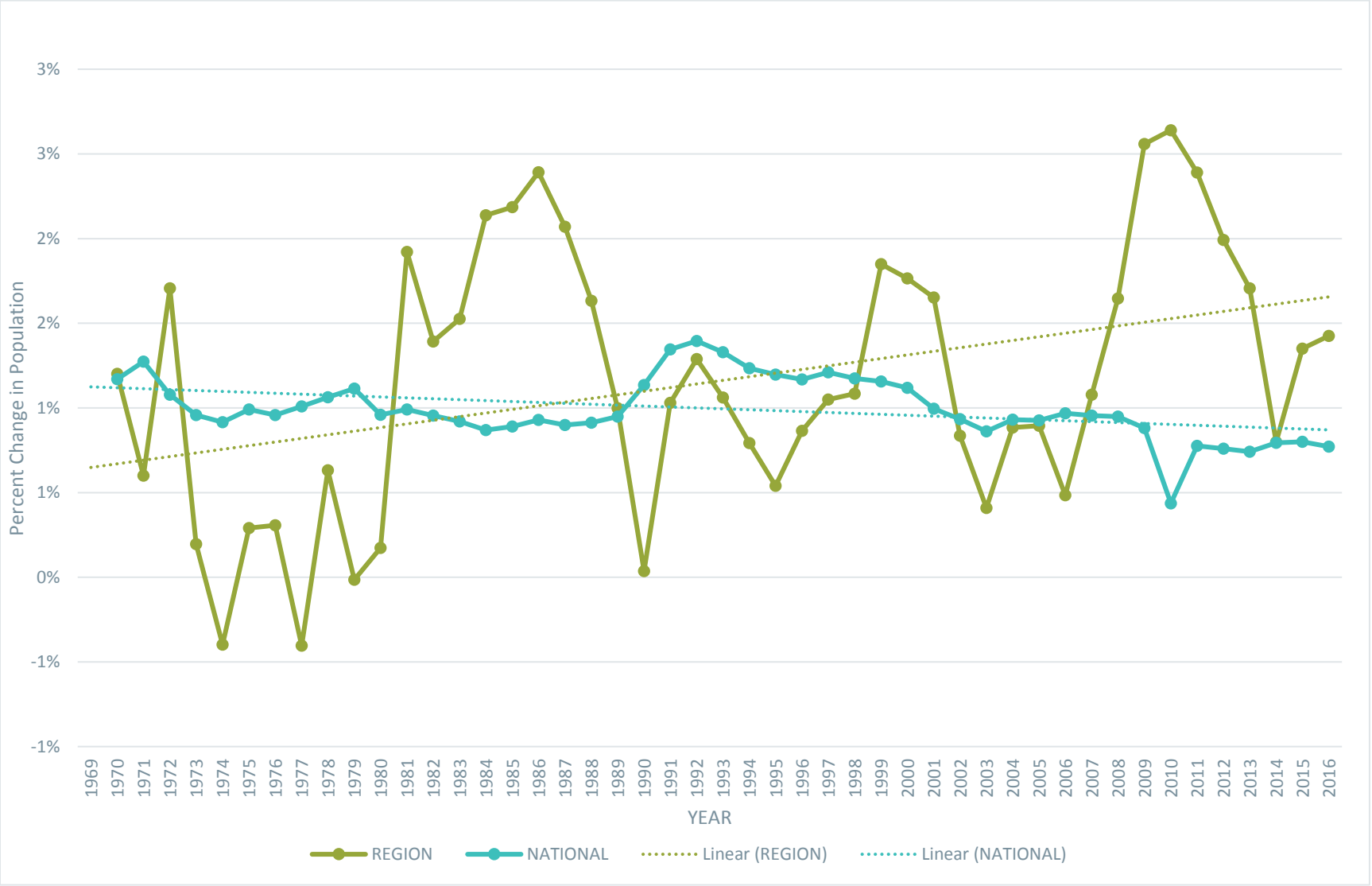


Figure 48 | Year-to-Year Percent Projected Population Change, 2015-2040

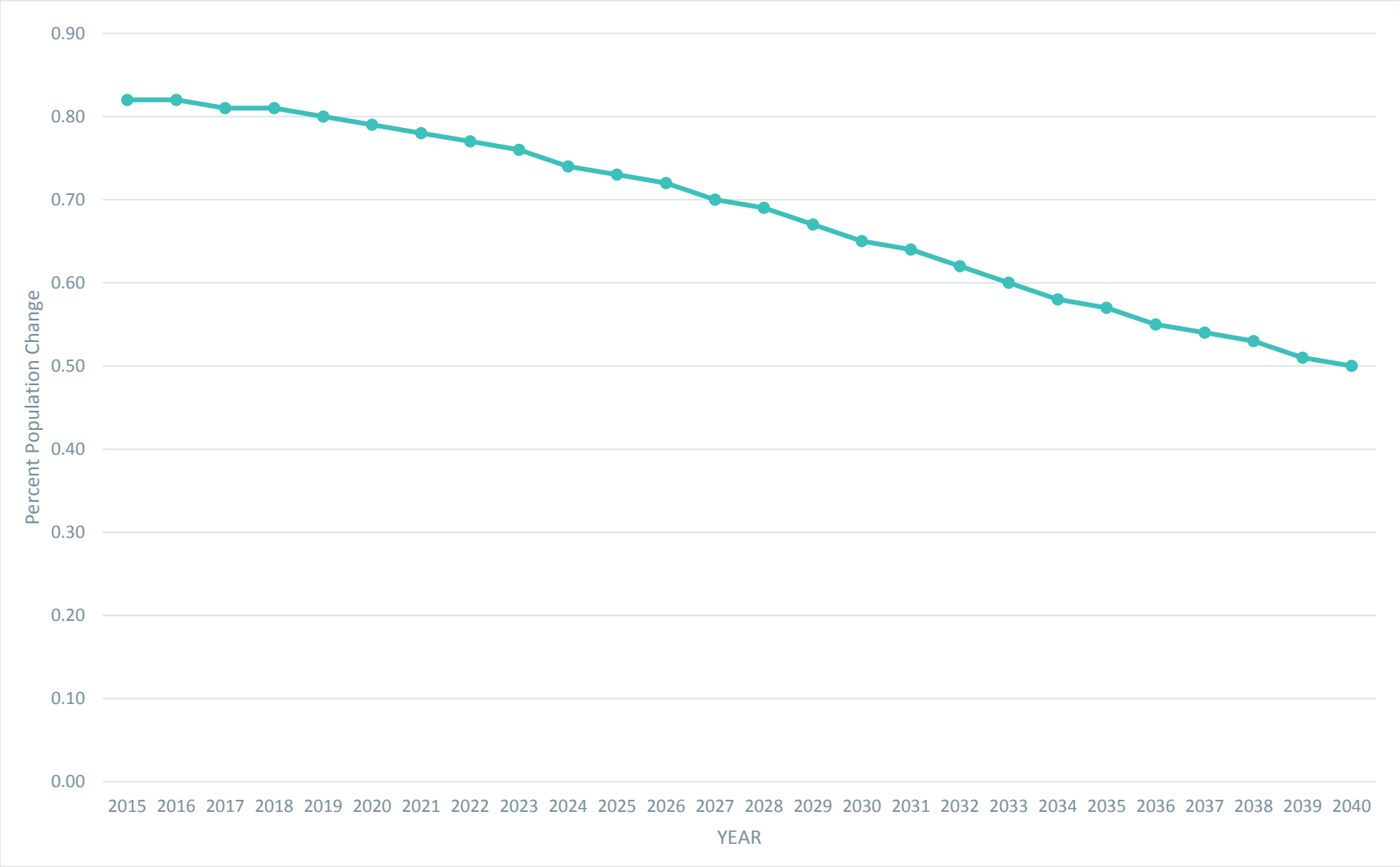


Figure 49 | Regional and National Employment, 1970-2016

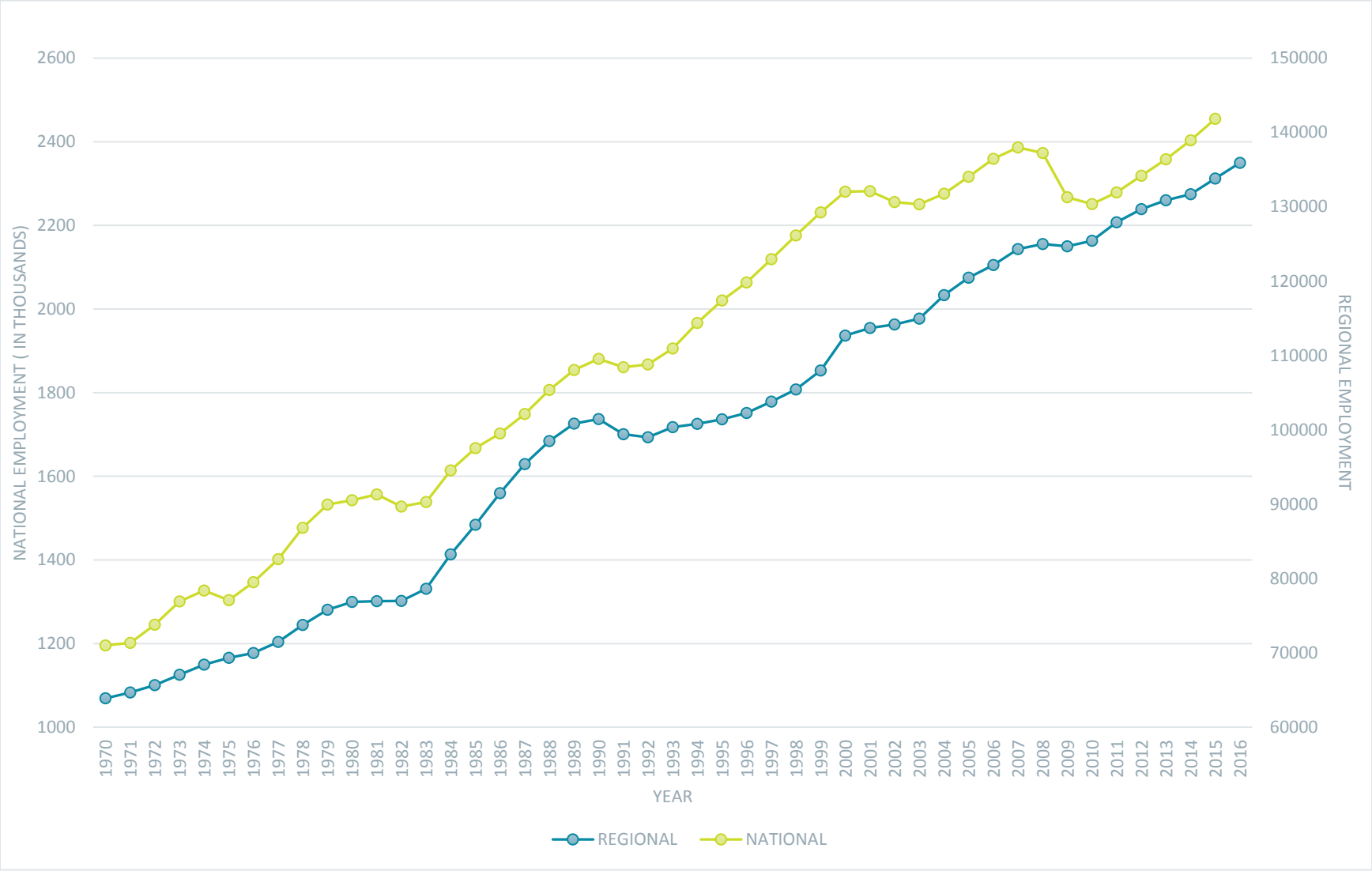
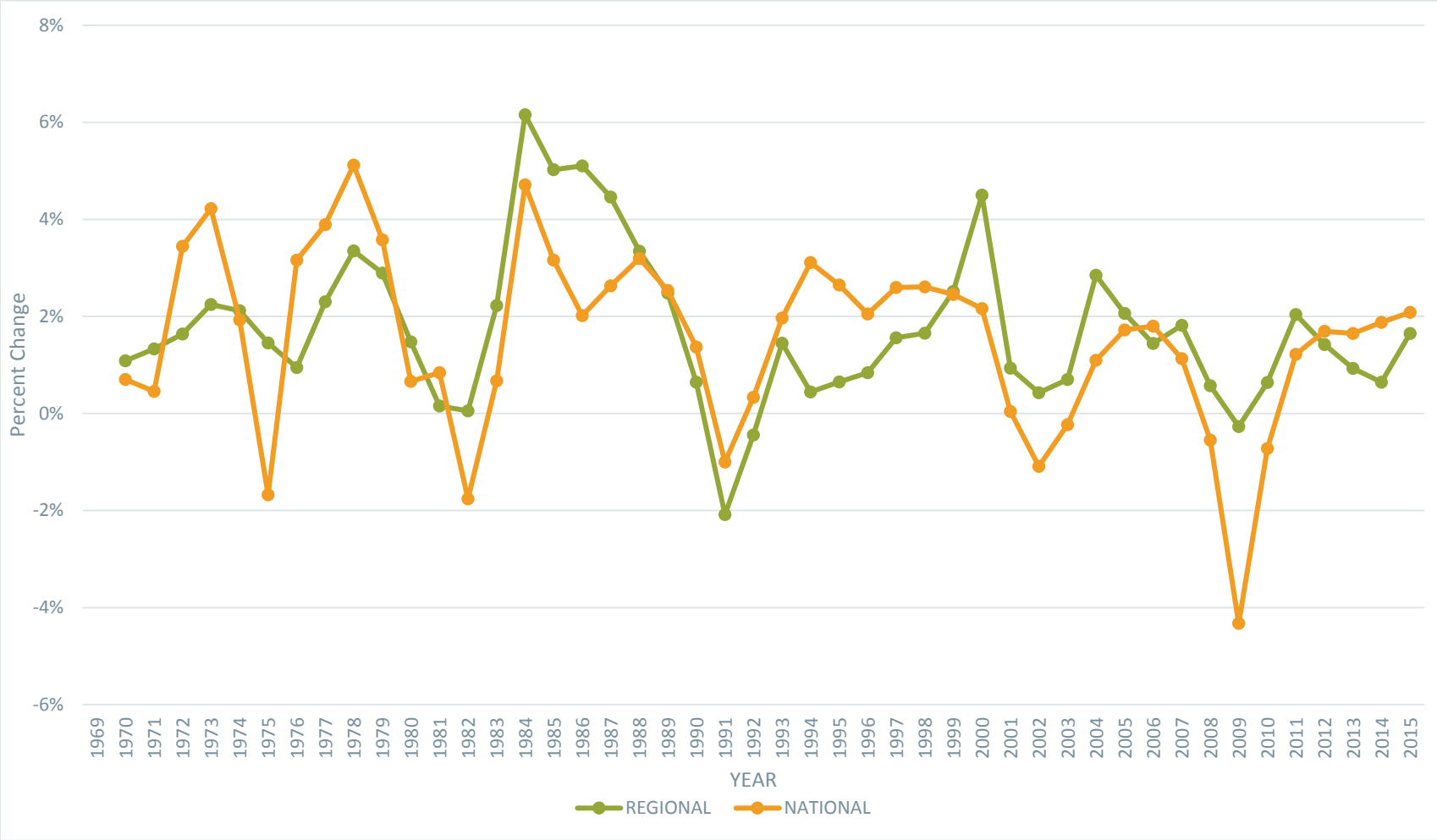


Figure 50 | Percent Change in Regional and National Employment, 1969-2015



V. MACROECONOMIC FORECAST

The basic approach for developing the macroeconomic forecast was to merge multiple outside forecasts with the findings of the macroeconomic assessment. The intent is to identify adjustments to Round 9.0 forecasts to better reflect macroeconomic trends and outside perspectives of regional growth.

Population Adjustments

Starting from the 2015 Census count, compound annual growth rates within each five-year period are shown for both Round 9.0 and Applied forecasts. Our evaluation identified the following adjustments:

- Overall, the Round 9.0 forecast projected slightly lower population growth than outside forecasts and the macroeconomic trend would suggest.
- The Round 9.0 forecast for the District of Columbia was dramatically higher than the outside forecasts and the macroeconomic finding of a region likely to experience less differentiation in growth patterns.
- The Round 9.0 forecast for Loudoun County was dramatically lower than the outside forecasts after 2025, responding to a policy-based expectation of long-term growth management. However, a regional evaluation of land availability and much higher outside forecasts led to upward adjustments in the applied forecast.
- Fairfax and Montgomery Counties were adjusted upwards in the applied forecasts, responding to outside forecasters higher growth expectations and the macroeconomic trends that suggested that this “favored quarter” of regional population will continue to be competitive based on recent robust growth and infrastructure investment.
- Prince George’s County was adjusted upwards in the applied forecast, with the expectation that long-term regional growth pressures and strong regional access to jobs and amenities in the county will outweigh the current lack of “favored quarter” status.
- While all forecasts deviate slightly from MWCOG, other adjustments are relatively small.

Table 7 and Table 8 below show compound annual growth rates (CAGR) for Macroeconomic and Round 9.0 forecasts, respectively.

Table 7 | Macroeconomic Population Forecast, 5-year CAGR

	2015-20	2020-25	2025-30	2030-35	2035-40
Alexandria	1.1%	0.8%	1.0%	0.8%	0.9%
Arlington County	1.1%	0.8%	1.0%	0.7%	0.9%
Charles County	1.5%	1.1%	1.2%	1.0%	1.1%
District of Columbia	1.2%	0.9%	1.1%	0.8%	1.0%
Fairfax County	1.2%	0.9%	1.0%	0.8%	0.9%
Frederick County	1.3%	1.0%	1.0%	0.9%	1.0%
Loudoun County	2.6%	1.8%	1.6%	1.1%	1.0%
Montgomery County	0.9%	0.7%	0.8%	0.6%	0.8%
Prince George's County	0.7%	0.6%	0.7%	0.6%	0.6%
Prince William County	1.3%	1.0%	1.2%	0.9%	1.1%

Table 8 | Round 9.0 Population Forecast, 5-year CAGR

	2015-20	2020-25	2025-30	2030-35	2035-40
Alexandria	1.1%	1.0%	0.9%	0.8%	0.9%
Arlington County	2.1%	1.3%	1.8%	1.3%	1.0%
Charles County	1.5%	1.0%	0.6%	0.9%	1.1%
District of Columbia	1.6%	1.5%	1.4%	1.2%	1.0%
Fairfax County	0.7%	0.9%	0.8%	0.8%	0.7%
Frederick County	1.7%	1.5%	1.0%	1.0%	0.8%
Loudoun County	2.7%	1.7%	0.9%	0.6%	0.3%
Montgomery County	0.7%	0.7%	0.8%	0.7%	0.5%
Prince George's County	0.4%	0.3%	0.3%	0.3%	0.3%
Prince William County	1.4%	1.3%	0.9%	0.7%	0.6%

Employment Adjustments

As in the population evaluation, compound annual growth rates within each five-year period are shown for both Round 9.0 and Applied forecasts. Our evaluation identified the following adjustments:

- Overall, employment is nearly identical at the regional scale between Round 9.0 and the applied forecast. The allocation of that regional total to the associated jurisdictions did have some differences.
- The Round 9.0 forecast for District of Columbia employment is notably higher than outside forecasts and would require a larger proportion of regional employment growth than the macroeconomic trend would suggest. This is consistent with Round 9.0 forecast for District of Columbia population, as well. As such, the applied forecast is approximately 50,000 employees lower than Round 9.0 forecasts.
- The Round 9.0 forecast for Loudoun County is viewed as too low for the reasons outlined in the population adjustments section (e.g. overemphasis on existing growth management intentions) and was thus adjusted upwards by 30,000.
- Prince George's County is viewed as too low, though by a smaller proportion than population due to the expectation that population demand will be the primary driver of county growth.
- While all forecasts deviate slightly from MWCOG, other adjustments are relatively small.

Table 9 and Table 10 below show compound annual growth rates (CAGR) for Macroeconomic and Round 9.0 employment forecasts, respectively.

Table 9 | Macroeconomic Employment Forecast, 5-year CAGR

	2015-20	2020-25	2025-30	2030-35	2035-40
Alexandria	1.0%	0.8%	0.9%	0.7%	0.8%
Arlington County	0.9%	0.7%	0.8%	0.6%	0.7%
Charles County	1.4%	1.2%	1.3%	1.1%	1.2%
District of Columbia	0.9%	0.7%	0.8%	0.6%	0.7%
Fairfax County	1.5%	1.1%	1.3%	1.0%	1.2%
Frederick County	1.4%	1.2%	1.3%	1.1%	1.2%
Loudoun County	2.8%	2.4%	2.7%	2.3%	2.4%
Montgomery County	1.0%	0.8%	1.0%	0.7%	0.9%
Prince George's County	1.0%	0.8%	0.9%	0.8%	0.9%
Prince William County	2.0%	1.5%	1.8%	1.4%	1.6%

Table 10 | Round 9.0 Employment Forecast, 5-year CAGR

	2015-20	2020-25	2025-30	2030-35	2035-40
Alexandria	0.7%	2.0%	0.9%	1.2%	1.1%
Arlington County	0.3%	1.1%	1.5%	1.1%	0.9%
Charles County	0.2%	0.9%	1.2%	1.2%	1.2%
District of Columbia	1.2%	1.1%	0.9%	0.8%	0.7%
Fairfax County	1.5%	1.3%	1.1%	0.9%	0.9%
Frederick County	0.8%	0.9%	1.0%	1.1%	0.9%
Loudoun County	2.7%	2.3%	2.2%	1.7%	1.4%
Montgomery County	0.9%	1.0%	1.1%	0.7%	0.8%
Prince George's County	0.6%	1.0%	0.5%	0.5%	0.4%
Prince William County	2.4%	2.0%	1.8%	1.6%	1.7%

Macroeconomic Forecast

The jurisdiction-level macroeconomic population and employment forecasts for select jurisdictions in the MWCOG region are shown in Table 12 and Table 18, respectively.

