WMATA
CONNECTGREATERWASHINGTON

CGW Policy Alternatives:

Task 7 Scenario Comparison Measures

Technical Memorandum

February 2015

Washington Metropolitan Area Transit Authority

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1. Introduction

This memorandum reports the results of the *ConnectGreaterWashington* (CGW) policy scenario modeling, including the detailed modeling assumptions used in each alternative. Three alternative policy scenarios were tested for the year 2040, with three different iterations of each:

- **Scenario A: Efficient Transit**
  - A prime – policies only (no land use shift)
  - A1 – land use shifted within jurisdictions with additional policies
  - A2 – land use shifted across jurisdictions with additional policies
- **Scenario B: Cost-Effective Transit**
  - B prime – policies only (no land use shift)
  - B1 – land use shifted within jurisdictions with additional policies
  - B2 – land use shifted across jurisdictions with additional policies
- **Scenario C: Maintain Current Travel Times**
  - C prime – policies only (no land use shift)
  - C1 – land use shifted within jurisdictions with additional policies
  - C2 – land use shifted across jurisdictions with additional policies

The scenario results were compared against each other and against the 2040 Base Case using a set of measures of effectiveness (MOEs) based on the study goals and objectives. This memorandum is organized as follows:

1. Introduction, including methodology for the travel demand modeling
2. Scenario development and strategies, including modeling assumptions
3. Scenario results, including MOEs
4. Key Findings

1.1. Methodology

Travel Demand Modeling

Model Version

The CGW Policy Alternatives modeling was conducted using the MWCOG Version 2.3.52 Model and the Regional Transit System Plan (RTSP) Model, both with draft MWCOG Round 8.3 Cooperative Land Use Forecasts. The original calibration of the MWCOG Version 2.3 model was based on household and transit surveys conducted in 2007. These surveys include the 2007 Metrorail survey and regional bus surveys funded by MTA as part of the Purple Line planning process. MWCOG made some calibration adjustments to the Version 2.3 model in 2013 based on 2010 Census data and traffic counts as part of the Air Quality Conformity update. MWCOG did not update or re-calibrate the mode choice models in 2013. For scenario modeling results that are compared with existing conditions as well as the 2040 Baseline conditions, 2010 is used as the existing base year.

Metrorail Constraint

The RTSP travel demand model was used both with and without a Metrorail ridership constraint for the 2040 Baseline forecast, and both sets of results are reported in this technical memorandum (constrained and unconstrained Base). The 2040 Policy Alternatives Scenarios were run without the Metrorail constraint. However, for some MOEs (those unrelated to transit ridership), the results for the constrained and unconstrained Baseline were the same and only one value is reported.

The "unconstrained" modeling process allows for unlimited Metrorail ridership with no limits on the carrying capacity of the Metrorail system. The "constrained" modeling process limits the number of Metrorail riders in the core to a pre-determined limit based on the 2020 system capacity, and assumes that potential passengers above this limit are shifted back to automobile modes as a result of passenger crowding. The National Capital Region Transportation Planning Board (TPB) added the transit constraint to the model (in place since at least 2008, model version 2.2) to address the lack of funding for WMATA's future rehabilitation, maintenance, and expansion needs after 2020.

Peak Periods

Peak periods are defined in the model as follows:

- Morning peak period: 6:00am-9:00am
- Evening peak period: 3:30pm-7:30pm

2040 Baseline Transit Network and Land Use

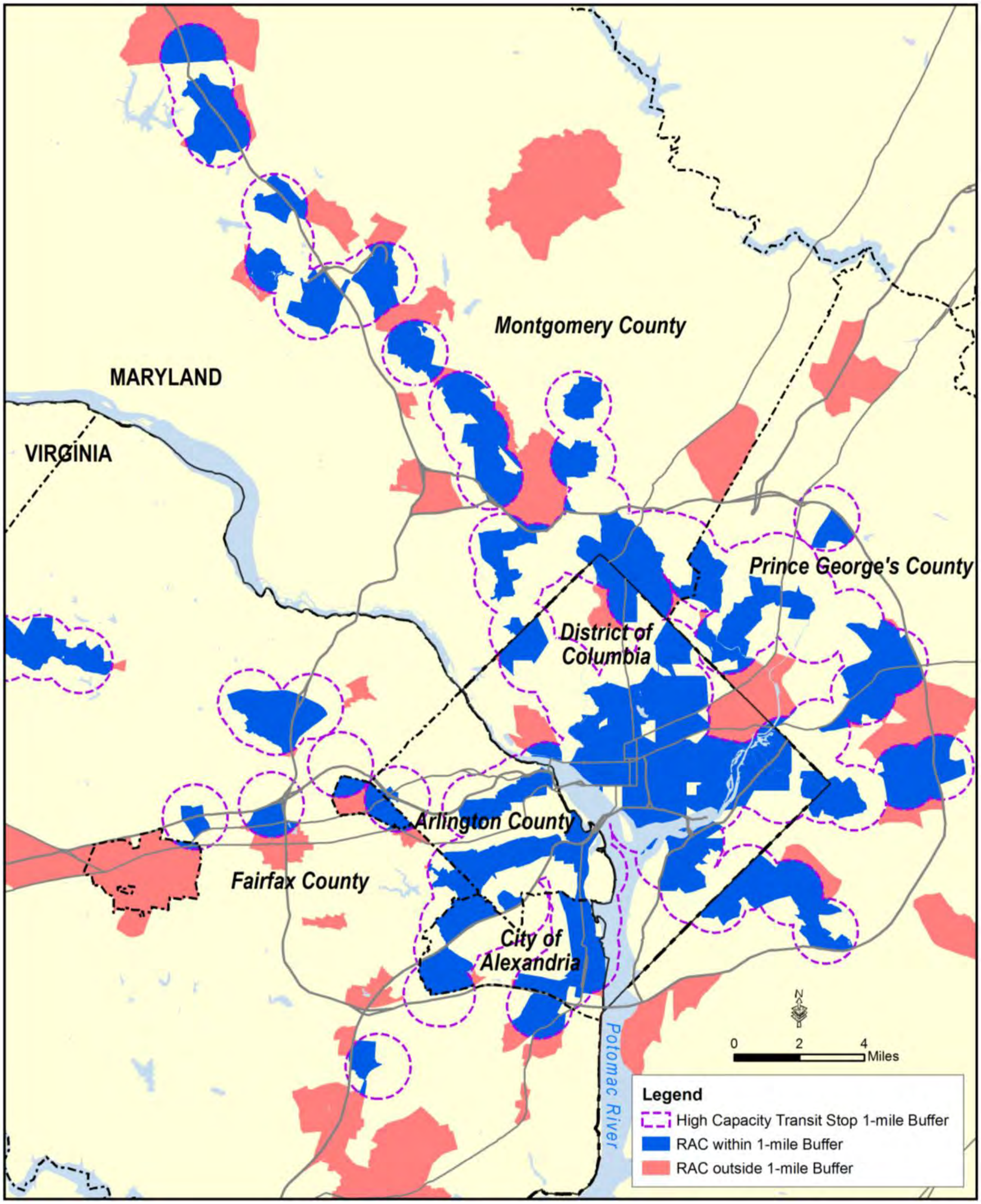
Both the 2040 Base Case and the policy alternative scenarios use the 2040 Baseline Transit Network, which consists of existing and planned improvements as documented in the region's adopted 2013 Constrained Long-Range Transportation Plan (CLRP) and WMATA Metro 2025 improvements documented in the 2013 *Momentum* strategic plan. The Baseline Transit Network is described in detail in the *Task 2 Methodology for Alternatives to the 2040 RTSP Network Technical Memorandum*.

The 2040 Base Case uses the MWCOG draft Round 8.3 Cooperative Land Use Forecasts. These conditions are described in detail in the *Task 4 Comparison of 2040 Adopted Cooperative Forecast to Existing Land Use Technical Memorandum*. The policy alternatives scenarios assume a set of varying travel policies in the region, in addition to alternative land use forecasts by relocating growth planned for 2020 and after.

Regional Activity Centers and Area Typology

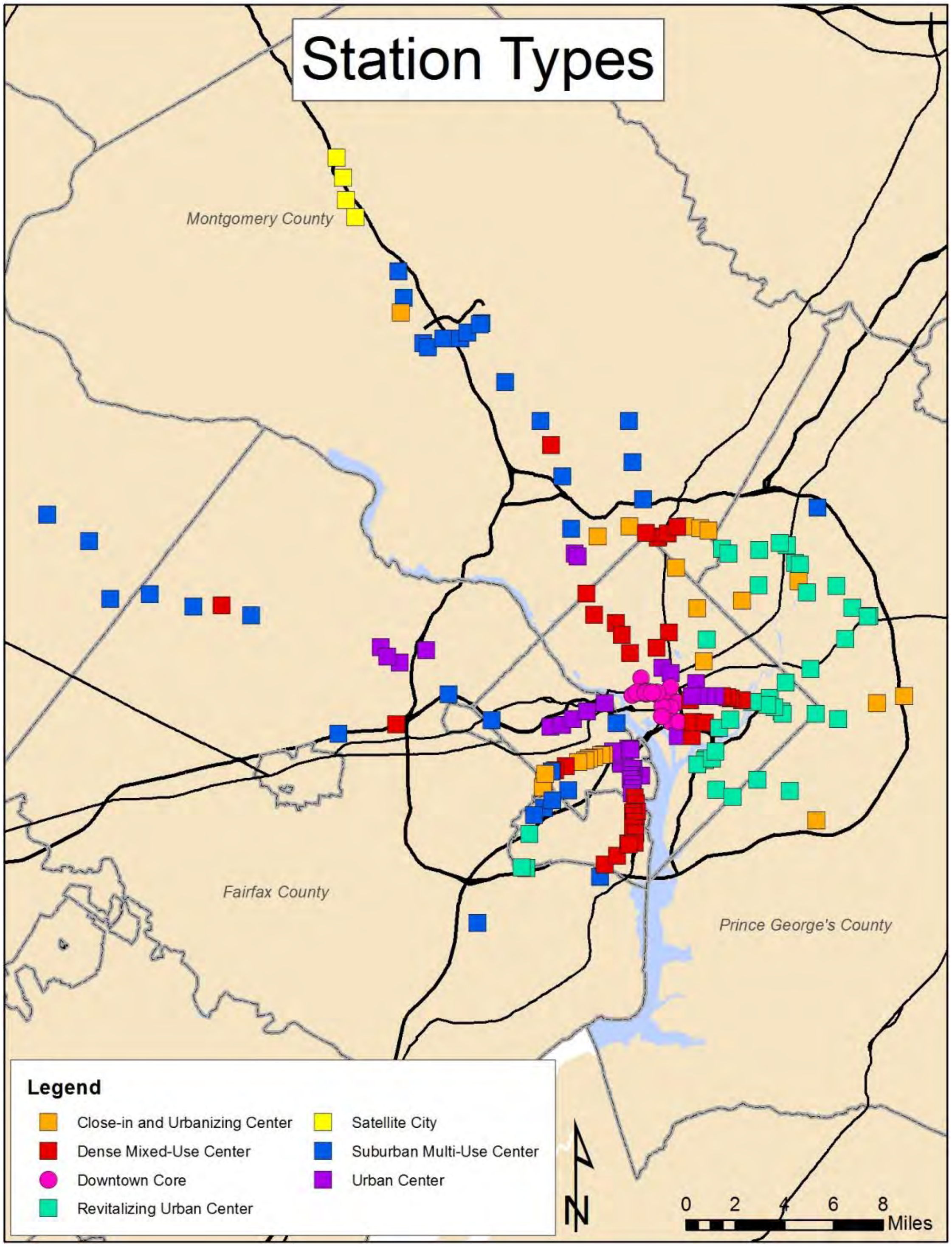
A major factor in developing the alternative land use scenarios was a determination of how dense the ultimate build-out for each Regional Activity Center (RAC) designated by MWCOG should be. Not all RACs can or should be dense urban centers, and this policy analysis wanted to be sensitive to the character and needs of each RAC as defined by the region's jurisdictions. The MWCOG report *Place + Opportunity: Strategies for Creating Great Communities and a Stronger Region* (2014) assigns one of six "Place Types" to most of the RACs in the region based on urban form and market characteristics. This study used the same characteristics to assign Place Types to the remaining RACs in the WMATA Compact Area. **Figure 1** shows the overlap between the 1-mile station areas and the RACs.

Figure 1: Station Areas and RAC Boundaries



Each high-capacity/high-frequency transit station was also assigned a Place Type based on the RAC in which it was located. The total land use density (jobs plus population) for 2040 was calculated within a one-mile radius of each of these stations, and an average total density was calculated for each Place Type. Based on this analysis, it was determined that a seventh Place Type was necessary to separate the highest density Urban Centers in the downtown core, from other Urban Centers in the region. **Figure 2** shows the Place Type assigned to each of these stations.

Figure 2: High-Capacity/High-Frequency Transit Station Place Types



The average 2040 total land use density for a representative station area was selected for each Place Type. The densities shown in **Table 1** were used as target values for the alternative land use scenarios; each station area was given the target density of the representative station for its Place Type. For example, the Dunn Loring Metrorail Station (categorized as a Dense Mixed-Use Center) was given a target density of 73,600 population plus employment per square mile.

Table 1: Representative Stations and Density Targets by Place Type

Station Place Type	Representative Station	Population + Employment Density (per square mile)
Suburban Multi-Use Center	Huntington	18,600
Revitalizing Urban Center	H St/42nd St	23,000
Satellite City	Cloverleaf	23,700
Close-in & Urbanizing Center	Takoma	25,000
Dense Mixed-Use Center	White Flint	73,600
Urban Center	Bethesda	133,100
Downtown Core	K St/22nd St	224,000

An automated program was developed that would reallocate land use growth across the region based on a set of target densities for population and employment. This program identified the portions of TAZs that were within ½- and 1-mile radii of high-capacity/high-frequency transit service as potential locations for increased densities (hereafter referred to as a station area), and reallocated land use growth to these station areas based on a set of user defined rules. Each of the tested scenarios used a different set of rules, as explained in more detail in Section 2 for each Scenario. Some of the capabilities of this program included the ability to:

- Prioritize changes within ½-mile and 1-mile station areas;
- Distinguish between RACs and non-RAC areas; and
- Differentiate between different planned years of implementation for land use growth, and prioritize between the different years.

The type of density (residential, employment, or mixed) that was allocated to each station area was also changed based on the goal of each Scenario. Because pre-2020 land use densities are considered to be fixed, the major factor limiting the ultimate density of a given zone or station area is the number of jobs and population available to be shifted, which is defined by the baseline growth projected between 2020 and 2040, and the constraints of each scenario which may limit the available land use growth by jurisdiction or by location within a RAC. For example, if the target densities are set so that an additional 500,000 jobs would need to be shifted to station areas in DC, but only 200,000 jobs are available to be shifted, those target densities cannot be fully met. **Table 2** details the land use available to be shifted by jurisdiction; depending on the outline of a specific Scenario, over 850,000 residents and almost 600,000 jobs could potentially be shifted. Very high target densities, lower growth projections in specific jurisdictions, and the type of land use identified for shifting all affected the ultimate resulting density for any of the land use alternatives.

Table 2: Potential Population and Employment Growth Available to be Shifted

Jurisdiction	Population			Employment		
	Inside RAC	Outside RAC	Total	Inside RAC	Outside RAC	Total
District of Columbia	6,121	11,684	17,805	1,196	2,595	3,790
Montgomery County	29,025	22,988	52,012	36,653	13,002	49,656
Prince George's County	20,235	41,326	61,561	53,899	18,606	72,505
Arlington County	585	431	1,016	4	15	19
City of Alexandria	1,273	1,724	2,997	1,671	315	1,986
Fairfax County	45,116	60,909	106,025	65,454	14,864	80,318
Loudoun County	11,623	44,885	56,508	34,519	30,951	65,470
Outside Compact Area	72,841	483,902	556,743	36,267	286,908	323,175
Regional Total	**186,819**	**667,848**	**854,667**	**229,663**	**367,256**	**596,918**

Note: Totals comprise all forecast population and employment growth between 2020 and 2040 outside of the high-capacity/high-frequency transit station areas.
Source: MWCOG Draft Round 8.3 Cooperative Land Use Forecast.

2. Scenario Development and Strategies

2.1. Scenario A: Efficient Transit

Scenario A focused on policy changes that will optimize the use of the Metrorail and other high-capacity transit systems. The "efficient transit" scenario intends to make optimal use of the 2040 Baseline transit infrastructure and services by attempting to maintain high ridership on all links in all directions while minimizing the potential for overcrowding. As compared to the Baseline conditions, Scenario A attempted to reduce peak-hour, peak-direction travel demand for Metrorail links that are projected to experience overcrowded conditions (>100 passengers per car) as well as increase ridership on underutilized links (<100 passengers per car) by increasing reverse peak-direction travel demand and off-peak travel demand by 2040.

2.1.1. Strategies and Implementation

In addition to changes in land use throughout the region, Scenario A also included several other policy-type strategies in order to help achieve the goals of an efficient transit system. These strategies, and the methods used to implement them are outlined in the following sections.

Parking Costs and Terminal Times

Parking costs and terminal times (time spent accessing a vehicle; includes walk time between origin/destination and parked car) are used in the mode choice model to determine the total time and cost associated with a driving trip. These attributes are calculated for each TAZ based on the MWCOG Area Type (e.g., Urban, Suburban, etc.), which is determined by the land use density in each zone. As densities change between tested scenarios, Area Types, parking costs, and terminal times were updated to match the new densities.

Pedestrian Environment Factor

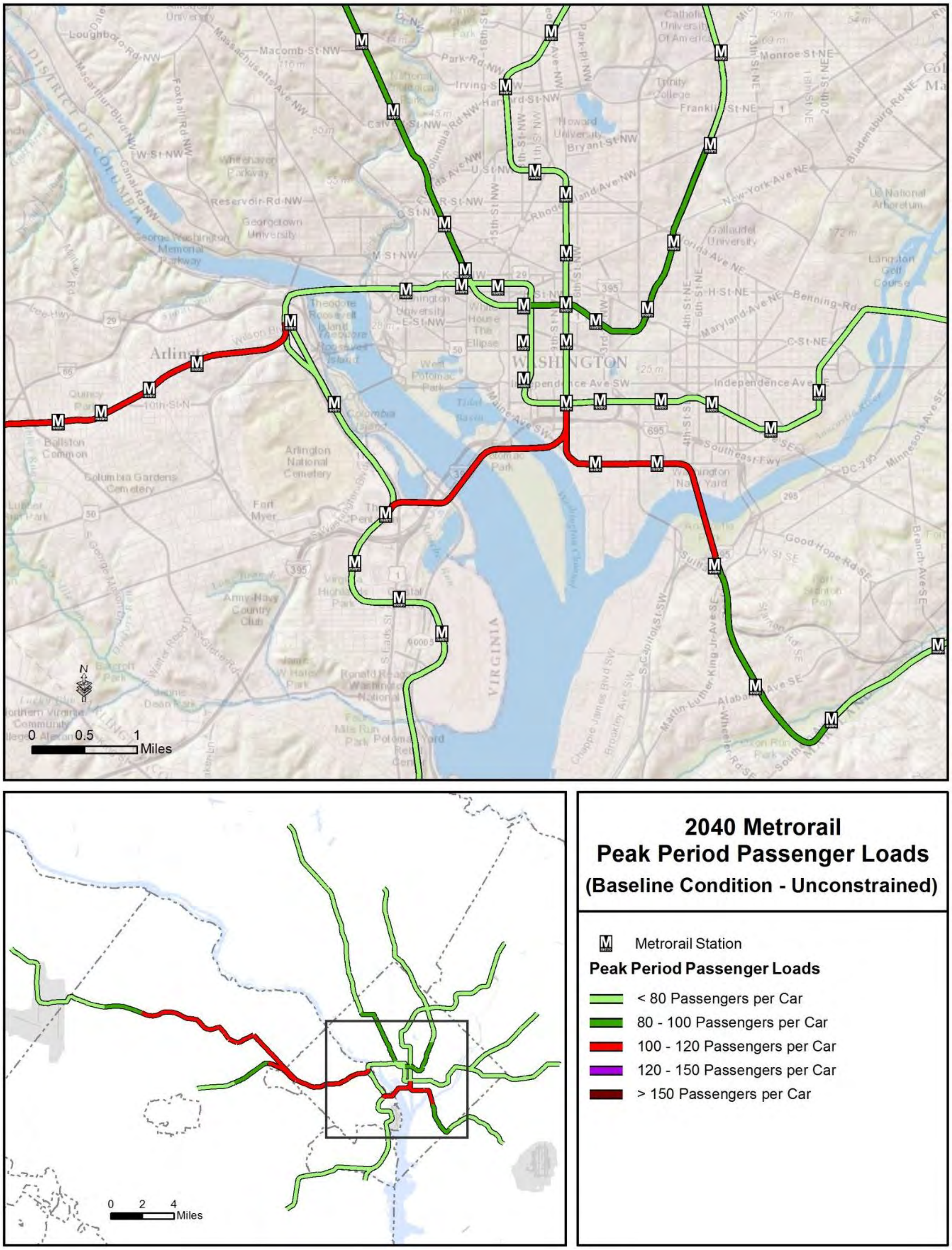
The Pedestrian Environment Factor (PEF) is used in the travel demand model to determine how conducive an area is for pedestrian travel, with higher values indicating a more walkable environment. The PEF was developed by WMATA as part of the RTSP model to improve mode choice modeling in the TPB Version 2.3 Travel Model. PEF measures the number of census blocks within a transportation analysis zone (TAZ) divided by the area of the TAZ in square miles. TAZs with a dense street grid have a higher PEF score than suburban areas with relatively few intersecting streets.

To relate the change in PEF to the change in land use in each scenario, PEF values in each zone were increased by the same percentage as the total land use (combined population and employment). PEF values are therefore different for each land use scenario.

Reverse-Peak Directional Fares

As encouragement for travelers to use underutilized service, a policy was applied to decrease peak period Metrorail fares by 50 percent for trips moving in the reverse-peak direction or utilizing uncongested peak-direction segments. While reverse-peak directionality is very clear on the outer portions of the Metrorail system, it is not as readily apparent where lines meet closer to the core. Reverse-peak direction trips were defined as any trip that could be made exclusively on links showing peak load factors of less than 80 passengers per car in the Baseline. As shown in **Figure 3**, any trips using green or red links in the inbound (morning peak) direction were excluded, in addition to the Yellow Line bridge (connection between the Pentagon and L'Enfant Plaza station) in both directions. (This bridge is the only link in the Baseline Metrorail system that operates at a peak-period load factor higher than 80 passengers per car in both directions). This strategy had the benefit of both encouraging reverse-peak direction trips (e.g., Farragut North to Shady Grove) and short peak-direction trips on uncongested portions of lines (e.g., Shady Grove to Bethesda).

Figure 3: 2040 Base (Unconstrained) Passenger Loads



Expand Bike Access to Transit

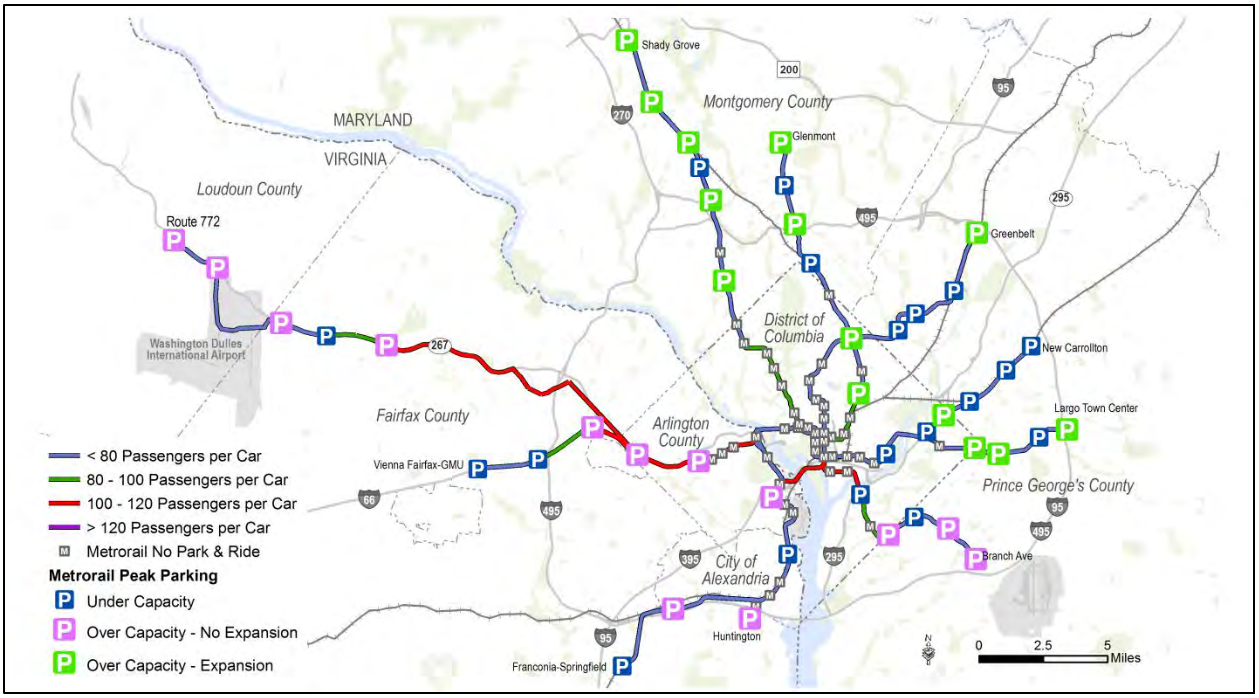
In the Baseline model, non-motorized access trips are limited to those within one mile of a transit stop. To simulate a policy by which bicycle access would be greatly enhanced, the non-motorized access distance assumed in the model was expanded past this limit. Under this policy, non-motorized access to transit (all modes) is now possible up to a 1.5-mile radius. This assumed maximum distance is designed to serve as a middle ground between pedestrians who are only likely to walk one mile, and bicyclists who may bike up to three miles to access transit.

Selective Expansion of Metrorail Park & Ride Capacity

The 2040 Baseline condition shows numerous Metrorail Park & Ride facilities where demand exceeds the available capacity during peak and off-peak periods, even with the model's shadow prices used to regulate demand by approximating the cost of finding an available parking space at over-capacity lots. The shadow price serves as a disincentive to potential Park & Ride users, and is used by the model to regulate demand for specific Park & Ride locations. The shadow price is expressed as a monetary value, converted to travel impedance at the value of time of $10 per hour. **Figure 4** shows all of the Park & Ride facilities that are over capacity during the peak period in the Baseline.

The Park & Ride policy for Scenario A expands the Park & Ride capacity at stations with high parking demand on Metrorail lines that are underutilized under the baseline conditions. To simulate this expansion of parking capacity, shadow prices (both peak and off-peak) were removed for over-capacity Park & Ride lots on Metrorail lines with peak load factors less than 100 passengers per car. As shown in **Figure 4**, these Metrorail lines with relatively low utilization include both branches of the Red Line (Shady Grove and Glenmont ends), the northern branch of the Green Line (Greenbelt end), the eastern branch of the Orange Line (New Carrolton end), and the eastern branch of the Blue Line (Largo end).

Figure 4: Scenario A Selected Park & Ride Expansions



2.1.2. Land Use Scenarios

The non-land use policies outlined above were initially tested using the 2040 baseline land use assumptions (Scenario A prime) to gauge the effectiveness of these policies alone. **Figure 5** shows the 2040 baseline land use density from the MWCOG Round 8.3 land use forecasts. The non-land use policies were then tested with two alternative land use scenarios described below (Scenarios A1 and A2).

As detailed in Section 1, total density goals (population plus employment) for each high-capacity/high-frequency transit station area within a designated Regional Activity Center (RAC) were developed based on the RAC types outlined in *Place + Opportunity: Strategies for Creating Great Communities and a Stronger* Region (MWCOG, 2014). See the *Task 4: Comparison of 2040 Forecast to Existing Land Use Technical Memorandum* for more details. Density goals for each station area were further defined based on the type of land use that needed be added to achieve a more balanced Metrorail network: employment, population, or mixed-use, as shown in **Figure 6**.

Figure 5: 2040 Baseline Land Use Density (Population + Employment)

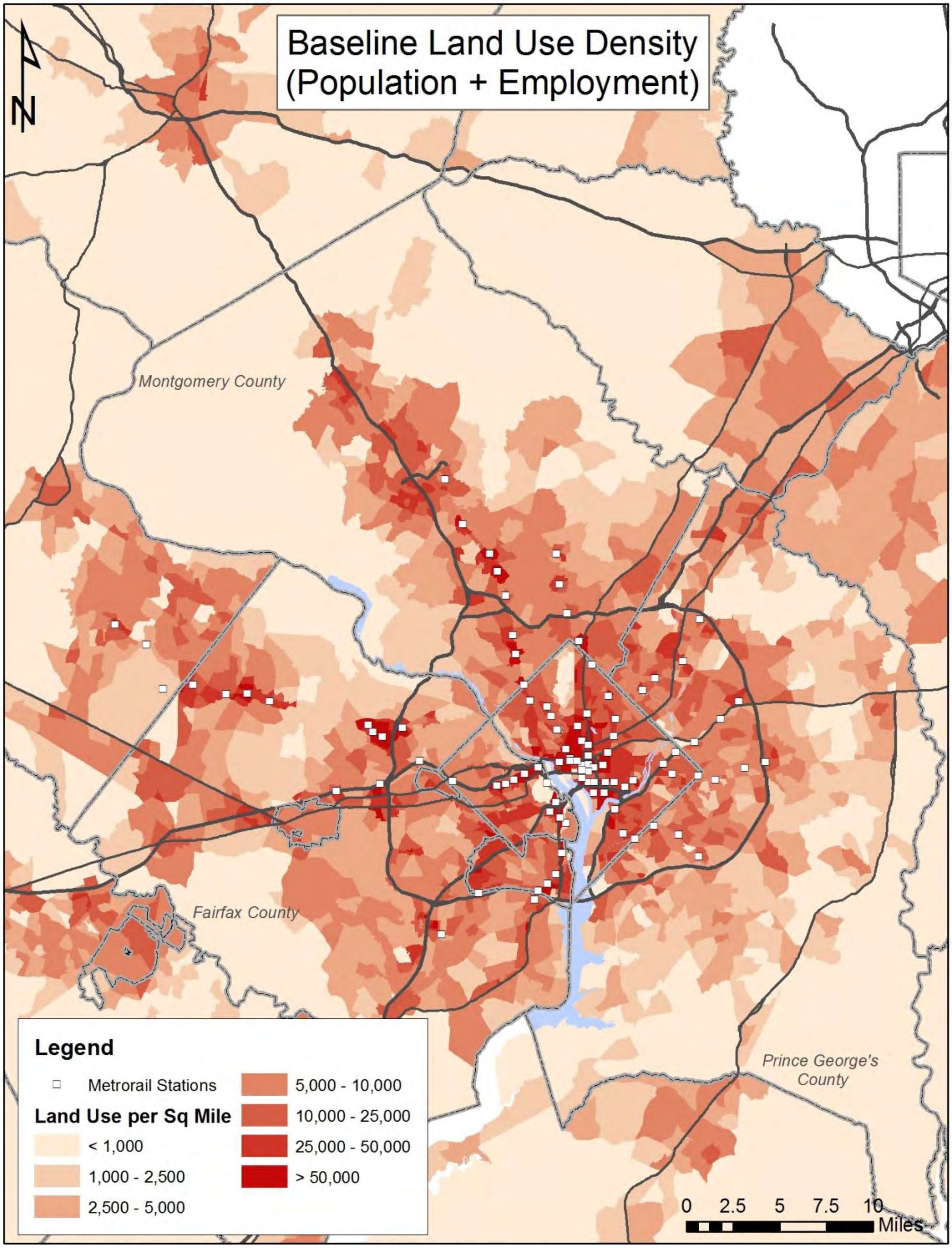
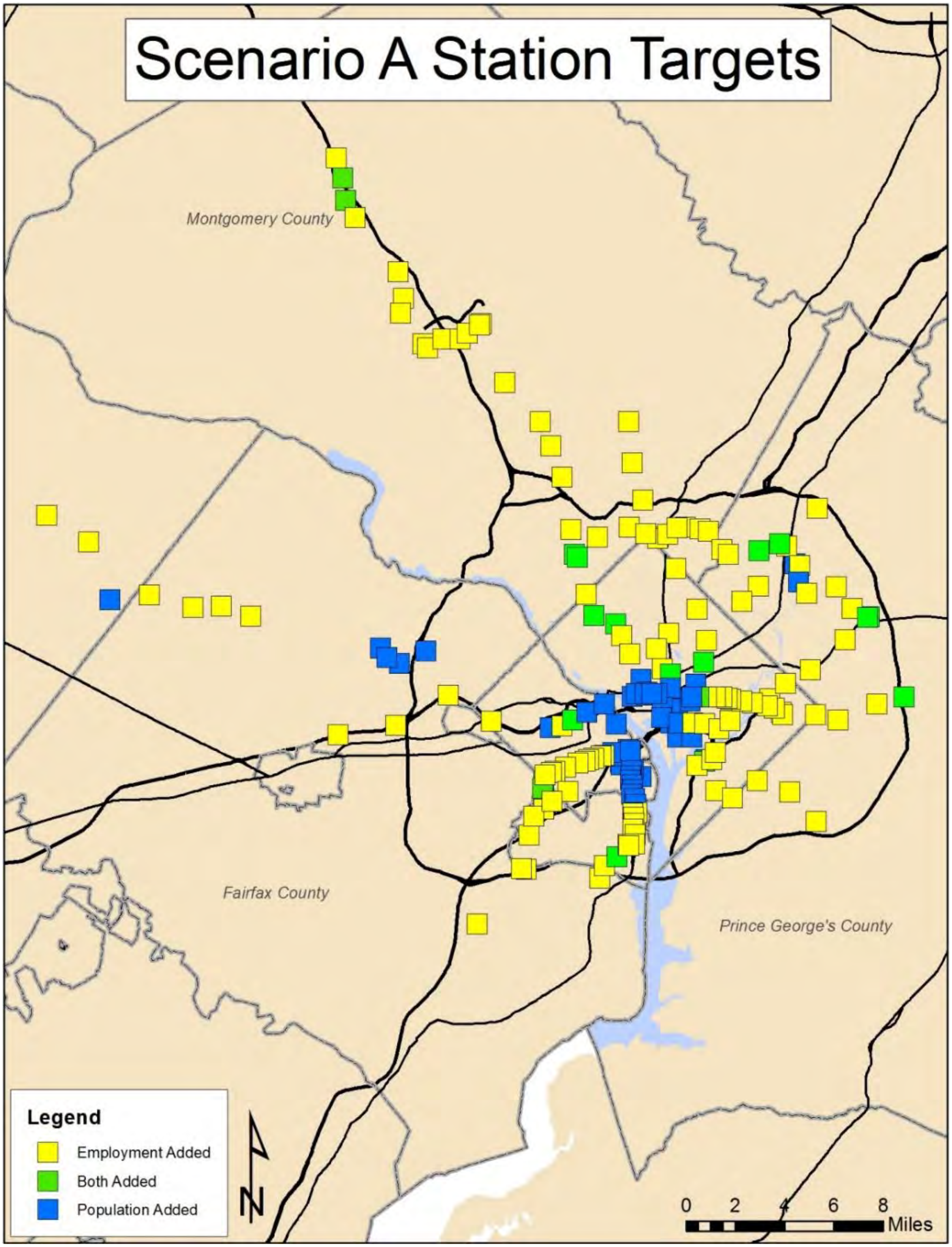


Figure 6: Scenarios A1 and A2 Land Use Targets



These density goals were used to reallocate post-2020 population and employment growth to more transit friendly areas as outlined below:

Scenario A1

- Jurisdictional population and employment totals were maintained
- Population and/or employment were moved from non-RAC locations
- Population and/or employment were moved to TAZs within RACs located within one mile of a high-capacity transit station (see **Figure 7** and **Figure 8**)

Figure 7: Scenario A1 Land Use Density (Population + Employment)

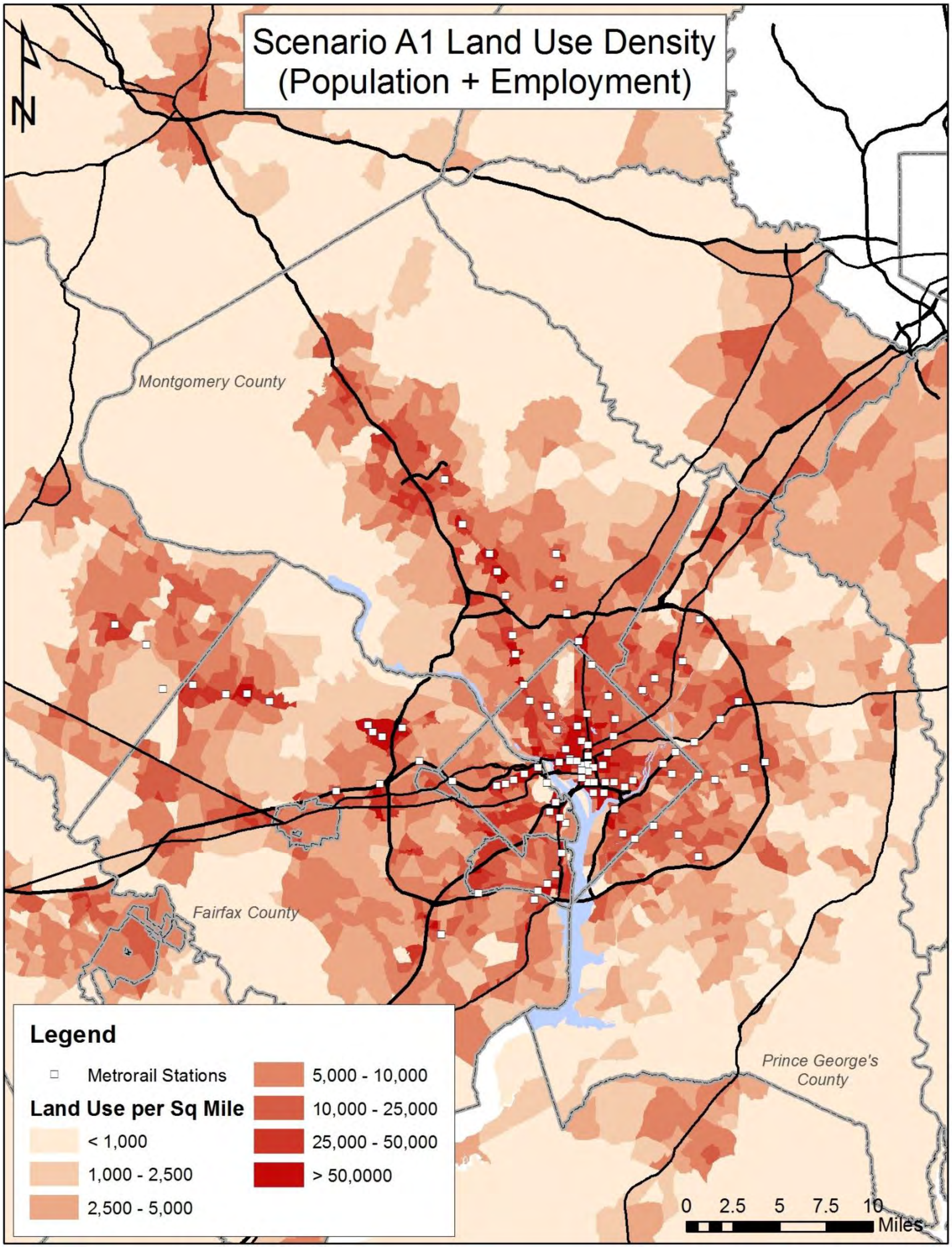
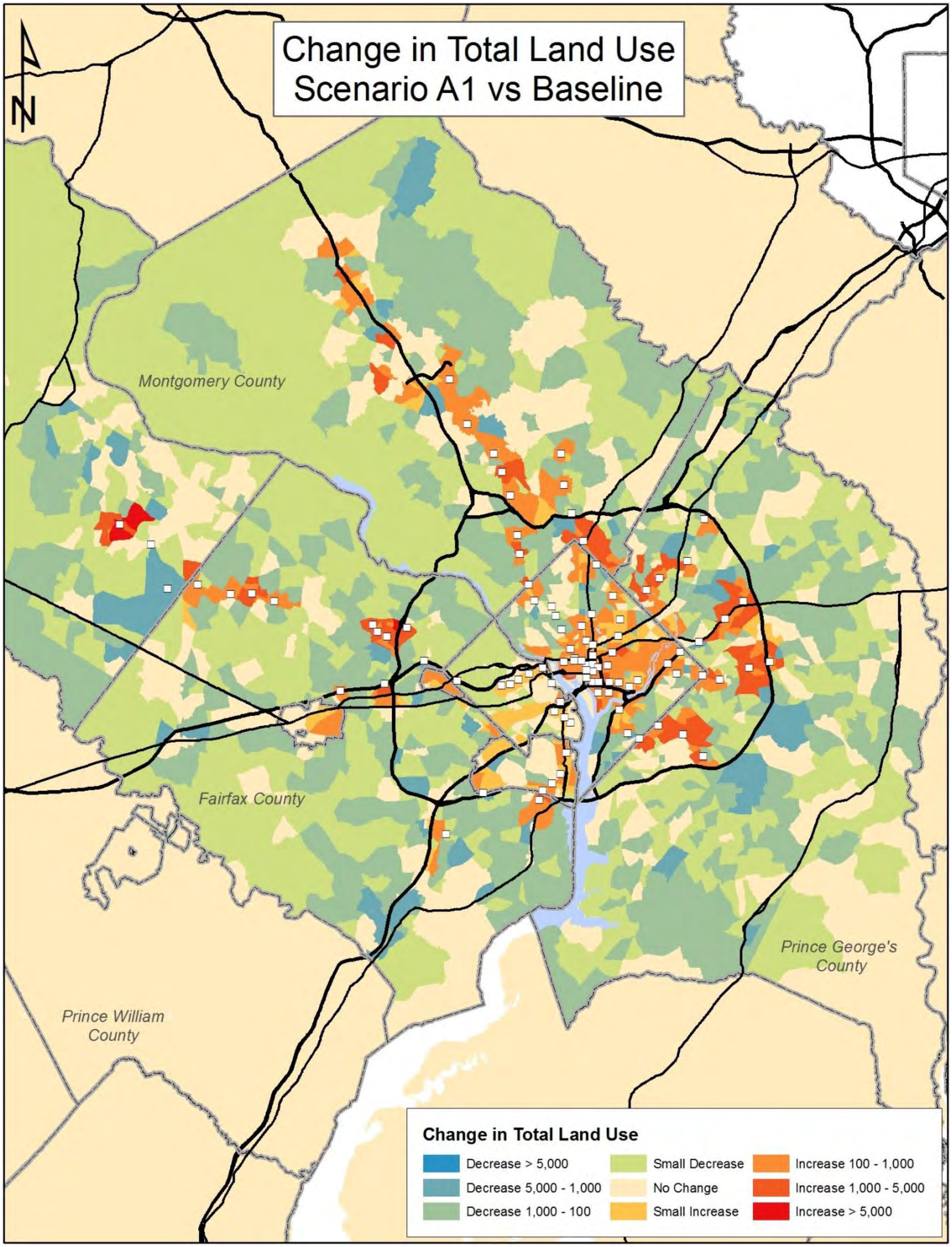


