The Purple Line Economic Development Technical Report

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Prepared by:

National Center for Smart Growth

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1 Introduction

The Purple Line represents the largest investment in Maryland's public transportation system in several decades. According to the State of Maryland, the Purple Line will cost nearly $2 billion in total to construct, and $150 million per year to operate.[1]

Hopes run high for benefits "beyond the tracks:" new business opportunities; better access to jobs; and more vibrant, livable communities for all. Experience with light rail investments elsewhere in the nation, however, suggests that these benefits do not materialize automatically. Capturing them requires the coordinated and persistent efforts of local governments, private corporations, and civic and neighborhood advocacy organizations.

These efforts typically start with the development of a strategic plan for economic development. Such a plan would describe a vision for the future and a path to achieve that vision. Developing that plan requires a long process that involves both technical analysis and community engagement.

This report provides relevant data and technical analyses to support the development of a strategic plan for economic development in the Purple Line corridor. It includes a description of the underlying trends in demographics, employment, transportation, and land use in the corridor. It also includes long run transportation and employment forecasts for the corridor based on the impact of the Purple Line. The National Center for Smart Growth, with support from the Maryland Department of Transportation, conducted the transportation and economic impact analyses and prepared this report.

The primary purpose of the report is to provide technical background information to assist in the development of an economic development strategy, based on the travel and economic trends and forecasts. This is a solid starting point for a multilateral conversation among stakeholders.

1.1 About the Purple Line

Prince George's County and Montgomery County are two suburban counties, adjacent to the region's core municipality of Washington DC. The east-west link between the two Maryland counties relies predominantly on the Capital Beltway (I-495), part of the interstate highway system built in the 1960s. As some of the suburban communities with the counties such as Bethesda, College Park and Silver Spring have grown into major residential and employment centers, the existing road capacity has been unable to keep up with demand. The Purple Line light-rail project is expected to add capacity to meet the demand for east-west connections. Furthermore, transit-oriented development at the stations along the Purple Line corridor is expected to spur economic development in the entire region.

Planning for a suburban rail line began nearly three decades ago, and progressed in fits and starts. In 1988, Montgomery County purchased the Georgetown Branch Railroad right-of-way to

[1] See Section 3.

repurpose as a transit way and multi-use trail. However, it was not until November 2013 that the Maryland Board of Public Works approved a Public-Private-Partnership (Purple Line Transit Partners) to proceed with development of the Line.

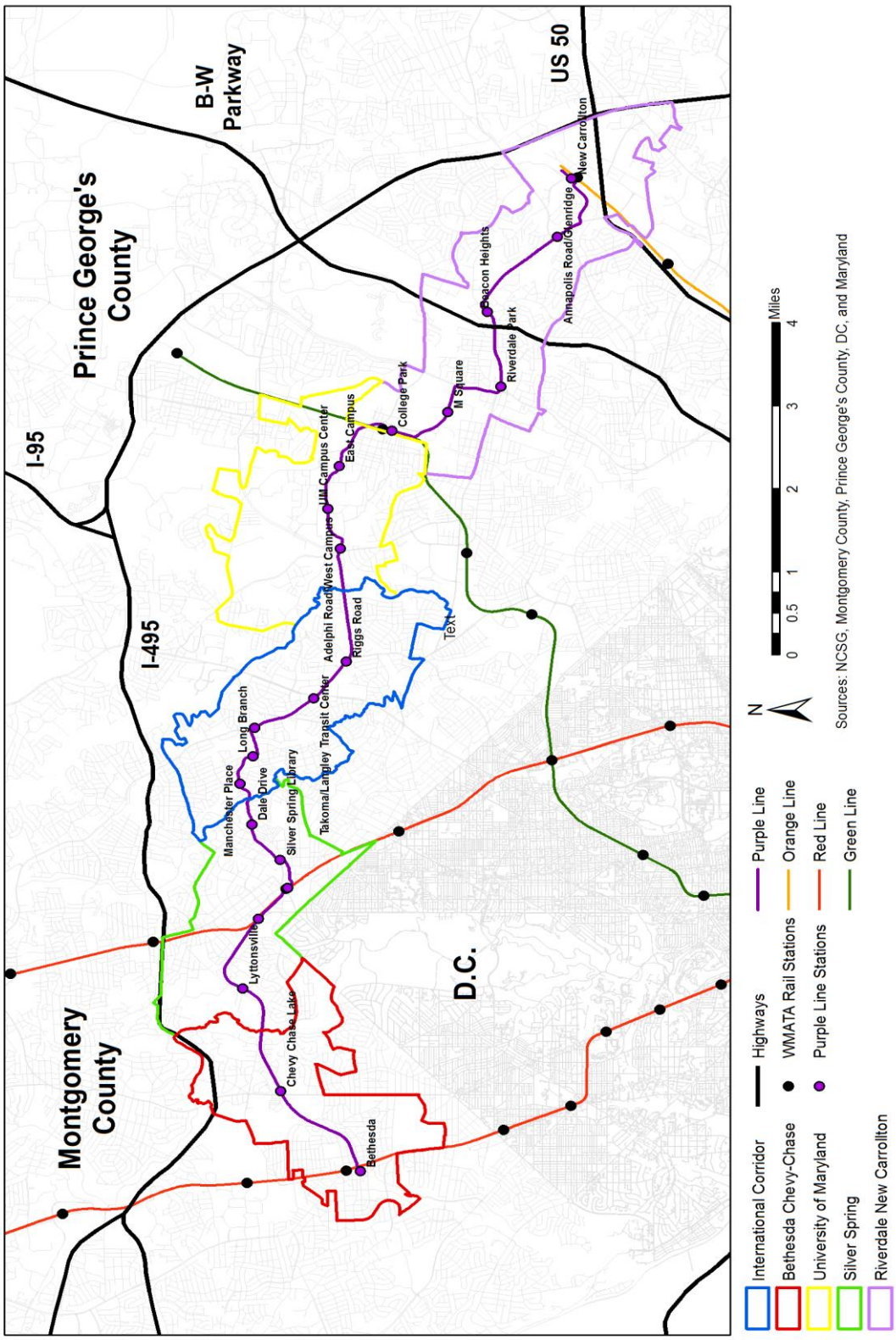
The Board of Public Works tasked the Partnership with the design, construction, operation, and maintenance of the Purple Line. The Partnership planned to start construction in 2015 and start service in 2020. Faced with controversies and legal challenges, the approval of construction funds from the Federal Transit Administration was significantly delayed. The project finally moved forward in September 2017. Purple Line Transit Partners now expects the Line to commercially operate no earlier than 2023.

The two-billion construction project will transport riders between Bethesda, MD and New Carrollton, MD. The corridor extends 16 miles, parallel with the Capital Beltway (Interstate 495), with 21 stations connecting major residential and employment centers in Prince George's County and Montgomery County.

Exhibit 1 shows the Purple Line route and the corridor area. The corridor consists of five subareas: Bethesda-Chevy Chase, Silver Spring, International Corridor, University of Maryland (College Park campus, or "UMD"), and Riverdale-New Carrollton. The transportation and economic impact of the light-rail project is most prominent within this half-mile buffer along the Purple Line. All five subareas have unique population, employment, and land use characteristics, which underscores the importance to analyze and develop economic development strategies at the subarea level.

The Purple Line will be the first light transit line in the Washington, D.C. region. It will be the first transit line to connect the spokes of the Metro System, and so will serve riders that travel from suburb to suburb as opposed to those who travel from the suburbs to the urban core. Traveling at grade, the Purple Line will meld with existing transportation infrastructure, including adjacent bicycle and pedestrian paths, and will pass gracefully by homes and businesses along the route.

Exhibit 1: The Purple Line Corridor



1.2 Report Purpose and Approach

The purpose of this report is to provide data and technical analyses to support future discussions about economic development policy in the Purple Line corridor. Therefore, this report begins with an overview of demographic, employment, transportation, and land use conditions in the corridor today. Based on the current information along with Purple Line construction and operation data, a state-wide travel demand model and an economic impact & forecast model are then applied to project travel and employment trends in the long run. The report concludes with a discussion of the analytical results, research limitations, and recommendations for next steps.

The Purple Line will cross through several diverse neighborhoods. It is necessary to divide the entire corridor into the following subareas to exploit their distinct trends in economic development and travel patterns, respectively:

- Bethesda-Chevy Chase
- Silver Spring
- International Corridor
- University of Maryland
- Riverdale-New Carrollton

We collected these data[2] at the Census block group level. To be included in the corridor, a block group must have 50 percent of its land area and its centroid within one half-mile of the Purple Line.

We used the Maryland State Transportation Model (MSTM) and the Transportation Economic Development Impact System (TREDIS) models to project the impact of the construction and operation of the Purple Line on travel patterns and employment growth. Our intent is not to provide definitive estimates of changes in travel patterns or economic growth. Our intent instead is to provide background information and simple projections to stimulate further analysis and to inform economic development planning.

1.3 Organization

This study is organized as follows. Section 2 describes the current trends in demographic, employment, transportation, and land use characteristics at the corridor and subarea levels. Section 3 presents forecasts for the Purple Line's effect on travel patterns and employment in the

[2] We used Census data and GIS data for the assessment of current conditions in the corridor:

- We used Census data from the American Community Survey (ACS) 5-year estimates to characterize the resident population in the corridor. We considered the following characteristics: race and ethnicity, education, income, and travel patterns.
- We used our own analysis of GIS data from the two counties to describe land use and zoning.
- We used data from another Census program, the 2013 Longitudinal Employer-Household Dynamics (LEHD) program, to describe the economy. We considered the following characteristics: employment by industry and wage level, and educational attainment.

long run. Section 4 offers a summary of the analysis, discusses the limitations of the analysis, and proposes next steps for further analysis.

2 Current Conditions in the Purple Line Corridor

This section characterizes current conditions in the Purple Line corridor in terms of (1) demographics, (2) employment, (3) transportation mode share, and (4) land use and zoning. It concludes with a synthesis of key trends at the corridor and sub corridor levels. Key points on current conditions include:

- The Purple Line corridor has steady population growth, with a noteworthy shift toward an increasing Hispanic population.
- The more affluent neighborhoods in Bethesda and Silver Spring attract high-income and educated residents. The less affluent areas in the International Corridor and Riverdale-New Carrollton host rapid growth in minority populations, which tend to be disadvantaged in socioeconomic status.
- The industry strength of each subarea differs substantially from others.
- The Purple Line corridor has a typical suburban transportation mode share with high auto-dependency and low walkability and public transit utility.
- The Purple Line corridor extends along densely populated residential neighborhoods, central business districts (CBDs), mixed use and public land, as well as industrial districts.

2.1 Demographics Trends

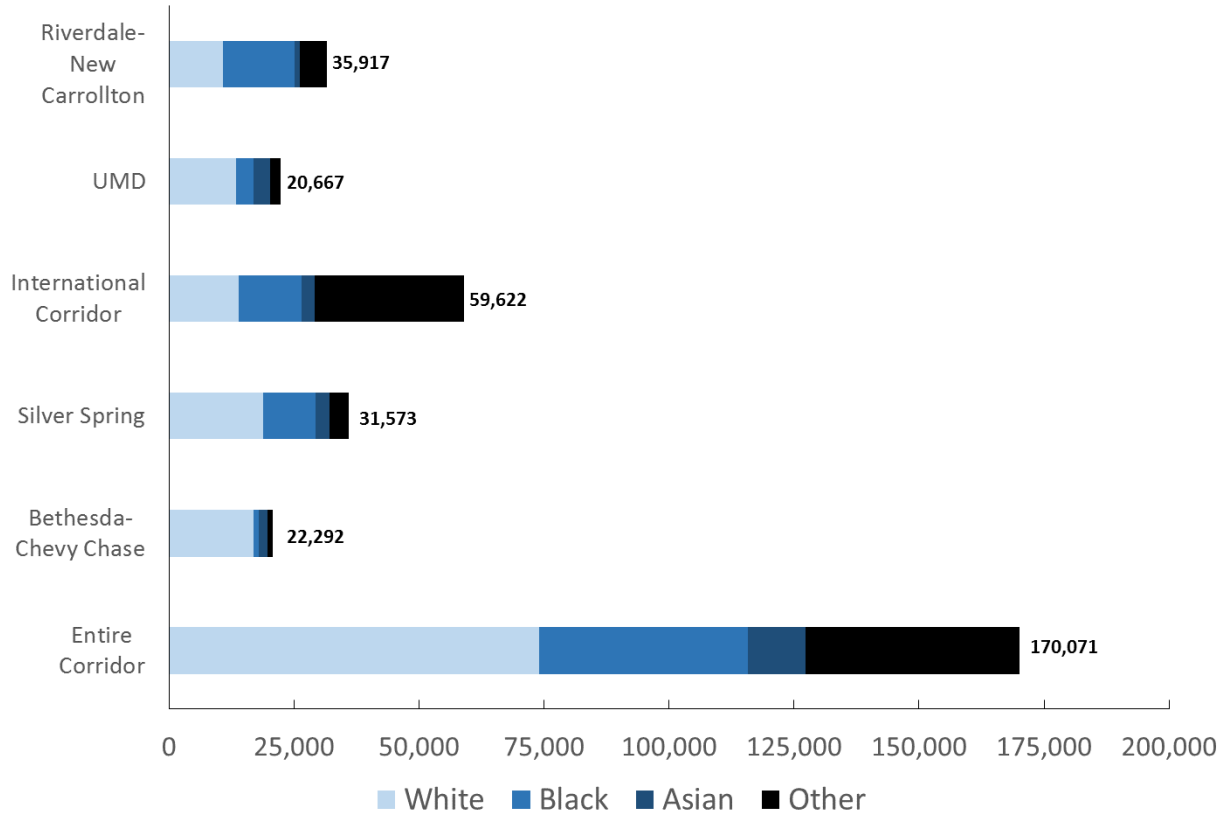
This subsection describes trends in population composition, educational attainment, and household income for the corridor and the individual subareas.

Population by Race and Ethnicity

The Purple Line will traverse an exceptionally diverse region in terms of race and ethnicity. The most recently available census data indicate that about 170,000 people live in the immediate transit corridor. It is a majority-minority area, as less than half of those individuals self-identify as white. While the area is diverse, it is also dynamic in two ways: first, through continued

population growth, and second, through transitions in racial composition. Exhibit details the population of the entire corridor in 2011-2015, by racial identity[3].

Exhibit 2: Population by Race and Ethnicity in 2015



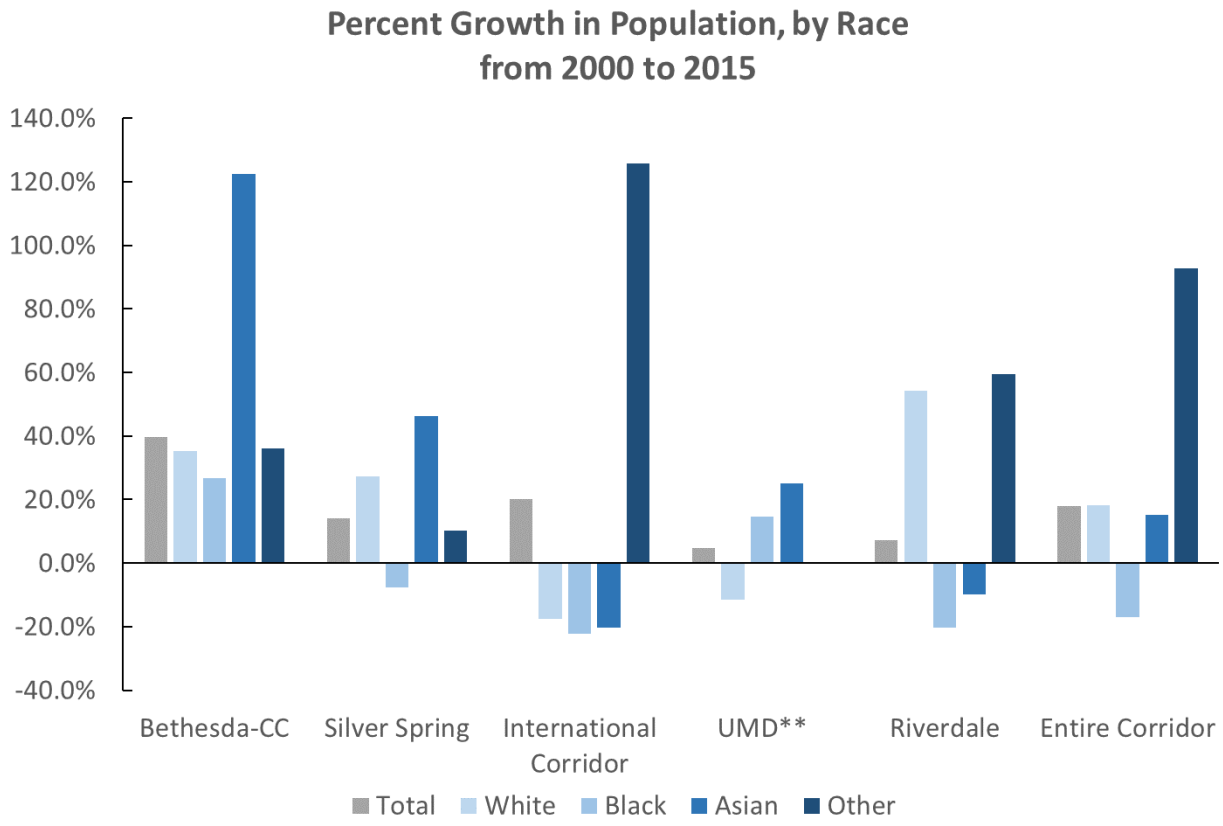
Source: NCSG with data from the U.S. Census, American Community Survey 2011-2015 Estimates.

It is evident that the Purple Line corridor is racially diverse, especially in the International Corridor subarea (with a high percentage of the Hispanic and Latino population) and Riverdale-New Carrollton subarea (with a high percentage of the Black population).

Nevertheless, the diversity of the corridor is not news. Even in 2000, only about half of the residents self-identified as white (see Appendix Exhibit 2.1). The corridor is, however, continuing to diversify even as that white population grows (by 18.2% since 2000). The population that is growing most is the Hispanic population – which has almost doubled from 32,000 to 58,000 in about fifteen years. The Asian population is also growing. The only shrinking population is the Black population, decreasing by 17 percent during the same period. Exhibit shows percentage growth by racial and ethnic category from the year 2000 to 2015.

[3] Hispanic is an ethnicity in Census accounting, so individuals who self-identify as Hispanic can be of any race. "Other" includes American Indian and Alaskan Native, Hawaiian or Pacific Islander, some other race, or racial identity composed of two or more of any category.

Exhibit 3: Population Growth by Race and Ethnicity from 2000 to 2015



** Due to population count discrepancies in the year 2000, change for the UMD subarea is displayed from 2006-2010 to 2011-2015.

Source: NCSG with data from the U.S. Census, American Community Survey 2011-2015 Estimates.