VI. SUPPLY-SIDE ANALYSIS

An analysis of land use in the Primary Market Area was conducted to understand the existing conditions for residential and non-residential development and availability of developable land by TAZ. This analysis identified land that is currently developed and land that has market viability for residential and commercial development. The socioeconomic projections for each TAZ were then evaluated in the context of the supply of developable land to provide a TAZ level 'reasonableness check' for the study area. In addition, there were other land use statistics available from this analysis that were inserted into the overall study area evaluation tool.

To conduct this analysis, the study area was analyzed using more fine-grained tools ranging from parcel-level to census block level metadata which was then aggregated to TAZ geographies. These attributes were queried to determine each parcel's development status, and whether that land was primarily in residential, or employment. Potentially developable lands are areas that are determined to be either vacant or under-utilized. The land supply side analysis yields the following statistics by TAZ:

- Existing Developable Land, including;

  - Vacant (residential, employment);
  - Under-utilized and/or able to redevelop (residential and employment);
  - Unbuildable land (ROW, Utilities, Easement, Federal Park, etc.);
- Multimodal link density;
- Existing net residential households per acre by TAZ;
- Existing net employees per acre by TAZ;
- Future net residential households per acre by TAZ;
- Future net employees per acre by TAZ; and
- Proximity to existing and planned high quality transit station areas for Metrorail, commuter rail, and future LRT and BRT lines.

The localized analysis incorporated a three-step analysis process. In the first step, some twenty land use policy variables were examined for their predictive power in explaining the MWCOG Round 9.0 forecast growth through 2040 using a linear regression model. These policy variables included elements that are explicitly included in the forecasting process, such as the presence of transit (all jurisdictions consider high quality transit access as one element in the planning and zoning process) and elements that are not necessarily incorporated in the forecasting process such as accessibility (most jurisdictions at least intuitively recognize the relationship between access to jobs (for residents) and to workers (for employers), but this relationship is generally not explicitly modeled in the allocation of jurisdictional growth totals to individual TAZs. The regression analyses considered both overall goodness-of-fit and the significance of individual candidate variables independent variables. The regression analyses yielded an R-squared value of 0.25 for density and 0.54 for diversity, indicating that 25% of the MWCOG forecast growth in total jobs and housing units at a TAZ level and 54% of the jobs/housing balance in that growth can be explained by the independent variables.

In the second step, a “heat” variable was derived that explained the difference between the Round 9.0 growth factor elements that were explained by the quantitative regression analysis and the actual TAZ-level forecasts. The heat variable is a surrogate for the many elements, both quantitative and qualitative, that enter the actual land development process, ranging from quantitative pro-forma feasibility details to the qualitative objectives and criteria that individual property owners and developers consider in their negotiation processes; an amalgam of considerations often described as institutional knowledge. This heat variable was used as a constant in the third step in the process, wherein the value of the quantitative analyses was gradually increased and the “heat” variables decreased using an iterative process so that the quantitative elements played a larger role in the allocation of jobs and population and the institutional knowledge played a somewhat lesser role, although the ultimate process still required substantial judgement.

Figure 51 shows the existing multimodal link density in 2015. A multimodal link is an intersection characterized by travel speeds less than 55 MPH, less than 8 travel lanes, and accommodations for pedestrians and cyclists. Link density measured by the number of multimodal intersections per square mile. Location data for multimodal links is from the US EPA Smart Location Database (SLD. In

general, a greater multimodal link density has a negative effect on forecast jobs and housing growth. This may initially seem counterintuitive as smart growth development patterns typically celebrate and benefit from a robust local street grid. However, the sign of an existing robust local street grid is typically an indication of long-established, residential communities.

Figure 52 displays the increase in auto accessibility to jobs from 2015 (existing condition) to 2040 (future condition). Auto accessibility to jobs is calculated with a decay-based curve that adjusts the data to incorporate the assumption that jobs that are closer have a higher value than jobs that are further away. Accessibility to jobs by auto is a key component of regional economic growth based on multimodal accessibility analyses that Renaissance has performed both for MWCOG and several of its member jurisdictions. Figure 52 also reinforces the value of the critical mass of development in the regional core. Over time, two opposing forces will affect the region: increased density will improve auto accessibility while increased congestion will decrease auto accessibility.

Figure 53 shows the increase in high-quality transit service coverage ratio from 2015 (existing condition) to 2040 (future condition). The increase in high-quality transit service is defined as future fixed-guideway transit improvements adopted in the regional Constrained Long-Range Plan (CLRP) and additional anticipated transit improvements (e.g. Columbia Pike BRT). Transit service coverage ratio measures the extent of coverage within each TAZ from a new transit line or station within walking distance, where a value of zero indicates none of the TAZ is within walking distance of the new investment and a value of one indicates the entire TAZ is within walking distance of the new transit investment. The investment in high-quality transit is a strong indicator of future growth.

Figure 54 illustrates existing “medium density” and “high density” development in 2015. Development density is calculated as the percent of land area within the TAZ designated “developed” at either “medium” or “high” densities. These designations are also derived from the US EPA SLD. The location of existing development is highly correlated with future growth; current development density indicates the degree to which future development will trend towards infill redevelopment within existing activity centers.

Figure 55 is a map of transit accessibility to jobs in 2040. This measure includes the sum of existing transit services as well as future transit investments. Transit accessibility to jobs, also derived from the MWCOG model analyses, have a positive effect on forecast density and diversity. The correlation to housing growth is intuitive - places with high jobs accessibility are desired smart growth locations for linking residents with job opportunities. The linkage to jobs growth is slightly less intuitive but is reflective of the concept that transit-oriented developments with high job accessibility are desirable places for both residential and commercial growth. Additionally, most transit-oriented activity centers have sufficient accessibility to attract office (and sometimes retail) density for both transit and walk/bike access considerations. Figure 55 shows a value similar in function to that shown in Figure 52, but for total 2040 conditions and for walk-access to transit trips only.