Figure 8: Change in Total Land Use – Scenario A1 versus 2040 Baseline



Scenario A2

Based on initial results of Scenario A1, the density goals for Scenario A2 were modified such that no additional population or employment (beyond what was added for Scenario A1) were added to the following station areas that were already experiencing Metrorail congestion in the 2040 Baseline scenario: Tysons Corner area, Rosslyn-Ballston corridor, L'Enfant Plaza, and the Waterfront/Navy Yard. **Figure 9** and **Figure 10** depict the following population and employment shifts used in Scenario A2:

- Jurisdictional population and employment totals were not maintained, but the overall regional population and employment totals were maintained.
- Step 1: Population and/or employment were moved to the ½-mile radius of a high-capacity transit station
    - Population and employment was shifted from non-RAC locations as well as RAC locations without high-capacity transit stations
- Step 2: Population and/or employment were moved to RACs between ½ mile and one mile of a high-capacity transit station
    - Population and/or employment were moved only from non-RAC locations

Figure 9: Scenario A2 Land Use Density (Population + Employment)

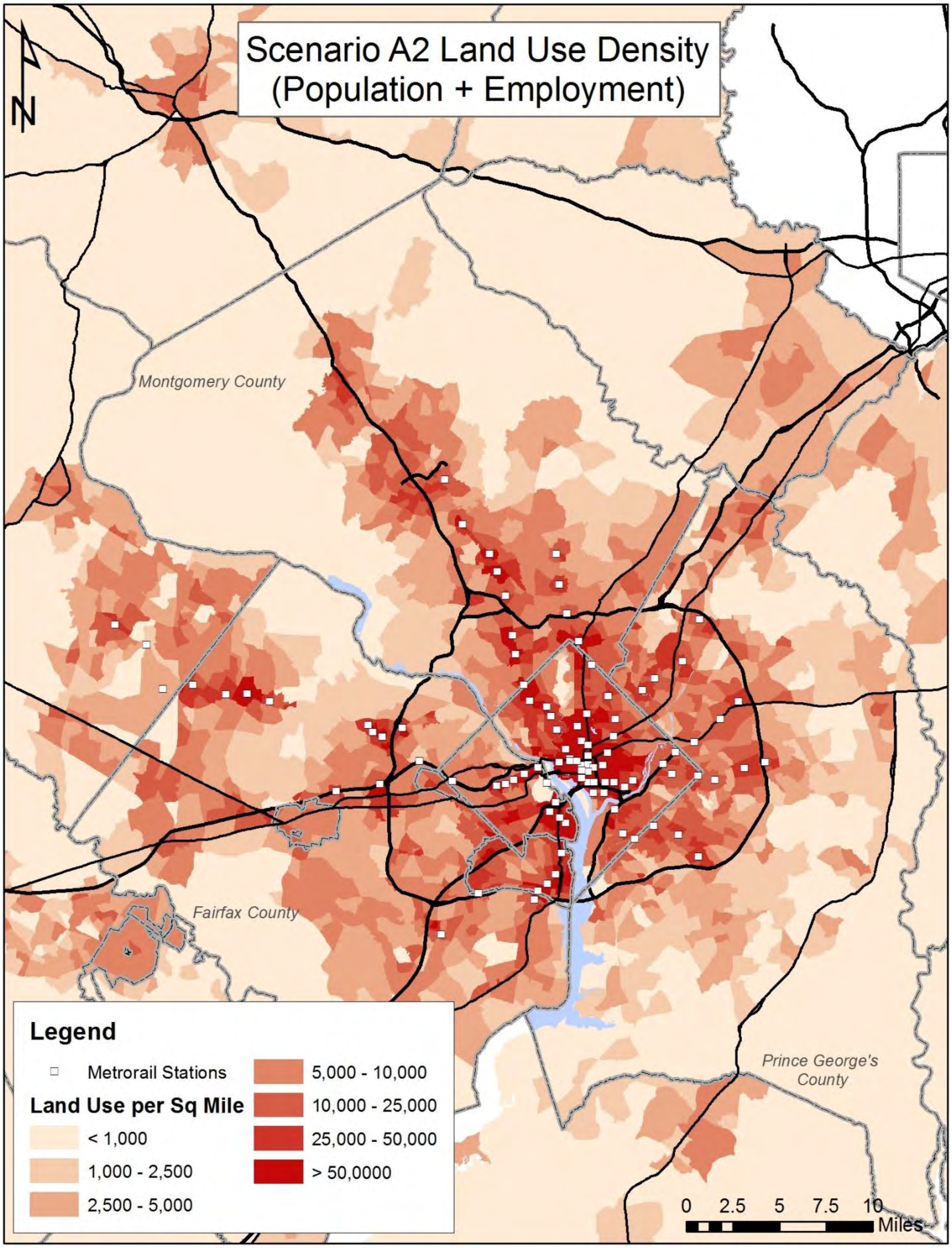
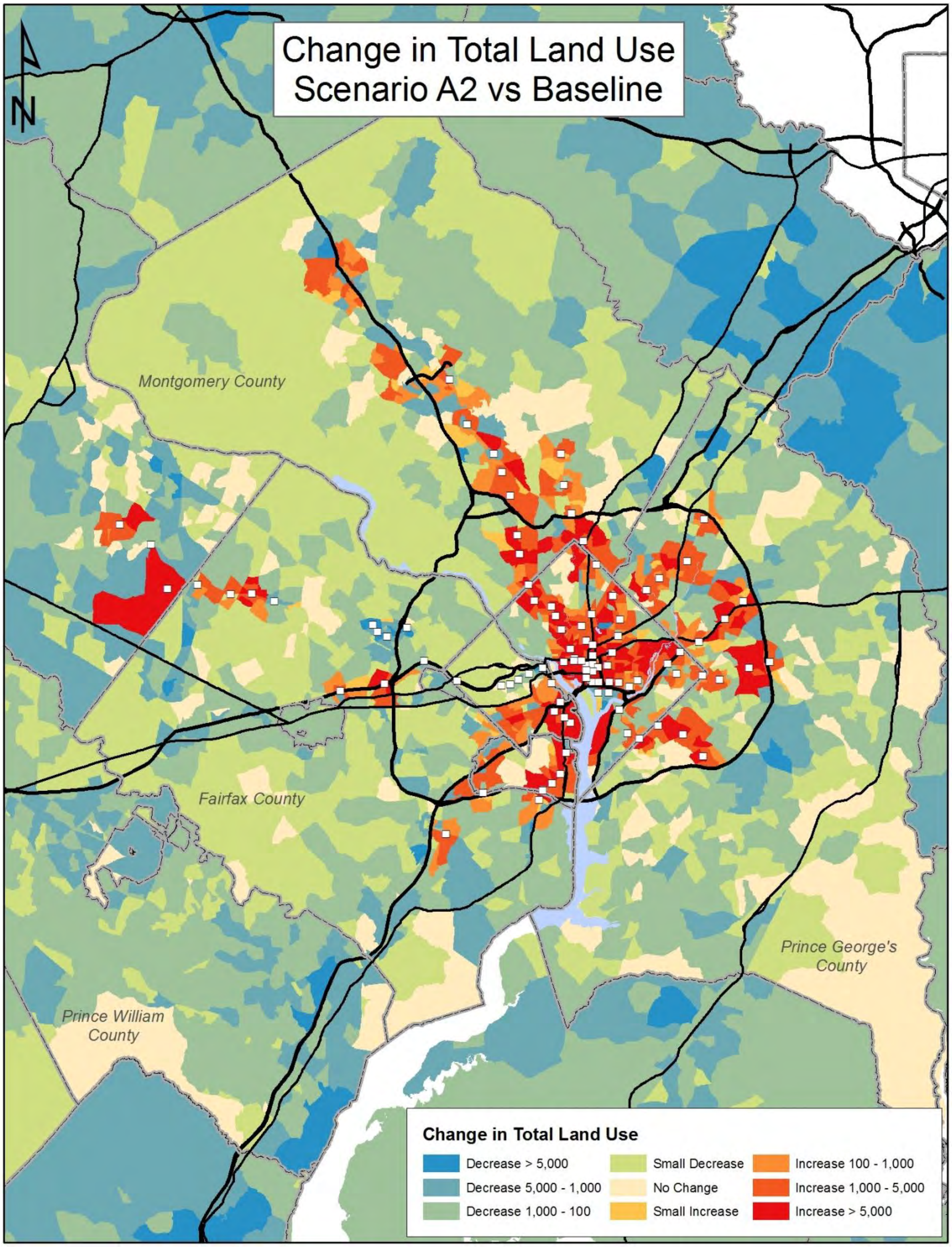


Figure 10: Change in Total Land Use – Scenario A2 versus 2040 Baseline



2.2. Scenario B: Cost-Effective Transit

Scenario B focused on policy changes intended to reduce the public subsidy required to cover the operating costs of the Metrorail system. WMATA estimates that the 2040 Baseline CLRP Metrorail system will cost $2.722 million annually to operate. Total annual revenues are estimated at $2.261 million, requiring a baseline public subsidy of approximately $440.6 million. To eliminate the need for this public subsidy without lowering operating costs or cutting service, the Metrorail system would require an additional $1.41 million in revenue on an average weekday. The goal of scenario B was to achieve this level of revenue by increasing ridership. Revenue sources used in this analysis were fare revenues and parking fees.

2.2.1. Strategies and Implementation

In addition to changes in land use throughout the region, Scenario B implemented several other policy strategies to help achieve the goal of a cost-effective transit system. These strategies, and the methods used to implement them, are outlined in the following sections.

Enhanced Pedestrian Environment Factors

PEF values in Scenario B were further enhanced over the values used in Scenario A to represent an even more drastic shift towards walkable station areas. PEF values in each zone were increased by the same percentage as the total combined population and employment density (as in Scenario A), and then further increased by ten percent. PEF values are therefore different for each land use scenario.

Intelligent Transportation Systems

This policy assumed that various technology enhancements will decrease the negative effects of wait time and transfer time on transit passenger demand. This policy was simulated in the model by decreasing the factors applied to wait times and transfer times by 25 percent in the transit skimming and transit assignment processes.

Expand Bike Access to Transit

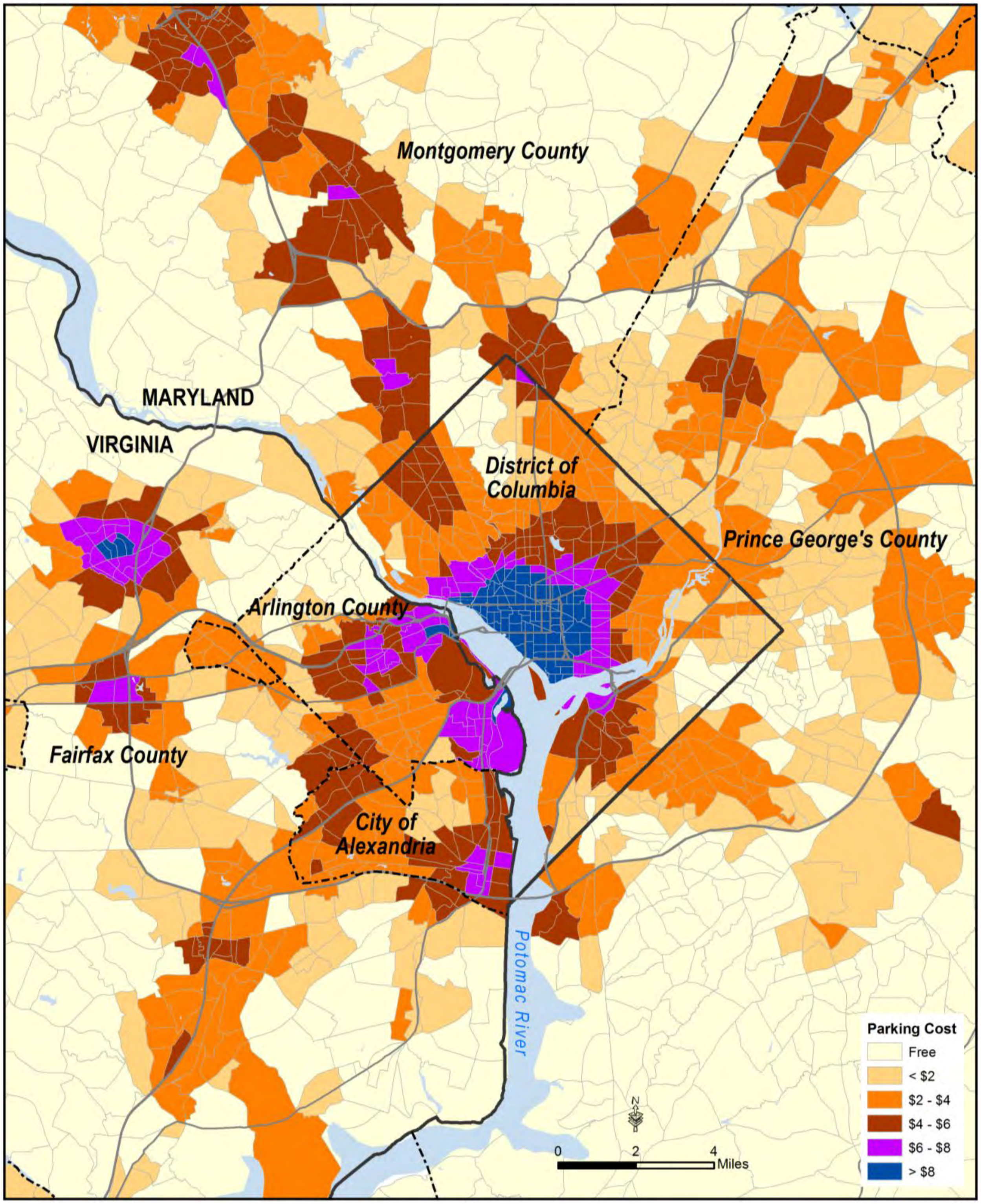
In the same manner as Scenario A, Scenario B extended the non-motorized access distance to transit past the baseline limit of a one-mile radius up to a 1.5-mile radius. The assumption of 1.5 miles served as a middle ground between pedestrians who are likely to walk up to one mile to access high-capacity transit, and bicyclists who are likely to bike up to three miles to access high-capacity transit.

Regional Parking Availability and Pricing

The goal of this policy was to limit the availability of cheap parking for auto trips around the region, making transit travel more attractive. The travel demand model assigns parking costs to each TAZ for each trip purpose based primarily on its Area Type (e.g., Urban, Suburban, etc., based on the land use density).

Figure 11 shows approximate parking costs for home-based work (HBW) trips in the 2040 Baseline scenario – which reach as high as $10 in the core of downtown DC.

Figure 11: Baseline Parking Costs by Zone – Home-Based Work (HBW) Trips



These modeled parking costs represent a parking cost per trip; because HBW trips are assumed to be significantly longer in duration than the other trip purposes, HBW parking costs are also significantly higher. A brief outline of baseline parking costs is shown in **Table 3.**

Table 3: Range of Baseline Zonal Parking Costs by Trip Purpose

Trip Type:	HBW	HBS	HBO	NHB
Baseline Parking Cost	Free-$10.19	Free or $2.00	$4.00, $2.00, $0.50, or Free	Same as HBO

HBW = Home Based Work; HBS = Home Based Shopping; HBO = Home Based Other; NHB = Non-Home Based

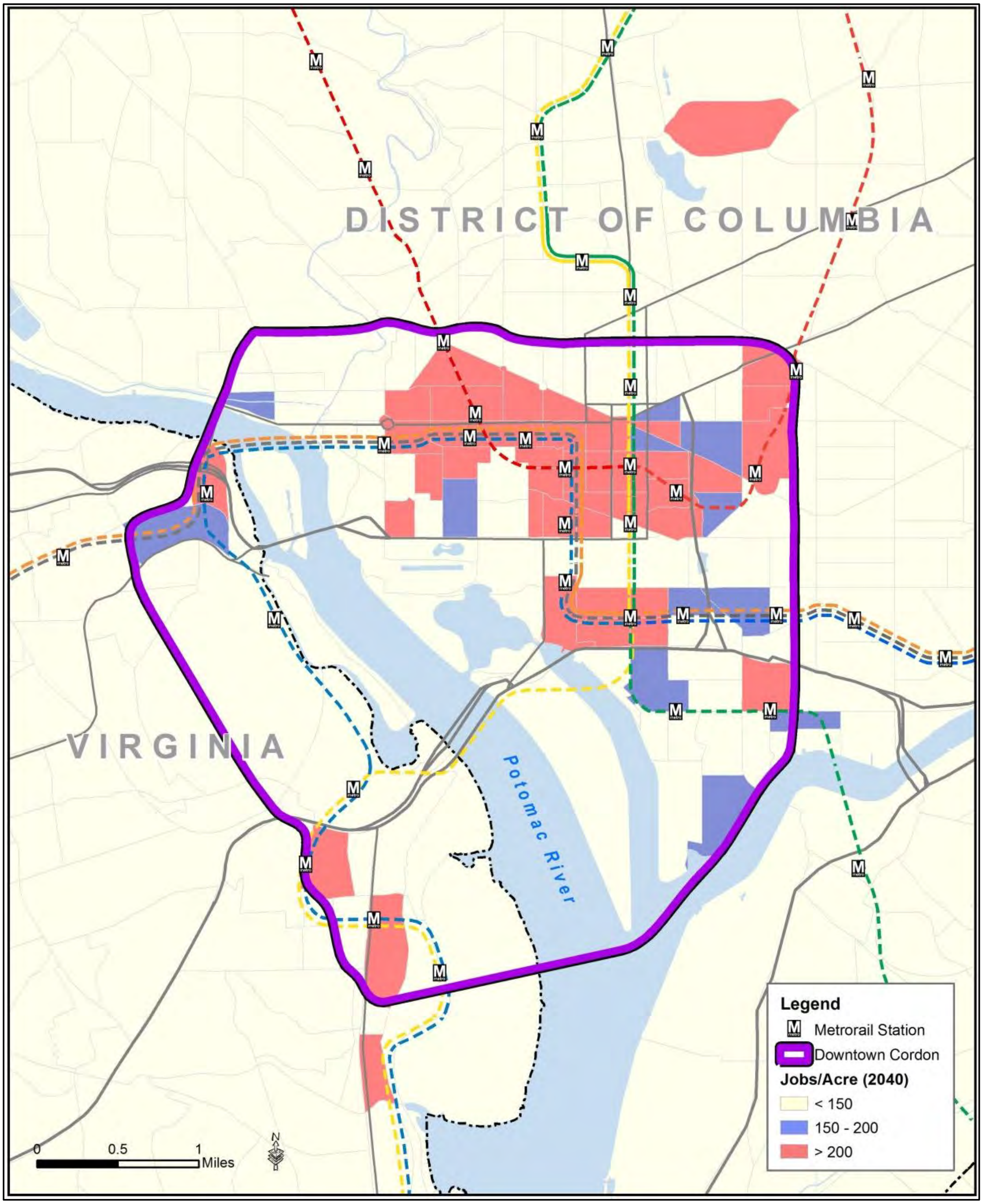
For Scenario B, these zonal parking costs were increased above those assumed by the model by 25 percent. In addition, minimum parking costs were applied to eliminate zones with free parking. All TAZs inside the Beltway were assigned a minimum HBW parking cost of $2.00; TAZs outside the Beltway were assigned a minimum HBW parking cost of $1.00. Minimum parking costs for other trip purposes were also assigned, but were lower based on the expected duration of the different types of trips.

Because the travel demand model calculates parking costs based on Area Type and density, each land use alternative tested for Scenario B has different parking costs.

Cordon Pricing

Cordon pricing, charging a toll for vehicles entering the region's employment core, was implemented in Scenario B as an additional method of encouraging transit use to the region's core, thereby increasing overall ridership and revenues. The cordon location was developed by defining the region's employment core as the area that encompasses the majority of TAZs with an employment density greater than 200 jobs per acre. As shown in **Figure 12,** the cordon includes most of downtown DC, Rosslyn, the Pentagon, and the Pentagon City area. A $5.00 toll was charged on all cordon links shown in the map in the inbound direction; outbound trips on those links were not charged a toll.

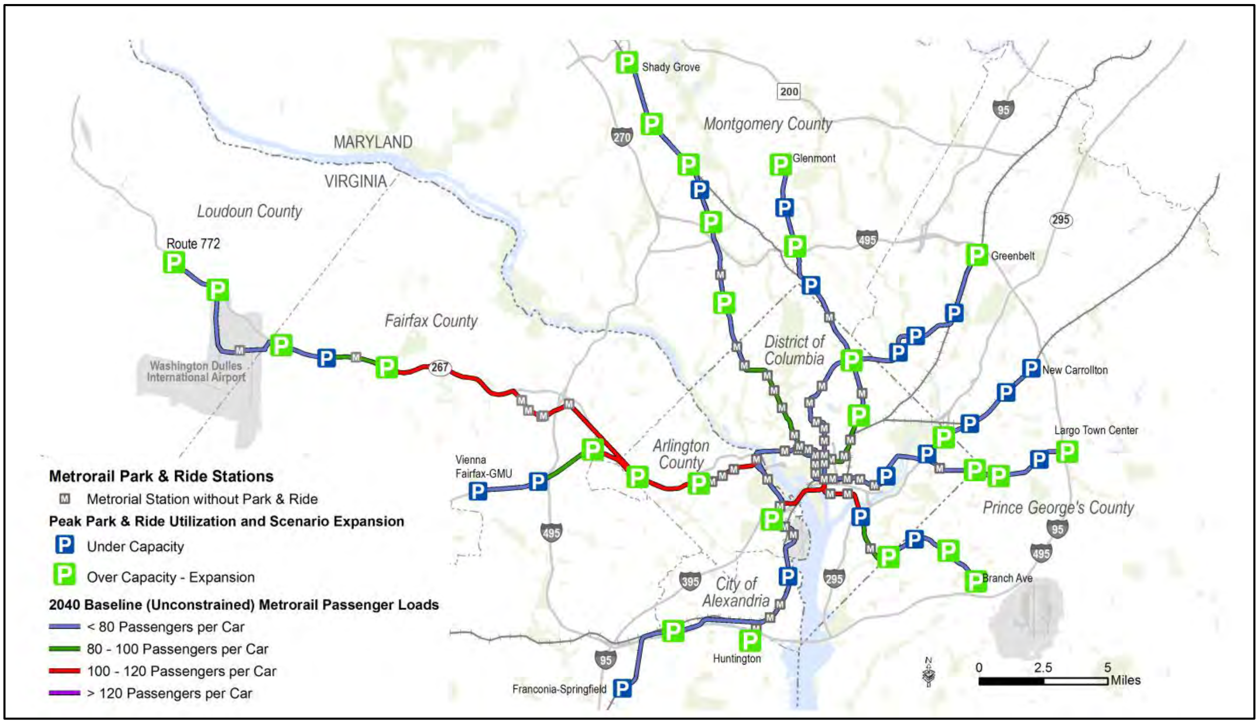
Figure 12: Location of Downtown Cordon and High-Density Employment



Metrorail Park & Ride Capacity Increase

To take advantage of potential ridership and revenues from Park & Ride passengers, Scenario B expanded the capacity of Metrorail Park & Ride lots at which demand was constrained by the available capacity in the 2040 Base. To model this policy, all shadow prices were removed from the model, essentially providing unlimited Park & Ride capacity at all Metrorail stations with a Park & Ride facility, as shown in **Figure 13**. The scenario did not add parking capacity to Metrorail stations currently without Park & Ride facilities.

Figure 13: Scenario B Park & Ride Expansion at Over Capacity Stations

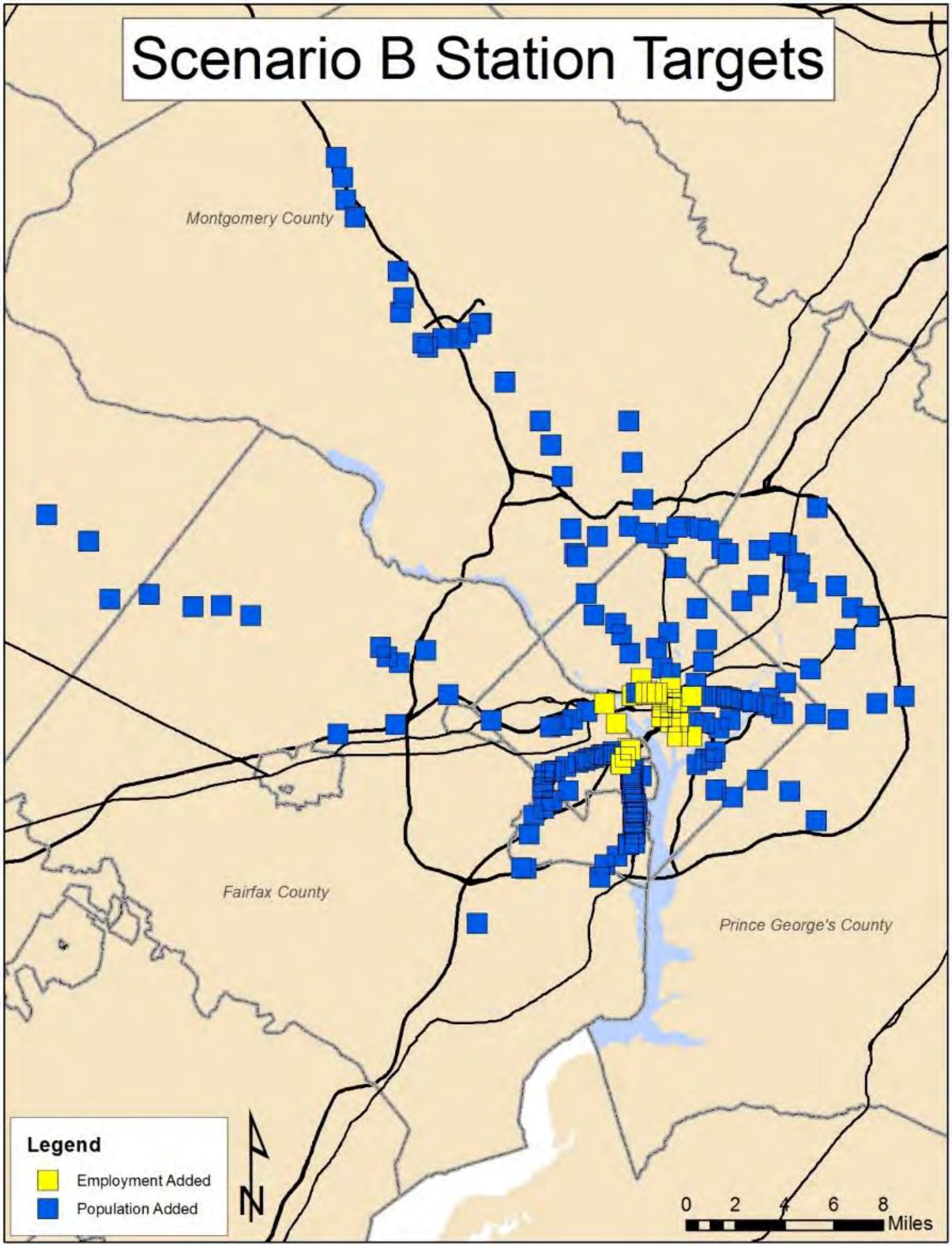


2.2.2. Land Use Scenarios

The non-land use policies outlined above were initially tested using the 2040 Baseline land use assumptions (Scenario B prime) to gauge the effectiveness of these policies alone. The non-land use policies were then tested with two alternative land use scenarios intended to increase Metrorail ridership described below (Scenarios B1 and B2).

The land use alternatives for Scenario B used the same total density goals (population plus employment) for each station area as those developed from the MWCOG *Place + Opportunity* report for Scenario A. However, the Scenario B alternatives focused on different types of development patterns. The land use strategy for Scenario B reinforced existing transit markets in order to increase transit ridership in places where service levels were already high. While the Scenario A land use alternatives focused on increasing mixed-use development and achieving a jobs-population balance within transit station areas, the Scenario B land use alternatives focused on reinforcing the existing land use in traditionally strong transit markets. Therefore, more residents were added in station areas that are currently population centers, while more jobs were added to existing employment centers, as shown in **Figure 14.**

Figure 14: Scenario B Station Targets



These density goals were used to reallocate post-2020 land use growth to more transit-friendly areas as outlined below:

Scenario B1

- Population and employment were moved only from non-RAC locations
- Population and employment were moved to TAZs in RACs located within 1-mile of a high-capacity transit station
- Jurisdictional population and employment totals were maintained

The resulting change in total land use densities are shown in **Figure 15**.

Scenario B2

Based on initial results of Scenario B1, the density goals for Scenario B2 were modified such that no additional land use was added to station areas that were already experiencing Metrorail congestion in the 2040 Baseline scenario, including the Tysons Corner area, the Rosslyn-Ballston corridor, L'Enfant Plaza, and the Waterfront/Navy Yard areas (see **Figure 16**)

- Step 1: Population and employment were moved to ½-mile radius of high-capacity transit stations
  - Population and employment were moved only from non-RAC locations
  - Jurisdictional population and employment totals were not maintained
- Step 2: Population and employment were moved to RACs between ½ mile and one mile of a high-capacity transit station
  - Population and employment were moved only from non-RAC locations
  - Jurisdictional population and employment totals were not maintained

Figure 15: Change in Total Land Use Scenario B1 vs Baseline

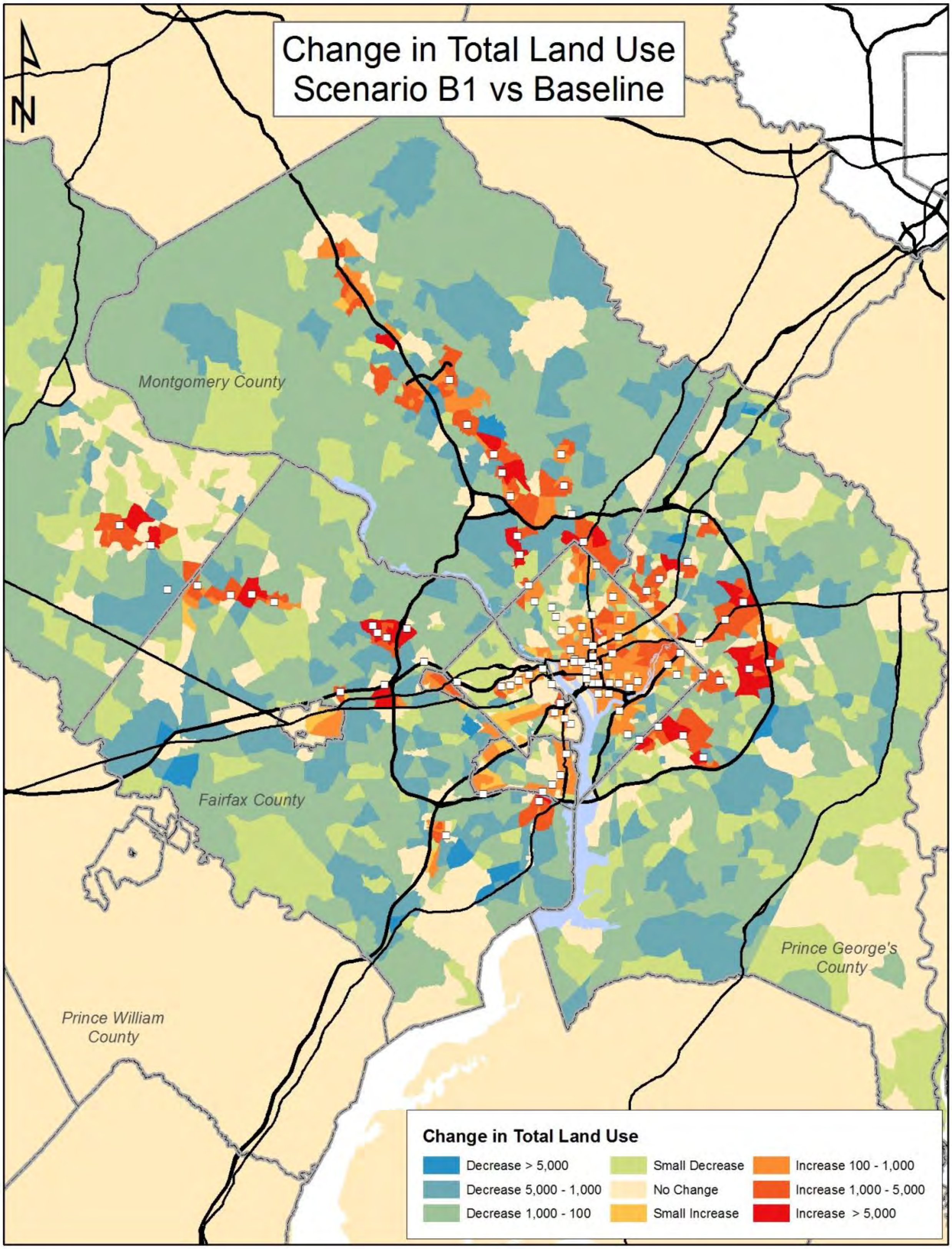
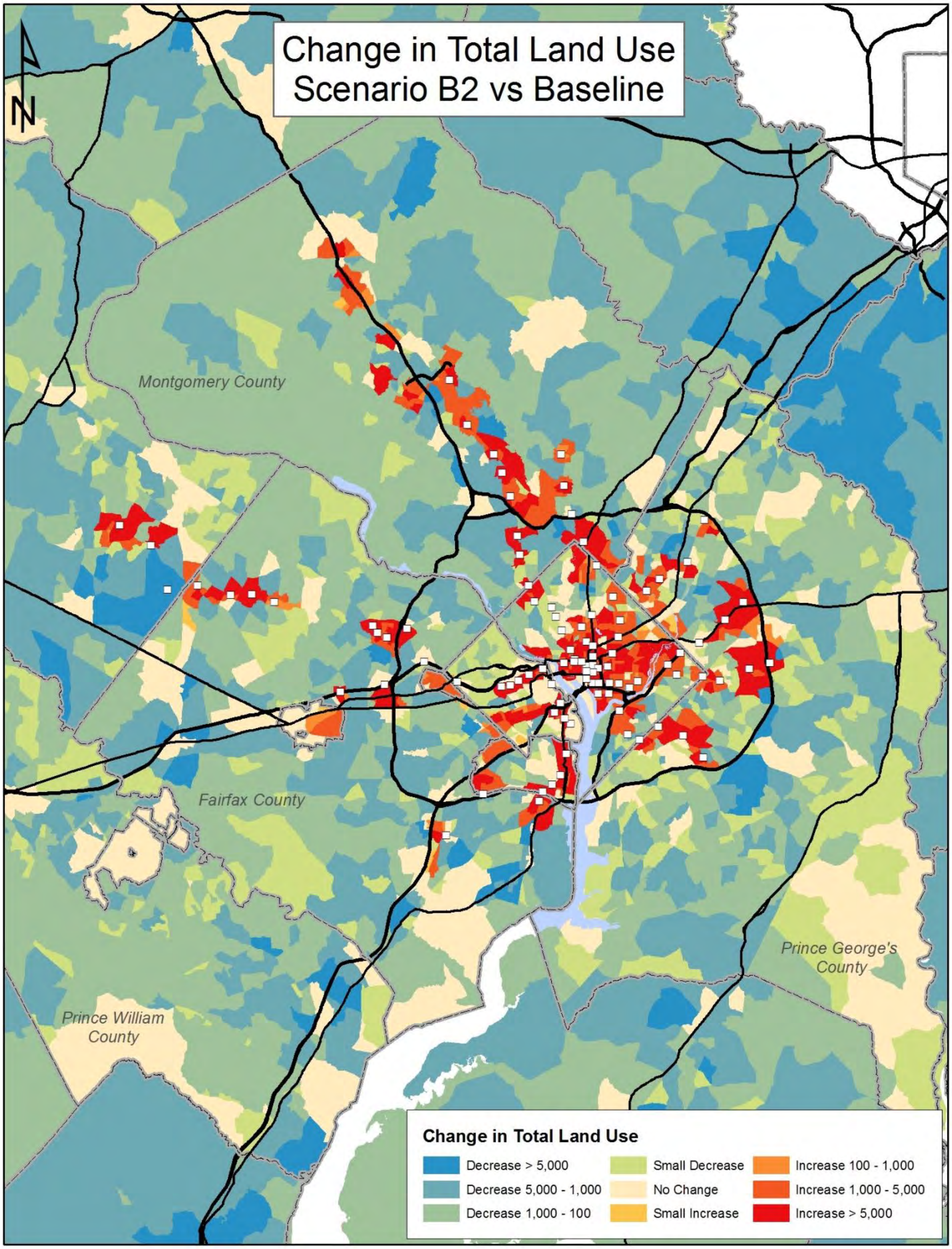


Figure 16: Change in Total Land Use Scenario B2 vs Base



2.3. Scenario C: Maintain Current Travel Times

Scenario C focused on limiting traffic congestion in the metropolitan region, with the stated goal of maintaining current travel times for peak period travel. To achieve this goal, the forecast regional growth in population and employment between 2014 and 2040 would have to be accommodated without exacerbating existing congestion levels on the region's roadways. Thus, the policies intended to achieve the goals of this scenario were designed to decrease the total demand for automobile travel during the peak periods.

2.3.1. Strategies and Implementation

In addition to changes in land use throughout the region, Scenario C implemented several other policy strategies designed to decrease the total demand for peak period travel, with a particular focus on reducing automobile travel. These strategies, and the methods used to implement them, are outlined in the following sections.

Driving-Related Tax Increase (Gas/Carbon/VMT Tax)

One strategy used to discourage automobile travel and encourage the use of transit for all trips (instead of just commuting trips as with the cordon toll in Scenario B) was the implementation of a new tax on driving. The actual form of this tax was not defined as part of this study; a gas tax increase, carbon tax, or vehicle miles traveled (VMT) tax could all serve the purpose of this policy. A review of some available research on the subject indicated that a revenue-neutral VMT tax would require a cost of between 1.1[1] and 1.2[2] cents per mile. For this analysis, 1.1 cents per mile was added to the baseline automobile operating cost assumed in the modeling of 10 cents per mile, for a total automobile operating cost of 11.1 cents per mile.

Telework

Telework has the potential to reduce the amount of peak period travel on an average weekday by reducing the total number of commute trips. The current rate of telework is already built into the calibration of the trip generation model – the total number of HBW trips generated by the model accounts for the number of trips that will not be taken due to telework. For Scenario C, a telework policy was implemented that increased the telework rate above the current rate and those trips were subtracted from the total motorized trips.

