WMATA
CONNECTGREATERWASHINGTON

CGW Policy Alternatives:

Task 8
Final Report

June 2015

Washington Metropolitan Area Transit Authority

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Executive Summary

Alternative 2040 policy scenarios were developed and tested to illustrate how the various goals and objectives of *ConnectGreaterWashington* (CGW) could potentially be addressed in ways other than the new transit facilities and services recommended in the CGW 2040 plan. Issues related to these goals and objectives that are of particular interest to WMATA's member jurisdictions and its customers, which will continue or even grow more acute by 2040, include transit crowding and underutilization, Metrorail operating subsidy amounts, and traffic congestion. The study investigated regional policies, such as alternative land use patterns, improvements to station area pedestrian and bicycle access, changes in the cost of driving, and others that might better utilize the 2040 baseline transit network of existing and already planned projects to address these issues.

Scenarios Developed

The study used the same broad goals as the 2040 CGW network. The key CGW objectives for each of the goals were tailored to supporting the existing and already planned high-capacity transit corridors and station areas. Based on these objectives, the study developed three scenarios, each intended to maximize a key regional objective (or two related objectives), while supporting the broader regional goals applicable to all scenarios. Table ES-1 lists the scenarios that were selected to illustrate different objectives of interest to WMATA's member jurisdictions and its customers.

Table ES-1: Key CGW Objectives and Identified Scenarios

CGW Objectives for Policy Alternatives	Scenario
• Minimize crowding on the 2040 Baseline Transit Network • Maximize transportation system efficiency	A: Efficient Transit
• Reduce transit operating subsidy	B: Cost-Effective Transit
• Minimize travel time to/from RACs	C: Maintain Current Travel Times
• Minimize transportation-related emissions • Increase transit mode share • Enhance transit mode share to/from Regional Activity Centers (RACs) • Maximize economic and fiscal benefits of the transit network • Maximize households and employment served by high-frequency, higher-speed service	All Scenarios

The three scenarios are described in Table ES-2 on the following page, including the general approaches and the specific land use and other policy measures used for each and tested as packages.

Table ES-2: Policy Alternative Scenarios

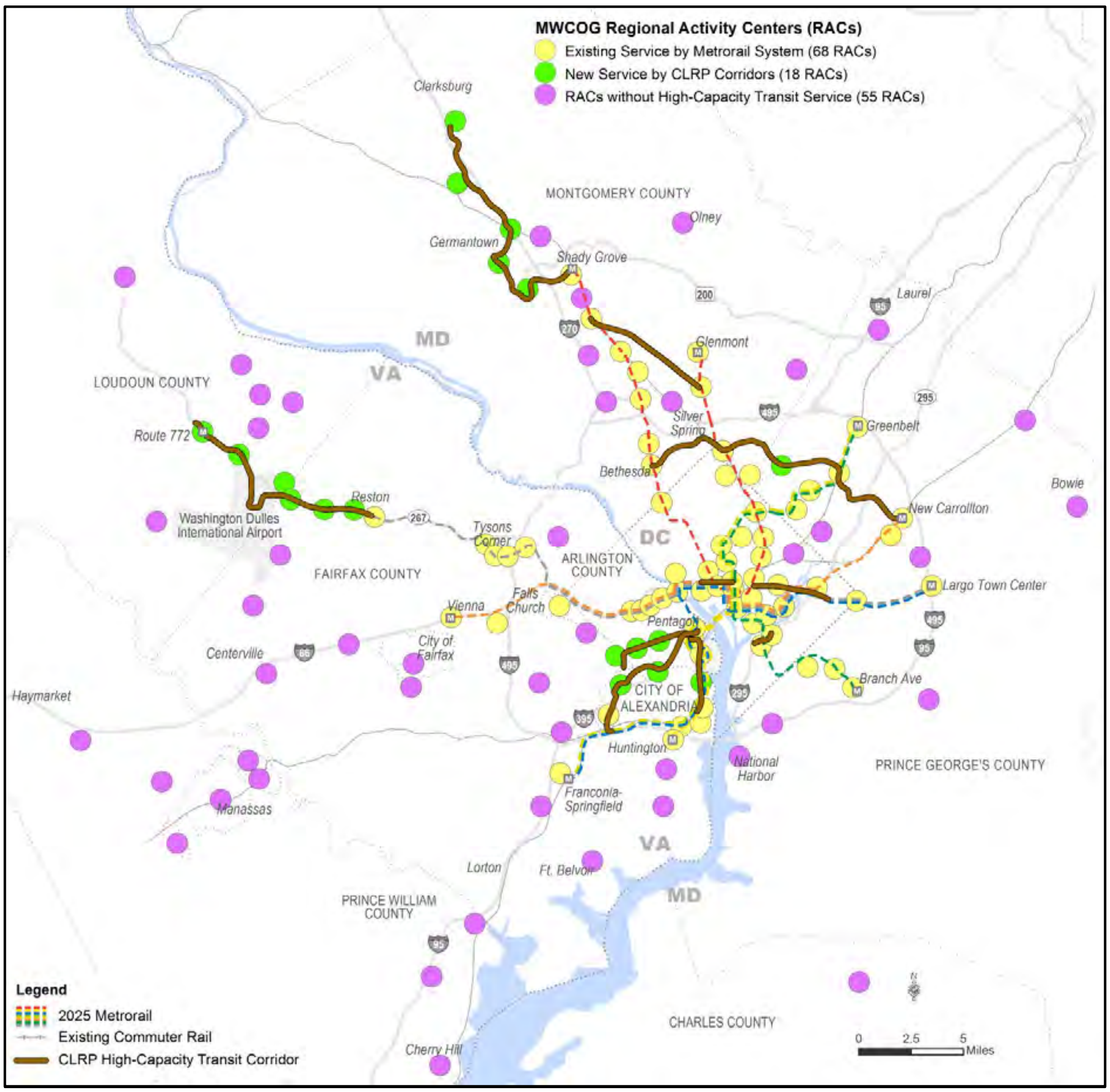
Scenario	Scenario Description	General Approaches	Specific Policies
A: Efficient Transit	Optimize use of Metrorail and other high-capacity transit systems. Intended to maintain high ridership on all links in all directions while minimizing the potential for overcrowding.	• Mixed land uses in station areas • Reverse commutes • Increased short trips on non-motorized modes	• Higher-density and more balanced mix of land uses in RACs served by high-capacity/high-frequency transit; • Enhanced station area walkability for areas with increased density; • Enhanced bicycle access to transit stations; • Lower reverse peak-direction Metrorail fares; and • Increased Park & Ride capacity on underutilized Metrorail lines.
B: Cost-Effective Transit	Designed to reduce the public subsidy required to cover the operating costs of the Metrorail system by increasing ridership and associated revenues. Did not use measures to limit crowding on transit vehicles.	• Increased transit mode share in main travel markets • More residents to station areas with strong population base • More jobs to station areas with strong job base • Increased cost of driving in main travel markets	• Higher-density land uses in RACs served by high-capacity/high-frequency transit and that are within strong transit markets; • Cordon toll for vehicles entering region's employment core; • Increased regional parking prices; • Increased Park & Ride capacity at all Metrorail Park & Ride stations over capacity in the 2040 baseline; • Enhanced station area walkability, even further than Scenario A relative to land use density; • Enhanced bicycle access to transit stations similar to Scenario A; and • Decreased transit wait times due to enhanced real-time service information.
C: Maintain Current Travel Times	Designed to maintain peak-period travel times at base year 2013 levels for transit and highway users. Intended to mitigate the increased travel times by 2040 primarily caused by increased roadway congestion.	• Travel Demand Management • Shorter trips • Increase potential for non-motorized trips	• Similar to Scenario A – higher-density and more balanced mix of land uses in RACs served by high-capacity/high-frequency transit; • Increased automobile operating costs (e.g., higher gas tax or Vehicle Miles Traveled (VMT) tax); • Increased teleworking and alternate commute hours; • Reduced all Metrorail fares by 25 percent; • Increased share of short trips by walking and biking; and • Enhanced station area walkability for areas with increased density, similar to Scenario A.
All Scenarios		• Enhanced access to transit • Enhanced access to non-motorized modes • Increased driving-related costs • Population & employment growth focused in transit station areas within RACs	

Land Use Reallocation

For the scenarios, future growth in population and employment between 2020 and 2040 was reallocated within the region from the 2040 baseline land use, the Metropolitan Washington Council of Governments (MWCOG) draft Round 8.3 Cooperative Forecast. The scenarios moved population and/or employment growth from areas outside of the MWCOG designated Regional Activity Centers (RACs) to RACs located within one mile of a high-capacity transit station. 2040 forecast regional totals for population and employment were maintained in all scenarios.

Figure ES-1 shows the region's 141 designated RACs in relation to existing and planned baseline high-capacity/high-frequency transit services by 2040. These nodes are designated by MWCOG as current or emerging nodes where the region's economic, social, institutional, and cultural activities are concentrated, and that the region has committed to support in its land use and transportation policies.

Figure ES-1: RACs Served and Unserved by High-Capacity/High-Frequency Transit



Target Densities Set by RAC Place Types – The relative mix of population and employment was reallocated based on the goals of each scenario, and the density was increased in the RACs up to the levels defined for each RAC "place type" as defined in the MWCOG report *Place + Opportunity: Strategies for Creating Great Communities and a Stronger Region* (2014). For each place type, the study identified a representative RAC with a Metrorail or other transit station and calculated its forecast 2040 total land use density (population + employment) in the 1-mile radius station area. These densities were used as the target density values for the station areas in the alternative land use scenarios according to the RAC place type.

For example, the Dunn Loring Metrorail Station is categorized by MWCOG as a Dense Mixed-Use Center; the current study selected the White Flint Metrorail station area (within a Dense Mixed-Use Center RAC) as a representative station area for that place type and calculated its 2040 forecast density at 73,600 population plus employment per square mile. Based on the representative station area, Dunn Loring was given a target density of up to 73,600 population plus employment per square mile for the policy scenarios.

Iterations of each Scenario – For each scenario, three iterations were modeled:

- Non-land use policies only; no reallocation of population or employment growth (Scenarios A, B, and C prime);
- Population and employment growth reallocated <u>within</u> jurisdictions, with non-land use policies (Scenarios A1, B1, and C1); and
- Population and employment growth reallocated <u>across</u> jurisdictions, with non-land use policies (Scenarios A2, B2, and C2).

Travel Demand Modeling

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 2040 baseline network consists of the existing transportation system plus projects in the adopted 2013 Constrained Long-Range Plan (CLRP) and Metro 2025. 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 due to previous model calibration adjustments based on that year.

The modeling allowed transit services in some runs to become extremely crowded rather than shifting passengers to other travel modes based on observed rider preferences and passenger capacities of transit vehicles. These modeling assumptions were intended to illustrate the demand resulting from the scenario policies.

Scenario Results

Table ES-3 summarizes the overall outcomes for the scenarios with fully applied land use and other policies (land use reallocation across jurisdictions with non-land use policies). Overall, the scenarios resulted in significant shifts in travel patterns with increased transit ridership, lower Metrorail operating subsidies, and lower roadway congestion, but none were able to fully resolve transit crowding while maintaining service and capacity at the 2040 Baseline level.

Table ES-3: Scenario Outcomes by Key Measures

Scenario	Reduces Metrorail Crowding	Increases Ridership along Underutilized Metrorail Lines/Directions	Increases Overall Transit Mode Share	Increases Metrorail Revenue		Maintains or Reduces Vehicle Miles and Hours Traveled	
				Reduces Operating Subsidy	Covers Entire Operating Subsidy	At/Below 2040 Base	At/Below 2010 Base
A	No	Yes	No	No	No	Yes	No
A1	No	Yes	No	No	No	No	No
A2	No	Yes*	Yes†	Yes	Yes†	Yes	Yes††
B	No	Yes	Yes	Yes	No	Yes	No
B1	No	Yes	Yes	Yes	No	Yes	No
B2	No	Yes	Yes*†	Yes*	Yes*†	Yes*	Yes*
C	No	Yes	No	No	No	Yes	No
C1	Yes*	Yes	No	No	No	No	No
C2	No	Yes	Yes	Yes	No	Yes	No

* Top performing scenario

† Some increased revenue depends on extremely high Metrorail passenger loads that would require additional service and operating costs.

†† Scenario A2 Vehicle Miles and Hours Traveled were slightly above 2010 levels (+2.5% and +0.7% above respectively), and Scenario A2 performed better than 2010 Base in other measures such as Average Travel Speed.

Note that extremely high transit passenger loads were observed in some of the scenario iterations (especially A2 and B2) and are not realistic given vehicle capacities and the likelihood of travelers to switch to other modes in such cases. However, the results are useful to illustrate the travel demand resulting from the scenario policies.

The scenario iterations that shifted land use increased the numbers of households and jobs near high-capacity/high-frequency transit (see Table ES-4 on the following page). This land use reallocation was an input to the modeling as opposed to a result, but it serves to show how land use planning and policies can affect one of the key CGW objectives, which is to increase accessibility of transit. The shift in housing and jobs into the WMATA Compact Area by Scenarios A2, B2, and C2 would also grow the Compact Area tax base, increasing property tax revenues by approximately $1.5 to $2.0 billion per year.

Table ES-4: Compact Area Households and Jobs within ½-Mile of High-Capacity/High-Frequency Transit

Scenario	2040 Baseline	A1/C1	A2/C2	B1	B2
Households					
Percent	29%	31%	38%	53%	64%
Number	614,000	648,000	946,000	1,114,000	1,697,000
Jobs					
Percent	46%	47%	54%	67%	72%
Number	1,810,000	1,841,000	2,522,000	2,606,000	3,446,000

Scenario A: Efficient Transit

Overall, Scenario A modestly increased reverse commutes – Scenario A1 and especially A2 increased reverse peak utilization of Metrorail segments above 50 passengers per car (ppc) in the core and immediately adjacent segments. However, the scenario still had strong peak directional patterns, with many outlying segments underutilized and many highly congested Metrorail segments (Scenario A2 had 15 segments with over 150 ppc), as shown in Figures ES-2 and ES-3 on the following pages.[1]

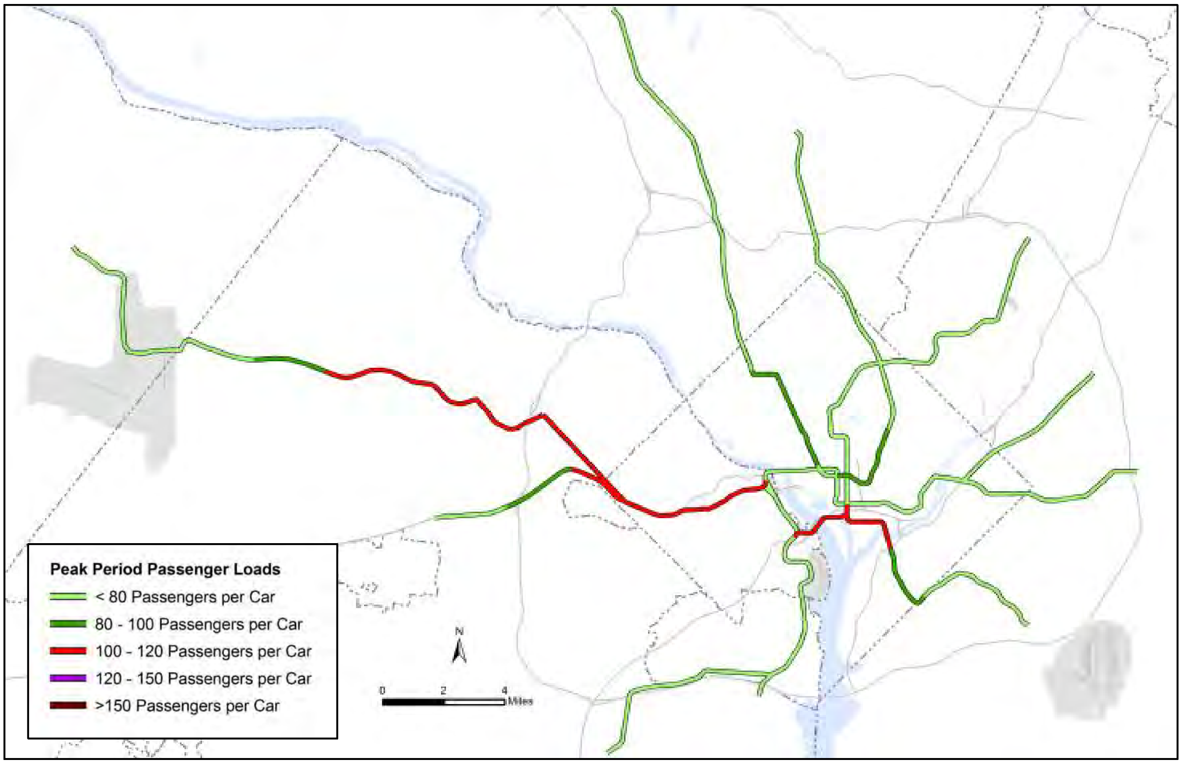
- Scenario A1 encouraged reverse peak trips along the Silver/Orange Lines, but overall volumes increased in both directions.
- Scenario A2, which limited the addition of further population and employment along the Silver and Orange Lines in Virginia, actually showed reverse peak directional increases more evenly distributed in the region, including along the Red, Green and Blue/Yellow Lines.
- Metrorail ridership increased overall – Scenario A2 had 1.74 million daily trips or a 69 percent increase above the 2040 baseline. This significantly increased ridership (if it did not result in significant crowding) would eliminate the need for the operating subsidy, even despite the 50 percent lower reverse-peak direction fares. However, in reality, these ridership and revenue levels depend on extremely high Metrorail passenger loads that would require additional service and operating costs to accommodate them.
- Ridership of other transit modes increased by a lower percentage than Metrorail due to the scenario's relative focus on Metrorail compared to other modes.

The significant increase in transit ridership and decrease in total vehicle miles traveled (VMT) (not just per capita VMT) under Scenario A2 is notable in that it was achieved without increasing driving costs ("sticks"), instead focusing on improving access to transit through land use and non-motorized modes ("carrots").

[1] Note that the 2040 Baseline Metrorail network includes the Blue Line split at Arlington Cemetery. The existing line segment north of Arlington Cemetery through Rosslyn to Foggy Bottom has higher demand than the stub service to the second Rosslyn station and carries higher passenger loads.