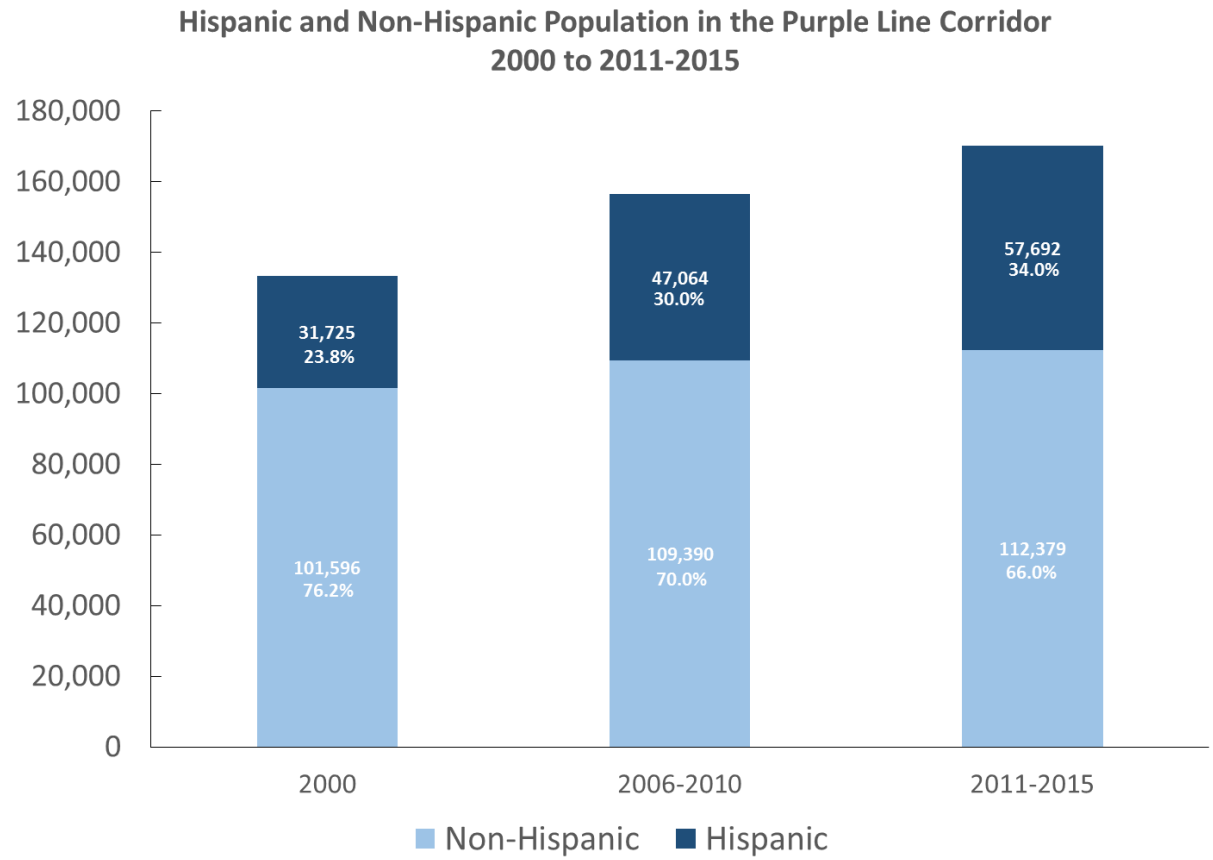
At the subarea level, Bethesda and Silver Spring have both seen growing populations over the period, with increases in every racial category except a slight decline in the Black population in Silver Spring. While starting from a smaller base, the highest percentage population growth in those twos subareas is in the Asian population. Bethesda itself has had the highest percentage population growth, likely due to residential densification around the Bethesda CBD.

The International Corridor has added more than 10,000 residents in about 15 years; this increase is entirely attributable to growth in the other racial categories, as counts for White, Black and Asian have fallen.[4] In the University of Maryland subarea, different dynamics are at play with the student population, but there has been substantial growth in both the Black and Asian populations. In Riverdale-New Carrollton, dramatic change has occurred: decreases in the Black population alongside a large increase in the White and other race populations.

[4] It is unfortunately not possible to differentiate growth across race and ethnicity. The Hispanic population has increased by about 16,000 since 2000. Hispanic residents of the corridor, however, could classify themselves as White, Black, some other race, or any other category available.

Exhibit 4 displays information on the ethnicity of the entire corridor. In fifteen years, the population of residents who identify as having Hispanic ethnicity has almost doubled from 31,725 to 57,692. Correspondingly, the Hispanic population has increased from under a quarter to more than a third of the population. Appendix Exhibit 2.1 displays population counts by subarea for race and ethnicity.

Exhibit 4: Ethnicity in the Purple Line Corridor, 2000 to 2011-2015



Source: NCSG with data from the U.S. Census, American Community Survey 2011-2015 Estimates.

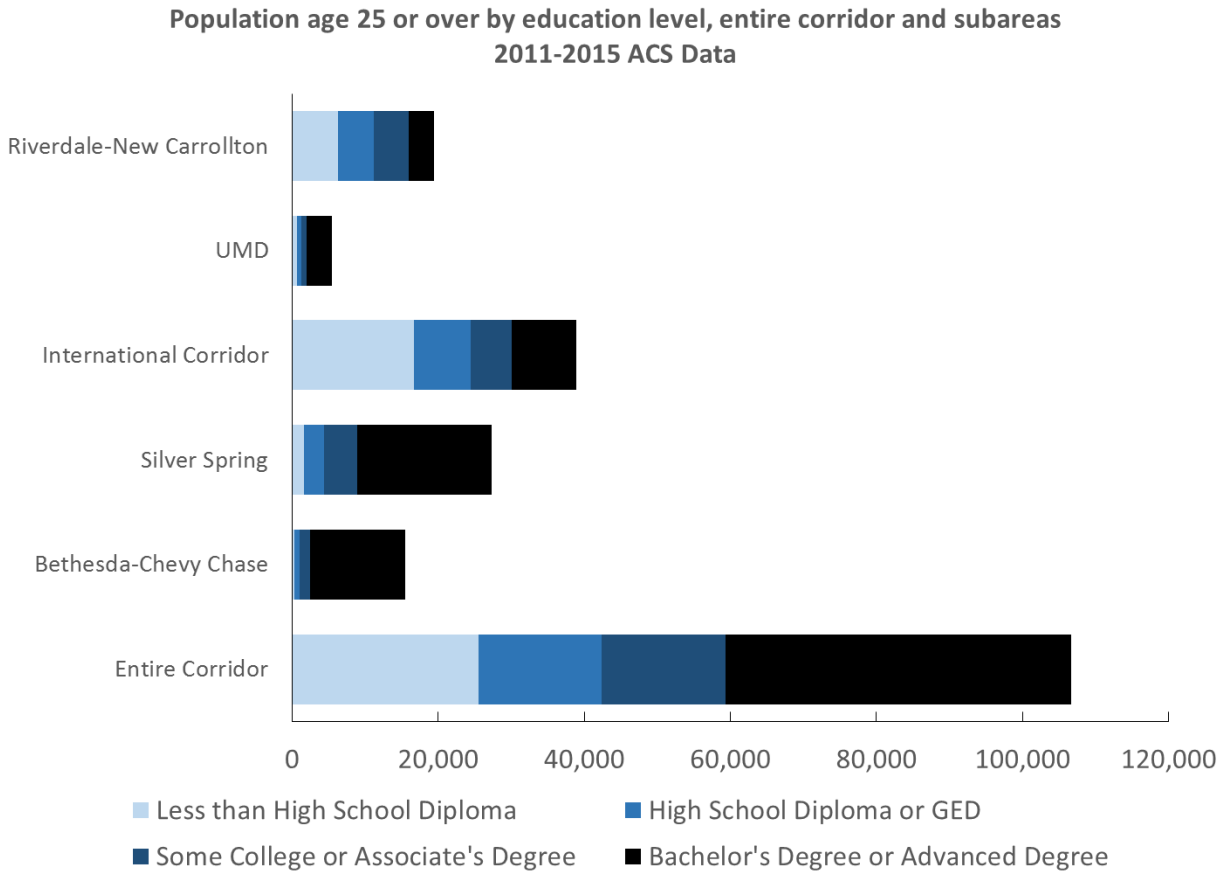
In sum, the Purple Line corridor is growing, and it is growing fastest in Bethesda and in the International Corridor. The growth in the Hispanic population has been the primary driver of population growth since the year 2000, both at the corridor level and in every subarea except Silver Spring and the University of Maryland. White and Asian populations have steadily increased as well. Only the Black population has decreased, from about 47,500 in 2000 to 41,700 in 2011-2015.

Educational Attainment of Residents

In aggregate, the corridor attracts well-educated residents. Almost half (44.3 percent) of the residents have a bachelors or advanced degree, compared to the national average of 29.7 percent. The share of residents with a college degree has increased 12.5 percent since 2000, indicating

that the region is becoming increasingly popular among working professionals. Exhibit 5 details the adult education attainment level at the corridor and subarea levels.

Exhibit 5: Educational Attainment of Adults Ages 25 Years and Older



Source: NCSG with data from the U.S. Census, American Community Survey 2011-2015 Estimates.

Educational attainment varies among subareas. Bethesda-Chevy Chase, the affluent subarea, has the greatest share of residents with a college degree (84%). Silver Spring and the University of Maryland also have high percentages of residents with college degrees (67% and 64%, respectively). The two most diverse subareas, International Corridor and Riverdale-New Carrollton, have significantly lower levels of average educational attainment: less than a quarter of residents in those two subareas have college degrees.

Like the corridor, average educational attainment in most subareas has increased substantially since 2000. The percentage of residents with college degrees increased by 11 to 12% during the period in three subareas—Bethesda-Chevy Chase, Silver Spring, and the University of Maryland. The percentage of residents with college degrees actually decreased in the International Corridor and Riverdale-New Carrollton, which is correlated with the concurrent growth in Hispanic population in those two subareas.

Income

The Washington D.C. Metropolitan Area, where the corridor resides, is among the most prosperous metro areas in the nation, but not all residents share in that prosperity. The median household income for D.C. metro households was $92,324 in 2015. In the corridor, median household incomes by subarea in 2015 ranged from $138,219 in Bethesda-Chevy Chase to $55,064 in the University of Maryland (College Park) subarea.

Income disparity has increased over time. The gap in median household income between the Bethesda and Riverdale-New Carrollton increased by nearly 40 percent from 2000 to 2015.

Changes in household income have roughly paralleled changes in educational attainment. Two subareas that experienced double-digit growth in the share of residents with a college degree from 2000 to 2015—Bethesda-Chevy Chase and Silver Spring—also experienced the highest income growth over that same time period. The two subareas that experienced a decline in the share of residents with a college degree—Riverdale-New Carrollton and International Corridor—also experienced stagnant income growth. The UMD subarea is an exception to this trend, which is likely attributable to Census measurement of student incomes, and the dominance of the student body at the University in that subarea's population.

In the meantime, the national level real median household income fell from $57,790 to $53,889, a 6.7 percent decline, indicating a strong regional economic growth and a rapid economic recovery from the recession despite the slow recovery nationwide.

As in most metropolitan areas, the cost of living in the nation's capital is high. Dr. Amy Glasmeier's Living Wage Calculator[5] indicates that a family with two adults and two children would require a living wage of about $28 per hour, with one full-time employed adult, to live comfortably in the DC area. That wage must cover housing, transportation, food, medical care, taxes, and other expenses – and it does not include childcare. That living wage translates into an annual salary of about $58,000, on par with the median household income in many subareas along the Purple Line corridor. However, in many neighborhoods along the corridor, people live in a household with income less than half of the living wage, indicating severe affordability crisis for the low-income households. Though many residents do not make enough money to live comfortably, there has been steady growth in incomes for most areas over the course of past fifteen years, despite the economic recession between 2007 and 2009. Exhibit 6 presents the average income growth for the entire corridor and its subareas.

[5] http://livingwage.mit.edu/pages/about

Exhibit 6: Real Median Household Income, 2015 dollars

Subarea	2000	2006-2010	2011-2015	Percent Change, 2000 to 2015	Annualized Percent change
Bethesda-Chevy Chase	$125,843	$127,290	$138,219	9.8%	0.7%
Silver Spring	$75,022	$78,662	$85,416	13.9%	1.0%
International Corridor	$66,138	$62,694	$68,077	2.9%	0.2%
University of Maryland	$72,690	$50,710	$55,064	-24.2%	-2.1%
Riverdale - New Carrollton	$66,369	$60,961	$66,195	-0.3%	0.0%
Entire Corridor	$78,154	$76,125	$82,661	5.8%	0.4%

Note: Values reported here are the average of the median household incomes for block groups composing the subareas.

Source: NCSG with data from the U.S. Census, American Community Survey 2011-2015 Estimates.

2.2 Employment Trends

This section describes trends in employment by industry, industrial specialization, and the education and wage levels of workers in the corridor.

Employment by Industry

Employment in the Purple Line corridor is industrially diverse: about 60 percent of residents work in five major industries with the remaining 40 percent working in various other sectors. As the home of the University of Maryland, the corridor has its largest share of residents (19%) employed in education services. The next largest share of residents work in professional, scientific, and business services, which is not surprising given the proximity to Washington, D.C. The other three largest sectors, which employ about eight percent of workers each, are administrative, support, and waste management services; health care and social assistance; and public administration. The corridor employs significantly more workers in administrative support and waste management than the national average, which is about 4.3 percent[6]. This is also true for the public administration sector, which has a national average of 4.6 percent[7] of jobs. On the other hand, the corridor area has a significantly lower share of workers in the healthcare and social assistance sector than the national average, which is about 13.8 percent[8]. The concentration of employment in administrative support (office support work) and government is likely due to the concentration of professional jobs in the area, and the DC region's specialization in government employment, respectively. Exhibit 7 details the industry

[6] 2011-2015 ACS Data.
[7] Ibid
[8] Ibid

composition of the labor force by the five major sectors and "the other sectors" at the corridor and its subarea levels.

Exhibit 7: Employment by Industry

Industry	Subarea					The Corridor	
	Bethesda-Chevy Chase	Silver Spring	Inter-national Corridor	UMD	Riverdale-New Carrollton	Total	%
Educational Services	994	2,326	1,113	18,815	1,092	24,340	19.0%
Professional, Scientific, and Technical Services	8,035	6,776	215	729	2,514	18,269	14.3%
Health Care and Social Assistance	4,854	3,023	2,109	181	574	10,741	8.4%
Public Administration	580	445	17	1,250	8,068	10,360	8.1%
Administrative, Support, Waste Management	5,601	3,139	320	385	914	10,359	8.1%
All other employment	21,889	14,149	3,780	2,490	11,601	53,909	42.1%
Total	41,953	29,858	7,554	23,850	24,763	127,978	100%

Source: NCSG with data from the U.S. Census, LEHD 2013. Detailed industry table available in Appendix.

Employment is concentrated in two subareas of the corridor, Bethesda-Chevy Chase and Silver Spring, which together comprise 56 percent of corridor employment. The largest sectors in these subareas are professional office jobs, located in the large central business districts of each subarea.

Riverdale-New Carrollton has the third largest share of employment. This subarea is the only one in the corridor with substantial industrial land. Hence, this subarea supports a large share of jobs in transportation and warehousing. This subarea is also home to many government offices, so public administration also dominates employment there.

The University of Maryland closely follows Riverdale-New Carrollton in share of corridor employment. As its name suggests, this subarea is home to the University of Maryland, College Park (Maryland's flagship State university) and hence a majority of its employees work in education services.

The International Corridor has about one-third the number of employees as University of Maryland subarea. The subarea is mostly zoned for residential use and, what little commercial use it has hosts services for residents.

Industry Specializations

Just because one industry has a dominant share of corridor employment does not mean that the corridor specializes or has a comparative advantage in that industry. An industry is disproportionately important to a region if it has a greater concentration of employment in that industry compared to a larger geography, commonly defined as the state in which the region is located or the nation as a whole.

A location quotient (LQ) is a measure of industry concentration. One can calculate a LQ for a single industry in a single region with the following equation:

$$\frac{regional\ employment\ in\ industry_i / total\ regional\ employment}{national\ employment\ in\ industry_i / total\ national\ employment}$$

If a region has a LQ index significantly larger than 1, it indicates that the industry concentration in that region is higher than the national average. On the other hand, if the LQ index's value is between 0 and 1, it indicates that the industry concentration in that region is lower than the national average.

We evaluated industry specializations at the corridor level by comparing the industry concentration in the Purple Line corridor with the industry concentration at the state level. The reference unit for each individual subarea is employment in Montgomery and Prince George's county. The results are presented in Exhibit 8. Cells highlighted in light blue represent industries that have location quotients greater than 1, which indicate industry concentration. Dark blue indicates a location quotient greater than 2, which indicates a very strong sector in the corridor.

At the corridor level, employment in transportation and warehousing, information, real estate, professional services, administrative, education, and other services all well exceed the statewide average. The highly urbanized Purple Line corridor has a much lower share, compared to the state, in blue-collar sectors such construction and manufacturing, but also in service sectors like healthcare, the arts, and accommodation and food services. The corridor roughly tracks the state in the financial industry and public administration.

At the subarea level, comparing industrial composition to the two-county area within which the corridor sits, differences are much greater. In Bethesda-Chevy Chase, there is very strong employment in white-collar sectors like finance, information real estate, and administrative support; but also in service sectors like the arts and accommodation and food services. Silver Spring has a composition similar to Bethesda. In the International Corridor, retail and health care jobs are disproportionately abundant, along with service sector jobs. At the University of Maryland, educational service employment dominates. In Riverdale-New Carrollton, the large amount of employment in transportation and warehousing near the nexus of transportation networks situates that sector as dominant, though public administration employment is very high as well.