The 2013 State of the Commute survey for the Washington Metropolitan region indicated that 7 percent of workers who do not currently telework "could and would telework regularly"[3] if given an opportunity. Based on this result, this study assumed that an enhanced telework policy would result in an additional seven percent of workers who currently commute to their jobs switching to telework two days per

[1] NCHRP Web Only Document 143: Implementable Strategies for Shifting to Direct Usage-Based Charges for Transportation Funding, June 2009. http://onlinepubs.trb.org/onlinepubs/nchrp/nchrp_w143.pdf

[2] Oregon's Mileage Fee Concept and Road User Fee Pilot Program Final Report, November 2007. http://www.oregon.gov/ODOT/HWY/RUFPP/docs/RUFPP_finalreport.pdf

[3] "Telework regularly" is compared with "telework occasionally" in this study. Occasional telework is considered to be very infrequent, i.e. once per month or on special occasions due to illness.

week. This switch would effectively remove 2.8 percent of commute trips from travel on an average weekday. This policy would equally affect automobile and transit commute trips.

Alternative Work Hours

This policy looks at enforcing alternative work schedules, such that some commuters would shift their trips out of the peak period. The baseline model in the region assigns between 50-58 percent of the home-to-work trips to the morning peak period (depending on auto occupancy); similarly, 58-66 percent of the work-to-home trips are assigned to the evening peak period. Scenario C reduced those percentages by five percentage points, increasing the number of driving commute trips that are assigned to the off-peak periods. Transit users were not assumed to be affected by this policy.

Transit Fare Reduction

To further increase the attractiveness of transit compared to automobiles, Metrorail fares were reduced by 25 percent for both the peak and off-peak periods.

Increase Non-Motorized Mode Share

The pedestrian and bicycle modes have the potential to reduce the number of motorized trips taken on a daily basis, but are only viable options for short trips. Analysis of the 2009 National Household Travel Survey (NHTS) in **Table 4**, shows that while the majority of trips less than a mile are currently made using non-motorized modes, the number drops off significantly for three-mile trips.

Table 4: Observed Non-Motorized Mode Share for Short Trips

Trip Length	Walk	Bike	Total Non-Motorized
≤ 0.5 miles	61%	3.1%	64.1%
≤ 1 mile	51%	3.3%	54.3%
≤ 3 miles	27%	2.2%	29.2%

Source: 2009 National Household Travel Survey, http://www.vtpi.org/tdm/tdm63.htm#_Toc272910898

To simulate a policy that facilitates the additional use of non-motorized modes above what would currently occur in the model based on land use densities, Scenario C identified all trips shorter than two miles as potential candidates for non-motorized travel. Ten percent of these trips shorter than two miles that occur on motorized modes were shifted onto non-motorized modes, helping to reduce congestion. This policy was applied to trips for all purposes during all time periods.

Pedestrian Environment Factor

PEF values in each zone were increased by the same percentage as the total land use density (combined population and employment). PEF values are therefore different for each land use alternative.

2.3.2. Land Use Scenarios

The non-land use policies outlined above were initially tested using the 2040 Baseline land use assumptions (Scenario C prime) to gauge the effectiveness of these policies alone. The non-land use policies were then tested with two alternative land use scenarios (Scenarios C1 and C2) based on the land use alternatives developed for Scenario A. These land use alternatives were designed to promote mixed-use development, which can also decrease trip lengths and maximize the potential for short non-motorized trips.

3. Scenario Results

The scenarios were evaluated based on their performance against the 31 Measures of Effectiveness (MOEs) that were developed based on the *ConnectGreaterWashington* (CGW) goals and objectives.[4]

Measures of Effectiveness (MOEs) for the CGW land use and policy alternatives were developed to measure the scenarios' performance relative to the goals and objectives established for the project, and the stated goals of each of the three Scenarios. **Table 5** lists the MOEs for the CGW land use and policy alternatives by the corresponding project objectives and goals. New MOEs, developed specifically for the land use and policy alternatives analysis and not used in previous CGW analyses of the 2040 Build network, are shown with an asterisk.

Table 6 lists the complete MOE results for the 2040 Baseline transit network (both constrained and unconstrained model results), and the results for each scenario described in Section 1: Scenario A (including A1 and A2); Scenario B (including B1 and B2); and Scenario C (including C1 and C2).

Table 5: ConnectGreaterWashington Goals, Objectives, and Measures of Effectiveness

Goal	Key Objectives for Land Use and Policy Analysis	Measure of Effectiveness (MOE)
Goal 1: Enhance environmental quality, improve energy efficiency, and protect human health and safety	Minimize transportation-related emissions	1.1 Total vehicle miles traveled (VMT)
	Maximize transportation system efficiency	1.2 Congested person miles of travel in autos and buses
		1.3 Average trip distance and average trip time*
Goal 2: Facilitate transit-oriented, mixed-use communities that capture employment and household growth, providing choices in where to live, work, and play	Enhance transit mode share to/from Regional Activity Centers (RACs)	2.1 Transit trips to/from Regional Activity Centers (RACs)
		2.2 Transit mode share to/from Regional Activity Centers (RACs)
		2.3 Transit trips outside RACs
		2.4 Transit modes outside RACs
	Minimize travel time to/from RACs	2.5 Change in highway travel times*
	Facilitate non-motorized trips	2.6 Percent of non-motorized trips*
		2.7 Number of intrazonal trips and intrazonal Trips as a percent of total motorized Trips*
	Maintain current travel times	2.8 Total vehicle hours traveled (VHT)
		2.9 Average travel speed*

[4] Not all measures were applied to all scenarios.

Goal 3: Maximize availability of and convenient access to integrated transit choices	Maximize households and employment served by high-frequency, higher-speed service	3.1 Number of jobs accessible with 45 minutes from households
		3.2 Households within 1/2 mile of high capacity transit
		3.3 Jobs within 1/2 mile of high capacity transit
		3.4 Jobs/Housing balance *
Goal 4: Provide a high-quality transit system that accommodates and encourages future ridership growth	Minimize crowding on the 2040 Baseline Transit Network	4.1 Person hours of transit travel on congested vehicles
		4.2 Metrorail transfer capacity - average weekday Metrorail transfers at core stations
		1.2 Congested person miles of travel in autos and buses
		4.3 Peak Metrorail load factors by direction
		4.4 Metrorail passenger miles traveled (PMT) by level of congestion
		4.5 Average load factor deviation from vehicle capacity*
	Increase transit mode share	4.6 Total transit ridership (linked trips)
		4.7 Total transit mode share*
Goal 5: Provide a financially viable and sustainable transit system that is efficient and effective for the region	Reduce transit operating subsidy	5.1 Transit utilization - passenger miles per seat mile
		5.2 Transit peak orientation factor
		5.3 Metrorail operating costs per passenger mile
		5.4 Change in property tax revenues (from base)*
		5.5 Metrorail fare and parking revenues*
		5.6 Metrorail operating subsidy by jurisdiction*
		5.7 Congestion toll and VMT tax revenue*
		5.8 Lost growth to congestion*

*New MOE developed for land use and policy alternatives analysis.

Table 6: MOE Summary Table

No.	Measure	2010*	2040 Base (Constrained)	2040 Base (Unconstrained)	Scenario A	Scenario A1	Scenario A2	Scenario B	Scenario B1	Scenario B2	Scenario C	Scenario C1	Scenario C2
1.1	**Vehicle Miles Traveled (VMT) - Daily**	170,307,284	194,822,000	194,146,000	194,032,000	215,175,000	171,454,000	188,934,000	185,455,000	141,913,000	192,608,000	198,453,000	190,487,000
1.2	**Congested Person Miles of Travel (PMT)**												
	Buses	--	1,876,000	1,910,000	1,886,000	3,064,000	2,849,000	2,278,000	1,990,000	2,306,000	1,836,000	1,766,000	1,714,000
	Auto	--	30,029,000	30,716,000	29,729,000	45,774,000	21,271,000	26,188,000	23,945,000	26,581,000	28,947,000	33,233,000	26,371,000
1.3	**Average trip distance and average trip time**												
	Distance (in miles)	8.1	8.2	7.8	8.2	9.2	8.8	8.1	8.0	8.4	8.2	8.2	8.2
	Time (in minutes)	18	20	19	20	18	23	20	20	29	20	17	19
2.1	**Transit Trips to/from Regional Activity Centers (RACs) - Daily**	--	1,660,000	1,415,000	1,770,000	1,968,000	2,796,000	2,042,000	2,204,000	5,940,000	1,779,000	1,729,000	2,212,000
2.2	**Transit Mode Share to/from Regional Activity Centers (RACs)**	--	15%	12%	15%	17%	25%	18%	18%	46%	16%	15%	19%
2.3	**Transit Trips outside RACs**	--	78,000	83,000	81,000	98,000	248,000	147,000	132,000	625,000	81,000	66,000	130,000
2.4	**Transit Mode Share outside RACs**	--	1%	1%	1%	1%	3%	1%	1%	11%	1%	1%	1%
2.5	**Change in Highway Travel Times (Change from 2010)**	--	16%	12%	11%	55%	-7%	-3%	-11%	-36%	10%	34%	3%
2.6	**Percent of non-motorized trips**												
	District of Columbia	--	32%	32%	32%	33%	52%	32%	33%	48%	34%	34%	53%
	Montgomery County	--	12%	12%	12%	13%	15%	12%	13%	19%	14%	15%	17%
	Prince George's County	--	9%	9%	9%	10%	12%	9%	10%	14%	11%	12%	13%
	Arlington County	--	25%	25%	25%	25%	38%	25%	25%	39%	27%	27%	39%
	City of Alexandria	--	23%	23%	23%	23%	28%	23%	23%	34%	26%	25%	31%
	Fairfax County	--	12%	12%	12%	13%	11%	12%	14%	20%	14%	15%	13%
	Loudoun County	--	8%	8%	8%	8%	8%	8%	8%	9%	10%	10%	10%
	Compact Area Total	--	15%	15%	15%	16%	23%	15%	16%	26%	17%	18%	25%
	Other	--	6%	6%	6%	6%	5%	6%	6%	6%	9%	9%	8%
	Regional Total	--	12%	12%	12%	12%	18%	12%	12%	20%	14%	14%	20%
2.7	**Number of Intrazonal trips**												
	District of Columbia	--	44,000	44,000	43,000	40,000	48,000	54,000	52,000	64,000	39,000	35,000	43,000
	Montgomery County	--	196,000	196,000	197,000	180,000	192,000	198,000	195,000	216,000	177,000	163,000	173,000
	Prince George's County	--	139,000	139,000	139,000	127,000	134,000	140,000	132,000	151,000	125,000	115,000	120,000
	Arlington County	--	33,000	33,000	33,000	29,000	28,000	42,000	42,000	47,000	29,000	27,000	25,000
	City of Alexandria	--	29,000	29,000	29,000	26,000	28,000	31,000	31,000	33,000	26,000	23,000	25,000
	Fairfax County	--	190,000	190,000	190,000	165,000	173,000	192,000	188,000	181,000	171,000	149,000	156,000
	Loudoun County	--	127,000	127,000	127,000	112,000	108,000	127,000	127,000	106,000	114,000	101,000	97,000
	Compact Area Total	--	758,000	758,000	758,000	681,000	711,000	785,000	768,000	799,000	682,000	612,000	640,000
	Other	--	1,361,000	1,361,000	1,361,000	1,247,000	821,000	1,362,000	1,363,000	779,000	1,224,000	1,122,000	739,000

No.	Measure	2010*	2040 Base (Constrained)	2040 Base (Unconstrained)	Scenario A	Scenario A1	Scenario A2	Scenario B	Scenario B1	Scenario B2	Scenario C	Scenario C1	Scenario C2
	Regional Total	--	2,119,000	2,119,000	2,119,000	1,927,000	1,532,000	2,147,000	2,130,000	1,578,000	1,906,000	1,734,000	1,379,000
	Intrazonal Trips as a percent of Motorized Trips	--	24%	24%	24%	22%	21%	24%	24%	23%	22%	20%	19%
2.8	**Total Vehicle Hours Traveled (VHT)**	5,262,030	6,594,000	6,529,000	6,500,000	8,829,000	5,390,000	6,132,000	5,915,000	3,890,000	6,402,000	7,094,000	6,110,000
2.9	**Average Travel Speed (mph)**												
	DC	29	27	27	27	26	29	29	29	32	27	27	29
	Montgomery	33	31	31	32	30	33	33	33	36	32	31	32
	Prince George's	35	32	32	32	29	33	33	34	37	32	31	33
	Arlington	34	33	34	34	32	35	35	35	38	34	32	35
	Alexandria	31	30	30	30	28	32	32	33	36	30	29	31
	Fairfax	34	34	35	35	31	37	36	36	40	35	33	35
	Loudoun	37	33	33	33	30	35	34	34	37	33	32	34
	Compact Area	34	32	32	32	29	34	33	34	37	32	31	33
	Other	39	36	36	36	33	39	36	37	39	36	35	37
	Total	36	34	34	34	31	36	35	35	38	34	33	35
3.1	**Number of Jobs Accessible within 45 Minutes from Households**												
	Auto	--	3,705,000	3,705,000	3,705,000	3,737,000	5,018,000	3,685,000	3,758,000	5,256,000	3,685,000	3,716,000	4,984,000
	Transit	--	1,339,000	1,339,000	1,339,000	1,383,000	2,562,000	1,339,000	1,463,000	2,764,000	1,339,000	1,383,000	2,562,000
3.2	**Households within 1/2 mile of High-capacity Transit**												
	Compact Area Total (Percent)	--	28.9%	28.9%	29%	31%	38%	29%	53%	64%	29%	31%	38%
	Compact Area Total (Number)	--	614,000	614,000	614,000	648,000	946,000	614,000	1,114,000	1,697,000	614,000	648,000	946,000
3.3	**Jobs within 1/2 mile of High-Capacity Transit**												
	Compact Area Total (Percent)	--	46%	46%	46%	47%	54%	46%	67%	72%	46%	47%	54%
	Compact Area Total (Number)	--	1,810,000	1,810,000	1,810,000	1,841,000	2,522,000	1,810,000	2,606,000	3,446,000	1,810,000	1,841,000	2,522,000
3.4	**Jobs/Housing balance**												
	District of Columbia	--	2.7	2.7	2.7	2.7	2.4	2.7	2.7	2.7	2.7	2.7	2.4
	Montgomery County	--	1.6	1.6	1.6	1.6	1.8	1.6	1.6	1.5	1.6	1.6	1.8
	Prince George's County	--	1.3	1.3	1.3	1.3	1.5	1.3	1.3	1.2	1.3	1.3	1.5
	Arlington County	--	2.4	2.4	2.4	2.4	1.5	2.4	2.4	1.7	2.4	2.4	1.5
	City of Alexandria	--	1.8	1.8	1.8	1.8	2.0	1.8	1.8	1.3	1.8	1.8	2.0
	Fairfax County	--	1.8	1.8	1.8	1.8	1.9	1.8	1.8	1.8	1.8	1.8	1.9
	Loudoun County	--	1.7	1.7	1.7	1.7	1.4	1.7	1.7	1.7	1.7	1.7	1.4
	Compact Area Total	--	1.8	1.8	1.8	1.8	1.9	1.8	1.8	1.8	1.8	1.8	1.9
	Other	--	1.3	1.3	1.3	1.3	0.9	1.3	1.3	1.0	1.3	1.3	0.9
	Regional Total	--	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6

No.	Measure	2010*	2040 Base (Constrained)	2040 Base (Unconstrained)	Scenario A	Scenario A1	Scenario A2	Scenario B	Scenario B1	Scenario B2	Scenario C	Scenario C1	Scenario C2
4.1	**Person Hours of Transit Travel on Congested Vehicles**												
	Metrorail (over 100 ppc)[5]	--	1,000	42,000	42,000	48,000	221,000	74,000	75,000	383,000	46,000	19,000	98,000
	LRT (over 140 ppc)	--	0	0	0	0	6,000	0	0	10,000	0	0	0
	Streetcar (over 115 ppc)	--	2,000	8,000	9,000	13,000	17,000	12,000	13,000	34,000	9,000	8,000	10,000
	All Buses (over 45 ppc)	--	36,000	39,000	38,000	55,000	79,000	56,000	52,000	104,000	38,000	28,000	123,000
4.2	**Metrorail Transfer Capacity - Average Weekday Metrorail Transfers at Core Stations**	--	338,000	372,000	372,000	443,000	632,000	488,000	514,000	988,000	395,000	376,000	515,000
4.4	**Metrorail passenger miles traveled by level of congestion**												
	Under 50 ppc	--	2,401,000	2,046,000	1,887,000	1,941,000	2,083,000	2,001,000	1,959,000	1,576,000	1,783,000	2,024,000	1,790,000
	50 - 80 ppc	--	2,373,000	2,587,000	2,877,000	3,236,000	1,713,000	2,659,000	2,761,000	1,574,000	2,838,000	2,439,000	2,453,000
	80 - 100 ppc	--	1,252,000	945,000	1,137,000	1,416,000	1,480,000	1,486,000	1,599,000	1,328,000	1,250,000	1,645,000	1,626,000
	100 - 120 ppc	--	33,000	1,258,000	1,166,000	880,000	2,508,000	1,598,000	944,000	2,062,000	1,175,000	500,000	851,000
	Over 120 ppc	--	0	0	113,000	526,000	3,820,000	546,000	1,316,000	9,142,000	216,000	0	1,947,000
	Total	--	6,059,000	6,836,000	7,180,000	7,999,000	11,602,000	8,289,000	8,579,000	15,682,000	7,263,000	6,608,000	8,667,000
4.5	**Average load factor deviation**												
	Metrorail (from 100 ppc)	--	61	58	56	52	47	51	51	48	56	58	52
	LRT (from 140 ppc)	--	99	97	94	89	59	85	83	63	95	97	81
	Streetcar (from 115 ppc)	--	71	74	80	90	86	87	83	128	79	78	73
	BRT (from 45 ppc)	--	23	22	21	20	21	20	19	26	21	21	20
4.6	**Total Transit Ridership (Linked Trips)**		2,535,000	2,659,000	2,730,000	3,195,000	4,474,000	3,465,000	3,634,000	9,582,000	2,757,000	2,620,000	3,395,000
4.7	**Total Transit Mode Share**	6%	7%	8%	7%	8%	15%	9%	10%	34%	7%	7%	9%
5.1	**Peak Transit Utilization - passenger miles per seat mile**												
	Peak	--	34%	37%	38%	43%	66%	48%	49%	101%	38%	32%	45%
	Off-Peak	--	12%	12%	13%	17%	25%	17%	19%	68%	13%	13%	19%
5.2	**Transit Peak Orientation Factor**												
	Percent	--	41%	42%	37%	39%	38%	38%	38%	32%	42%	42%	42%
	Total	--	380,000	435,000	405,000	476,000	654,000	494,000	509,000	793,000	457,000	432,000	546,000
5.3	**Metrorail operating costs per passenger mile**	--	$0.93	$0.86	$0.83	$0.71	$0.49	$0.69	$0.66	$0.30	$0.81	$0.86	$0.63
5.4	**Change in Property Tax Revenues (from Base)**												
	District of Columbia					-$7,725,000	$1,264,703,000		-$252,931,000	$975,074,000		-$7,725,000	$1,264,703,000

[5] PPC = Passengers per car or per bus

No.	Measure	2010*	2040 Base (Constrained)	2040 Base (Unconstrained)	Scenario A	Scenario A1	Scenario A2	Scenario B	Scenario B1	Scenario B2	Scenario C	Scenario C1	Scenario C2
	Montgomery County					-$3,363,000	$91,759,000		-$60,062,000	$136,871,000		-$3,363,000	$91,759,000
	Prince George's County					-$3,726,000	$94,225,000		-$39,114,000	-$5,063,000		-$3,726,000	$94,225,000
	Arlington County					$12,000	$474,386,000		$9,013,000	$499,198,000		$12,000	$474,386,000
	City of Alexandria					$479,000	$129,948,000		$51,085,000	$348,794,000		$479,000	$129,948,000
	Fairfax County					-$59,000	-$360,932,000		$39,488,000	$206,056,000		-$59,000	-$360,932,000
	Loudoun County					$1,924,000	-$133,927,000		$30,186,000	-$171,260,000		$1,924,000	-$133,927,000
	Compact Area Total					-$12,459,000	$1,560,162,000		-$222,333,000	$1,989,670,000		-$12,459,000	$1,560,162,000
	Other Total						-$1,477,283,000			-$1,811,076,000			-$1,477,283,000
	Regional Total					-$12,459,000	$82,879,000		-$222,333,000	$178,595,000		-$12,459,000	$82,879,000
5.5	**Metrorail Fare and Parking Revenues**	--	$3,611,000	$3,914,000	$3,654,000	$3,793,000	$5,879,000	$4,487,000	$4,708,000	$10,678,000	$3,307,000	$3,164,000	$4,344,000
5.6	**Metrorail Operating Subsidy**												
	Total	--	$440,600,000	$345,697,000	$427,062,000	$383,799,000	-$269,278,000	$166,430,000	$97,161,000	-$1,771,433,000	$535,930,000	$580,580,000	$211,105,000
5.7	**Congestion Toll and VMT Tax Revenue**												
	Cordon Toll Revenues							$1,111,790,000	$1,080,692,000	$778,239,000			
	VMT Tax Revenues										$761,164,000	$662,828,000	$715,509,000
5.8	**Lost growth to congestion – Productivity Change in GDP (in millions) Compared to Constrained Base: 2025-2059**			$172	$29,591	$24,822	$10,081	$2,959	$4,207	$10,879	$405	$28,063	$7,680

*2010 results are provided as a reference where existing data are available. New 2010 analysis was not conducted as part of this task, and, thus, 2010 data are not available for all MOEs, notably the new MOEs developed specifically for the land use and policy alternatives analysis.

3.1. Measures of Effectiveness – Goal 1

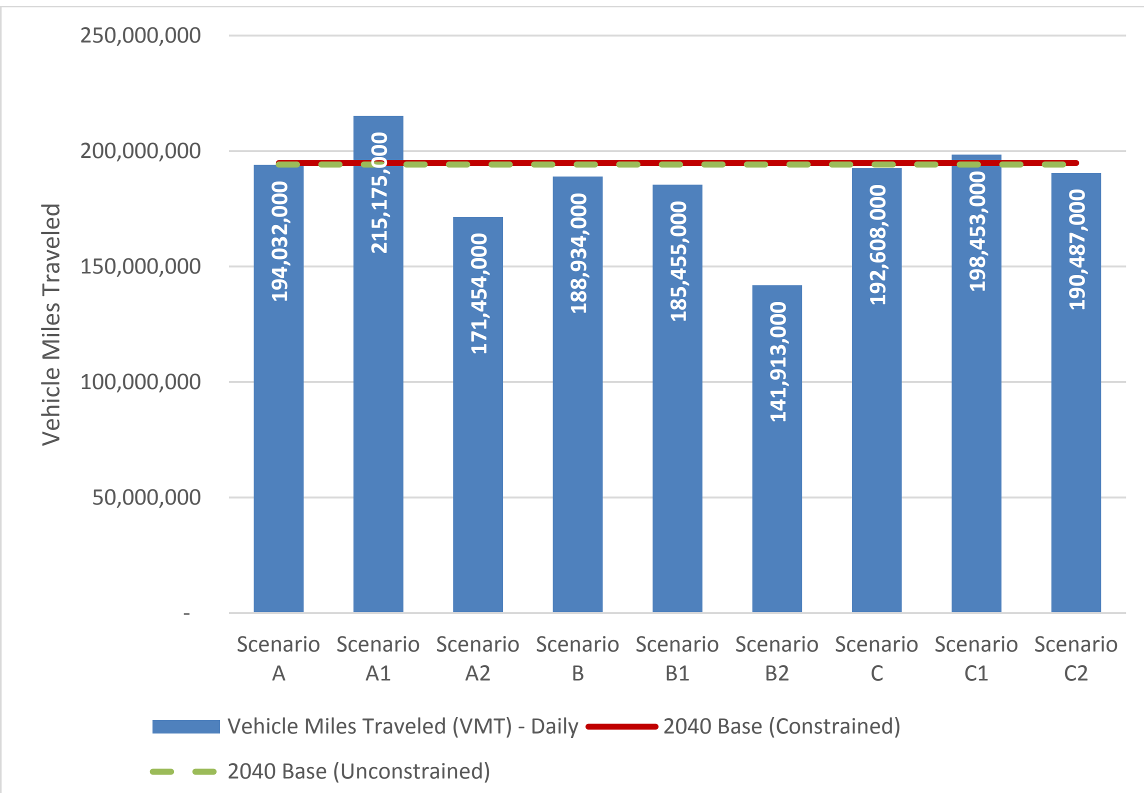
Goal 1: Enhance environmental quality, improve energy efficiency, and protect human health and safety.

3.1.1. Total Vehicle Miles Traveled (Daily) (MOE 1.1)

As shown in **Figure 17**, Scenario B2 has the lowest VMT – even lower than existing 2010. All scenarios decreased slightly from the base, except for Scenarios A1 and C1 which show some increases over the Baseline.

A1 and C1 focused land use to foster mixed-use development – which was expected to result in more very short trips, but the regional trip distribution model still included large numbers of longer-distance radial trips (i.e., trips from outside the compact area) resulting in high VMT (and VHT, as shown in Section 3.2.8) despite efforts to reinforce shorter trips.

Figure 17: Total Vehicle Miles Traveled (Daily)

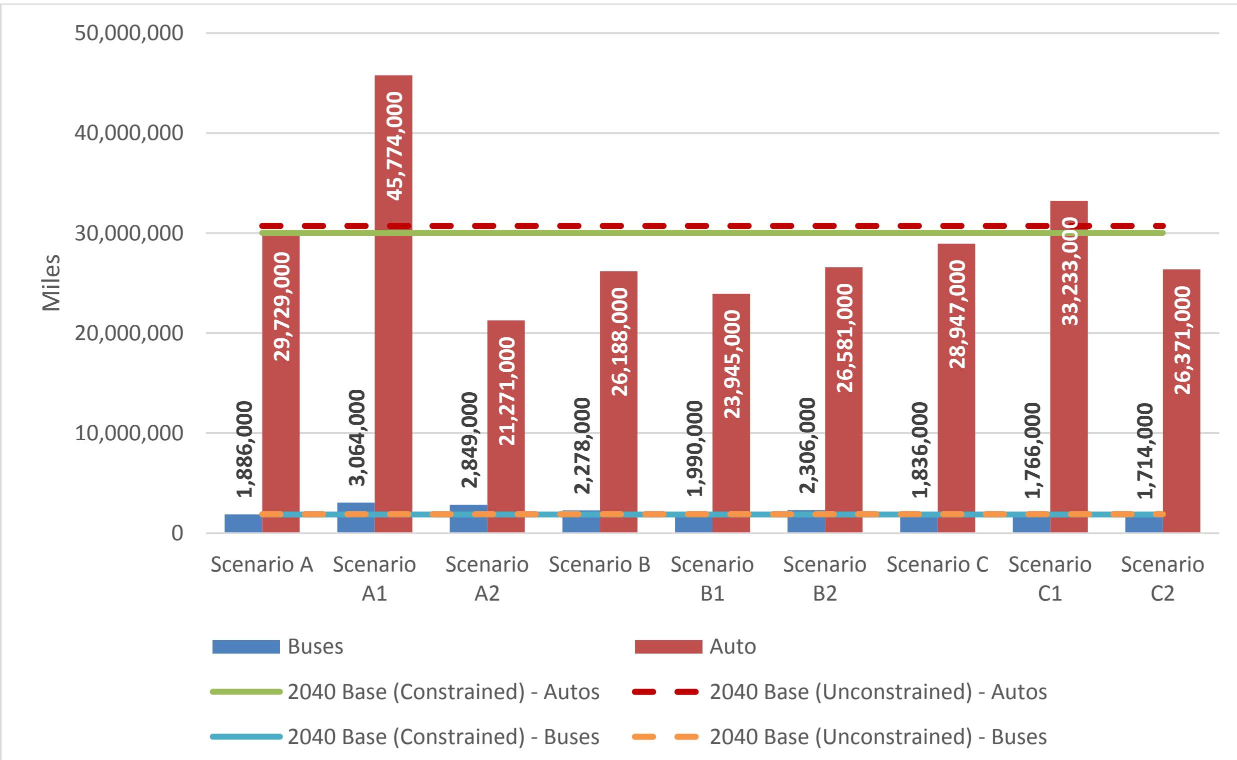


3.1.2. Congested Persons Miles of Travel in Autos and Buses (MOE 1.2)

This MOE shows the congested person miles of travel in autos and buses that occurs on roadways where travel time is greater than twice the free flow time. Scenario A1 – which has the highest total VMT – yielded the highest number of congested person miles of travel in automobiles (see **Figure 18**).

Scenario A2 had the lowest congested PMT in autos through a combination of more transit trips and mixed-use land use scenarios. Scenario C2 had the lowest congested PMT in buses due primarily to lower overall congestion levels and lower peak period travel demand.

Figure 18: Daily Congested Person Miles Traveled (Bus and Automobile)

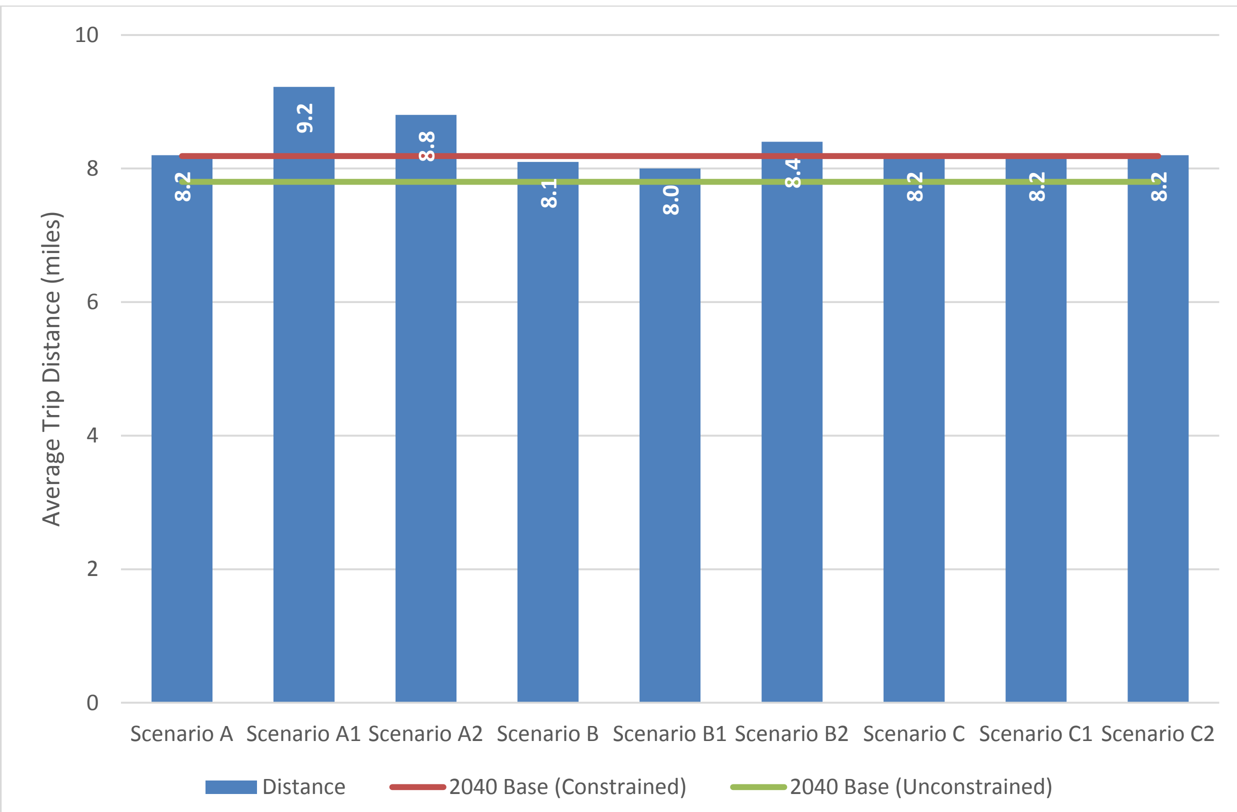


3.1.3. Average Trip Distance and Average Trip Time (MOE 1.3)

Average trip distances for all daily trips (all modes, all purposes, all time periods) were the highest in Scenario A (see **Figure 19**); however, there was not a lot of variation in average trip length associated with land use alternatives. The A scenarios showed the biggest increases, even though these land use scenarios were designed to foster shorter trips by creating mixed use-station areas.

The gravity model used to distribute trips in the region behaved in somewhat unexpected ways, resulting in many trips between these mixed-use areas, instead of within individual mixed-use areas. The average trip distance is dependent on the relative locations of job and population centers within the region and the time required to travel between them. Other factors being equal, less congestion results in longer average trip lengths; however, few factors are equal between the tested alternatives, making comparisons difficult for this measure. All three C scenarios have the added effect of the VMT tax tempering the attractiveness of long-distance trips.

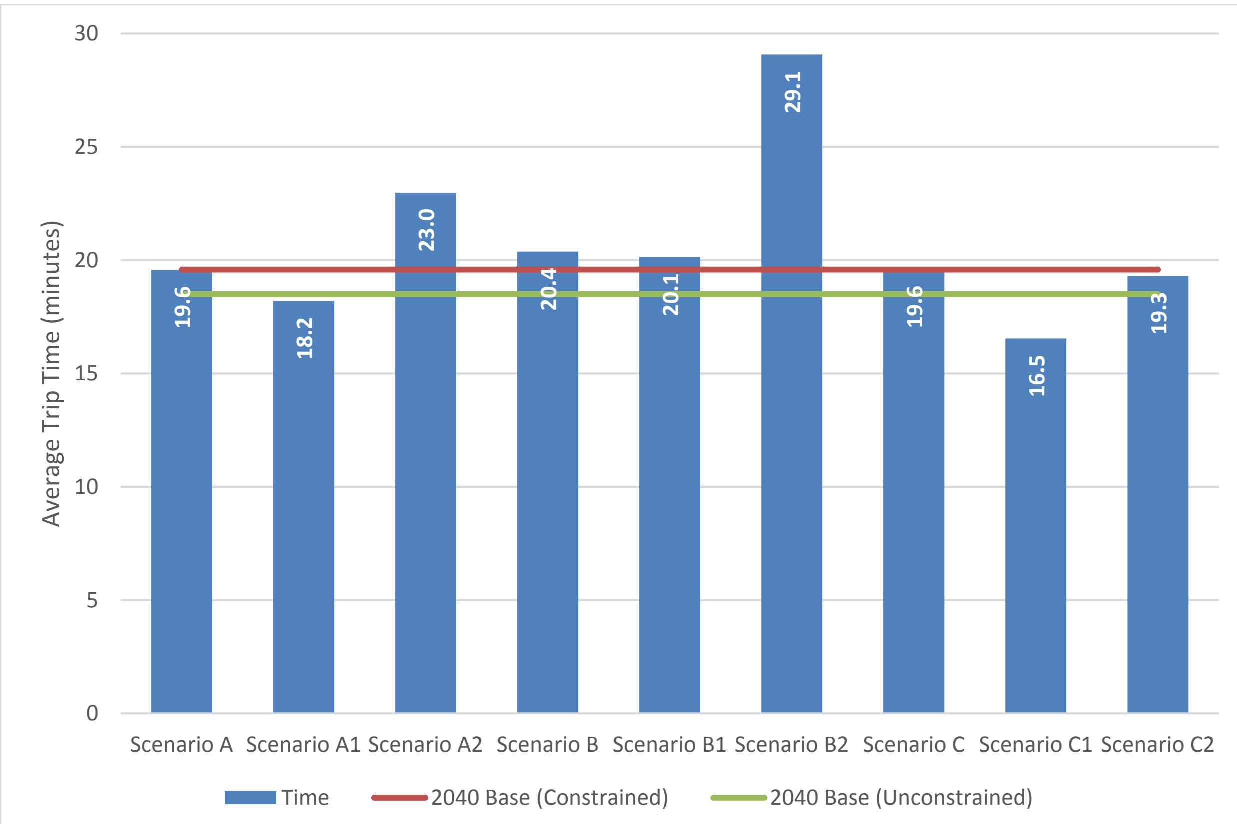
Figure 19: Average Daily Trip Distance



Trip time is the average of all daily trips taken on all modes, and this MOE averages the auto and transit trips based on the number of people using each mode. As such, this measure is sensitive both to the level of roadway congestion (for the auto modes) and the mode share results.

As shown in **Figure 20**, Scenario B2 has the highest average trip time by a substantial margin. The policy measures in the B scenarios focused on encouraging the use of transit in strong existing transit markets. Therefore, the B scenarios, especially Scenario B2 with its very high transit ridership, resulted in trips being taken on transit that would have been very unattractive for transit users under different conditions due to long travel times. When averaged together, these longer transit trips result in higher average trip times. This result does not reflect an increase in the time required for a bus to get from Point A to Point B, rather a change in the number and lengths of trips being made on transit.

Figure 20: Average Daily Trip Time



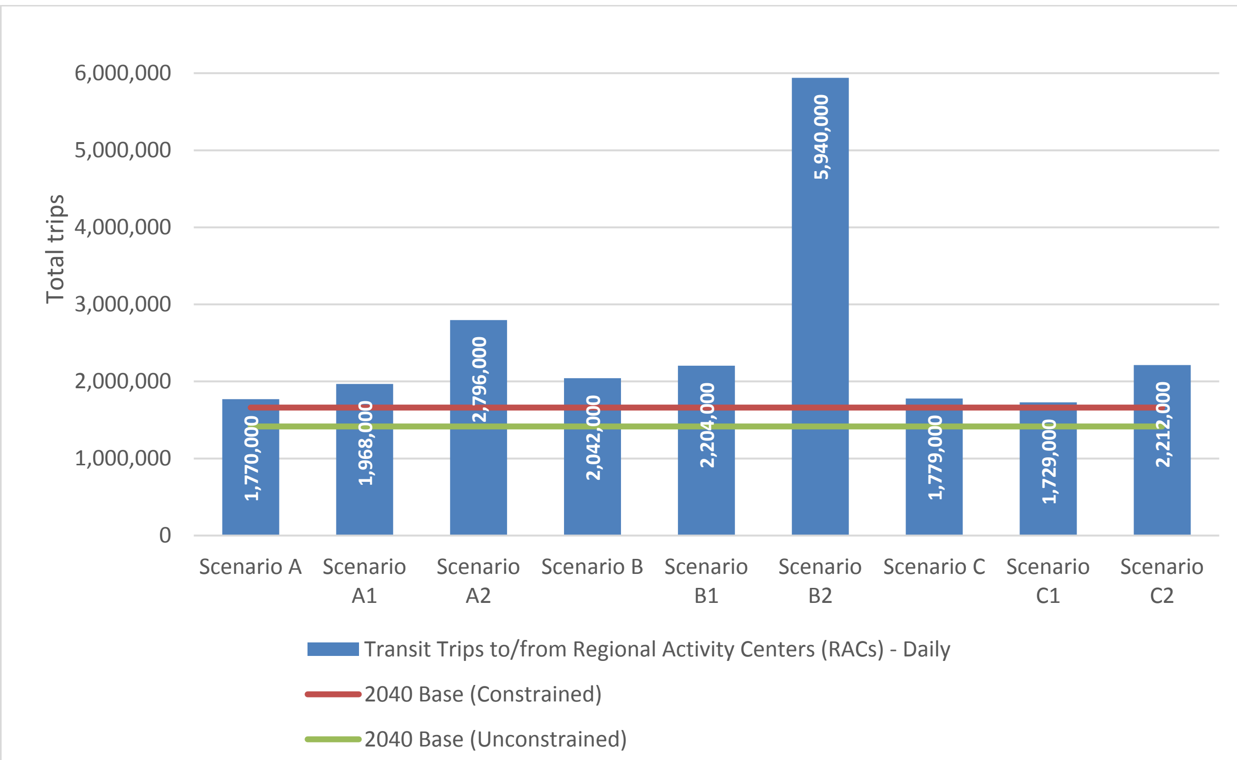
3.2. Measures of Effectiveness – Goal 2

Goal 2: Facilitate transit-oriented, mixed-use communities that capture employment and household growth, providing choices in where to live, work, and play.

3.2.1. Transit Trips to/from Regional Activity Centers (RACs) (MOE 2.1)

This MOE measures the number of trips with either one or both ends in a RAC that are made using transit (see **Figure 21**). All of the tested alternatives had a higher number of transit trips to/from the RACs, due to transit-friendly policies implemented and the clustering of land uses around the RACs. Because Scenario B2 had the highest number of total transit trips and the highest transit mode share by far, it also had the highest number of transit trips to and from RACs. The same result was true for transit trips outside of RACs (MOE 2.3), due to the sheer number of transit trips in Scenario B2.