Figure 51 | Existing Multimodal Link Density, 2015

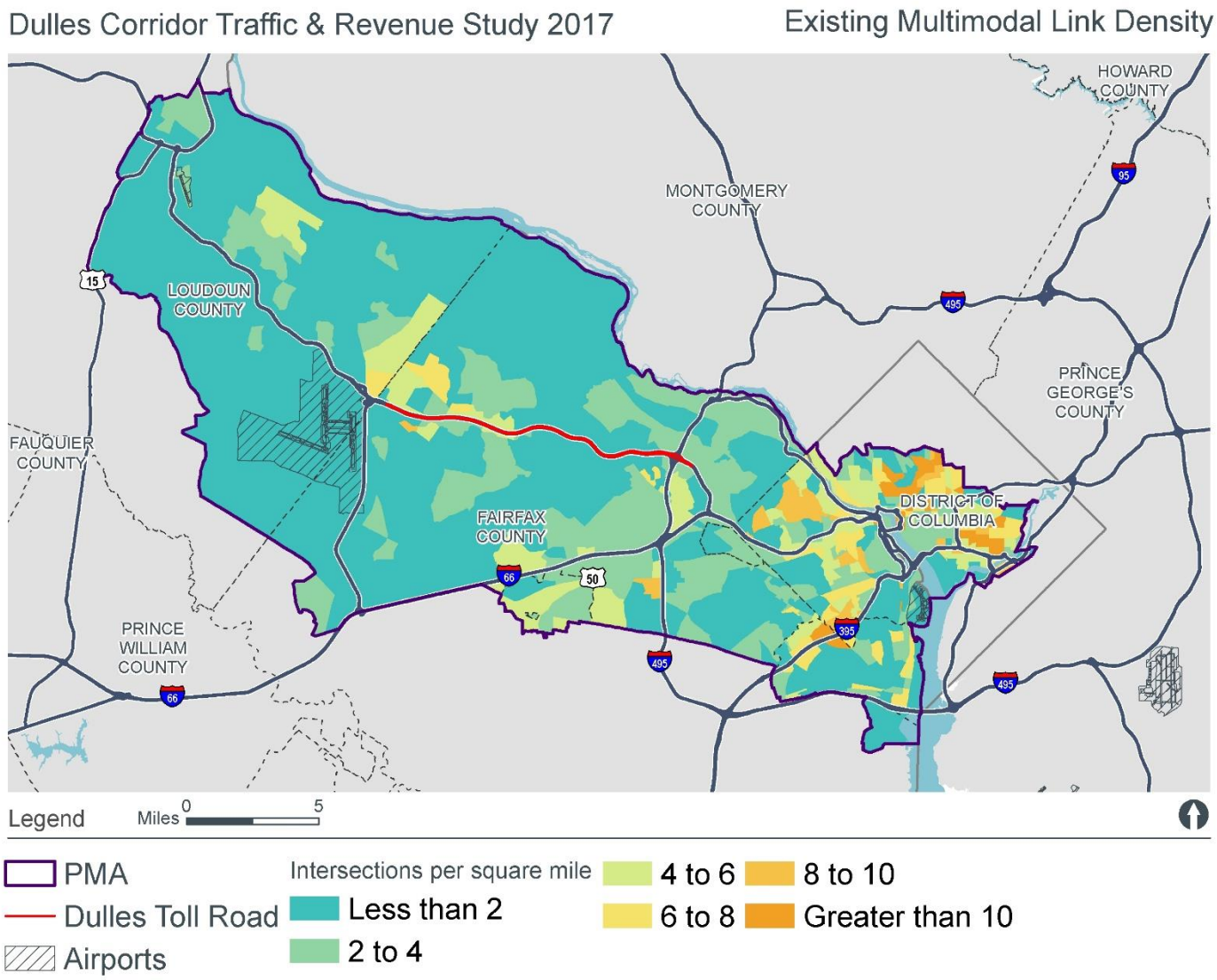


Figure 52 | Change in Auto Accessibility to Jobs, 2015 – 2040

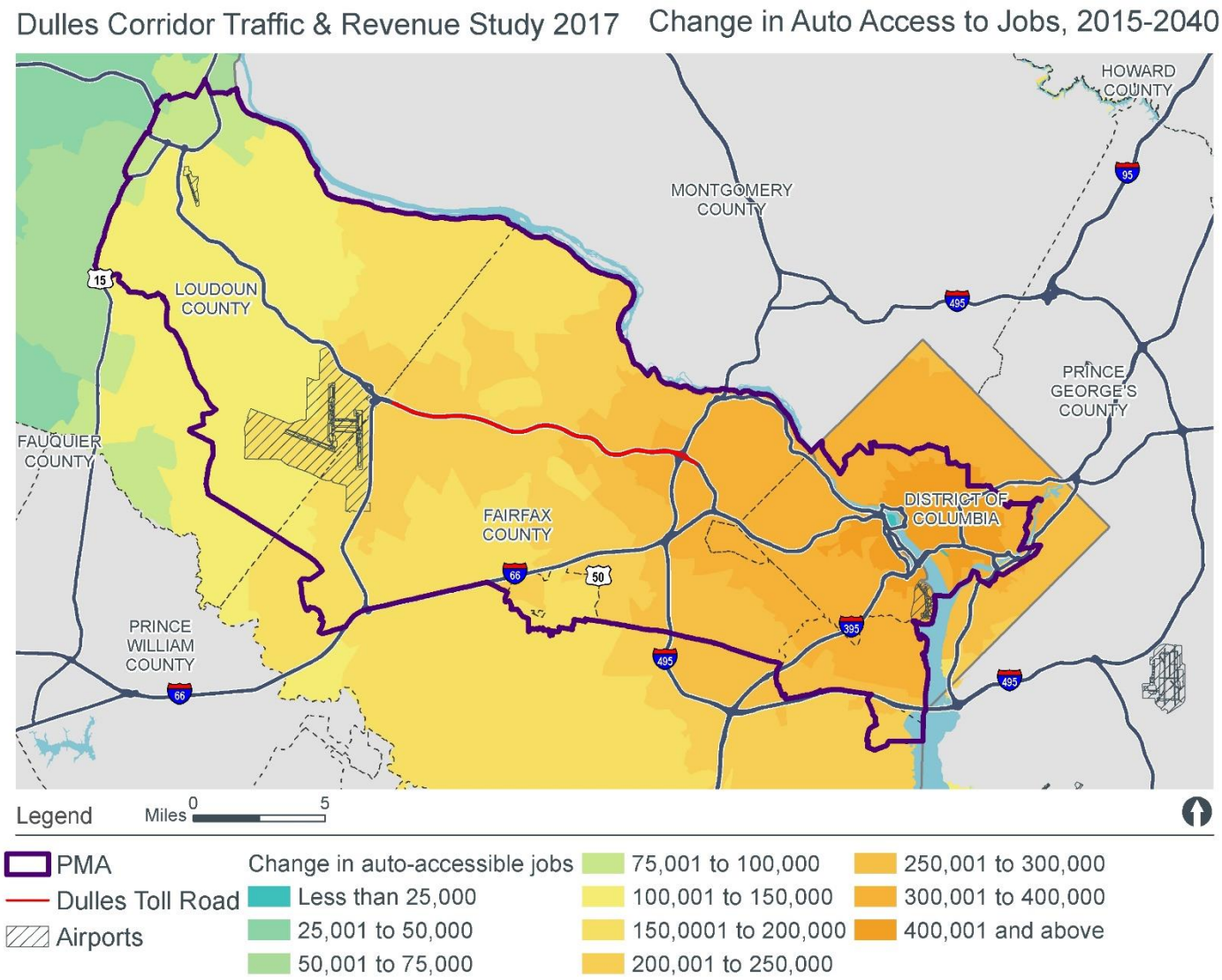


Figure 53 | Change in Transit Service Coverage Ratio, 2015-2040

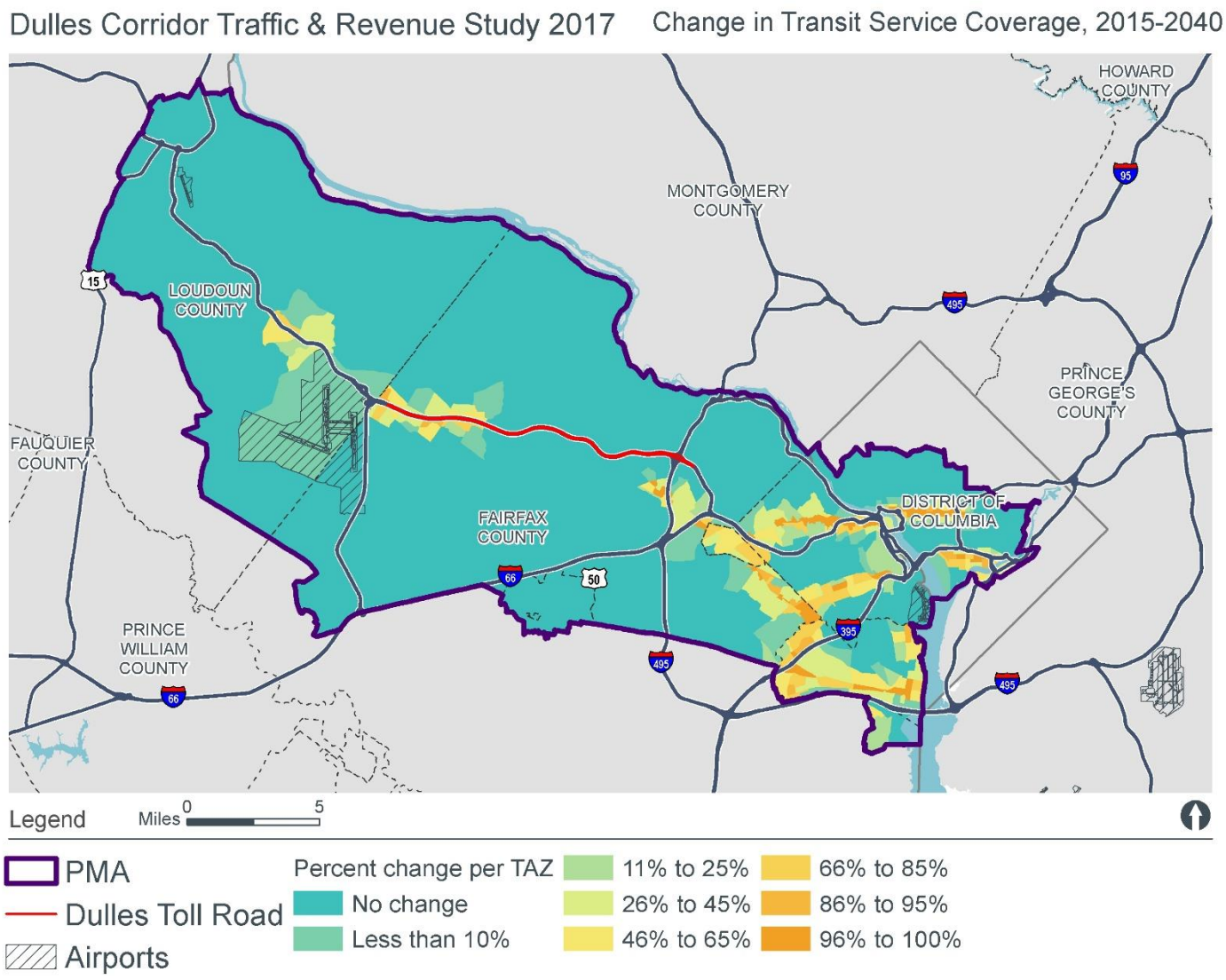


Figure 54 | Existing Development Coverage Ratio, 2015

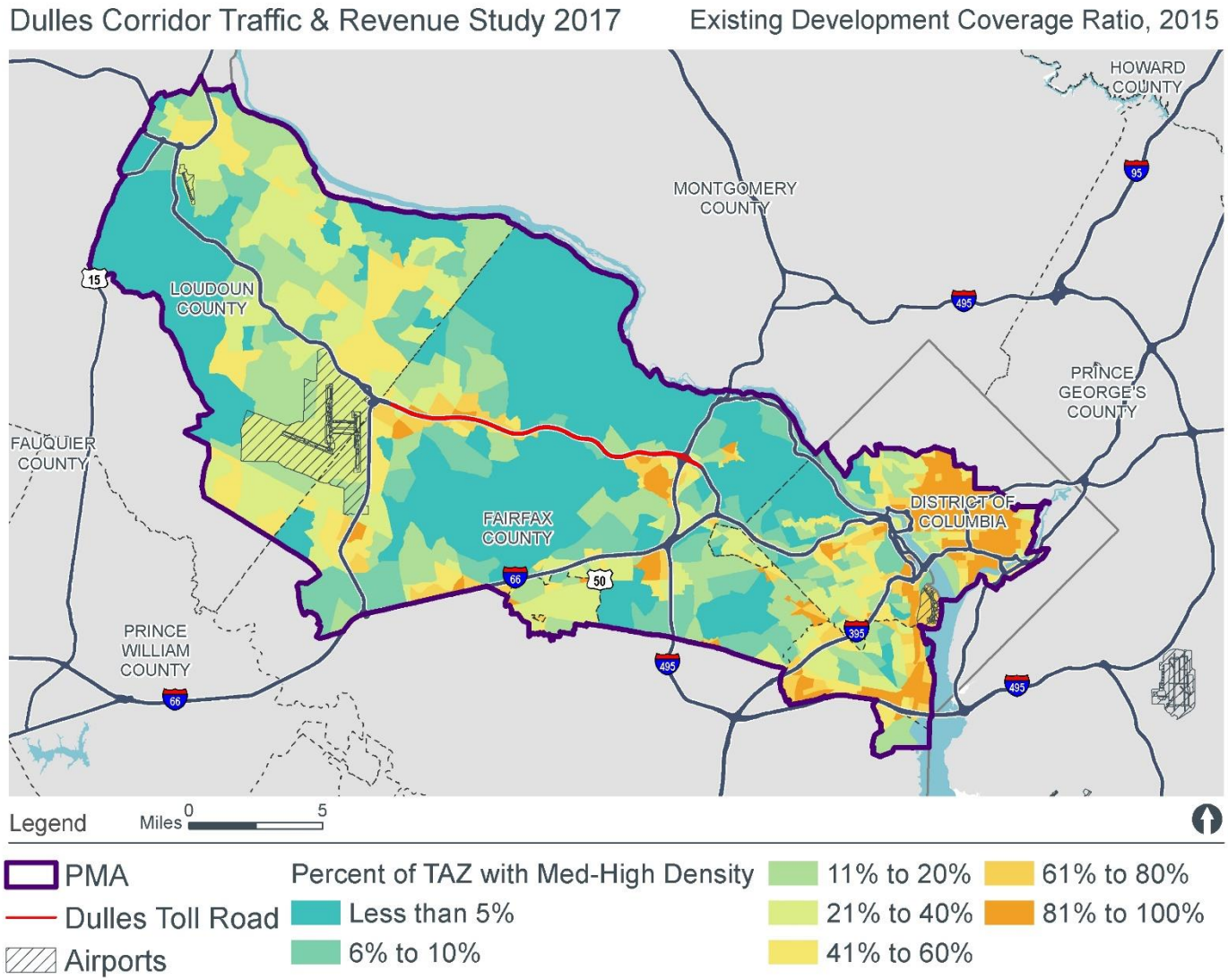
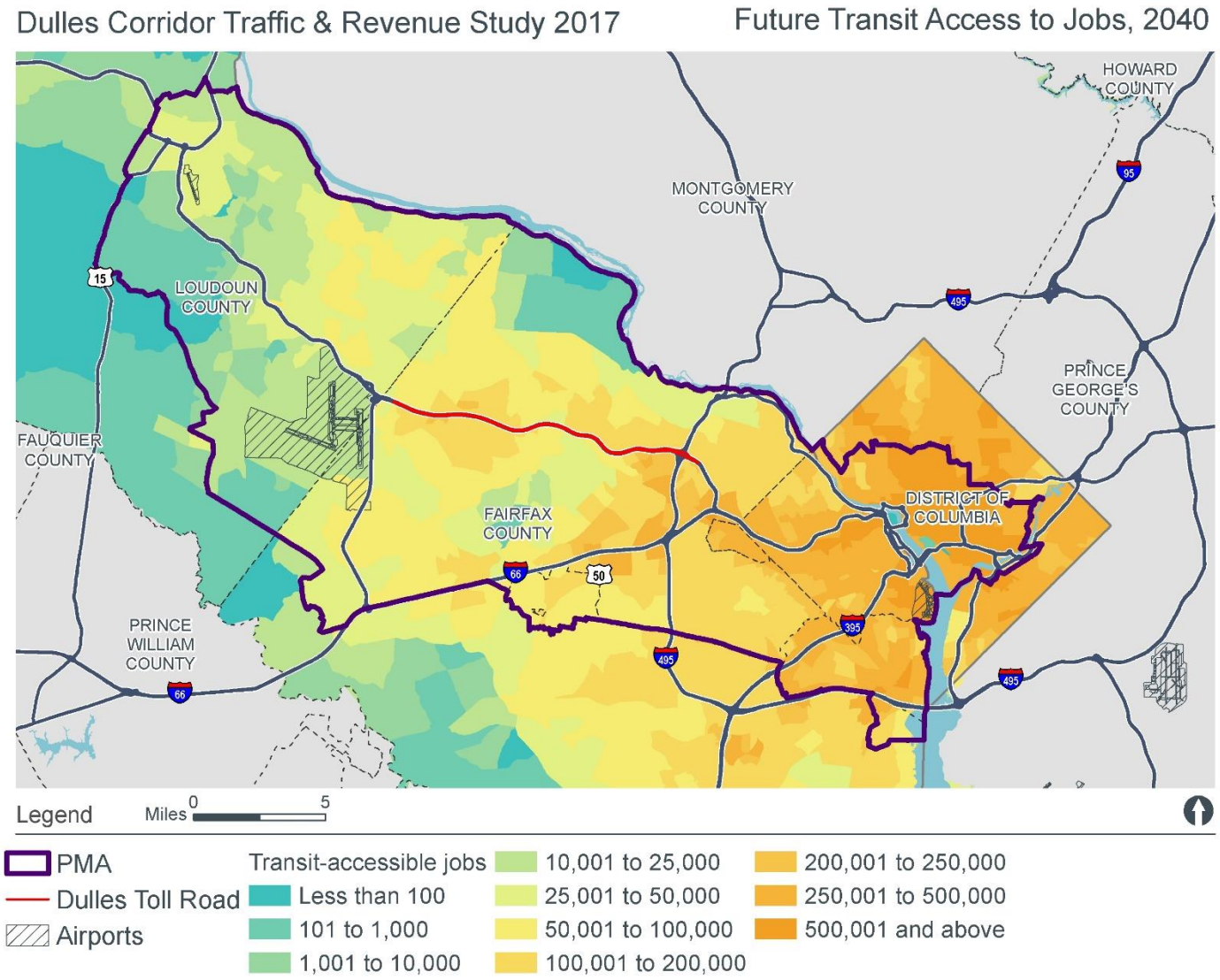


Figure 55 | Future Transit Accessibility to Jobs, 2040



VII. METHODOLOGY AND TOOL FOR TESTING MWCOG FORECASTS

Land use development patterns and absorption rates are influenced by a wide range of independent policy and market variables. Policy variables include federal agency employment decisions, such as the Base Realignment and Closure (BRAC) initiative, local jurisdiction master plans, zoning, and subdivision regulations. Market variables include regional econometric trends, local property characteristics, and the specific interests of individual property owners. The Renaissance approach to the independent economic assessment was to identify the relative effect of those variables on population and employment. The basic unit of the forecasting process is TAZ-level density. In other words, the process forecasts the total number of jobs per TAZ-acre and the total population per TAZ-acre.

The approach combines systematic application of independent variables with site-specific local knowledge to derive TAZ-specific forecasts that pivot from the Round 9.0 forecasts to reflect both macroeconomic trends and assumptions regarding site-specific development activity. The forecasting process includes three basic components:

- A top-down analysis of macroeconomic trends, described in Section V, used to identify trends at the jurisdictional level;
- A bottom-up regression analysis of current property attributes, described in Section VI and aggregated at the TAZ level, that explains the growth rates observed in the Round 9.0 forecasts; and
- Submarket analysis that considers updated base year (2015) conditions, macroeconomic forecasts, and recent or anticipated policy changes to guide the TAZ-level forecasts toward the macroeconomic trends.

These forecasting process components provide a rough correlation between certain market and policy indicators of growth and the increases in density by TAZ contained in the Round 9.0 forecasts. It is important to note that while these relationships are numerical, they reflect a combination of art and science. The regression analysis provided a useful quick-response tool to aid in the forecasting process, but the approach is not intended to serve as an independent land use model or replacement for the more detailed and time-intensive approach taken by the local jurisdictions in coordination with MWCOG. The application and results of this methodology are described in detail in Section VIII.

VIII. ASSUMPTIONS, FORECAST COMPARISONS, AND FINAL ADJUSTED FORECAST

The Renaissance forecasts pivot from the Round 9.0 forecasts considering recent or anticipated policy changes such as master plan or zoning changes and macroeconomic source guidance. The forecasts reflect changes to the local market expected to be prompted by master plan and zoning amendments in the primary market area, most notably those recently completed or underway in the Silver Line corridor Metrorail station areas. We applied the forecasting tool as a dashboard to adjust jobs and population densities based on assumed changes to the local market factor described above. And finally, the forecasts are guided by the macroeconomic trends so that the local forecasting tool results generally follow the blended jurisdictional control totals. The following sections describe the detailed interventions made inside the Primary Market Area, present the forecasts at the jurisdictional level, show the overall jobs to housing balance within the region and each jurisdiction over time, and indicate the effect of population and employment adjustments in the Primary Market Area. These sections are followed by maps that represent the forecasts and their differences at the TAZ level.

Updated MWCOG Regional Forecasts

The current forecasts from the Metropolitan Washington Council of Governments (MWCOG) are labeled Round 9.0 and were adopted by the region's Transportation Planning Board in November 2016. These forecasts are derived from the same general process as the Round 8.4 forecasts used as a basis for developing the 2014 independent economic forecasts but reflected a new set of regional econometric model outputs (whereas the interim forecasts in Round "8.x" reflect pivots from the Round 8.0 econometric model set). The 2040 forecasts for Round 9.0 at a regional level are generally comparable to those of Round 8.4, with some adjustments reflecting continued local plan amendments in many jurisdictions that reflect an overall shift towards a more balanced jobs/housing balance. The 2040 regional employment total is reduced by about 240,000 jobs; a 6% reduction from Round 8.4 and Round 9.0. The 2040 regional population total is increased by about 80,000; a 1% increase from Round 8.4 to Round 9.0.

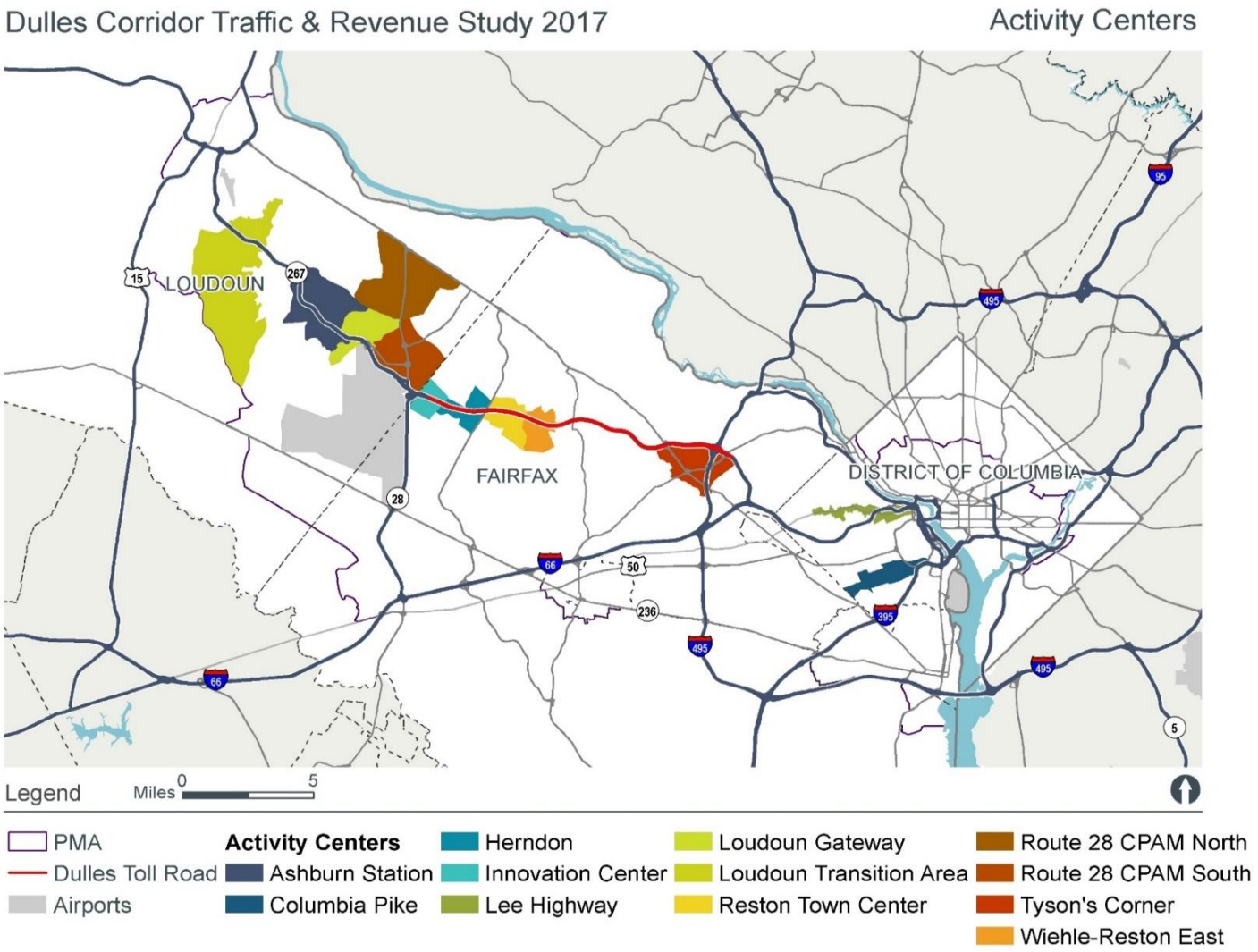
At the TAZ level, the change from Round 8.4 to Round 9.0 included some notable changes. For instance, the District of Columbia had chosen not to participate in the Round 8.4 forecasts, so that the Round 9.0 forecasts represented their first update since Round 8.3 was prepared in 2014. This is not an unusual finding; all member jurisdictions have substantial participation in the development of a new major round (i.e., Rounds 7.0, 8.0, and 9.0), but participation in the annual updates (i.e., Rounds 8.1, 8.2, 8.3 and 8.4) is at the discretion of each jurisdiction. The District of Columbia also substantially improved their geocoding process in preparation for Round 9.0, which resulted in many jobs being shifted from one TAZ to another adjacent TAZ (literally moving across the street) between the forecasts used in Round 8.3 (and therefore also Round 8.4) and those submitted for Round 9.0.

Primary Market Area Development Trends and Adjustments

In general, each of the jurisdictions in the Primary Market Area continues to pursue planning and zoning opportunities that direct economic growth towards transit areas, particularly existing and new Metrorail stations. This trend is strongest in the Silver Line/Dulles Toll Road corridor, with master plans for each of the transit station areas along the Dulles Toll Road either adopted (Tysons Corner, 2010; Route 28 Corridor Plan, 2011; Reston Master Plan, 2014; Route 28 CPAM South, 2013; Lee Highway Visioning Study, 2016) or underway (continuing Lee Highway Master Plan studies). The maps provided at the end of this report demonstrate the degree to which increased density and development growth is being channeled by all jurisdictions into growth areas in their individual comprehensive plans and collectively described in the MWCOG Region Forward initiatives, including the report on place and opportunity adopted by the MWCOG Board in January 2014. Additional details on expected focal areas for development and notable revisions to the Round 9.0 forecasts regarding local development are summarized in the following paragraphs.

The Renaissance forecasts include TAZ-specific revisions to the MWCOG Round 9.0 forecasts throughout the Primary Market Area. The balancing of macroeconomic forces, localized quantitative factors that influence development suitability and market response, as well as site-specific or property concerns results in some notable adjustments at the TAZ level for many of the key activity centers in the Primary Market Area. In general, these activity centers are places where mixed use development is encouraged with some flexibility for jobs/housing balance in recently developed or pending local planning and zoning regulations. In general, the Renaissance forecasts include somewhat higher levels of residential development and slightly lower levels of commercial development than is included in the Round 9.0 forecasts. Key trends affecting development potential as well as notable changes to the forecasts in several key activity centers are summarized below, focusing on those shown in Figure 56.

Figure 56 | Activity Centers



Washington, D.C.

Development in D.C. is characterized by fast growing mixed used centers anchored by Class A office space. Many key sites are on track to come on line between 2017 and 2019, drawing substantial employment growth and moderate residential growth although generally at a slightly slower pace than anticipated in the MWCOG Round 9.0 forecasts, particularly affecting assumptions for opening dates slipping beyond the 2017 horizon year. A cluster of phased developments in the Northwest Quadrant includes the ambitious Capitol Crossing – a seven-acre deck-over of I-395 between 2nd Street, 3rd Street, Massachusetts Avenue and E Street. Capitol Crossing is expected to house 1.5 million square feet of new, Class A office space, and 85,000 square feet of retail. Phase 1, 200 Massachusetts Ave, is expected to deliver in 2018.

Loudoun County

Loudoun County is expected to grow within four distinct geographic and policy areas: developments surrounding the two Metrorail stations, Loudoun Gateway and Ashburn Station; the Route 28 Corridor, the suburban areas, and the rural policy area. Loudoun County continues to be a jurisdiction where westward growth pressures are perhaps the most pervasive given its proximity to both Dulles International Airport and the existing and emerging centers along the Silver Line. Absent policy guidance that reinforces the environmental, fiscal, and community interests, the market potential for residential growth would be significantly higher.

Figure 56 identifies the Loudoun Transition Area as a place of interest and current policy study by the County; in this area we expect growth pressures will facilitate more development than currently planned by the County, yet still at very low-density levels. The Round 9.0 forecasts show 9,900 people and 2,300 jobs in the Loudoun Transition Area, and our forecasts are for 12,000 people and 2,300 jobs. Yet our forecasts only yield a gross density of 2 activity units (jobs plus population) per acre, still about half that which would normally be considered a minimum to support fixed-route local bus service, so we concur that while this transition area will develop, it will still very much serve as a transition area between the Dulles Airport and Silver Line activity centers to the east and the rural and agricultural western half of the County. Note that our focus on the transition area in Figure 56 focuses on the Lower Sycolin and Middle Goose subwatersheds, which form only a portion of the full Transition Policy Area as defined by Loudoun County which extends southward to the County line and beyond our PMA.

Of the two Metrorail stations being brought to Loudoun County, Loudoun Gateway is not expected to attract as much development, as it falls within noise contour districts applied by both Loudoun and Fairfax Counties to minimize adverse impacts of airport noise on residential development. Nonetheless, the station and surrounding area will be instrumental in improving accessibility to Dulles International Airport. Within the Loudoun Gateway area, our forecasts are similar to MWCOG with no new dwelling units due to the airport noise contour concerns and about 14,500 jobs by 2040. The Loudoun Gateway is still by far the least densely developed activity center shown in Figure 56, at only 8 activity units per acre (compared to 13-17 activity units per acre for the immediately

adjacent activity centers, indicating that the types of jobs most suitable for this zone will remain somewhat more industrial and tech-oriented than in other Metrorail station areas.

In contrast, existing and proposed development surrounding Ashburn Station is shaping this station area to be a mixed-use hub. For example, the Gramercy District development is more than 2.5 million square feet, providing 1,470 residential units, 250 hotel rooms and 765,000 sf of mixed-use office and retail space. Although the project is still in its early phases, approved proposals include 3 million sf of Class A office space, over 1,000 residential units, 40 townhomes and 160 multifamily units. Additionally, multiple developments have been proposed for the Ashburn Station Area, including Moorefield Station, a mixed-use community approved for 9.5 million sf of office space, 599 townhomes, a hotel, as well as retail and commercial space. We expect 2040 population totals of 39.400 in the Ashburn Station area, higher than the 33,300 forecast in Round 9.0; our jobs totals are similar to Round 9.0 at about 21,500.

Loudoun County envisions the Route 28 Corridor, split into North and South segments, as an airport-anchored gateway into the county offering a positive and welcoming business environment that supports significant job growth and economic activity in varied settings. The County also envisions the corridor evolving into a premier location for regional, national, and international businesses with a high-quality image that offers employees vibrant centers of activity and highly-integrated pedestrian and transit-friendly employment developments. This vision reinforces the County's commitment to the continued commercial growth of the corridor that in turn contributes to the overall fiscal health and economy of the County. The emphasis on Route 28 Corridor as an employment hub does not preclude residential development; however, it is expected that the South Corridor is less likely to attract residential development based on its proximity to the airport. Our 2040 forecasts for the north and south portions of these corridors are generally similar to MWCOG's for employment, with about 39,700 in the northern area and 43,400 in the southern area as contrasted with the MWCOG values of 38,900 and 32,300, respectively. We foresee greater residential growth in this jobs center than the Round 9.0 forecasts with 2040 population forecasts of 19,100 and 12,700 for the northern and southern centers respectively contrasted with Round 9.0 values of 15,900 and 10,000.

Fairfax County

The Tysons area is the single largest activity center for planned new development in the Primary Market Area, with a planned transformation underway from an auto-oriented commercial center into a more walkable, diverse urban center. This renaissance is focused around the four Silver Line stations: McLean, Tyson's, Spring Hill, and Greensboro. The 2010 Tysons Plan was developed to increase land use density and diversity widely described as accommodating a residential population of 100,000 residents and a daytime population of 200,000 jobs (and retained as a benchmark in the 2013 annual report to the Board of Supervisors). However,

Tysons has yet to realize these targets; in 2017, Fairfax County reported that Tysons hosted a residential population of approximately 21,400 and a daytime population of about 88,030 jobs. [17]

Within walking distance of the four Metrorail stations, density is likely to be constrained by market-based and site development factors. However, there has been no significant inhibitor to station area development yet. In fact, several developments have emerged to meet the anticipated demand of the metro. For example, The Boro is a mixed-use project adjacent to the Greensboro Metro station, with 750 luxury residential units, 400K sf of office and 266K SF of retail across four buildings. Additionally, some existing developments are receiving necessary upgrades. Capital One has proposed modifications to its headquarters campus that would increase development at the site from just shy of 5 million square feet to 5.2 million square feet, with the floor-area ratio rising from 3.9 to 4.1. Under the proposed plans, the site would have nearly 3.2 million square feet of office space, 253,000 square feet of retail space, 1,230 residential units, and 665,000 square feet of hotel space. Finally, the real estate developer Dittmar has plans to demolish and replace the Westpark Hotel with four new buildings configured around a central park. The new construction will feature up to 1,300 residential units in two buildings, 150 to 300 hotel rooms in a third building, an amenity-only building constructed atop a 2,267-space parking garage and up to 24,500 square feet of retail overall.

Our forecast trends reflect the fact that Tysons remains one of the most attractive suburban activity centers in both Fairfax County and the region. Tysons is in the “favored quarter” midway between downtown Washington and Dulles International Airport, with premium multimodal accessibility provided by the confluence of the Dulles Toll Road and Silver Line for regional radial connectivity and the Capital Beltway for regional circumferential accessibility. Sufficient capacity remains for continued growth beyond 2050. However, we expect the full development of Tysons as a true live-work center to take longer to develop than indicated in Round 9.0 where the 2040 population and jobs totals are 91,000 and 149,300, respectively. Our 2040 forecasts are for 80,000 people and 132,000 jobs; a level of development that, at 97 activity units (jobs plus population) per acre will be similar to that for the core area of the District of Columbia within our PMA.