Exhibit 8: Location Quotient

Location Quotient	Subarea					The Corridor
	Bethesda-Chevy Chase	Silver Spring	International Corridor	UMD	Riverdale-New Carrollton	
Agriculture, Forestry, Fishing and Hunting	0.34	0.00	0.00	0.44	0.00	0.05
Mining, Quarrying, and Oil and Gas Extraction	0.00	0.00	0.00	0.00	0.00	0.00
Utilities	0.61	0.00	0.00	0.00	0.00	0.09
Construction	0.87	0.92	0.56	0.21	0.29	0.67
Manufacturing	0.27	0.44	0.30	0.01	0.86	0.22
Wholesale Trade	0.43	0.58	0.59	0.03	0.84	0.36
Retail Trade	0.62	0.60	1.83	0.15	0.48	0.54
Transportation and Warehousing	0.12	0.31	0.26	0.01	**9.82**	1.79
Information	1.44	**3.24**	0.06	0.27	0.26	1.61
Finance and Insurance	**2.93**	0.65	0.88	0.11	0.36	1.09
Real Estate and Rental and Leasing	**2.41**	1.45	**2.06**	0.30	0.40	1.67
Professional, Scientific, and Technical Services	1.53	1.81	0.23	0.24	0.81	1.45
Management of Companies and Enterprises	1.30	0.63	0.04	0.11	0.07	0.72
Administrative, Support, Waste Management	**2.02**	1.59	0.64	0.24	0.56	1.30
Educational Services	0.21	0.70	1.32	**7.08**	0.40	1.74
Health Care and Social Assistance	0.99	0.86	**2.38**	0.06	0.20	0.61
Arts, Entertainment, and Recreation	1.74	0.48	0.19	0.07	0.17	0.63
Accommodation and Food Services	1.24	1.29	1.47	0.60	0.34	0.89
Other Services [except Public Administration]	1.51	1.94	1.22	0.25	0.76	1.39
Public Administration	0.13	0.14	0.02	0.48	**2.95**	0.96

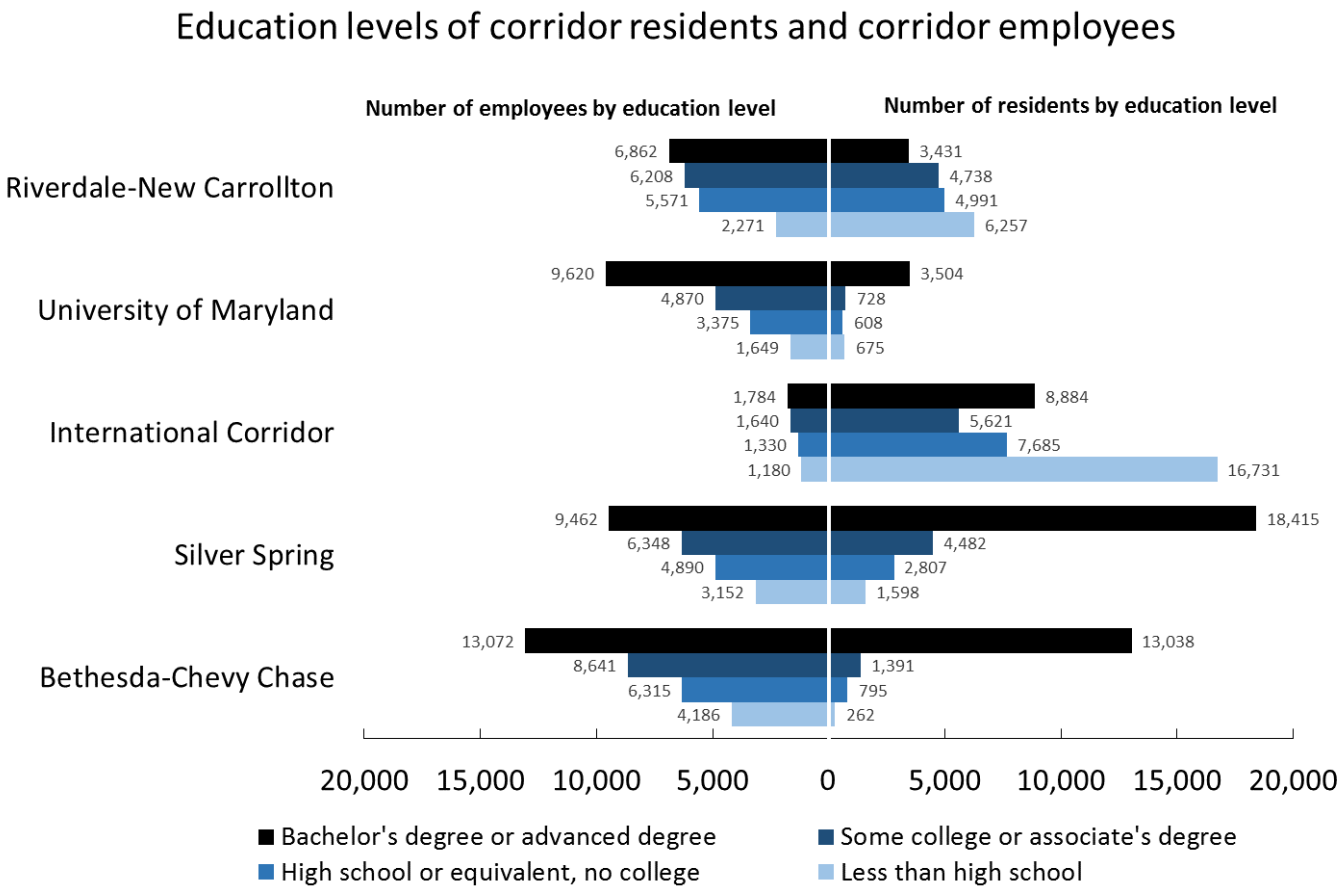
Source: NCSG with Data from the U.S. Census, LEHD 2013

Jobs-Worker Balance by Skill Level

Exhibit 9 compares the education credentials of individuals who work at jobs located in various corridor subareas, versus the education credentials of individuals who live in the various subareas. Jobs-worker balance indicates how self-contained a subarea is in terms of the labor market, specifically if the area could possibly satisfy its own demand for employment with its own residents. If employment significantly exceeds the number of residents, then the subarea must attract a labor force (and work-related traffic) from neighboring areas. On the other end, if residents significantly exceeds employment, then the subarea does not necessarily satisfy its residents' demand for jobs.

Education is broken down into two categories, representing lower and higher skill levels. In the pale shades of gray and blue, workers and residents with a high school degree or no high school degree are represented. In black and dark blue, workers and residents with at least some college experience, a bachelor's degree, or an advanced degree are represented. Both data by residence and employment are for workers age 25 or over.

Exhibit 9: Jobs-Worker Balance by Sub-corridor



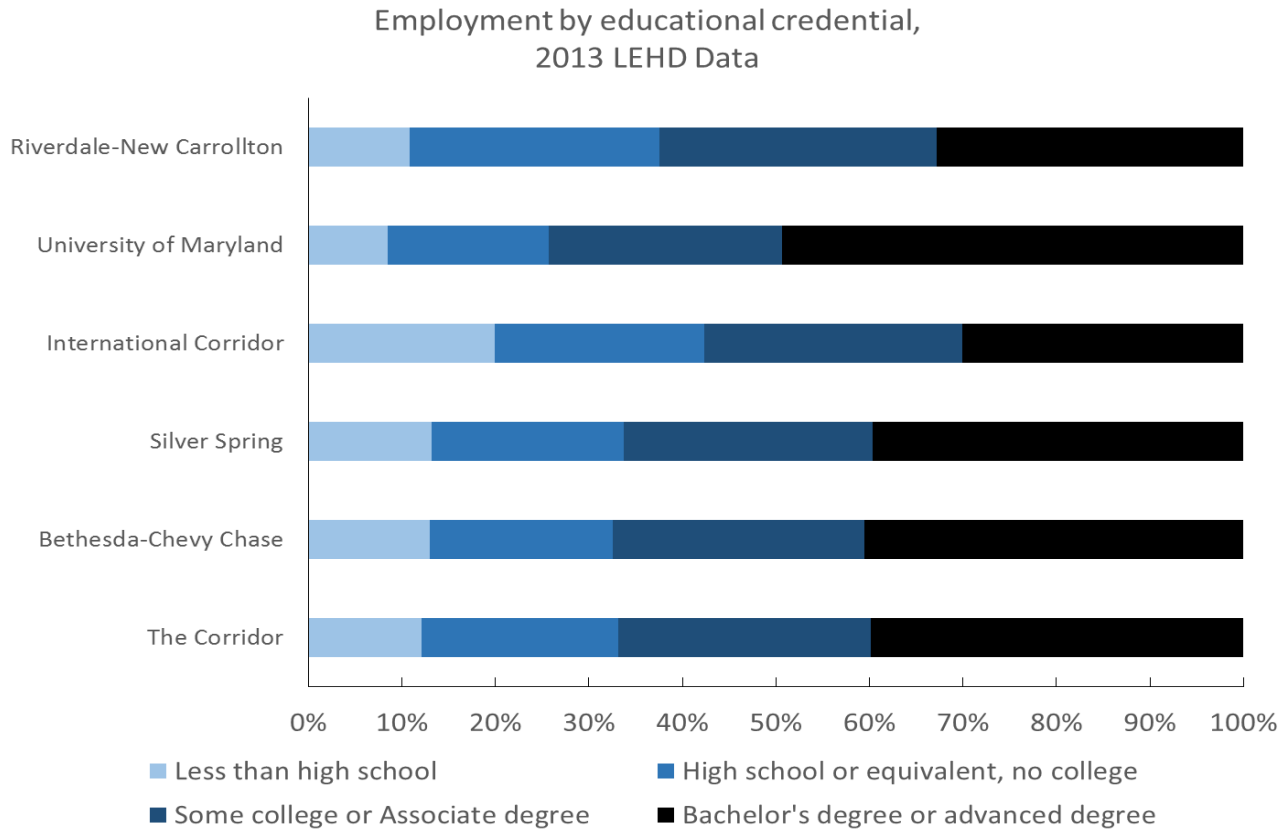
Source: NCSG analysis of LEHD (2013) and ACS (2011-2015) Data.

In Bethesda-Chevy Chase, there are significantly more employees than residents, especially low-skilled employees. Silver Spring has more residents than workers, but there are again more low-skilled employees than there are low-skilled residents. The International Corridor, as discussed, as a paucity of jobs, so there are significantly more residents at any skill level than there are jobs. The University of Maryland subarea has the opposite conditions, with significantly more jobs than residents in all skill categories. Riverdale-New Carrollton comes closest to a balance of the five subareas, but there are still more high-skill jobs than high skill residents, and more low-skill residents than low-skill jobs.

Educational Attainment of Employees in the Corridor

Exhibit 10 details the educational attainment of employees at the corridor and its subareas levels. The educational attainment of employees who hold jobs in the corridor differs slightly from the educational attainment of residents in the corridor; 44.3 percent of residents in the corridor have at least a bachelor's degree, while slightly less, 39.8 percent, of workers in the corridor have that same level of education. However, while 39.7 percent of residents of the corridor have a high school diploma or less, 33.1 percent of workers in the corridor have such qualifications.

Exhibit 10: Employment by Educational Attainment



Source: NCSG with Data from the U.S. Census, LEHD 2013

There are pronounced differences in educational attainment among employees in different subareas. University of Maryland has the most highly educated employee population, with 49.2 percent of employees holding a college degree.

Those subareas with high shares of employment in professional services, management and administration, and health care also had well-educated employee populations. Just 60 percent of employees in the Bethesda-Chevy Chase and Silver Spring subareas hold college degrees.

Educational attainment rates among employees in Riverdale-New Carrollton and the International District were the lowest among the subareas. This trend is the result of the types of jobs in those subareas; retail and transportation and warehousing jobs typically do not require college degrees.

Employment by Wage Level

More than half of workers in the Purple Line corridor earn over $3,333 per month, or $40,000 per year. On the other hand, about a fifth of workers in the corridor are employed in jobs that pay under $15,000 per year. The remaining roughly thirty percent of workers earn an annual salary between those figures. Note that LEHD data includes all jobs located in the geographic area regardless of how many hours the workers there work per week or per year, and unfortunately no distinctions on full or part time job data are available at this level of geography. Thus, it is not possible to determine what share of the low-wage jobs are actually part-time work that may pay above the minimum wage[9]. Exhibit 11 details these breakdowns at the corridor and subarea level.

Exhibit 11: Employment by Wage

Monthly earnings	Subarea					The Corridor
	Bethesda-Chevy Chase	Silver Spring	Inter-national Corridor	UMD	Riverdale-New Carrollton	
Earnings $1,250/month or less	8,568	5,966	2,097	5,397	3,861	25,889
Earnings $1,251 to $3,333/month	11,424	8,583	3,035	7,002	4,475	34,519
Earnings greater than $3,333/month	21,961	15,309	2,422	11,451	16,427	67,570
Earnings $1,250/month or less	20.4%	20.0%	27.8%	22.6%	15.6%	20.2%
Earnings $1,251 to $3,333/month	27.2%	28.7%	40.2%	29.4%	18.1%	27.0%
Earnings greater than $3,333/month	52.3%	51.3%	32.1%	48.0%	66.3%	52.8%
Total	41,953	29,858	7,554	23,850	24,763	127,978

Source: NCSG with Data from the U.S. Census, LEHD 2013.

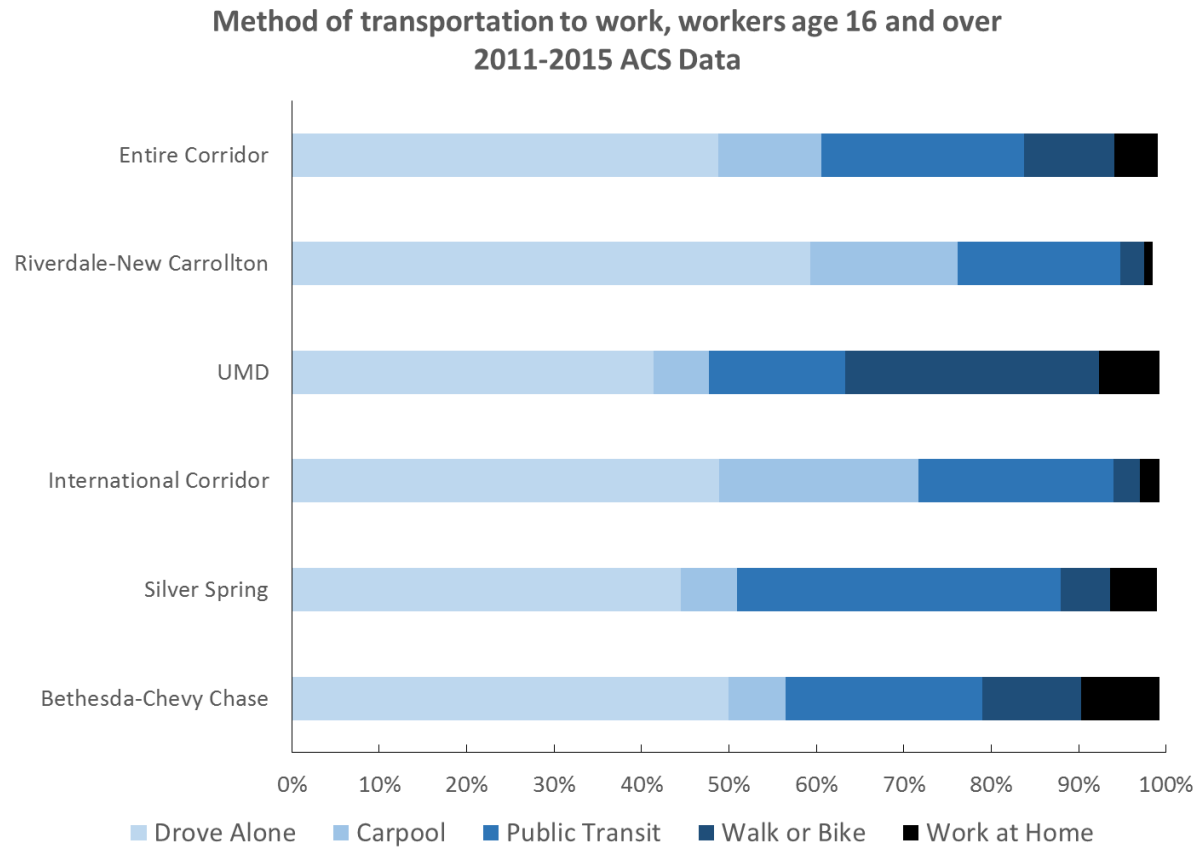
[9] However, in Maryland, the mandatory minimum wage is currently set at $8.75 per hour, which at a full-time employment of 52 weeks per year, 40 hours per week, pays $18,200. Thus, the workers earning under $15,000 per year are likely not working "full-time" as traditionally defined. Further, the LEHD data does not distinguish between individuals – meaning that some of the jobs counted in the table may be held by the same person, working more than one job.

At the subarea level, worker earnings are broadly consistent with the corridor-wide breakdown, except two subareas. In the International Corridor, less than a third of workers earn more than $40,000 per year, and accordingly a much larger share earns under that figure than at the corridor average. This aligns with the industrial breakdown described in 3.1.1, though the LEHD data do not provide wage breakdowns by industrial sector. In Riverdale-New Carrollton, fully two-thirds of workers earn more than $40,000 per year, which is likely attributable to the industrial composition of employment there. In that subarea, 70 percent of workers are employed in transportation and warehousing, public administration, and professional services, all relatively high-wage sectors, at least on the wage scale available from LEHD data.

2.3 Transportation Mode Share

Exhibit displays the modes that corridor residents use to travel to work, and travel modes at the subarea level. Fewer than 50 percent of corridor residents commute via single-occupancy vehicle, compared to 66% at the metropolitan area level. They rely on different commuting arrangements: about 1 in 4 takes public transit, 1 in 10 carpools, and 1 in 10 walks or bikes.

Exhibit 12: Mode of Transportation to Work, Workers Ages 16 and Over in 2015



Source: NCSG with data from the U.S. Census, American Community Survey 2011-2015 Estimates.

Although public transit use in the corridor is relatively high, it has decreased in the last five years. Several factors are at play:

- The percentage of residents walking or biking to work has doubled since 2000.
- The share of residents working from home has increased from 3 percent to 5 percent since 2000.
- The price of gas has dropped since 2009, contributing to auto-dependence.

Residents' choices differ among subareas:

- Single-occupancy vehicle commuting is highest at the east and west ends of the corridor (though still below the metro area average)
- The rate of residents who commute by carpool is double in more diverse subareas
- Lower income subareas have fewer residents who work from home.

2.4 Land Use and Zoning

The Purple Line will travel through a string of densely built suburban communities. Bethesda, Silver Spring, Langley Park, College Park, Riverdale, and New Carrollton have the highest densities. Some of these areas are home to early 20th century and pre-war streetcar and rail-oriented suburbs, in places like Silver Spring, Hyattsville, Takoma Park, and College Park. Other areas are oriented in a traditional post-war style, with *cul-de-sac* subdivisions oriented around wide arterial roads, as in Bethesda, the International Corridor, and New Carrollton. Between the dense nodes and arterial commercial use lies mostly single-family residential development. The zoning map below illustrates this broad pattern.

The Purple Line corridor has two additional unique features:

- Tax-exempt institutional land (green) is a dominant feature of land-use in the corridor. Some of this tax-exempt land is federal or municipal parkland, but nearly ten percent of the land, or about 1,335 acres, is held by the University of Maryland.
- There is a paucity of industrial land in the corridor. The majority of industrial land is concentrated near the New Carrollton area at the confluence of US Route 50, I-495, the Baltimore-Washington Parkway, and heavy rail lines. There is also some industrial land in Riverdale, North College Park, and Lyttonsville (between Silver Spring and Bethesda).

Residential and commercial land uses dominate the corridor. The Purple Line will be an important connector for both. It will be strategically located within walking distance of many multi-family developments, notably in the major nodes of Bethesda, Silver Spring, Riverdale, and New Carrollton, but also along the route in smaller nodes like Chevy Chase Lake, Long Branch, and Langley Park. The Purple Line will also provide a fixed transit link between most commercial nodes within the corridor, including areas zoned for commercial, mixed use, and industry. For a detailed accounting of land use by acreage and parcel counts, see Appendix 2.

Exhibit 13 and Exhibit 14 details the zoning and land use for the corridor.

Exhibit 13: Zoning in the Corridor

Source: NCSG analysis of Montgomery County, WMATA, and Prince George's County Data.