Figure ES-2: Scenario A – Metrorail Utilization, Peak Direction

2040 Baseline



Scenario A2

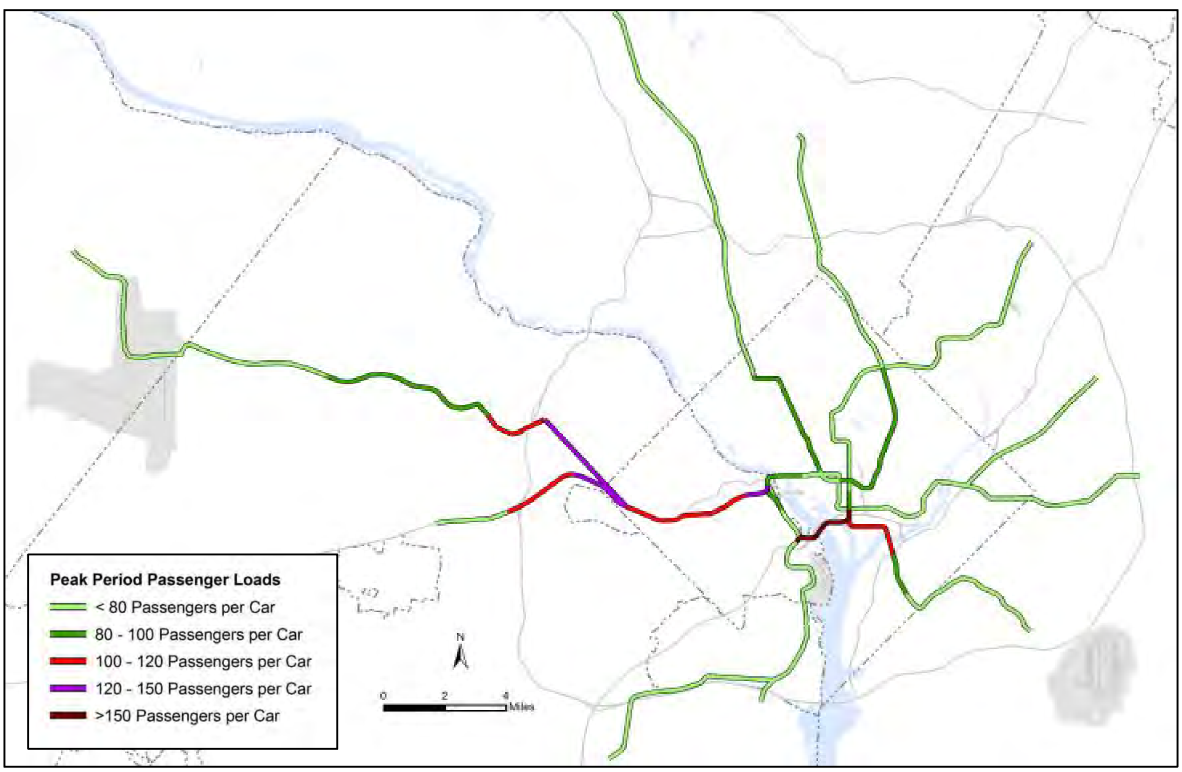
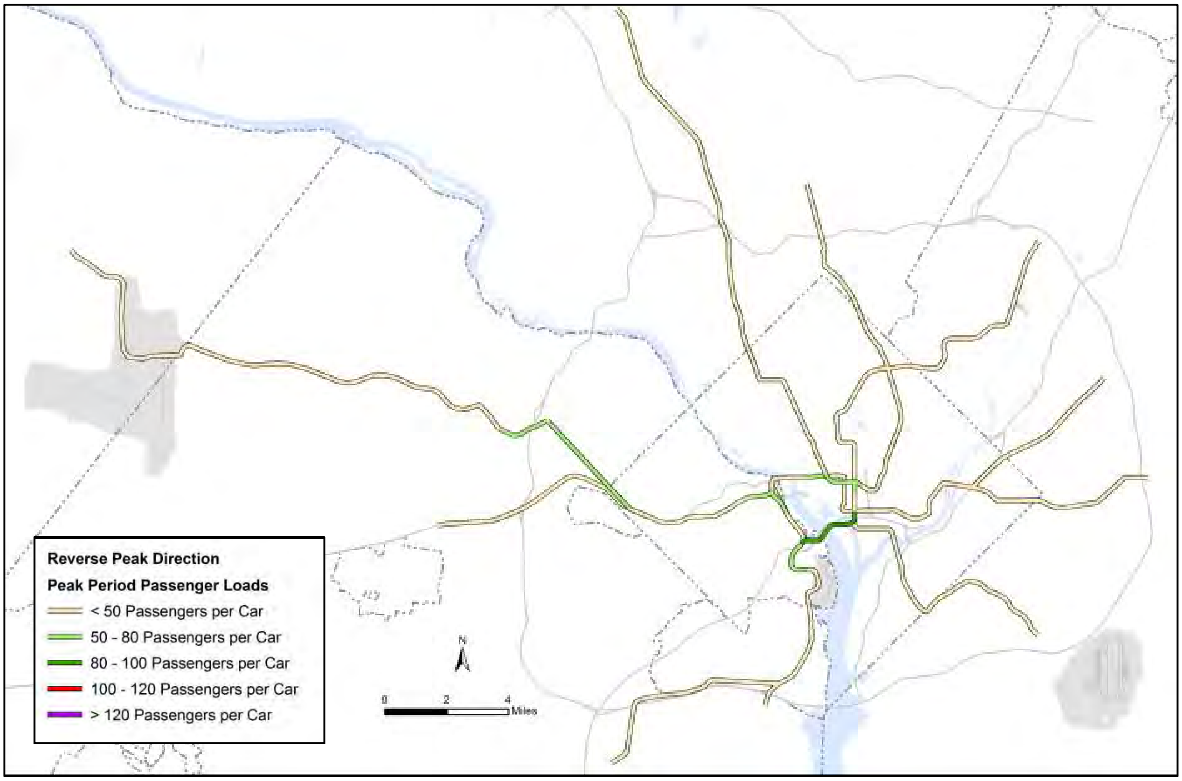
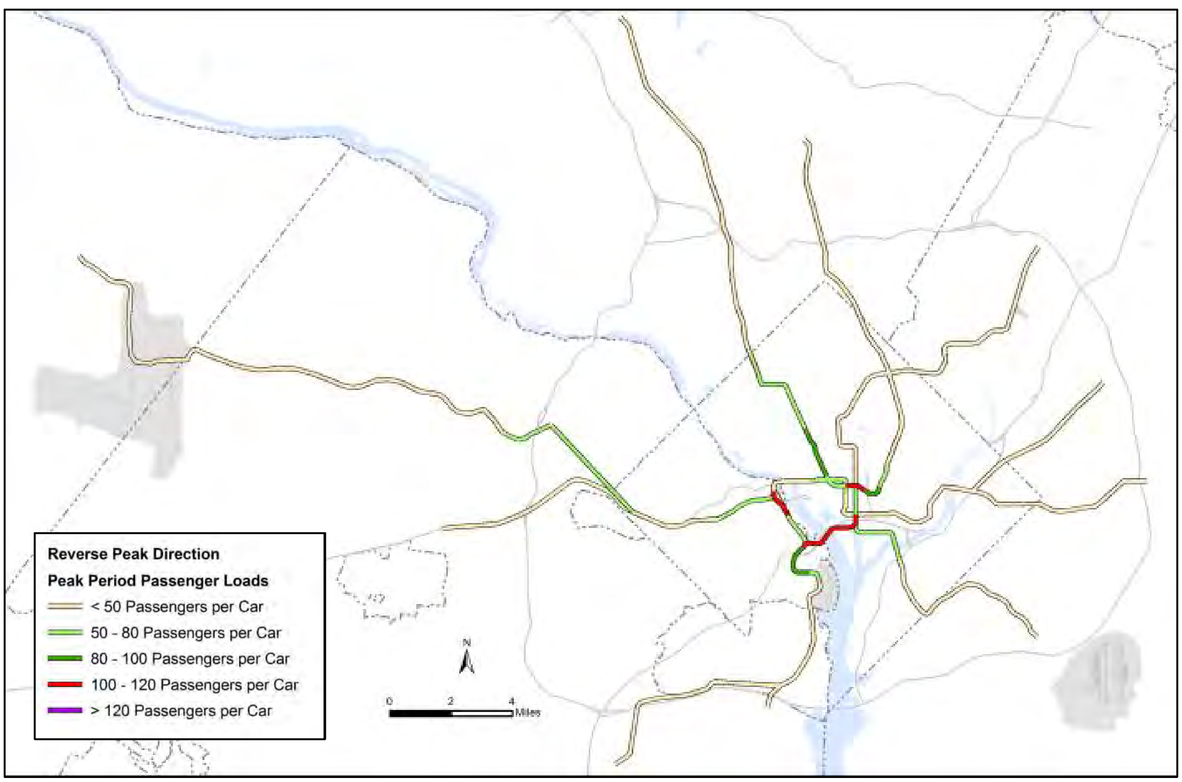


Figure ES-3: Scenario A – Metrorail Utilization – Reverse Peak Direction

2040 Baseline



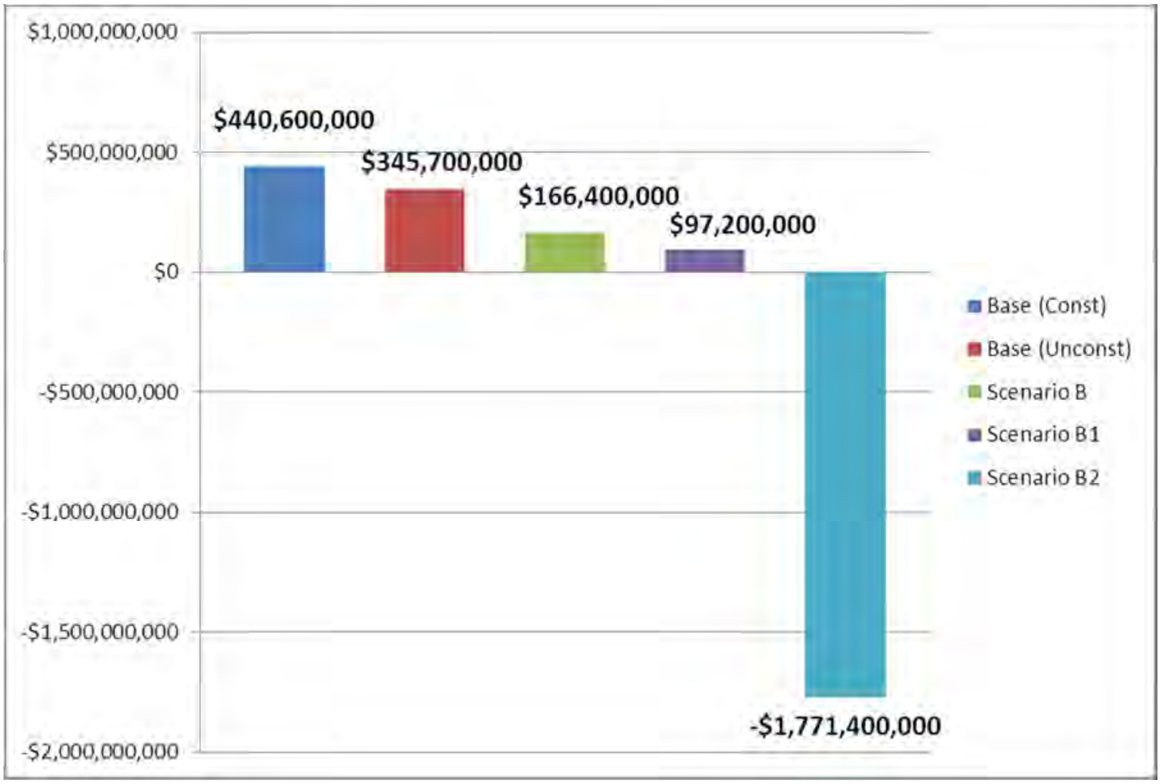
Scenario A2



Scenario B: Cost-Effective Transit

All three of the Scenario B iterations decreased the Metrorail operating subsidy by 62 percent or greater, resulting from higher Metrorail revenues (the cordon toll was designed to be revenue neutral and was not applied to Metrorail), as shown in Figure ES-4. However, the ridership and revenues assume that the baseline Metrorail service levels could accommodate up to 3 million more riders per day.

Figure ES-4: Effect of Scenario B on Metrorail Operating Subsidy



Note: Subsidy amounts are in year of expenditure dollars for 2040.

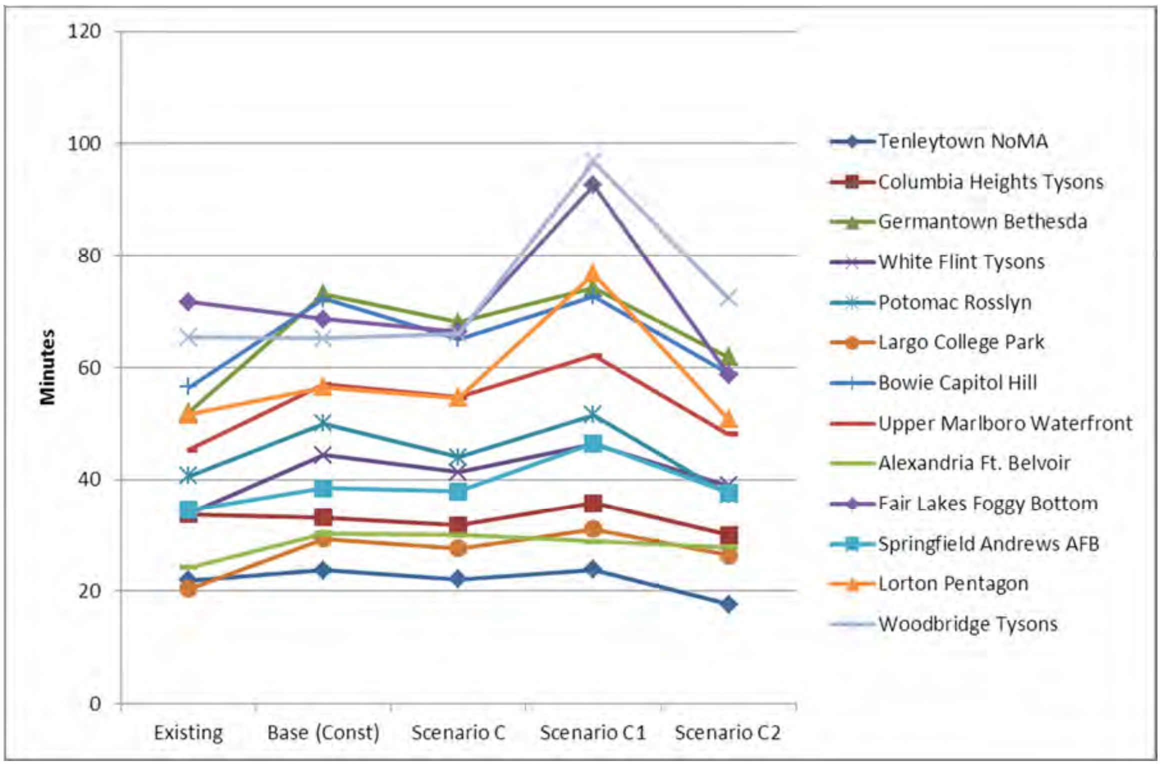
- Scenario B2 would eliminate the need for a Metrorail operating subsidy, but at a cost of unrealistic crowding (32 segments had load factors higher than 150 ppc).
- Scenarios B prime and B1 would significantly reduce the operating subsidy. Although these scenarios also had high Metrorail crowding (multiple segments over 120 ppc compared to none in the Baseline).
- The B scenario policies discouraged vehicle trips to downtown (increased parking cost, cordon price), while the land use reallocation created more radial transit trips to downtown. This combination caused a drastic increase in transit usage (34 percent mode share under B2 compared to the 8 percent baseline transit mode share). As a result, B2 had a higher percentage increase in overall transit usage compared to Metrorail boardings, with a threefold increase in transit boardings compared to the 2040 baseline.

A notable finding of Scenario B is that auto pricing strategies by themselves (B prime) and reallocating land use just within jurisdictions (B1) can have major effects on transit use and operating subsidies.

Scenario C: Maintain Current Travel Times

Scenario C prime and C2 were able to lower regional VMT and Vehicle Hours Traveled (VHT) below 2040 Baseline levels (1.9 percent and 6.4 percent decreases, respectively, in Scenario C2) but not below 2010 levels, as significant growth in population and employment needs to be accommodated in the region between now and 2040. Though for some key regional Origin-Destination pairs, travel times decreased slightly below 2010 levels, especially under Scenario C2 for radial trips to the Core (e.g., Fair Lakes, Fairfax County to Foggy Bottom, DC), as shown in Figure ES-5.

Figure ES-5: Effect of Scenario C on Auto Travel Times for Key Regional Origin-Destination Pairs



- Scenario C1's reallocation of land use only within individual Compact Area jurisdictions, without regional reallocation, actually worsened overall regional roadway congestion (8 percent higher congested auto person miles of travel) and increased VMT (2.2 percent higher) compared to the Baseline (with similar results in Scenario A1).
- Scenario C had policies designed to reduce the overall demand for peak-period motorized travel (teleworking, alternate work hours, non-motorized trips), and these strategies helped ease congestion on the roadway network without some of the drastic transit crowding resulting in Scenario B.

- Scenario C1 had fewer congested Metrorail segments than the 2040 Baseline because it reduced overall Metrorail ridership, while C2 increased Metrorail ridership and crowding above the 2040 Baseline (three segments had load factors over 150 ppc).
- Conversely, transit mode share largely did not benefit from the Scenario C policies, as the VMT tax was spread evenly across the region, rather than focusing on areas with competitive transit options that could attract drivers.

Conclusions

The policy alternatives showed that land use and mobility/accessibility policies can have significant results on transit utilization and performance of the transit system and overall transportation system. However, in a region expected to continue growing in population and employment, some capacity improvements to the transit network would also be needed to address forecast transit crowding and Metrorail core capacity limitations. That said, changes in land use decisions while adding pricing strategies could provide the region with the necessary funds to make expansion possible.

Land Use Findings

Achieving purely balanced passenger loads is difficult considering that most of the land use (existing and land use changes through 2020) is fixed. Increasing population and employment densities generally across the Metrorail and other high-capacity transit stations across the region results in higher ridership throughout the system – in all directions. The scenarios showed how effective land use combined with walkability can be in fostering ridership. Scenario A in particular showed that transit usage can increase significantly through land use policies and improved walking and biking access alone (carrots), even without increases in the cost of driving (sticks). However, the general increase in ridership results in additional crowding on Metrorail and other transit modes, unless additional capacity is provided.

Shifting population and employment growth across jurisdictions was needed to see noticeably higher utilization of Metrorail lines on the east side of the region and in reverse peak-direction trips (Scenario A2). However, these greater overall shifts in population and employment towards transit station areas, compared to just shifting land use within jurisdictions (Scenario A1) also resulted in higher crowding on already crowded Metrorail segments. Shifting population and employment growth only within jurisdictions (Scenarios A1, B1, and C2) was also unable to address long-distance driving commutes from outer suburban locations and these scenarios actually had higher total VMT unless significant driving policies were included, such as the cordon pricing in Scenario B1.

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. However, currently strong travel markets, such as the Orange and Silver Line corridor will remain in high demand and continue to experience congestion without additional capacity, even if future growth in population and employment is more evenly balanced across the region.

MWCOG's designated place types for the RACs served as useful guidelines for shifting land use in a manner consistent with broad regional goals and local visions for their activity centers and station areas. However, these place types also limited the amounts of population and employment that could be reallocated to reduce the spatial mismatch in housing and jobs.

Travel Policy Findings

Non-land use travel policies also showed the potential to significantly affect the transit and overall transportation system performance. Some of the limited policy changes, such as those in Scenario A prime, had very limited effects, but others (Scenarios B and C prime) that included more significant measures, such as cordon pricing and teleworking, had noticeable effects on regional travel patterns.

Cordon pricing produced major travel demand shifts to transit even without any land use changes. A $5 toll (inbound only) was assumed in this analysis and a more optimal charge could be identified depending on the desired outcome and transit ridership levels.

Similarly, the VMT tax rate selected for the C scenarios (1.1 cent/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.

In addition, the policies designed to reduce the overall demand for peak-period motorized travel (teleworking, alternate work hours, non-motorized trips) can help ease congestion on the roadway network without necessarily adding to transit crowding. These policies also reduce Metrorail ridership and revenue as well as auto travel, so their effects on the transit system would need to be considered in addition to their recognized benefits in managing roadway congestion.

1.0 Introduction

Alternative 2040 policy scenarios were developed and tested to illustrate how the various goals and objectives of *ConnectGreaterWashington* (CGW) could potentially be addressed in ways other than the new transit facilities and services recommended in the CGW 2040 plan. Issues related to these goals and objectives that are of particular interest to WMATA's member jurisdictions and its customers, which will continue or even grow more acute by 2040, include:

- Transit crowding and underutilization – In 2040, even with all eight-car trains in the peak periods, 15 percent of Metrorail links in the peak direction will have over 100 passengers per car, even while other links will remain underutilized.
- Metrorail operating subsidy – Although Metrorail revenues cover nearly 80 percent of its operating costs, the system still requires a large annual subsidy from member jurisdictions. The FY2015 estimated operating subsidy is $238 million, which is forecast to grow to up to $440 million (current year dollars) by 2040 as a result of expanded system operations.
- Traffic congestion – Daily vehicle miles traveled on the WMATA Compact Area's roadways will increase by 14 percent overall and by 21 percent during the peak periods by 2040. As a result, average travel speeds will decrease by 6 percent overall during that time period.

Based on these key issues, the three scenarios selected were:

- Scenario A: Efficient Transit
- Scenario B: Cost-Effective Transit
- Scenario C: Maintain Current Travel Times

This final report of the CGW Policy Alternatives study summarizes the land use and other policy strategies developed for each scenario, the methodology for modeling the scenarios, the evaluation results, and the overall study findings.

1.1. Study Purpose

The purpose of the Policy Alternatives study was to ask the question of how different policy decisions, such as alternative land use patterns, changes in the cost of driving, and other regional policies, might better utilize the 2040 baseline transit network. The 2040 baseline transit network is defined as the existing system plus the Constrained Long-Range Plan (CLRP) projects and Metro 2025 projects. The project tested various scenarios above and beyond the region's adopted cooperative land use forecast to determine how the region's transit system, as well as the overall transportation network, might achieve similar goals as the 2040 CGW plan. The study was not intended to identify an optimal land use, rather to develop different policy alternatives for comparison with the capital improvements of the 2040 CGW network, informing discussion of the opportunities and limitations of each approach.

2040 CGW Network

The final 2040 transit network identified by the CGW plan, referred to as the Region's Transit System Plan (RTSP), considered a single land use forecast, the Metropolitan Washington Council of Governments (MWCOG) Round 8.2 Cooperative Forecast, and assumed the continuation existing transportation policies and relative costs in the region. For example, the number and type of tolled roadways in the region, the average cost of parking relative to land use density, transit fare structures, and pedestrian/bicycle accessibility relative to land use density were assumed to be similar to today's conditions. The CGW planning process for the RTSP held the land use and cost/accessibility of travel options fixed and varied the transit network, testing strategies for new transit facilities and services and combining transit strategies into alternative scenarios.

Alternate Approach –2040 Land Use and Policy Alternatives

The Policy Alternatives study uses the alternate approach of holding the transit network fixed while varying the land use and cost/accessibility of travel. The goal was to investigate how the 2040 baseline transit network can accommodate the region's expected growth through changes to land use densities, locations of growth, and policies to facilitate mobility and accessibility, in contrast to building additional new transit capacity.