Moving west from Tysons, the Silver Line includes stations at Wiehle-Reston East, Reston Town Center, Herndon, and Innovation Center prior to reaching Dulles International Airport. Taken together, these four station areas have a larger area than Tysons (about 3,000 acres in Fairfax County, compared to about 1,900 for Tysons) and slightly lower development levels. Our forecasts for each of these areas are generally commensurate with those in the Round 9.0 forecasts, with slight modifications that reflect the relative market power of commercial development eastward along the Silver Line and residential development of appropriate price-points westward along the Silver Line. In the Reston Town Center, Herndon, and Innovation Center activity centers, our 2040 population

[17] . Tysons 2016-2017 Progress Report on the Implementation of the Comprehensive Plan, https://www.fairfaxcounty.gov/tysons/sites/tysons/files/assets/documents/pdf/annual_reports/2017_annual_report.pdf

totals and employment totals are each within 10% of the Round 9.0 forecast. We see slightly higher population totals in Reston Town Center, Herndon, and Innovation Center and slightly lower employment totals in Herndon and Innovation Center.

Arlington County

Arlington County is considering the expansion of high quality transit in the Columbia Pike and Lee Highway corridors. The Columbia Pike Streetcar project, between Pentagon City and Bailey's Crossroads, was cancelled in November 2014. However, this corridor has continued to develop in a transit-oriented pattern and an alternate transit mode, perhaps Bus Rapid Transit (BRT), is anticipated. Adverse economic effects from BRAC 2005 and the fiscal austerity programs of other federal agencies, including the relocation of the National Science Foundation and the US Fish and Wildlife Service to neighboring Alexandria, remain a concern to the County. However, the County is well-resourced to weather federal spending cycles, due to the sustained combination of regional accessibility provided by Metrorail, national accessibility through Washington Reagan National Airport, and quality of life amenities that cater to residents seeking both urban and suburban environments.

The Rosslyn-Ballston corridor along the Metrorail Orange Line is recognized nationally as one of the success stories of transit-oriented development emerging around the four Metrorail stations opened in 1978. This corridor is entering a second-generation of land use investment, although its immediate economic outlook is buffered by short-term effects including high vacancy rates. The tallest building in northern Virginia, 1812 North Moore Street, was completed in 2013 with over 570,000 GSF of office space. After four years of vacancy, Nestle USA announced it would relocate its US headquarters to the building

The County is actively pursuing initiatives to accommodate infill residential development in formerly jobs-only activity centers such as Rosslyn and Crystal City as well as investigate the next generation of development for the Columbia Pike and Lee Highway corridors. We see greater market potential for Arlington's residential base, with a 2040 population of 285,200 that is slightly higher than the 278,100 in Round 9.0; with a similarly lower employment total of 253,400 jobs as contrasted with the 267,600 in Round 9.0. Our forecasts for the Columbia Pike and Lee Highway corridors are generally similar to those in the Round 9.0 forecast.

City of Alexandria

The City of Alexandria continues to focus development along it's Metrorail stations on the Blue and Yellow Lines, including Braddock Road, King Street, Eisenhower Avenue, and Van Dorn Street. The infill Potomac Yard station is a notable anchor for the last significant remaining brownfield site in the City. Redevelopment plans for the Beauregard/Van Dorn transitway corridor will also include redevelopment of the Landmark Mall into a mixed use center and redevelopment of the Mark Center, one of the cities older planned unit developments in the West End whose residential units are now nearing the end of their life cycle. The City of Alexandria's tallest buildings are at the Eisenhower Avenue Metrorail Station adjacent to the Capital Beltway. The relocation of the National Science Foundation from Arlington County is delayed beyond 2017 but construction is about to commence. To the west,

the Victory Center is a 500,000 GSF building that has been vacant for the past decade. The Round 2040 forecasts for Alexandria include 190,800 people and 142,700 jobs. As with Arlington County, we see a slight shift towards a greater balance between housing and jobs with population of 193,300 slightly higher than Round 9.0 and our 140,000 jobs slightly lower than the Round 9.0 forecasts.

MWCOG Region Population Forecast Comparison

Table 11 through Table 16 present MWCOG Round 9.0, Macroeconomic, and final Renaissance population forecasts. The macroeconomic forecast was used as guidance in generating Renaissance forecasts. In general, the macroeconomic forecasts for interim years are allowed to "float" slightly to balance the range of jurisdictional absorption patterns so that some differences greater that attributable to rounding error are acceptable in interim years.

Table 11 | MWCOG Round 9.0 Population Forecasts

	2015	2017	2020	2025	2030	2035	2040
Arlington County	220.5	225.4	232.7	244.8	256.0	266.3	278.1
City of Alexandria	147.6	152.3	159.2	167.5	172.8	180.5	190.8
District of Columbia	672.2	695.1	729.5	787.1	842.2	893.9	940.7
Fairfax County	1,163.2	1,179.0	1,202.7	1,255.1	1,308.0	1,358.7	1,407.6
Loudoun County	363.5	384.0	414.7	451.1	470.7	484.4	492.5
Prince William County	488.0	502.5	524.4	558.1	584.6	606.8	625.4
Montgomery County	1,015.3	1,030.0	1,052.0	1,087.3	1,128.8	1,167.7	1,197.1
Prince George's County	904.4	911.9	923.1	938.0	953.0	967.8	982.4
Frederick County	246.5	255.0	267.8	288.7	303.6	319.4	332.2
TOTAL	5,221.3	5,335.1	5,506.1	5,777.7	6,019.6	6,245.5	6,446.8

Table 12 | Macroeconomic Population Forecasts

	2015	2017	2020	2025	2030	2035	2040
Arlington County	227.9	232.9	240.4	250.3	262.7	272.5	285.2
City of Alexandria	153.2	156.7	161.9	168.8	177.5	184.4	193.3
District of Columbia	670.4	686.7	711.3	743.8	784.6	817.4	859.8
Fairfax County	1,175.2	1,191.6	1,216.3	1,264.3	1,320.6	1,370.8	1,429.7
Loudoun County	374.6	393.3	421.4	458.2	492.6	518.5	541.8
Prince William County	488.0	500.9	520.2	545.9	578.4	604.7	638.8
Montgomery County	1,015.3	1,034.8	1,064.0	1,102.3	1,149.9	1,186.7	1,234.4
Prince George's County	904.4	918.2	938.8	969.1	1,003.2	1,033.6	1,066.8
Frederick County	246.5	253.0	262.8	275.8	290.3	303.5	318.7
TOTAL	5,255.3	5,368.0	5,537.0	5,778.7	6,059.9	6,292.1	6,568.5

Table 13 | Renaissance Population Forecasts

	2015	2017	2020	2025	2030	2035	2040
Arlington County	227.9	233.0	240.4	251.0	263.2	273.1	285.2
City of Alexandria	153.2	156.5	161.9	169.4	177.5	184.2	193.3
District of Columbia	670.4	686.5	711.3	744.1	784.5	818.7	859.8
Fairfax County	1,175.2	1,191.7	1,216.3	1,263.3	1,321.2	1,370.8	1,429.7
Loudoun County	374.6	394.2	421.4	460.3	493.5	518.9	541.8
Prince William County	488.0	500.9	520.2	545.9	578.4	604.7	638.8
Montgomery County	1,015.3	1,034.8	1,064.0	1,102.3	1,149.9	1,186.7	1,234.4
Prince George's County	904.4	918.2	938.8	969.1	1,003.2	1,033.6	1,066.8
Frederick County	246.5	253.0	262.8	275.8	290.3	303.6	318.7
TOTAL	5,255.3	5,368.7	5,537.0	5,781.1	6,061.7	6,294.3	6,568.5

Table 14 | Difference between MWCOG Round 9.0 and Macroeconomic Population Forecasts

	2015	2017	2020	2025	2030	2035	2040
Arlington County	7.4	7.5	7.7	5.6	6.7	6.2	7.1
City of Alexandria	5.5	4.4	2.7	1.3	4.7	3.9	2.4
District of Columbia	-1.9	-8.4	-18.2	-43.3	-57.5	-76.5	-80.9
Fairfax County	12.0	12.7	13.6	9.2	12.6	12.1	22.1
Loudoun County	11.0	9.3	6.7	7.1	21.9	34.1	49.3
Prince William County	0.0	-1.7	-4.2	-12.2	-6.2	-2.2	13.4
Montgomery County	0.0	4.8	12.0	15.1	21.1	19.0	37.3
Prince George's County	0.0	6.3	15.7	31.1	50.2	65.7	84.4
Frederick County	0.0	-2.0	-5.0	-12.9	-13.2	-15.8	-13.5
TOTAL	34.1	32.9	30.9	1.0	40.3	46.6	121.8

Table 15 | Difference between MWCOG Round 9.0 and Renaissance Population Forecasts

	2015	2017	2020	2025	2030	2035	2040
Arlington County	7.4	7.6	7.7	6.2	7.2	6.8	7.1
City of Alexandria	5.5	4.2	2.7	1.8	4.7	3.7	2.4
District of Columbia	-1.9	-8.6	-18.2	-43.0	-57.6	-75.2	-80.9
Fairfax County	12.0	12.8	13.6	8.2	13.2	12.1	22.1
Loudoun County	11.0	10.2	6.7	9.1	22.8	34.5	49.3
Prince William County	0.0	-1.7	-4.2	-12.2	-6.2	-2.1	13.4
Montgomery County	0.0	4.8	12.0	15.1	21.1	19.0	37.3
Prince George's County	0.0	6.3	15.7	31.1	50.2	65.7	84.4
Frederick County	0.0	-2.0	-5.0	-12.9	-13.2	-15.8	-13.5
TOTAL	34.1	33.6	30.9	3.4	42.1	48.8	121.8

Table 16 | Difference between Renaissance and Macroeconomic Population Forecasts

	2015	2017	2020	2025	2030	2035	2040
Arlington County	0.0	0.1	0.0	0.6	0.5	0.6	0.0
City of Alexandria	0.0	-0.2	0.0	0.5	0.0	-0.2	0.0
District of Columbia	0.0	-0.2	0.0	0.3	-0.1	1.3	0.0
Fairfax County	0.0	0.1	0.0	-1.0	0.6	0.0	0.0
Loudoun County	0.0	0.9	0.0	2.0	0.9	0.4	0.0
Prince William County	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Montgomery County	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Prince George's County	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Frederick County	0.0	0.0	0.0	0.0	0.0	0.0	0.0
TOTAL	0.0	0.7	0.0	2.4	1.9	2.2	0.0

MWCOG Region Employment Forecast Comparison

Table 17 through Table 22 present MWCOG Round 9.0, Macroeconomic, and final Renaissance population forecasts. The macroeconomic forecast was used as guidance in generating Renaissance forecasts. In general, the macroeconomic forecasts for interim years are allowed to "float" slightly to balance the range of jurisdictional absorption patterns so that some differences greater that attributable to rounding error are acceptable in interim years.

Table 17 | MWCOG Round 9.0 Employment Forecast

	2015	2017	2020	2025	2030	2035	2040
Arlington County	209.6	211.0	213.2	225.2	242.1	255.8	267.6
City of Alexandria	106.2	107.8	110.1	121.8	127.3	135.3	142.7
District of Columbia	798.3	817.5	846.3	895.1	937.9	978.2	1,011.8
Fairfax County	686.9	707.6	738.8	788.3	831.9	870.5	908.4
Loudoun County	164.2	173.7	188.0	211.0	235.5	255.6	273.9
Prince William County	175.0	183.6	196.6	217.5	238.3	257.7	280.5
Montgomery County	520.2	529.5	543.5	572.5	604.5	627.4	653.9
Prince George's County	338.6	342.7	349.0	366.3	375.7	385.5	393.3
Frederick County	106.2	107.9	110.6	115.6	121.3	127.8	133.9
TOTAL	3,105.1	3,181.4	3,296.1	3,513.3	3,714.5	3,893.7	4,066.3

Table 18 | Macroeconomic Employment Forecast

	2015	2017	2020	2025	2030	2035	2040
Arlington County	209.6	213.5	219.3	227.4	236.9	244.2	253.4
City of Alexandria	106.2	109.0	113.0	119.3	126.3	132.7	140.0
District of Columbia	798.3	813.0	835.0	863.8	899.6	927.5	962.0
Fairfax County	686.9	707.6	738.7	780.6	833.7	876.2	929.8
Loudoun County	164.2	174.0	188.8	212.8	242.2	269.0	297.0
Prince William County	175.0	182.3	193.4	208.6	228.4	244.6	265.4
Montgomery County	520.2	530.8	546.7	567.6	595.1	616.7	643.6
Prince George's County	338.6	345.3	355.5	370.6	388.2	403.9	422.1
Frederick County	106.2	109.2	113.6	120.4	128.4	135.7	143.8
TOTAL	3,105.1	3,184.7	3,304.0	3,471.1	3,678.7	3,850.5	4,057.1

Table 19 | Renaissance Employment Forecast

	2015	2017	2020	2025	2030	2035	2040
Arlington County	214.0	216.7	223.1	229.6	238.8	246.9	253.4
City of Alexandria	106.2	110.4	118.9	125.2	132.0	138.2	140.0
District of Columbia	798.3	811.5	835.1	863.5	898.7	927.8	962.1
Fairfax County	686.9	711.4	746.8	793.7	845.7	885.2	929.8
Loudoun County	164.2	173.9	188.7	212.8	241.9	268.7	297.0
Prince William County	175.0	182.4	193.4	208.6	228.4	244.6	265.4
Montgomery County	520.2	530.7	546.6	567.6	595.1	616.8	643.7
Prince George's County	338.6	345.2	355.4	370.5	388.1	403.9	422.1
Frederick County	106.2	109.1	113.6	120.4	128.4	135.7	143.8
TOTAL	3,109.5	3,191.2	3,321.6	3,492.0	3,697.2	3,867.8	4,057.2

Table 20 | Difference between MWCOG Round 9.0 and Macroeconomic Employment Forecasts

	2015	2017	2020	2025	2030	2035	2040
Arlington County	0.0	2.4	6.1	2.2	-5.3	-11.5	-14.3
City of Alexandria	0.0	1.2	2.9	-2.4	-1.0	-2.6	-2.7
District of Columbia	0.0	-4.5	-11.3	-31.3	-38.3	-50.7	-49.8
Fairfax County	0.0	0.0	0.0	-7.7	1.7	5.7	21.3
Loudoun County	0.0	0.3	0.8	1.8	6.7	13.4	23.0
Prince William County	0.0	-1.3	-3.2	-8.9	-9.9	-13.1	-15.1
Montgomery County	0.0	1.3	3.1	-4.9	-9.4	-10.6	-10.3
Prince George's County	0.0	2.6	6.4	4.3	12.5	18.4	28.8
Frederick County	0.0	1.2	3.1	4.8	7.1	7.9	9.8
TOTAL	0.0	3.2	8.0	-42.2	-35.8	-43.2	-9.1

Table 21 | Difference between MWCOG Round 9.0 and Renaissance Employment Forecasts

	2015	2017	2020	2025	2030	2035	2040
Arlington County	4.4	5.6	9.9	4.4	-3.3	-8.9	-14.2
City of Alexandria	0.0	2.6	8.8	3.4	4.8	3.0	-2.7
District of Columbia	0.0	-5.9	-11.2	-31.6	-39.2	-50.4	-49.7
Fairfax County	0.0	3.7	8.0	5.4	13.8	14.8	21.3
Loudoun County	0.0	0.2	0.7	1.8	6.4	13.1	23.1
Prince William County	0.0	-1.2	-3.2	-8.9	-9.9	-13.1	-15.1
Montgomery County	0.0	1.1	3.1	-4.9	-9.3	-10.6	-10.3
Prince George's County	0.0	2.4	6.3	4.2	12.4	18.3	28.8
Frederick County	0.0	1.2	3.1	4.8	7.1	7.8	9.8
TOTAL	4.4	9.8	25.6	-21.4	-17.3	-25.9	-9.0

Table 22 | Difference between Renaissance and Macroeconomic Employment Forecasts

	2015	2017	2020	2025	2030	2035	2040
Arlington County	4.4	3.2	3.9	2.2	2.0	2.6	0.0
City of Alexandria	0.0	1.5	5.8	5.9	5.8	5.6	0.0
District of Columbia	0.0	-1.4	0.1	-0.3	-0.9	0.3	0.0
Fairfax County	0.0	3.7	8.1	13.1	12.0	9.0	0.0
Loudoun County	0.0	-0.1	-0.1	0.0	-0.3	-0.3	0.0
Prince William County	0.0	0.1	0.0	0.0	0.0	0.0	0.0
Montgomery County	0.0	-0.1	-0.1	0.0	0.0	0.0	0.0
Prince George's County	0.0	-0.1	-0.1	-0.1	-0.1	0.0	0.0
Frederick County	0.0	-0.1	0.0	0.0	0.0	0.0	0.0
TOTAL	4.4	6.6	17.6	20.9	18.5	17.3	0.1

Primary Market Area Population Forecast Comparison

Table 23 through Table 28 present a comparison of Renaissance and MWCOG Round 9.0 population forecasts for the Primary Market Area which includes all of Arlington and Alexandria and portions of the District of Columbia, Fairfax County, and Loudoun County as shown in Figures 1 and 2.

Table 23 | MWCOG Round 9.0 Population Forecast

	2015	2017	2020	2025	2030	2035	2040
Arlington County	220.5	225.4	232.7	244.8	256.0	266.3	278.1
City of Alexandria	147.6	152.3	159.2	167.5	172.8	180.5	190.8
District of Columbia	332.9	347.3	368.8	403.0	433.4	457.3	479.6
Fairfax County	629.0	642.9	663.7	705.5	746.3	785.6	823.1
Loudoun County	287.3	299.2	317.2	340.4	352.6	361.9	366.3
TOTAL	1,617.3	1,667.0	1,741.6	1,861.2	1,961.1	2,051.6	2,137.9

Table 24 | Macroeconomic Population Forecast

	2015	2017	2020	2025	2030	2035	2040
Arlington County	227.9	232.9	240.4	250.3	262.7	272.5	285.2
City of Alexandria	153.2	156.7	161.9	168.8	177.5	184.4	193.3
District of Columbia	332.0	343.0	359.6	380.8	403.8	418.2	438.4
Fairfax County	635.5	649.8	671.2	710.7	753.5	792.6	836.0
Loudoun County	296.0	306.5	322.3	345.8	369.0	387.3	402.9
TOTAL	1,644.5	1,688.9	1,755.4	1,856.4	1,966.5	2,055.0	2,155.8

Table 25 | Renaissance Population Forecast

	2015	2017	2020	2025	2030	2035	2040
Arlington County	227.9	233.0	240.4	251.0	263.2	273.1	285.2
City of Alexandria	153.2	156.5	161.9	169.4	177.5	184.2	193.3
District of Columbia	332.0	342.8	359.6	381.1	403.6	419.5	438.4
Fairfax County	635.5	649.9	671.2	709.6	754.1	792.6	836.0
Loudoun County	296.0	307.4	322.3	347.8	369.9	387.8	402.9
TOTAL	1,644.5	1,689.6	1,755.4	1,858.8	1,968.3	2,057.2	2,155.8

Table 26 | Difference between MWCOG Round 9.0 and Macroeconomic Population Forecasts

	2015	2017	2020	2025	2030	2035	2040
Arlington County	7.4	7.5	7.7	5.6	6.7	6.2	7.1
City of Alexandria	5.5	4.4	2.7	1.3	4.7	3.9	2.4
District of Columbia	-0.9	-4.2	-9.2	-22.2	-29.6	-39.1	-41.2
Fairfax County	6.5	6.9	7.5	5.2	7.2	7.0	12.9
Loudoun County	8.7	7.3	5.1	5.4	16.4	25.5	36.7
TOTAL	27.2	21.9	13.9	-4.7	5.4	3.4	17.9

Table 27 | Difference between MWCOG Round 9.0 and Renaissance Population Forecasts

	2015	2017	2020	2025	2030	2035	2040
Arlington County	7.4	7.6	7.7	6.2	7.2	6.8	7.1
City of Alexandria	5.5	4.2	2.7	1.8	4.7	3.7	2.4
District of Columbia	-0.9	-4.4	-9.2	-21.9	-29.7	-37.8	-41.2
Fairfax County	6.5	7.0	7.5	4.2	7.8	7.0	12.9
Loudoun County	8.7	8.2	5.1	7.4	17.3	25.9	36.7
TOTAL	27.2	22.6	13.8	-2.4	7.3	5.6	17.9

Table 28 | Difference between Renaissance and Macroeconomic Population Forecasts

	2015	2017	2020	2025	2030	2035	2040
Arlington County	0.0	0.1	0.0	0.6	0.5	0.6	0.0
City of Alexandria	0.0	-0.2	0.0	0.5	0.0	-0.2	0.0
District of Columbia	0.0	-0.2	0.0	0.3	-0.1	1.3	0.0
Fairfax County	0.0	0.1	0.0	-1.0	0.6	0.0	0.0
Loudoun County	0.0	0.9	0.0	2.0	0.9	0.4	0.0
TOTAL	0.0	0.7	0.0	2.4	1.8	2.2	0.0

Primary Market Area Employment Forecasts Comparison

Table 29 through Table 34 present a comparison of Renaissance and MWCOG Round 9.0 employment forecasts for the Primary Market Area shown in