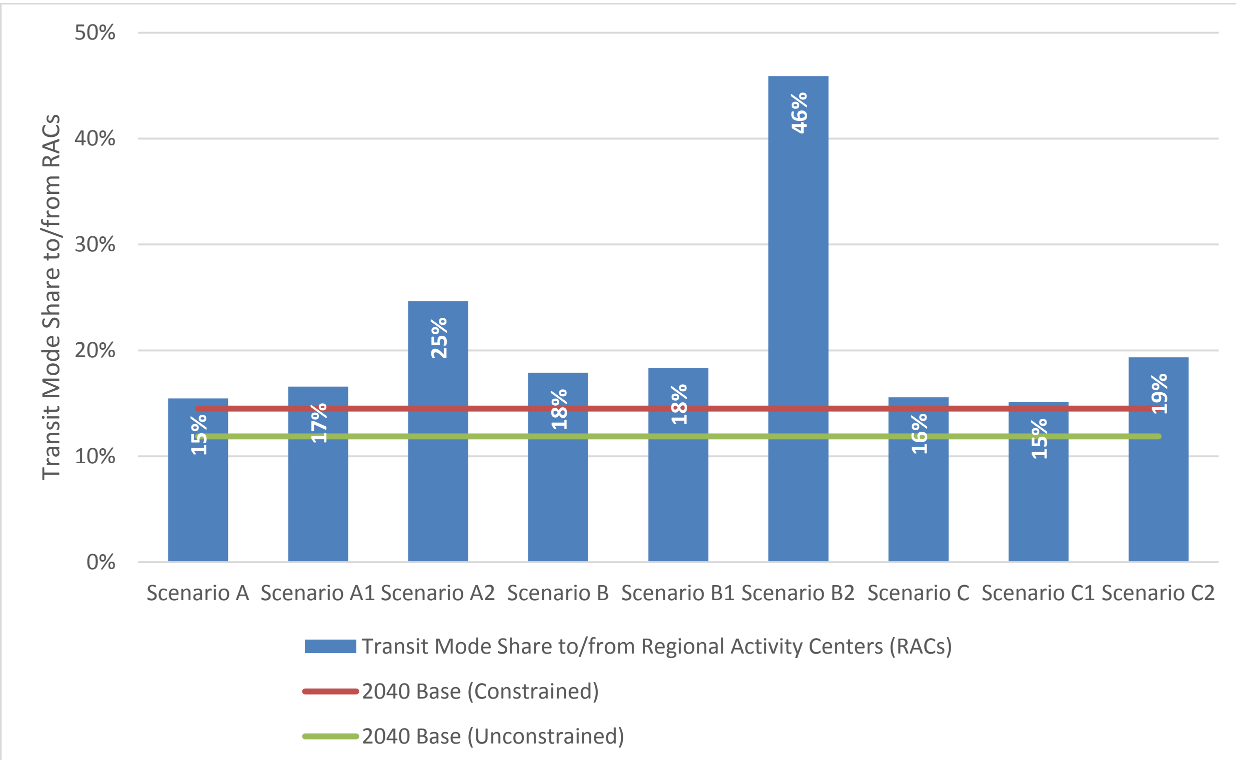
Figure 21: Total Daily Transit Trips to/from Regional Activity Centers (RACs)



3.2.2. Transit Mode Share to/from RACs (MOE 2.2)

This MOE shows the percentage of trips with either one or both ends in a RAC that are made using transit (see **Figure 22**). Due to the transit-friendly policies or land use alternatives, all of the tested scenarios performed better than the baseline for this MOE. Similar to MOE 2.1, Scenario B2 had the highest transit mode share for trips to/from RACs because it had the highest overall transit mode share. The same result was true for transit trips outside of RACs (MOE 2.4).

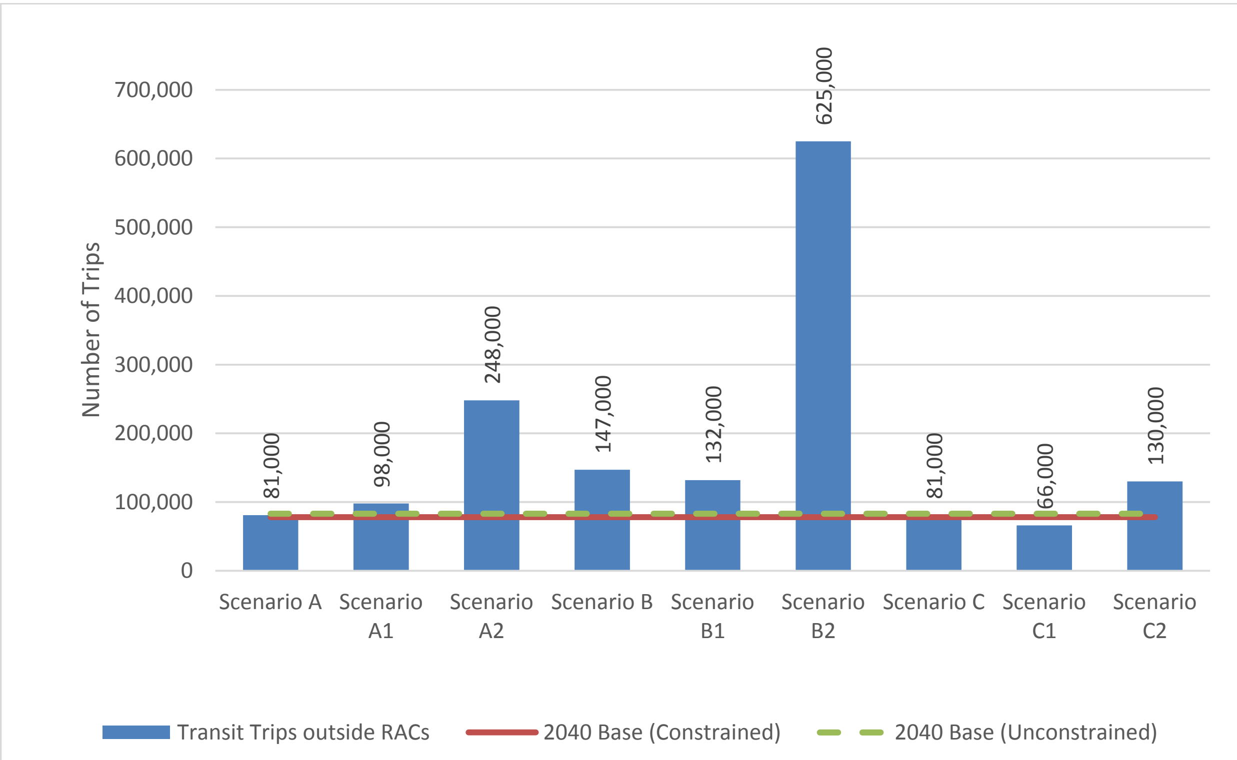
Figure 22: Daily Transit Mode Share To/From Regional Activity Centers (RACs)



3.2.3. Transit Trips Outside RACs (MOE 2.3)

As shown in **Figure 23**, this MOE measures the number of transit trips with neither an origin nor destination in a RAC. Because Scenario B2 had by far the highest total transit trips in the region, it also had the highest total transit trips outside of RACs. The policies and land use alternatives resulted in several scenarios showing fewer transit trips than the baseline, including Scenario C and Scenario C1, due to their lower total travel demand.

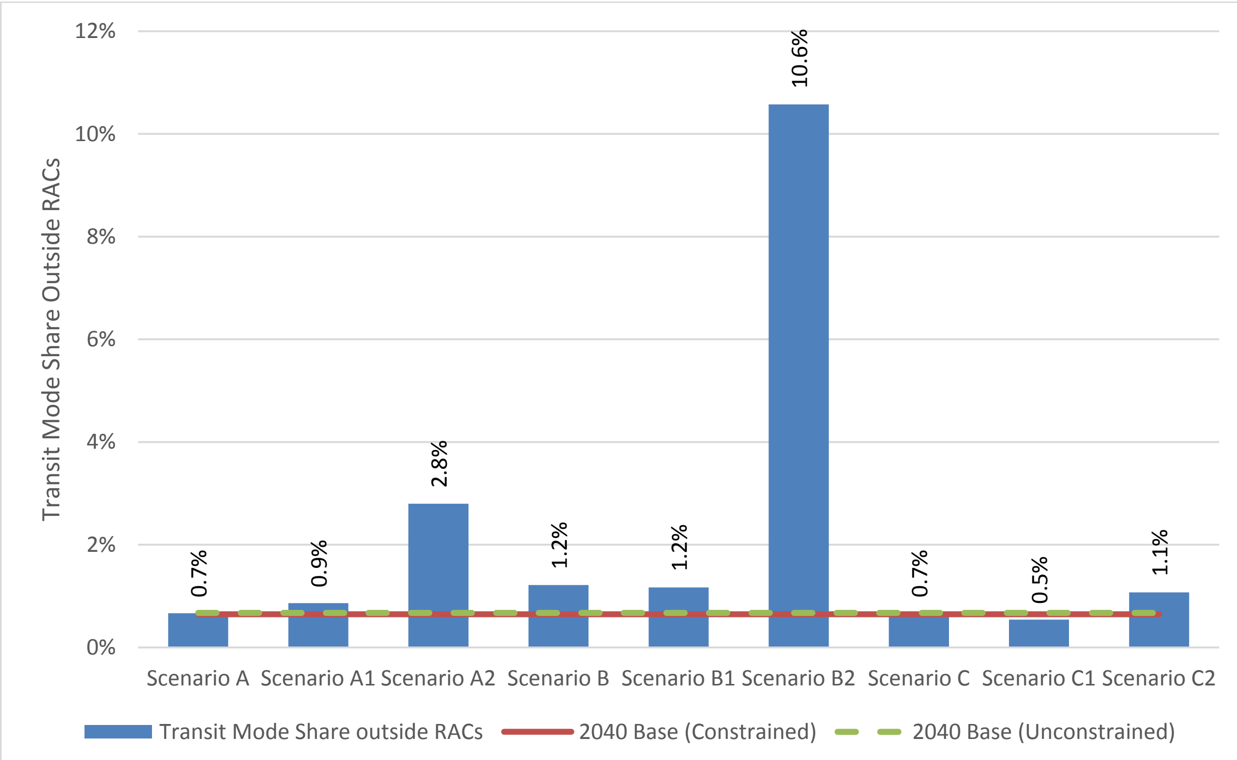
Figure 23: Daily Transit Trips Outside Regional Activity Centers (RACs)



3.2.4. Transit Mode Share Outside RACs (MOE 2.4)

This MOE measures the percentage of transit trips with neither an origin nor a destination in a RAC. Similar to MOE 2.3, because Scenario B2 had by far the highest transit mode share overall, it also had the highest transit mode share outside of RACs (see **Figure 24**).

Figure 24: Daily Transit Mode Share Outside of Regional Activity Centers (RACs)



3.2.5. Change in Highway Travel Times (MOE 2.5)

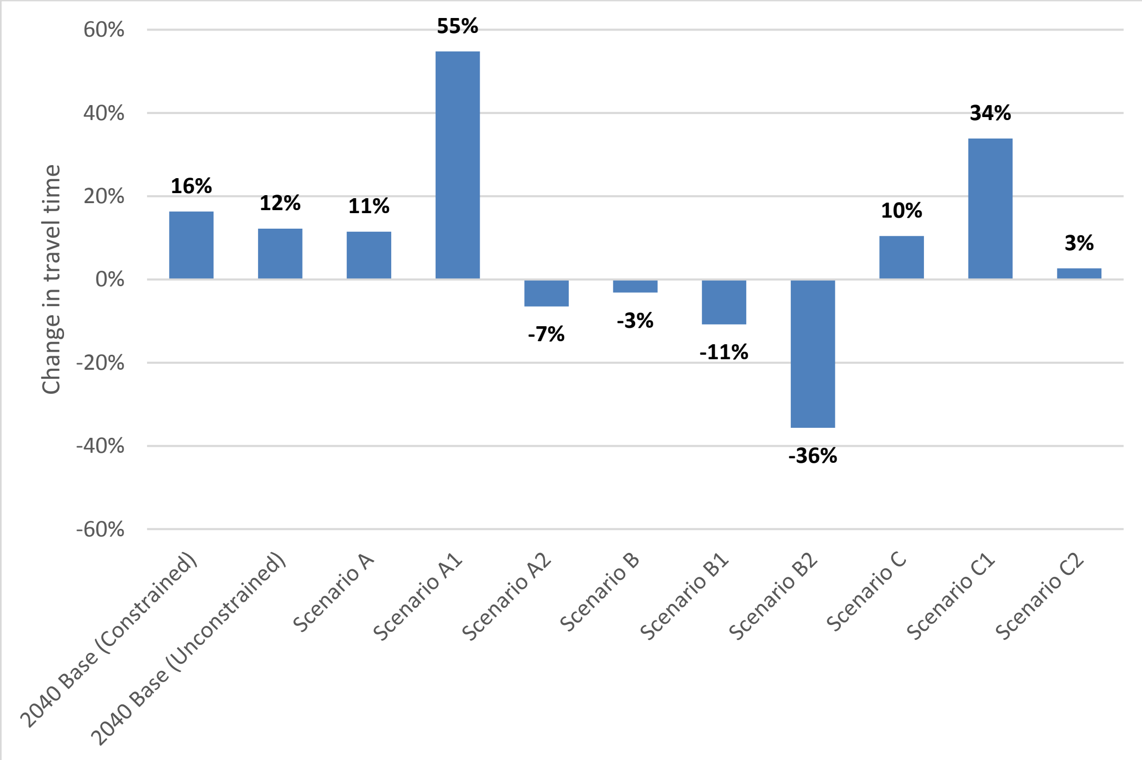
This MOE shows the change in morning peak period highway travel times between the regional destinations listed below compared to 2010 conditions. This MOE summed the total travel times between the origin-destination pairs listed in **Table 7** as a representative measure for travel time in the region. As shown in Figure 25, the changes varied greatly among the scenarios, and were very dependent on the level of congestion on the roadway network. For example, Scenario B2 had the highest transit mode share in the region and, therefore, had the lowest levels of vehicle travel and congestion of any of the tested scenarios (see MOEs 1.1 and 4.6). This low level of congestion in turn resulted in the largest decrease in total highway travel times among the origin-destination pairs. Meanwhile, Scenarios A1 and C1 had higher VMT (MOE 1.1) and, therefore, resulted in the greatest increases in average highway travel times.

It should also be noted that the percentages shown in **Figure 25** are for the total of all 13 origin-destination pairs listed. Individual pairs may have performed better or worse based on the localized effects of the policies and land use alternatives that were tested.

Table 7: Origin-Destination Pairs used to Calculate Travel Time

From	To
Tenleytown	NoMA
Columbia Heights	Tysons
Germantown	Bethesda
White Flint	Tysons
Potomac	Rosslyn
Largo	College Park
Bowie	Capitol Hill
Upper Marlboro	Waterfront
Alexandria	Ft. Belvoir
Fair Lakes	Foggy Bottom
Springfield	Andrews AFB
Lorton	Pentagon
Woodbridge	Tysons

Figure 25: Change in Highway Travel Times Compared to 2010 Existing Conditions (Morning Peak)



3.2.6. Percent Non-Motorized Trips (MOE 2.6)

This MOE calculates the total number of non-motorized trips generated in each of the tested alternatives. As shown in **Figure 26**, the percent of non-motorized trips was higher in the Compact Area than the region as a whole in all of the scenarios; **Table 8** highlights additional variations by jurisdiction within the Compact Area. The land use scenarios that shifted population and employment across jurisdictions (A2, B2, C2) had the highest numbers and highest percentages of non-motorized trips, because these scenarios were able to achieve the highest land use densities.

Figure 26: Percent Daily Non-Motorized Trips (Compact Area and Region)

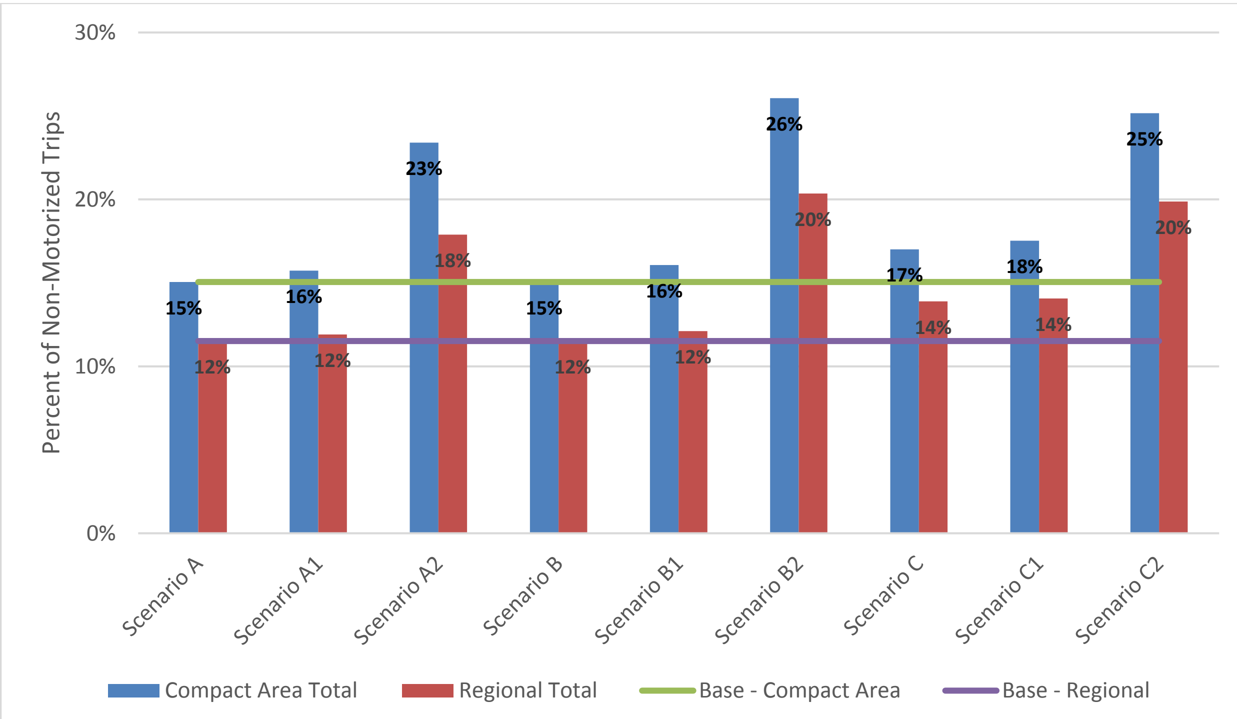


Table 8: Percent of Non-Motorized Trips (Jurisdiction)

	Base	A	A1	A2	B	B1	B2	C	C1	C2
District of Columbia	32%	32%	33%	52%	32%	33%	48%	34%	34%	53%
Montgomery County	12%	12%	13%	15%	12%	13%	19%	14%	15%	17%
Prince George's County	9%	9%	10%	12%	9%	10%	14%	11%	12%	13%
Arlington County	25%	25%	25%	38%	25%	25%	39%	27%	27%	39%
City of Alexandria	23%	23%	23%	28%	23%	23%	34%	26%	25%	31%
Fairfax County	12%	12%	13%	11%	12%	14%	20%	14%	15%	13%
Loudoun County	8%	8%	8%	8%	8%	8%	9%	10%	10%	10%
Compact Area Total	15%	15%	16%	23%	15%	16%	26%	17%	18%	25%
Other	6%	6%	6%	5%	6%	6%	6%	9%	9%	8%
Regional Total	**12%**	**12%**	**12%**	**18%**	**12%**	**12%**	**20%**	**14%**	**14%**	**20%**

3.2.7. Intrazonal Trips (MOE 2.7)

This MOE measures intrazonal trips, or trips that occur within a single TAZ. Calculated separately from non-motorized trips but closely related, intrazonal trips represent very short trips that occur using motorized modes, including relatively short transit and auto trips. As shown in **Figure 27** and **Table 9**, in most scenarios these intrazonal trips on motorized modes stayed the same or decreased, as many short trips were shifted to non-motorized modes as the densities were increased (see MOE 2.6). The exceptions were Scenarios B and B1 which showed small increases in intrazonal trips but did not see large increases in non-motorized trips.

The percentage of intrazonal trips compared to the total number of motorized trips held fairly steady across all scenarios (see **Figure 28**). Of note, A2 and C2 (same land use) showed more significant decreases in the percentages of intrazonal trips, which further supports the finding that the model was distributing trips between RACs, instead of within RACs.

Table 9: Daily Intrazonal Trips (by jurisdiction)

	Base	A	A1	A2	B	B1	B2	C	C1	C2
District of Columbia	44,000	43,000	40,000	48,000	54,000	52,000	64,000	39,000	35,000	43,000
Montgomery County	196,000	197,000	180,000	192,000	198,000	195,000	216,000	177,000	163,000	173,000
Prince George's County	139,000	139,000	127,000	134,000	140,000	132,000	151,000	125,000	115,000	120,000
Arlington County	33,000	33,000	29,000	28,000	42,000	42,000	47,000	29,000	27,000	25,000
City of Alexandria	29,000	29,000	26,000	28,000	31,000	31,000	33,000	26,000	23,000	25,000
Fairfax County	190,000	190,000	165,000	173,000	192,000	188,000	181,000	171,000	149,000	156,000
Loudoun County	127,000	127,000	112,000	108,000	127,000	127,000	106,000	114,000	101,000	97,000
Compact Area Total	758,000	758,000	681,000	711,000	785,000	768,000	799,000	682,000	612,000	640,000
Other	1,361,000	1,361,000	1,247,000	821,000	1,362,000	1,363,000	779,000	1,224,000	1,122,000	739,000
Regional Total	**2,119,000**	**2,119,000**	**1,927,000**	**1,532,000**	**2,147,000**	**2,130,000**	**1,578,000**	**1,906,000**	**1,734,000**	**1,379,000**

Figure 27: Daily Intrazonal Trips (Compact Area and Region)

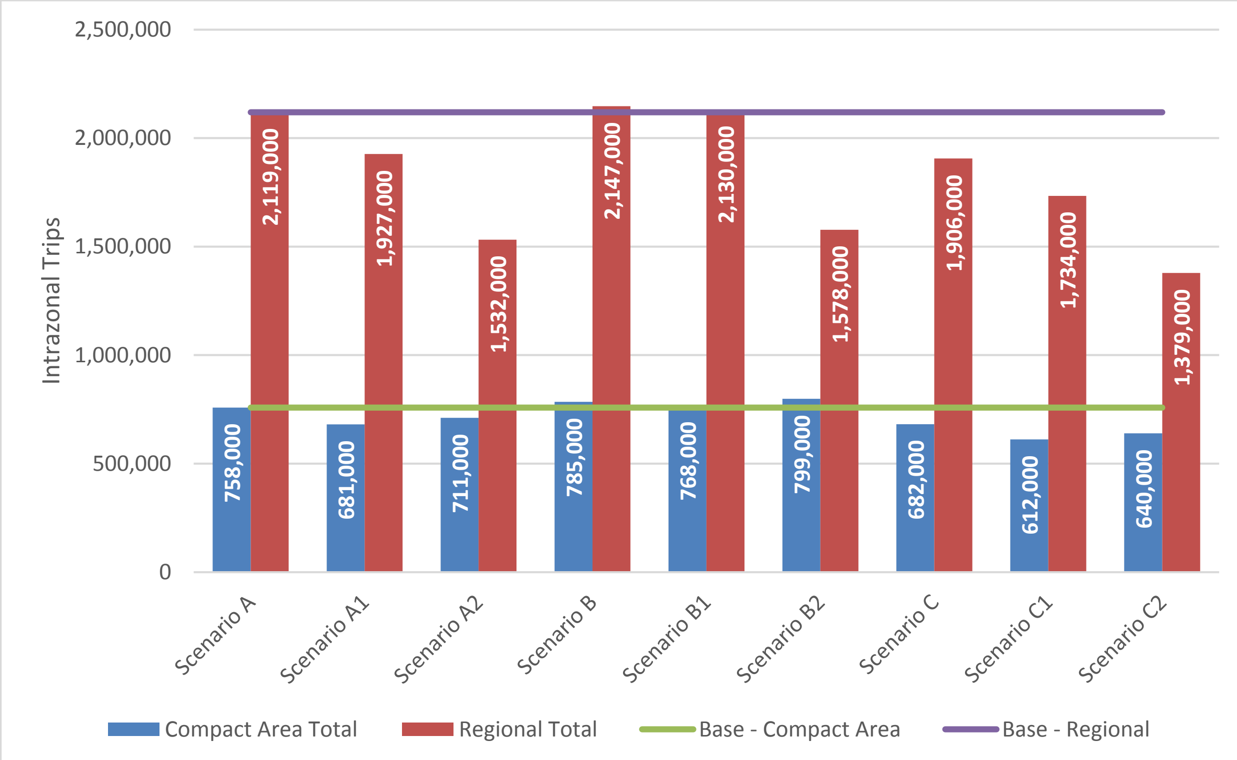
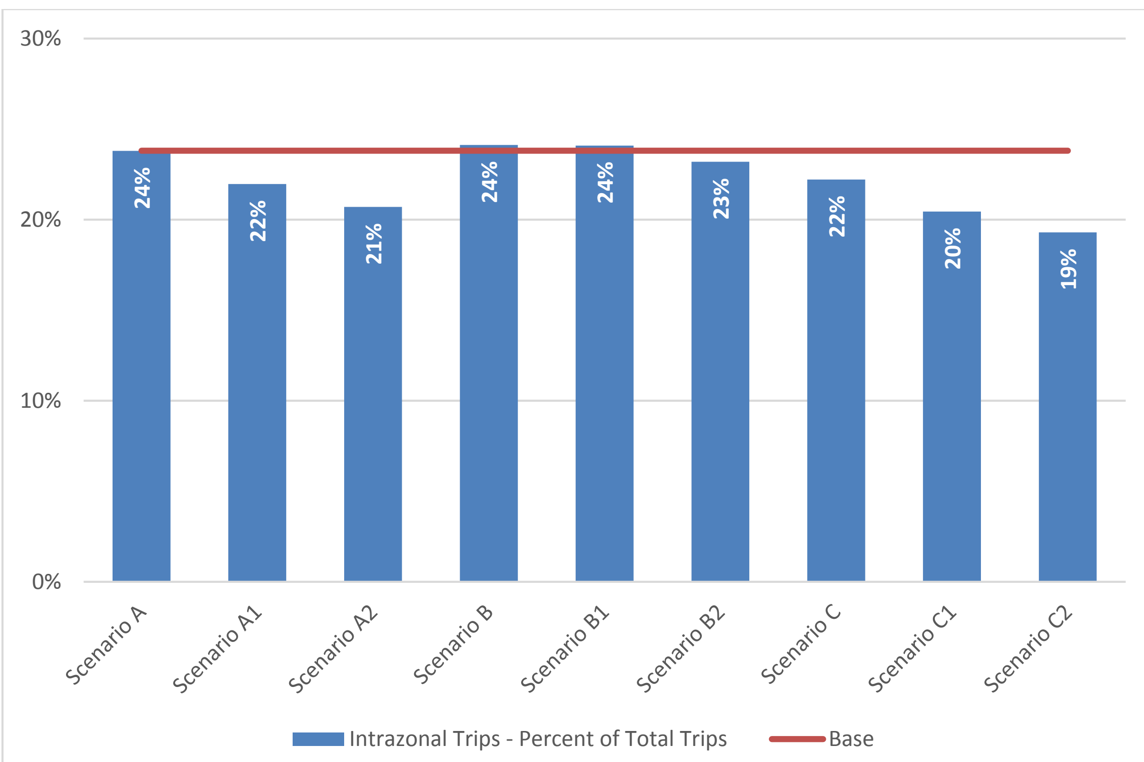


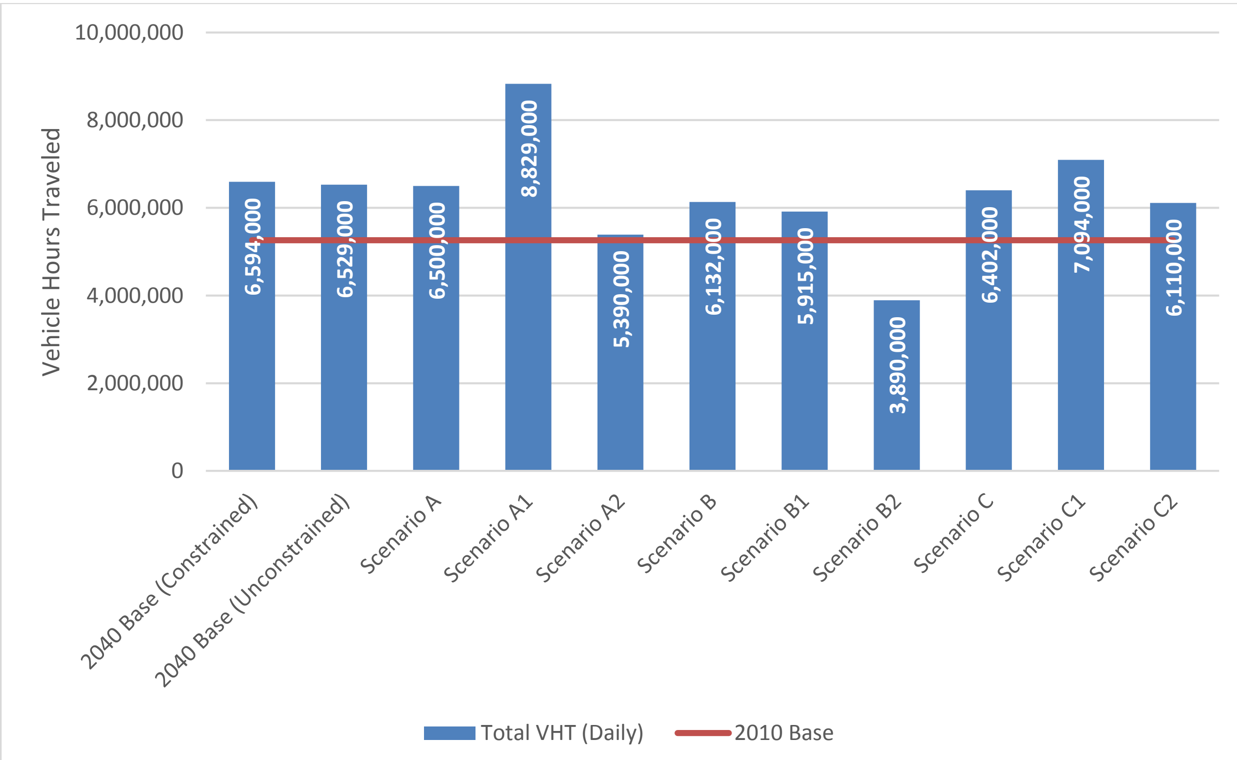
Figure 28: Daily Intrazonal Trips as a Percent of Total Motorized Trips



3.2.8. Total Vehicle Hours Traveled (VHT) (MOE 2.8)

VHT is related to VMT (MOE 1.1) but also varies with the level of congestion, as congestion causes more time to be spent traveling the same distance. As shown in **Figure 29**, Scenario B2 had the lowest VHT, as it had the fewest auto trips. Scenarios C1 and A1 had higher VHT (and VMT) than the 2040 Base, as a result of the growth of long distance trips in the region. In these land use scenarios, population and employment were shifted within the Compact Area, generally away from its edges, while the population and employment outside the Compact Area remained constant.

Figure 29: Total Vehicle Hours Traveled (Daily)



3.2.9. Average Travel Speed (MOE 2.9)

This MOE was developed specifically to measure the success of the Scenario C alternatives at maintaining travel speeds, but can be used to judge the level of congestion occurring in all scenarios. As shown in **Figure 30**, Scenario B2 had the highest average speeds in the region and Compact Area, due to its high transit ridership and resulting lower congestion levels. Scenarios A1 and C1 decreased average speeds below 2040 Base conditions, which was consistent with the finding of increased congestion caused by their land use changes. **Table 10** shows the variation in average speeds by jurisdiction – there is some variation depending on changes to localized traffic patterns and congestion levels.

Figure 30: Average Morning Peak Travel Speed

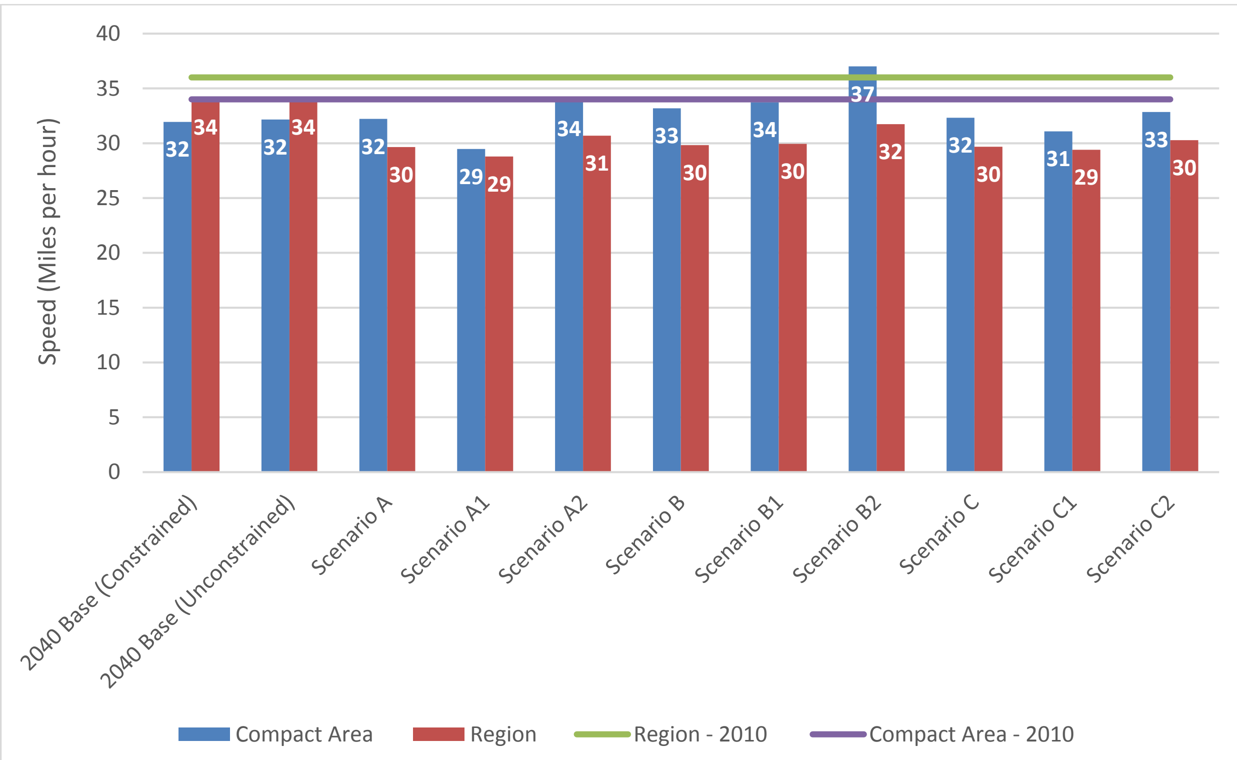


Table 10: Average Travel Speed During Morning Peak –by Jurisdiction

	2010	**2040 Constrained**	**2040 Unconstrained**	**A**	**A1**	**A2**	**B**	**B1**	**B2**	**C**	**C1**	**C2**
District of Columbia	29	27	27	27	26	29	29	29	32	27	27	29
Montgomery County	33	31	31	32	30	33	33	33	36	32	31	32
Prince George's County	35	32	32	32	29	33	33	34	37	32	31	33
Arlington County	31	33	34	34	32	35	35	35	38	34	32	35
City of Alexandria	34	30	30	30	28	32	32	33	36	30	29	31
Fairfax County	37	34	35	35	31	37	36	36	40	35	33	35
Loudoun County	37	33	33	33	30	35	34	34	37	33	32	34
Compact Area	34	32	32	32	29	34	33	34	37	32	31	33
Other	39	36	36	36	33	39	36	37	39	36	35	37
Total	**36**	**34**	**34**	**34**	**31**	**36**	**35**	**35**	**38**	**34**	**33**	**35**

3.4. Measures of Effectiveness – Goal 3

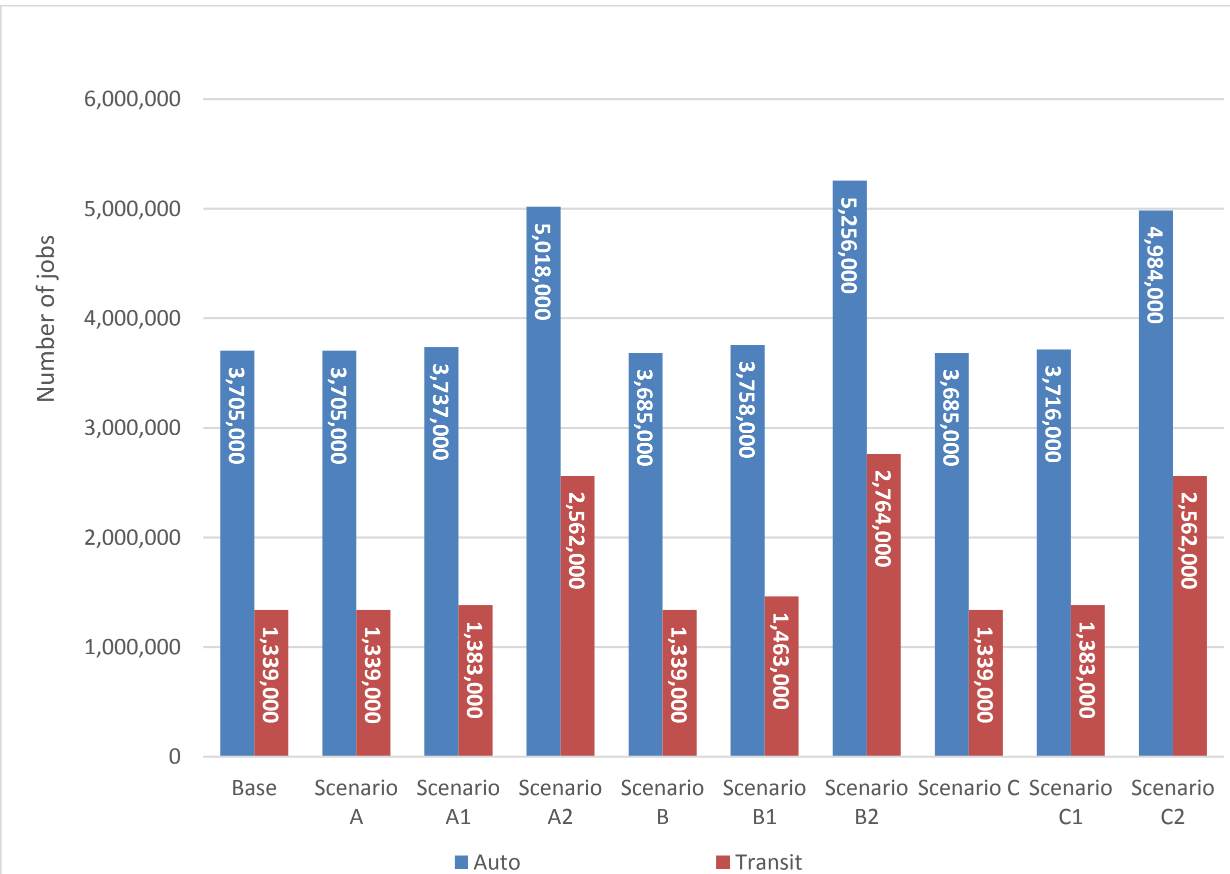
Goal 3: Maximize availability of and convenient access to integrated transit choices.

3.4.1. Number of Jobs Accessible within 45 Minutes from Households (MOE 3.1)

This MOE shows the number of households that are 45 minutes from employment when traveling by transit or auto. As shown in **Figure 31**, the greatest increase in number of households occurred in scenarios where the baseline jurisdictional land use totals did not need to be maintained when moving land use. This result was driven by two conditions:

- Concentration of land use around transit stations – The number of jobs accessible was much higher in the scenarios that moved land use across jurisdictions and further concentrating it around transit stations. The concentration near transit stations made the relative increase in accessibility by transit even higher than for auto in these scenarios; and
- Changes in auto travel speeds – Therefore, job accessibility was higher in scenarios with lower congestion, such as B2.