Outcomes of the Two Approaches

The outcome of this work is being used to engage the public and local jurisdiction decision-makers in the connections between transportation and land use.

- One anticipated outcome of this work is the ability to illustrate for local jurisdictions how their land use and other policy decisions affect the performance of their transit services, their operating subsidy to WMATA, and overall mobility and accessibility in the region – and also how those policies help support the region's priority activity centers.
- Another outcome is to illustrate what policies by themselves can achieve and the degree to which new transit investments will be needed regardless of the region's future growth patterns and policies for mobility and accessibility.

The scenario study is intended to complement the 2040 CGW plan and assist the regional conversations during its public involvement phase and implementation.

1.2. Study Goals and Objectives

The study used the same broad goals as the 2040 CGW network (see Table 1). These goals are also supportive of the MWCOG Region Forward goals. However, the specific objectives for each of the goals were tailored to the policy questions of interest, focused on supporting the existing and already planned high-capacity transit corridors and station areas.

Table 1: CGW Goals and Policy Analysis Objectives

CGW Regional Goals	Key Objectives for CGW Policy Alternatives
1. Enhance environmental quality, improve energy efficiency, and protect human health and safety	• Minimize transportation-related emissions • Maximize transportation system efficiency
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) • Minimize travel time to/from RACs
3. Maximize availability of and convenient access to integrated transit choices	• Maximize households and employment served by high-frequency, higher-speed service
4. Provide a high-quality transit system that accommodates and encourages future ridership growth (*on the 2040 Baseline Transit Network*)	• Minimize crowding on the 2040 Baseline Transit Network • Increase transit mode share
5. Provide a financially viable and sustainable transit system that is efficient and effective for the region	• Reduce transit operating subsidy • Maximize economic and fiscal benefits of the transit network

1.3. Scenarios Identified

The study developed three scenarios, each intended to maximize a key regional objective or related objectives, while supporting the broader regional goals. Table 2 on the following page lists the scenarios that were selected to illustrate different objectives of interest to WMATA's member jurisdictions and its customers. The remaining objectives were intended to be supported by all three scenarios.

Table 2: CGW Objectives and Identified Scenarios

CGW Objectives	Scenario	Description
• Minimize crowding on the 2040 Baseline Transit Network • Maximize transportation system efficiency	A: Efficient Transit	Focuses on policy changes that will optimize the use of Metrorail and other high-capacity transit systems. The scenario is intended to maintain high ridership on all links in all directions while minimizing the potential for overcrowding.
• Reduce transit operating subsidy	B: Cost-Effective Transit	Includes policies designed to reduce the public subsidy required to cover the operating costs of the Metrorail system by increasing ridership and associated revenues.
• Minimize travel time to/from RACs	C: Maintain Current Travel Times	Includes policies designed to maintain peak-period travel times at base year 2013 levels for transit and highway users. The increases in travel times seen in the 2040 Baseline conditions are primarily caused by increased roadway congestion
• Minimize transportation-related emissions (as estimated by reductions in vehicle miles traveled) • Increase transit mode share • Enhance transit mode share to/from Regional Activity Centers (RACs) • Maximize economic and fiscal benefits of the transit network • Maximize households and employment served by high-frequency, higher-speed service	All Scenarios	Intended to achieve specific objective of each scenario while also supporting broader CGW objectives of supporting RACs, facilitating mobility by transit and non-motorized modes, and enhancing access to transit.

1.4. Report Organization

The report is organized as follows:

- Section 2: 2040 Baseline Conditions – summarizes the forecast demographic and travel conditions that inform the development of the scenarios;
- Section 3: Scenario Development and Modeling Methodology – describes the detailed policies, land use strategies, and modeling methodology used for the scenarios;
- Section 4: Scenario Results and Findings – summarizes the results of the scenarios with regard to their objectives and the measures of effectiveness (MOEs) used to evaluated them;
- Section 5: Stakeholder Engagement – summarizes the study's stakeholder engagement activities and the feedback provided; and
- Section 6: Conclusion – states the key findings of the study.

2.0 Baseline Conditions

This section summarizes forecast 2040 baseline conditions for the:

- Transit network
- Demographics
- Metrorail ridership and crowding

This assessment of future conditions informed the development of the Policy Alternatives scenarios and also served as a baseline against which to evaluated the performance of the scenario strategies. Baseline population and employment forecasts were based on MWCOG's Round 8.3 Land Use Forecast. The CGW Study Area corresponds to the MWCOG travel demand model and land use forecast area.

Forecast population and employment growth occurring between 2020 and 2040 is highlighted, due to its relevance for the policy scenarios. Growth occurring in the short-term between 2015 and 2020 is expected to largely occur within already planned or approved developments and would not be significantly affected by new land use policies, such as those used in each of the scenarios.

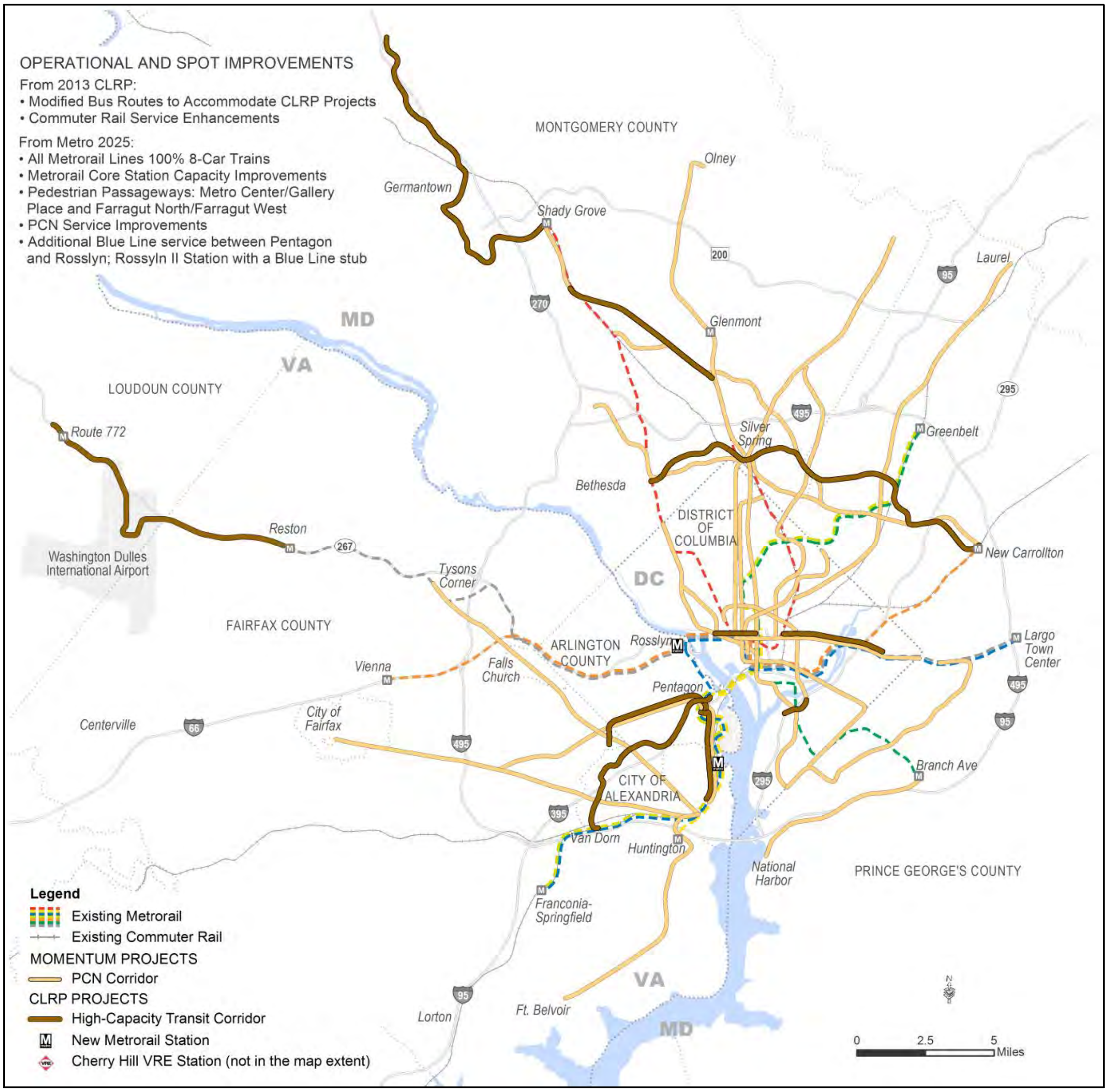
2.1. 2040 Baseline Transit Network

Planned Transit Projects and Service Enhancements

The Policy Alternative scenarios used the 2040 Baseline Transit Network, similar to the Baseline referenced in the CGW Final Report. The 2040 Baseline Transit Network consists of existing and planned improvements as documented in the region's adopted 2013 Constrained Long-Range Transportation Plan (CLRP) for the year 2040 and WMATA's Metro 2025 improvements documented in the 2013 *Momentum* strategic plan.

The 2040 Baseline Transit Network incorporates the planned transit elements shown in Figure 1 on the following page. Detailed operating plans are documented in the *RTSP Round 3 Scenario Evaluation Technical Memorandum*.

Figure 1: 2040 Baseline Transit Network



High-Capacity/High-Frequency Transit Modes

The Policy Alternatives Scenarios focused on supporting the high-capacity and high-frequency transit modes in the Baseline Network:

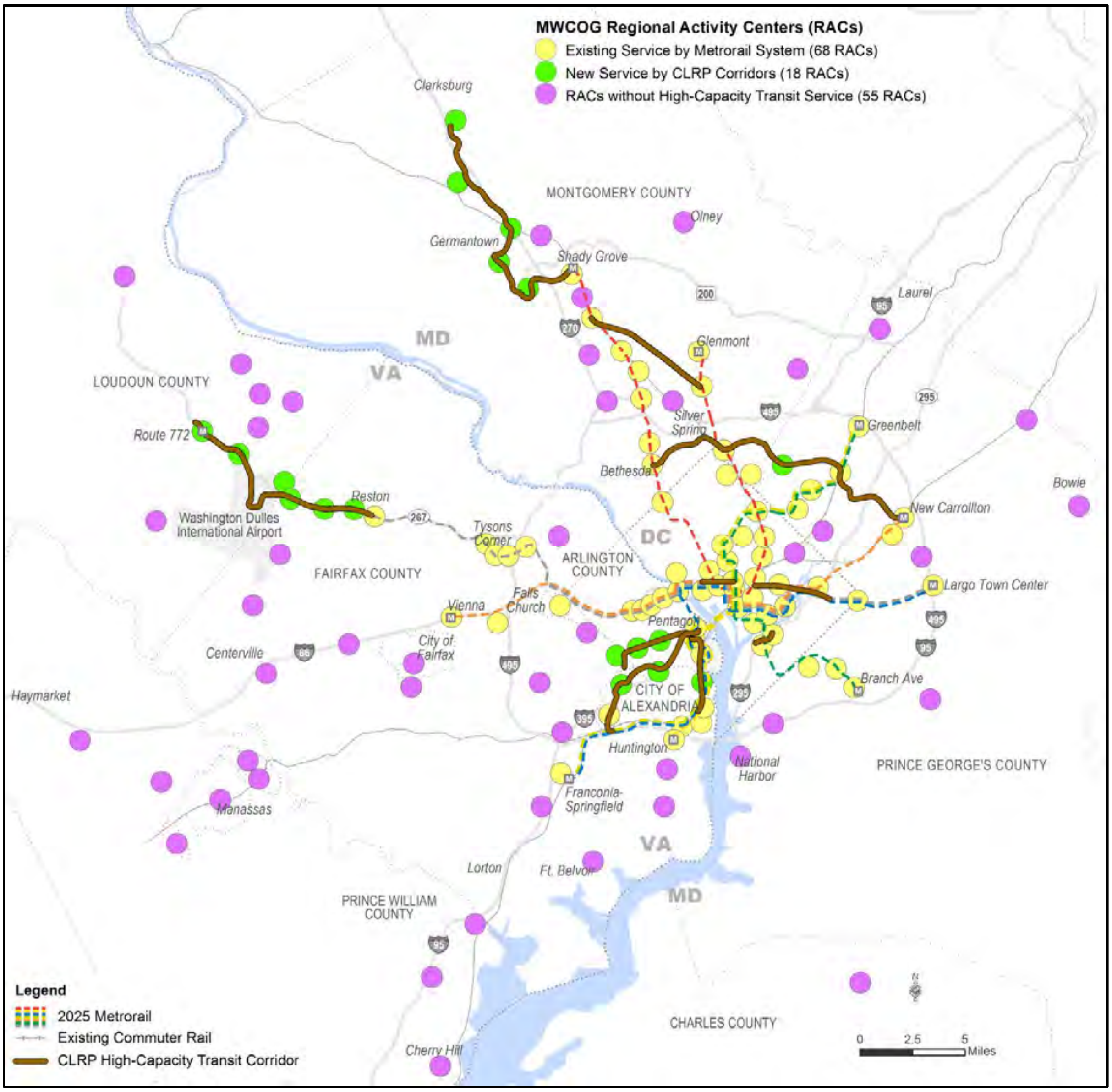
- Heavy Rail (Metrorail)
- Light Rail Transit (Purple Line)
- Bus Rapid Transit (e.g., Crystal City/Potomac Yard Transitway)
- Modern Streetcar (e.g., DC Streetcar H St NE/Benning Rd line)
- Enhanced Bus (e.g., Metrobus PCN lines with service and runningway improvements)

Commuter rail (e.g., VRE and MARC) is a high-capacity transit mode, but the frequencies and non-peak service are not sufficient to be considered a high-frequency mode.

Service to Regional Activity Centers (RACs)

Figure 2 shows the region's 141 designated RACs in relation to existing and planned baseline high-capacity/high-frequency transit services by 2040. These nodes are designated by MWCOG as current or emerging nodes where the region's economic, social, institutional, and cultural activities are concentrated, and that the region has committed to support in its land use and transportation policies.

Figure 2: RACs Served and Unserved by High-Capacity/High-Frequency Transit



Of the region's 141 RACs:

- 86 RACs (61%) will have high-capacity/high-frequency transit service in 2040:
  - 63 (45%) by the existing Metrorail system
  - 23 (16%) by CLRP projects (including the Metrorail Silver Line Phase 2)
- 55 RACs (39%) will continue to lack high-capacity/high-frequency transit service in 2040. Note that 14 of these have PCN service.

As a result, key considerations for the alternative scenarios were:

- What RACs will have existing or planned high-capacity/high-frequency transit?
- What RACs will continue to lack high-capacity/high-frequency transit in 2040?
- What are the RACs and Metrorail station areas that have more capacity to grow in terms of availability of (re)development sites and supportive Small Area Plans?
- What are the RACs and Metrorail station areas that do not have additional build-out capacity?

2.2. Forecast Growth in Regional Activity Centers

Table 3 and Table 4 list the forecast population and employment growth in the region and in RACs. Although most of the WMATA Compact Area's population and employment growth will occur in RACs, approximately one fifth of the population and employment located in RACs by 2040 will continue to lack access to high-capacity/high-frequency transit through 2040 based on the Round 8.3 forecast.

Table 3: Population Forecast 2015-2040

Region	Population 2015	Population 2020	Population 2040	Difference in Population (2020 - 2040)	Percent Growth in Population (2020 - 2040)
CGW Study Area	7,057,000	7,475,000	8,795,000	1,320,000	18%
WMATA Compact Area	4,455,000	4,688,000	5,451,000	763,000	16%
Regional Activity Centers (RACs)	1,521,000	1,689,000	2,280,000	592,000	35%
RACs served by high-capacity/high-frequency transit service in 2040	1,192,000	1,327,000	1,785,000	458,000	35%

Source: MWCOG Draft Round 8.3 Cooperative Land Use Forecast

Table 4: Employment Forecast 2015-2040

Region	Employment 2015	Employment 2020	Employment 2040	Difference in Employment (2020 - 2040)	Percent Growth in Employment (2020 - 2040)
CGW Study Area	4,127,000	4,450,000	5,520,000	1,070,000	24%
WMATA Compact Area	2,919,000	3,153,000	3,900,000	747,000	24%
Regional Activity Center (RACs)	2,157,000	2,362,000	3,023,000	661,000	28%
RACs served by high-capacity/high-frequency transit service in 2040	1,760,000	1,921,000	2,409,000	488,000	25%

Source: MWCOG Draft Round 8.3 Cooperative Land Use Forecast

The forecast population and employment growth suggest that the policy alternatives prioritize reallocating population and employment growth to RACS served by high-capacity/high-frequency transit. In addition, some existing RACs and transit station areas are employment centers with very little residential development, while others tend to be mostly residential in character. A more balanced mix of population and employment in station areas within RACs could reduce peak-hour/peak-direction trips and crowding on high-capacity transit links, while better utilizing non-peak direction links.

2.3. Metrorail Ridership and Crowding

The Metrorail ridership resulting from the projected growth in population and employment is forecast to exceed capacity along several lines. As shown in Figure 3 on the following page, existing segments of the Metrorail system already experience crowding (over 100 passengers per car). The conversion to all eight-car trains in the peak hours included in the Metro 2025 plan will result in some relief, but by 2040 crowding is still projected for the following segments of the Metrorail system:

- Silver Line between East Falls Church and Wiehle-Reston East
- Combined Orange/Silver Line between Rosslyn and East Falls Church
- Orange Line between East Falls Church and West Falls Church
- Green Line between Congress Heights and L'Enfant Plaza
- Yellow Line between Pentagon and L'Enfant Plaza

Figures 4 and 5 on the following pages depict the relative magnitude of population and employment growth by Metrorail line segment service areas and superimpose the 2040 Metrorail peak hour passenger loads on the regional system map.