Table 29 | MWCOG Round 9.0 Employment Forecast

	2015	2017	2020	2025	2030	2035	2040
Arlington County	209.6	211.0	213.2	225.2	242.1	255.8	267.6
City of Alexandria	106.2	107.8	110.1	121.8	127.3	135.3	142.7
District of Columbia	680.6	693.1	711.9	753.6	787.4	815.7	841.2
Fairfax County	484.8	499.0	520.3	555.3	581.5	610.7	638.7
Loudoun County	147.5	156.2	169.2	191.0	214.2	233.2	250.8
TOTAL	1,628.7	1,667.1	1,724.7	1,846.8	1,952.6	2,050.6	2,141.1

Table 30 | Macroeconomic Employment Forecast

	2015	2017	2020	2025	2030	2035	2040
Arlington County	209.6	213.5	219.3	227.4	236.9	244.2	253.4
City of Alexandria	106.2	109.0	113.0	119.3	126.3	132.7	140.0
District of Columbia	680.6	689.3	702.4	727.2	755.3	773.4	799.8
Fairfax County	484.8	499.0	520.2	549.8	582.8	614.7	653.7
Loudoun County	147.5	156.5	169.9	192.6	220.4	245.4	271.9
TOTAL	1,628.7	1,667.2	1,724.9	1,816.4	1,921.5	2,010.4	2,118.8

Table 31 | Renaissance Employment Forecast

	2015	2017	2020	2025	2030	2035	2040
Arlington County	214.0	216.7	223.1	229.6	238.8	246.9	253.4
City of Alexandria	106.2	110.4	118.9	125.2	132.0	138.2	140.0
District of Columbia	680.6	687.9	702.4	726.9	754.3	773.7	799.8
Fairfax County	484.8	502.7	528.3	562.9	594.9	623.8	653.8
Loudoun County	147.5	156.4	169.9	192.6	220.1	245.1	271.9
TOTAL	1,633.1	1,674.1	1,742.6	1,837.3	1,940.2	2,027.7	2,118.9

Table 32 | Difference between MWCOG Round 9.0 and Macroeconomic Employment Forecasts

	2015	2017	2020	2025	2030	2035	2040
Arlington County	0.0	2.4	6.1	2.2	-5.3	-11.5	-14.3
City of Alexandria	0.0	1.2	2.9	-2.4	-1.0	-2.6	-2.7
District of Columbia	0.0	-3.8	-9.5	-26.4	-32.2	-42.3	-41.4
Fairfax County	0.0	0.0	0.0	-5.4	1.2	4.0	15.0
Loudoun County	0.0	0.3	0.7	1.6	6.1	12.2	21.1
TOTAL	0.0	0.1	0.2	-30.4	-31.1	-40.1	-22.2

Table 33 | Difference between MWCOG Round 9.0 and Renaissance Employment Forecasts

	2015	2017	2020	2025	2030	2035	2040
Arlington County	4.4	5.6	9.9	4.4	-3.3	-8.9	-14.2
City of Alexandria	0.0	2.6	8.8	3.4	4.8	3.0	-2.7
District of Columbia	0.0	-5.2	-9.5	-26.7	-33.1	-42.0	-41.3
Fairfax County	0.0	3.7	8.1	7.7	13.3	13.1	15.0
Loudoun County	0.0	0.2	0.7	1.7	5.9	12.0	21.1
TOTAL	4.4	7.0	18.0	-9.5	-12.4	-22.9	-22.2

Table 34 | Difference between Renaissance and Macroeconomic Employment Forecasts

	2015	2017	2020	2025	2030	2035	2040
Arlington County	4.4	3.2	3.9	2.2	2.0	2.6	0.0
City of Alexandria	0.0	1.5	5.8	5.9	5.8	5.6	0.0
District of Columbia	0.0	-1.4	0.0	-0.3	-0.9	0.3	0.0
Fairfax County	0.0	3.7	8.1	13.1	12.1	9.1	0.0
Loudoun County	0.0	-0.1	0.0	0.1	-0.3	-0.3	0.0
TOTAL	4.4	6.9	17.8	20.9	18.6	17.3	0.1

Primary Market Area Forecast Maps

The figures below illustrate TAZ-level forecasts of the extent and type of growth for the Primary Market Area Jurisdictions.

Figure 57 through Figure 62 show MWCOG Round 9.0 population and employment forecast density, presented as persons and jobs per TAZ acre, for 2015, 2025, and 2040. Figure 63 through Figure 68 show Renaissance population and employment forecasts, presented as persons and jobs per TAZ acre, for 2015, 2025, and 2040. These maps demonstrate the influence of Dulles International Airport and the region's core on population and employment density and growth. Jobs growth is particularly concentrated in the D.C. core as well as activity centers along the Silver Line/Dulles Toll Road, Orange Line/I-66 and Blue Line/I-95 corridors. Population growth is more dispersed throughout the region.

Figure 69 through Figure 71 and Figure 74 through Figure 76 show Renaissance forecasts absolute change in both population and jobs for the following intervals: 2015-2025, 2025-2040, and 2015-2040. Figure 72 and Figure 77 show MWCOG Round 9.0 forecast absolute change for population and jobs, respectively, from 2015-2040. Finally, Figure 73 and Figure 78 compare the Renaissance and Round 9.0 forecast change on population and jobs from 2015-2040. These maps suggest a wider distribution of population growth in Loudoun County. However, this result could be misrepresented by the larger TAZ boundaries in the western portion of the county.