Figure 31: Number of Jobs within 45 minutes of Households by Transit or Auto (Daily Total)



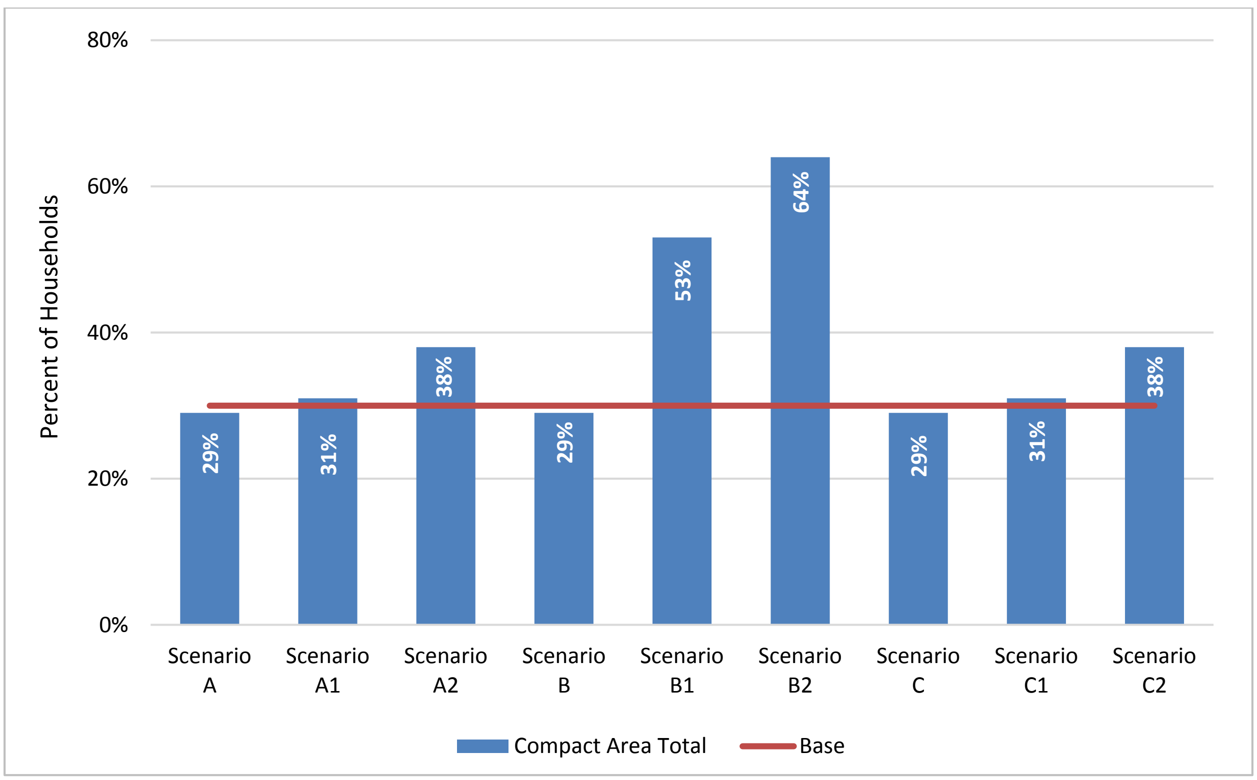
3.4.2. Households within 1/2 mile of High-Capacity Transit (MOE 3.2)

Table 11 lists the percentages of households in proximity to high-capacity transit by jurisdiction, and **Figure 32** shows the total percentages for the WMATA Compact Area. Scenarios B1 and B2 – which intensified existing land use patterns around transit stations – had the largest percentage of households in this category for both the jurisdictions and the overall Compact Area. These results directly reflect the assumed land use inputs for the modeling process.

Table 11: Percent of Households within ½ Mile of High-Capacity Transit (by jurisdiction)

	Base	A	A1	A2	B	B1	B2	C	C1	C2
DC	61%	61%	62%	67%	61%	85%	90%	61%	62%	67%
Montgomery County	26%	26%	27%	28%	26%	50%	59%	26%	27%	28%
Prince George's County	12%	12%	15%	18%	12%	40%	48%	12%	15%	18%
Arlington County	73%	73%	73%	75%	73%	88%	93%	73%	73%	75%
City of Alexandria	59%	59%	60%	59%	59%	89%	92%	59%	60%	59%
Fairfax County	13%	13%	16%	11%	13%	36%	42%	13%	16%	11%
Loudoun County	2%	2%	3%	3%	2%	17%	28%	2%	3%	3%
Compact Area Total	**29%**	**29%**	**31%**	**38%**	**29%**	**53%**	**64%**	**29%**	**31%**	**38%**

Figure 32: Percent of Households within ½ Mile of High-Capacity Transit (Compact Area)



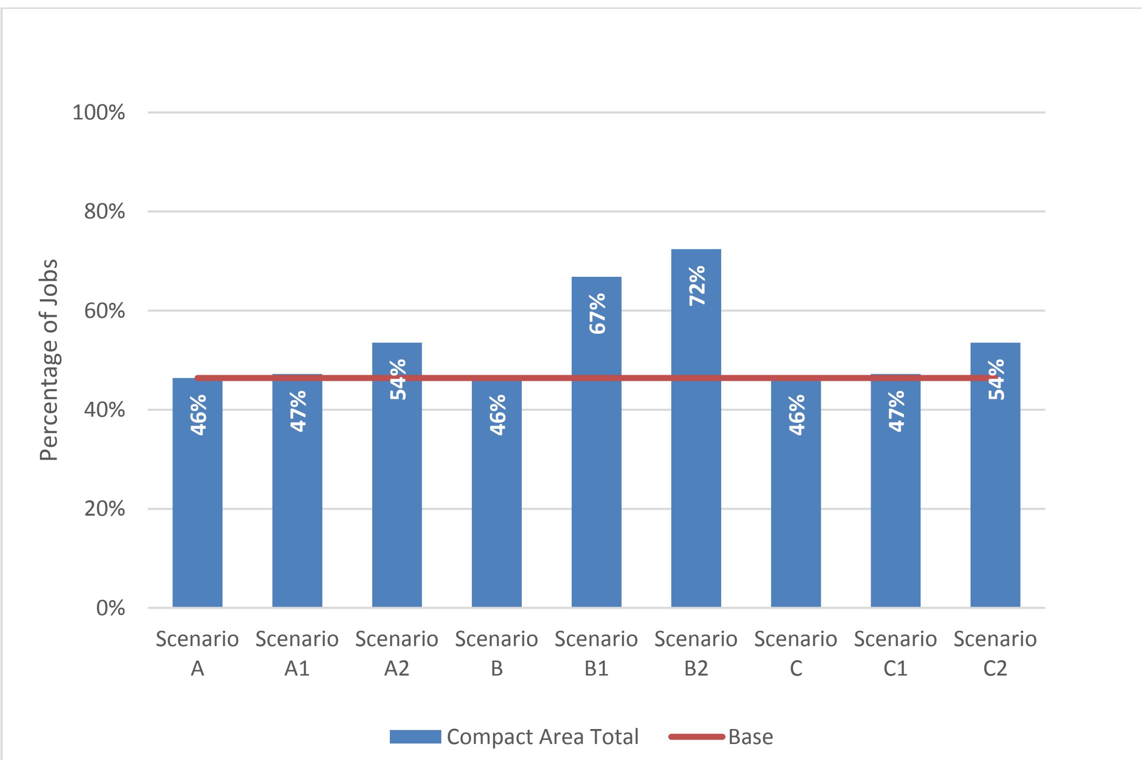
3.4.3. Jobs within 1/2 mile of High-Capacity Transit (MOE 3.3)

Table 12 lists the percentages of jobs in proximity to high-capacity transit by jurisdiction, and **Figure 33** shows the total percentages for the WMATA Compact Area. As in MOE 3.2, Scenarios B1 and B2 – which intensified existing land use patterns around Metrorail stations – had the largest percentages of jobs in this category for both the jurisdictions and the overall Compact Area.

Table 12: Jobs within 1/2 mile of High-Capacity Transit (by jurisdiction)

	Base	A	A1	A2	B	B1	B2	C	C1	C2
DC	77%	77%	78%	80%	77%	94%	92%	77%	78%	80%
Montgomery County	43%	43%	43%	46%	43%	75%	78%	43%	43%	46%
Prince George's County	18%	18%	20%	27%	18%	40%	44%	18%	20%	27%
Arlington County	89%	89%	89%	88%	89%	96%	97%	89%	89%	88%
City of Alexandria	71%	71%	72%	69%	71%	92%	93%	71%	72%	69%
Fairfax County	25%	25%	26%	26%	25%	42%	44%	25%	26%	26%
Loudoun County	4%	4%	6%	6%	4%	31%	34%	4%	6%	6%
Compact Area Total	**46%**	**46%**	**47%**	**54%**	**46%**	**67%**	**72%**	**46%**	**47%**	**54%**

Figure 33: Percent of Jobs within ½ mile of High-Capacity Transit (Compact Area)



3.4.4. Jobs/Housing Balance (MOE 3.4)

Table 13 lists the ratio of jobs to housing by jurisdiction, WMATA Compact Area, and the region. The ratio at the regional level remained constant, because the regional population and employment totals were maintained in all scenarios. Likewise, the land use scenarios that maintained jurisdictional totals (A1, B1, and C1) had no changes at the jurisdictional level or at the Compact Area level.

In the land use scenarios that shifted population and employment across jurisdictions (Scenarios A2, B2 and C2), the overall Compact Area ratio had only minor changes, because the amount of land use available to be moved (includes only job and population growth from 2020-2040) was small in comparison with the existing (pre-2020) population and employment in the Compact Area (see **Figure 34**). Meanwhile, this growth represented more of the total land use in many of the outer jurisdictions, and major changes in the jobs-housing balance were observed outside the Compact Area.

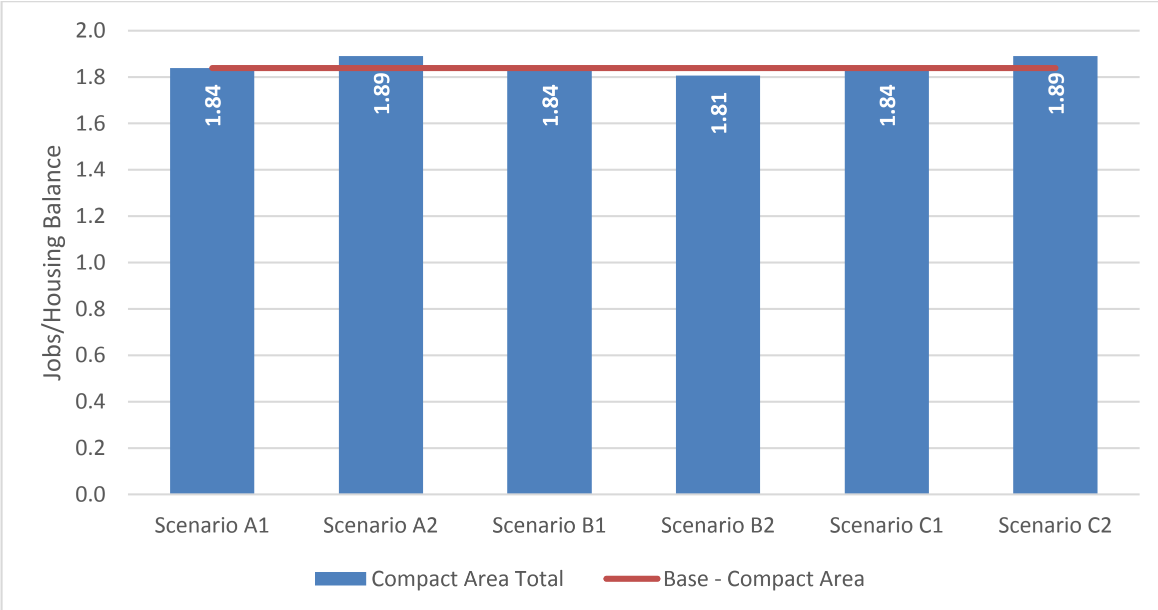
As designed, Scenarios A2 and C2 helped balance the number of jobs per household at the jurisdictional level, while Scenario B2, which focused on reinforcing existing transit markets, exacerbated existing jurisdictional imbalances.

Table 13: Jobs/Housing Balance (by jurisdiction)

	Base	A1	A2	B1	B2	C1	C2
District of Columbia	2.70	2.70	2.39	2.70	2.70	2.70	2.39
Montgomery County	1.55	1.55	1.81	1.55	1.48	1.55	1.81
Prince George's County	1.31	1.31	1.54	1.31	1.22	1.31	1.54
Arlington County	2.40	2.40	1.51	2.40	1.70	2.40	1.51
City of Alexandria	1.77	1.77	1.99	1.77	1.34	1.77	1.99
Fairfax County	1.78	1.78	1.91	1.78	1.78	1.78	1.91
Loudoun County	1.69	1.69	1.37	1.69	1.66	1.69	1.37
Compact Area Total	**1.84**	**1.84**	**1.89**	**1.84**	**1.81**	**1.84**	**1.89**
Other	1.29	1.29	0.92	1.29	1.03	1.29	0.92
Regional Total	1.64	1.64	1.64	1.64	1.64	1.64	1.64

Note: The Baseline values apply to all of the Prime Scenarios as well, in which no land use changes were implemented.

Figure 34: Jobs/Housing Balance - Compact Area



3.5. Measures of Effectiveness – Goal 4

Goal 4: Provide a high-quality transit system that accommodates and encourages future ridership growth.

3.5.1. Person Hours on Congested Transit Vehicles (MOE 4.1)

This MOE is based on the estimated total daily person hours of travel on congested transit links. The results were highly correlated with total transit ridership. The policies and land use reallocation resulted in enormous levels of Metrorail congestion in Scenario B2 and to a lesser extent in Scenarios A2 and C2. These results were also indicative of total higher passenger miles traveled (PMT) on transit. LRT only showed any congestion in Scenarios A2 and B2. The B scenarios showed a lot more congestion on buses – even in B prime – then some of the other scenarios, because the cordon toll and other measures made driving less attractive (see **Table 14**).

Table 14: Person Hours of Travel on Congested Transit Vehicles during the Peak Period

	2040 Constr.	2040 Uncon.	A	A1	A2	B	B1	B2	C	C1	C2
Metrorail (over 100 ppc)	1,000	42,000	42,000	48,000	221,000	74,000	75,000	383,000	46,000	19,000	98,000
LRT (over 140 ppc)	-	-	-	-	6,117	-	-	10,000	-	-	-
Streetcar (over 115 ppc)	2,000	8,000	9,000	13,000	17,000	12,000	13,000	34,000	9,000	8,000	10,000
All Buses (over 45 ppc)	36,000	39,000	38,000	55,000	79,000	56,000	52,000	104,000	38,000	28,000	123,000

Note: ppc = passengers per car

3.5.2. Metrorail Transfer Capacity – Average Weekday Metrorail Transfers at Core Stations (MOE 4.2)

This MOE is based on the projected number of passenger transfers at key core area stations that serve as major transfer points for the Metrorail system (transfer stations are listed in **Table 15**). The number of transfers was directly related to total number of transit trips, with Scenario B2 the highest (see **Figure 35**).

Scenarios B1 and B prime also had increases in the transfer rate, indicating that the cordon toll (and other measures designed to encourage transit use) resulted in longer trips with more transfers that travelers did not consider in the other scenarios. This result was consistent with the MOE 1.3 average travel time findings.

Another notable result was that the B scenarios resulted in very few transfers via the Gallery Place-Metro Center pedestrian tunnel. This result was due to the policy that reduced the effects of transit wait/transfer time (related to ITS) included in the B Scenarios, making the rail transfer more attractive than walking via the tunnel.

Figure 35: Average Weekday Metrorail Transfers at Core Stations (Daily Total)

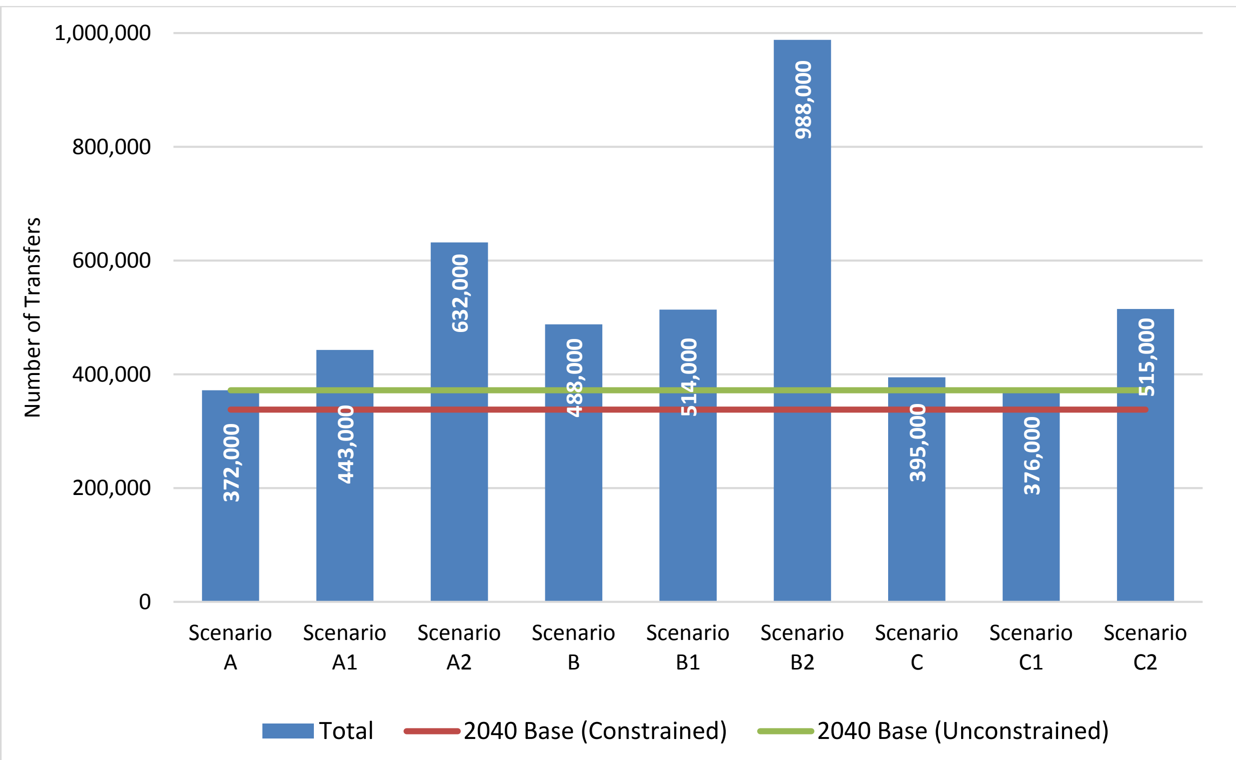


Table 15: Average Weekday Metrorail Transfers at Core Stations (Daily Total)

	Base (Unconstrained)	A	A1	A2	B	B1	B2	C	C1	C2
Fort Totten Station	39,000	37,000	41,000	79,000	46,000	49,000	104,000	41,000	41,000	64,000
L'Enfant Plaza Station	78,000	80,000	94,000	144,000	103,000	110,000	233,000	82,000	78,000	109,000
Metro Center Station	93,000	91,000	108,000	146,000	130,000	138,000	230,000	99,000	93,000	123,000
Gallery Place Station	91,000	91,000	106,000	141,000	124,000	125,000	199,000	97,000	91,000	122,000
Rosslyn Station	34,000	37,000	48,000	60,000	48,000	51,000	137,000	38,000	36,000	50,000
Farragut North-West	26,000	26,000	35,000	43,000	34,000	35,000	76,000	28,000	26,000	31,000
Gallery Place - Metro Center	11,000	11,000	12,000	18,000	5,000	5,000	10,000	11,000	11,000	16,000
Total	**372,000**	**372,000**	**443,000**	**632,000**	**488,000**	**514,000**	**988,000**	**395,000**	**376,000**	**515,000**

3.5.3. Link Loads by Direction and Time of Day – Peak and Off-Peak Direction (MOE 4.3)

Figure 36 through **Figure 46** show the morning peak period, peak direction Metrorail vehicle loads for the 2040 Base and the scenarios. All scenarios increase passenger loads compared to the 2040 Unconstrained Base and result in at least one segment with Metrorail loads over 120 ppc. Typically, the Yellow Line between Pentagon and L'Enfant Plaza, the Green Line between Anacostia and L'Enfant Plaza, and the Orange/Silver Line segments near Rosslyn and Tysons Corner become more congested; however, the various scenarios result in different patterns of crowding across the system.

- The A scenarios, especially A2, resulted in slightly higher utilization of Metrorail on the eastern side of the region but also increased crowding in the core and the radial lines that were already heavily used in the 2040 Base. This result was primarily because the major job centers continued to be important even considering the alternative land use scenarios, and further clustering of land use near transit stations increased the demand for transit in the markets that already showed high ridership in the existing conditions.
- The B scenarios increased passenger loads throughout the system, although loads on some underutilized lines such as the eastern legs of the Orange and Blue Lines and southern legs of the Blue and Yellow Lines did not increase significantly until the B2 land use strategies are applied. However, these strategies and policies combined overwhelmed much of the system, resulting in passenger loads above 120 and 150 ppc on many segments.
- The C scenarios increased passenger loads more moderately than the A and B scenarios but still resulted in additional crowded segments once land use changes were introduced. These more moderate changes can be partially attributed to the lower total peak period travel demand caused by some of the TDM-type strategies included in these alternatives.

Figure 47 through **Figure 51** show the morning peak period, reverse peak direction Metrorail loads for the 2040 Base and the A Scenarios, which had the objective of increasing ridership on underutilized lines. Scenario A1 and especially A2 increased reverse peak utilization of system segments above 50 ppc in the core and immediately adjacent segments, while most segments beyond the core remained underutilized with load factors below 50 ppc similar to the 2040 Base. Scenario A1 also resulted in crowding (>100 ppc) near Tysons Corner, which was mitigated by the Scenario A2 land use shifts, which limited additional population and employment in that area.