Figure 3: Metrorail Passenger Loads

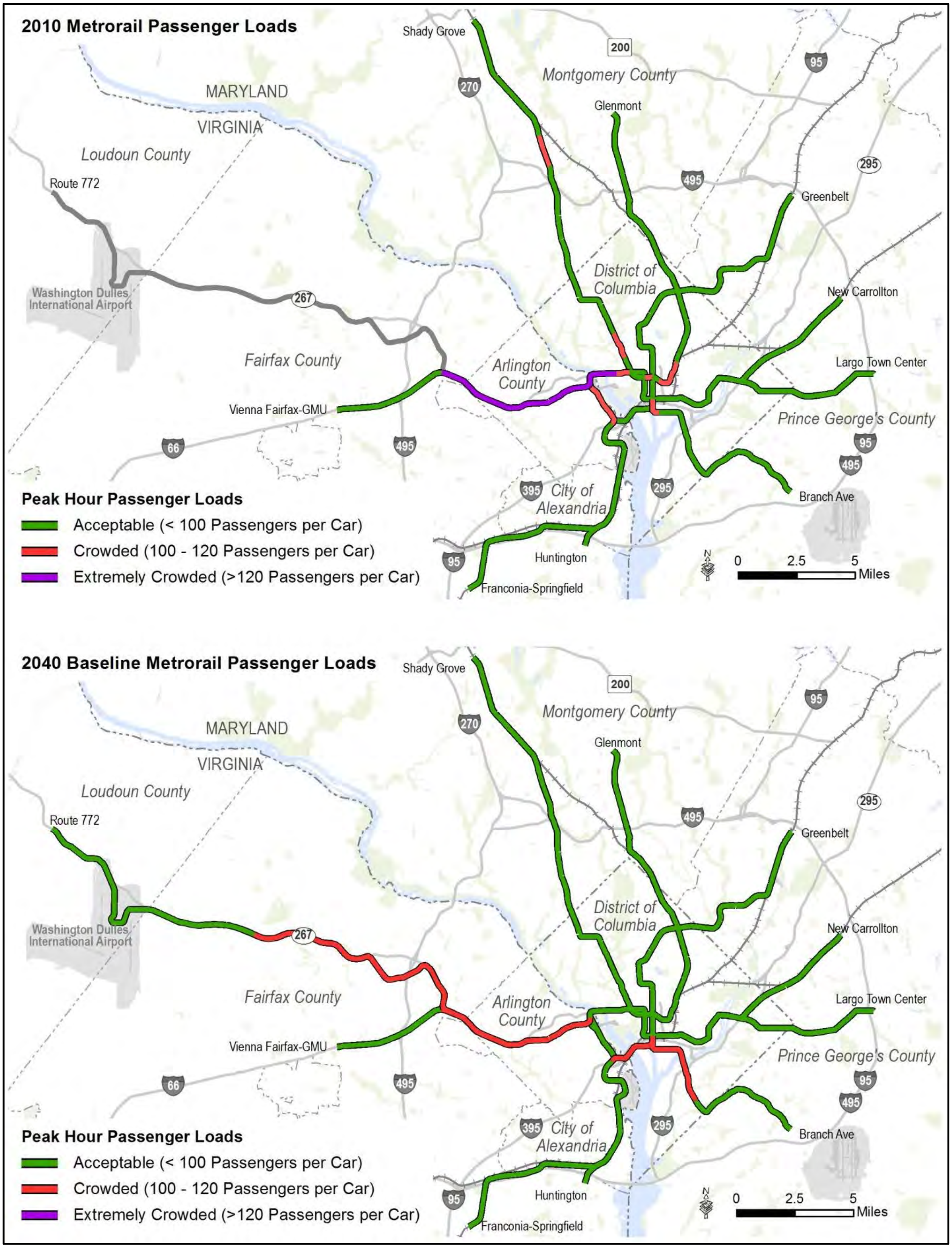


Figure 4: Population Change 2020-2040 by Metrorail Line Segment

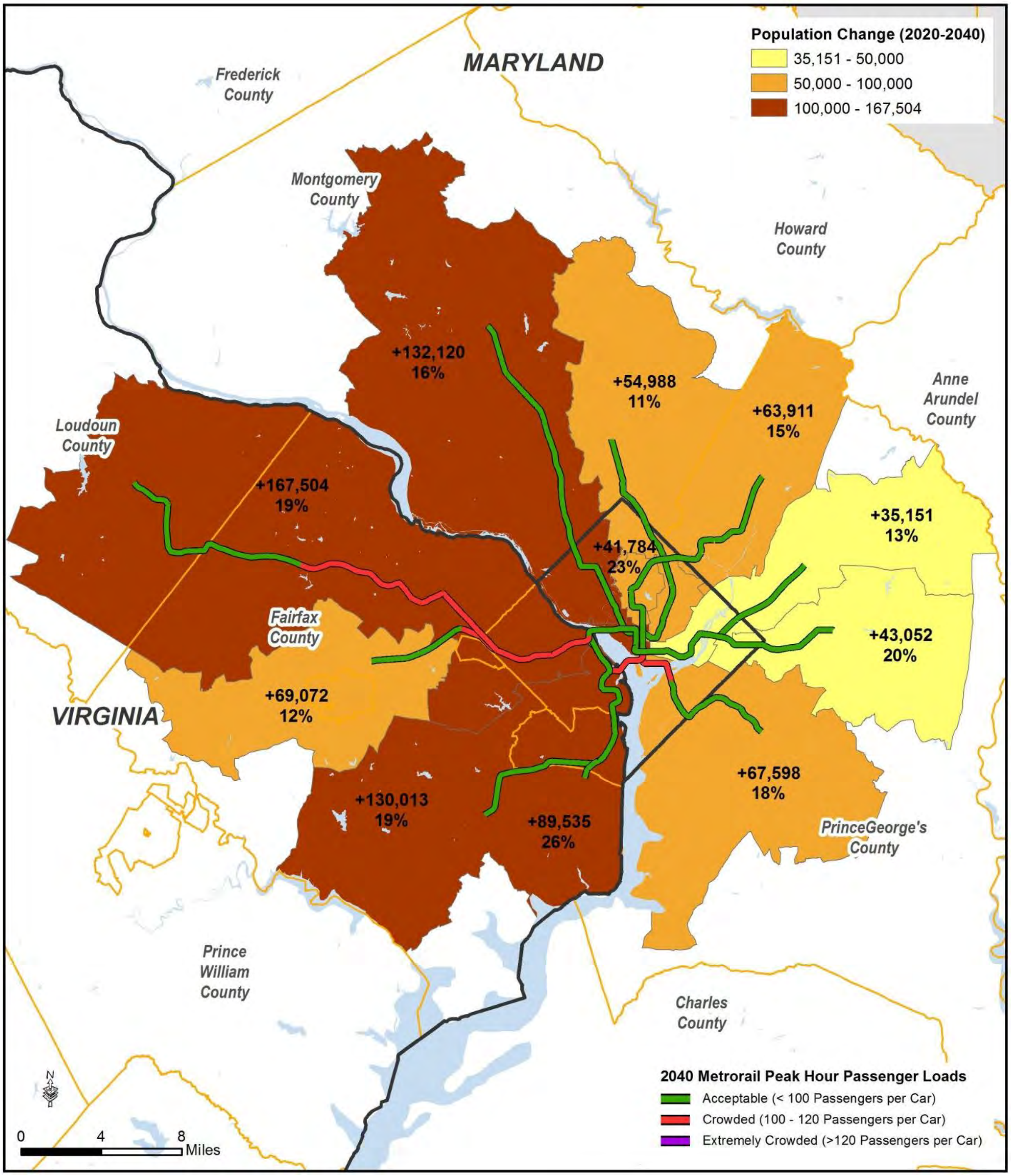
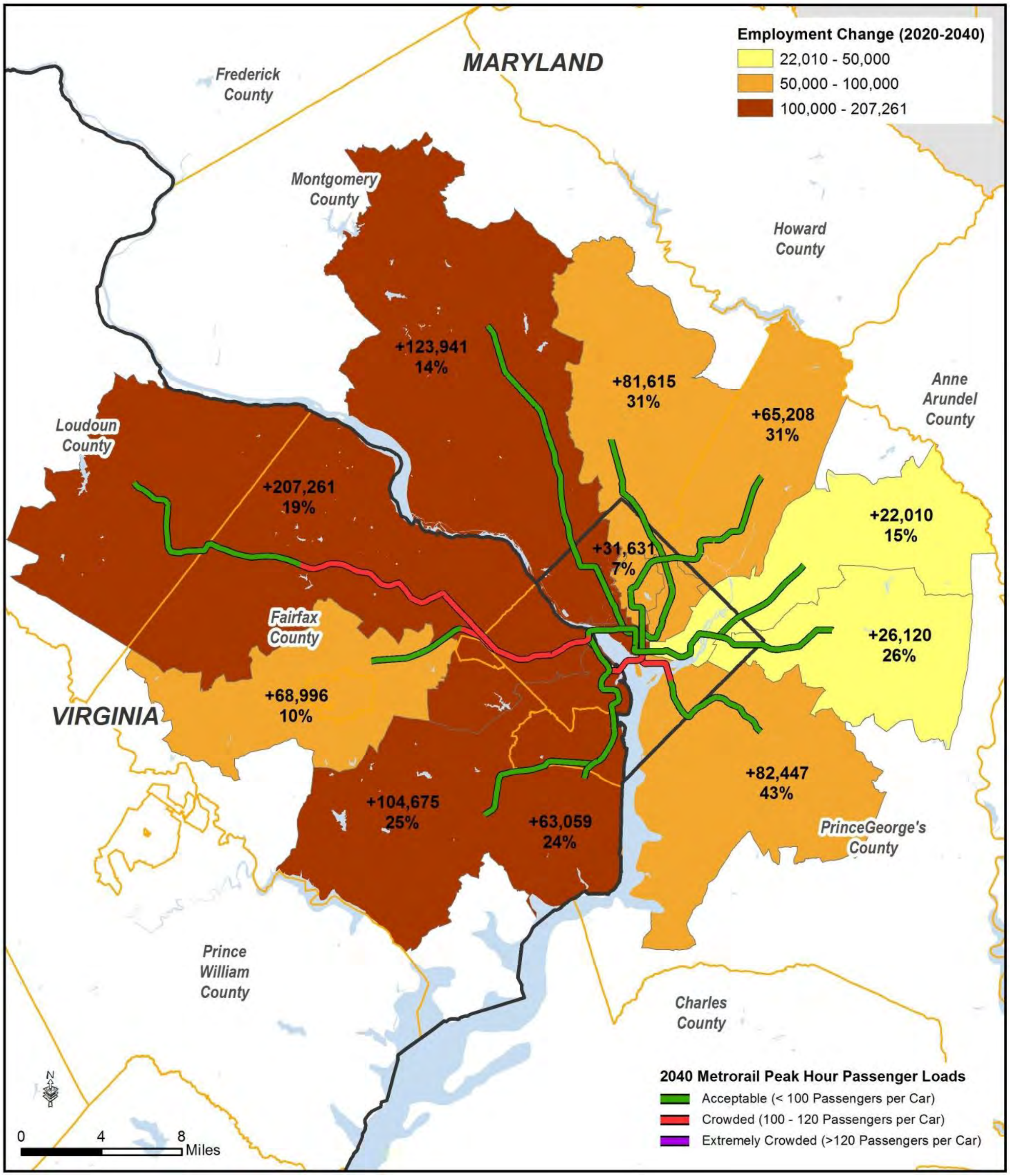


Figure 5: Employment Change 2020-2040 by Metrorail Line Segment



As shown in the figures, the forecast ridership for the Virginia Silver Line, southeast Green Line, and Virginia Yellow Line segments will exceed the capacity of those lines and result in crowded conditions during peak hours, while most of the other Metrorail segments are forecast to experience acceptable conditions.

The demographic data combined with the Metrorail ridership forecasts suggest that in addition to focusing on a balanced mix of population and employment growth in RACS served by high-capacity/high-frequency transit, a more balanced distribution of population and employment growth across the region needed to be considered as part of the policy analysis. Simulating a more balanced region involved considering:

- Shifts in projected population and employment from areas served by Metrorail lines that are forecast to experience crowded conditions by 2040 (Sliver Line West, Orange Line West, Yellow Line South, and Green Line Southeast); and
- Shifts in population and employment growth towards areas with lower forecast population and employment and served by Metrorail lines that are not forecast to approach or exceed ridership capacity (Orange Line East, Blue Line East, and Silver Line East).

3.0 Scenario Development and Modeling Methodology

Three alternative policy scenarios for the year 2040 were developed, with three different iterations of each:

- Scenario A: Efficient Transit
  - A prime – policies only (no land use reallocation)
  - 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 reallocation)
  - 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 reallocation)
  - C1 – land use shifted within jurisdictions with additional policies
  - C2 – land use shifted across jurisdictions with additional policies

Note that 2040 MWCOG Round 8.3 forecast regional totals for population and employment were maintained in all scenarios.

This section describes for each scenario the mobility and accessibility policies, reallocation of land use by shifting forecast population and employment growth, and how these were applied in the travel demand modeling. Table 5 on the following page summarizes the approaches and policies of each of the three scenarios, as well as the general CGW objectives that all scenarios were intended to support. These approaches and policies were tested as nine packages (three scenarios, each with three land use iterations).

Table 5: Policy Alternative Scenarios

Scenario	Scenario Description	General Approaches	Specific Policies
A: Efficient Transit	Optimize use of Metrorail and other high-capacity transit systems. Intended to maintain high ridership on all links in all directions while minimizing the potential for overcrowding.	• Mixed land uses in station areas • Reverse commutes • Increased short trips on non-motorized modes	• Higher-density and more balanced mix of land uses in RACs served by high-capacity/high-frequency transit; • Enhanced station area walkability for areas with increased density; • Enhanced bicycle access to transit stations; • Lower reverse peak-direction Metrorail fares; and • Increased Park & Ride capacity on underutilized Metrorail lines.
B: Cost-Effective Transit	Designed to reduce the public subsidy required to cover the operating costs of the Metrorail system by increasing ridership and associated revenues. Did not use measures to limit crowding on transit vehicles.	• Increased transit mode share in main travel markets • More residents to station areas with strong population base • More jobs to station areas with strong job base • Increased cost of driving in main travel markets	• Higher-density land uses in RACs served by high-capacity/high-frequency transit and that are within strong transit markets; • Cordon toll for vehicles entering region's employment core; • Increased regional parking prices; • Increased Park & Ride capacity at all Metrorail Park & Ride stations over capacity in the 2040 baseline; • Enhanced station area walkability, even further than Scenario A relative to land use density; • Enhanced bicycle access to transit stations similar to Scenario A; and • Decreased transit wait times due to enhanced real-time service information.
C: Maintain Current Travel Times	Designed to maintain peak-period travel times at base year 2013 levels for transit and highway users. Intended to mitigate the increased travel times by 2040 primarily caused by increased roadway congestion.	• Travel Demand Management • Shorter trips • Increase potential for non-motorized trips	• Similar to Scenario A – higher-density and more balanced mix of land uses in RACs served by high-capacity/high-frequency transit; • Increased automobile operating costs (e.g., higher gas tax or Vehicle Miles Traveled (VMT) tax); • Increased teleworking and alternate commute hours; • Reduced all Metrorail fares by 25 percent; • Increased share of short trips by walking and biking; and • Enhanced station area walkability for areas with increased density, similar to Scenario A.
All Scenarios		• Enhanced access to transit • Enhanced access to non-motorized modes • Increased driving-related costs • Population & employment growth focused in transit station areas within RACs	

3.1. 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.

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.

Reduced Fares for Reverse-Peak Direction Travel

As encouragement for travelers to use underutilized Metrorail service, a policy was applied to decrease peak period fares by 50 percent for trips moving in the reverse-peak direction or utilizing uncongested (less than 80 passengers per car) peak-direction segments. This strategy had the benefit of both encouraging reverse-peak direction trips (e.g., Farragut North to Shady Grove in the AM peak) and short peak-direction trips on uncongested portions of lines (e.g., Shady Grove to Bethesda in the AM peak).

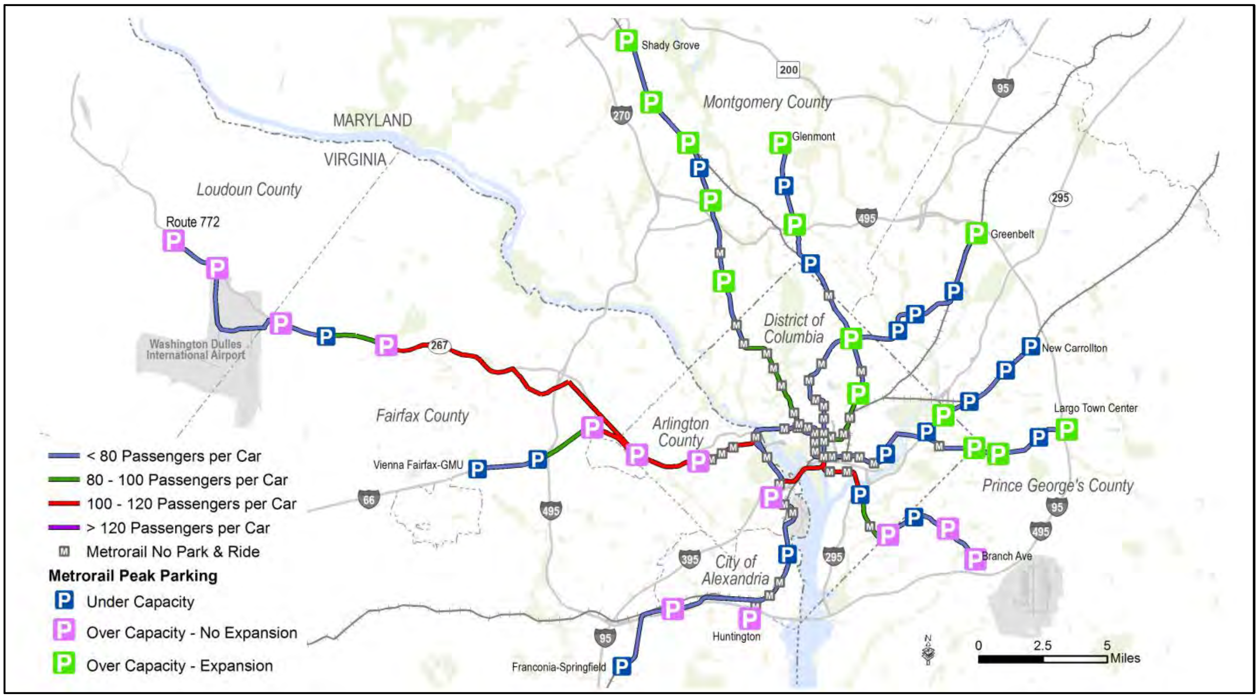
Expanded Bike Access to Transit

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 used in the model (for both pedestrians and bicyclists) was expanded past its assumed limit of one mile to a 1.5-mile radius. This assumed maximum distance was intended to serve as a middle ground between pedestrians, who are only likely to walk up to one mile, and bicyclists, who may bike up to three miles to access transit.

Selective Expansion of Metrorail Park & Ride Capacity

Scenario A expanded the Park & Ride capacity at stations with high parking demand but that are located on underutilized Metrorail lines. As shown in Figure 6, these Metrorail lines with relatively low utilization in the Baseline include both branches of the Red Line, the northern branch of the Green Line, the eastern branch of the Orange Line (New Carrolton end), and the eastern branch of the Blue Line.

Figure 6: Scenario A Selected Park & Ride Expansions



Updated Parking Costs and Walkability based on Scenario Land Use Changes

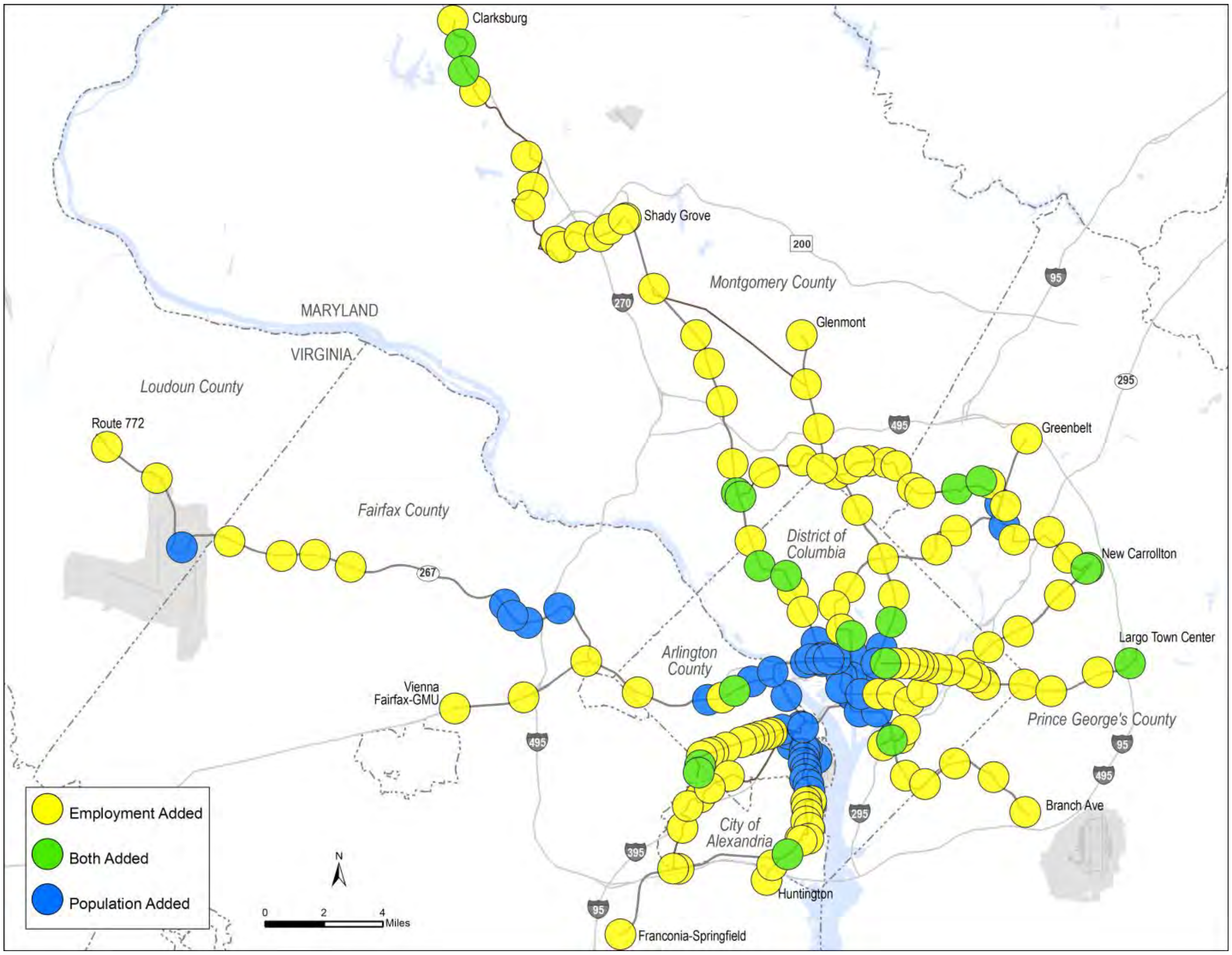
Parking costs and terminal times (time spent accessing a vehicle; includes walk time between origin/destination and parked car) are used in the mode choice model to determine the total time and cost associated with a driving trip. These attributes are calculated for each Transportation Analysis Zone (TAZ) within the model 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.

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. 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).

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 those policies alone. The non-land use policies were then tested with two alternative land use scenarios described below (Scenarios A1 and A2). Density goals for each station area were defined based on the type of land use intensity that needed to be added to achieve a more balanced Metrorail network: employment, population, or mixed-use, as shown in Figure 7 on the following page.

Figure 7: 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 8 and Figure 9).

Scenario A2

Based on the 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 station areas already experiencing Metrorail congestion in the 2040 Baseline scenario: Tysons Corner area, Rosslyn-Ballston corridor, L'Enfant Plaza, and the Waterfront/Navy Yard.