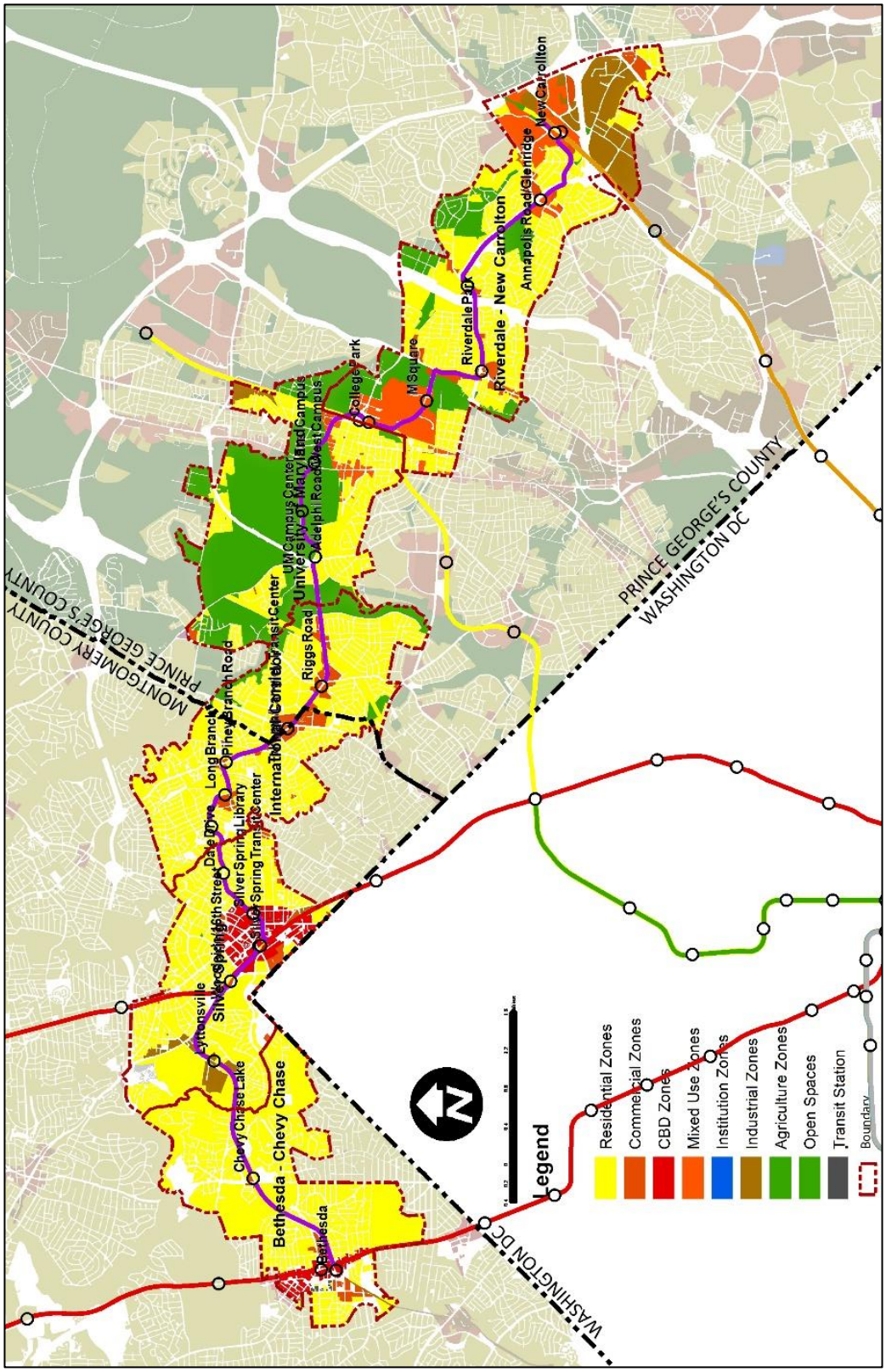


Exhibit 14: Land Use in the Corridor

Source: NCSG analysis of Montgomery County, WMATA, and Prince George's County Data.

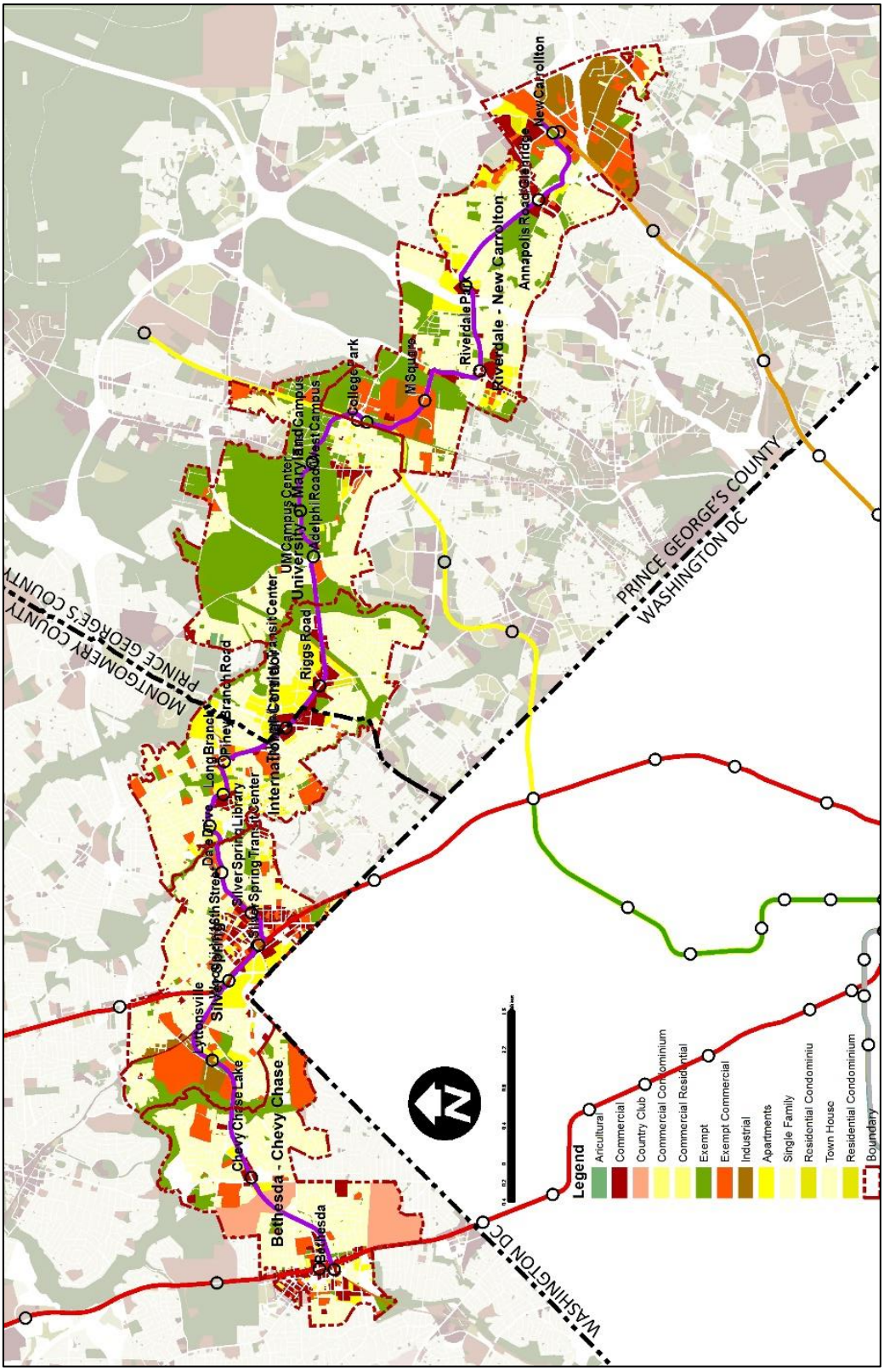


Exhibit 15 displays vacancy by parcel, and the total square feet of built space. Vacancy is defined as the percentage of developed parcels[10] with an improved value of less than $10,000. Built space is a simple aggregation of the total number of finished structure space on each parcel. Vacancy is significantly higher in the Riverdale-New Carrolton area. That area, however, does have the largest amount of structure space, likely due to the large number of transportation and warehousing facilities in its industrial zones. The built-up areas of Bethesda and Silver Spring have a large amount of building space, and varying vacancy rates. Surprisingly, given the area's socioeconomic diversity, the International Corridor has the lowest vacancy rate in the corridor, with less than three percent of parcels vacant. There are still hundreds of vacant or underused parcels spread throughout the corridor, with a small concentration in Riverdale-New Carrollton.

Exhibit 15: Parcel Vacancy and Structural Development by Corridor Subarea

	Bethesda - Chevy Chase	Silver Spring	Inter-national Corridor	UMD	Riverdale - New Carrolton	Total
Number of vacant parcels	200	379	206	252	697	1,734
Number of undeveloped or exempt parcels*	438	475	420	736	1,391	3,460
Number of developed parcels	4,576	5,256	8,329	3,759	8,125	30,045
Vacancy rate (Vacant parcels/developed parcels)	4.4%	7.2%	2.5%	6.7%	8.6%	5.8%
Number of Total Parcels	5,014	5,731	8,749	4,495	9,516	33,505
Total SQFT of built space	23,073,659	24,937,521	14,988,250	7,111,389	34,959,578	105,070,397

*Land use denoted as agricultural, exempt, exempt commercial, marsh land, roads

Source: NCSG analysis on the Prince George's County data and the Montgomery County data.

2.5 Summary

The Purple Line corridor is a microcosm of the Washington DC region: wealthy, segregated, diverse, well educated, disadvantaged, and densely populated. The growing and dynamic area that will be home to the Purple Line has a large immigrant population and a strong and diverse industrial base. A large university and federal and state government jobs anchor the region's employment, which also has an extensive amount of other professional employment. The corridor's residents already rely on public transportation to commute to work – and in recent

[10] Parcels with a land use description of apartments, commercial, commercial condo, commercial residential, country club, industrial residential, residential commercial, residential condo, and town house. The remaining land use descriptions of agricultural, exempt, exempt commercial, and marsh land were excluded from the vacancy rate calculation.

years, more have done so. The west side of the corridor, in Silver Spring and Bethesda, is becoming increasingly higher-income and better educated, while the eastern side, especially in the densely populated International Corridor and Riverdale-New Carrollton, continues to be disadvantaged in terms of income, education, and status.

Bethesda-Chevy Chase is the least diverse subarea in the corridor, its residents are the best educated and have the highest incomes. Incomes in this area well exceed the corridor and regional average, as it is one of the wealthiest parts of the area. The central business district in Bethesda attracts many employees in finance, insurance, real estate and other professional occupations, but also service sector employees in the vast commercial district there. Recent trends in this area indicate a continued progression toward a subarea that is highly segregated by income; but the Purple Line will offer a currently unmatched ability to commute to the large jobs center.

Just to the east in Silver Spring, trends are similar. While Silver Spring is less segregated by income and has significantly more racial diversity than Bethesda, this has been changing during this century. Downtown Silver Spring continues to attract residential and commercial development, and many higher-income professionals, who tend to be white, are calling Silver Spring home.

The burgeoning suburban International Corridor anchors the center of the Purple Line Corridor. This area has the highest population of any subareas, and is most diverse, with a large proportion of Hispanic residents. Many of these residents are immigrants or the children of immigrants, have lower levels of education, and are paid less than other residents of the corridor. Population growth in this part of the corridor has been strong, though progression toward economic equity has been relatively slow.

The University of Maryland subarea is dominated by the College Park campus of the University of Maryland, which employs tens of thousands in full-time jobs while attracting tens of thousands more students studying for college and advanced degrees. The employees of the University are generally highly educated. The resident population of the area is dominated by low-income students who generally reside in the area for four years or less. That said, the subarea is diverse, and its own growing central business district which is an employment node for the subarea.

Perhaps the most industrially and residentially diverse area is Riverdale-New Carrollton, which combines traits of the other areas. The large, low-density suburban part of this subarea houses many lower-educated residents and immigrants, but it is also home to middle-income professionals and families. This racially and ethnically diverse area also as a large and unique light industrial employment area situated at the nexus of multiple important regional highways. This subarea is unique in that it is losing many African-American residents while gaining White and Hispanic residents.

3 Purple Line Corridor Employment Forecast

This section presents a 25-year and employment forecast for the Purple Corridor region, which consists of all of Prince George's County and Montgomery County[11]. A statewide transportation forecast model and a statewide economic forecast model are applied to the analytical framework. There are two parts to the results. The first part details the long run forecast of travel patterns at the Purple Line region – through analysis of variables such as annual transit trips and annual vehicle miles traveled. The second part presents employment projection from the economic forecast model, specifically regarding the geographic location and industry sector of new employment.

3.1 Analysis Framework

Transportation Investments Impacts on Economic Development

In their book, *The Geography of Transport Systems*, Dr. Jean-Paul Rodrigue and Dr. Theo Notteboom identify eight impacts of transportation investments on economic development. Those impacts fall under four categories (core, operational, geographical, and expenditure). The impacts by category are:

- **Core Impacts:** fundamental improvements in the physical capacity to move people and goods.
    1. Increase capacity to transport people and goods
    2. Decrease cost to transport people and goods
- **Operational Impacts:** improvements in the utilization of existing transportation assets, measured in terms of time performance (e.g., reliability) and loss or damage.
    3. Reduce travel time
    4. Improve reliability
- **Geographical Impacts:** increases in the accessibility of new places, which can improve the productivity of existing economic activity and spur new activity.
    5. Increase accessibility
    6. Impact location decisions for people and businesses
- **Expenditure Impacts:** increases in economic activity due to expenditures on construction and maintenance
    7. Construction expenditures
    8. Operations and maintenance expenditures.

Tools Used to Evaluate Impacts

Research in transportation economics has firmly established the pathways through which investments in transit can impact regional economies. These impacts, and their associated benefits, are often estimated using transportation and economic models. Here, we use two such

[11] Forecasts for auto travel on the regional road network, and transit travel, are available in Appendix 3. That Appendix also contains model documentation.

models, MSTM and TREDIS, to estimate the impacts of the Purple Line on travel behavior and employment, respectively.

The MSTM is a trip-based, four-step travel demand forecasting model developed by NCSG and Parsons Brinkerhoff (now WSP USA) for the Maryland State Highway Administration to estimate the impacts of transportation investments, changes in land use, and exogenous factors beyond state boundaries like freight flows. The model input data include population and employment by model zones, highway and public transit networks, and parameters that govern travel behavior. Model outputs include traffic flows on the overall system, as well as specific corridor and individual links.

TREDIS is a transportation economics model that spans economic impact analysis, benefit-cost analysis, financial analysis, as well as freight and trade impact analysis. One can use it to assess impacts and benefits of capital investments, operations, maintenance, and financing for all transportation modes and types of projects. TREDIS estimates regional impacts in terms of changes in costs, productivity, employment, and economic growth. It can also provide the benefits associated with energy use and environmental effects.

TREDIS relies on a set of unique modules to calculate those impacts:

- The **travel cost module** translates changes in travel time, costs, reliability, and safety into impacts to household income and business productivity.
- The **market access module** translates changes in labor market access and intermodal connectivity into impacts to business productivity and growth in employment.
- The **economic adjustment module** incorporates IMPLAN, an input-output software that models industry linkages, to estimate industry dependency and trade flows. The module then applies a time series, multi-regional economic model to calculate long-term impacts on job growth, income, and business productivity.

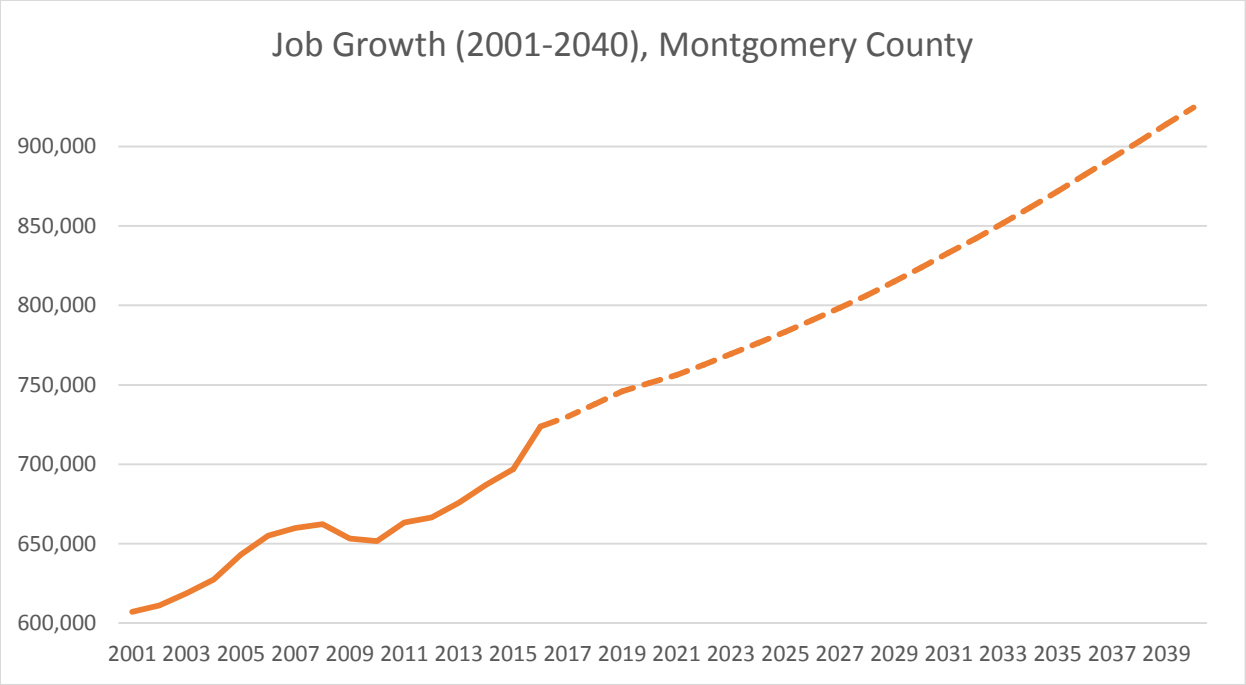
The models are fully calibrated to Maryland's economy, and the analysis parameters reflect local economic characteristics and household behavior. Purple Line Employment Forecast

This section describes the employment forecast for the Purple Line region from the baseline to 2040. It describes the employment forecast given construction of the Purple Line at the regional, county, and subarea level. The employment forecast provides a broader overview of employment trends in the long run. The regional and subarea analyses emphasize regional employment clustering effect by industry sectors, underlining the importance of understanding regional industry dynamics in developing economic strategies along the Purple Line corridor.