Figure 57 | Round 9.0 Population Density 2015

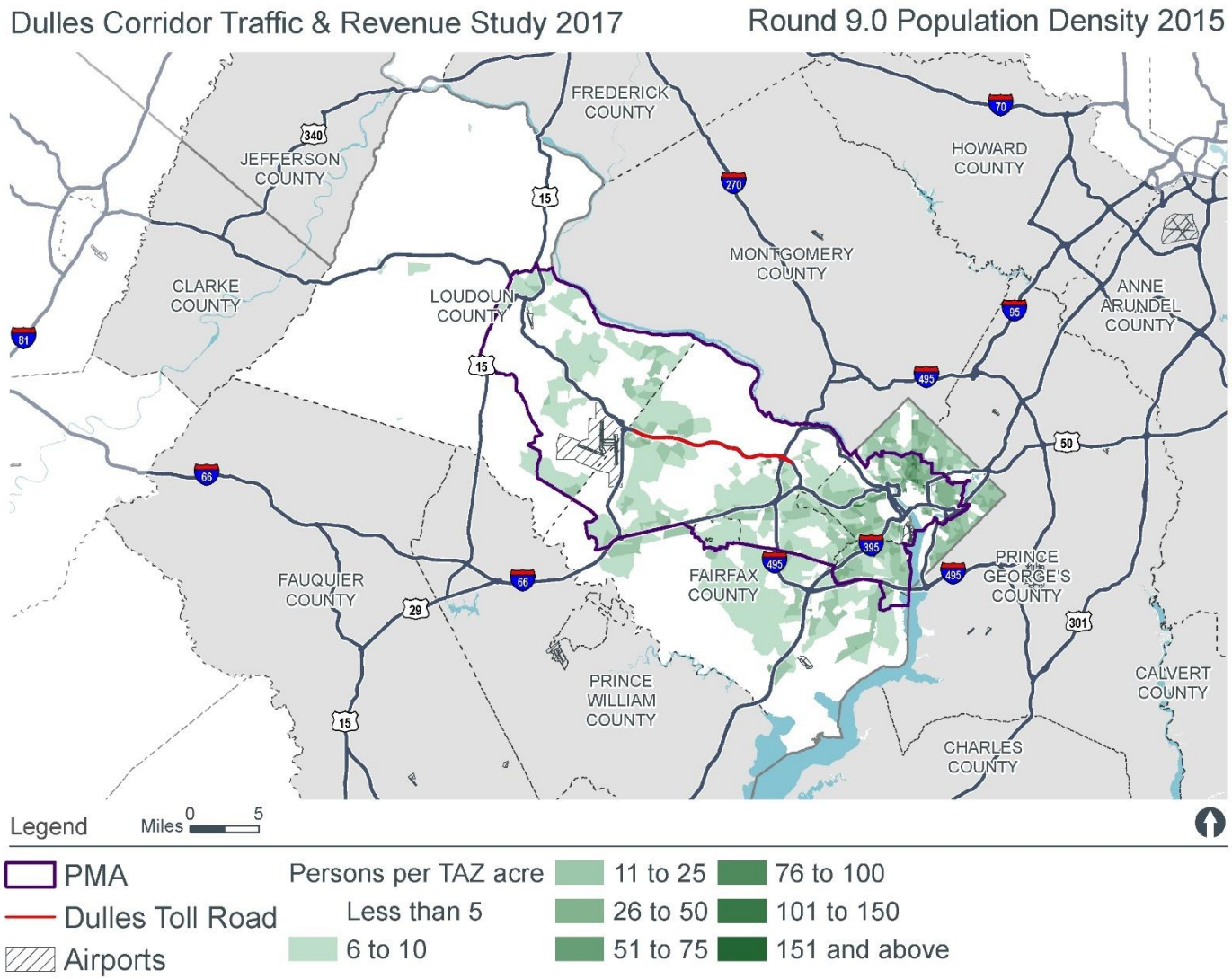


Figure 58 | Round 9.0 Population Density 2025

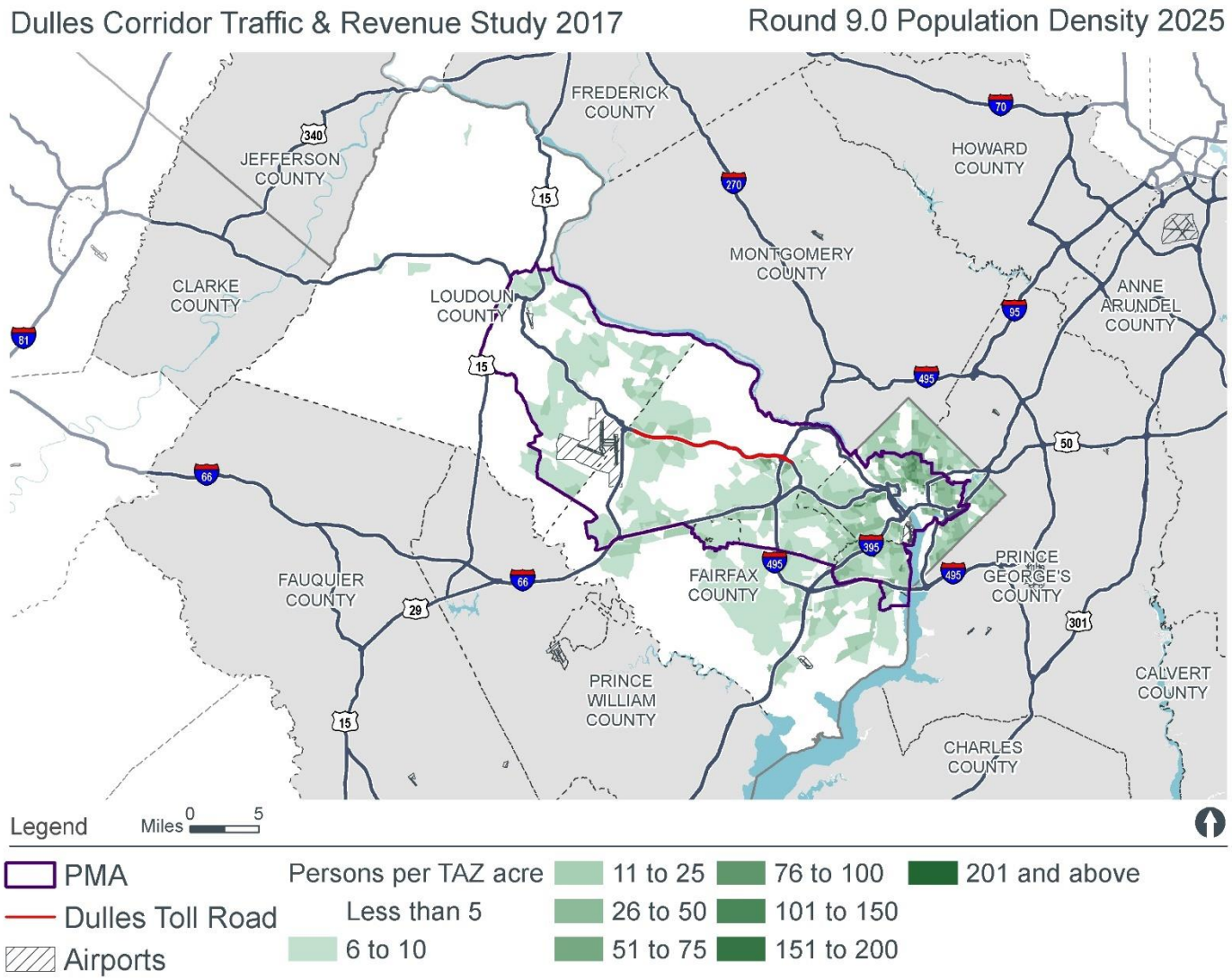


Figure 59 | Round 9.0 Population Density 2040

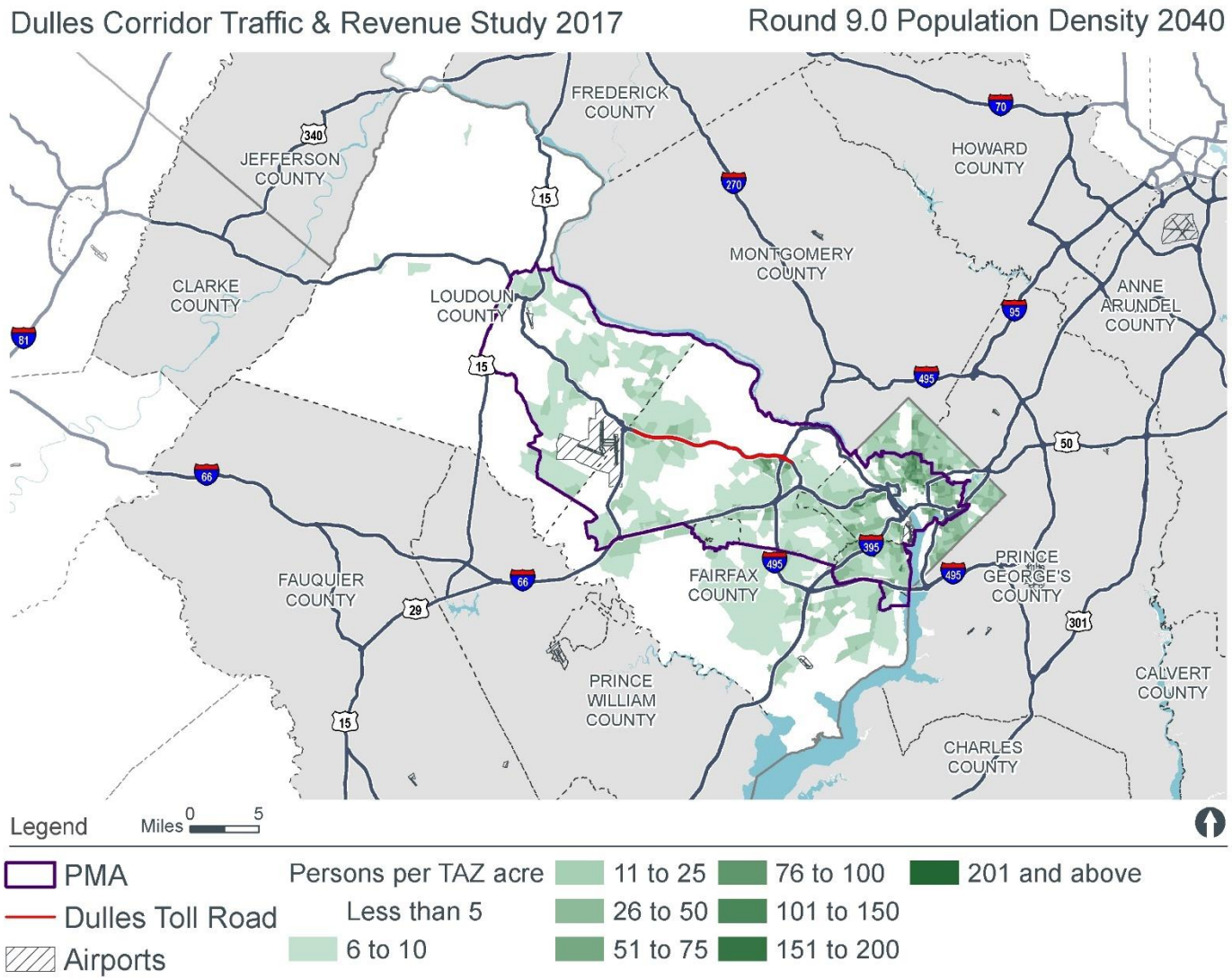


Figure 60 | Round 9.0 Employment Density 2015

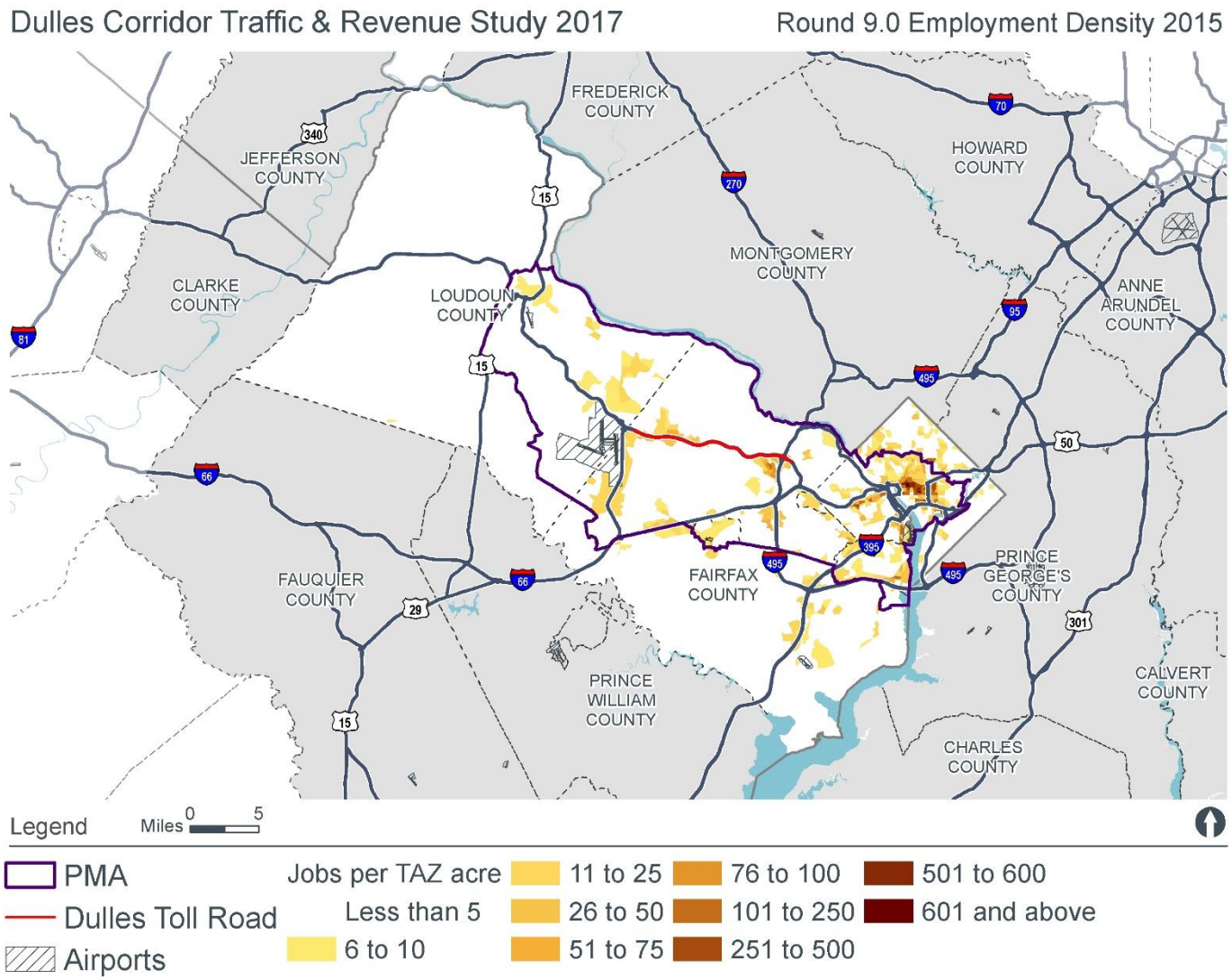


Figure 61 | Round 9.0 Employment Density 2025

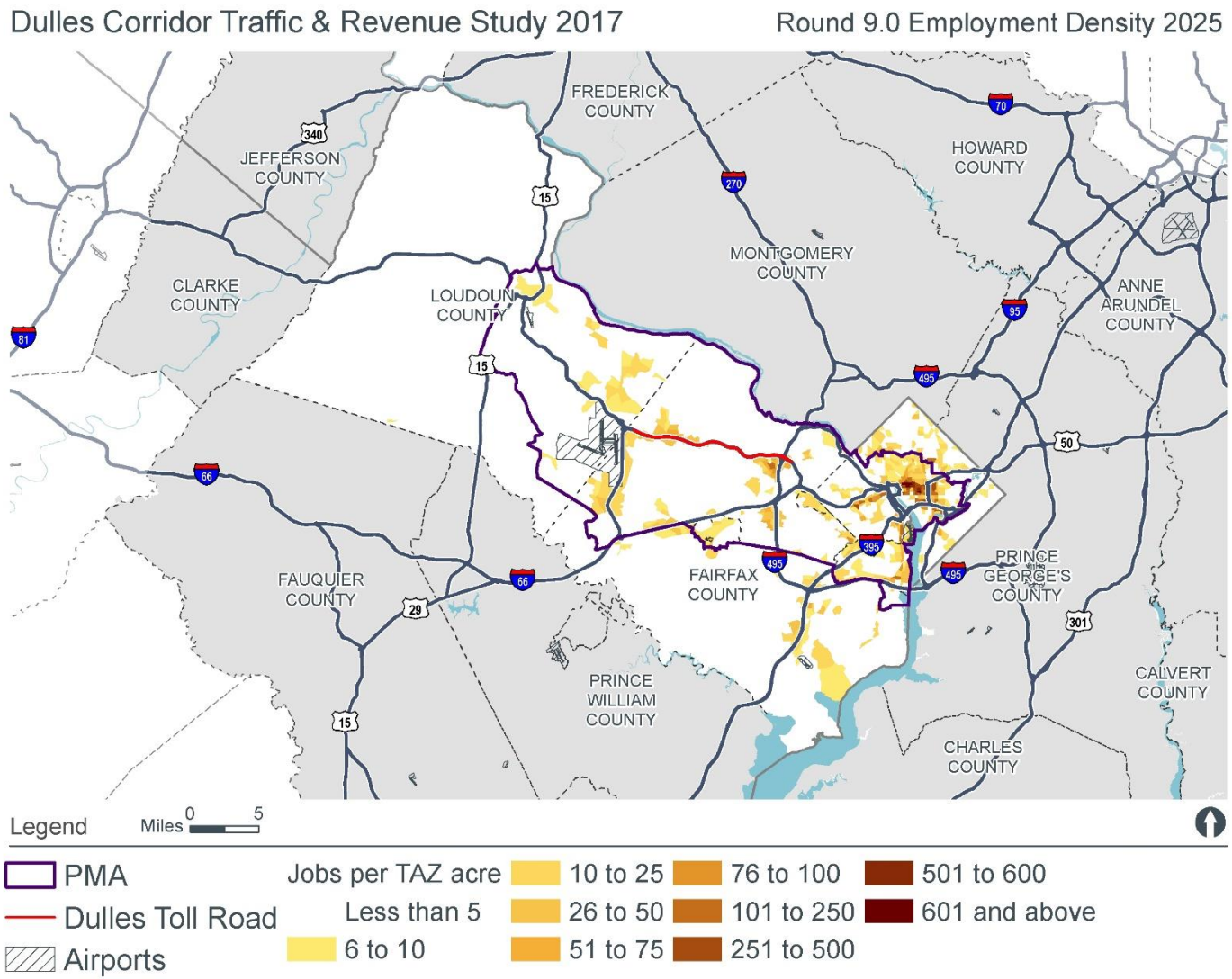


Figure 62 | Round 9.0 Employment Density 2040

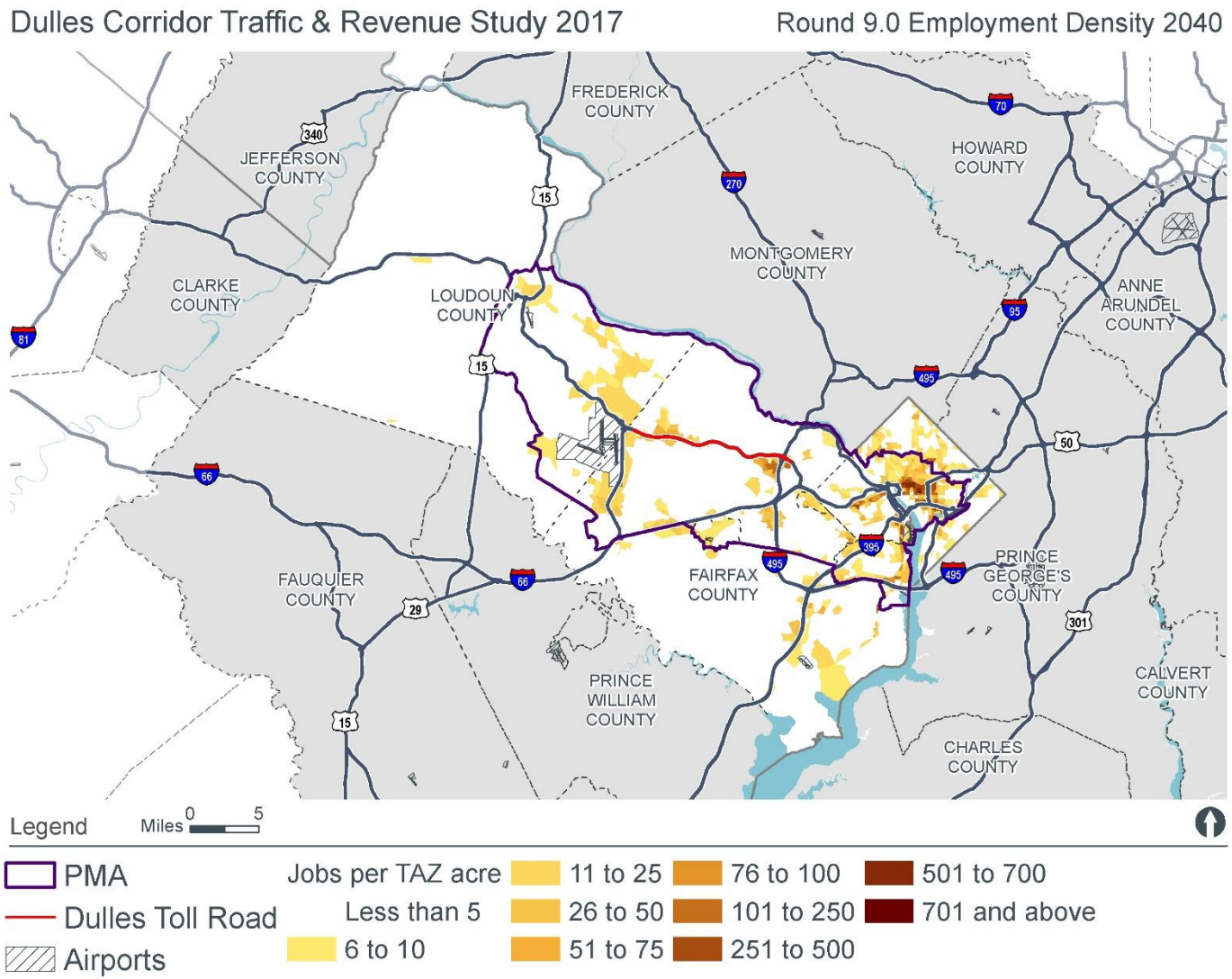


Figure 63 | Renaissance Population Density 2015

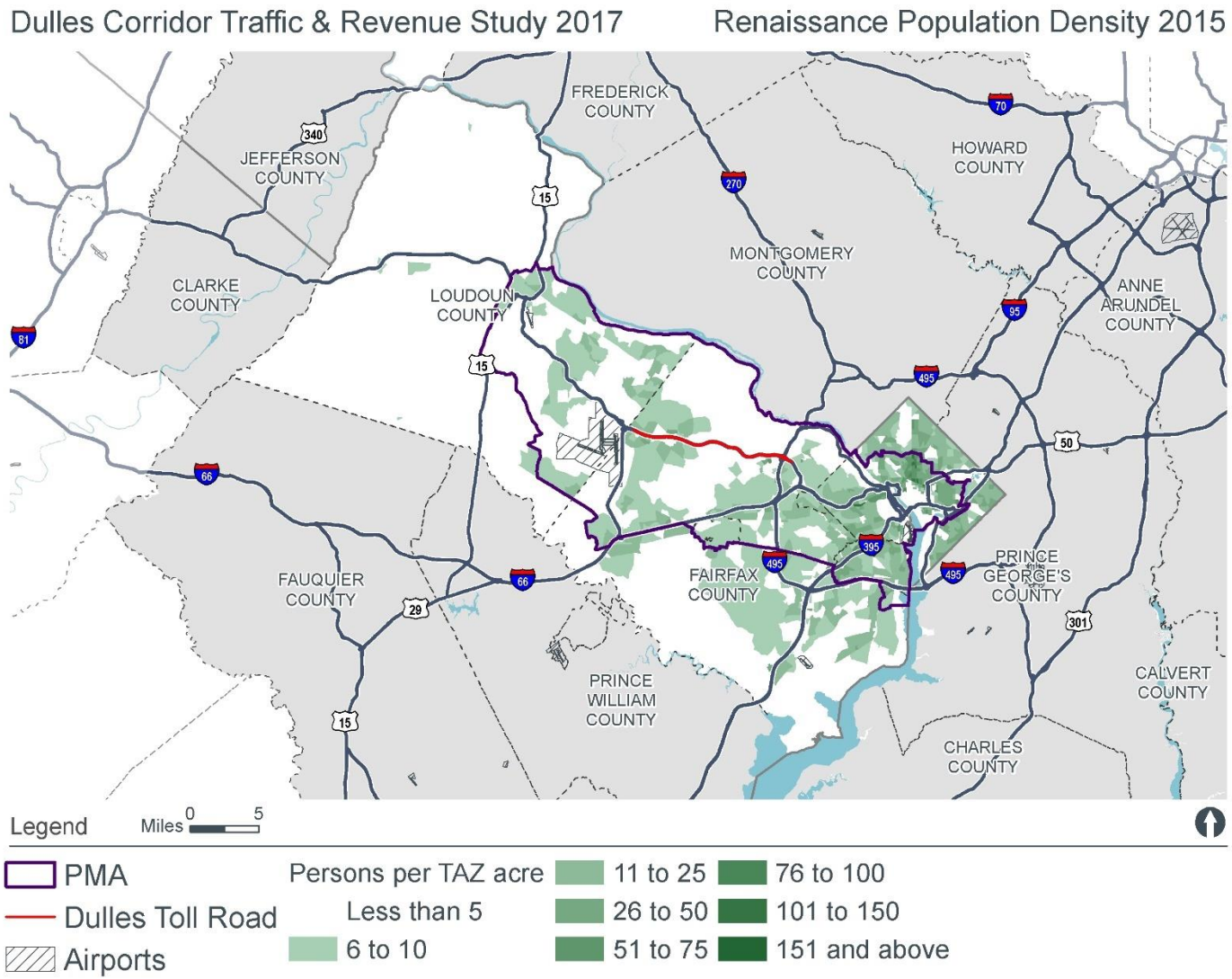


Figure 64 | Renaissance Population Density 2025