Figure 8: Scenario A1 Land Use Density (Population + Employment)

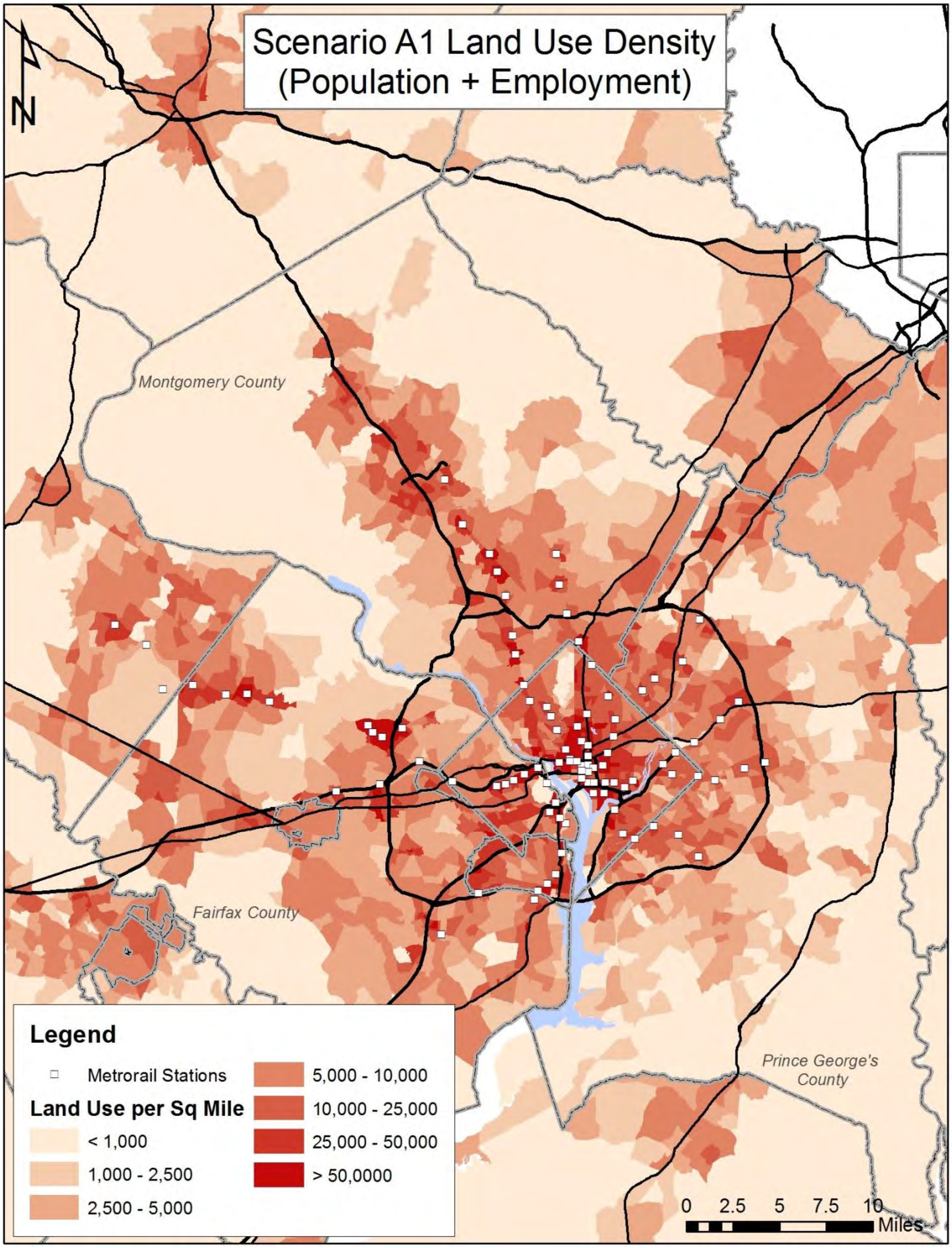


Figure 9: Change in Total Land Use – Scenario A1 versus 2040 Baseline

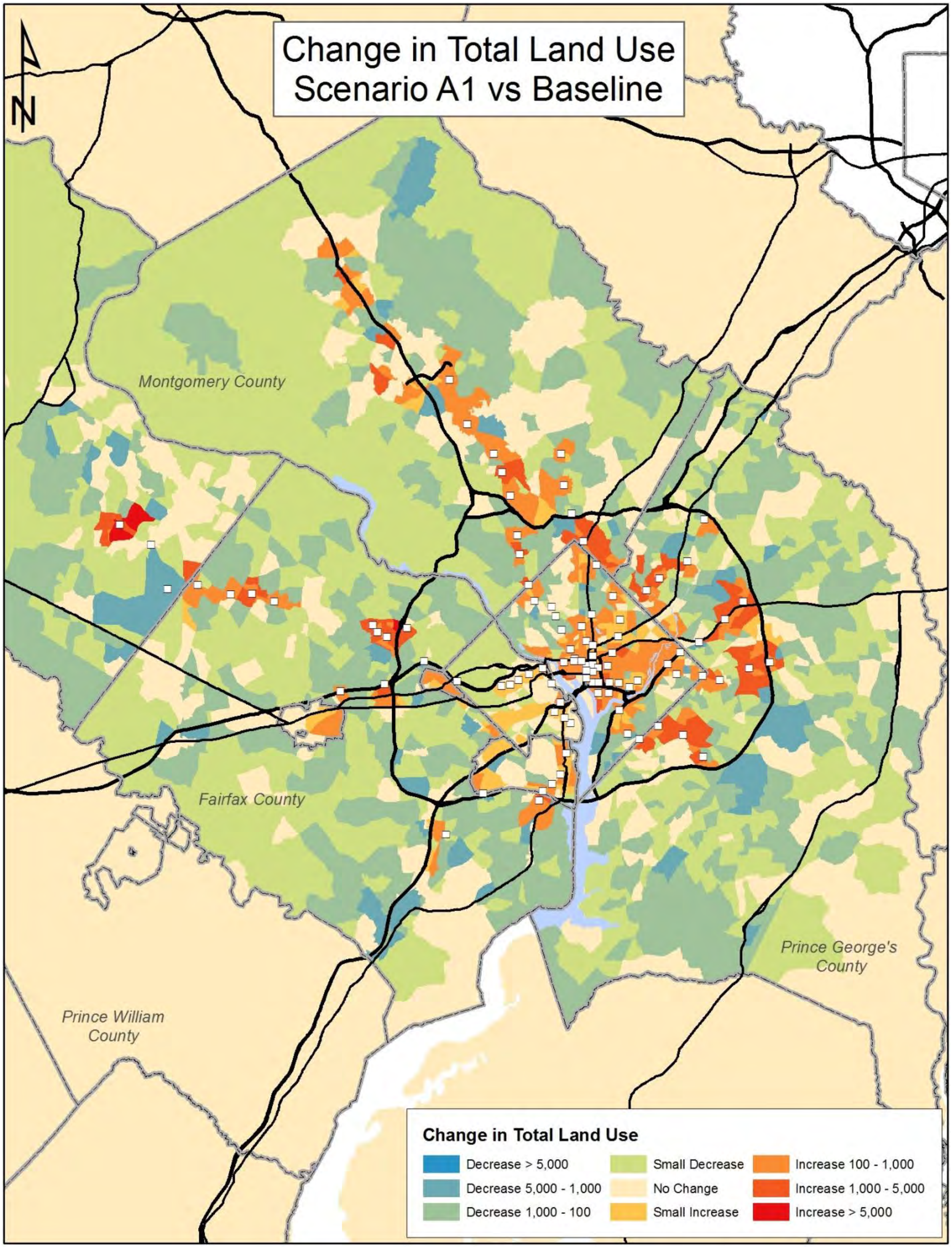


Figure 10 and Figure 11 on the following pages depict the following population and employment shifts used in Scenario A2:

- 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 were 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 10: Scenario A2 Land Use Density (Population + Employment)

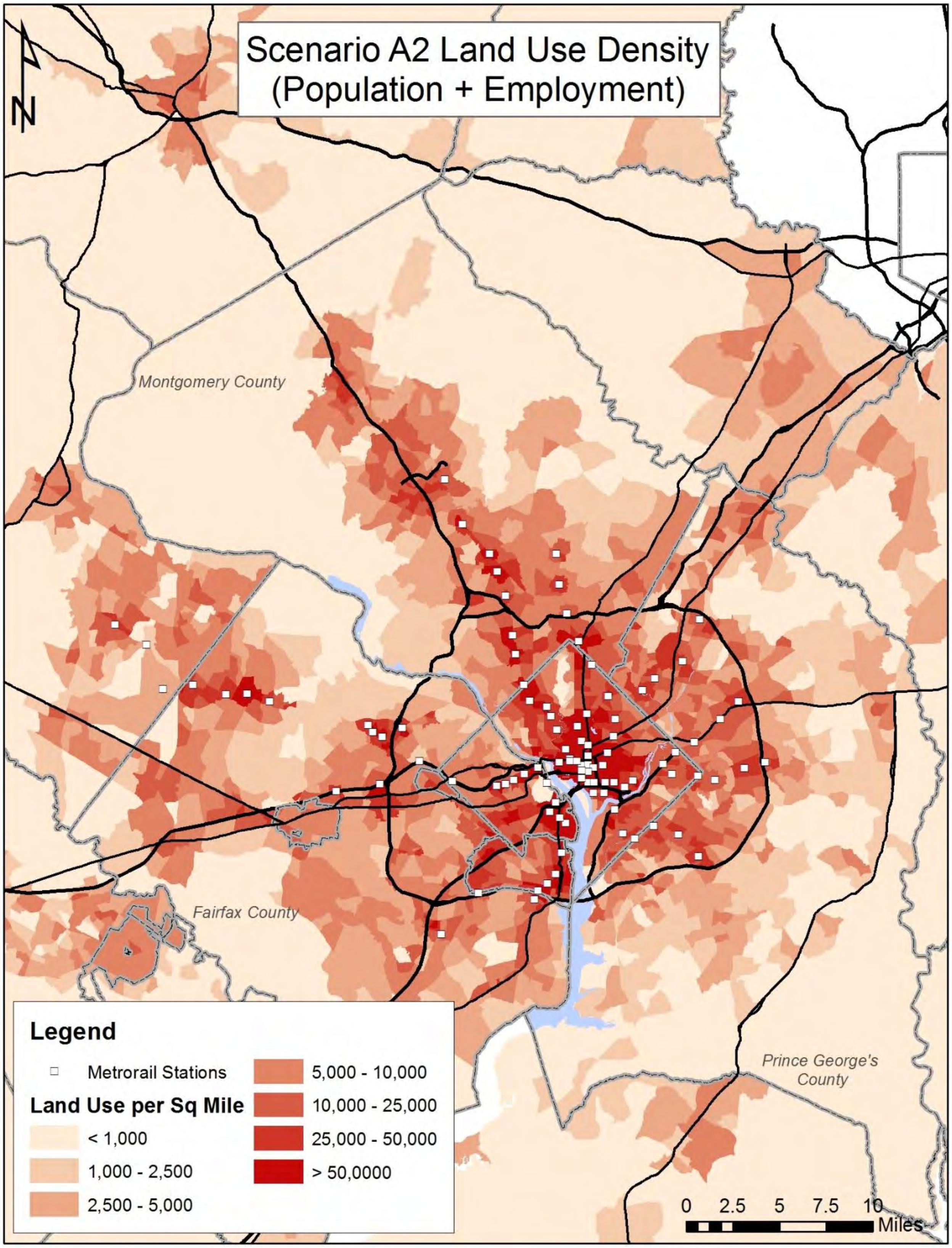
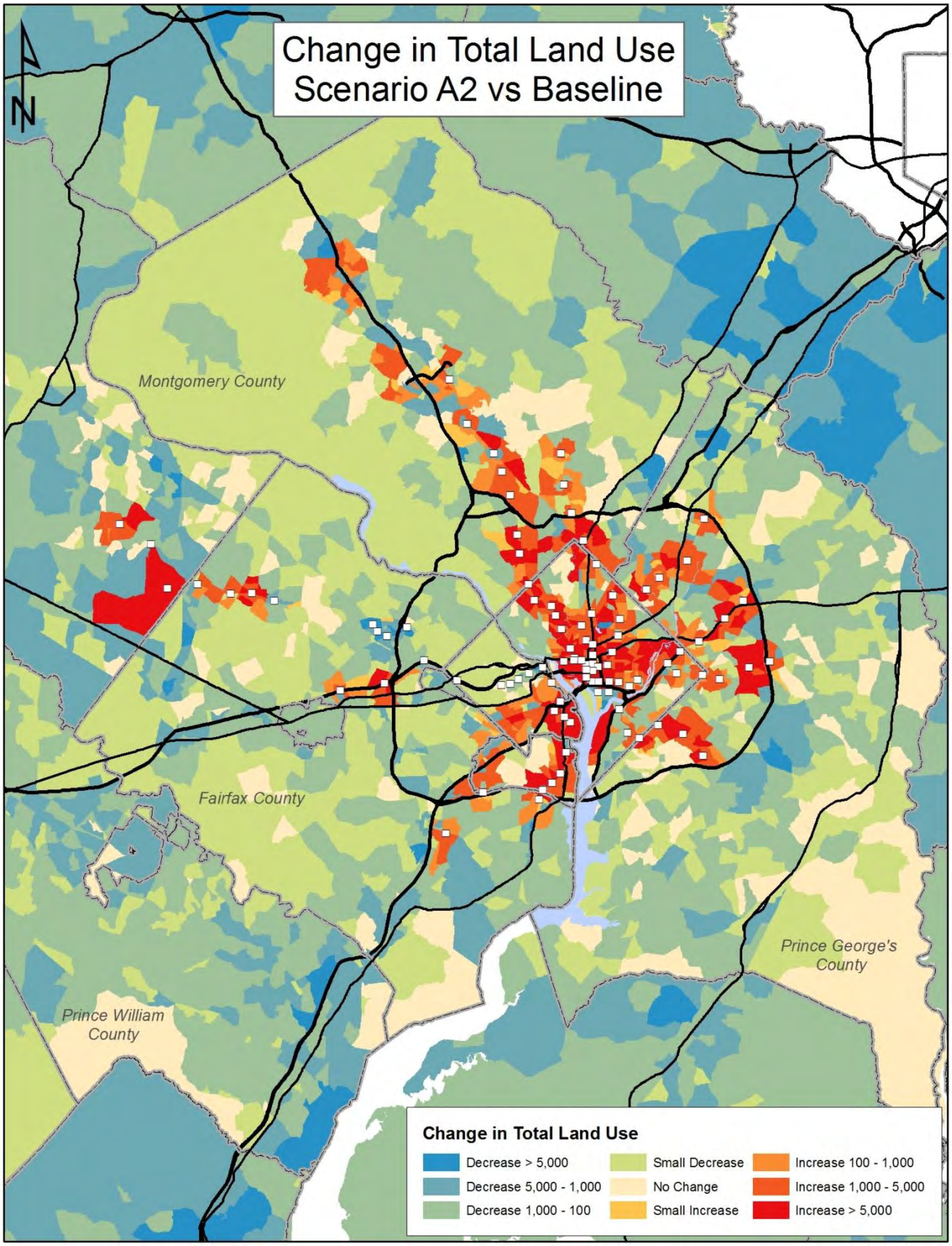


Figure 11: Change in Total Land Use – Scenario A2 versus 2040 Baseline



3.2. 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.

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.

Enhanced Walkability

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.

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.

Expanded 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.

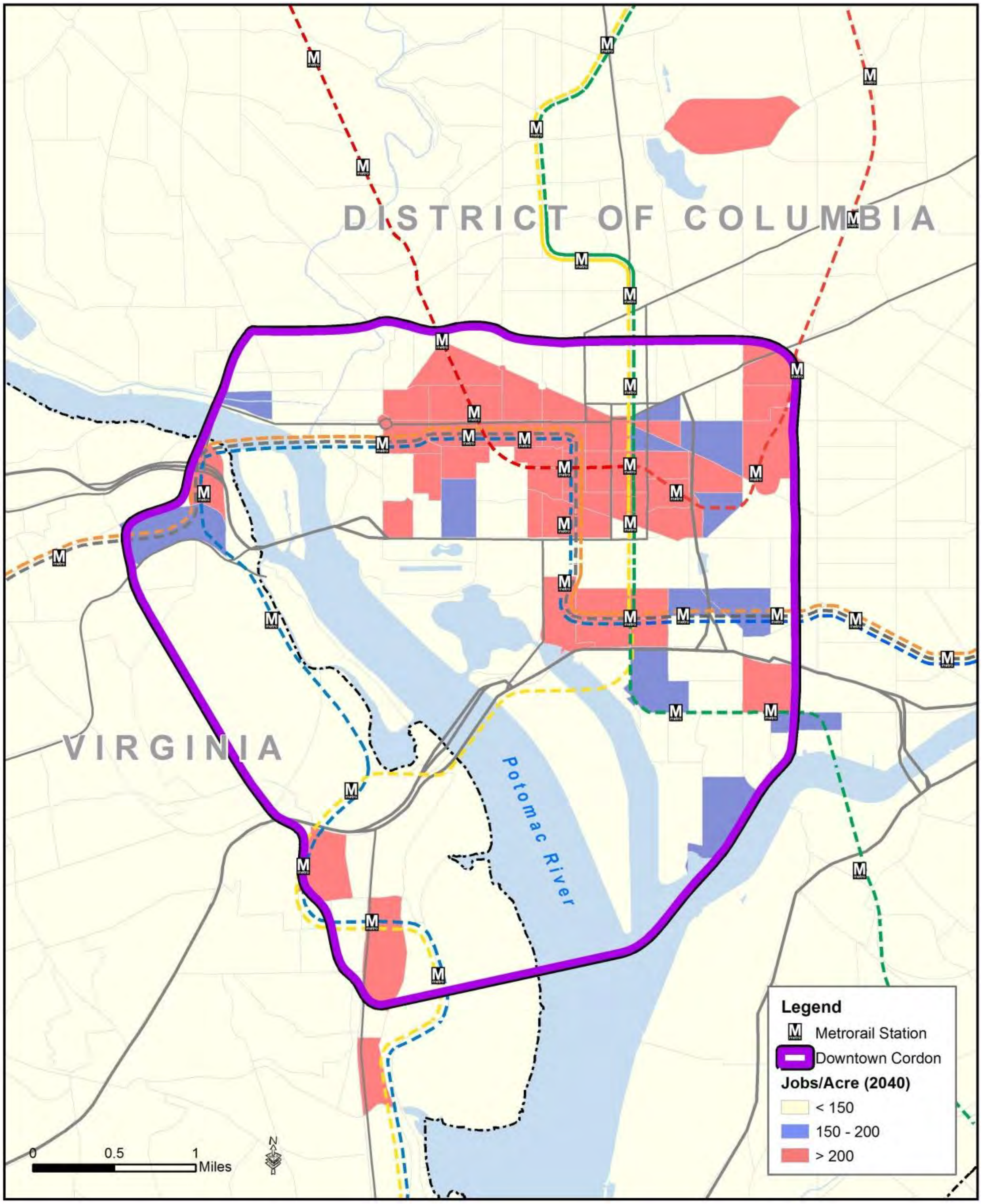
Regional Parking Availability and Pricing

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 based on the land use density. For Scenario B, these assumed parking costs in the model were increased by 25 percent. In addition, minimum parking costs were applied to eliminate TAZs with free parking.

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 included 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.