3.2 Long-Run Employment Forecast at the County Level

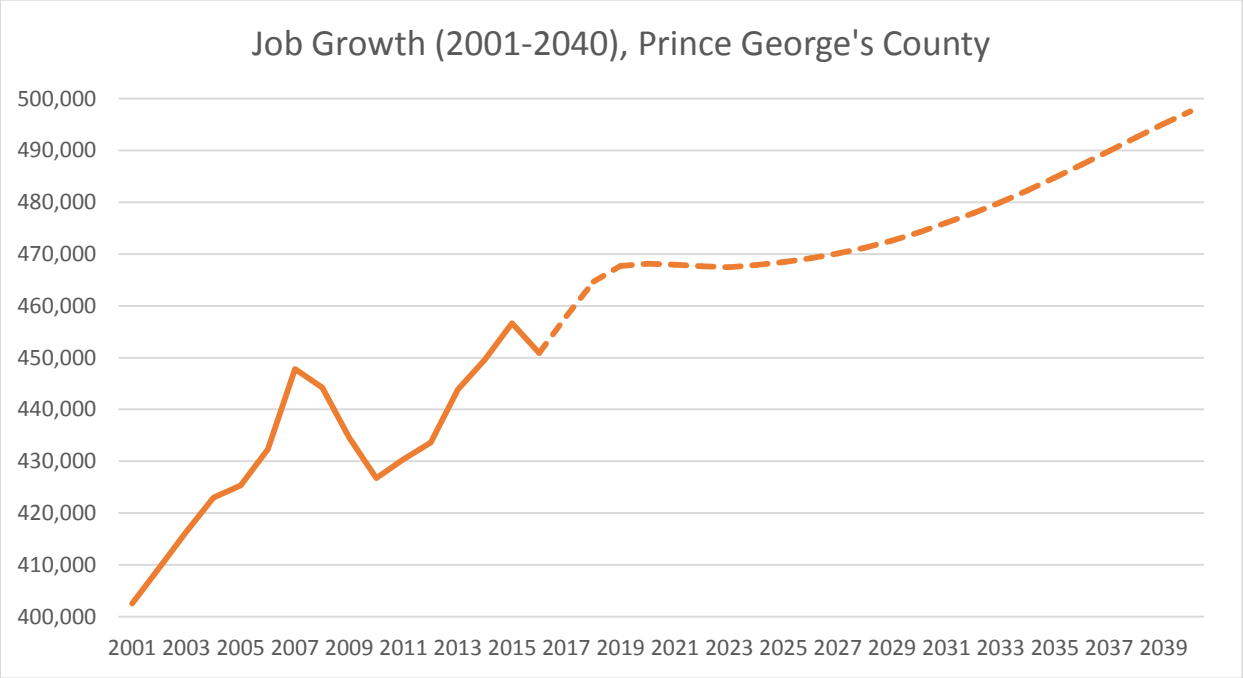
Exhibit andExhibit show total employment in Montgomery and Prince George's Counties, respectively, over the study period. 2016 is the assumed "start year" for construction in all projections; 2023 is the assumed year that operations begin. The solid trend line represents existing data while the dash trend line shows the employment forecast.

Exhibit 16: Employment Growth in Montgomery County, 2001 - 2040



Source: NCSG with data from LEHD, TREDIS Model

Exhibit 17: Employment Growth in Prince George's County, 2001 - 2040



Source: NCSG with data from LEHD, TREDIS Model

Both counties exhibit substantial employment growth based on the economic forecast results from TREDIS. Montgomery County is expected to have more than 920,000 employees by 2040, or 27.8% growth from the 2016 employment level. Prince George's County is expected to have almost 500,000 employees by 2040, or 10.3% growth from the 2016 employment level. Montgomery County has a stronger employment base and growth trend than Prince George's County.

In the next sections, a detailed industry breakdown at the corridor and subarea level will be provided to understand the regional employment clusters by industry and their dynamic growth in the long run based on economic forecast.

3.3 Employment Forecasts at the Corridor Level

Error! Reference source not found.24 shows employment forecasts by industry at the two-county and corridor levels in selected years given construction of the Purple Line. The two counties will add about 250,000 jobs, and the corridor will capture about 1/5 (43,000) of those jobs. The inner suburbs of Prince George's and Montgomery Counties will continue to grow as regional employment clusters. Growth will be especially strong in industrial sectors, such as construction, finance and insurance, professional and technical services, administrative support, and health care.

Exhibit 18: Employment Forecast by Industry at the two-county and Corridor levels

Industry	Montgomery & Prince George's			The Corridor		
	2016	2040	2040-2016	2016	2040	2040-2016
Agriculture, Forestry, Fishing and Hunting	1,580	1,675	95	49	51	2
Mining, Quarrying, and Oil and Gas Extraction	884	1,263	379	0	0	0
Utilities	1,707	1,653	-54	46	45	-1
Construction	95,110	131,377	36,267	10,609	15,278	4,669
Manufacturing	20,002	17,827	-2,175	1,230	1,071	-159
Wholesale Trade	22,668	25,299	2,631	1,754	1,986	232
Retail Trade	99,768	107,090	7,322	9,208	10,075	867
Transportation and Warehousing	33,650	33,531	-119	10,040	9,369	-671
Information	24,991	26,561	1,570	5,581	6,038	457
Finance and Insurance	51,284	82,453	31,169	10,427	17,149	6,722
Real Estate and Rental and Leasing	62,833	70,217	7,384	14,421	16,526	2,105
Professional, Scientific, and Technical Services	147,746	168,256	20,510	27,126	31,229	4,103
Management of Companies and Enterprises	9,388	9,273	-115	919	926	7

Administrative and Support and Waste Management and Remediation Services	77,948	133,175	55,227	15,100	26,774	11,674
Educational Services	24,668	27,221	2,553	4,580	4,843	263
Health Care and Social Assistance	126,287	166,121	39,834	13,946	18,801	4,855
Arts, Entertainment, and Recreation	26,281	27,432	1,151	3,106	3,293	187
Accommodation and Food Services	74,503	98,046	23,543	11,881	16,086	4,205
Other Services [except Public Administration]	84,263	100,514	16,251	16,599	20,165	3,566
Public Administration	189,000	193,217	4,217	28,041	27,812	-229
Total	1,174,561	1,422,201	**247,640**	184,663	227,517	**42,854**

Source: TREDIS Projection

3.4 Employment Forecast at the Subarea Level

Exhibit 25 takes the information from Exhibit 24 and Exhibit 25 and disaggregates the numbers to the subarea level under the assumption that each segment of the corridor retains a constant share of county employment in each industry.

Exhibit 19: Change in Jobs (2016-2040) by Industry at the corridor and subarea levels, Build Scenario

Industry	Subarea					The Corridor
	Bethesda-Chevy Chase	Silver Spring	Inter-national Corridor	UMD	Riverdale-New Carrollton	
Agriculture, Forestry, Fishing and Hunting	4	0	0	-2	0	2
Mining, Quarrying, and Oil and Gas Extraction	0	0	0	0	0	0
Utilities	-1	0	0	0	0	-1
Construction	2,382	1,808	187	143	211	4,732
Manufacturing	-13	-14	-12	-2	-115	-156
Wholesale Trade	100	96	7	1	29	233
Retail Trade	475	328	87	-5	-18	866
Transportation and Warehousing	30	55	0	-1	-938	-853
Information	175	279	1	-2	-2	451
Finance and Insurance	5,297	831	232	73	243	6,677

Real Estate and Rental and Leasing	1,402	600	81	8	10	2,101
Professional, Scientific, and Technical Services	2,221	1,873	36	4	14	4,149
Management of Companies and Enterprises	10	3	0	-4	-3	6
Administrative and Support and Waste Management	6,535	3,662	325	336	798	11,656
Educational Services	61	142	54	5	0	262
Health Care and Social Assistance	2,230	1,389	950	66	209	4,845
Arts, Entertainment, and Recreation	154	30	0	0	0	185
Accommodation and Food Services	2,008	1,485	274	275	161	4,202
Other Services [except Public Administration]	1,705	1,564	148	32	103	3,552
Public Administration	57	44	1	-45	-287	-229
Total	**24,832**	**14,175**	**2,372**	**883**	**415**	**42,678**

Source: TREDIS Projection

In the build scenario, nearly 43,000 additional permanent jobs will occur in the corridor by the year 2040. If subsectors retain their proportionate share in each industry, Bethesda-Chevy Chase will add nearly 25,000 jobs, Silver Spring will add over 14,000 jobs, the International Corridor will add less than 2,500 jobs and the University of Maryland and Riverdale-New Carrolton will add less than 1,000[12].

4 Summary, Caveats, and Next Steps

This section presents a summary of the findings, identifies caveats, and offers suggestions for next steps.

4.1 Summary of Findings

The long run projections in travel patterns and employment suggest that the Purple Line corridor is likely to witness continuous economic growth, accompanied by increasing traffic in the region. The light-rail project will significantly boost transit use, but it has limited impact in reducing

[12] We also compared the 2040 Build and No Build scenarios in terms of total employment and industry breakdown to estimate the net employment impact of the Purple Line. The results are attached in Appendix Exhibit 3.9. We are likely to observe an additional 2,000 jobs per year as a direct result of the Purple Line construction and operation, 500 of which are generated within the corridor area. The Purple Line, *per se*, impacts regional employment marginally, even though the entire region is projected to have a steady increase in employment in the long run.

auto traffic. Furthermore, although limited in its scope and approach, the analyses offer the following insights:

- The Purple Line corridor is home to a diverse population and economy.
- The corridor will continue to diversify with growth in the Hispanic population, though this diversification will occur unevenly across the corridor.
- The corridor hosts a rich stock of human capital by attracting highly educated residents, unevenly across different subareas.
- The corridor economy is diverse with specializations in Transportation and Warehousing; Educational Services; Real Estate and Rental and Leasing; Information; Professional, Scientific, and Technical Services; Accommodation and Food Services; Administrative, Support, and Waste Management; and Finance and Insurance.
- Subareas of the corridor have clear industrial specializations, correlated with the diverse demographic compositions.
- The region is auto-dependent with some subareas more walkable than the others.
- Zoning and land use are also diverse across different subareas.

Although the corridor has a robust overall economic performance, there are important disparities among subareas. As measured by educational attainment level and median household income, Bethesda-Chevy Chase and Silver Spring are more affluent than the International Corridor and Riverdale-New Carrollton. For example, Bethesda-Chevy Chase has a median household income of $138,219 and 84 percent of residents with a college degree, compared to $66,195 and 17.7 percent in Riverdale-New Carrollton.

The disparities between these subareas grew between 2000 and 2015 and, without intervention, will likely continue to enlarge in the future. It is this growing inequality that raises the concerns about the need for additional intervention to support economic development in the Purple Line corridor. Without such investments, our analysis suggests that the Purple Line may not catalyze significant change in those regions that need it most.

Employment composition also varies among subareas. Although the Bethesda and Silver Spring subarea are home to only 33.3 percent of the population, they are home to 56.1 percent of corridor employment. Much of this employment is in high-wage industries, like Finance and Insurance; Real Estate and Rental and Leasing; and Professional, Scientific, and Technical Services. The International Corridor and Riverdale-New Carrollton, on the other hand, together house about 53 percent of the corridor's residents, but only about 25 percent of the jobs in the corridor. The jobs in these areas are in lower wage, lower skill sectors like retail, transportation and warehousing, and other service industries. The University of Maryland houses about 13 percent of corridor residents is home to about 19 percent of corridor jobs, 75 percent of which are in education services, tied to the University.

Against this background, our models suggest the Purple Line will have modest (compared to the existing landscape) impacts on travel behavior and economic growth. We expect that it will eliminate half of one percent of vehicle trips in the two counties each year, or 13.1 million trips. The Purple Line will spur 29 million more annual trips by rail transit, a 11.4 percent increase

from the no-build scenario. And, as a result of construction and operations expenditures alone, it will create 2,620 net new jobs—part of the 247,640 anticipated new jobs in the region.

Although the Purple Line is not directly responsible for the quarter-million new jobs that will come to the two-county region by 2040, it can impact where those jobs locate and how they shape the long-term health of the economy. Without policy intervention, growth will likely continue to accrue in the more prosperous subareas, and travel will continue to become more inefficient with congested trains traveling west and trains with spare capacity traveling east in the AM peak (and the reverse in the PM peak). Targeted interventions to support transit oriented and economic development in less prosperous subareas in the corridor could help balance inequities.

4.2 Caveats and Limitations

While our analysis provides several new insights, it is important to understand the limitations of our approach. Our characterization of existing conditions provides a useful overview of the populations and industries in the Purple Line Corridor and its subareas. But, the American Community Survey data are only a sample, and the LEHD data are dated and often imprecise at small levels of geography. The land use data are also limited; it would be useful, for example to have better data on commercial vacancies and rents.

The models we employed are state of the art and used extensively in the state of Maryland. The MSTM, however, is better suited for analysis of transportation investments that have impacts over large areas. The Purple Line project meets that criterion, but not by much. More importantly, MSTM is better suited for analyzing travel impacts on roadways, not rail transit. It is not well suited, importantly, for developing sound transit ridership estimates.

TREDIS, although the best option for this analysis, is not well suited for analysis at the sub-county scale. Our approach of assuming that the corridor and subareas of the corridor will maintain a constant share of 2013 employment levels provides a reasonable benchmark for estimating how subareas might grow. But, it is almost surely the case that, with only a little public-sector support, the corridor could capture more than its current share of county employment and that the Eastern segments of the corridor could capture more than their current share of corridor employment. Finally, we have focused our future forecasts almost exclusively on employment. TREDIS has the capacity to explore a number of additional measures, such as cost-benefit ratios, fiscal impact, and net social benefit. We leave that for future research.

4.3 Next Steps

Our goal for this report was to provide baseline data, projections, and analysis to inform the creation of a comprehensive economic development plan for the corridor. That is the next step.

Since our preliminary analysis reveals stark differences between subareas, the next step will require further, more in-depth analysis of the populations and economies of each subarea. The next step will also require community engagement. Data and analysis alone cannot form policy. Policy development requires the qualitative weighing of impacts – what do we value most, and

how do our different options impact those values? Getting answers to those questions requires going out to the community.

5 Appendices

Appendix 2

Appendix Exhibit 2.1 provides historical data to append Exhibits 3 and 4, which showed population by race and ethnicity in the most recent 2011-2015 period. All subareas have experienced absolute population growth since the year 2000, with percentage growth highest in Bethesda and the International Corridor. Growth in the Hispanic population has been particularly strong since 2000 in every subarea, with the exception of the University of Maryland subarea.

Appendix Exhibit 2.1 Population by Race and Ethnicity

		Bethesda-Chevy Chase	Silver Spring	Inter-national Corridor	UMD	Riverdale-New Carrollton	Entire Corridor
2000	**Total**	14,801	31,504	49,605	7,960	29,452	133,322
	White	12,492	14,822	16,842	5,244	7,040	56,440
	Black	778	11,349	16,230	1,302	17,876	47,534
	Asian	803	1,879	3,275	764	1,118	7,839
	Hispanic*	915	4,314	20,755	760	4,982	31,726
2006-2010	**Total**	18,703	31,493	55,257	21,277	29,108	155,838
	White	16,000	16,924	16,644	15,228	8,711	73,507
	Black	1,302	10,549	15,908	2,979	16,729	47,467
	Asian	1,709	2,180	2,742	2,724	603	9,958
	Hispanic	1,030	4,191	30,488	1,857	9,498	47,064
2011-2015	**Total**	20,667	35,917	59,622	22,292	31,573	170,071
	White	16,905	18,884	13,873	13,494	10,850	74,006
	Black	986	10,474	12,632	3,411	14,269	41,772
	Asian	1,786	2,748	2,614	3,406	1,007	11,561
	Hispanic	1,469	4,936	36,187	1,838	13,262	57,692

Percent Change, 2000 to 2011-2015

		Bethesda-CC	Silver Spring	International Corridor	UMD**	Riverdale	Entire Corridor
	Total	39.6%	14.0%	20.2%	4.8%	7.2%	17.9%
	White	35.3%	27.4%	-17.6%	-11.4%	54.1%	18.2%
	Black	26.7%	-7.7%	-22.2%	14.5%	-20.2%	-17.0%
	Asian	122.4%	46.2%	-20.2%	25.0%	-9.9%	15.3%
	Hispanic	60.5%	14.4%	74.4%	-1.0%	166.2%	80.4%

*The Census classifies "Hispanic" as an ethnicity, which can be associated with any race.

** Percent change for UMD population reported from 2006-2010 to 2011-2015 due to discrepancies in population counts for the UMD area in the year 2000. Accordingly, change for the entire corridor from 2000 to 2011-2015 excludes UMD area data.

Source: NCSG with data from the U.S. Census, American Community Survey 20011-2015 Estimates.

Appendix Exhibit 2.2 displays estimated population counts by four levels of education, and a total count. These population counts are for individuals 25 and over, and the counts are based on where the individuals live – in each of the subareas, and in the entire corridor. Two dates are displayed, 2000 and 2011-2015, along with the percentage breakdown of the counts. Bethesda and Silver Spring have consistently been very well educated, while the eastern side of the corridor has actually seen rising shares of low education, and falling shares of high education.

Appendix Exhibit 2.2 Population age 25+ by Education

		Bethesda-Chevy Chase	Silver Spring	Inter-national Corridor	UMD	Riverdale – New Carrollton	Entire Corridor
2000	**Less than High School Diploma**	431	2,519	10,069	547	4,127	17,693
	High School Diploma or GED	642	2,805	6,164	666	4,912	15,189
	Some College or Associate's Degree	1,168	4,596	5,733	799	4,273	16,569
	Bachelor's Degree or Advanced Degree	6,266	12,521	8,006	2,173	3,156	32,122
	Sum	8,507	22,441	29,972	4,185	16,468	81,573
2011-2015	**Less than High School Diploma**	262	1,598	16,731	675	6,257	25,523

	High School Diploma or GED	795	2,807	7,685	608	4,991	16,886
	Some College or Associate's Degree	1,391	4,482	5,621	728	4,738	16,960
	Bachelor's Degree or Advanced Degree	13,038	18,415	8,884	3,504	3,431	47,272
	Sum	15,486	27,302	38,921	5,515	19,417	106,641

Percentage Change 2000 – 2015

2000	**Less than High School Diploma**	5.1%	11.2%	33.6%	13.1%	25.1%	21.7%
	High School Diploma or GED	7.5%	12.5%	20.6%	15.9%	29.8%	18.6%
	Some College or Associate's Degree	13.7%	20.5%	19.1%	19.1%	25.9%	20.3%
	Bachelor's Degree or Advanced Degree	73.7%	55.8%	26.7%	51.9%	19.2%	39.4%
	Sum	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
2011-2015	**Less than High School Diploma**	1.7%	5.9%	43.0%	12.2%	32.2%	23.9%
	High School Diploma or GED	5.1%	10.3%	19.7%	11.0%	25.7%	15.8%
	Some College or Associate's Degree	9.0%	16.4%	14.4%	13.2%	24.4%	15.9%
	Bachelor's Degree or Advanced Degree	84.2%	67.4%	22.8%	63.5%	17.7%	44.3%
	Sum	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%

Note: educational attainment data, at the block group level, is unavailable prior to the 2009-2013 5-year ACS averages, so only 2000 and 2011-2015 data are displayed here.

Source: NCSG with data from the U.S. Census, American Community Survey 20011-2015 Estimates.

Appendix Figure 2.3 completes Exhibit 7 from Section 2, with a complete breakdown of industries by number of jobs in each subarea. The chart shows that traditional primary sector industries in natural resources and manufacturing are a small component of this dense residential

and commercial area. Service sector jobs like in health care and the food service sector are important components of corridor employment.