Figure 36: Metrorail Peak Load Factor 2040 Base Constrained

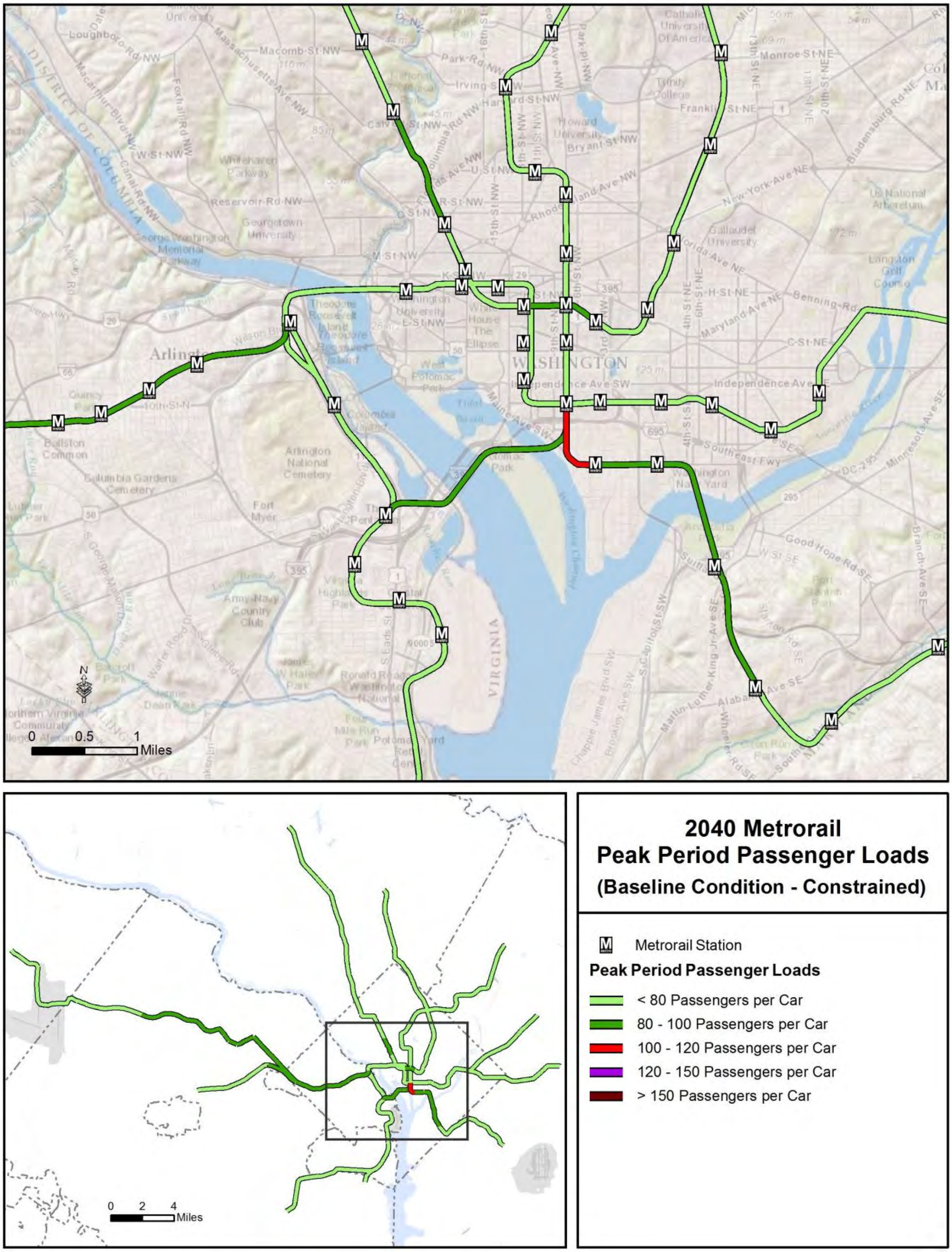


Figure 37: Metrorail Peak Load Factor 2040 Base Unconstrained

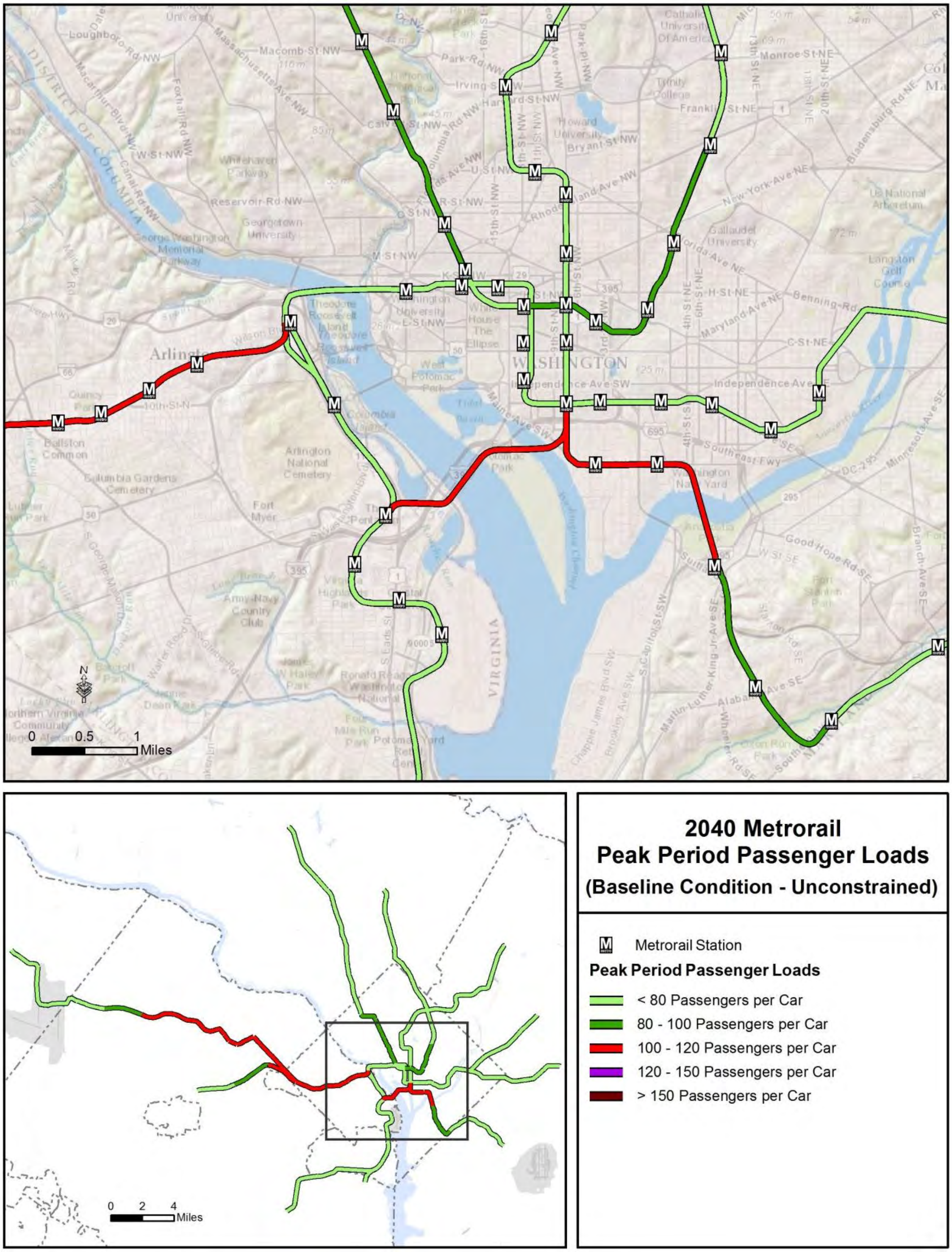


Figure 38: Metrorail Peak Load Factor Scenario A

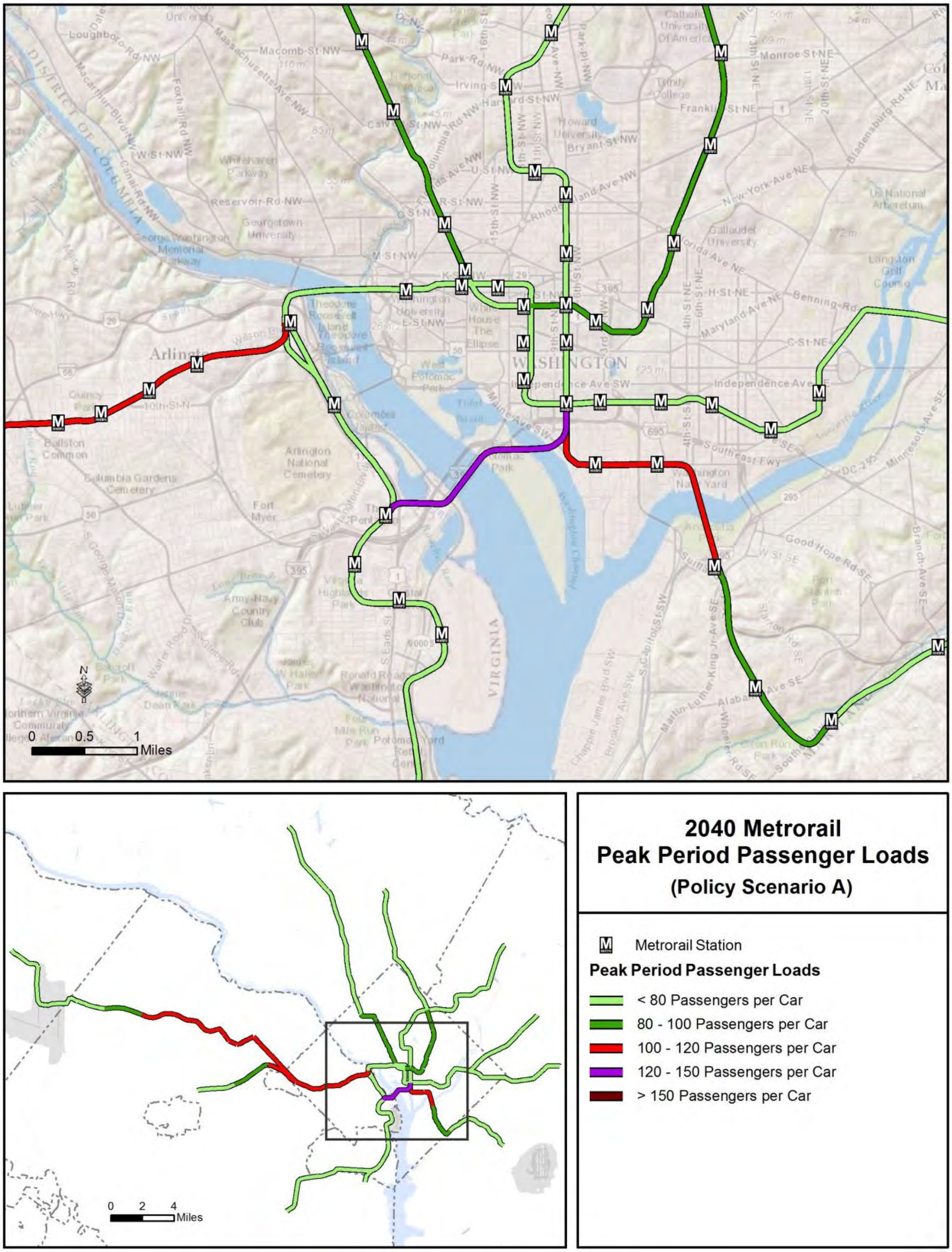


Figure 39: Metrorail Peak Load Factor Scenario A1

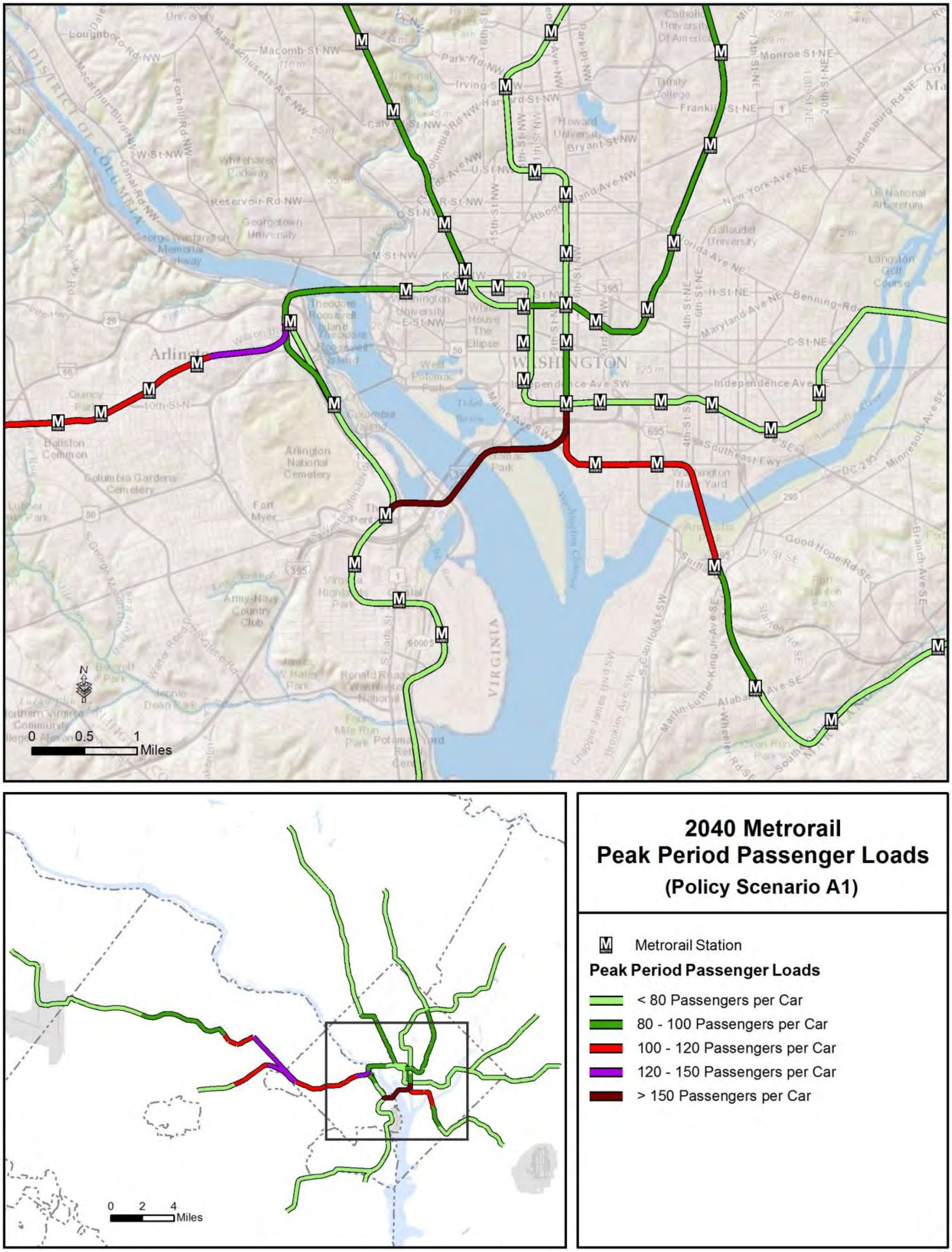


Figure 40: Metrorail Peak Load Factor Scenario A2

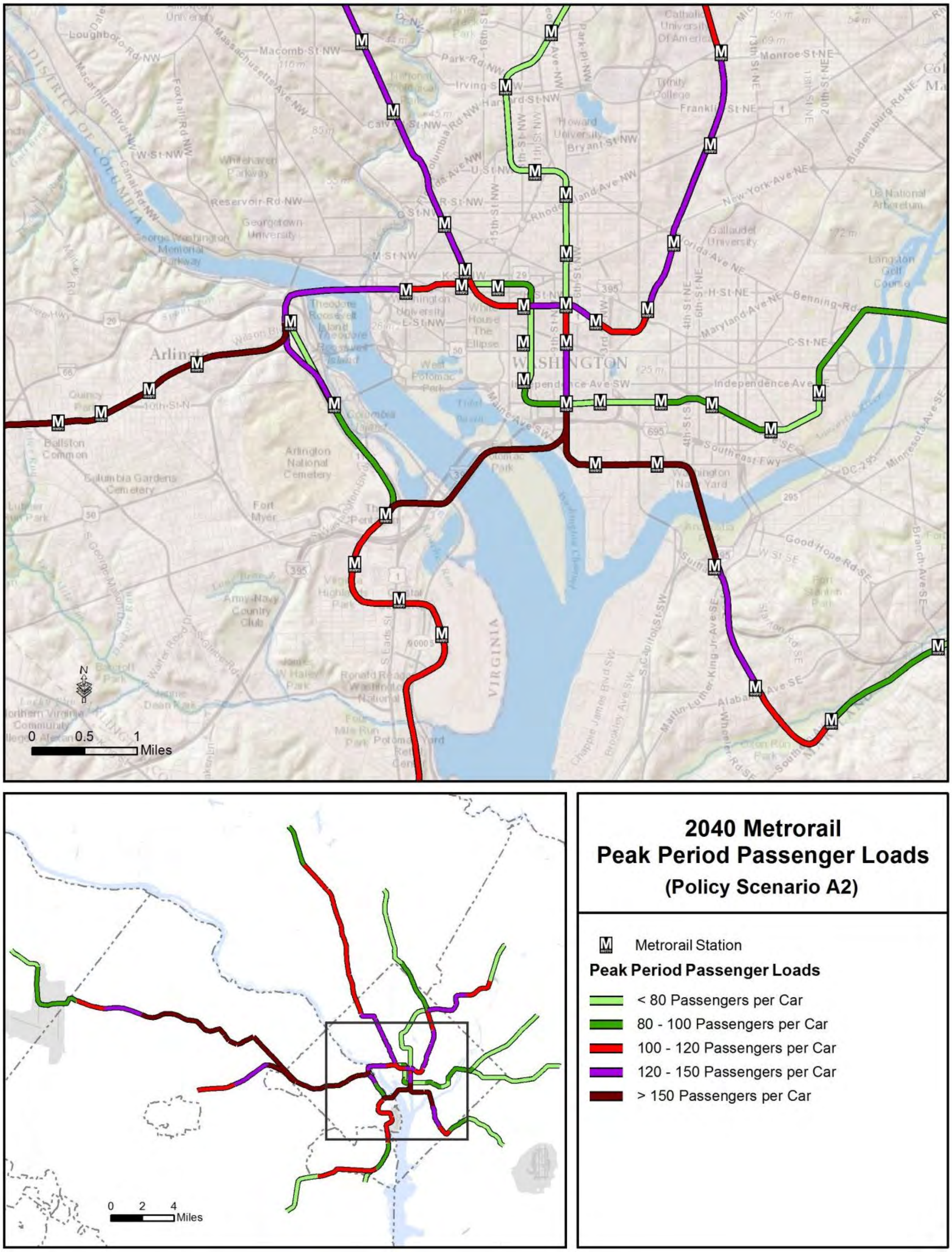


Figure 41: Metrorail Peak Load Factor Scenario B

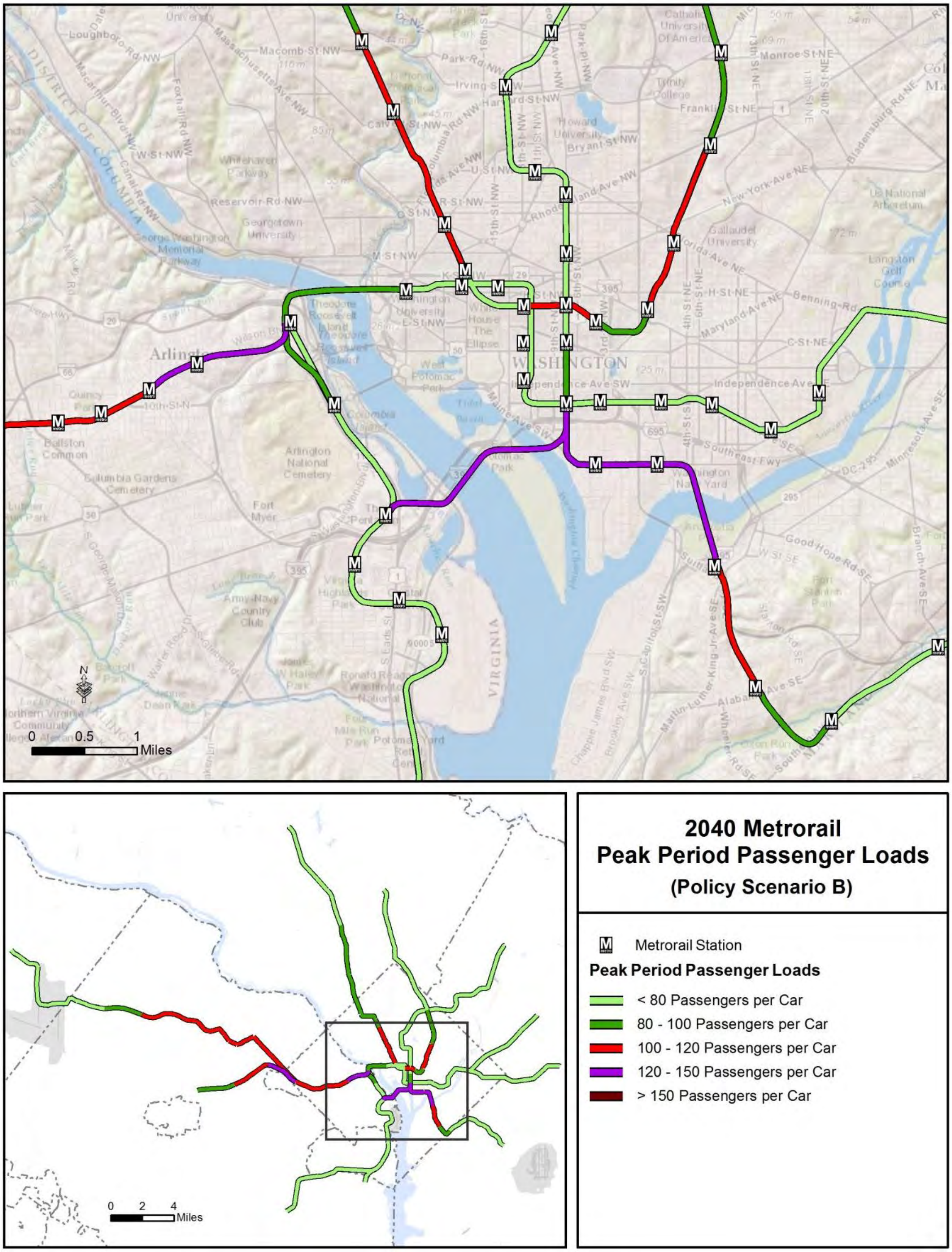


Figure 42: Metrorail Peak Load Factor Scenario B1

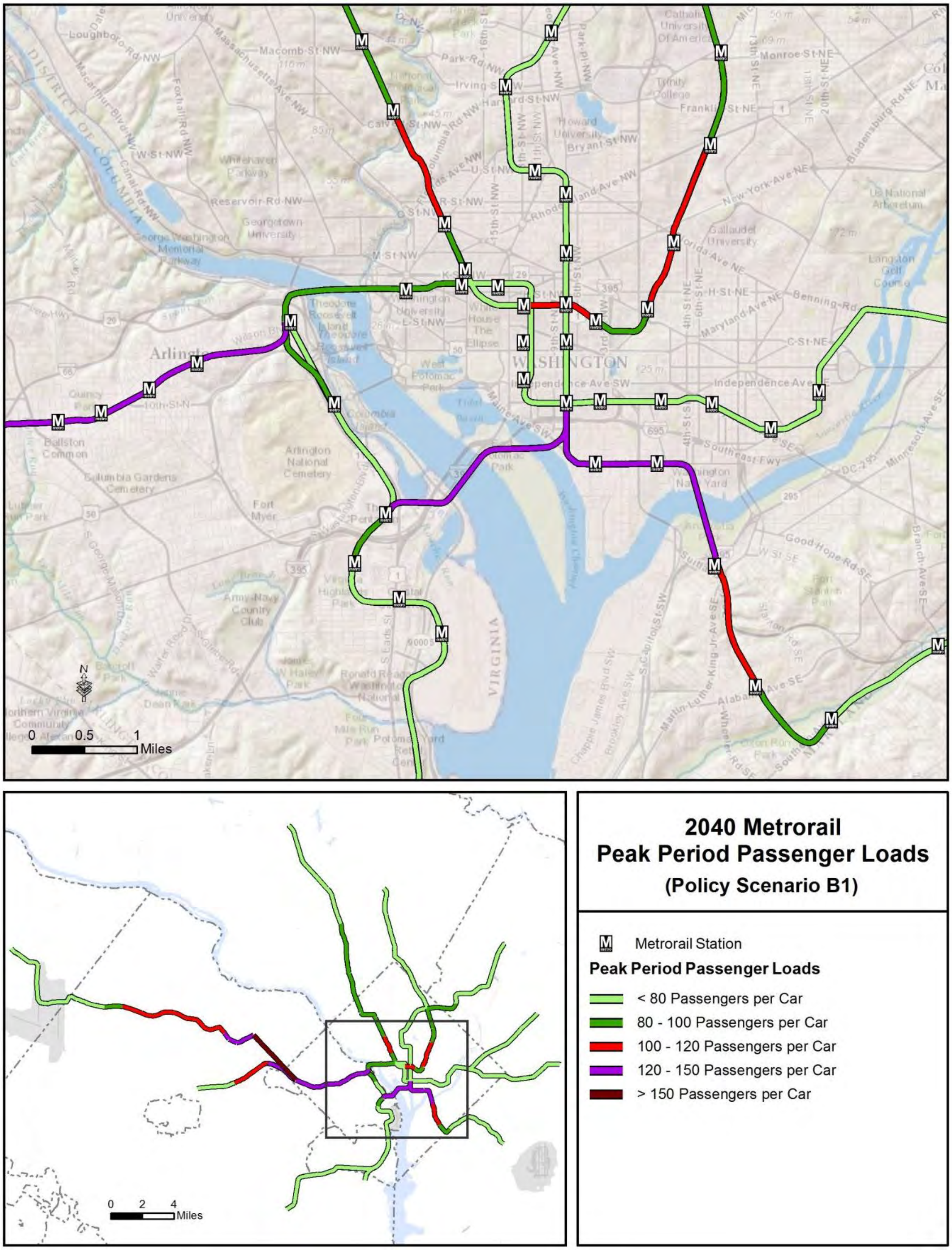


Figure 43: Metrorail Peak Load Factor Scenario B2

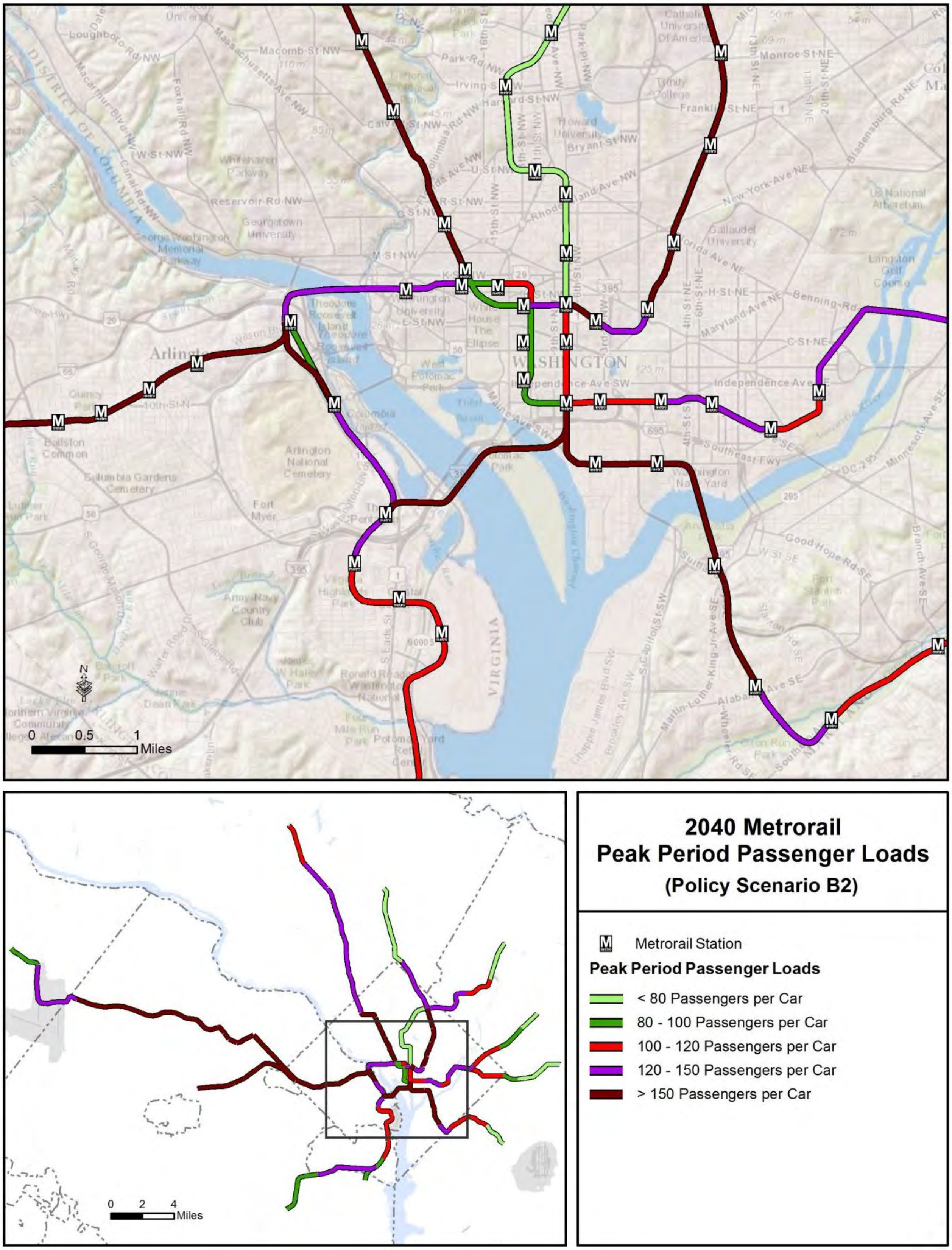


Figure 44: Metrorail Peak Load Factor Scenario C

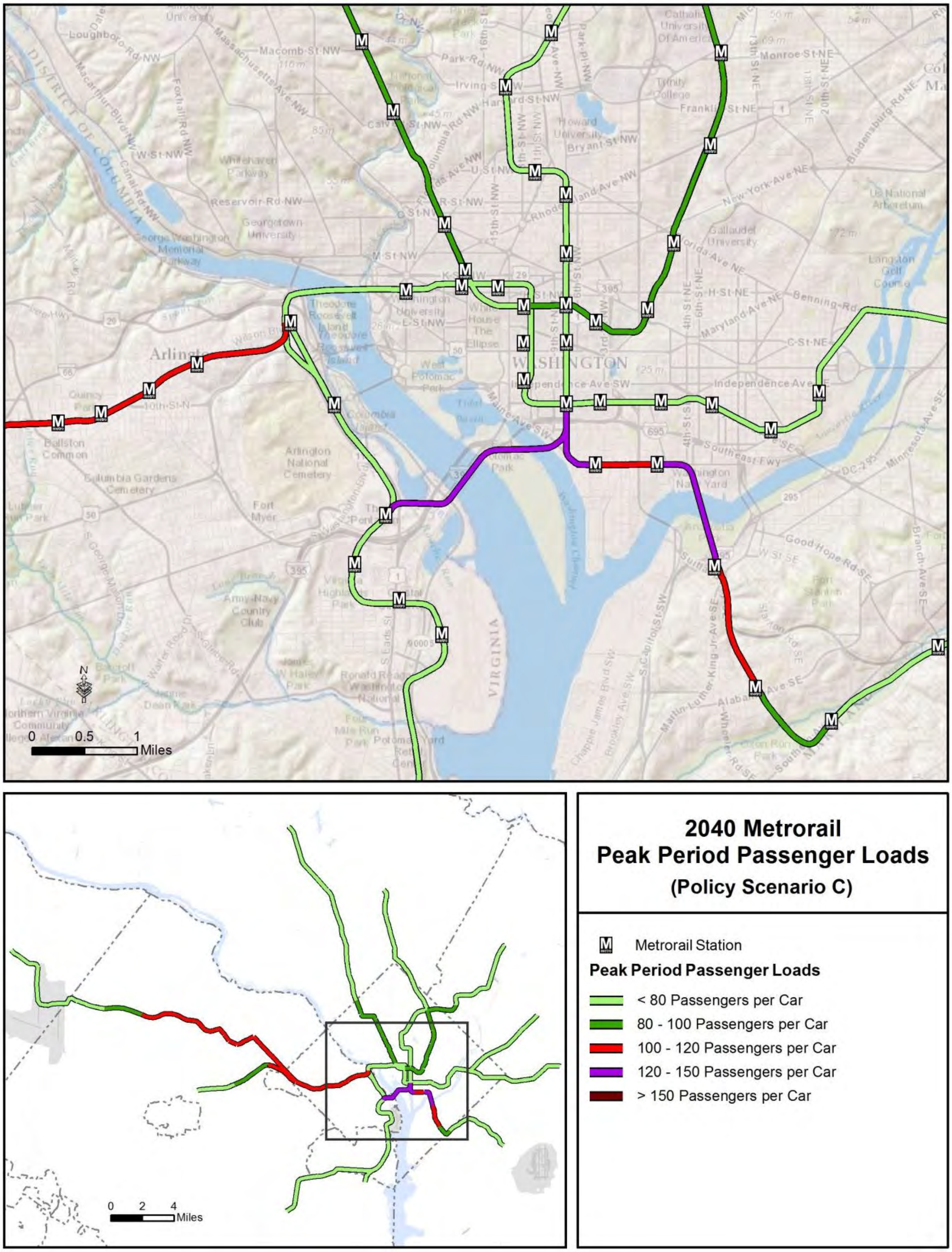


Figure 45: Metrorail Peak Load Factor Scenario C1

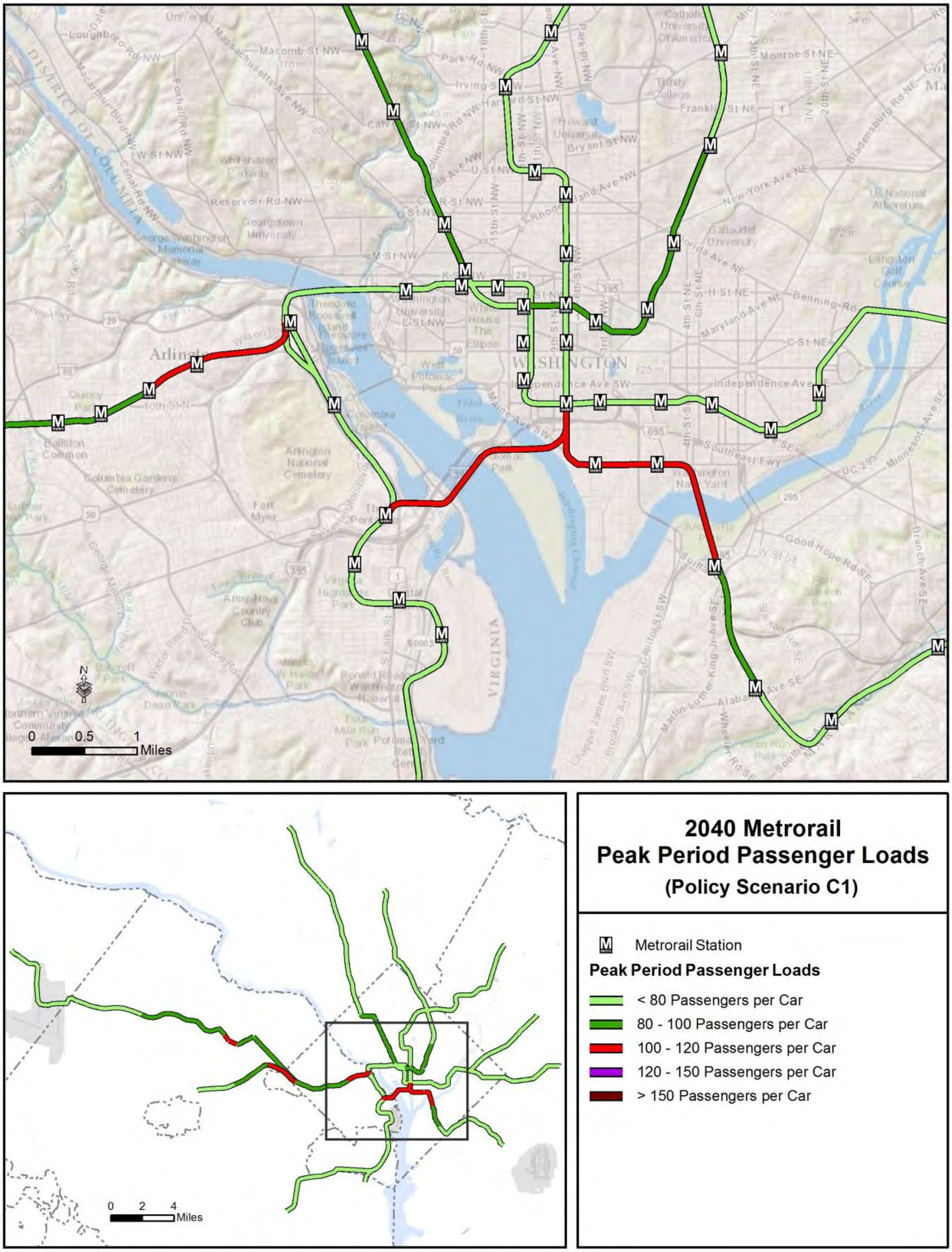


Figure 46: Metrorail Peak Load Factor Scenario C2

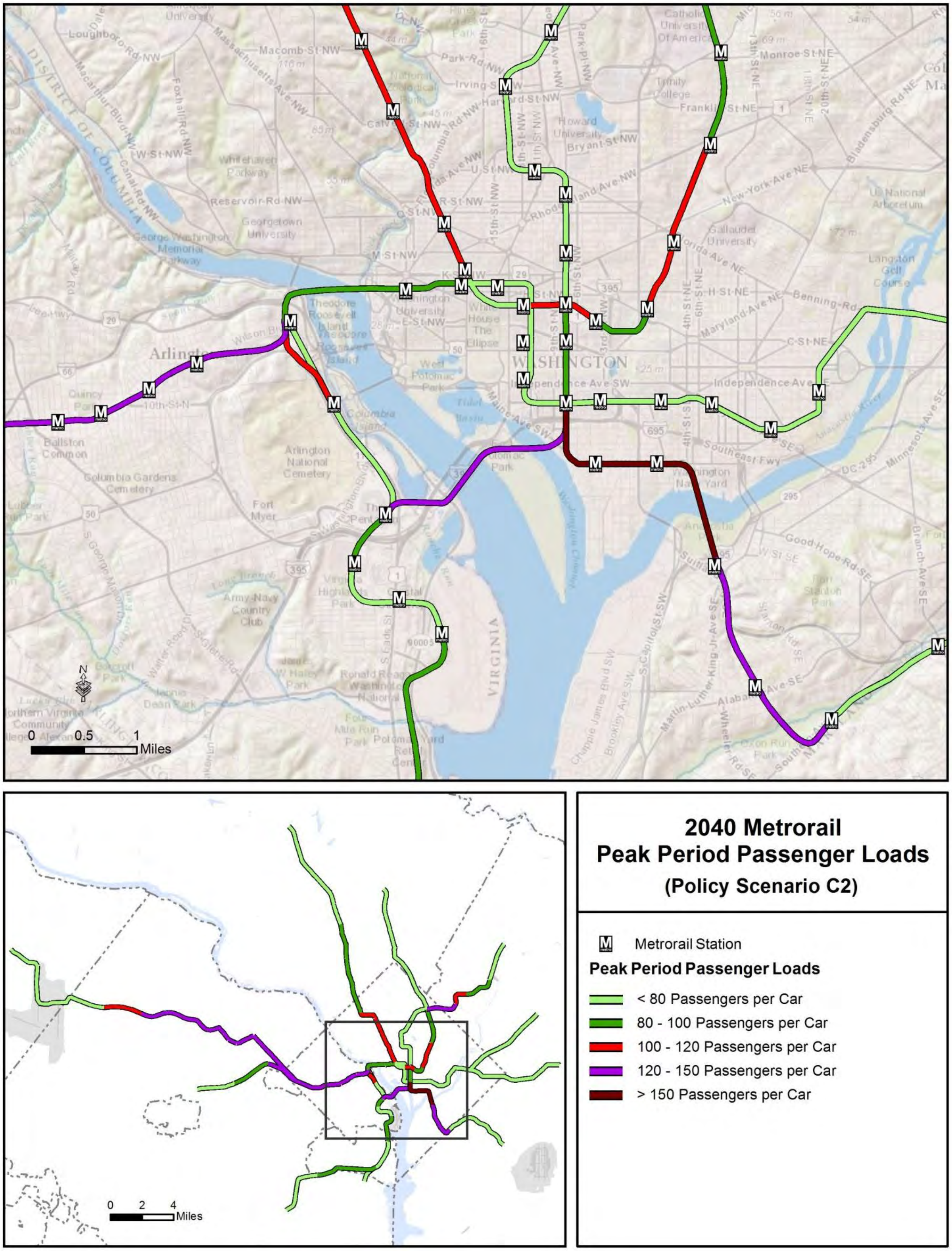


Figure 47: Reverse Peak Direction Peak Period Passenger Loads (2040 Base – Constrained)

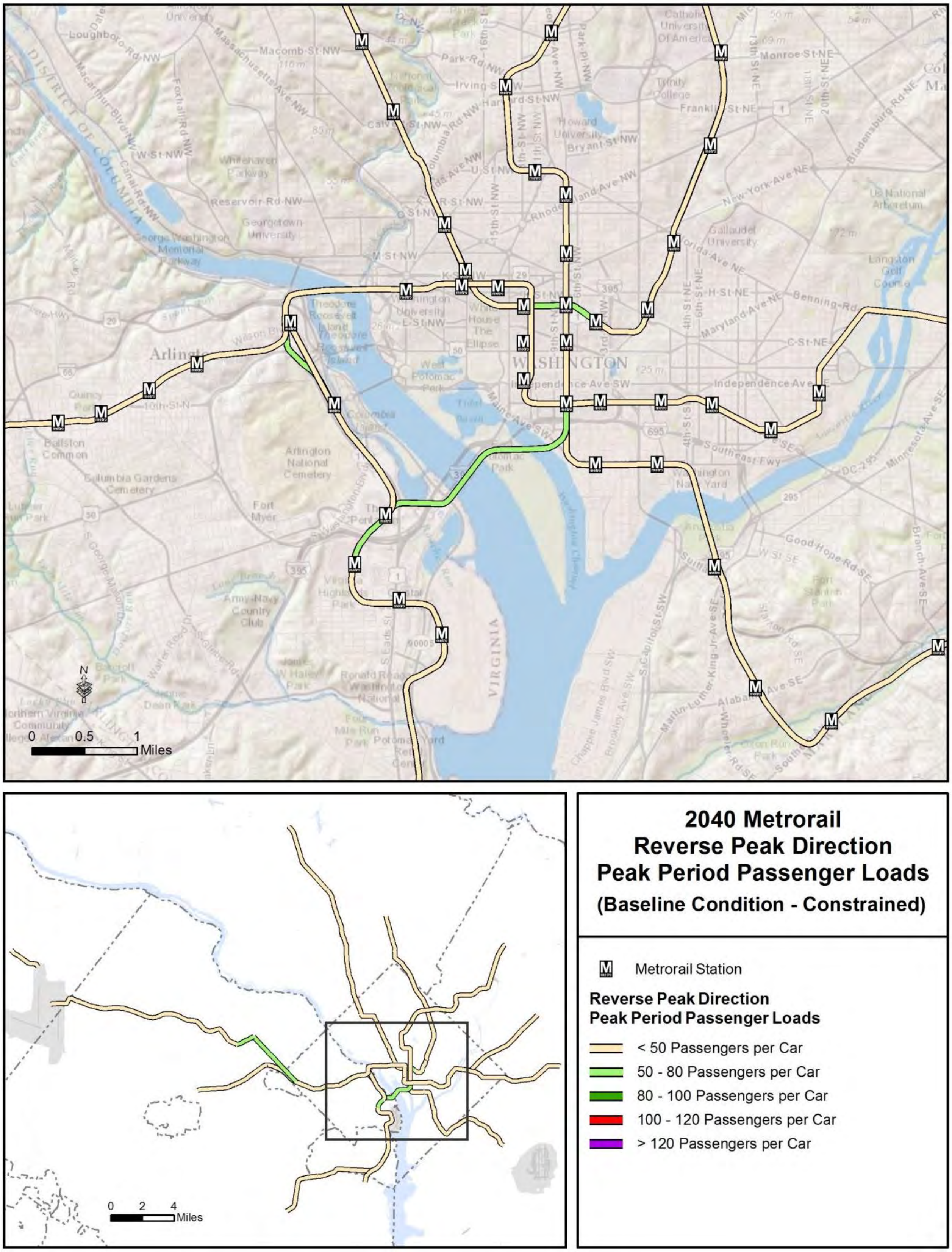


Figure 48: Reverse Peak Direction Peak Period Passenger Loads (2040 Base – Unconstrained)

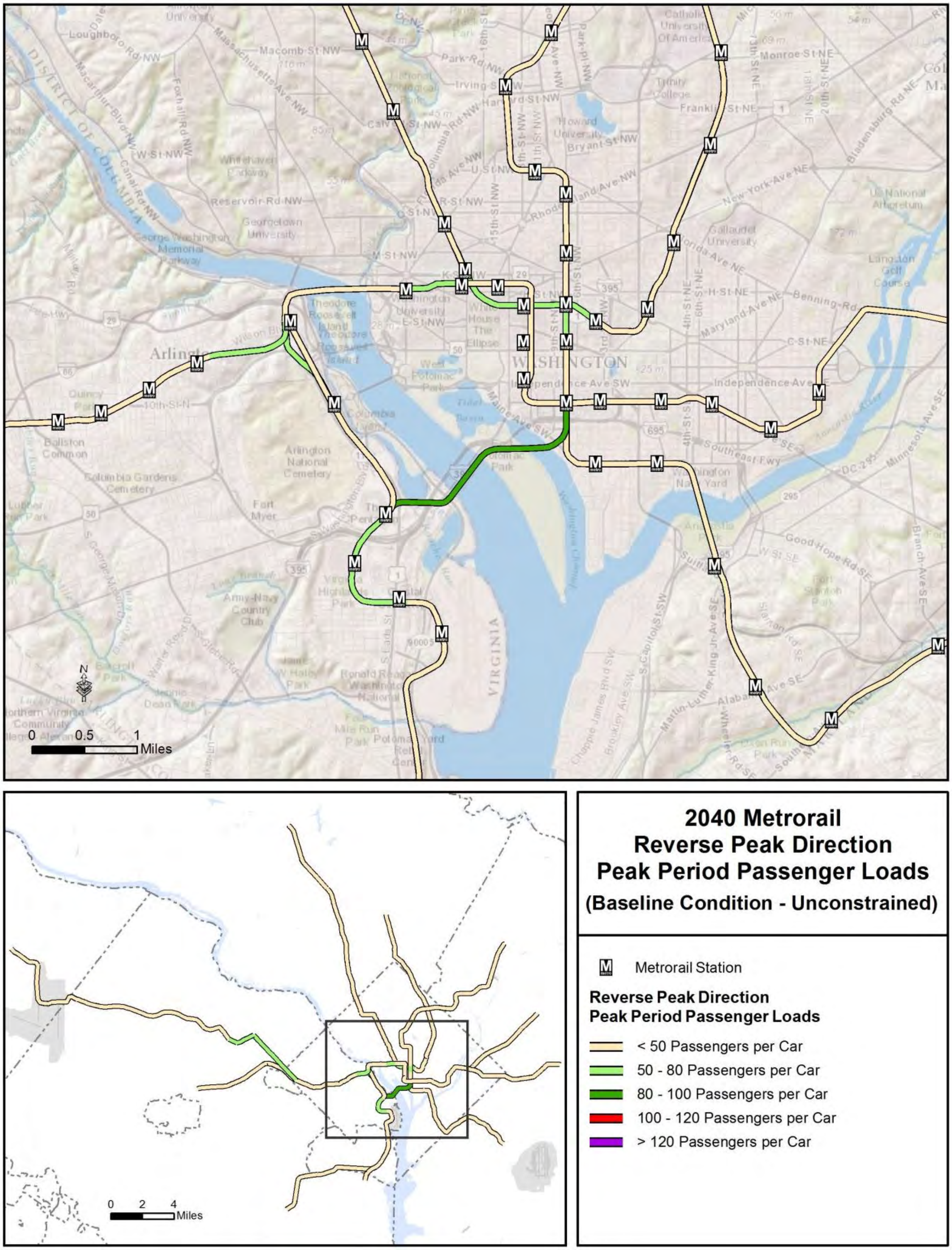


Figure 49: Scenario A Reverse Peak Direction Peak Period Passenger Loads

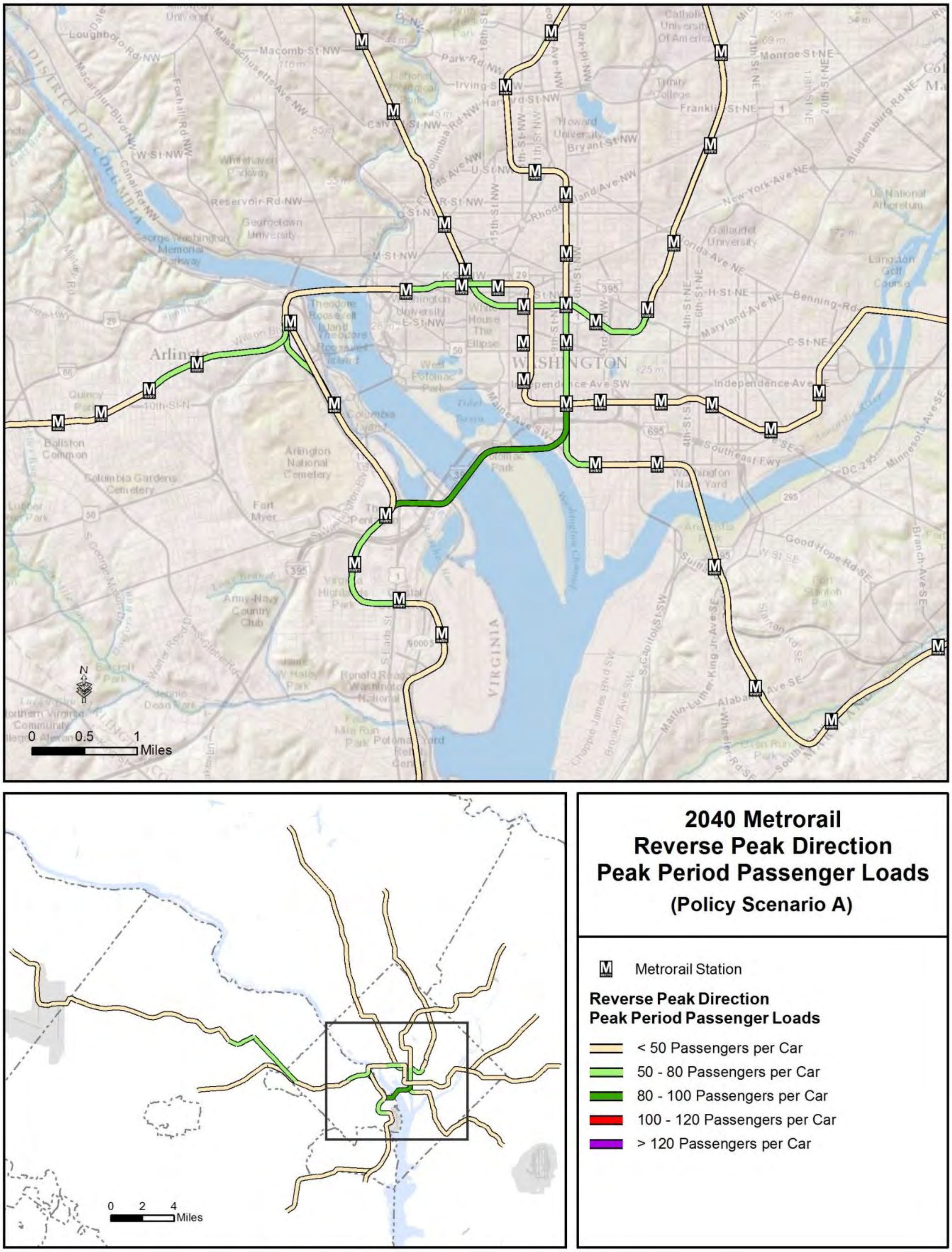


Figure 50: Scenario A1 Reverse Peak Direction Peak Period Passenger Loads

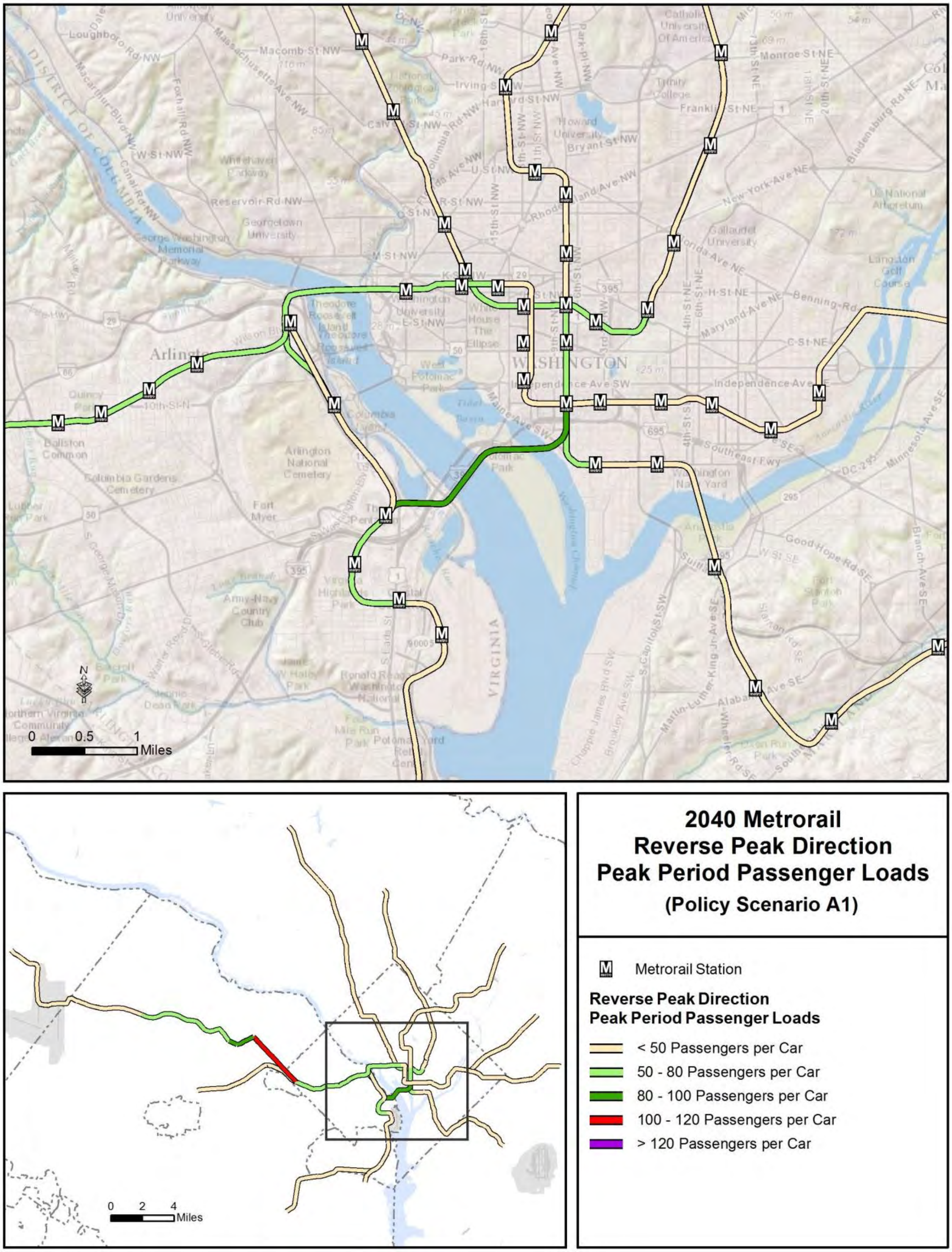
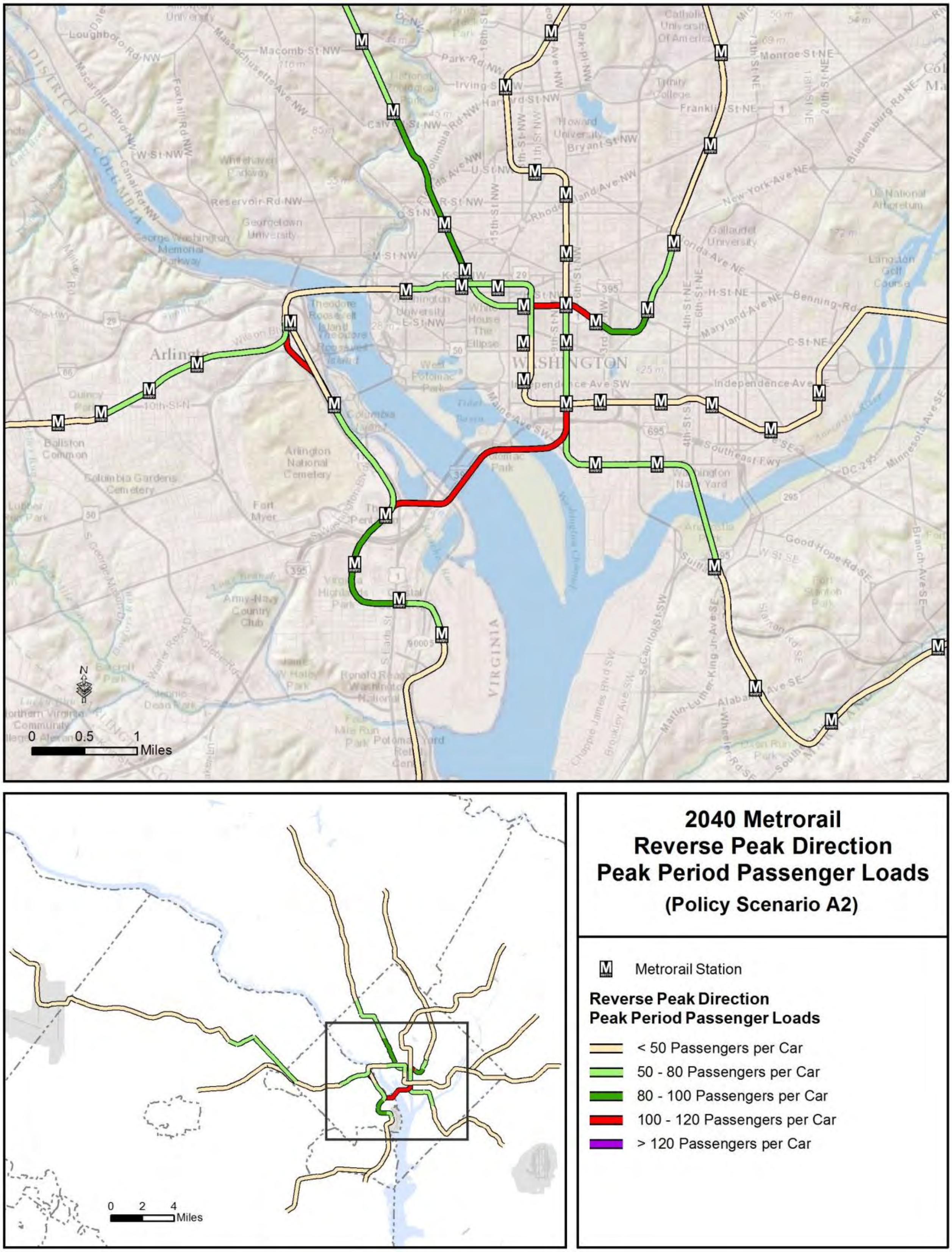


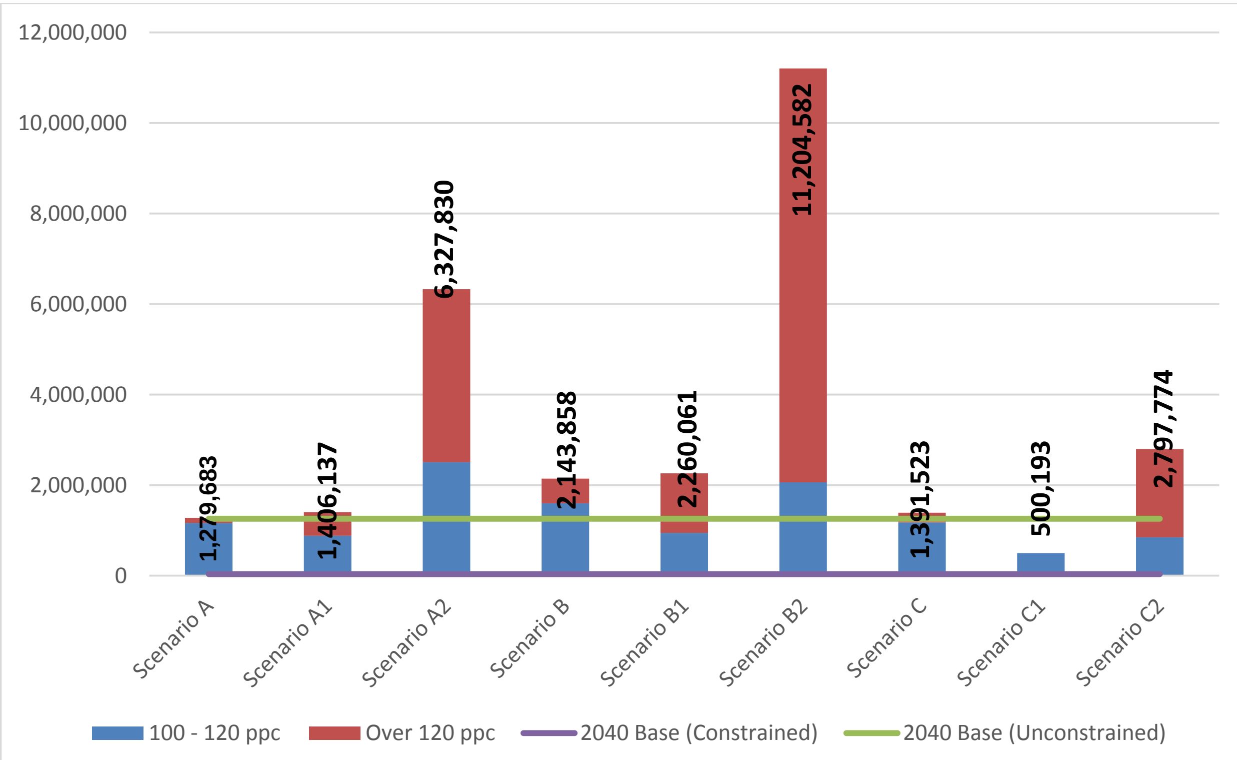
Figure 51: Scenario A2 Reverse Peak Period Passenger Loads



3.5.4. Metrorail Passenger Miles Traveled by Level of Congestion (MOE 4.4)

Figure 52 shows Metrorail passenger miles traveled (PMT) by level of congestion. Results for this MOE were highly correlated to the total transit ridership results (MOE 4.6), as higher ridership resulted in the higher load factors shown in the Metrorail passenger load maps for MOE 4.3. Scenarios A2, B2, and C2 (the highest ridership scenarios) clearly had the highest total and percentage of congested PMT on Metrorail. Scenario C1 did the best job of managing congestion on Metrorail compared with the 2040 Base but was still higher than the 2040 Constrained Base due to its higher ridership levels.