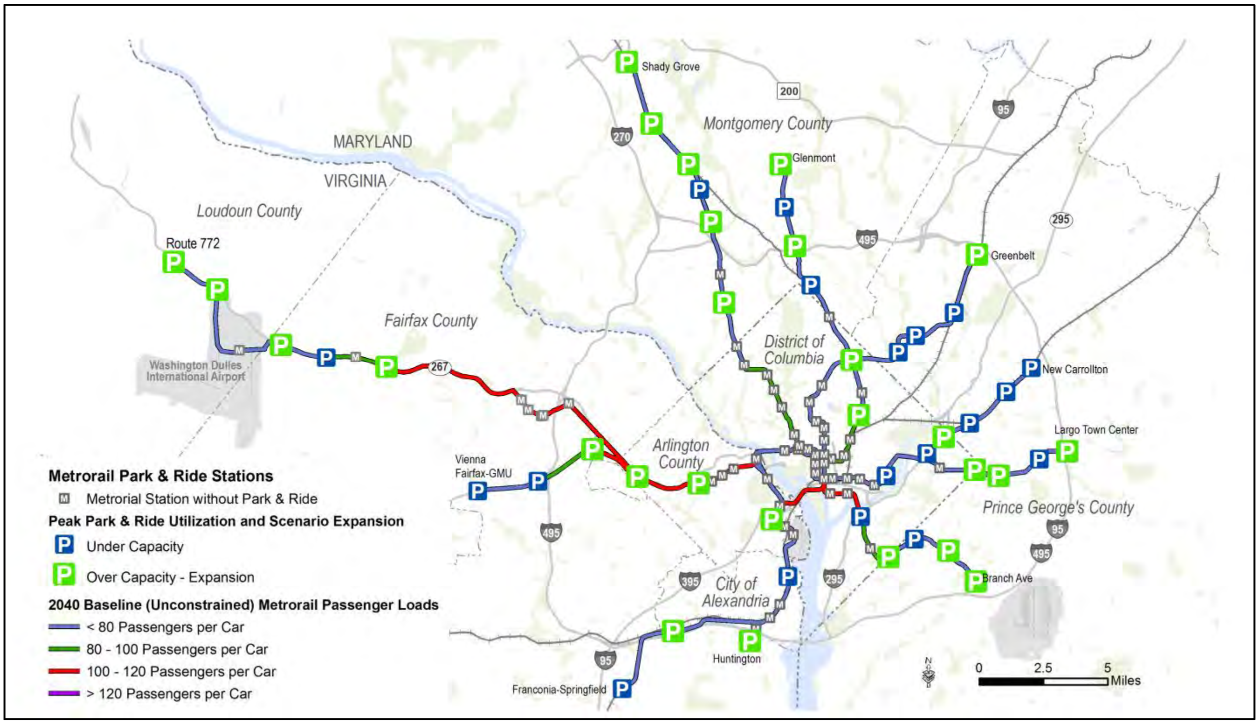
Figure 12: Location of Downtown Cordon and High-Density Employment



Metrorail Park & Ride Capacity Increase

To take advantage of potential ridership and revenues from Park & Ride passengers, Scenario B expanded the capacity of all 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

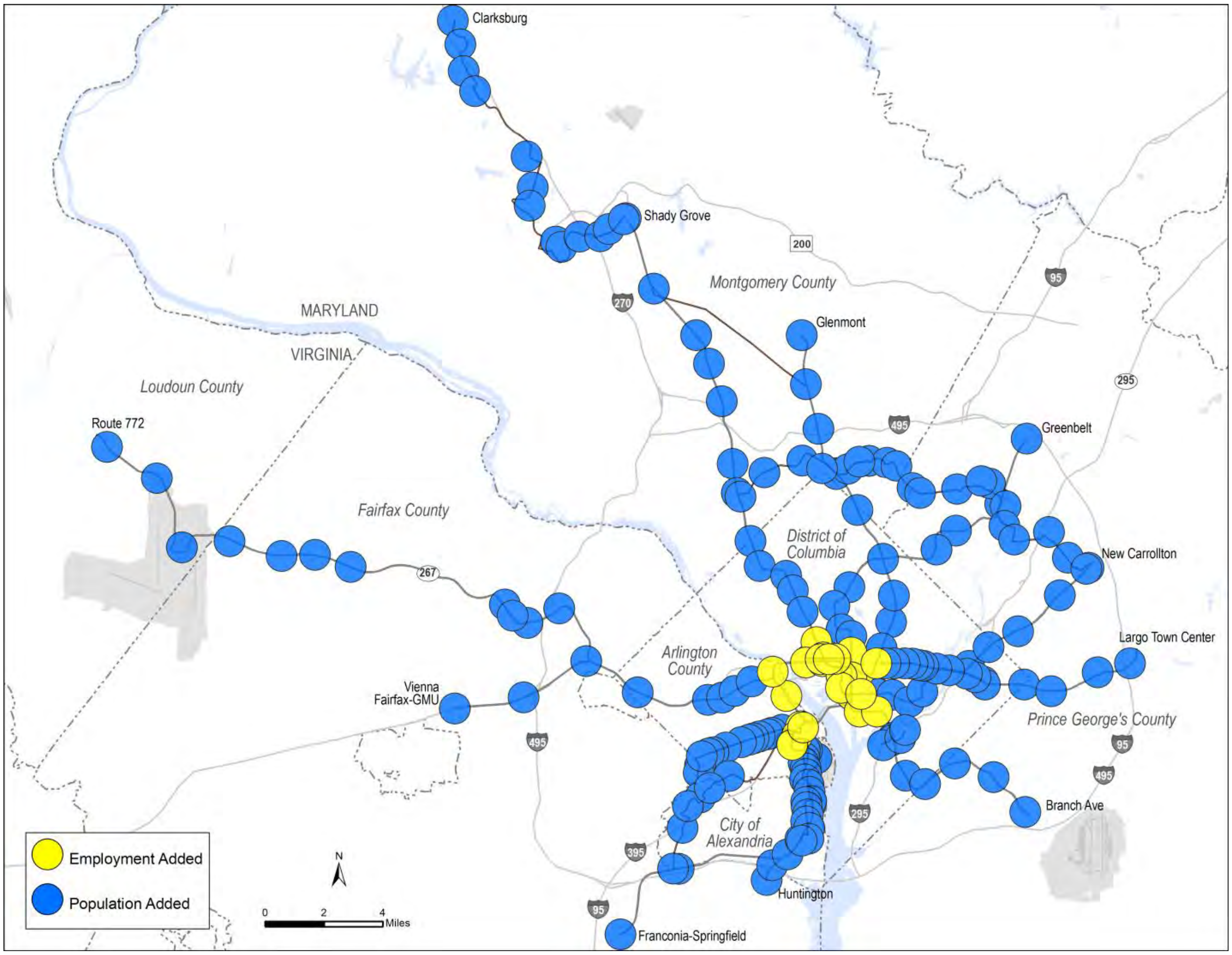


Land Use Scenarios

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 2014 MWCOG *Place + Opportunity* report for Scenario A. However, 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



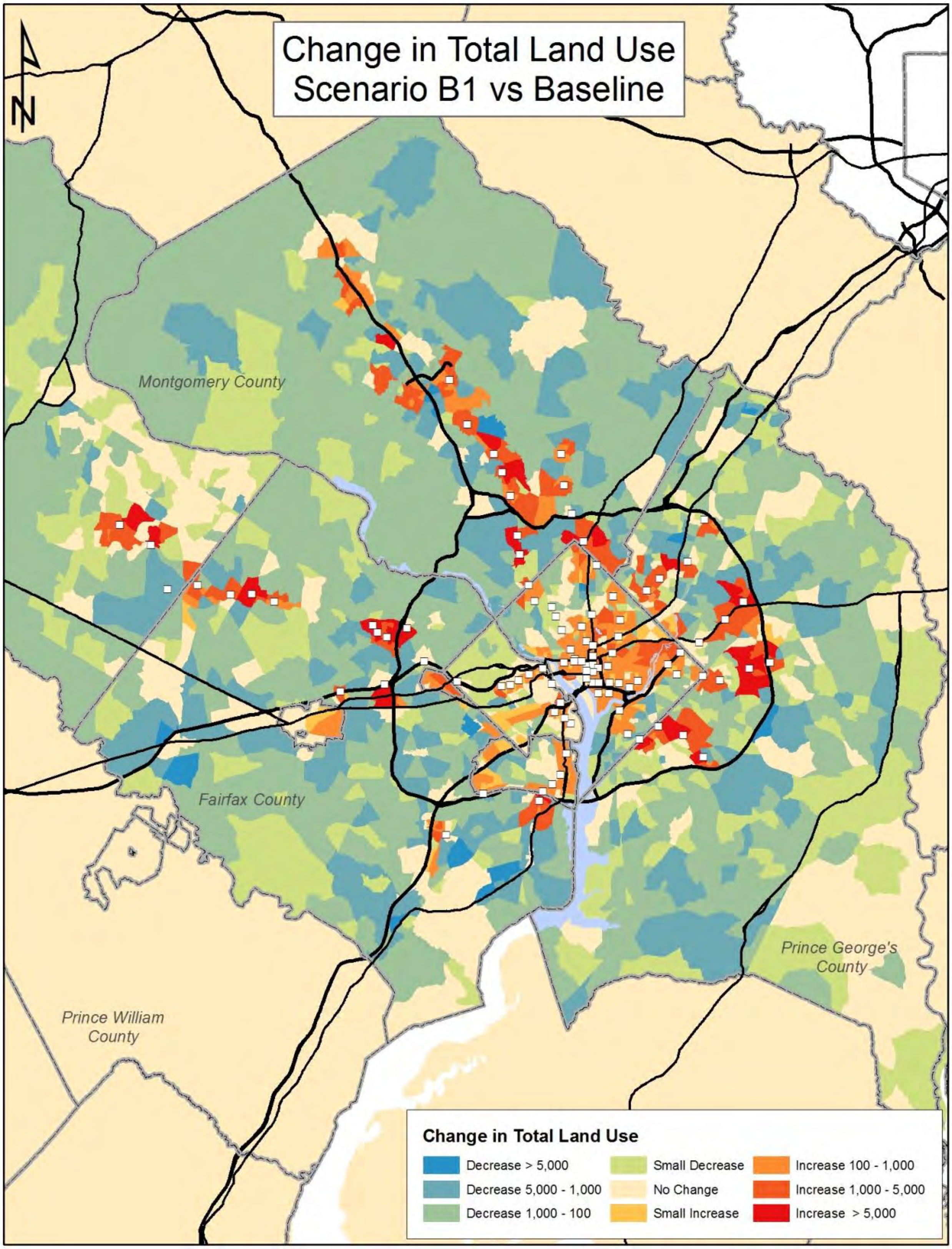
These density goals were used to reallocate post-2020 land use growth to more transit-friendly areas as outlined below:

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 on the following page.

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

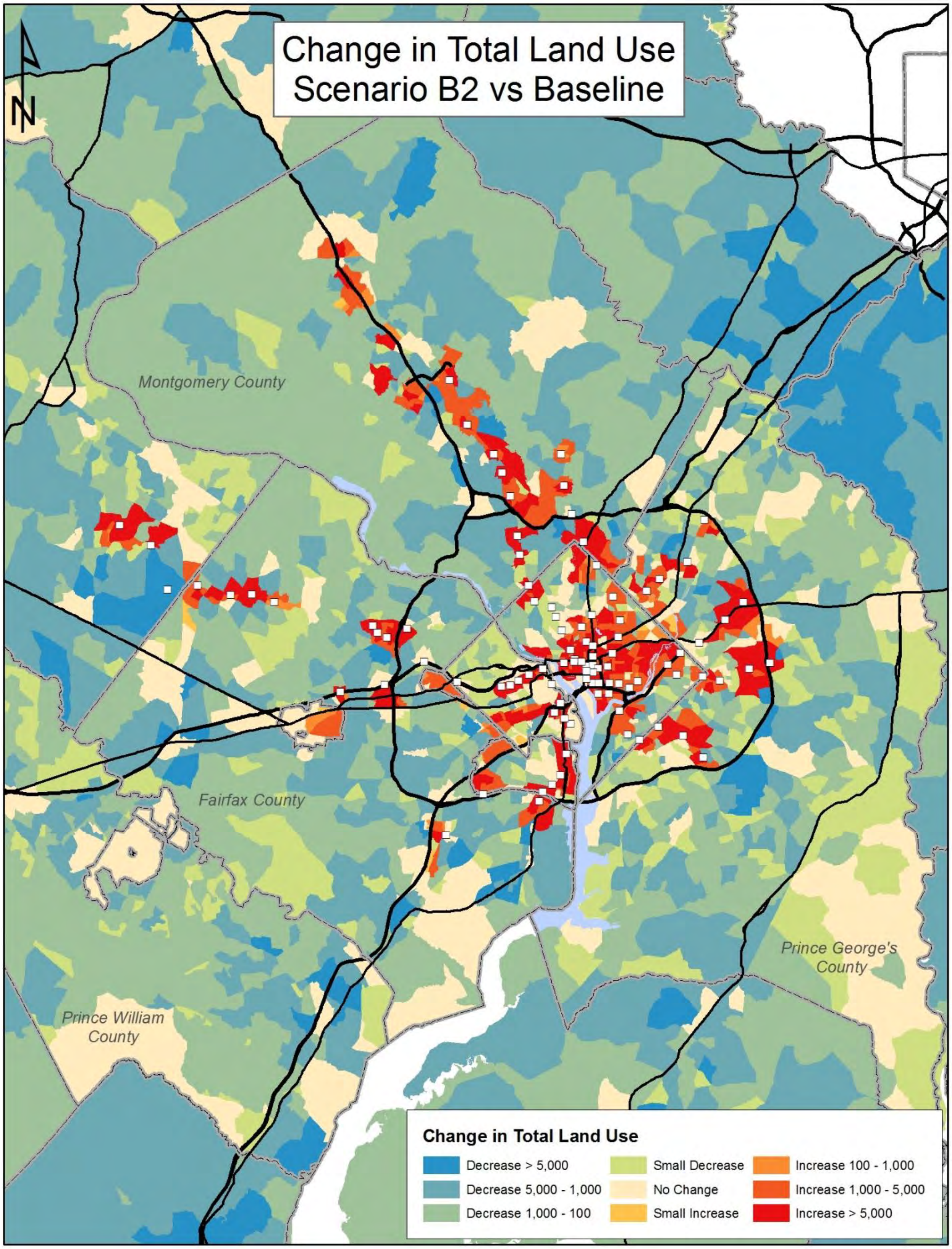


Scenario B2

Based on the 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 on the following page).

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

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



3.3. 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.

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.

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

One strategy used to discourage automobile travel and encourage the use of transit for <u>all</u> 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. For this analysis, a revenue neutral tax of 1.1 cents per mile was added to the baseline automobile operating cost assumed in the travel demand model 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. For Scenario C, a telework policy was implemented that increased the telework rate above the current regional rate, which is already included in the travel demand model, and those trips were subtracted from the total motorized trips. TPB's 2013 State of the Commute Survey for the Washington Metropolitan Region found that seven percent of workers who do not currently telework "could and would telework regularly" if given an opportunity. Scenario C assumed that this additional seven percent of workers, who currently commute to their jobs, were able to switch to teleworking two days per week. This switch effectively removed 2.8 percent of commute trips from travel on an average weekday, affecting both automobile and transit commute trips.

Alternative Work Hours

This policy enforced 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.

Increased 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. 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.

Walkability

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

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), which used the same land use reallocations developed for Scenario A1 and A2. The Scenario A land use alternatives were designed to promote mixed-use development, which is applicable to Scenario B because it can decrease trip lengths and maximize the potential for short non-motorized trips, removing vehicles from roadways.

3.4. Modeling and Land Use Reallocation Methodology

Travel Demand Modeling

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. 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 due to previous model calibration adjustments based on that year. The 2040 Policy Alternatives Scenarios were run without the Metrorail constraint. The “unconstrained” modeling process allows for unlimited Metrorail ridership with no limits on the carrying capacity of the Metrorail system.

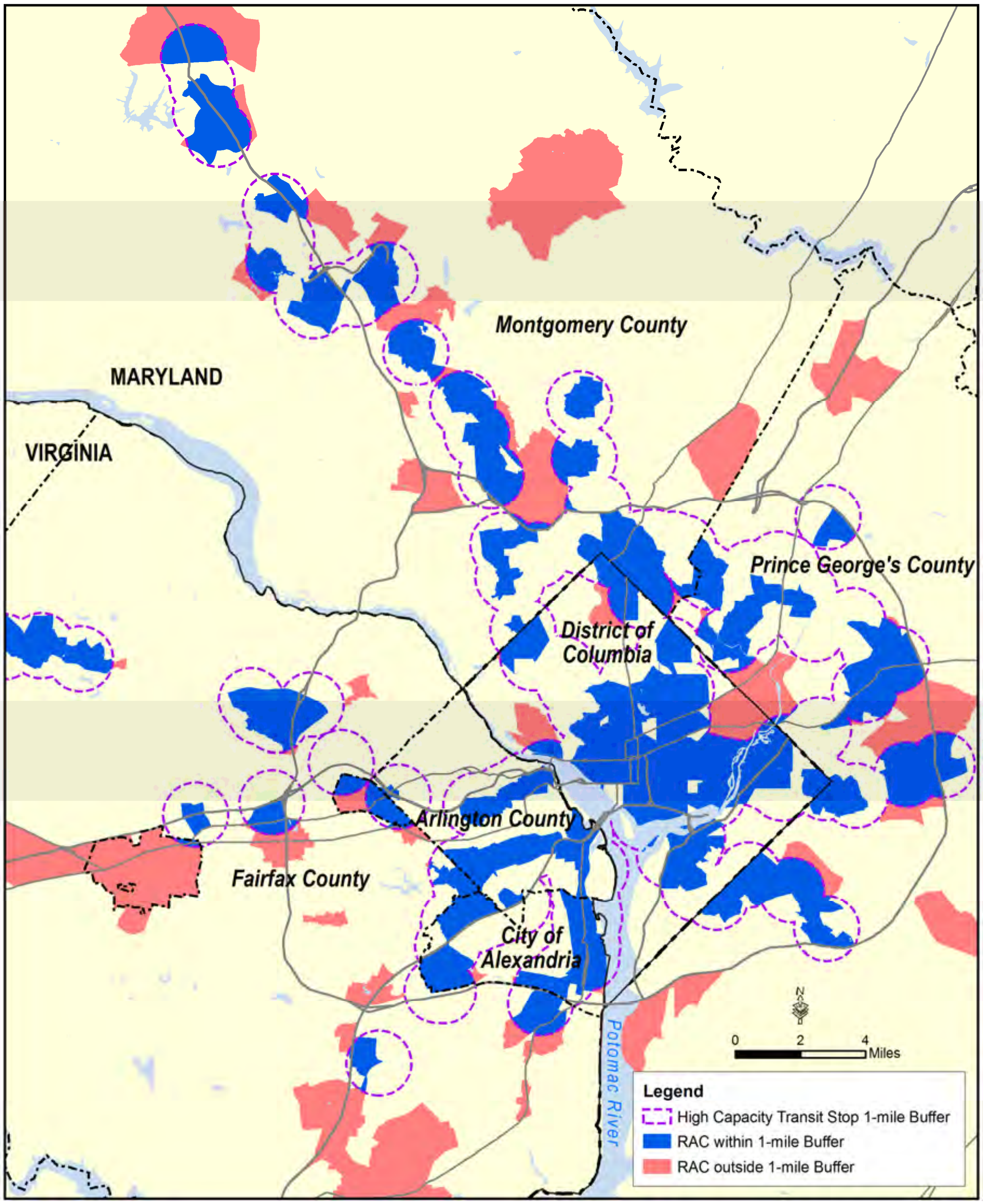
The modeling allowed transit services in some runs to become extremely crowded rather than shifting passengers to other travel modes based on observed rider preferences and passenger capacities of transit vehicles. These modeling assumptions were intended to illustrate the demand resulting from the scenario policies. Thus, the extremely high transit passenger loads observed in some of the scenario iterations are not realistic but are used for illustrative purposes.

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 +*

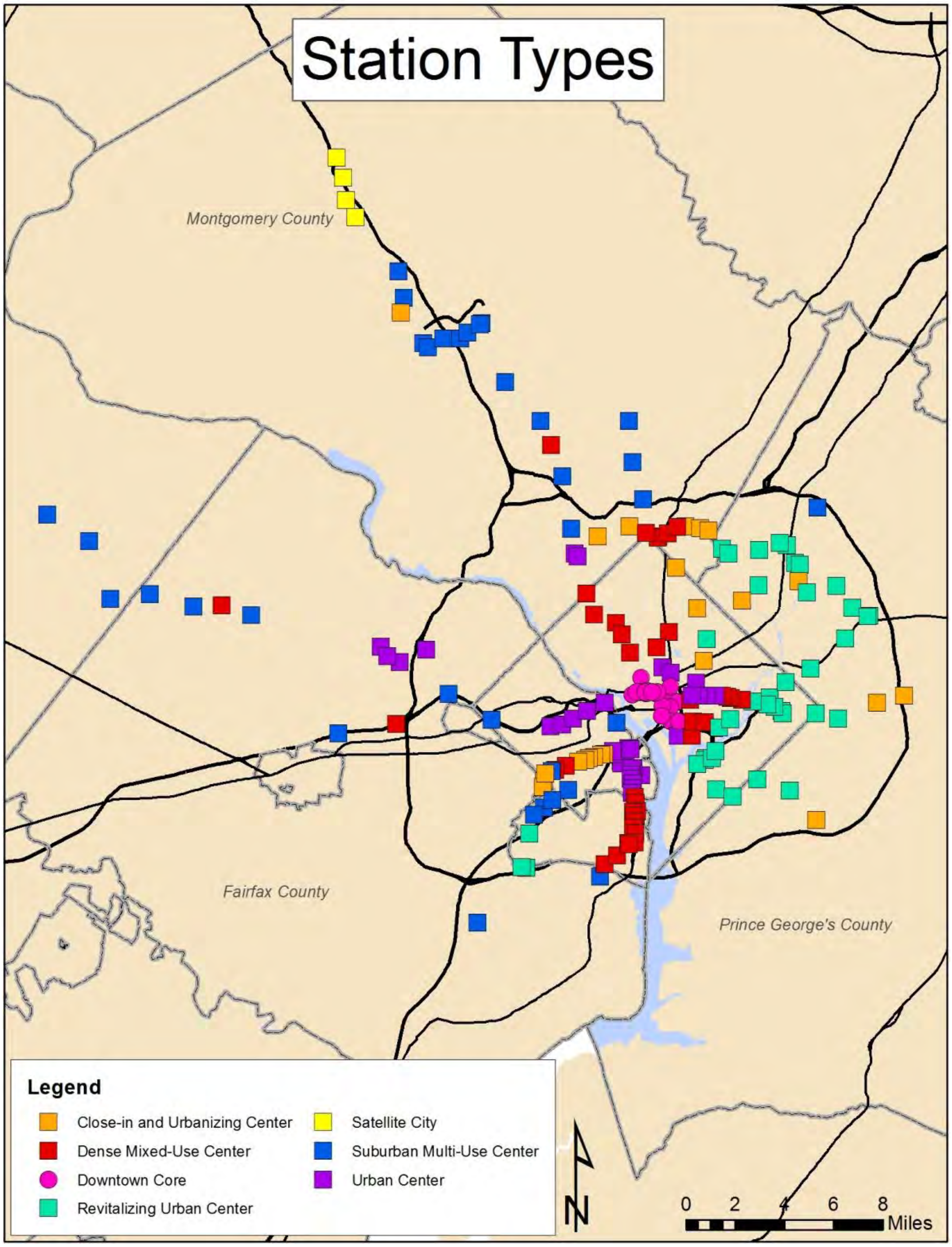
Opportunity: Strategies for Creating Great Communities and a Stronger Region (2014) assigns one of six "Place Types" to most of the RACs in the region based on urban form and market characteristics. This study used the same characteristics to assign Place Types to the remaining RACs in the WMATA Compact Area. Figure 17 shows the overlap between the 1-mile station areas and the RACs.