Appendix Exhibit 2.3 Employment by Industry

Industry	Subarea					The Corridor	
	Bethesda-Chevy Chase	Silver Spring	Inter-national Corridor	UMD	Riverdale-New Carrollton	Total	Percent
Agriculture, Forestry, Fishing and Hunting	8	0	0	6	0	14	0.0%
Mining, Quarrying, and Oil and Gas Extraction	0	0	0	0	0	0	0.0%
Utilities	48	0	0	0	0	48	0.0%
Construction	2,127	1,614	248	289	427	4,705	3.7%
Manufacturing	284	327	57	8	534	1,210	0.9%
Wholesale Trade	473	456	117	17	550	1,613	1.3%
Retail Trade	2,797	1,930	1,478	375	1,263	7,843	6.1%
Transportation and Warehousing	137	254	53	4	6,654	7,102	5.5%
Information	1,367	2,185	10	145	145	3,852	3.0%
Finance and Insurance	4,161	653	225	92	305	5,436	4.2%
Real Estate and Rental and Leasing	2,169	928	335	155	211	3,798	3.0%
Professional, Scientific, and Technical Services	8,035	6,776	215	729	2,514	18,269	14.3%
Management of Companies and Enterprises	675	232	4	33	22	966	0.8%
Administrative, Support, Waste Management	5,601	3,139	320	385	914	10,359	8.1%
Educational Services	994	2,326	1,113	18,815	1,092	24,340	19.0%
Health Care and Social Assistance	4,854	3,023	2,109	181	574	10,741	8.4%
Arts, Entertainment, and Recreation	1,019	200	20	22	58	1,319	1.0%

Accommodation and Food Services	3,965	2,932	845	1,098	642	9,482	7.4%
Other Services [except Public Administration]	2,659	2,438	388	246	790	6,521	5.1%
Public Administration	580	445	17	1,250	8,068	10,360	8.1%
Total	**41,953**	**29,858**	**7,554**	**23,850**	**24,763**	**127,978**	**100.0%**

Source: NCSG with data from the U.S. Census, American Community Survey 20011-2015 Estimates.

Appendix Exhibit 2.4 displays mode share information for three time periods: 2000, 2006-2010, and 2011-2015, providing historical data for Exhibit 11. Over time, transit modes (for the commute to work for workers age 16 and over) have become more diverse in every subarea. Silver Spring leads in public transit, the International Corridor in carpooling, Bethesda in telecommuting, UMD in walking to work, and Riverdale in driving alone. There have been large increases in the share walking, biking, or telecommuting over time in the entire corridor.

Appendix Exhibit 2.4 Transportation Mode Share

		Bethesda-Chevy Chase	**Silver Spring**	**Inter-national Corridor**	**UMD**	**Riverdale – New Carrollton**	**Entire Corridor**
2000	Drove Alone	58.8%	51.2%	52.4%	61.8%	57.2%	54.4%
	Carpool	6.8%	9.4%	20.3%	6.4%	20.3%	14.8%
	Public Transit	18.5%	30.7%	20.8%	12.0%	17.5%	22.0%
	Walk or Bike	8.3%	4.6%	2.1%	17.2%	2.3%	4.5%
	Work at Home	7.0%	3.8%	2.0%	2.1%	1.8%	3.0%
2006-2010	Drove Alone	50.5%	45.0%	43.6%	39.2%	57.3%	46.7%
	Carpool	6.4%	8.6%	24.6%	9.7%	19.6%	16.3%
	Public Transit	23.0%	34.4%	25.7%	10.6%	19.9%	25.0%
	Walk or Bike	10.7%	5.8%	3.3%	33.9%	1.5%	7.4%
	Work at Home	8.1%	5.4%	2.2%	6.0%	0.8%	3.8%
2011-2015	Drove Alone	49.9%	44.5%	48.8%	41.3%	59.3%	48.8%
	Carpool	6.5%	6.4%	22.8%	6.3%	16.8%	11.8%
	Public Transit	22.5%	37.0%	22.3%	15.7%	18.6%	23.2%
	Walk or Bike	11.3%	5.6%	3.0%	29.0%	2.7%	10.3%
	Work at Home	9.0%	5.4%	2.3%	6.9%	1.0%	4.9%

Note: mode share for primary method of commuting for workers age 16 and over.

Source: NCSG with data from the U.S. Census, American Community Survey 20011-2015 Estimates.

Appendix Exhibit 2.5 displays the educational credentials of the workforce that is employed in the Purple Line Corridor (not those who *live* in the corridor, as in 2.1). This exhibit shows a detailed breakdown of Exhibit 10. Patterns, however, mirror Exhibit 2.1, with well-educated workers having jobs in Silver Spring, Bethesda, and the University of Maryland. Low-skill (high school or less) employment is highest in Riverdale and the International Corridor. On the whole, two thirds of workers who have jobs in the Corridor have at least some college experience.

Appendix Exhibit 2.5 Workforce by Educational Credential

Educational Attainment	Subarea					Entire Corridor
	Bethesda-Chevy Chase	Silver Spring	International Corridor	UMD	Riverdale-New Carrollton	
Less than high school	4,186	3,152	1,180	1,649	2,271	12,438
High school or equivalent, no college	6,315	4,890	1,330	3,375	5,571	21,481
Some college or Associate degree	8,641	6,348	1,640	4,870	6,208	27,707
Bachelor's degree or advanced degree	13,072	9,462	1,784	9,620	6,862	40,800
Less than high school	13.0%	13.2%	19.9%	8.5%	10.9%	12.1%
High school or equivalent, no college	19.6%	20.5%	22.4%	17.3%	26.6%	21.0%
Some college or Associate degree	26.8%	26.6%	27.6%	25.0%	29.7%	27.1%
Bachelor's degree or advanced degree	40.6%	39.7%	30.1%	49.3%	32.8%	39.8%
Total	**32,214**	**23,852**	**5,934**	**19,514**	**20,912**	**102,426**

Note: Educational Attainment is only available for workers age 30 and older.

Source: LEHD 2013

Appendix Exhibit 2.6 breaks down land use and zoning by the number of acres and parcels across the Corridor and its subareas. Single Family residential is the dominant form of land use across the corridor, with roughly 75% of each area comprised of neighborhoods of this type. Land use for apartments is more common in the International Corridor, and commercial land use

is highest in Bethesda-Chevy Chase and Silver Spring. Zoning matches this pattern of land use accordingly.

Appendix Exhibit 2.6 Detailed Land Use and Zoning Table

Appendix Table 3. Zoning and Land Use in the Purple Line Corridor

		Bethesda - Chevy Chase		Silver Spring		International Corridor		University of Maryland		Riverdale - New Carrollton		Total	
		Acres	# of parcels	Acres	# of parcels	Acres	# of parcels	Acres	# of parcels	Acres	# of parcels	Acres	# of parcels
Land Use	**Agricultural**	0	0	0	0	0	0	9	3	0	0	9	3
	Commercial	127	395	154	439	172	169	58	101	233	296	744	1400
	Country Club	9	4	0	0	0	0	0	0	0	0	9	4
	Commercial Condominium	8	11	6	36	0	0	142	41	133	67	289	155
	Commercial Residential	1	4	1	1	0	2	1	4	4	14	7	25
	Exempt	147	122	144	146	221	179	380	622	399	786	1291	1855
	Exempt Commercial	80	57	144	149	75	52	57	91	354	411	710	760
	Industrial	0	1	67	117	0	0	9	11	308	357	383	486
	Apartments	52	55	126	93	248	331	18	48	170	78	614	605
	Single Family	874	4101	816	4512	1057	7089	680	3251	1360	6394	4787	25347
	Town House	1	1	0	0	0	0	2	36	18	261	20	298
	Residential Condominium	0	4	0	58	1450	738	485	267	2782	658	4717	1725
	Roads & Others	396	259	253	180	230	189	6	20	60	194	944	842
	Total	*1694*	*5014*	*1713*	*5731*	*3452*	*8749*	*1847*	*4495*	*5819*	*9516*	*14526*	*33505*
Zoning	**Agriculture Zones**	0	0	0	1	0	0	0	0	0	0	0	1
	Residential Zones	1148	4228	1059	4496	3036	8347	1587	4148	2634	7840	9464	29059
	Commercial Zones	41	93	50	121	157	149	20	58	277	274	546	695
	Industrial Zones	6	2	78	131	0	0	10	13	310	197	404	343
	CBD Zones	75	291	187	504	0	0	0	0	0	0	262	795
	Planned Development Zones	2	1	13	106	0	0	0	0	0	0	16	107
	Transit Zones	5	62	0	0	0	0	0	0	0	0	5	62
	Mixed Zone	0	0	0	0	0	0	198	244	2448	839	2646	1083
	Road & Others	418	337	324	372	259	253	32	32	150	366	1183	1360
	Total	*1694*	*5014*	*1713*	*5731*	*3452*	*8749*	*1847*	*4495*	*5819*	*9516*	*14526*	*33505*

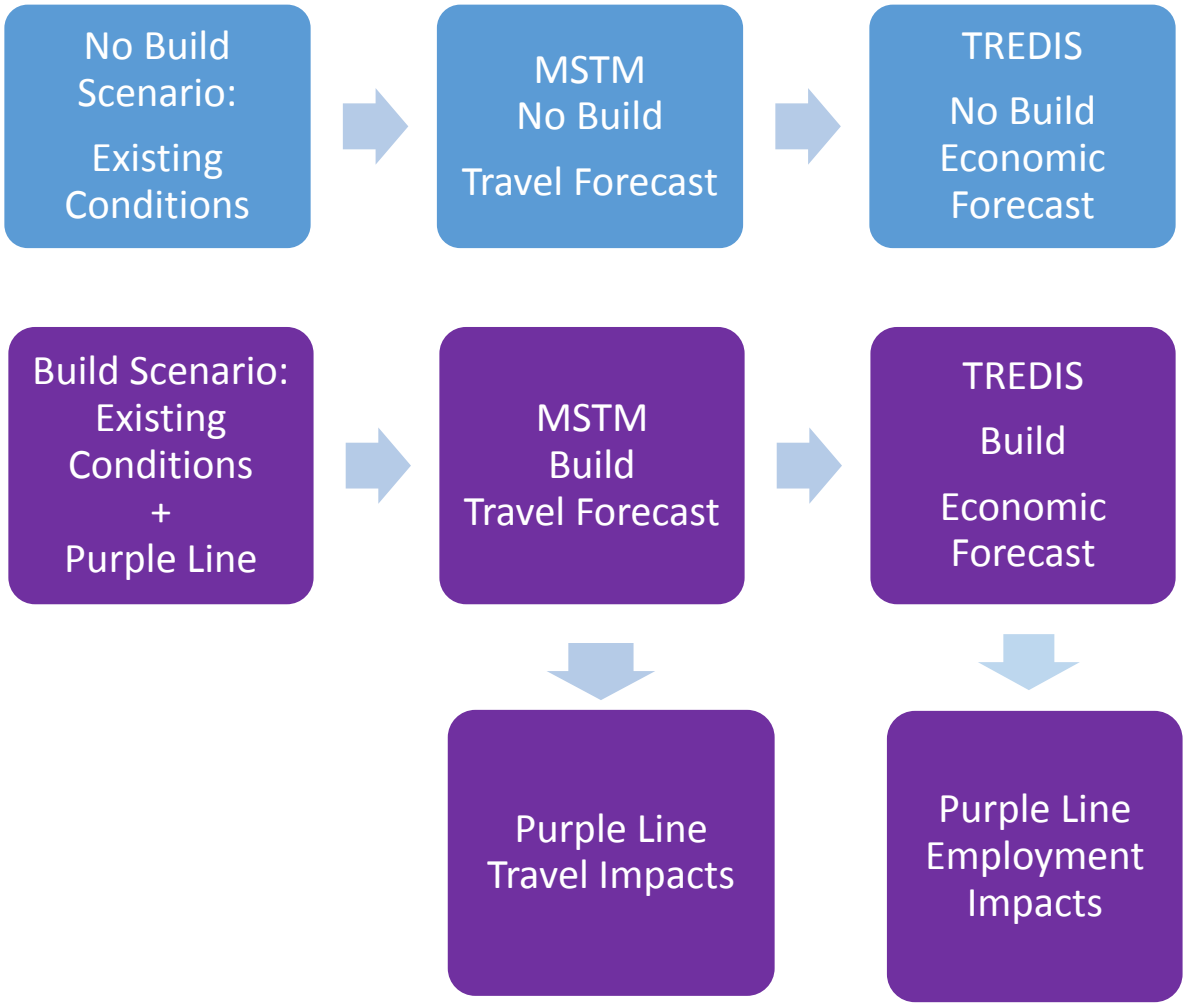
Appendix 3

Scenario Analysis Framework

To understand the net impacts of the Purple Line, those impacts that would not exist but for the construction or operation of the Line, we calculated impacts under two scenarios: (1) Build (with the Purple Line), and No Build (without the Purple Line). We calculate impacts of both scenarios at specific points in time over the next 23 years.

Appendix Exhibit 3.1 summarizes the scenario analysis framework for the report.

Appendix Exhibit 3.1: Scenario Analysis Framework



Source: NCSG.

Model Inputs

The MSTM and TREDIS models require many inputs and parameter values. The most important to understand for this analysis are: the definition of the study area, the existing location of jobs and households, the existing transportation network, the location and capacity of the planned transportation project(s), and estimates of construction and maintenance costs.

Study Area

The focus of our analysis is the Purple Line corridor, which is fully contained in Montgomery and Prince George's counties. We collected demographic and economic data for the corridor at the Census block group level. We used the counties in which the corridor is contained, Montgomery and Prince George's, for the MSTM and TREDIS model runs. The MSTM model study area includes the entire Baltimore-Washington Consolidated metropolitan area and parts of six surrounding states. While MSTM is a statewide model, it can report results at the county level. Thus, we extracted model output data for Montgomery and Prince George's counties. We then input these data into TREDIS and ran TREDIS to estimate impacts in the same two-county region.

We then had to scale the results for the two-county region to the corridor. We assumed that each corridor subarea would maintain its share of County employment. So, we distributed impacts to subareas based on their shares of county employment. We do not assert that the corridor and its subareas will capture a proportionate share of growth; we simply offer proportionate share as a benchmark from which to make appropriate judgements and adjustments.

Cost Estimates and Schedule

We collected information on construction and operating costs from multiple sources including the Final Environmental Impact Statement (FEIS) for the Purple Line[13] and various reports on the Line from the Maryland Department of Transportation[14]. MTA's most recent estimates put construction and operating costs, in millions of 2016 dollars, at:

- 2016-2022 Construction Phase - $1.99 billion total ($284 million per year)
  On an annual basis:
  - $85 million for engineering and design
  - $57 million in right away acquisition
  - $57 million in transportation structure costs
  - $28 million in terminal construction costs
  - $57 million in vehicle acquisition costs
- 2023-2040 Operations Phase - $150 million per year

[13] http://www.purplelinemd.com/en/about-the-project/studies-reports/feis-document

[12] http://www.purplelinemd.com/en/p3

On an annual basis:

- $108 million for ongoing operations
- $42 million for maintenance and rehabilitation

The TREDIS model considers annual expenditure of capital costs to estimate employment annually during the construction phase. We assume construction costs are spent equally over the construction period.

Purple Line Travel Behavior Forecast

We used the MSTM model to project travel patterns in 2040 as compared to the baseline scenario in year 2012. We report forecasts in the following categories using the following measures:

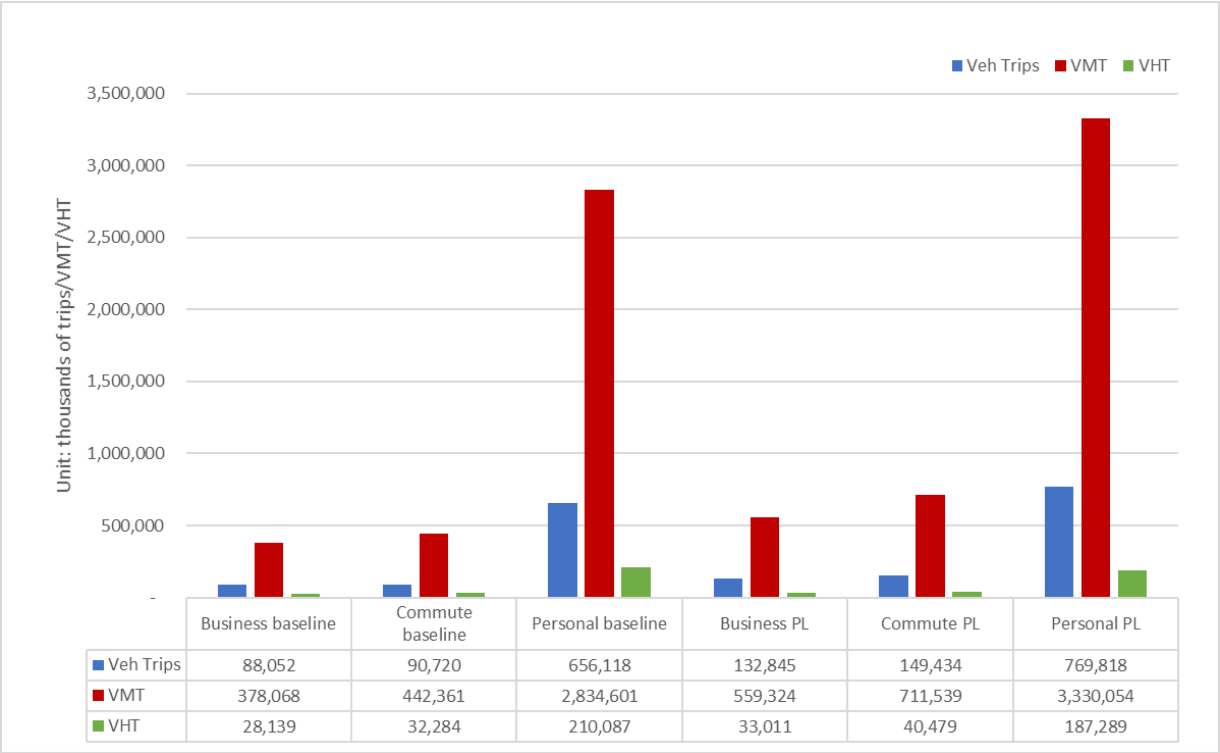
- **Auto travel,** as measured by Vehicle Miles Traveled (VMT), Vehicle Hours Traveled (VHT), and number of trips (Veh-Trips)
- **Transit travel,** as measured by Transit Mode Share and rail transit Annual Passenger Rail Miles Traveled, Annual Passenger Hours Traveled, and number of trips[15].

Auto Travel Forecast

Appendix Exhibits 3.2 and 3.4 present the auto travel forecast estimates on an annual basis (in the final year, 2040) under two scenarios, baseline (2012) and build (PL 2040), for Montgomery County and Prince George's County, respectively. The table disaggregates impacts by trip purpose: business, commute, or personal.

[15] Note that these transit use statistics are not direct outputs of the MSTM model but required as input for TREDIS. Therefore, an approximation method is utilized to estimate them.