Figure 52: Metrorail Peak Period Person Miles Traveled on Congested Cars



3.5.5. Average Load Factor Deviation (MOE 4.5)

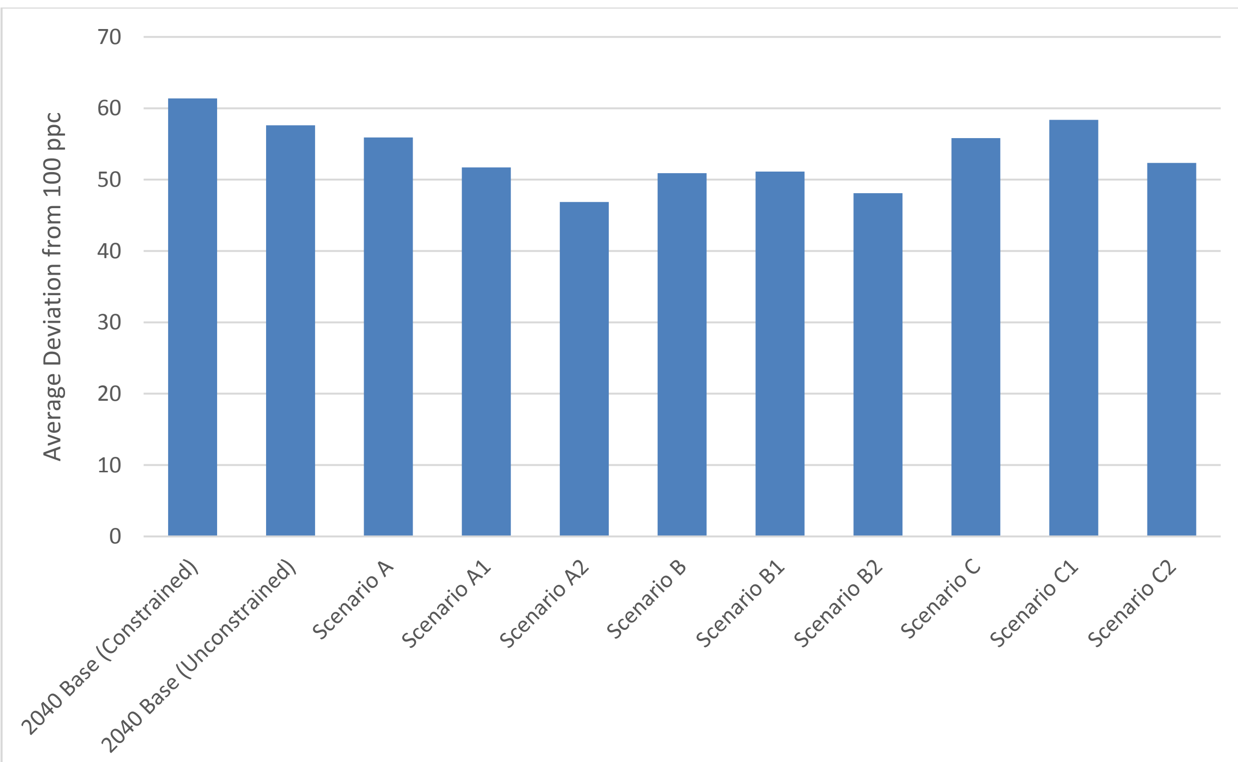
This MOE measures transit service utilization as the average deviation from optimal passenger loads, including both underutilization and overutilization of a transit service. Efficient transit utilization was a key objective for Scenario A. The MOE was calculated for the peak period in all directions and for each mode as the average of all links in the system.

Metrorail Load Factor Deviation

Figure 53 shows the load deviation for the Metrorail system, measured as the difference between the ideal utilization of 100 passengers per car and the actual average utilization. A value of zero in the chart would represent perfect utilization in which the whole system operated with loads of 100 ppc during the peak period. It is important to note that overutilized and underutilized links are counted as equal in the calculation of this MOE; for example, a Metrorail link carrying 165 ppc and a link carrying 35 ppc both have a load deviation of 65 ppc.

All scenarios except C1 lowered the deviation compared to the 2040 Base. Scenario C1 had no over-congested links to offset the underutilized links.

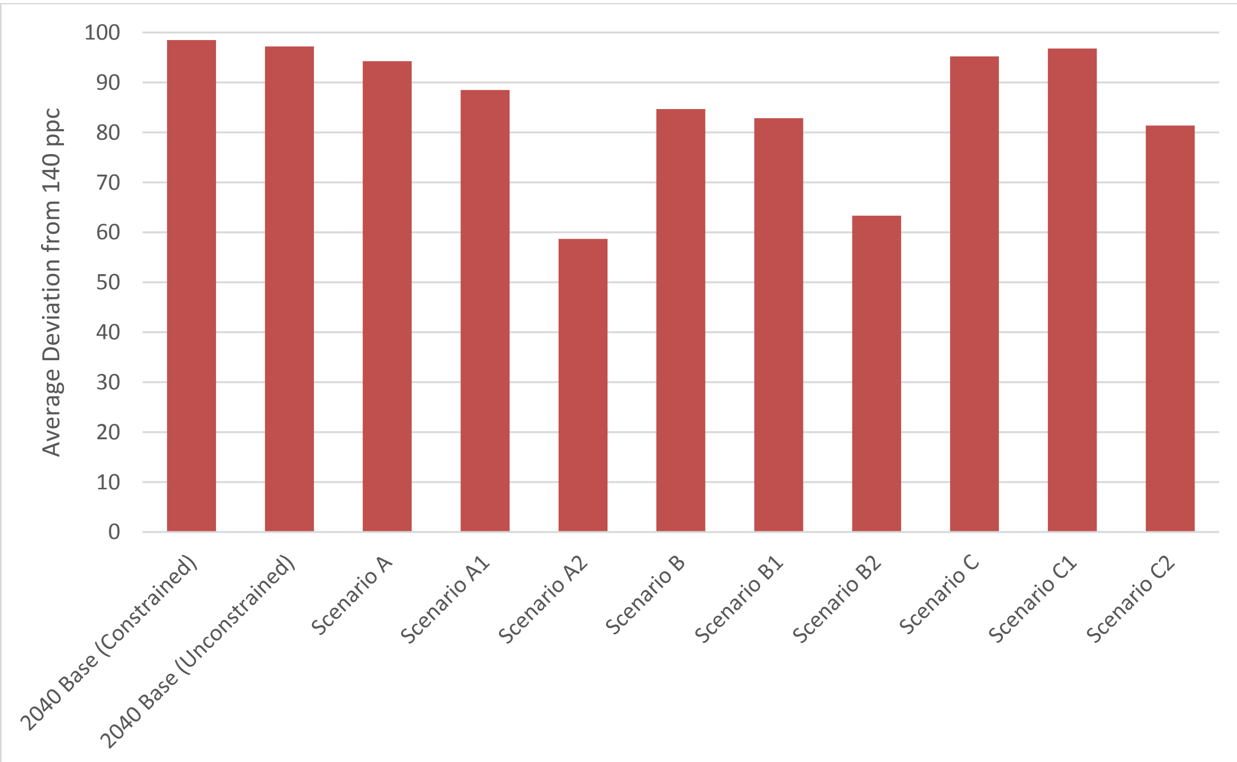
Figure 53: Peak Period Load Factor Deviation - Metrorail



Light Rail Transit (LRT) Load Factor Deviation

Ideal load factors for LRT are higher than Metrorail, at 140 ppc. As shown in **Figure 54**, all scenarios lowered the deviation for LRT compared to the 2040 Base, as ridership increased and load factors increased towards 140 ppc. Scenarios A2 and B2 had the highest LRT ridership (see MOE 4.6) and, therefore, had the lowest load factor deviation.

Figure 54: Peak Period Load Factor Deviation – LRT



Streetcar Load Factor Deviation

The ideal load factor for the Streetcar network is 115 passengers per car, a figure that was already exceeded along some streetcar lines in the 2040 Base, as shown in **Figure 56** on the following page. The load factor deviation results (below in **Figure 55**) for the Streetcar network showed increases in all of the scenarios compared to the baseline. This general increase was caused by the higher transit ridership that further exacerbated the crowding on the streetcar network. An example of this overcrowding is shown in **Figure 57**, which highlights the Scenario B2 results.

Figure 55: Peak Period Load Factor Deviation - Streetcar

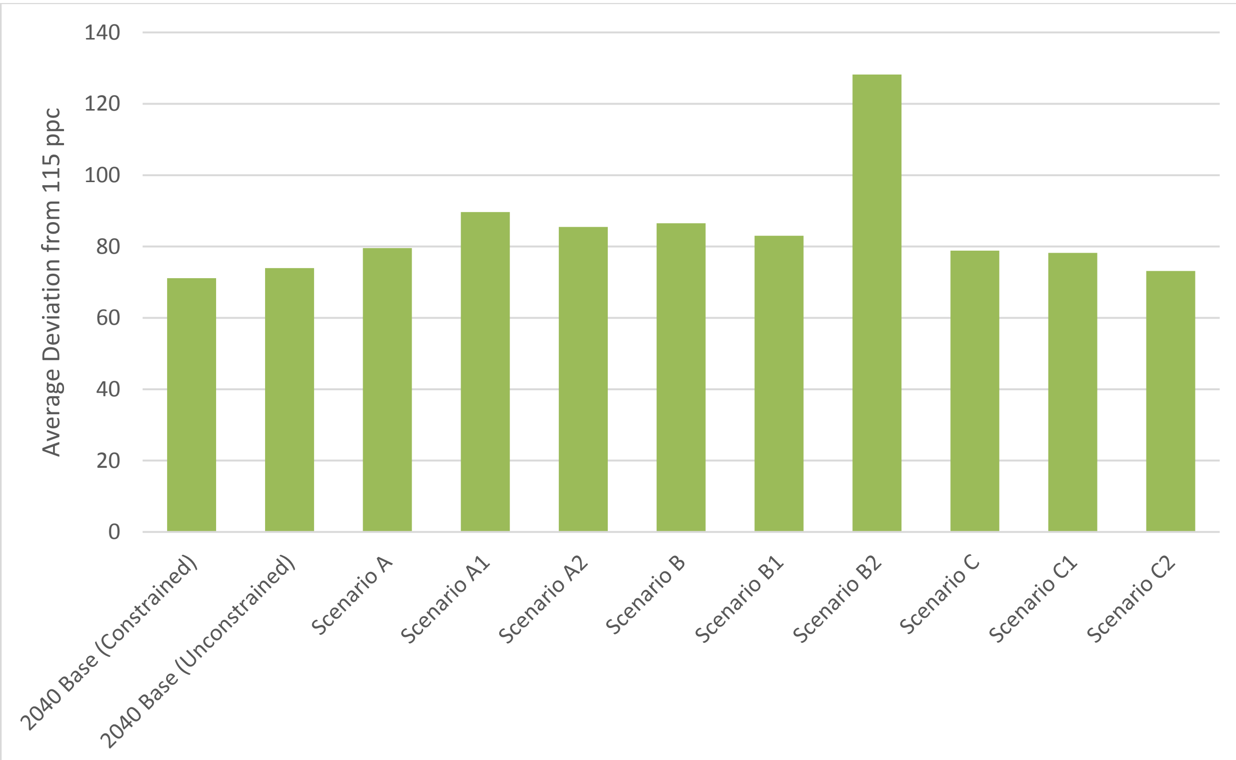


Figure 56: Streetcar Network Peak Period Load Factors – Baseline (Constrained)

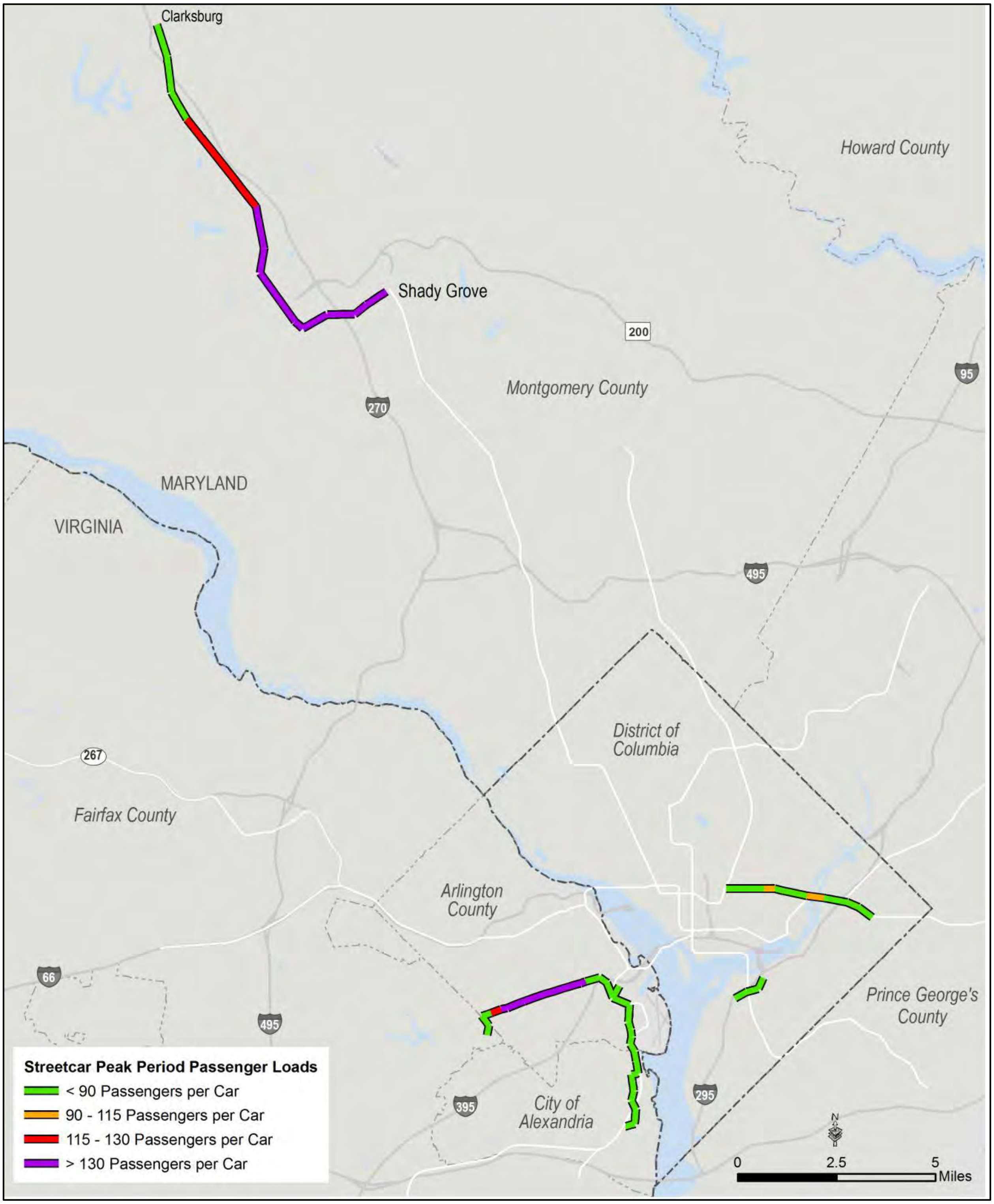
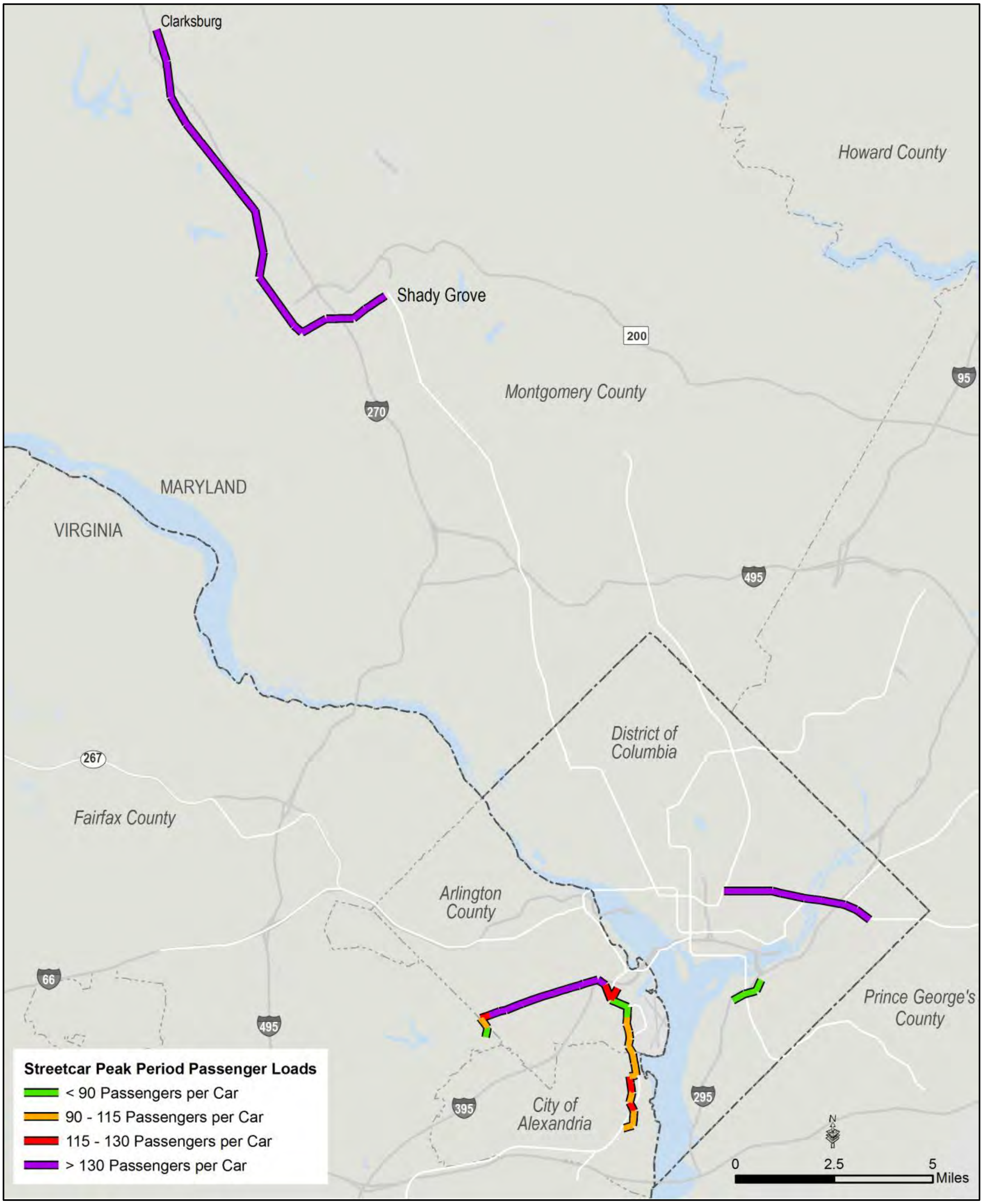


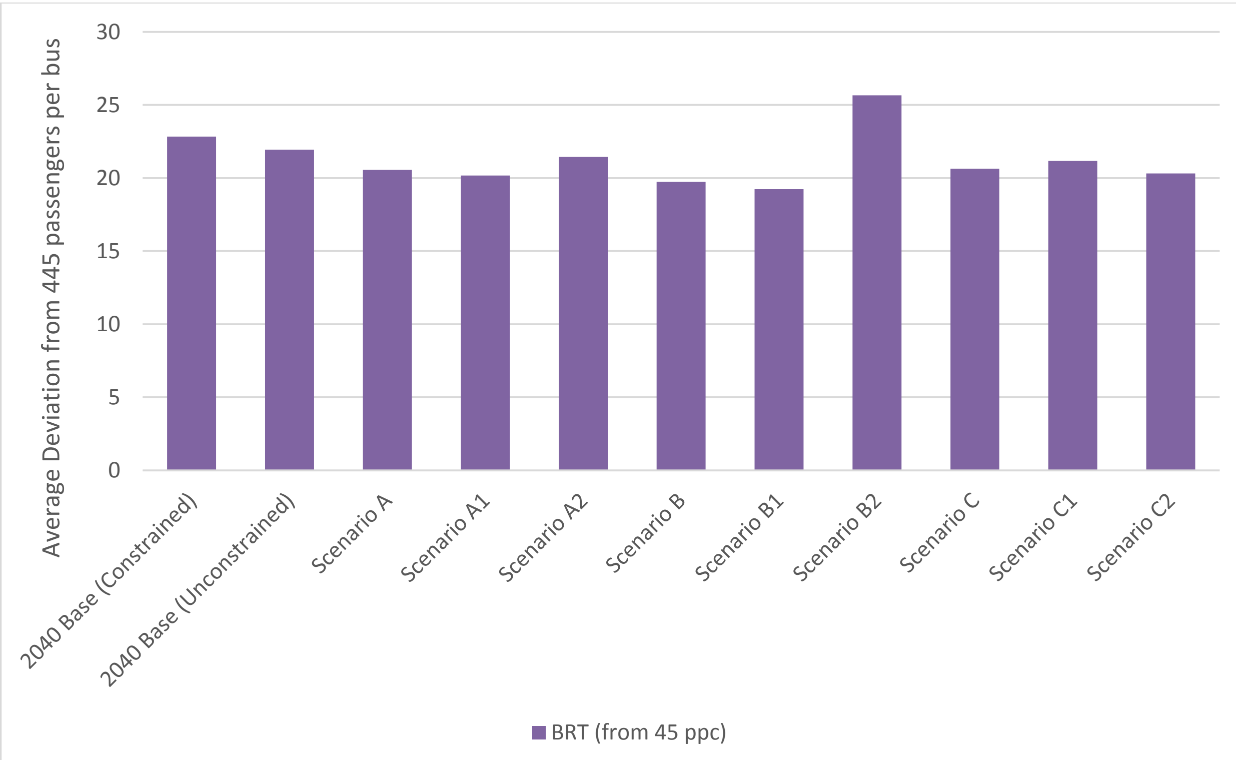
Figure 57: Streetcar Network Peak Period Load Factors – Scenario B2



Bus Rapid Transit (BRT) Load Factor Deviation

The optimal load factor for BRT is 45 passengers per vehicle. As shown in **Figure 58**, all scenarios, except B2, lowered the load deviation for the BRT network as compared to the 2040 Base. Scenario B2 had very high overall transit ridership that resulted in many over capacity and congested BRT vehicles.

Figure 58: Peak Period Load Factor Deviation - BRT



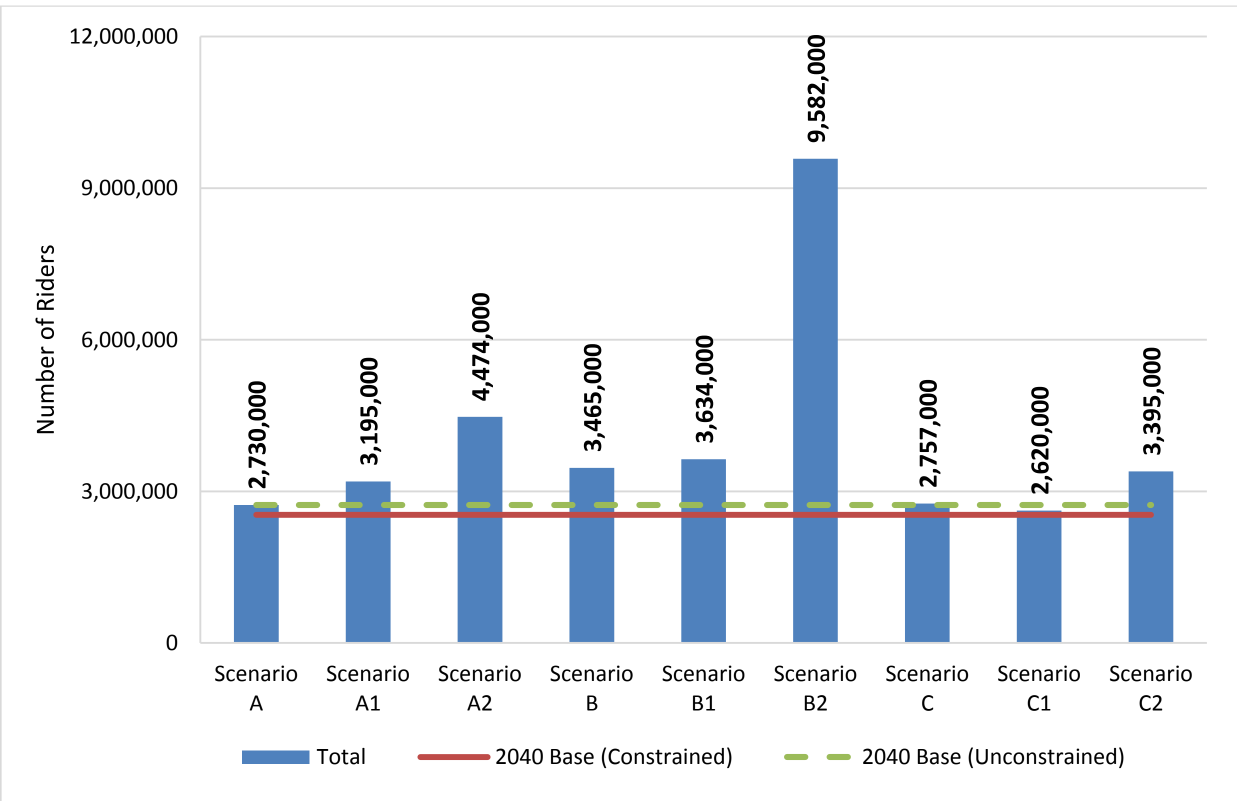
3.5.7. Total Transit Ridership (Linked Trips) (MOE 4.6)

Most of the scenarios had a slight to moderate increase above the base, with the largest increases in Scenarios B2, A2 and C2, where baseline jurisdictional land use totals did not need to be maintained (see **Figure 59**). Scenario B2 had more than three times the total transit trips as the baseline.

Only Scenario C1 had lower total transit trips than the 2040 Base, due to the shift in trips to telework and non-motorized modes. However, Scenario C1 had higher Metrorail boardings than the 2040 Base, indicating that the decrease was on other transit modes, primarily buses that served some of the shorter trips which shifted to non-motorized modes.

In other scenarios, overall transit and Metrorail trips increased in similar ways, but some scenarios were more focused on Metrorail growth than others. The A and C scenarios all increased Metrorail trips proportionally more than overall transit trips, while the B scenarios increased overall transit trips proportionally more than Metrorail trips.

Figure 59: Total Daily Transit Ridership (Linked Trips)

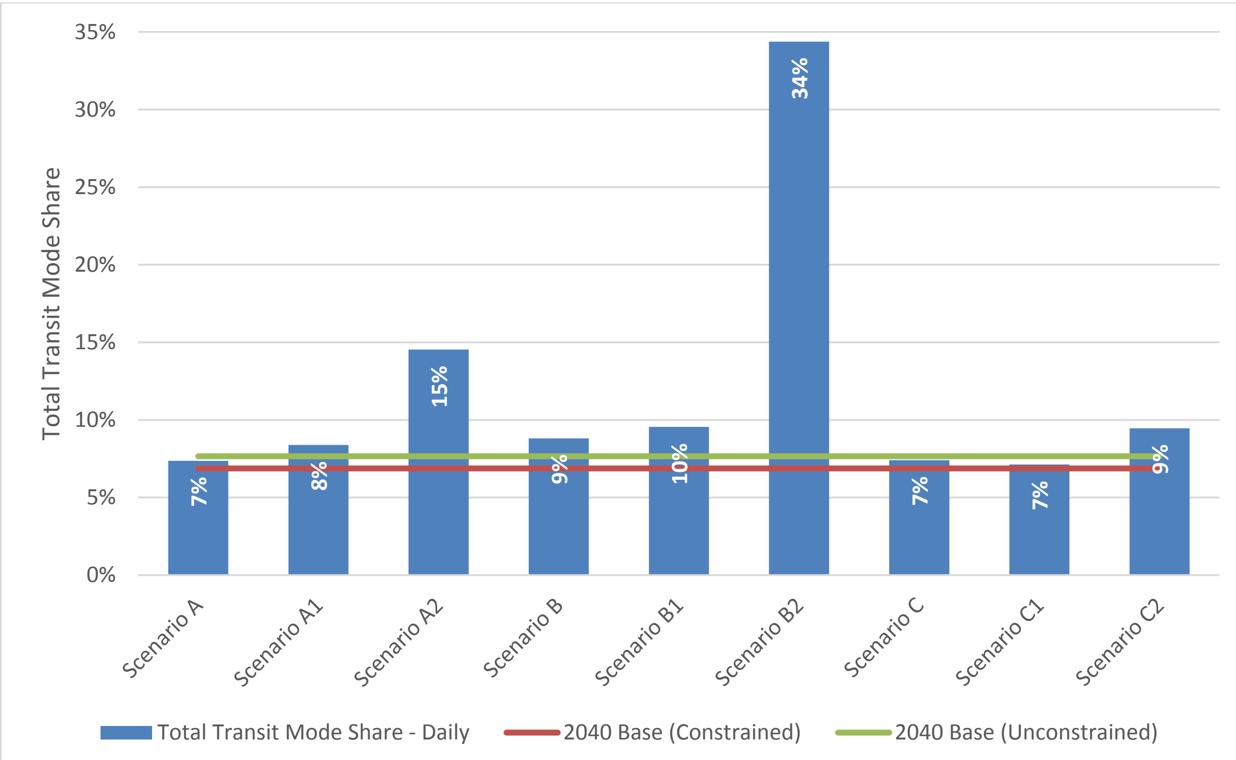


It is important to note that the number of transit boardings (both total and by mode) forecast for each of the scenarios did not consider the capacity of the transit services being provided, and only showed the overall demand given the policies and land use alternatives. As shown in the passenger load maps for MOE 4.3, the vehicles may not be able to accommodate these passenger volumes given the levels of service assumed.

3.5.8. Total Transit Mode Share (MOE 4.7)

Most scenarios saw no change or slight increases in the percentage of daily trips taken by transit, except for Scenarios B2 and A2 (see **Figure 60**). The results were similar to transit ridership trends (MOE 4.6): higher ridership led to higher mode share.

Figure 60: Total Daily Transit Mode Share



3.6. Measures of Effectiveness – Goal 5

Goal 5: Provide a financially viable and sustainable transit system that is efficient and effective for the region.

3.6.1. Transit Utilization - Passenger Miles per Seat Mile (MOE 5.1)

This MOE shows transit utilization by looking at the percentage of passenger miles on transit compared to the number of seat miles (including rail mode standee capacity). All of the scenarios except C1 increased transit utilization from the base, with the highest utilization by Scenarios B2 and A2 as shown in **Figure 61**. During the peak period, Scenarios A2 and B2 had utilization higher than 100 percent – particularly on buses, PCN, and streetcar, as shown in **Table 16**. Overall, average utilization was greater than 100 percent only for Scenario B2.

Figure 61: Peak Transit Utilization (passenger miles per seat mile)

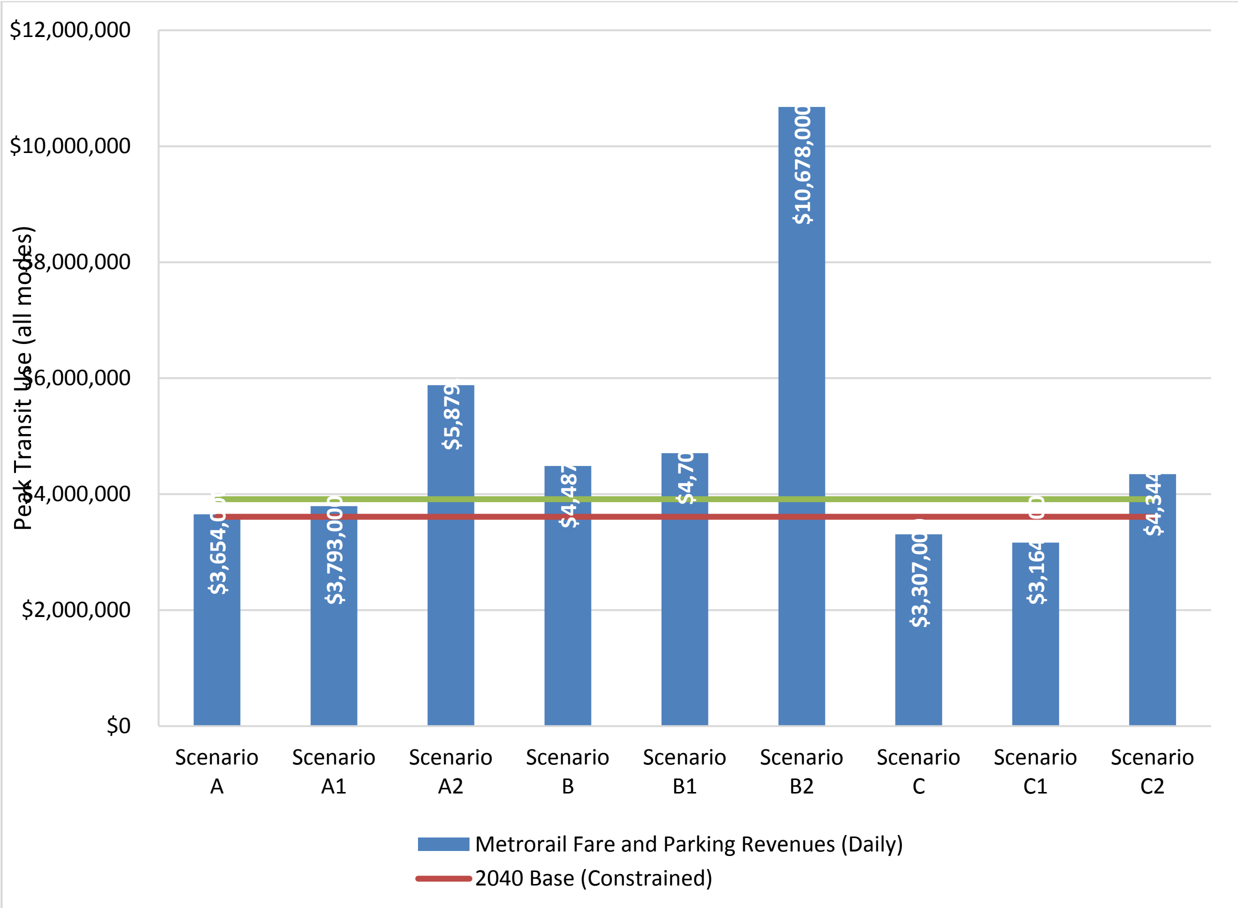


Table 16: Peak Transit Utilization by Mode (passenger miles per seat mile)

	2040 Constrained	2040 Unconstrained	A	A1	A2	B	B1	B2	C	C1	C2
Bus	60%	63%	63%	82%	116%	96%	95%	219%	63%	53%	69%
BRT	46%	49%	54%	62%	65%	56%	57%	101%	55%	52%	57%
Commuter Rail	34%	34%	35%	23%	68%	35%	36%	88%	35%	22%	47%
Metrorail	25%	29%	30%	33%	49%	35%	36%	66%	30%	28%	36%
LRT	24%	25%	27%	30%	51%	33%	34%	60%	26%	25%	35%
PCN	56%	58%	57%	66%	102%	74%	72%	170%	57%	53%	66%
Streetcar	59%	63%	65%	89%	111%	87%	90%	190%	65%	63%	70%
ALL	**34%**	**37%**	**38%**	**43%**	**66%**	**48%**	**49%**	**101%**	**38%**	**32%**	**45%**

3.6.2. Transit Peak Orientation Factor (MOE 5.2)

This MOE measures the percentage of Metrorail riders travelling in the peak period and the peak direction who cross into the Central Business District (CBD) out of total peak period Metrorail riders. The CBD boundary is defined by the following station links in the Metrorail system:

- Court House
- Pentagon City
- Waterfront
- Federal Center
- Union Station
- Mt Vernon Square
- Dupont Circle
- Rosslyn

All scenarios except the C Scenarios showed a lower peak orientation factor than the baseline scenario, as shown in **Figure 62** below. However, as shown in **Figure 63** on the following page, almost all scenarios had a higher total number of passengers traveling in the peak period in the peak direction across the cordon. These results indicate that while this peak movement increased, overall peak period ridership increased even more. The lowest peak orientation factor was for Scenario B2 – which was surprising given its land use changes and policies that emphasized the existing strong travel markets – but was mostly because the total ridership was so much higher overall.