Figure 17: 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 (see Figure 18). 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. 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 18: High-Capacity/High-Frequency Transit Station Place Types



For each place type, the study identified a representative RAC with a Metrorail or other transit station and calculated its forecast 2040 total land use density (population + employment) in the 1-mile radius station area (based on MWCOG Transportation Analysis Zones). These densities were used as the target density values for the station areas in the alternative land use scenarios according to their RAC place type (see Table 6).

Table 6: 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

For example, the Dunn Loring Metrorail Station is categorized by MWCOG as a Dense Mixed-Use Center; the current study selected the White Flint Metrorail station area (within a Dense Mixed-Use Center RAC) as a representative station area for that place type and calculated its 2040 forecast density at 73,600 population plus employment per square mile. Based on the representative station area, Dunn Loring was given a target density of up to 73,600 population plus employment per square mile for the policy scenarios.

Reallocation of Population and Employment Growth

Population and employment growth across the region was reallocated based on the set of target densities for RACs described above and based on the specific strategies of each scenario. For all scenarios, TAZs within ½- and 1-mile radii of high-capacity/high-frequency transit service were identified as potential locations for increased densities. Growth was reallocated to these station areas, prioritizing:

- 1) ½-mile station areas, and then 2) 1-mile station areas second;
- 1) RACs within station areas, and then 2) non-RAC areas within station areas ; and
- 1) Outer years toward 2040 (more likely to be affected by changes in land use policies), and then 2) years closer to 2020.

The amount and type of density (residential, employment, or mixed) that was reallocated to each station area varied based on the strategies in each Scenario described above.

Table 7 and Table 8 detail the population and employment growth available within each jurisdiction to be shifted to station areas, respectively. Over 850,000 residents and almost 600,000 jobs could potentially be shifted depending on the particular strategies used by each scenario.

Table 7: Potential Population Growth Available to be Reallocated (2020-2040)

Jurisdiction	Outside of Station Areas			Inside Station Areas	Total
	Inside RAC	Outside RAC	Total		
District of Columbia	6,121	11,684	17,805	150,269	168,074
Montgomery County	29,025	22,988	52,012	83,727	135,739
Prince George's County	20,235	41,326	61,561	34,030	95,591
Arlington County	585	431	1,016	38,973	39,989
City of Alexandria	1,273	1,724	2,997	33,791	36,788
Fairfax County	45,116	60,909	106,025	114,523	220,548
Loudoun County	11,623	44,885	56,508	10,004	66,512
Outside Compact Area	72,841	483,902	556,743	0	556,743
Regional Total	186,819	667,848	854,667	465,317	1,319,984

Table 8: Potential Employment Growth Available to be Reallocated (2020-2040)

Jurisdiction	Outside of Station Areas			Inside Station Areas	Total
	Inside RAC	Outside RAC	Total		
District of Columbia	1,196	2,595	3,790	136,210	140,000
Montgomery County	36,653	13,002	49,656	101,088	150,744
Prince George's County	53,899	18,606	72,505	47,268	119,773
Arlington County	4	15	19	32,530	32,549
City of Alexandria	1,671	315	1,986	48,800	50,786
Fairfax County	65,454	14,864	80,318	92,087	172,405
Loudoun County	34,519	30,951	65,470	15,481	80,951
Outside Compact Area	36,267	286,908	323,175	0	323,175
Regional Total	229,663	367,256	596,918	473,465	1,070,383

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.

4.0 Scenario Results and Findings

4.1. Scenario Evaluation Measures

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.[2] Table 9 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 9: 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*
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 *

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

Goal	Key Objectives for Land Use and Policy Analysis	Measure of Effectiveness (MOE)
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.

The results for the key MOEs for the scenarios are reported in Appendix A. The complete MOE results are reported in the *Task 7: Scenario Comparison Measures Technical Memorandum*.

The key objectives and MOEs that correspond to each scenario and for which the results proved to be meaningful in differentiating them from the 2040 Baseline conditions are listed in Table 10.

Table 10: Key Objectives and MOEs by Scenario

Scenario	CGW Objectives	Key MOEs	Strategies
A: Efficient Transit	• Minimize crowding on the 2040 Baseline Transit Network • Maximize transportation system efficiency	• 4.3 Transit Load Factor • 4.5 Transit Load Factor Deviation • 5.1 Transit Utilization	• Mixed land use • Reverse commutes • Increased short trips on non-motorized modes
B: Cost-Effective Transit	• Reduce transit operating subsidy	• 5.6 Decrease or remove the operating subsidy • 5.5 Fare Revenues	• Increased transit mode share in main travel markets • Increased cost of driving in main travel markets
C: Maintain Current Travel Times	• Minimize travel time to/from RACs	• 2.8 Vehicle Hours Traveled (VHT) • 1.3 Average Travel Time • 2.5 Travel Times between Key Origin-Destinations	• Travel Demand Management • Shorter trips
All Scenarios	• Minimize transportation-related emissions • Increase transit mode share • Enhance transit mode share to/from Regional Activity Centers (RACs) • Maximize economic and fiscal benefits of the transit network • Maximize households and employment served by high-frequency, higher-speed service*	• 1.1 Vehicle Miles Traveled (VMT) • 4.7 Transit Mode Share • 2.2 Transit Mode Share to/from Regional Activity Centers (RACs) • 3.2 Households within ½-mile of High-Capacity Transit • 3.3 Jobs within ½-mile of High-Capacity Transit*	• Enhanced access to transit • Enhanced access to non-motorized modes • Increased driving and parking costs • Population & employment growth focused in RACs*

* Input of the scenario development rather than modeling result.

4.2. Overall Outcomes

Table 11 on the following page summarizes the overall outcomes for the scenarios with fully applied land use and other policies (land use reallocation across jurisdictions with non-land use policies). Overall, the scenarios resulted in significant shifts in travel patterns with increased transit ridership, lower Metrorail operating subsidies, and lower roadway congestion, but none were able to fully resolve transit crowding while maintaining service and capacity at the 2040 Baseline level.

Table 11: Scenario Outcomes by Key Measures

Scenario	Reduces Metrorail Crowding	Increases Ridership along Underutilized Metrorail Lines/Directions	Increases Overall Transit Mode Share	Increases Metrorail Revenue		Maintains or Reduces Vehicle Miles and Hours Traveled	
				Reduces Operating Subsidy	Covers Entire Operating Subsidy	At/Below 2040 Base	At/Below 2010 Base
A	No	Yes	No	No	No	Yes	No
A1	No	Yes	No	No	No	No	No
A2	No	Yes*	Yes†	Yes	Yes†	Yes	Yes††
B	No	Yes	Yes	Yes	No	Yes	No
B1	No	Yes	Yes	Yes	No	Yes	No
B2	No	Yes	Yes*†	Yes*	Yes*†	Yes*	Yes*
C	No	Yes	No	No	No	Yes	No
C1	Yes*	Yes	No	No	No	No	No
C2	No	Yes	Yes	Yes	No	Yes	No

* Top performing scenario
† Some increased revenue depends on extremely high Metrorail passenger loads that would require additional service and operating costs.
†† Scenario A2 Vehicle Miles and Hours Traveled were slightly above 2010 levels (+2.5% and +0.7% above respectively), and Scenario A2 performed better than 2010 Base in other measures such as Average Travel Speed.

Note that extremely high transit passenger loads were observed in some of the scenario iterations (especially A2 and B2) and are not realistic given vehicle capacities and the likelihood of travelers to switch to other modes in such cases. However, the results are useful to illustrate the travel demand resulting from the scenario policies.

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

Land Use Inputs

The land use in Scenario A 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 forecast growth in the outer areas of the region beyond the WMATA Compact Area. As a result, long distance trips in the region still occurred at the rate in the 2040 Baseline conditions, contributing to high VMT/VHT and continued roadway congestion.

Key MOEs for the Scenario

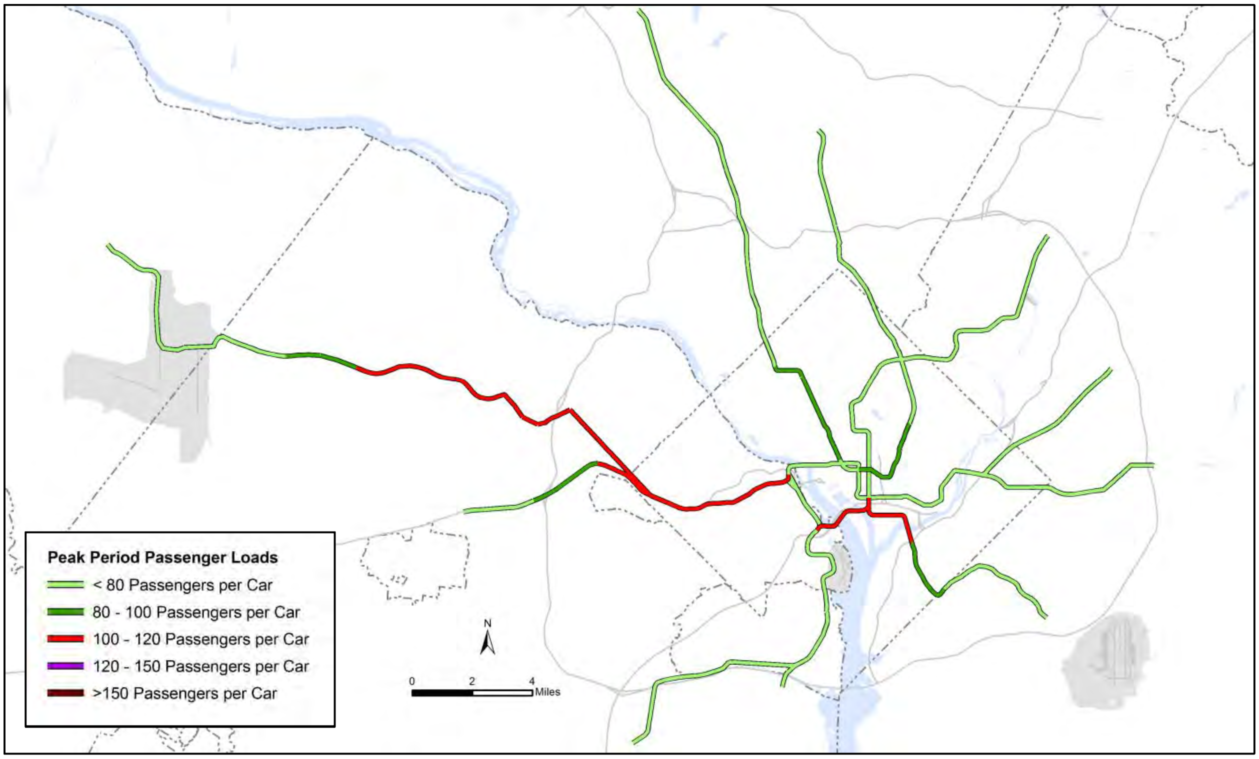
MOEs used to measure success of the scenario:

- MOE 4.3: Load Factor –
  - As shown in the maps on the following pages, passenger 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, higher ridership 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).

On the following pages, Figure 19 illustrates the Metrorail Utilization for the 2040 Baseline and Scenarios A, A1, and A2, for the peak direction. Figure 20 illustrates the Metrorail Utilization for the 2040 Baseline and Scenarios A, A1, and A2, for the reverse peak direction. Note that the 2040 Baseline Metrorail network includes the Blue Line split at Arlington Cemetery. The existing line segment north of Arlington Cemetery through Rosslyn to Foggy Bottom has higher demand than the stub service to the second Rosslyn station and carries higher passenger loads.

Figure 19: Scenario A – Metrorail Utilization, Peak Direction

2040 Baseline



Scenario A (Prime)

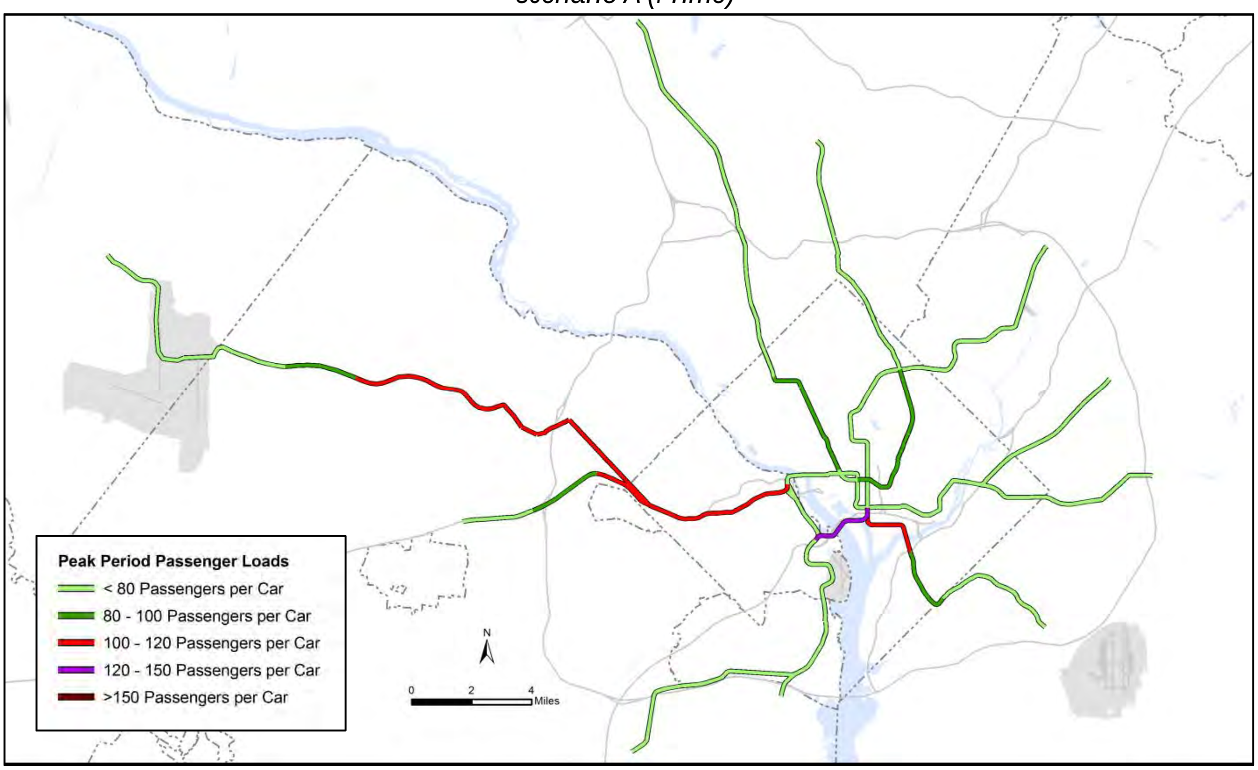
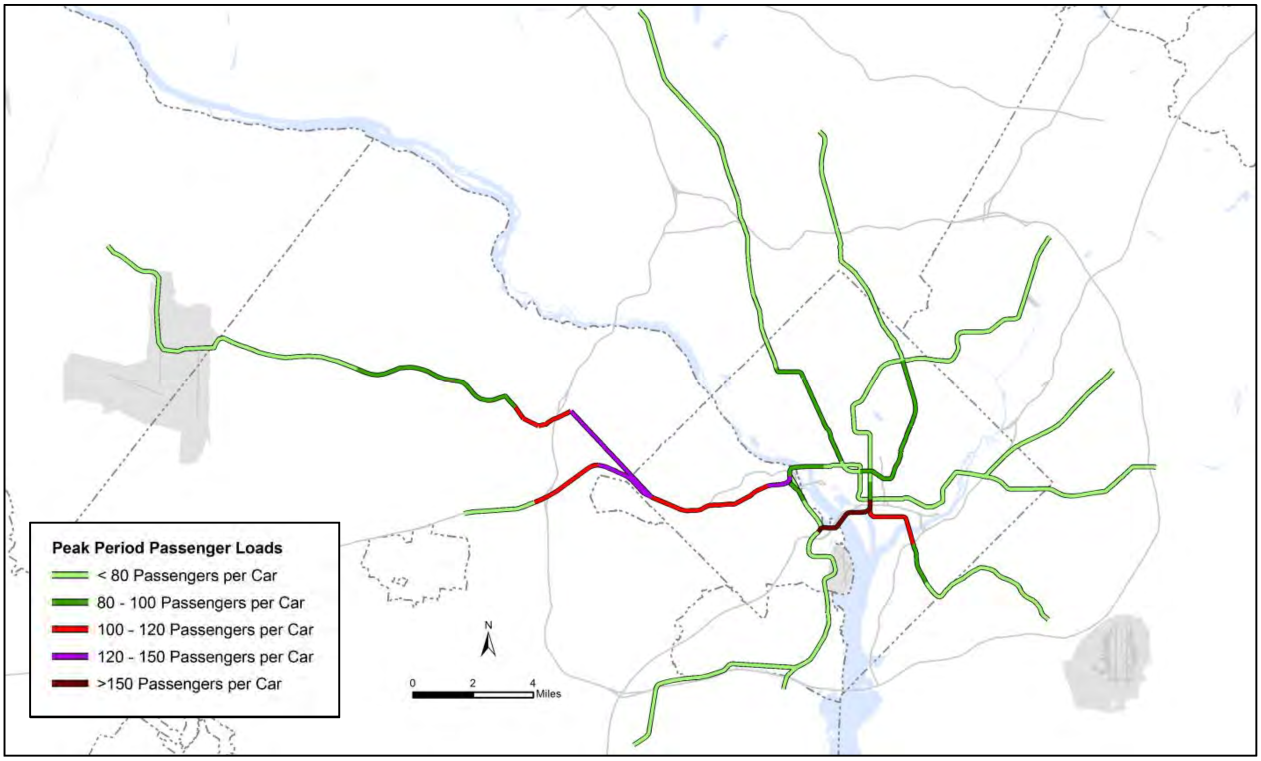


Figure 19: Scenario A – Metrorail Utilization, Peak Direction (continued)