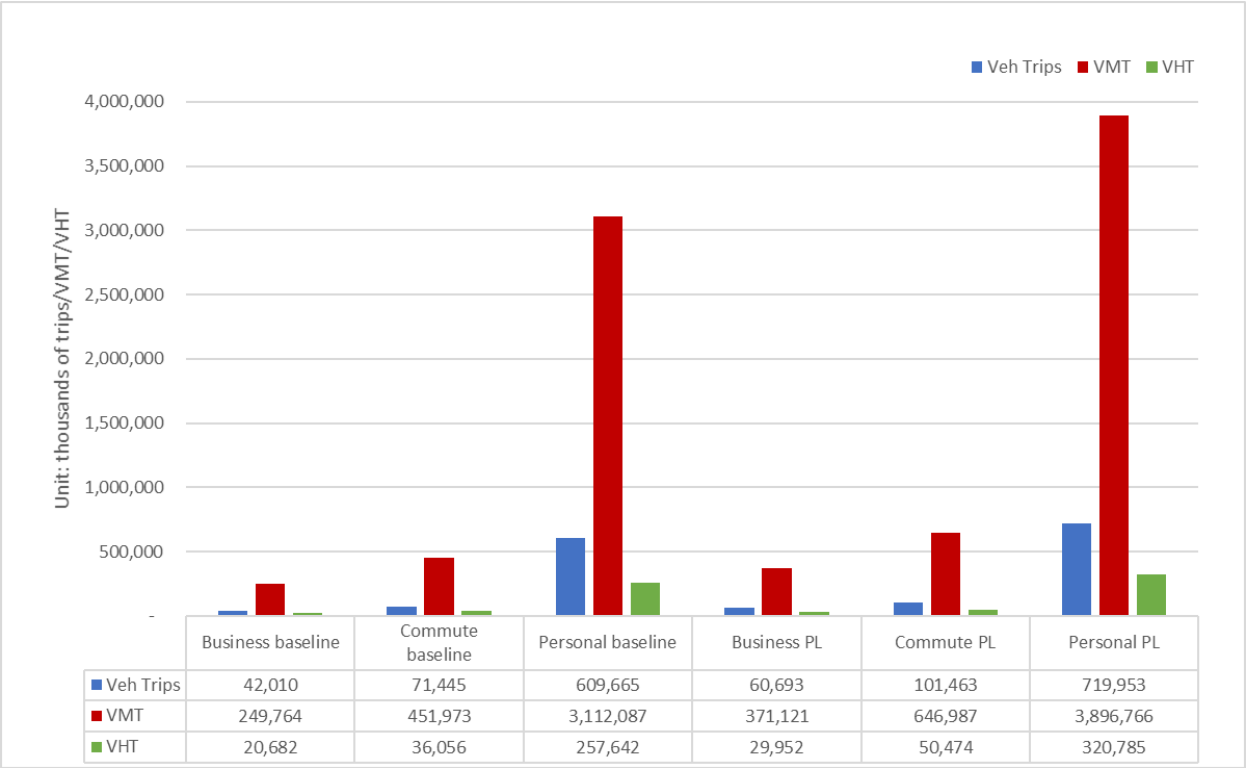
Appendix Exhibit 3.2: Auto Travel Forecasts by Trip Purpose in Montgomery County



	Business baseline	Commute baseline	Personal baseline	Business PL	Commute PL	Personal PL
Veh Trips	88,052	90,720	656,118	132,845	149,434	769,818
VMT	378,068	442,361	2,834,601	559,324	711,539	3,330,054
VHT	28,139	32,284	210,087	33,011	40,479	187,289

Source: NCSG analysis of MSTM model run, version v.1.0.8.5

Appendix Exhibit 3.3: Auto Travel Forecasts by Trip Purpose in Prince George's County



	Business baseline	Commute baseline	Personal baseline	Business PL	Commute PL	Personal PL
Veh Trips	42,010	71,445	609,665	60,693	101,463	719,953
VMT	249,764	451,973	3,112,087	371,121	646,987	3,896,766
VHT	20,682	36,056	257,642	29,952	50,474	320,785

Source: NCSG analysis of MSTM model run, version v.1.0.8.5

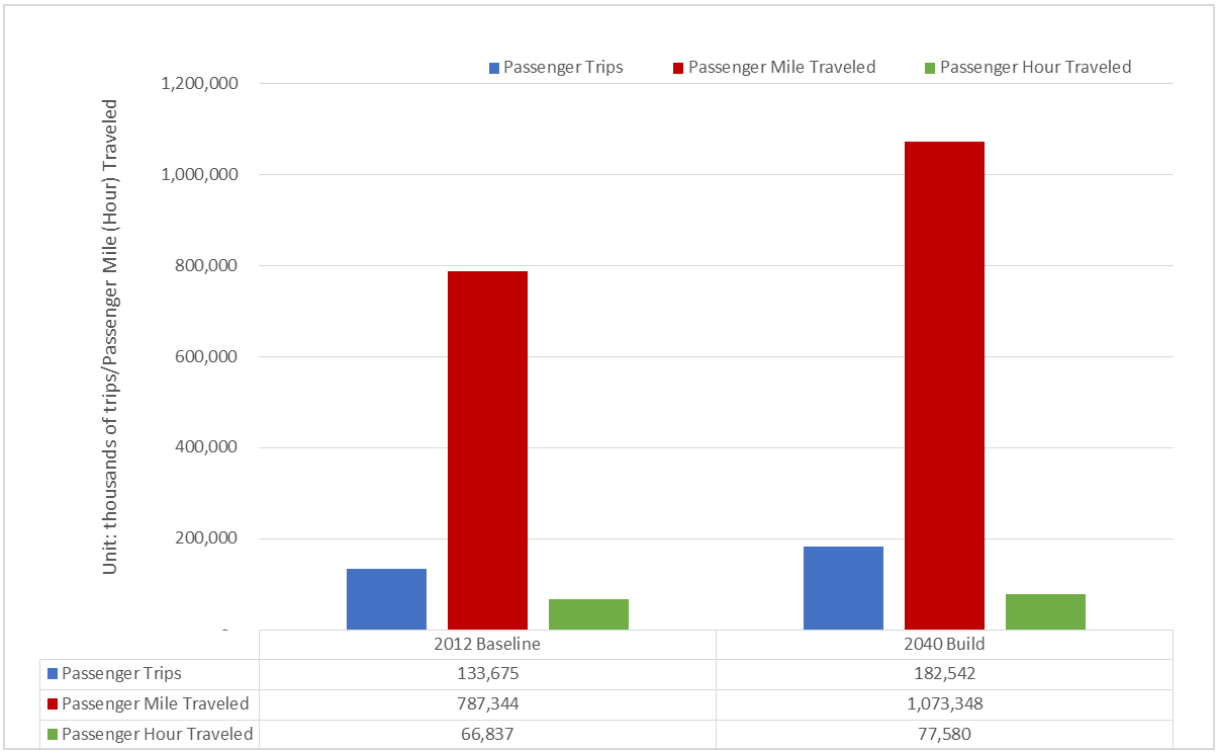
Compared to the baseline scenario (2012), the 2040 Build "PL" scenario exhibits substantial growth in vehicle trips, VMT, and VHT for all trip purposes in both counties. Vehicle trip growth and VMT growth suggest that both counties will have significant more road traffic in 2040. This is likely correlated with population growth, employment growth, and continued suburbanization of the two counties. If roadway capacity is not expanded as fast as VMT growth, we are likely to observe more crowded roadways and extending driving time. This is evident from the growth in VHT statistics for all trip purposes in both counties.

We also compared the 2040 no-build scenario and the 2040 Build scenario to estimate the net impact of the Purple Line on travel pattern changes in both Montgomery County and Prince George's County. The results are attached in Appendix 3, Appendix Exhibit 3.2 and 3.3. It appears that Purple Line will contribute to a slight decline in vehicle trips and VMT, although the magnitude of such impact is not statistically significant.

Rail Transit Travel Forecast

Exhibit 3.4 and 3.5 present the forecasts of the Purple Line from a 2012 Baseline scenario to a 2040 Build scenario on rail transit for Montgomery County and Prince George's County, respectively.

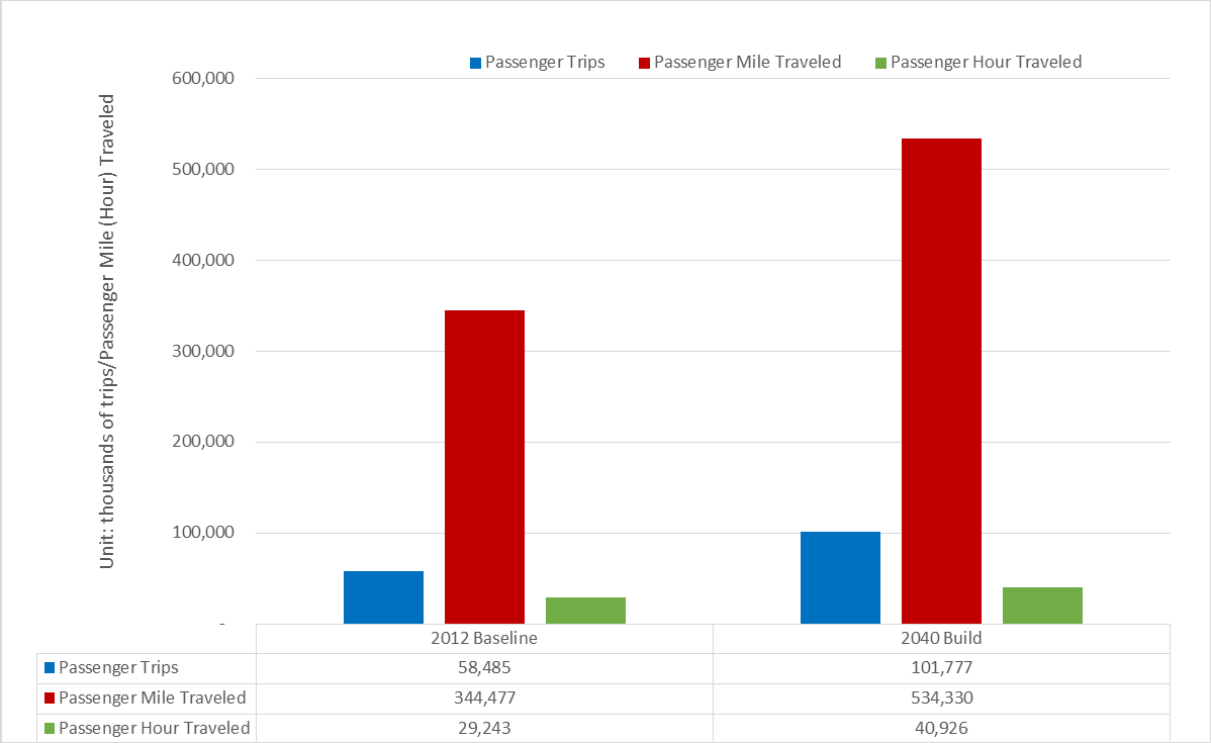
Appendix Exhibit 3.4: Transit Travel Impacts by Trip Purpose in Montgomery County



	2012 Baseline	2040 Build
Passenger Trips	133,675	182,542
Passenger Mile Traveled	787,344	1,073,348
Passenger Hour Traveled	66,837	77,580

Source: NCSG analysis of MSTM model run, version v.1.0.8.5

Appendix Exhibit 3.5: Transit Travel Impacts by Trip Purpose in Prince George's County



	2012 Baseline	2040 Build
Passenger Trips	58,485	101,777
Passenger Mile Traveled	344,477	534,330
Passenger Hour Traveled	29,243	40,926

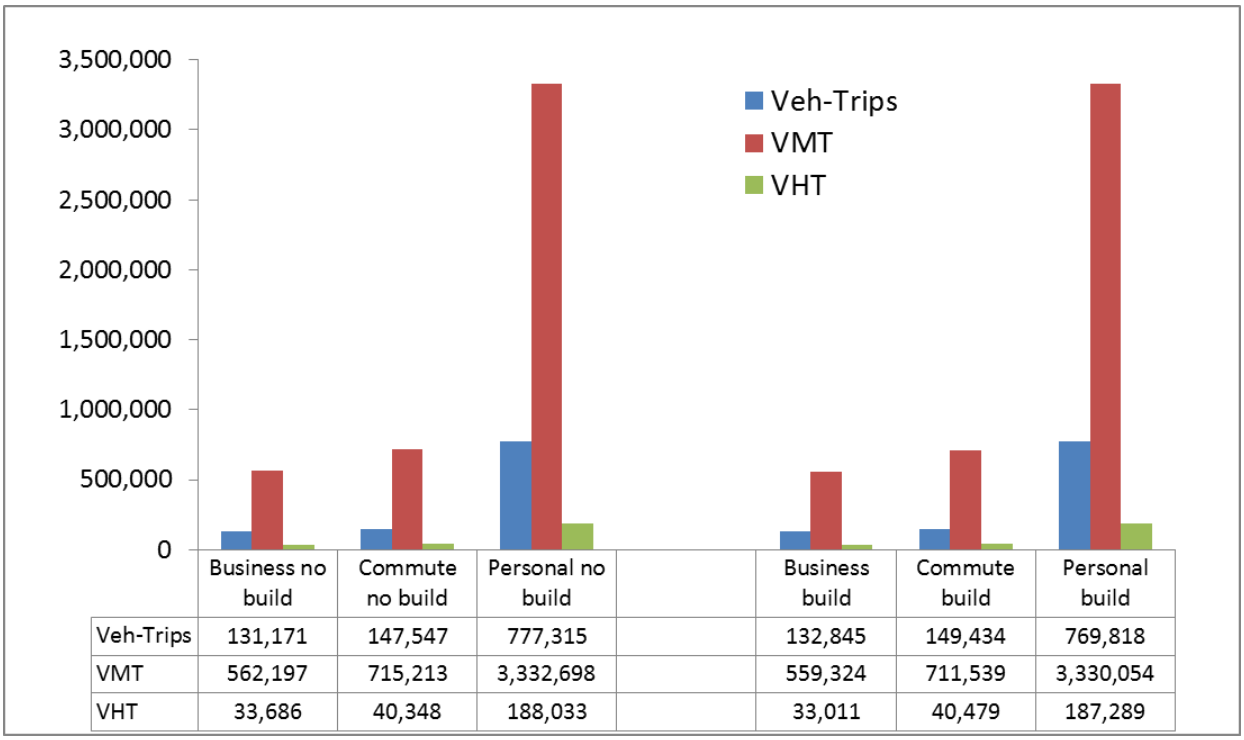
Source: NCSG analysis of MSTM model run, version v.1.0.8.5

Total number of passenger trips, passenger miles traveled, and passenger hours traveled increased significantly in both counties. Transit utility growth is particularly prominent in Prince George's County, where more low-income households reside as compared to its wealthy neighbor, Montgomery County. Transit will benefit households of lower socioeconomic status through better accessibility to employment and commercial activities. Quantitatively, the number of passenger trips grows by 33% in Montgomery County from the 2012 Baseline to the 2040 Build scenario, while Prince George's County saw a 66% increase in passenger trips.

We also estimated the net impact of the Purple Line on transit travel patterns by comparing the Build and No Build scenarios at the 2040 horizon year. The results are attached in Appendix 3, Appendix Exhibit 3.8 and 3.9. It appears that a net benefit of 5.1% and 17.9% increase in transit passenger trips comes solely from the Purple Line.

Appendix Exhibit 3.6 and 3.7 show the auto travel impact estimates on an annual basis (in the final year, 2040) under the two scenarios, No Build and Build. The table disaggregates impacts by trip purpose: business, commute, or personal.

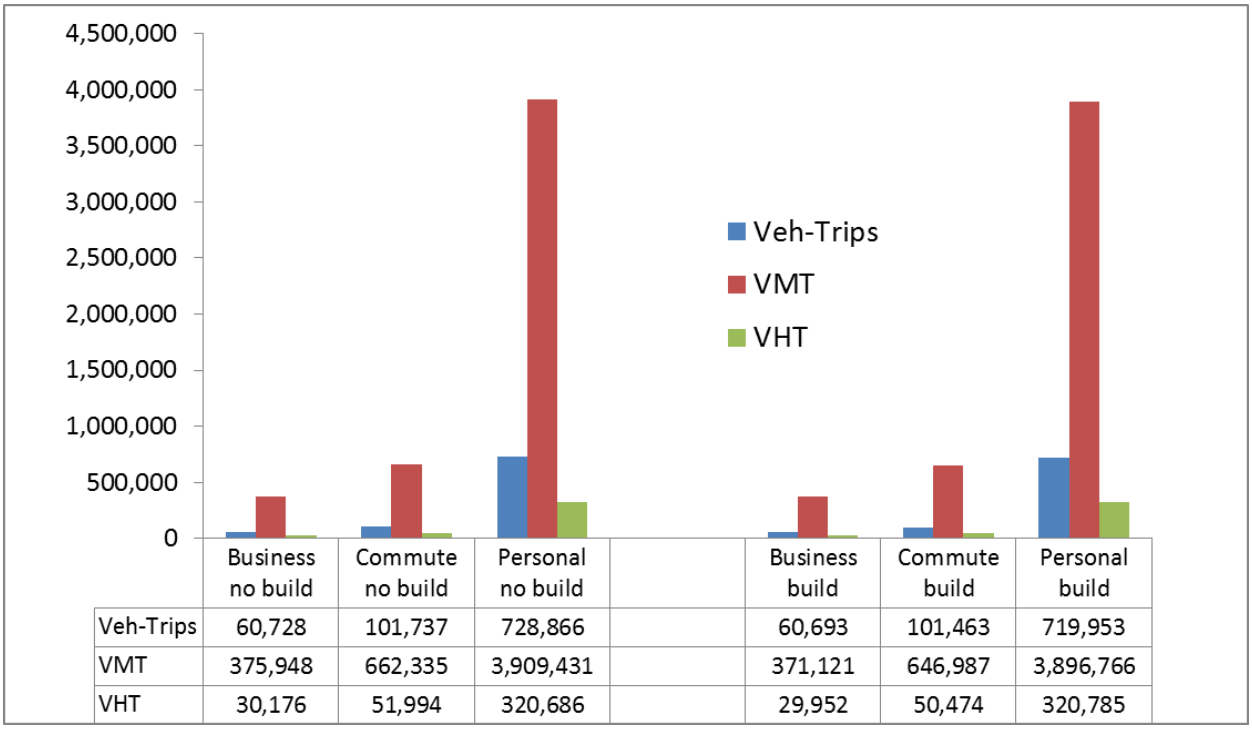
Appendix Exhibit 3.6: Auto Travel Impacts by Trip Purpose in Montgomery County (thousands of Vehicle Trips, VMT, and VHT)



	Business no build	Commute no build	Personal no build		Business build	Commute build	Personal build
Veh-Trips	131,171	147,547	777,315		132,845	149,434	769,818
VMT	562,197	715,213	3,332,698		559,324	711,539	3,330,054
VHT	33,686	40,348	188,033		33,011	40,479	187,289

Source: NCSG analysis of MSTM model run, version v.1.0.8.5

Appendix Exhibit 3.7: Auto Travel Impacts by Trip Purpose in Prince George's County (thousands of Vehicle Trips, VMT, and VHT)



	Business no build	Commute no build	Personal no build		Business build	Commute build	Personal build
Veh-Trips	60,728	101,737	728,866		60,693	101,463	719,953
VMT	375,948	662,335	3,909,431		371,121	646,987	3,896,766
VHT	30,176	51,994	320,686		29,952	50,474	320,785

Source: NCSG analysis of MSTM model run, version v.1.0.8.5

The Purple Line causes several notable impacts on automobile travel in Montgomery County:

- An increase in the number of vehicle trips for business and commute purposes, but a decrease in the number of personal trips.
- A decrease in VMT, which (in conjunction with the increased number of trips) means that people are typically taking shorter trips under the Build scenario.