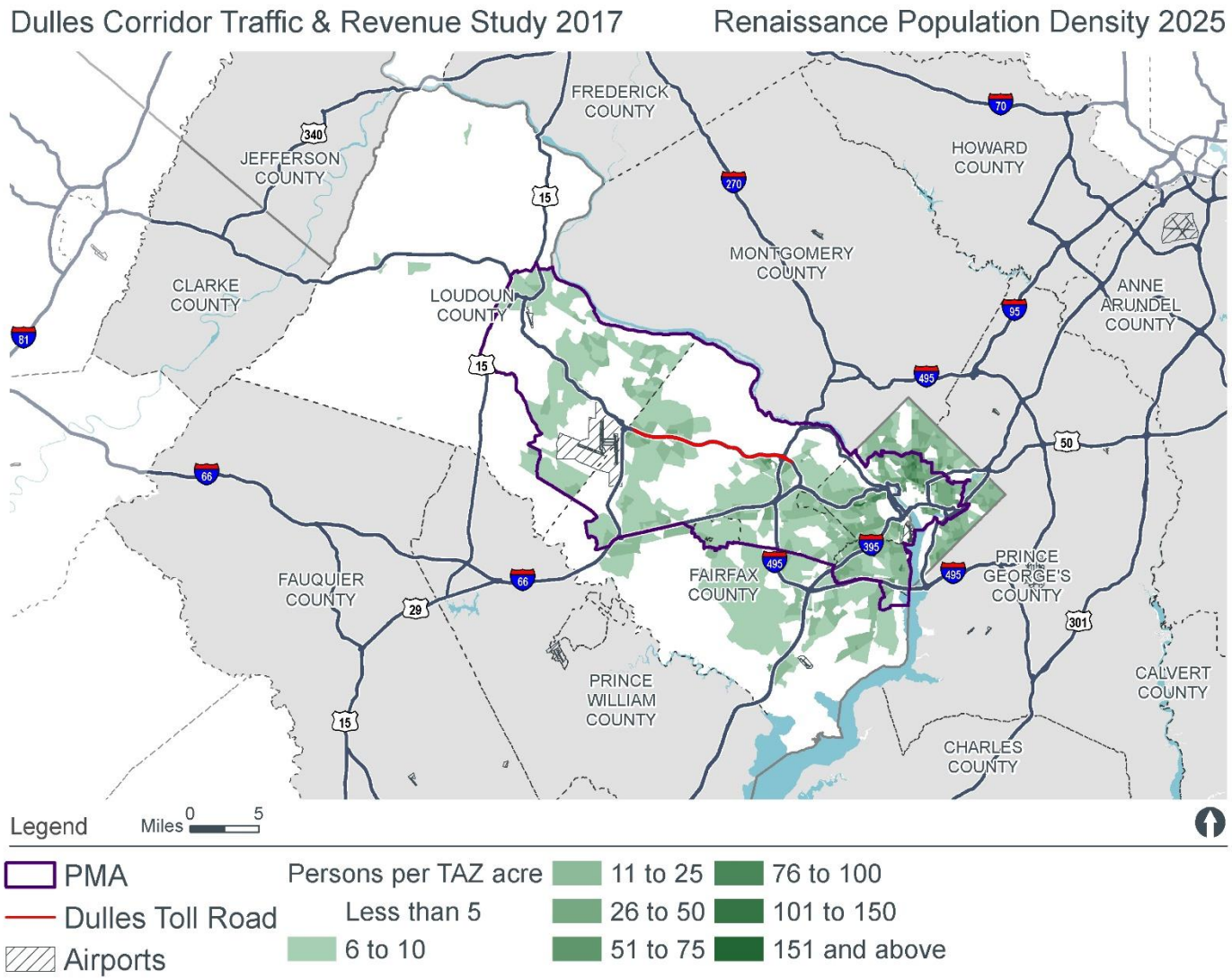


Figure 65 | Renaissance Population Density 2040

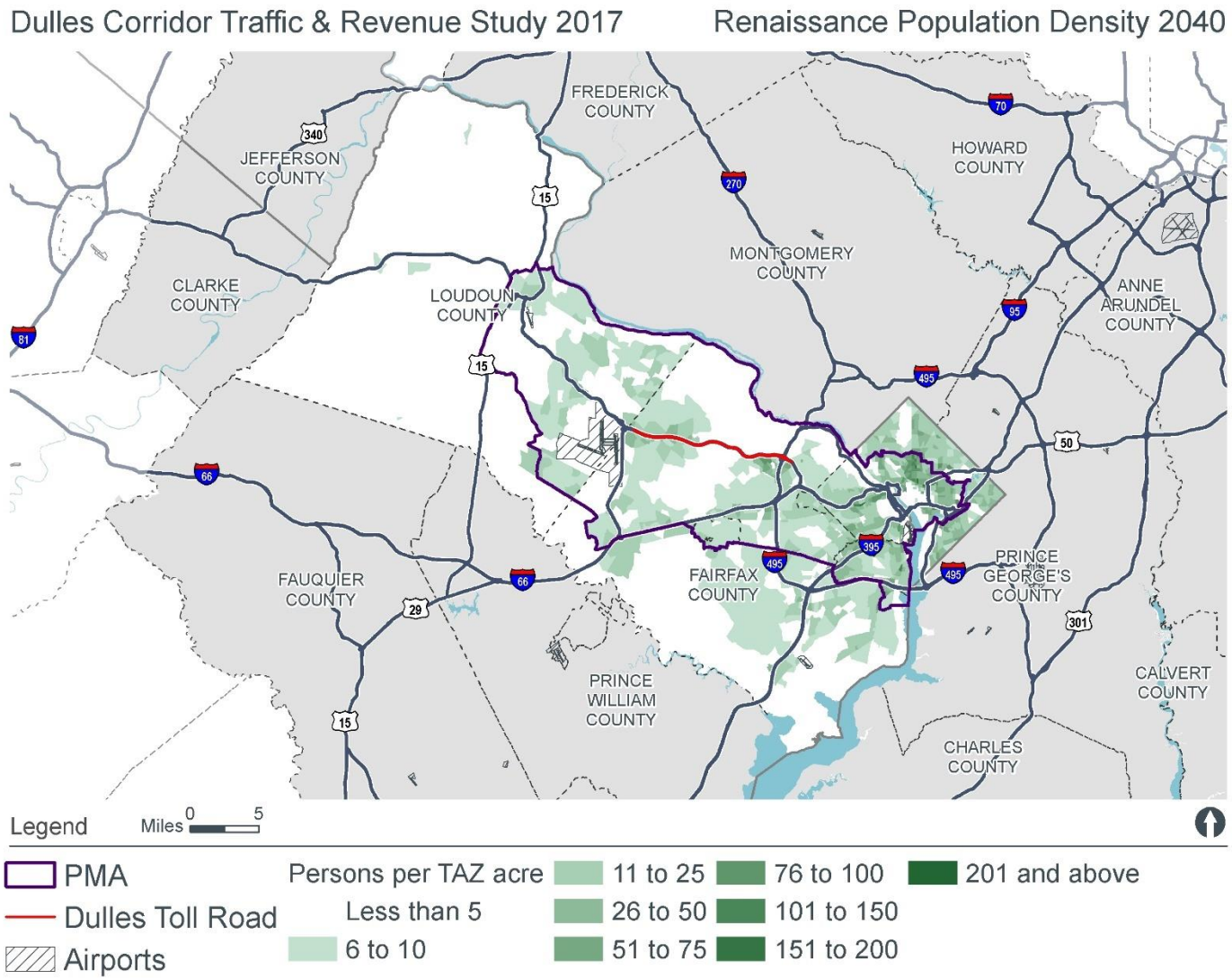


Figure 66 | Renaissance Employment Density 2015

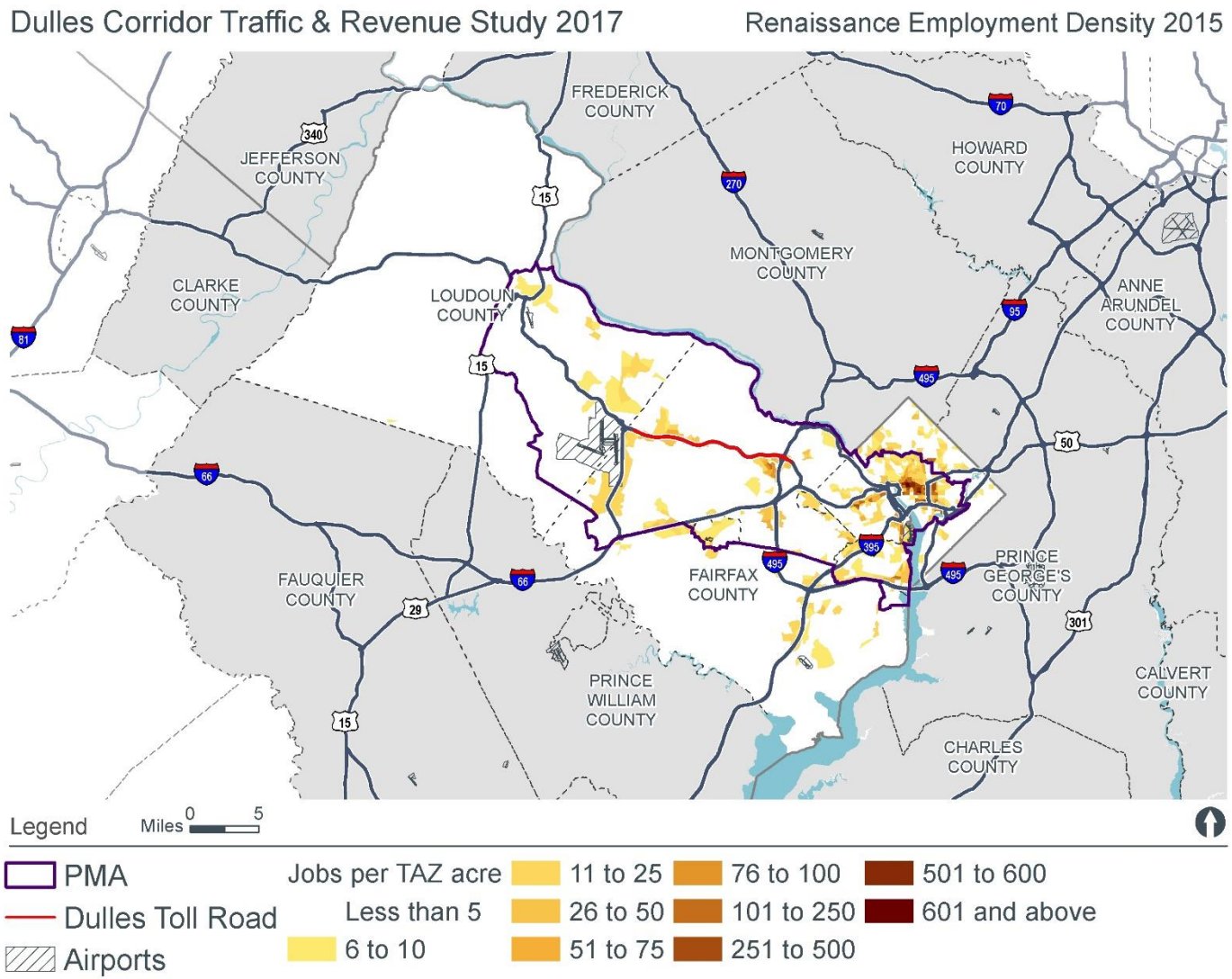


Figure 67 | Renaissance Employment Density 2025

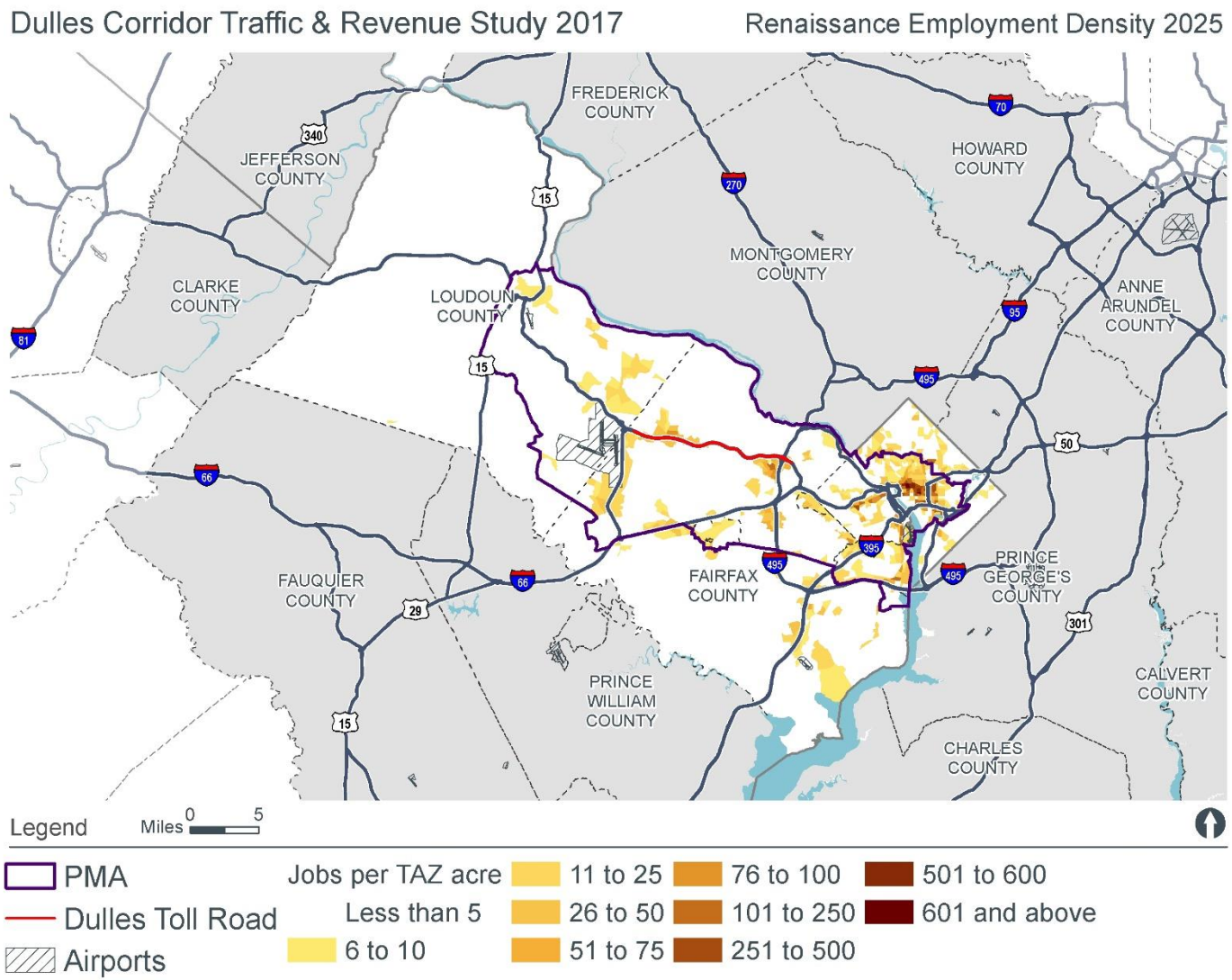


Figure 68 | Renaissance Employment Density 2040

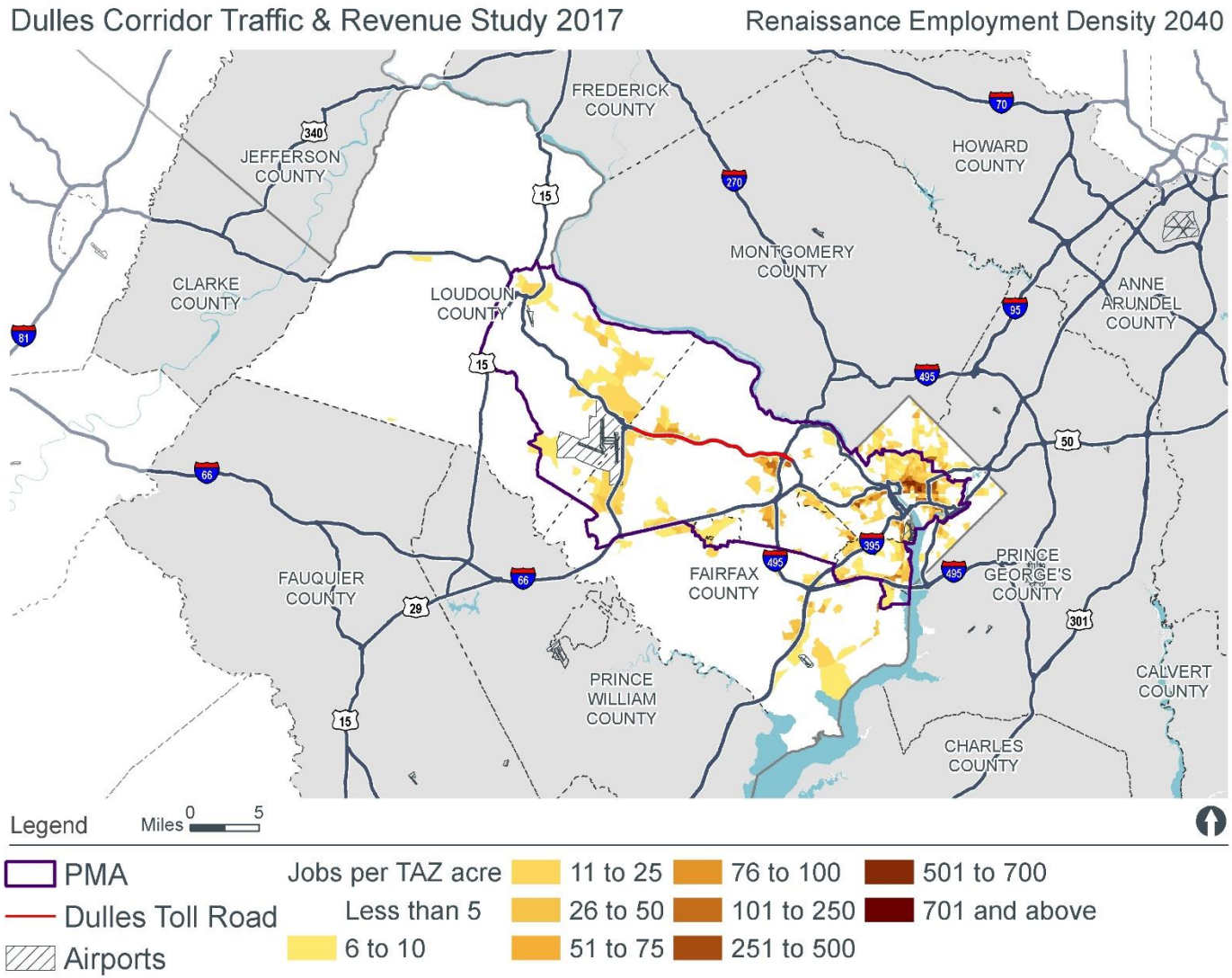


Figure 69 | Renaissance Population Forecast 2015-2025

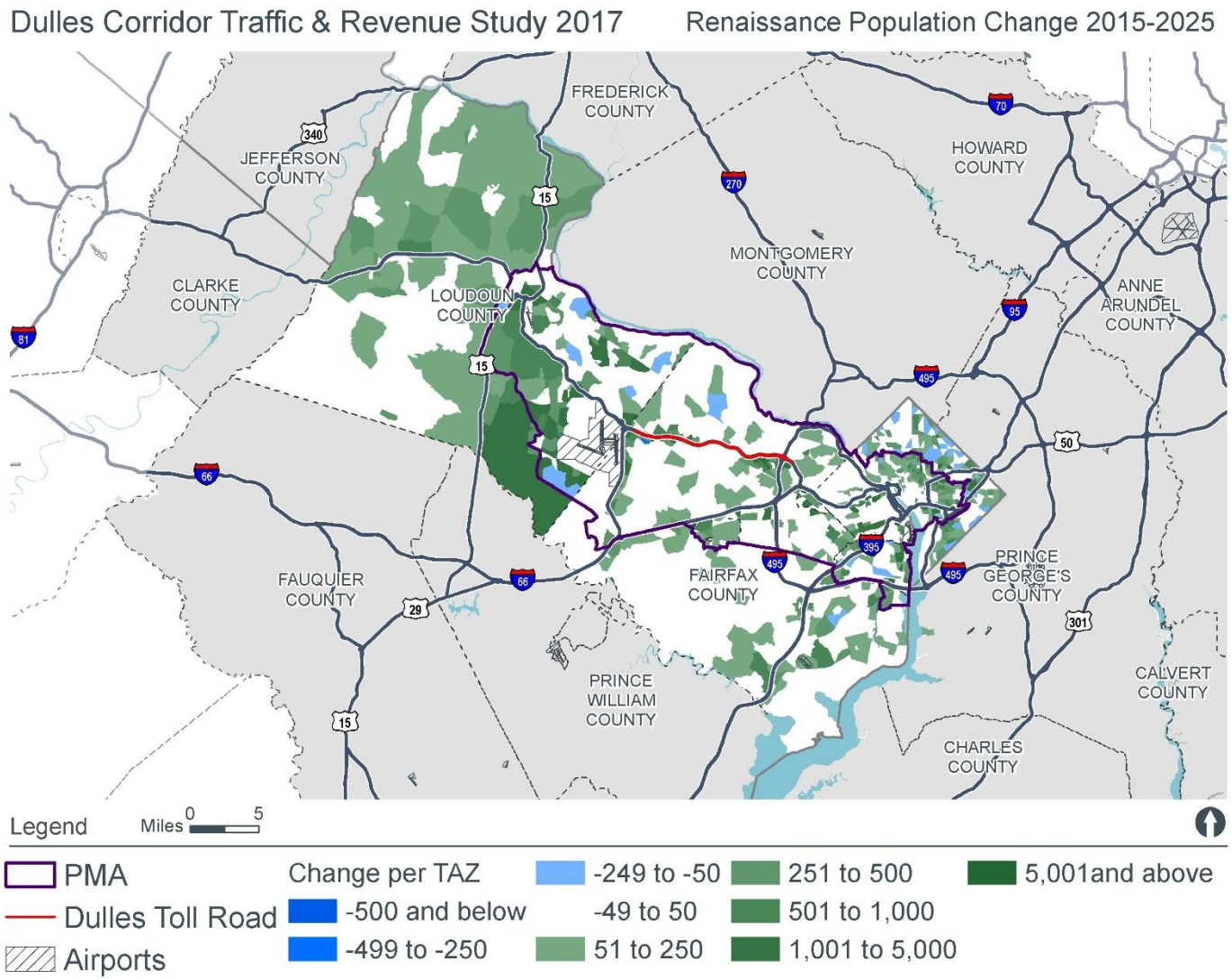


Figure 70 | Renaissance Population Forecast 2025-2040

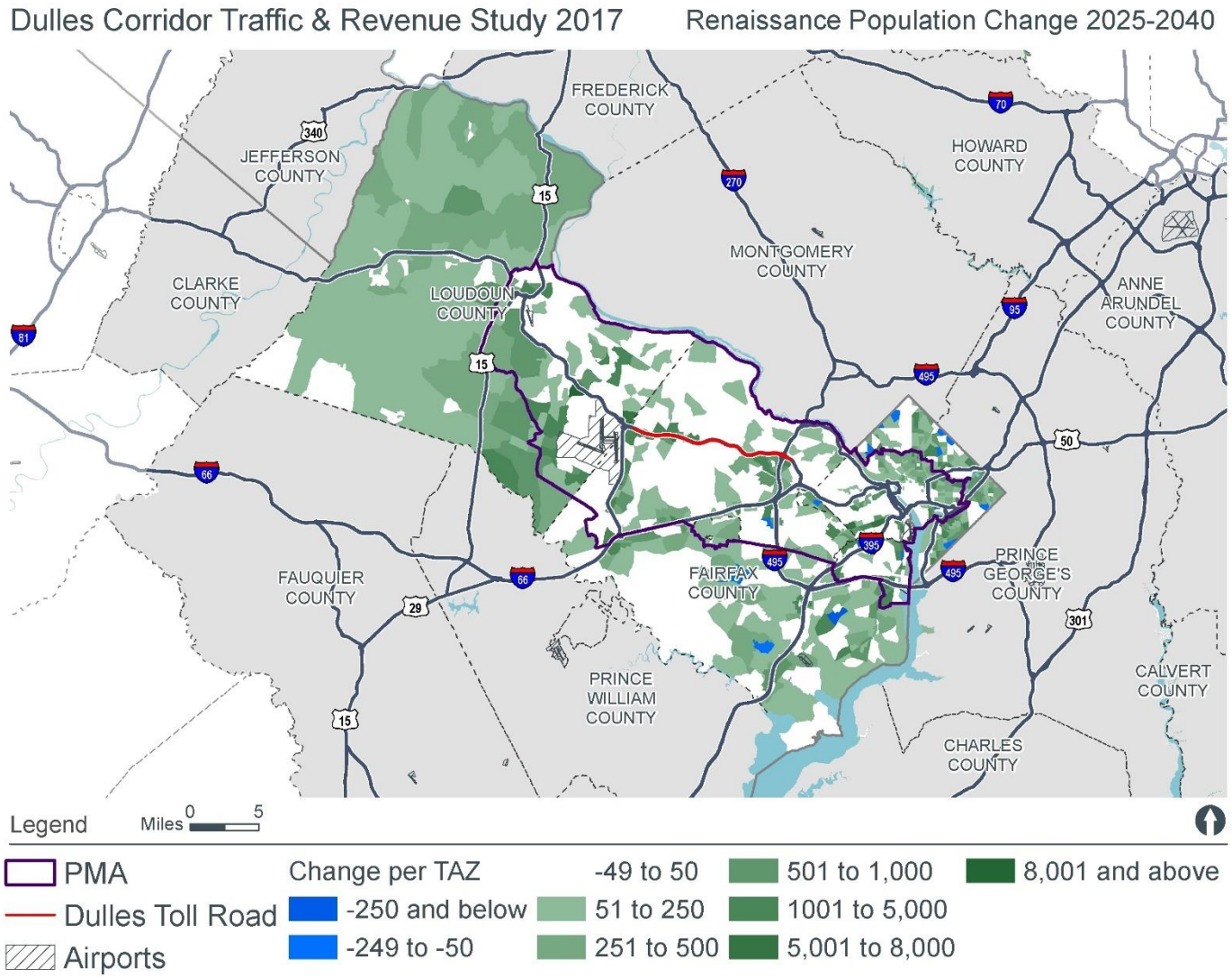


Figure 71 | Renaissance Population Change 2015-2040

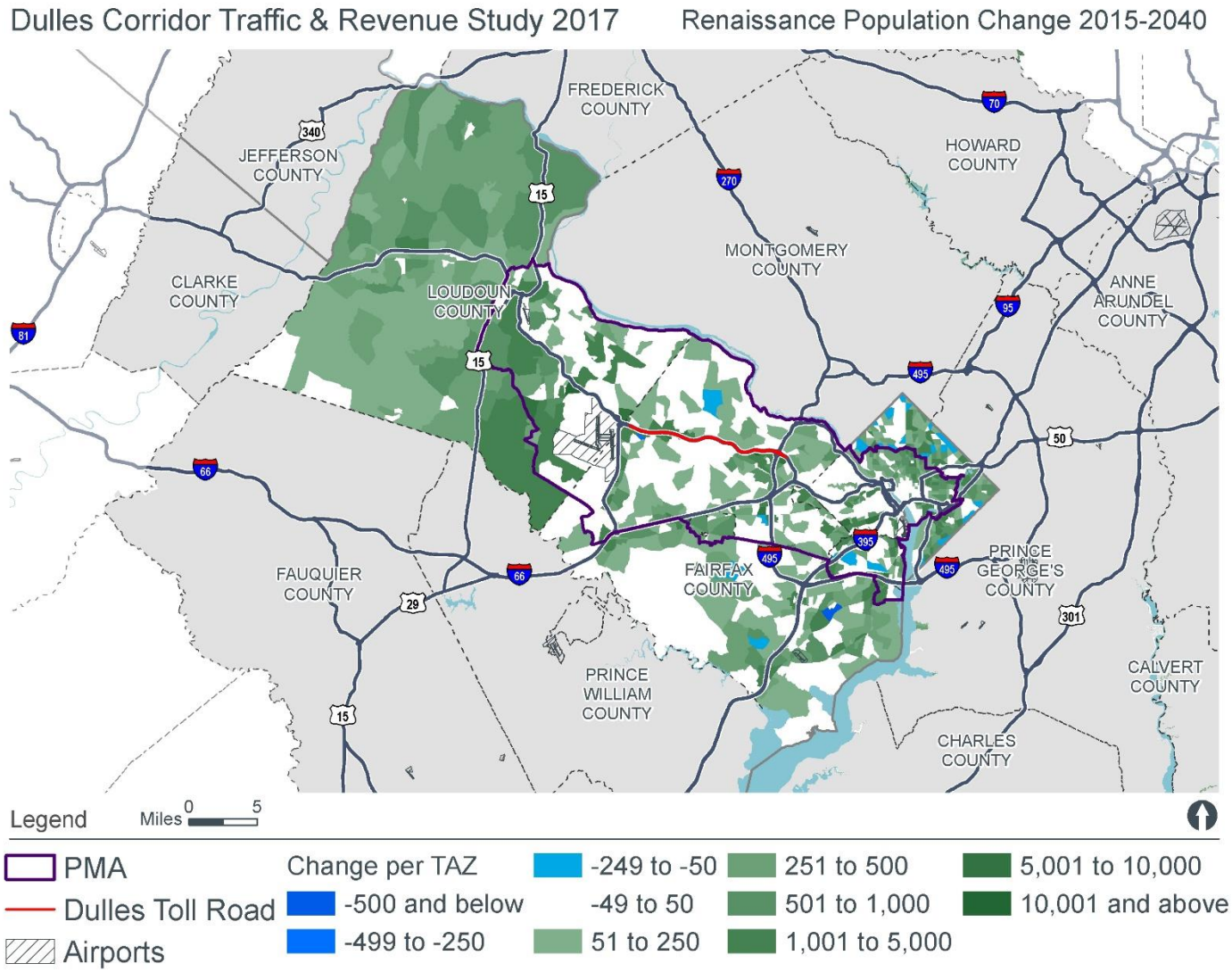