Figure 62: Metrorail Peak Orientation Factor

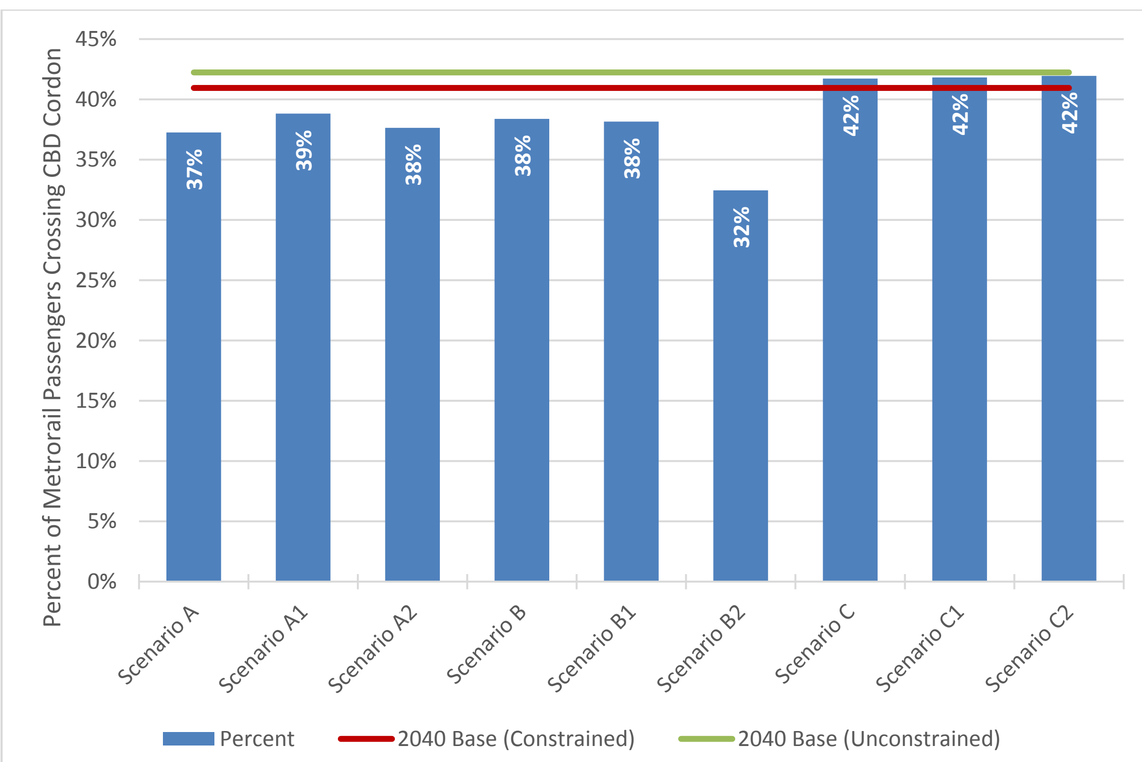
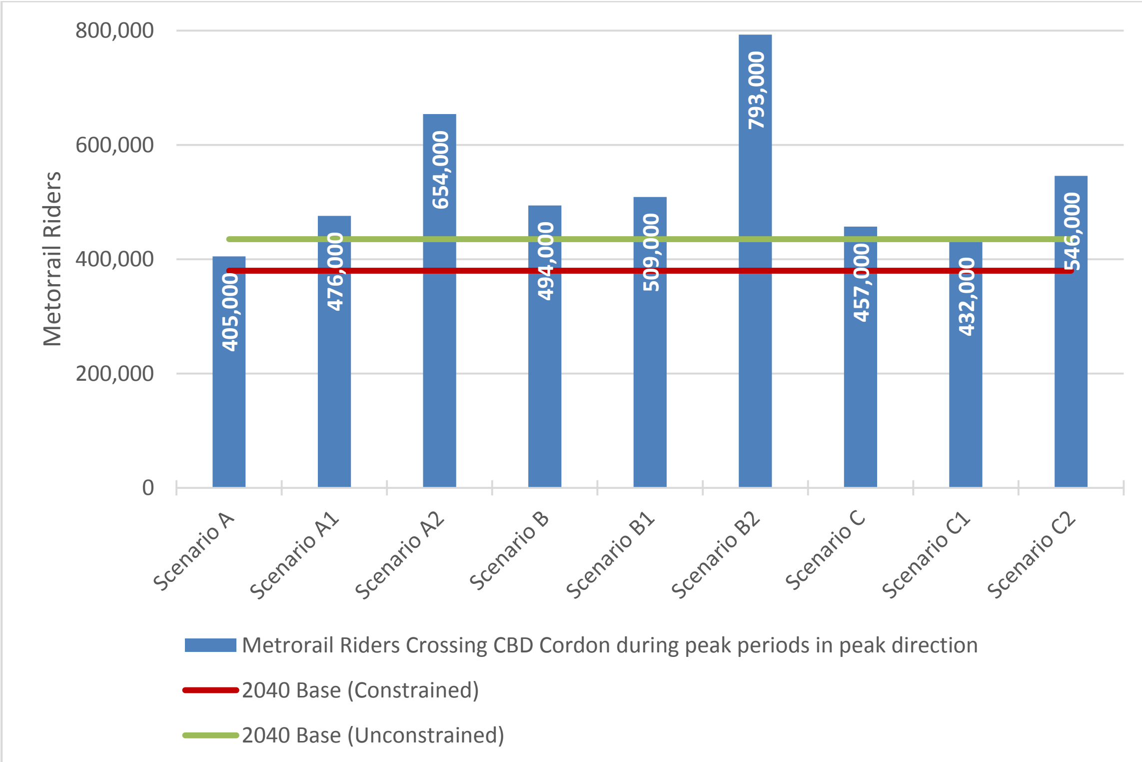


Figure 63: Metrorail Riders Crossing CBD Cordon in Peak Period/Peak Direction



3.6.3. Metrorail Operating Costs per Passenger Mile (MOE 5.3)

This MOE helps identify those scenarios that provide Metrorail service at the lowest cost per passenger mile. Because the same transit network and level of service are being operated in each scenario, the measure is directly related to the total Metrorail PMT. The lowest cost scenario was the one with the highest ridership (i.e., B2). All of the scenarios showed decreases in operating costs from the 2040 Base, and the greatest decreases were in Scenarios B2 and A2 as shown in **Figure 64**.

Figure 64: Metrorail Annual Operating Costs per Passenger Mile

3.6.4. Change in Property Tax Revenues (MOE 5.4)

This MOE, estimating the expected property tax revenue by jurisdiction for each of the land use alternatives, is based on existing differences in tax rates both between jurisdictions and inside and outside of transit station areas. Using a range of sources,[6] parcel level real estate assessment data were used to calculate the average tax assessment (per household and per employee) inside and outside of existing station areas in each jurisdiction. The resulting average tax assessments are listed in **Table 17**.

Table 17: Average Property Tax Assessments by Jurisdiction

Jurisdiction	Inside Station Area		Outside of Station Areas	
	Per HH	Per Job	Per HH	Per Job
District of Columbia	$1,018	$1,412	$3,162	$1,784
Montgomery Co.	$2,046	$458	$2,764	$364
Prince George's Co.	$1,379	$500	$1,747	$503
Arlington Co.	$4,150	$883	$4,192	$424
City of Alexandria	$3,853	$1,178	$2,687	$664
Fairfax Co.	$4,947	$1,227	$5,223	$763
Loudoun Co.*	$4,505	$1,314	$4,757	$817
Prince William Co.	N/A	N/A	$4,482	$1,524
Frederick Co.	N/A	N/A	$2,095	$462
Howard Co.	N/A	N/A	$3,032	$434
Anne Arundel Co.	N/A	N/A	$2,256	$343
Charles Co.	N/A	N/A	$2,848	$548
Carroll Co.	N/A	N/A	$2,418	$267
Calvert Co.	N/A	N/A	$2,644	$299
St Mary's Co.	N/A	N/A	$1,904	$193
King George Co.	N/A	N/A	$1,379	$73
City of Fredericksburg	N/A	N/A	$1,465	$318
Stafford Co.	N/A	N/A	$2,491	$480
Spotsylvania Co.	N/A	N/A	$1,787	$494
Fauquier Co.	N/A	N/A	$2,556	$418
Clarke Co.	N/A	N/A	$1,714	$211
Jefferson Co.	N/A	N/A	$1,714	$211

*Note: Loudoun County's current tax base does not include any parcels near existing high-capacity/high-frequency transit. However, to estimate Inside Station Area average assessments near planned Metrorail Silver Line Phase 2 stations within the county, the analysis applied the percentage difference between Inside/Outside Station Area observed within Fairfax County, its closest neighbor.

[6] Parcel level assessment data and parcel shapefiles were obtained from either the real estate assessments office or the Geographic Information Systems (GIS) department for each of the thirteen study area jurisdictions. Please see the *CGW Economic Benefits Technical Memorandum*, October 2014 for more details on the datasets and their aggregation.

Based on existing tax rates and assessed values, the property tax revenue per employee is generally higher inside the station areas compared with outside. However, there are two exceptions, the District of Columbia and Prince George's County. These two jurisdictions both have a large presence of government employees based within properties (many within transit station areas) that are exempt from local property taxes. This factor may change in the future depending on the locations of federal facilities and workforce size; however, for the purpose of this study, the MOE was calculated using existing relative assessment values assumed to continue through 2040.

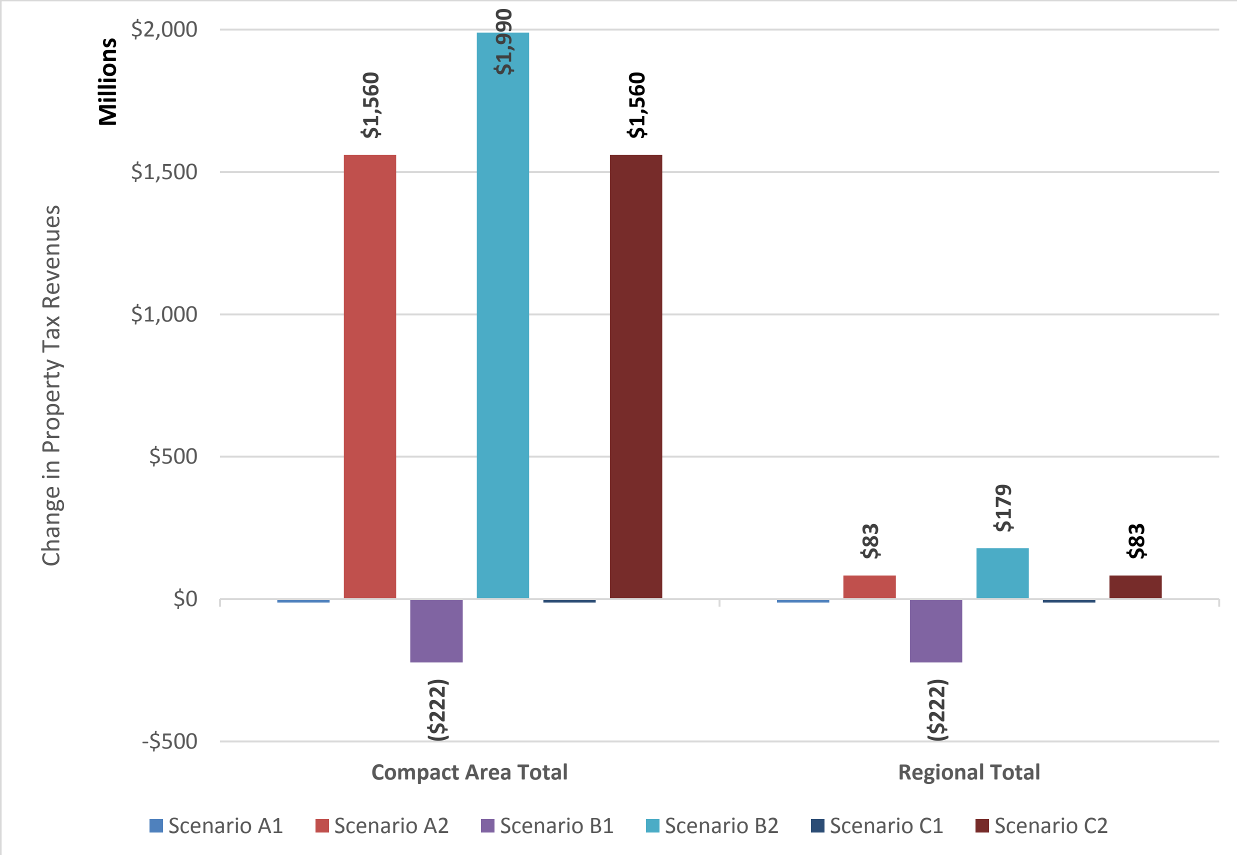
In contrast, the tax revenues per household are higher outside of the station areas in almost all of the jurisdictions (although revenue per square foot may actually be higher closer to the stations). This finding is primarily due to differences in the type and value of the housing currently located near transit stations versus away from transit stations – large, high-value housing units currently tend to be located far from high-capacity/high-frequency transit stations where land is more readily available. It is possible that the significant land use shifts in this study's scenarios (bringing a larger percentage of the region's residents closer to transit) would result in changes to the types and values of housing stock near transit stations, including the development of higher-value multi-family or townhome units. Such a change in housing stock and demand would change the results of this MOE; however, no data for these potential trends were available. Therefore, current average residential tax assessments were used in this analysis.

Due to these currently observed differences in assessed values for housing and job sites inside and outside of station areas, Scenarios A1, B1, and C1 all resulted in losses of property tax revenue in the Compact Area as households and jobs were moved inside of station areas within the same jurisdictions. Scenarios A2, B2, and C2 showed major increases in revenues for the region (due to higher tax rates in the Compact Area jurisdictions) but losses in revenues for jurisdictions outside the Compact Area, from which population and employment were shifted (see **Table 18** and **Figure 65**). The scenario most beneficial for both the region and the Compact Area was Scenario B2, which increased annual property tax revenue in the Compact Area by almost two billion dollars.

Table 18: Change in Annual Property Tax Revenues (from Base)

	Scenario A1	Scenario A2	Scenario B1	Scenario B2	Scenario C1	Scenario C2
District of Columbia	-$7,725,000	$1,264,703,000	-$252,931,000	$975,074,000	-$7,725,000	$1,264,703,000
Montgomery County	-$3,363,000	$91,759,000	-$60,062,000	$136,871,000	-$3,363,000	$91,759,000
Prince George's County	-$3,726,000	$94,225,000	-$39,114,000	-$5,063,000	-$3,726,000	$94,225,000
Arlington County	$12,000	$474,386,000	$9,013,000	$499,198,000	$12,000	$474,386,000
City of Alexandria	$479,000	$129,948,000	$51,085,000	$348,794,000	$479,000	$129,948,000
Fairfax County	-$59,000	-$360,932,000	$39,488,000	$206,056,000	-$59,000	-$360,932,000
Loudoun County	$1,924,000	-$133,927,000	$30,186,000	-$171,260,000	$1,924,000	-$133,927,000
Compact Area Total	-$12,459,000	$1,560,162,000	-$222,333,000	$1,989,670,000	-$12,459,000	$1,560,162,000
Regional Total	**-$12,459,000**	**$82,879,000**	**-$222,333,000**	**$178,595,000**	**-$12,459,000**	**$82,879,000**

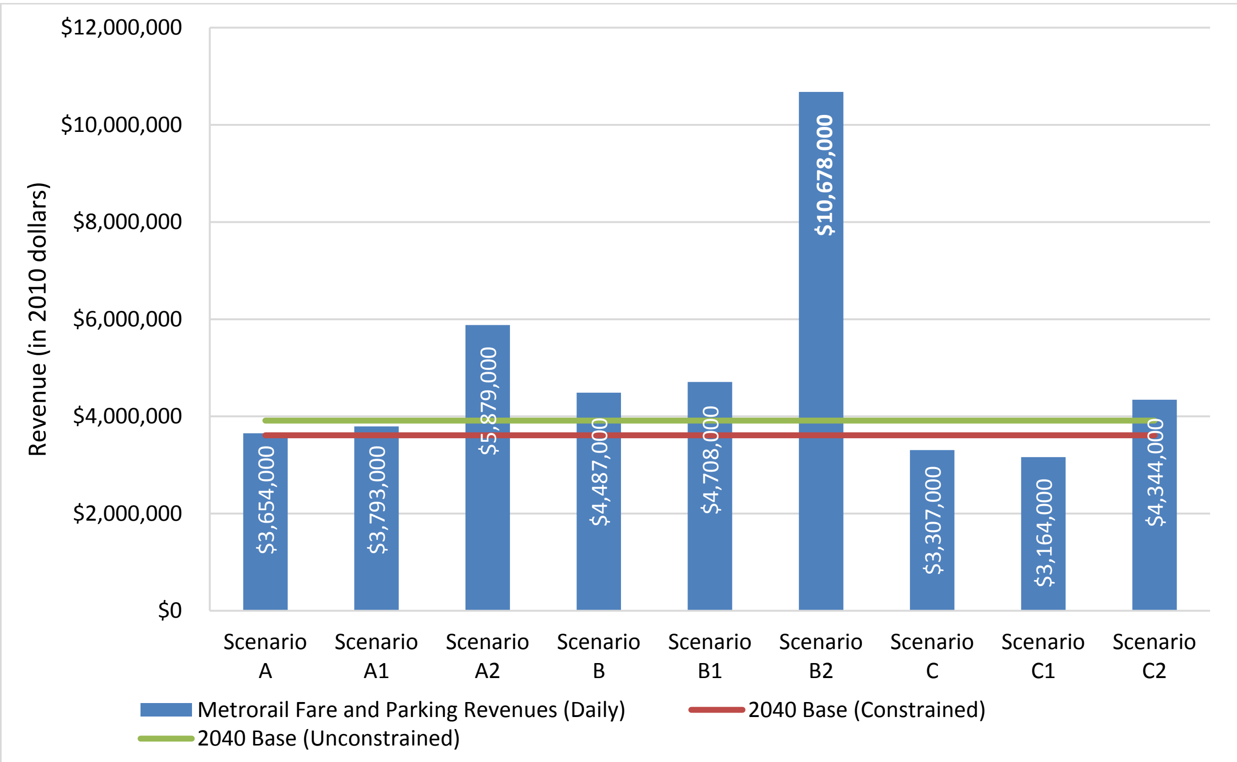
Figure 65: Change in Annual Property Tax Revenues (from base)



3.6.5. Metrorail Fare and Parking Revenues (MOE 5.5)

This MOE calculates the average weekday revenues from fares and parking fees as shown in **Figure 66**. All A and B scenarios increased daily fare revenues through a combination of increased ridership, increased Park & Ride use, and higher Metrorail fares (in the A scenarios only). The C scenarios implemented lower fares for all Metrorail trips, and the ridership increases in Scenario C prime and Scenario C1 were not enough to offset them – the total fare revenue decreased in those two scenarios.

Figure 66: Metrorail Total Daily Fare and Parking Revenues



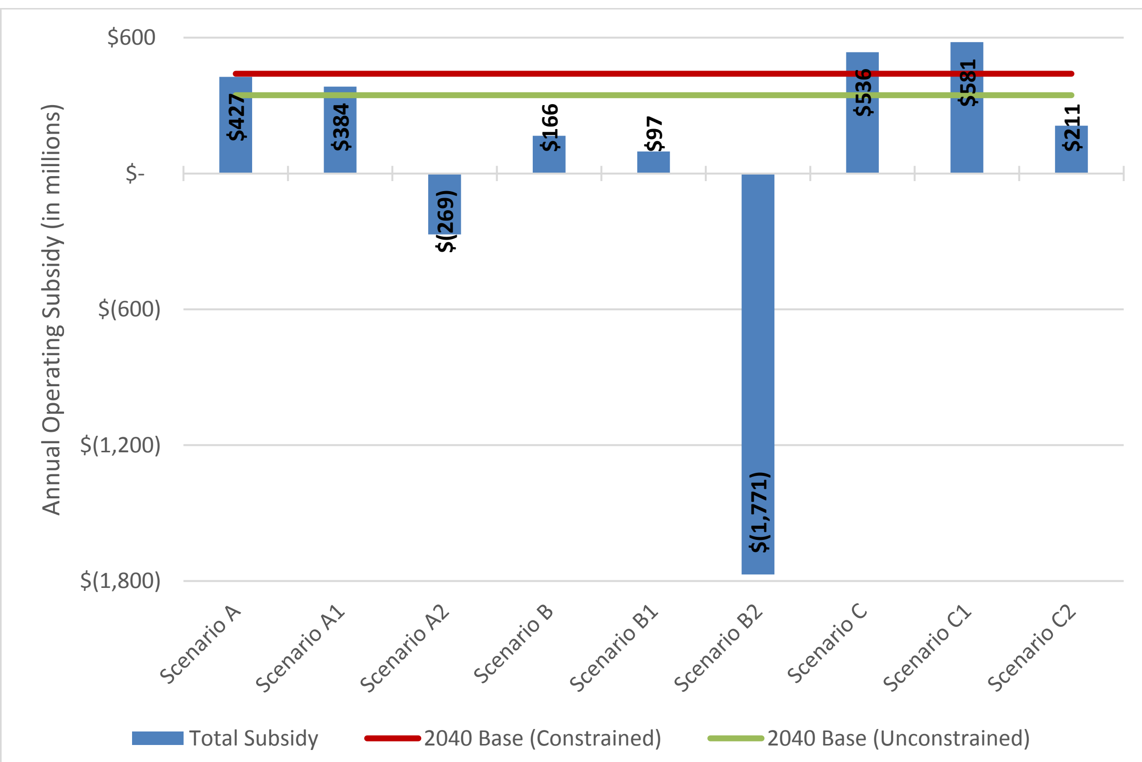
3.6.6. Metrorail Operating Subsidy (MOE 5.6)

The Metrorail Operating Subsidy is the amount of subsidy required by each jurisdiction, and is calculated using a set formula[7] based on the difference between the total operating costs and the total annual revenue. This formula incorporates four elements:

1. The maximum fare allocation: related primarily to long-distance trips subject to the "taper" and "cap" features of the Metrorail fare structure;
2. Average weekday ridership by jurisdiction of residence;
3. Number of rail stations in each jurisdiction; and
4. Density-weighted population of each jurisdiction.

As shown in **Figure 67**, Scenarios A2 and B2 removed the need for any operating subsidy and actually resulted in substantial annual profits. Although it should be noted that especially for Scenario B2 this level of ridership could not realistically be accommodated on the service being provided, and, therefore, increased costs to expand service would be necessary. Total subsidies went down for all scenarios except Scenario C prime and Scenario C1, in which fare revenues dropped due to the implementation of lower fares as part of the policy scenario.

Figure 67: Metrorail Annual Operating Subsidy



[7] More details regarding the Metrorail subsidy formula can be found here: http://www.wmata.com/about_metro/docs/Approved_FY2013_Annual_Budget.pdf#page=60

The effects varied for the individual jurisdictions though, as shown in **Table 19** – for example, Scenario A showed increased subsidies in the inner jurisdictions (DC, Arlington, and Alexandria), despite a lower total subsidy for the Compact Area as a whole. The different fare policies included in Scenario A and Scenario C resulted in different distributions of the operations subsidy across the jurisdictions.

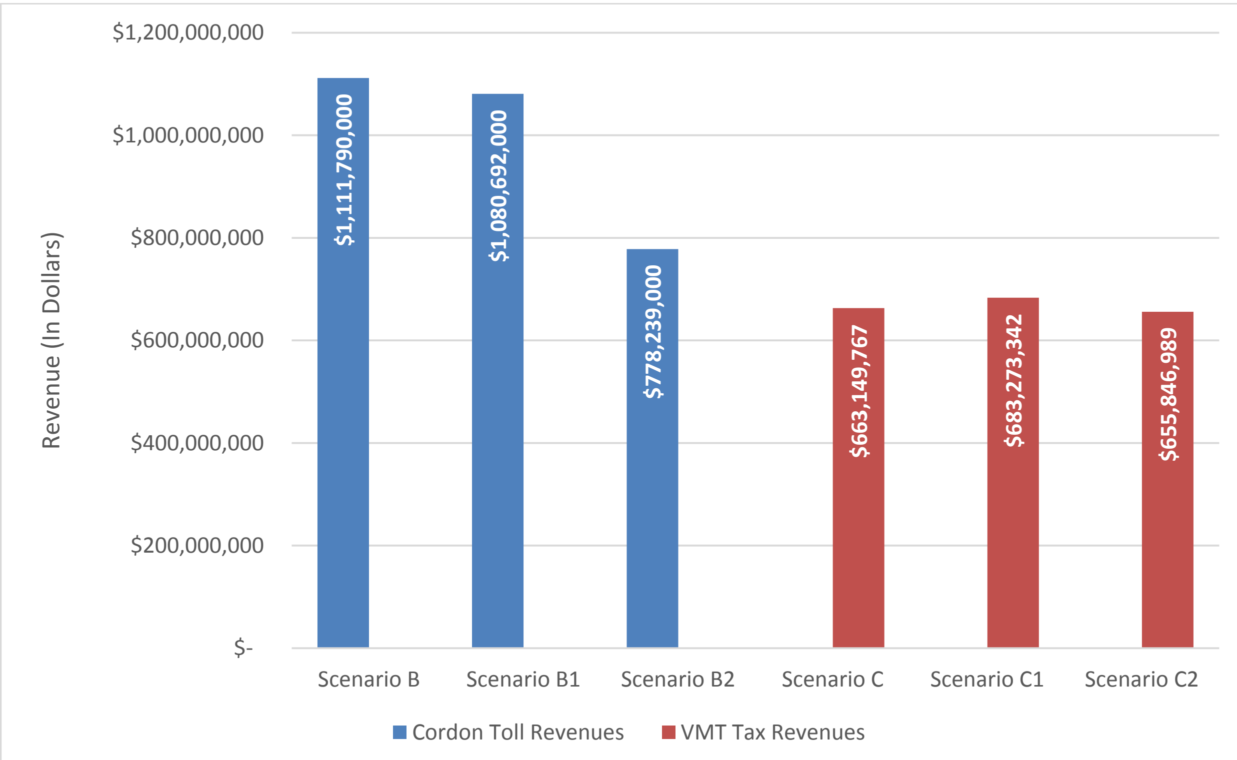
Table 19 – Annual Metrorail Operating Subsidy by Jurisdiction (in millions)

	2040 Const	2040 Unconst	A	A1	A2	B	B1	B2	C	C1	C2
District of Columbia	$138.20	$105.40	$144.70	$117.80	$0.00	$44.40	$21.90	$0.00	$169.30	$188.80	$72.70
Montgomery County	$98.60	$78.50	$90.80	$87.90	$0.00	$41.30	$24.50	$0.00	$119.80	$128.70	$41.90
Prince George's County	$61.00	$47.20	$57.70	$50.70	$0.00	$21.10	$11.50	$0.00	$74.80	$79.00	$26.50
Arlington County	$37.90	$29.10	$40.30	$33.40	$0.00	$12.70	$6.10	$0.00	$46.70	$51.40	$17.10
City of Alexandria	$14.90	$11.40	$15.00	$13.30	$0.00	$5.10	$2.60	$0.00	$18.20	$20.20	$6.80
Fairfax County	$69.60	$55.70	$64.80	$65.30	$0.00	$28.70	$18.80	$0.00	$84.20	$92.30	$32.60
Loudoun County	$20.30	$18.40	$13.80	$15.40	$0.00	$13.20	$11.70	$0.00	$23.10	$20.10	$13.40
Compact Area Total	$440.60	$345.70	$427.10	$383.80	$0.00	$166.40	$97.20	$0.00	$535.90	$580.60	$211.10

3.6.7. Congestion Toll and Vehicle Miles Traveled (VMT) Tax Revenue (MOE 5.7)

Cordon toll revenues (applied in Scenarios B, B1 and B2) and VMT tax revenues (applied in Scenarios C, C1 and C2) were compared within each scenario group (see **Figure 68**). The cordon toll raised the most revenue in the scenario without land use changes (Scenario B prime). Scenarios B1 and B2 had progressively lower volumes crossing the cordon via auto as travelers switched to transit. The VMT Tax revenues were highest in Scenario C1 as previously discussed as having the highest VMT (MOE 1.1).

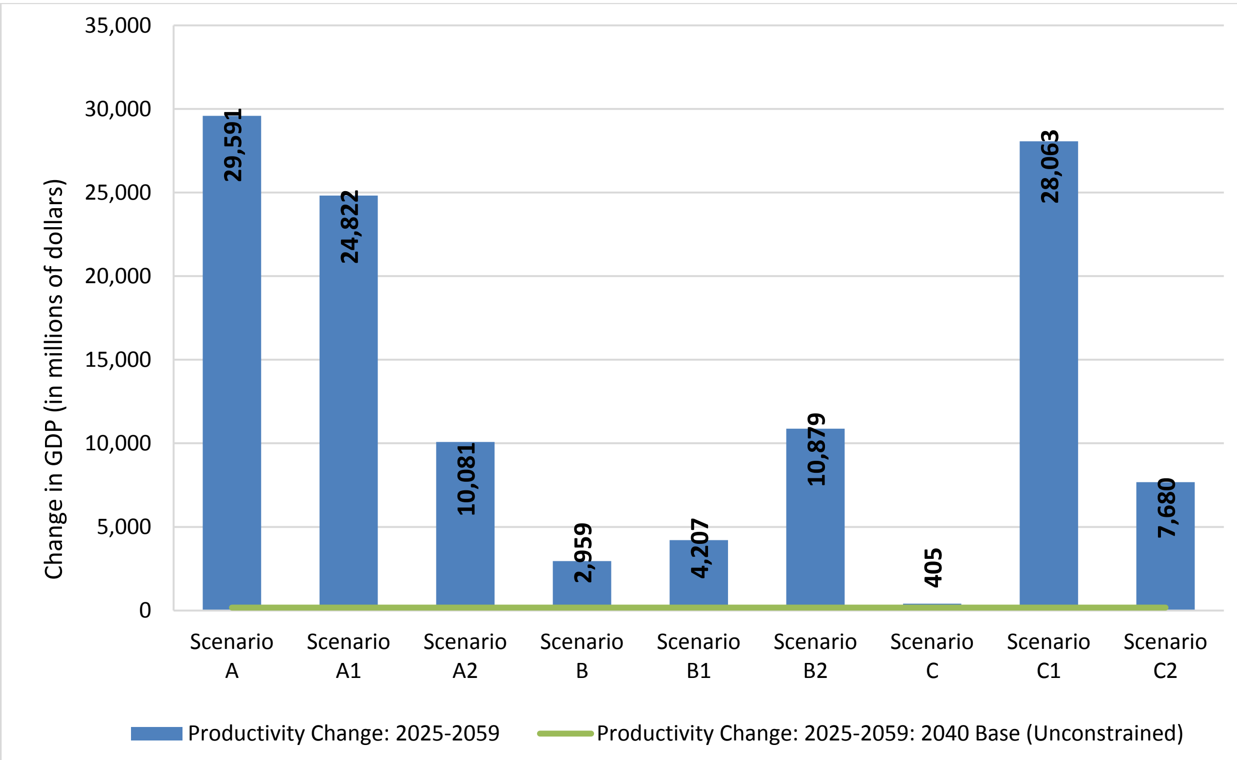
Figure 68: Projected Annual Toll and VMT Revenues



3.6.8. Lost Growth to Congestion (MOE 5.8)

This MOE looks at the lost growth due to congestion by measuring the productivity change of Gross Domestic Product (GDP) compared to the constrained 2040 Base, compounded between 2025 and 2059. The results were tied to decreases in freeway VMT. As shown in **Figure 69**, all of the scenarios decreased freeway VMT compared to the 2040 Base (even the scenarios that increased total VMT), and, therefore, all scenarios showed an increase in productivity. Scenario A had the highest productivity increase, as the most VMT was removed from the freeway system.

Figure 69: Projected Change in GDP from Constrained Base Due to Congestion (in millions)



4. Key Findings

4.1. Scenarios A, A1, and A2 – Efficient Transit

Land Use Inputs

The land use in these Scenarios was designed to encourage:

- Mixed-use development and, therefore, shorter trips; and
- Reverse commute trips within the compact area.

As a result:

- Scenario A1 only moved 35,000 households and 30,000 jobs to station areas. This shift was by far less drastic than the changes seen in A2, which moved 322,200 households and 712,300 jobs to station areas.
- A1 land use maintained all non-Compact Area land use projections, so that long distance trips in the region were still occurring at the rate projected by the 2040 Base adopted land use, contributing to high VMT/VHT and continued roadway congestion.

Key MOEs for the Scenario

MOEs used to measure success of the scenario:

- MOE 4.3: Load Factor – As shown in the load factor maps presented in Section 3.5.3, load factors increased in all of the A Scenarios, with particularly high loads along the Orange and Silver Lines in Virginia and the Yellow Line bridge between the Pentagon and L'Enfant Plaza. The land use and policy changes resulted in improvements to average Metrorail utilization throughout the system, but not nearly approaching the desired level of 100 ppc on many of the outlying or reverse-peak direction links.
- MOE 4.5: Load Deviation –
  - For Metrorail this MOE looked at how far the average peak load was from 100 ppc (over is equally as bad as under). All three A scenarios were better (lower deviation) than the baseline for Metrorail due to increased ridership on many previously underutilized links in the Metrorail system.
  - Other modes also performed better in this MOE, except for Streetcar which experienced very crowded conditions in some of the scenarios with high transit ridership. Because streetcar started off over capacity in the 2040 Base (see Figure 56), higher ridership (such as that shown in Figure 57) resulted in higher load deviations.
- MOE 5.1: Transit Utilization – Measures the passenger miles traveled on transit compared to the passenger mile capacity provided by transit. Scenario A2 had the highest utilization overall and for each individual mode, but showed some congestion on several modes during the peak period (Bus, PCN, and Streetcar).

Key Results

- Achieving purely balanced loads is difficult considering that most of the land use (existing and land use changes through 2020) is fixed. Thus, even the most aggressive land use alternative tested (Scenario A2), which shifted job and household growth across jurisdictional boundaries while limiting shifts in areas experiencing congestion on Metrorail in the Base, resulted in unbalanced loads across the system and increased congestion, as shown in Figure 40.

- Of the three A scenarios, A2 performed the best at achieving the goal of balanced ridership (based on the load deviation metric). However, A2 achieved this result by balancing underutilized segments (almost 20 percent of Metrorail links in Scenario A2 had a peak load factor less than 30 ppc) with unrealistically high loads on some links (a peak load factor of 234 ppc on the Yellow Line bridge). As it is not physically possible to fit 234 people on a Metrorail car, the average load deviation also may not be achievable.
- Considering the goal of encouraging reverse peak trips, Scenario A1 encouraged these trips along the Silver/Orange Lines, but increased volumes in both directions. Scenario A2 (which limited the land use shifts along the Silver/Orange Lines) actually showed reverse peak directional increases more evenly distributed in the region, including along the Red, Green and Blue/Yellow Lines.
- Scenario A2's high ridership levels resulted in some extreme congestion in the peak periods/peak directions. 15 segments had load factors greater than 150 ppc (including the Silver Line to Wiehle Avenue, the Orange Line to West Falls Church, and both the Yellow and Green Line river crossings). The Yellow Line bridge between the Pentagon and L'Enfant Plaza had a maximum load factor of 234 ppc.
- All A Scenarios showed higher percentage increases for Metrorail transit boardings than overall transit boardings. This result was probably due to the focus of Scenario A policies on Metrorail.
- The policies implemented in the A scenarios (tested without land use shifts in Scenario A Prime), including PEF improvements, reductions to reverse peak Metrorail fares, selected Park & Ride capacity increases, and expanded bike access distance, resulted is a 3 percent increase in overall transit boardings, with slight increases in congestion levels on the Metrorail system.

4.2. Scenarios B, B1, and B2 – Cost-Effective Transit

Land Use Inputs

In order to decrease the jurisdictional operating subsidies, the land use strategy was designed to increase ridership. Therefore, the land use changes were intended to encourage and exaggerate the existing successful transit markets, particularly the radial suburb-to-DC core market.

As a result:

- Scenario B1 shifts were a lot more substantial than A1 shifts, moving 500,000 households and 400,000 jobs to within station areas; and
- Scenario B2 moved a total of over 1 million households and 1.6 million jobs. Under Scenario B2, over 30 percent of the region's jobs were located in DC (compared to 18 percent in the 2040 Baseline land use), making DC an even more attractive commute destination than currently. The biggest population increases occurred in Arlington and Montgomery Counties.

Key MOEs for the Scenario

MOEs used to measure success of the scenario:

- MOE 5.6: Decrease or remove the operating subsidy – All three scenarios decreased the operating subsidy significantly (by a minimum of 62 percent). Scenario B2 actually made a substantial profit – although it should be noted that the number of riders could not be realistically accommodated on the services being provided at that cost.

- MOE 5.5: Fare Revenues – All revenue increases were related to ridership increases. Scenarios B and B1 actually showed a decrease in parking revenues, despite the removal of Park & Ride capacity constraints – which leads to the conclusion that the combination of policies and land use strategies in this scenario must have made non-motorized and bus access to transit more attractive options.

Key Results

- Scenario B2 attracted the most transit trips by a large margin (2.6 times 2040 Base volumes), including the highest transfers and highest load factors for most modes, and, therefore, had the lowest congestion on the roadway network (lowest VMT/VHT and highest average speed).
- However, it is important to note that the levels of congestion predicted on the Metrorail system would be unachievable (32 segments had load factors higher than 150 ppc, with a max system load factor of 253 ppc), and congested conditions throughout the transit network would be likely to discourage passengers from using the system in these overall numbers.
- All B scenarios showed higher percentage increases for overall transit trips than for Metrorail trips in particular. The policies and land use strategies in the B scenarios encouraged transit usage generally, instead of focusing on Metrorail.
- The B scenario policies discouraged vehicle trips to downtown (increased parking cost, cordon price), while the land use shifts in Scenarios B1 and B2 created more radial trips to downtown. This combination caused a drastic increase in transit usage:
    - Scenario B policies alone (B Prime) showed a 30 percent increase in transit ridership compared to the 2040 Base, and increased transit crowding as a result.
    - The Cordon Pricing scheme was one of the major drivers in this scenario, as evident in the significant transit ridership increase in the B prime scenario, compared to the A and C prime scenarios. The assumed cordon price was set at $5, but a different toll would result in different results.

4.3. Scenarios C, C1, and C2 – Maintain Travel Times

Land Use Inputs

Based on the assumption that mixed-use land use patterns would encourage shorter trips and lower congestion levels, the land use strategies were identical to those used in the A scenarios.

Key MOEs for the Scenario

MOEs used to measure success of the scenario:

- MOE 2.8: Vehicle Hours Traveled (VHT) – Scenario C2 had the lowest VHT for these scenarios, though no C scenarios had VHT lower than 2010 conditions.
- MOE 1.3: Average Travel Time – Scenario C1 had a lower average trip time than 2010 conditions, although it had a somewhat longer average trip distance. The lower travel demand included in these scenarios resulted in less congestion, allowing longer distances to be traveled in the same (or less) amount of time.

- MOE 2.5: Change in highway travel times between specific origin-destination pairs – None of the C scenarios showed a decrease in the total travel times compared to 2010, although some individual origin-destination pairs improved, especially those to/from downtown DC.
- MOE 2.9: Average Speed – No C scenarios were able to maintain the 2010 average travel speeds in the Compact Area or region as a whole, although Scenarios C and C2 performed better in specific jurisdictions.

Key Results

- Scenario C1 performed best according to the average trip length (MOE 1.3), with a shorter average trip time than the 2010 existing conditions.
- Scenario C2 performed the best in terms of maintaining speeds (highest average speed) and the total amount of time spent traveling (lowest VHT), primarily due to the higher number of transit trips and the higher numbers of non-motorized trips produced with the denser land use alternative. C2 was also able to improve travel times between four of the 13 origin-destination pairs studied.
- All of the C scenarios included policies designed to reduce the overall demand for peak-period motorized travel (TDM, non-motorized trips). These strategies helped ease congestion on the roadway network without some of the drastic ridership increases/load factors resulting from some of the B scenarios.
- Some of the Scenario C policies targeted Metrorail (e.g., Metrorail fare decrease), and, accordingly, all three C scenarios showed a higher percentage increase in trips for Metrorail than for transit overall. Scenario C1 actually showed a decrease in the total number of transit trips when compared with the 2040 Base due to decreases in overall travel demand.
- The non-land use policies in Scenario C were designed primarily to decrease peak demand for motorized travel, and also to encourage transit usage through the implementation of a VMT tax. Scenario C Prime showed a 4 percent increase in overall transit trips just through the implementation of these policies, with only limited increases in transit crowding. However, a different per-mile tax rate could drastically change these results.

5. Conclusions

Land Use and Transit Utilization

The results of testing multiple iterations of each of the Scenarios lead to the conclusion that it is not possible to use a blanket strategy of regional land use changes to increase transit ridership for specific directions and locations. The goal of Scenario A (efficient transit) was difficult to accomplish using the parameters of this study's scenario approach. Increasing population and employment densities at Metrorail and other high-capacity transit stations results in higher ridership throughout the system – in all directions – and additional crowding on Metrorail and other transit modes.

Increasing density only at specific stations may have more success in changing ridership patterns and growing ridership on underutilized lines and directions. This more targeted strategy would help to increase overall transit ridership while not exacerbating crowding. Generally though, clustering land use growth in station areas does show some promise as a potential tool for increasing transit ridership but would need to be considered carefully at station, corridor, and jurisdictional levels.

Auto Travel Pricing and Transit Ridership

Cordon Pricing produces major travel demand shifts to transit even without any land use changes. However, the $5 toll (inbound only) included in this analysis may not be the optimal cordon price. As different prices would produce different results, additional sensitivity analysis on the toll price could help determine a toll price that produces more optimal (and realistic) transit ridership levels.

The VMT tax rate selected for the C scenarios (1.1 cents/mile) was identified as a revenue-neutral tax level and may have only a limited effect on mode choice. A higher VMT tax could be applied that would encourage additional transit usage and further reduce congestion levels. Additional testing would be necessary to determine what VMT tax rate would result in success for the Scenario C goal of "maintaining travel times."