The impact in Prince George's County differs in important ways:

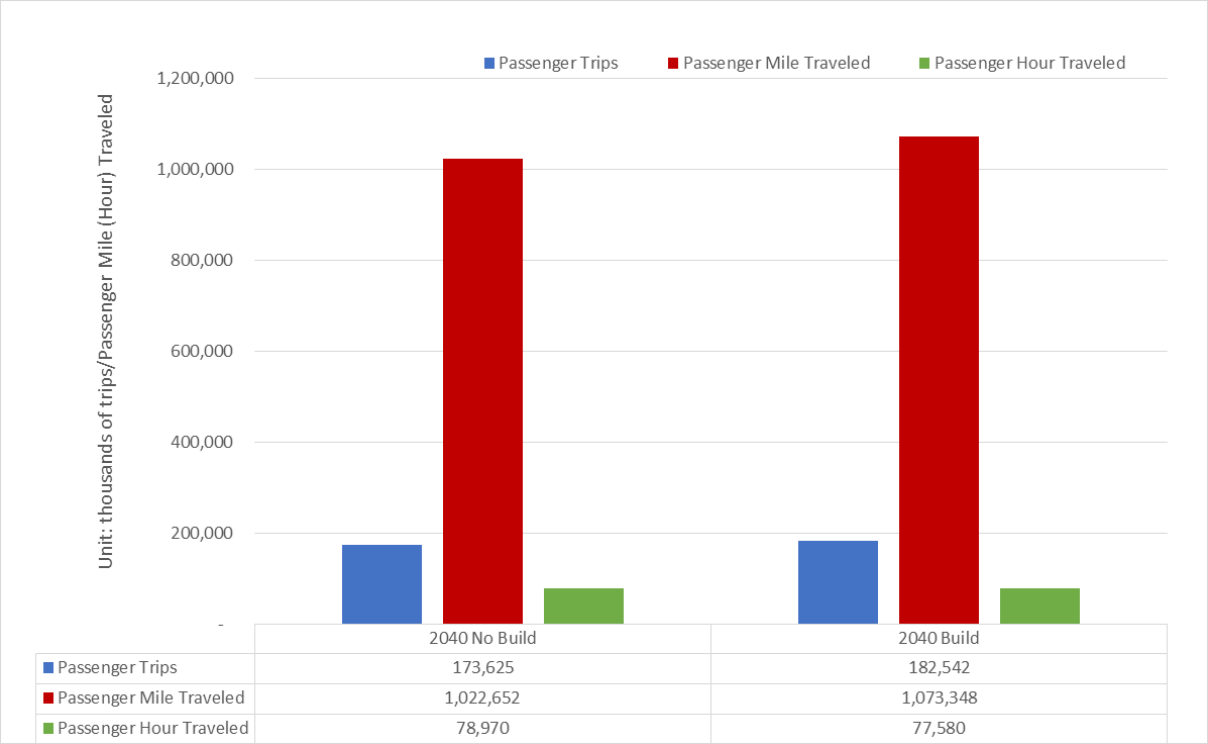
- There is a decline in vehicle trips for all purposes.
- There is also a decline in VMT and VHT for all purposes in, with the exception of a slight increase in VHT for personal trips.

The increase in the number of trips under the Build scenario is as expected, considering the number of jobs in the area increases by 21 percent from start of construction until 2040. The number of annual vehicle trips in the build scenario is a bit less than one percent lower than the number of vehicle trips in the no-build scenario. Impacts in the counties, however, are different. In Prince George's the build scenario results in one percent less vehicle trips annually, while in Montgomery County, there are about 0.3 percent fewer vehicle trips.

Appendix Exhibits 3.8 and 3.8 show rail transit travel under the No Build and Build scenarios. The Purple Line causes several notable impacts:

- Annual passenger trips on the rail network (including the WMATA subway lines, Commuter Rail lines, and the Purple Line) increase by 5.1 percent in Montgomery County and 24.6 percent in Prince George's County. The greater increase in transit trips in Prince George's is consistent with the auto travel increase discussed previously.
- The increase in passenger miles is almost proportional to the increase in passenger trips in Prince George's County, suggesting the length of travel per trip is similar to before with Purple Line. The passenger miles traveled slightly decreased in Montgomery County with a mild increase in passenger trips, suggesting that the average transit trip length shrinks slightly with the connection of the Purple Line.
- The decrease in passenger hours in Montgomery County means that some passengers can get from point A to point B in less time with the Purple Line whereas some passengers travel longer in Prince George's County.

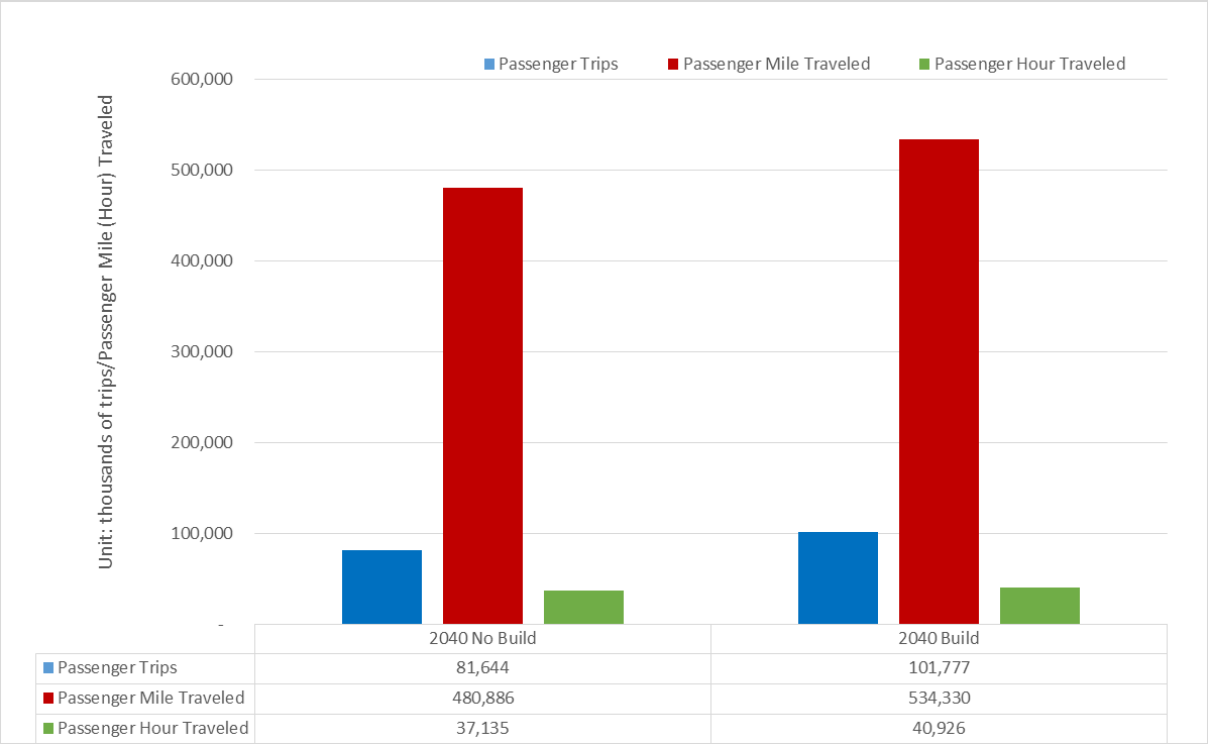
Appendix Exhibit 3.8: Rail Transit Travel Impacts in Montgomery County



	2040 No Build	2040 Build
Passenger Trips	173,625	182,542
Passenger Mile Traveled	1,022,652	1,073,348
Passenger Hour Traveled	78,970	77,580

Source: NCSG analysis of MSTM model run, version v.1.0.8.5

Appendix Exhibit 3.9: Rail Transit Travel Impacts in Prince George's County



Source: NCSG analysis of MSTM model run, version v.1.0.8.5

No-Build Scenario: Employment Projection

Appendix Exhibit 3.10: Employment Projection by Industry at the two-county and Corridor levels, No Build Scenario

Industry	Montgomery & Prince George's			The Corridor		
	2016	2023	2040	2016	2023	2040
Agriculture, Forestry, Fishing and Hunting	1,580	1,676	1,675	49	52	51
Mining, Quarrying, and Oil and Gas Extraction	884	1,043	1,263	0	0	0
Utilities	1,705	1,720	1,650	46	46	45
Construction	94,351	107,582	131,228	10,531	12,135	15,263
Manufacturing	19,930	19,481	17,812	1,226	1,194	1,070
Wholesale Trade	22,630	23,944	25,271	1,751	1,858	1,983
Retail Trade	99,637	99,891	106,951	9,196	9,230	10,062

Transportation and Warehousing	33,620	33,660	32,800	10,032	9,807	9,179
Information	24,975	25,177	26,522	5,578	5,608	6,029
Finance and Insurance	51,210	56,131	82,162	10,412	11,449	17,090
Real Estate and Rental and Leasing	62,777	64,731	70,144	14,410	14,880	16,510
Professional, Scientific, and Technical Services	147,142	151,523	167,942	27,023	27,946	31,172
Management of Companies and Enterprises	9,377	9,377	9,259	918	925	924
Administrative and Support and Waste Management	77,834	92,774	132,943	15,079	18,233	26,734
Educational Services	24,648	25,437	27,191	4,576	4,715	4,837
Health Care and Social Assistance	126,159	138,005	165,900	13,932	15,230	18,777
Arts, Entertainment, and Recreation	26,250	27,417	27,364	3,102	3,241	3,287
Accommodation and Food Services	74,405	81,039	97,934	11,866	12,983	16,068
Other Services [except Public Administration]	84,180	87,321	100,360	16,584	17,192	20,136
Public Administration	188,995	187,328	193,210	28,040	27,676	27,811
Total	**1,172,289**	**1,235,257**	**1,419,581**	**184,351**	**194,400**	**227,028**

Source: TREDIS Projection

Appendix Exhibit 3.10 shows the net impact of the Purple Line on employment in the two-county region and the corridor. The most prominent impacts reflect hiring for the construction and operation of the line. Construction will require new employment in the construction and professional, scientific, and technical services industries. In the longer-term, operations will require new employment in transportation and warehousing and administrative and support and waste management.

Appendix Exhibit 3.11: Difference in Employment by industry at the two-county and corridor levels, (Build – No Build Scenario)

Industry	Montgomery & Prince George's	The Corridor

	2016	2023	2040	2016	2023	2040
Agriculture, Forestry, Fishing and Hunting	0	0	0	0	0	0
Mining, Quarrying, and Oil and Gas Extraction	0	0	0	0	0	0
Utilities	2	1	3	0	0	0
Construction	759	128	149	78	13	15
Manufacturing	72	6	15	4	0	1
Wholesale Trade	38	39	28	3	3	3
Retail Trade	131	82	139	12	7	13
Transportation and Warehousing	30	828	731	8	217	190
Information	16	10	39	3	2	9
Finance and Insurance	74	102	291	15	18	59
Real Estate and Rental and Leasing	56	40	73	11	7	16
Professional, Scientific, and Technical Services	604	104	314	103	17	57
Management of Companies and Enterprises	11	5	14	1	1	2
Administrative and Support and Waste Management	114	65	232	21	11	40
Educational Services	20	14	30	4	4	6
Health Care and Social Assistance	128	100	221	14	9	24
Arts, Entertainment, and Recreation	31	24	68	4	3	6
Accommodation and Food Services	98	61	112	15	9	18
Other Services [except Public Administration]	83	66	154	15	11	29
Public Administration	5	3	7	1	0	1
Sum	**2,272**	**1,678**	**2,620**	**312**	**332**	**489**

Source: TREDIS Projection

Transportation Metrics

Detailed transit travel output by trip purposes is not available from MSTM. The Federal Transit Administration's NTD database records the financial, operating and asset condition of all transit systems in the United States. Among these metrics, annual passenger miles travelled and annual passenger hours travelled by major rail systems in Maryland were obtained and recalibrated based on the results from FEIS (Chapter 3.0 Transportation Effects). Consultations with TREDIS researchers yielded the conclusion that all transit trips were assumed as personal trips. [16]

The above categories of information were calculated for both the base and project scenarios for a minimum of two years: a current year (i.e. 2016) and a future year (i.e. 2040). These travel input data were also categorized into three travel purposes in TREDIS: business, commute and personal. Trips purposes in TREDIS are categorized differently from MSTM. All six categories of information were reconciled using the lookup table below.

Appendix Exhibit 3.12: Travel Purpose Reconciliation

Travel Purposes in TREDIS	Travel Purposes in MSTM[17]
Business	NHBWork
Commute	HBWork
Personal	HBShop, HBSchool, HBOther, NHBOther

Travel Time and Market Access

The analysis process for the market access module relies on travel outcome data derived from the travel demand model. Required inputs for road travel include Vehicle Trips (VT), Vehicle Miles Traveled (VMT), and Vehicle Hours Traveled (VHT). In terms of transit travel, required input include: Passenger Trips (PT), Passenger Miles Traveled (PMT), Passenger Hours Travelled (PHT), In Vehicle Travel Time (IVTT), and Out of Vehicle Travel Time (OVTT) (which also includes out of vehicle wait time). The highway travel characteristics were derived from the MSTM and transit travel characteristics were derived from the MSTM and calibrated using parameters obtained from the National Transit Database (NTD).

Market access measures the changes in the access to total labor force in a 40-minute drive time and the changes in access to employment within a 3-hour drive time resulting from the Purple Line investment. The former measures the local market potential and captures agglomeration

[16] While MSTM output reports detail mode share information among different transit and auto modes for an average day, they do not directly output the necessary transit related inputs for the TREDIS travel cost module, which are annual passenger miles (APM) and annual passenger hours (APH). These measures are computed based on assumptions and data from the NTD reports and FEIS reports.

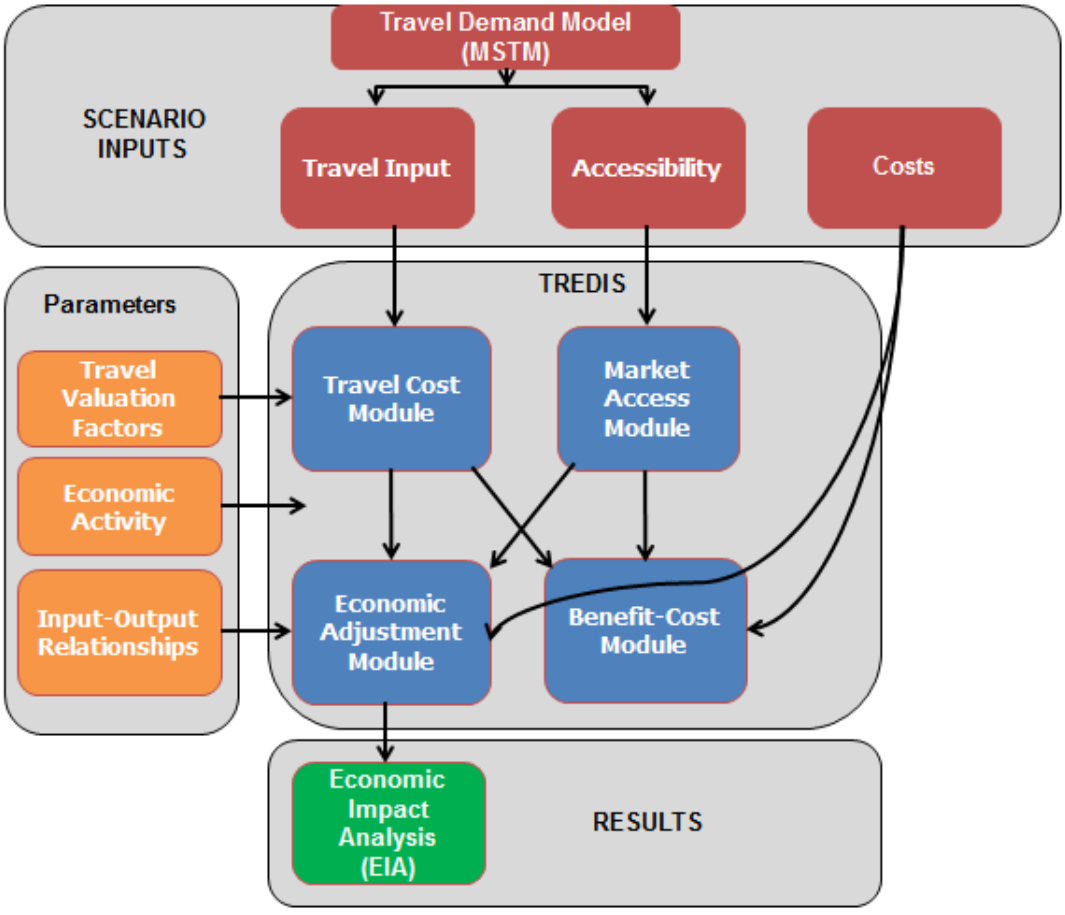
[15] NHBwork: Non home based work; HBWork: home based work; HBShop: home based shopping; HBSchool: home based school; HBOther: home based other; NHBOther: Non home based other.

effects related to labor market matching. The latter measures the regional market potential. The MSTM road network was used to create commute sheds for both base and project scenarios. Then labor force and employment data were calculated based on the commute sheds.

Model Integration

The MSTM is a trip-based, four-step travel demand forecasting model developed by the NCSG and Parsons and Brinkerhoff (now WSP) for the Maryland State Highway Administration (FHWA, 2014) to estimate the impacts of transportation investments, changes in land use, and impacts from exogenous factors beyond state boundaries, particularly freight flows. The model input data include population and employment by model zones, highway and public transit networks, and parameters that govern travel behavior. Model outputs include traffic flows on the overall system, as well as specific corridors and individual links. Appendix Exhibit 3.13 displays the model integration structure of MSTM. Further detail about the model structure can be found in the Model Documentation for the MSTM[18].

Appendix Exhibit 3.13: Model Integration



[18] http://smartgrowth.umd.edu/assets/documents/presto/2.900_mstm_documentation_oct152013.pdf

The MSTM demand input is comprised of two major categories: number of households and employment. The year 2040 is used for the analysis to reflect the increase in demand by the time the Purple Line construction is complete and functional, leaving travel demand enough time to adjust to the new network conditions. These data are projected from 2012 values to 2040.

Appendix Exhibit 3.14 MSTM demand input and projections (State of Maryland only)

	Model Projections	2012	2040	% Change
MARYLAND	Households	2,202,116	2,689,939	+22.15%
	Employment	2,976,610	3,862,033	+29.75%
Montgomery County	Households	366,383	458,768	+25.22%
	Employment	539,659	742,869	+37.66%
Prince George's County	Households	313,009	380,413	+21.53%
	Employment	345,779	494,693	+43.07%

Source: NCSG analysis of MSTM model run, version v.1.0.8.5

The data sources used in this study include the 2012 Base year model (No Built) and 2040 Constrained Long Range Plan (Built) model, which identifies the location of households and employment throughout the state (Appendix Exhibit 3.14). Both models are the latest available official model version (MSTM_v1.0.8.5) that is used by the Maryland SHA. The CLRP model represents the network improvements and growth allocation anticipated by the Baltimore Metropolitan Council and the Metropolitan Washington Council of Governments.