Figure 72 | Round 9.0 Population Change 2015-2040

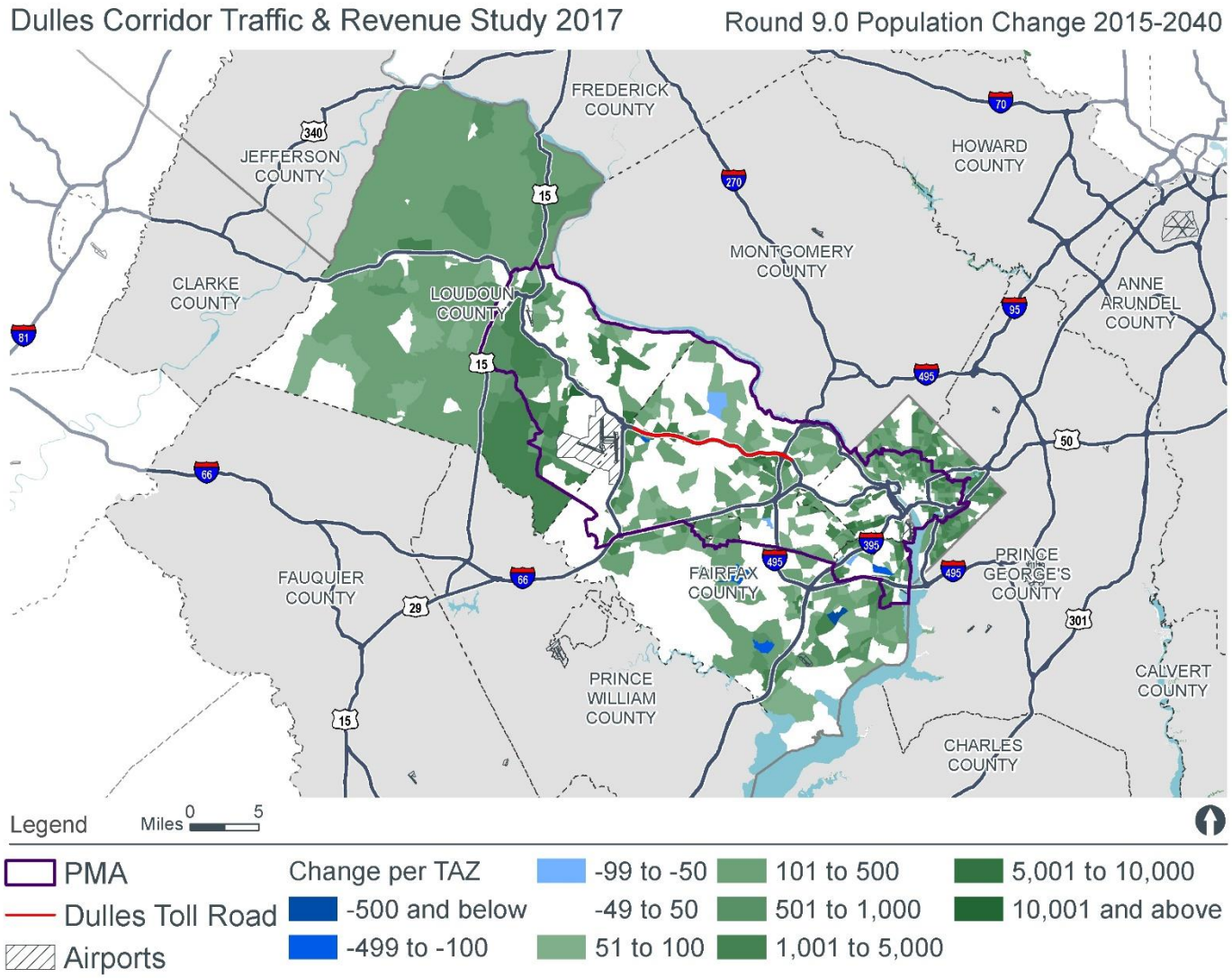


Figure 73 | Difference between Renaissance and Round 9.0 Population 2015-2040

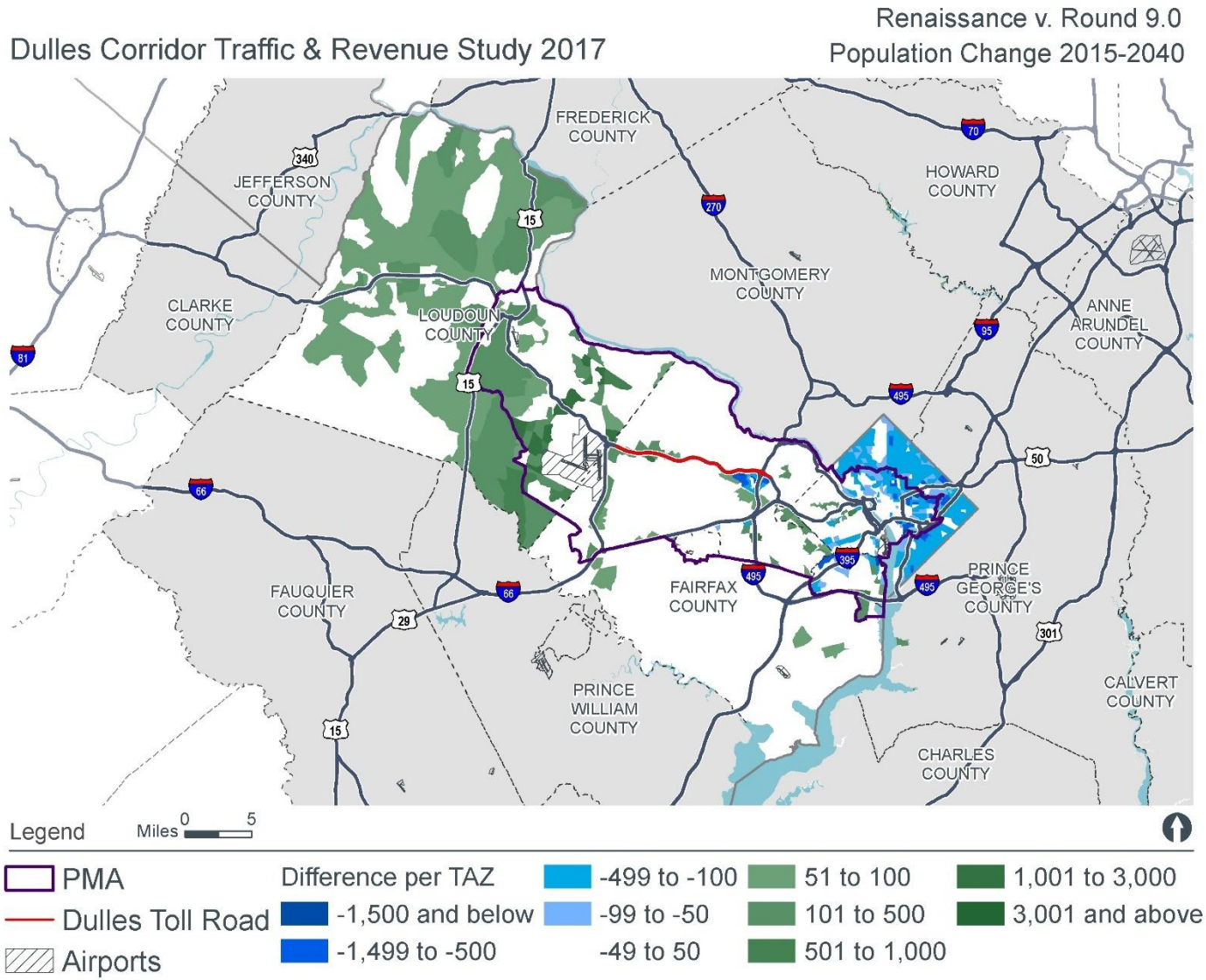


Figure 74 | Renaissance Employment Forecast 2015-2025

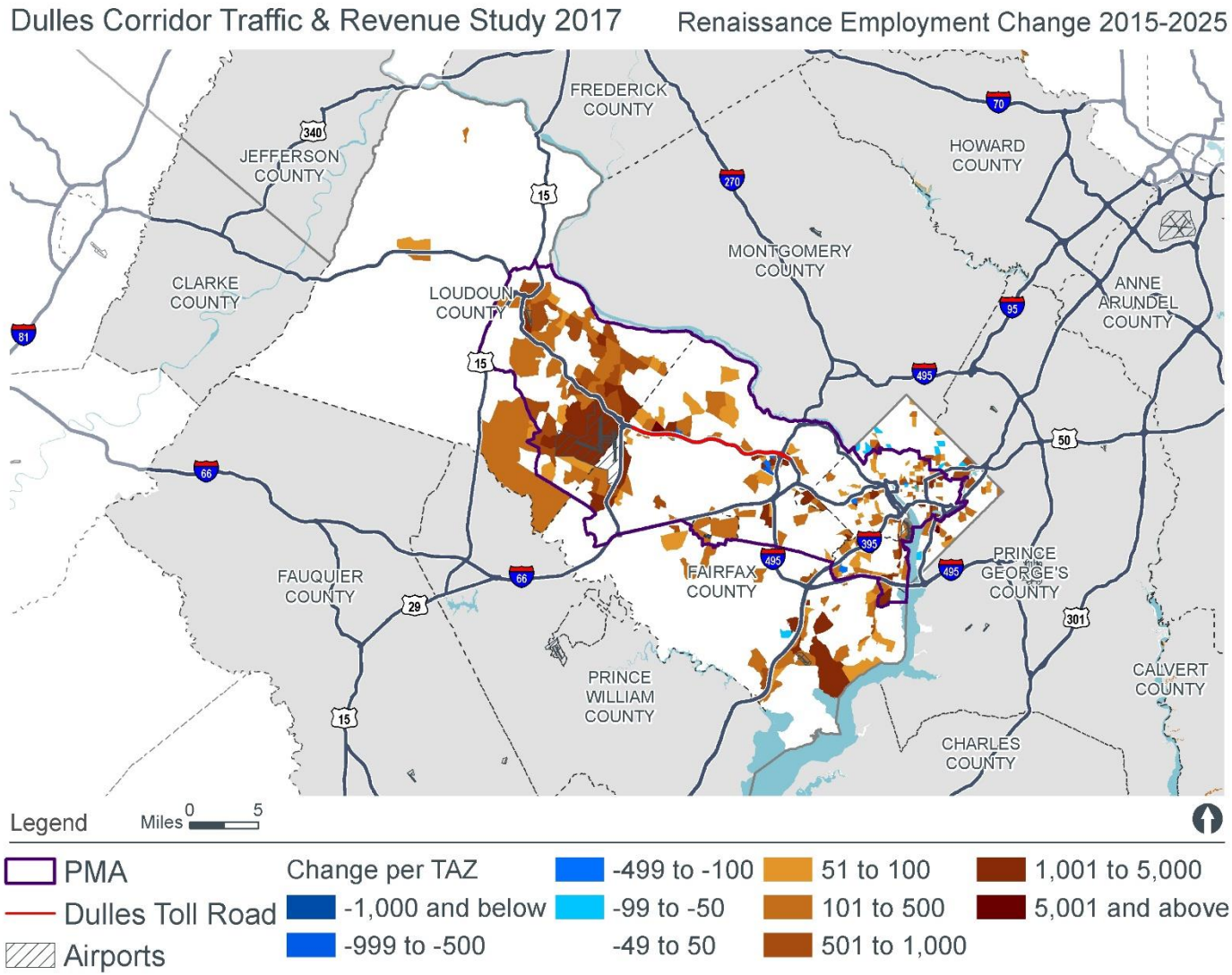


Figure 75 | Renaissance Employment Forecast 2025-2040

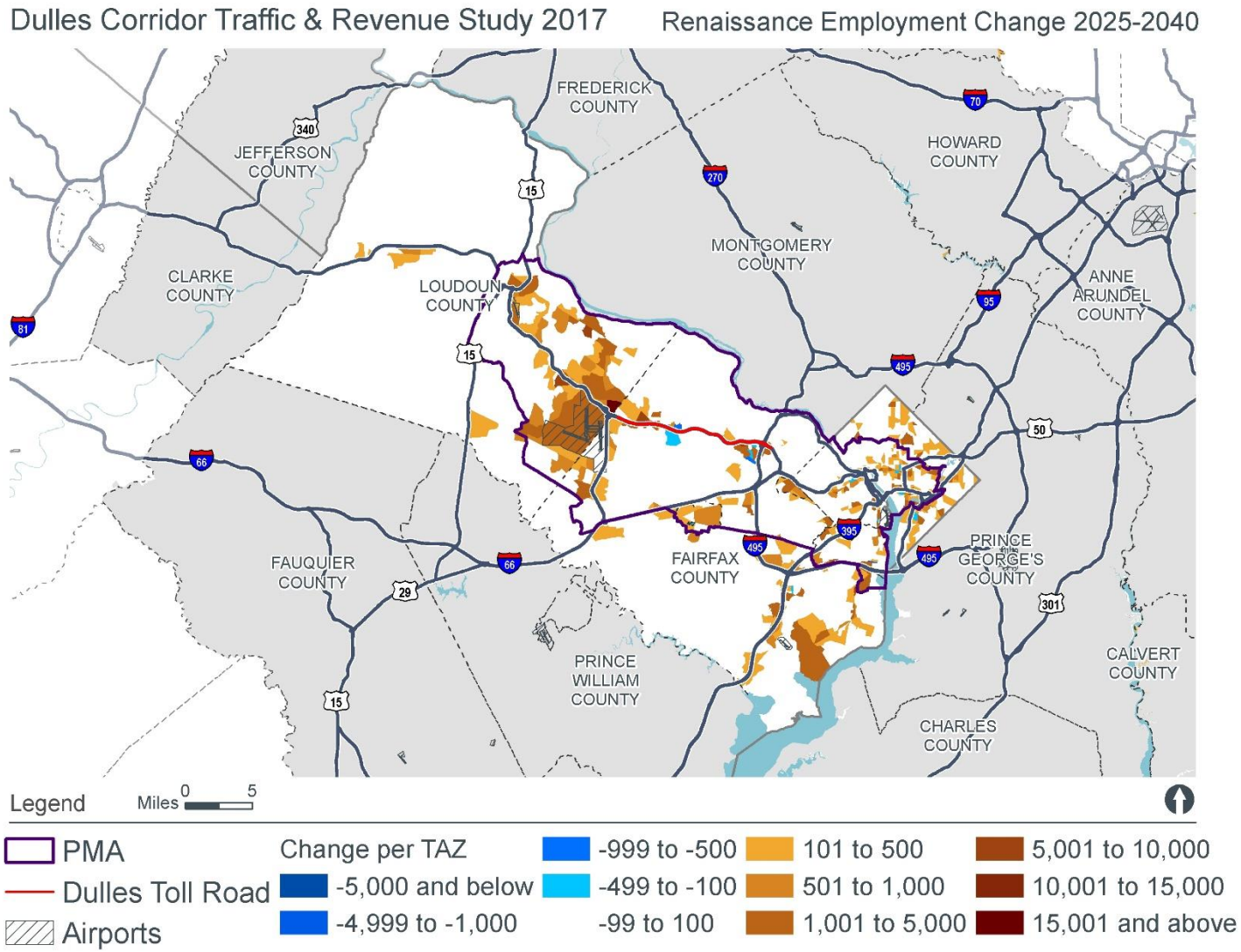


Figure 76 | Renaissance Employment Change 2015-2040

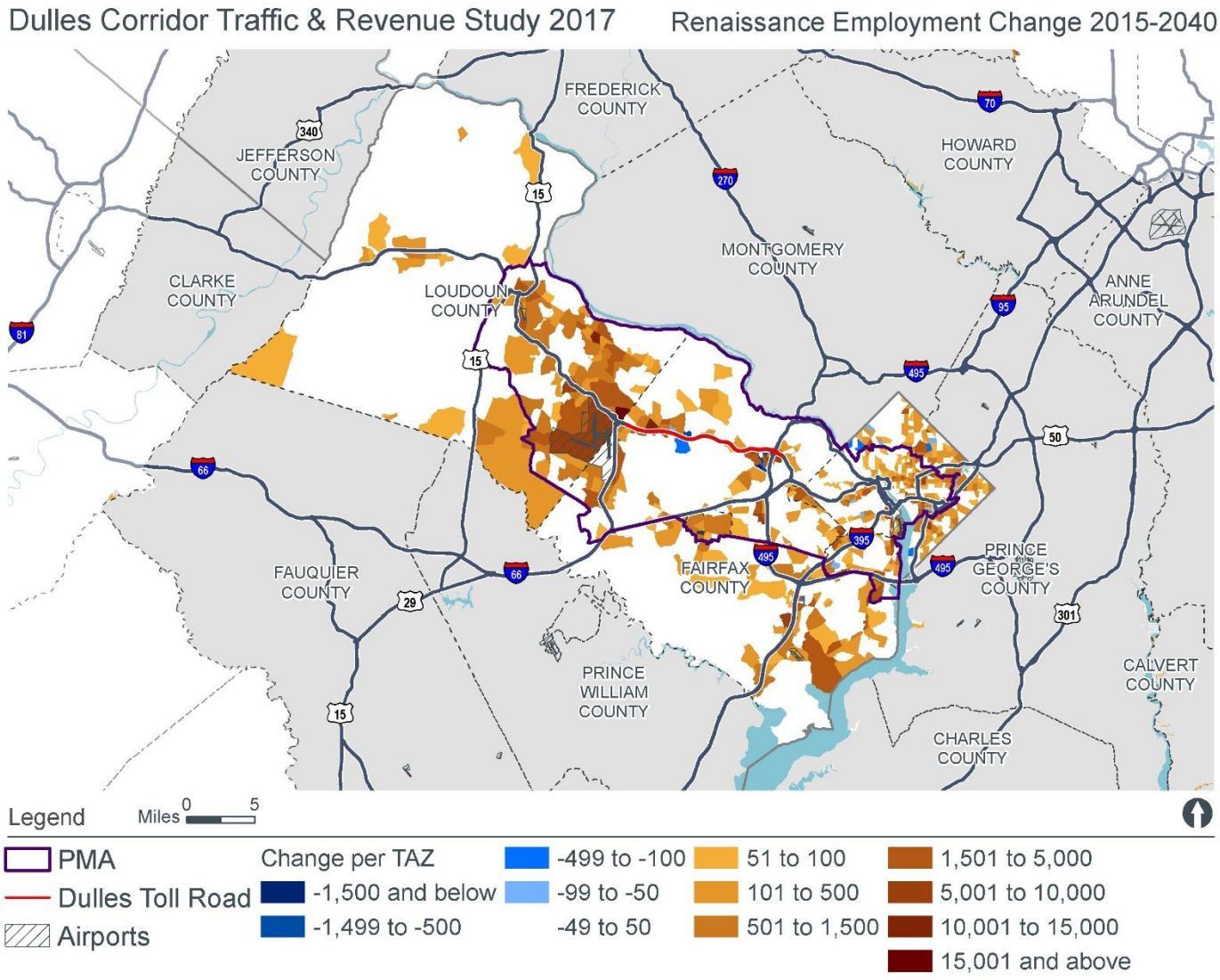


Figure 77 | Round 9.0 Employment Change 2015-2040

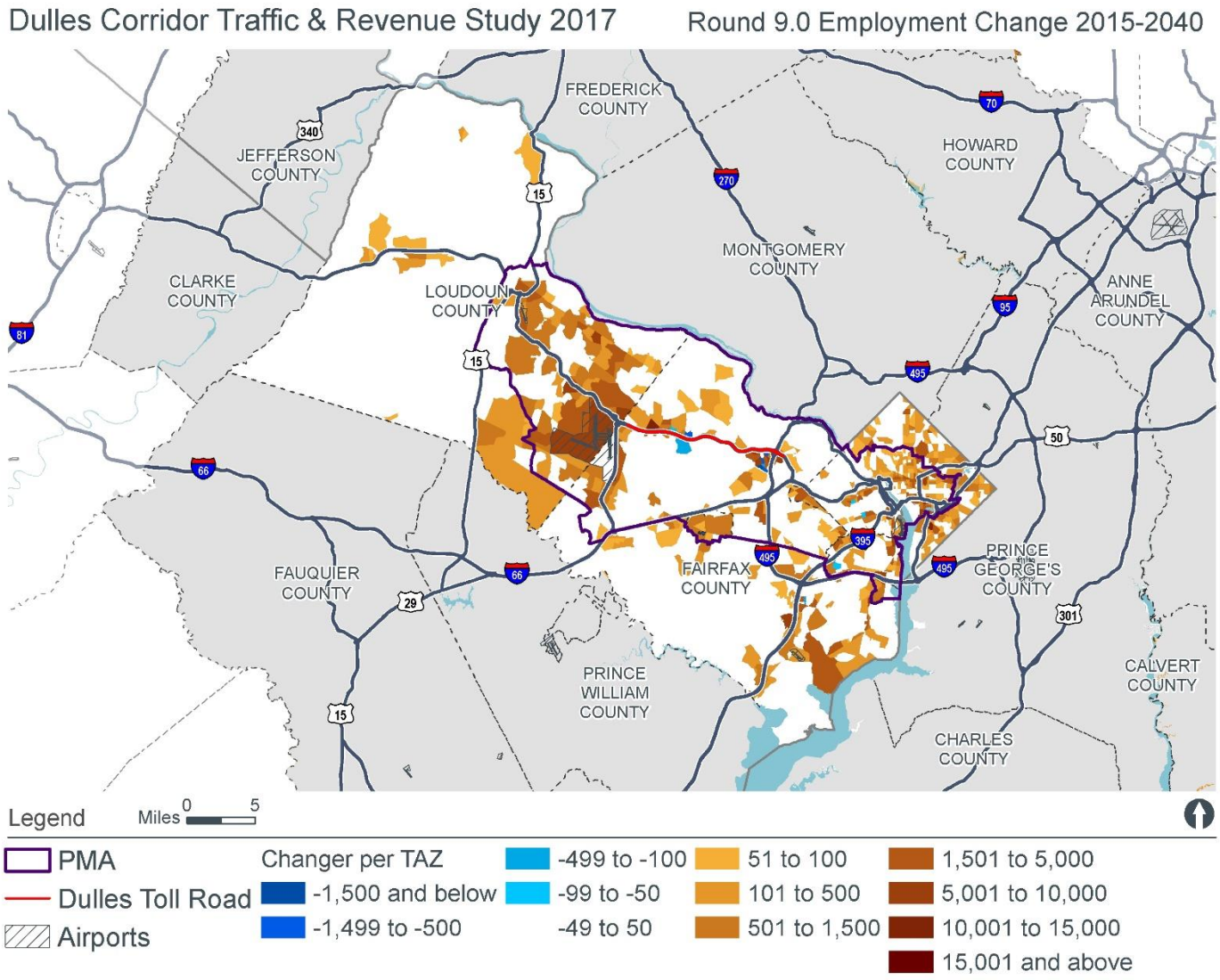


Figure 78 | Difference between Renaissance and Round 9.0 Employment 2015-2040