Scenario A1



Scenario A2

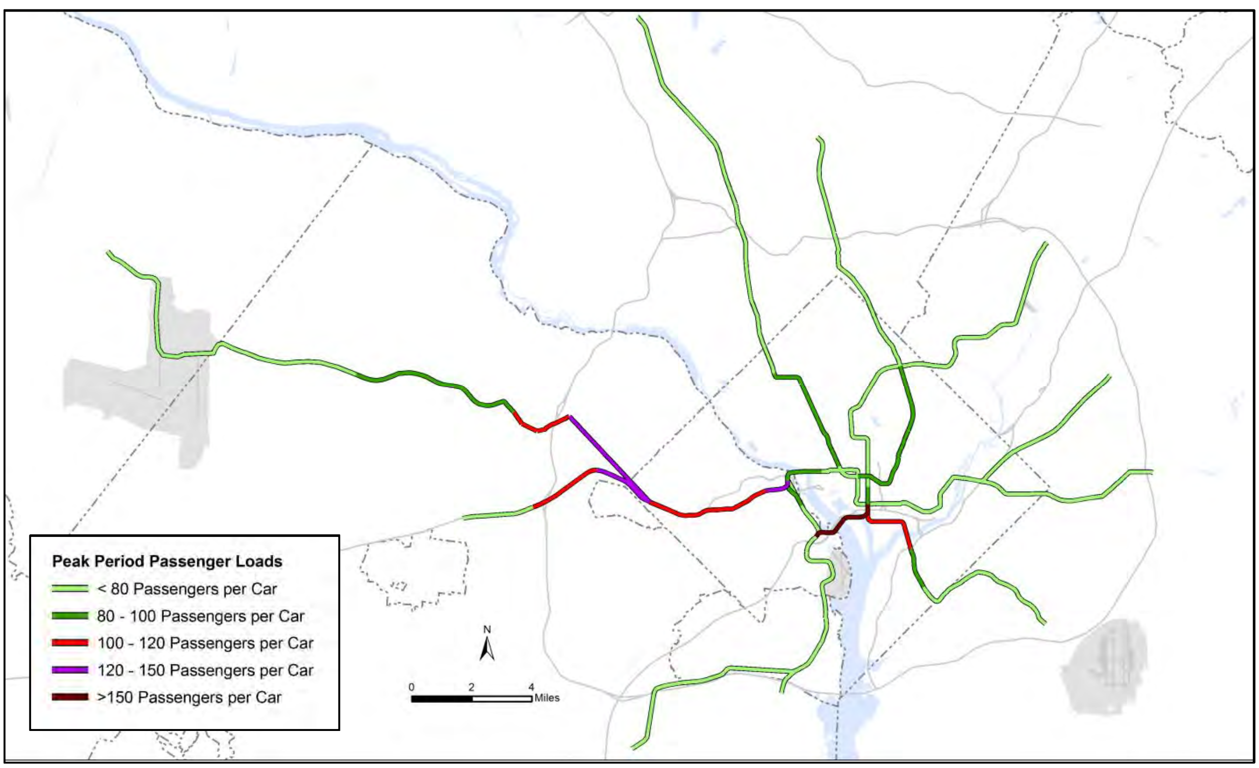
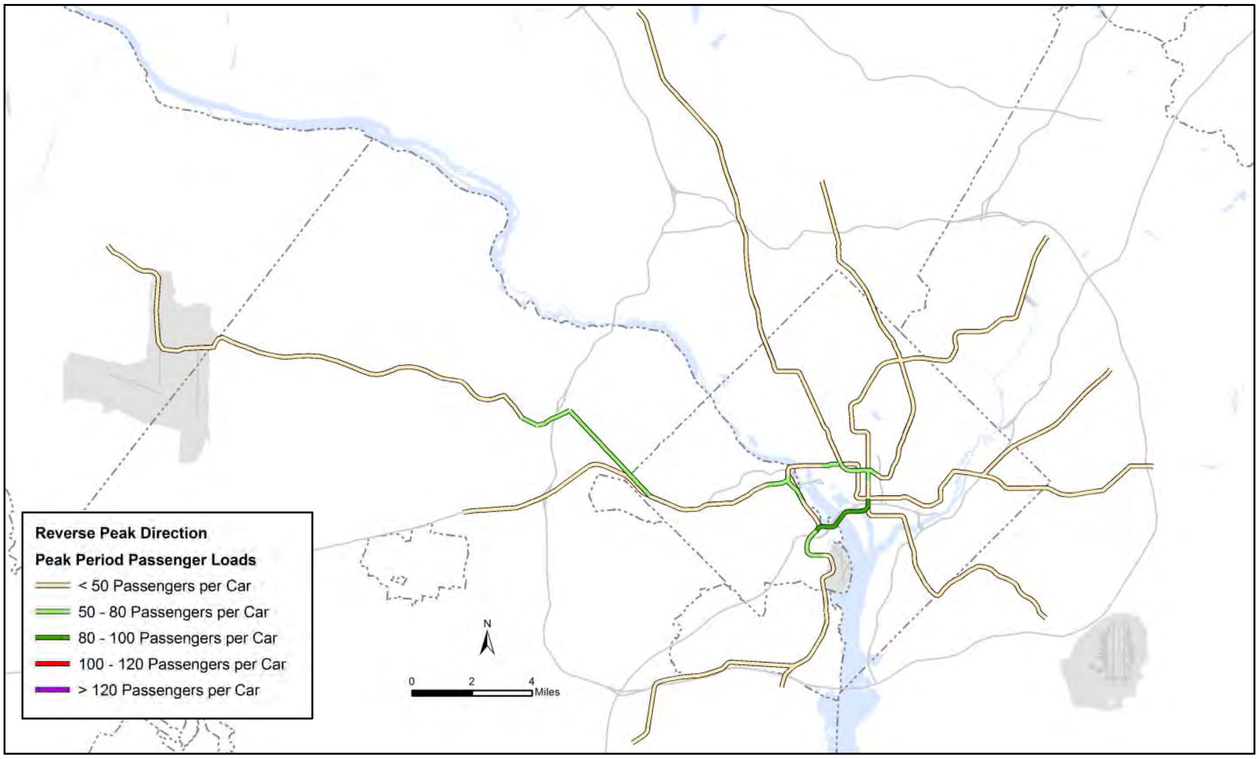


Figure 20: Scenario A – Metrorail Utilization, Reverse Peak Direction

2040 Baseline



Scenario A (Prime)

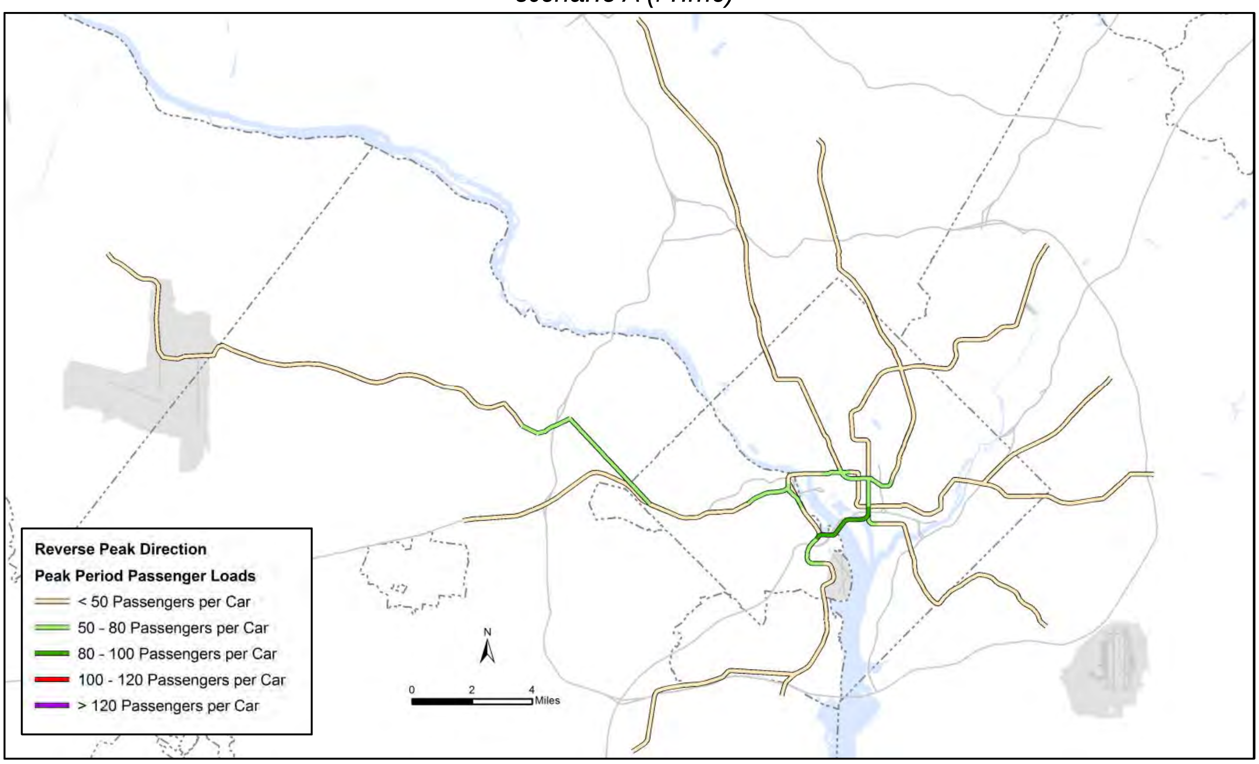
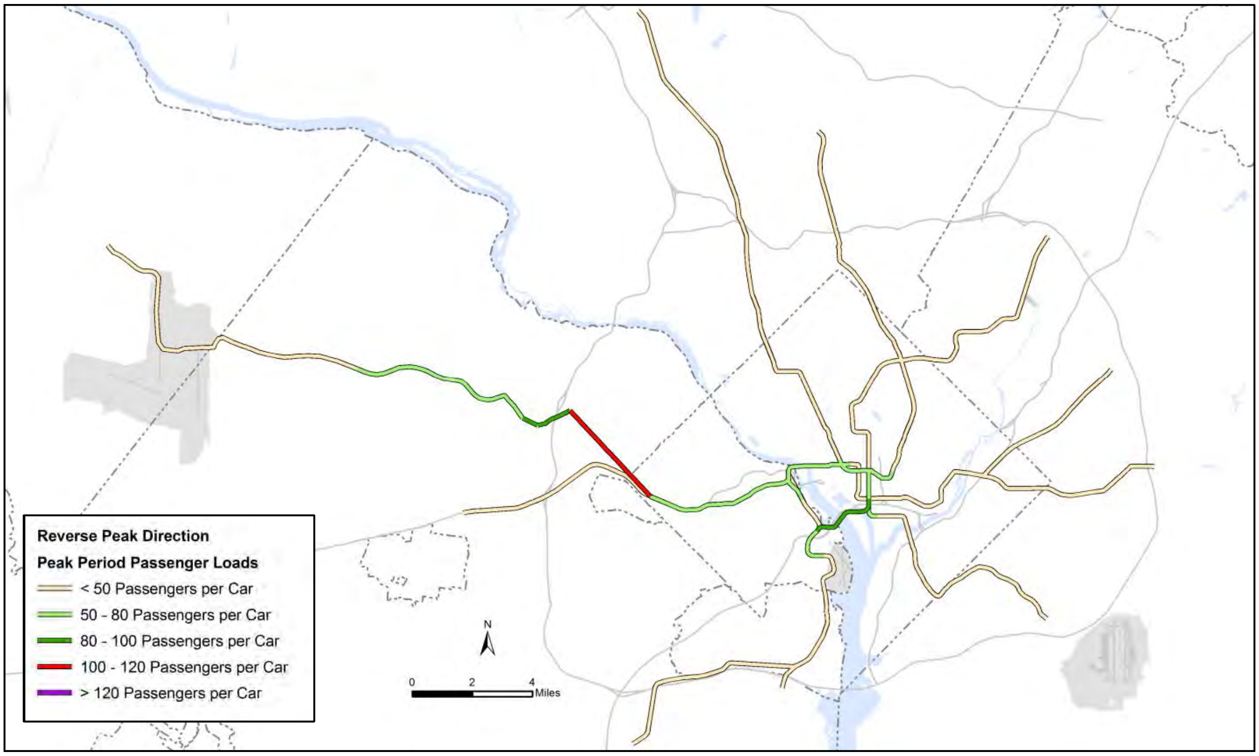
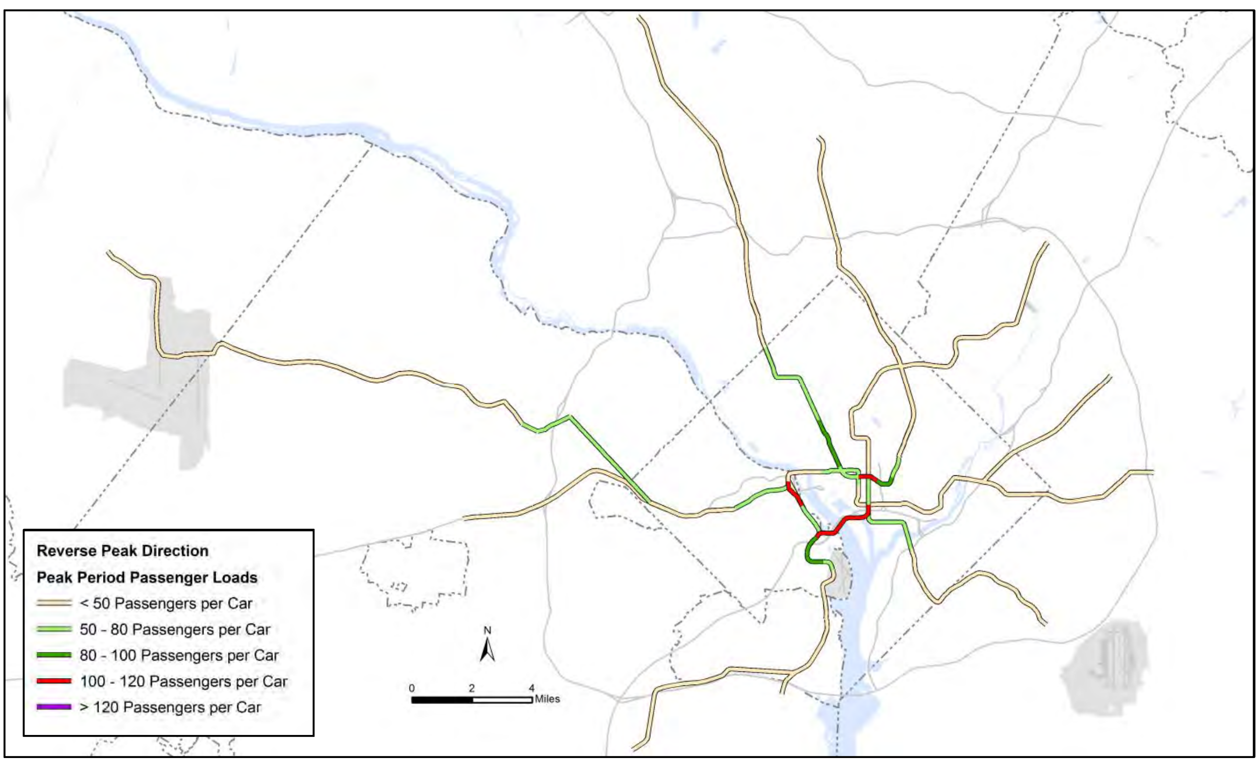


Figure 20: Scenario A – Metrorail Utilization, Reverse Peak Direction (continued)

Scenario A1



Scenario A2



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.
- 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.

4.4. 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:

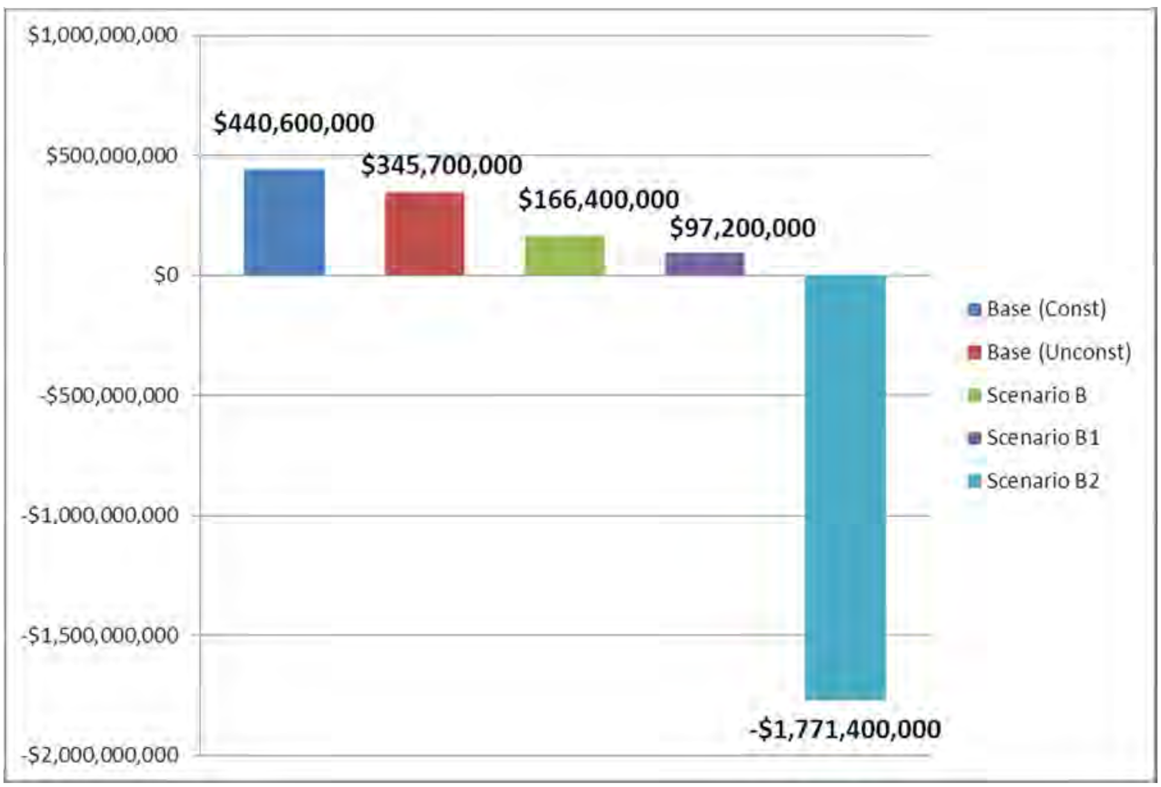
- Scenario B1 shifts were a lot more substantial than A1 shifts, moving 500,000 households and 400,000 jobs to within station areas; and
- Scenario B2 moved a total of over 1 million households and 1.6 million jobs. Under Scenario B2, over 30 percent of the region's jobs were located in DC (compared 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, see Figure 21). Scenario B2's revenues would exceed its costs (if it did not result in significant crowding). However, in reality, these ridership and revenue levels depend on extremely high Metrorail passenger loads that would require additional service and operating costs to accommodate them.
- 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.

Figure 21: Effect of Scenario B on Metrorail Operating Subsidy



Note: Subsidy amounts are in year of expenditure dollars for 2040.

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.

4.5. 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:

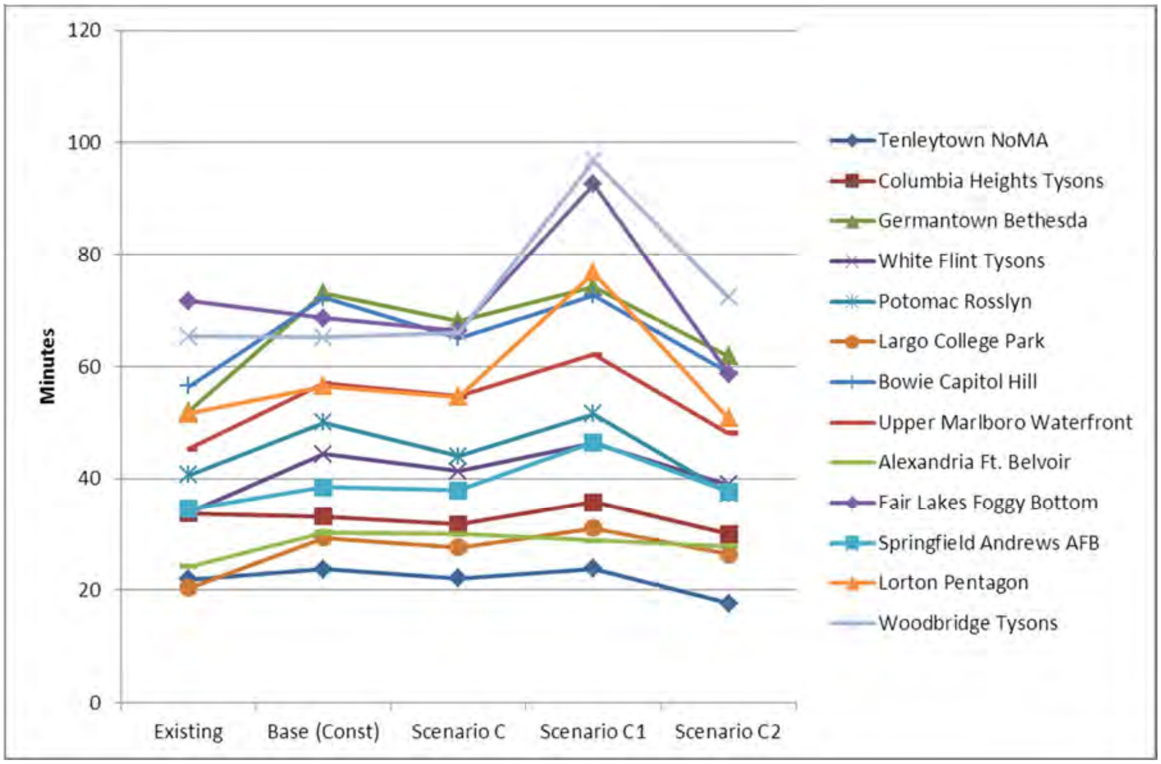
- MOE 2.8: Vehicle Hours Traveled (VHT) – Scenario C2 had the lowest VHT for these scenarios, though no C scenarios had VHT lower than 2010 conditions.
- MOE 1.3: Average Travel Time – Scenario C1 had a lower average trip time than 2010 conditions, although it had a somewhat longer average trip distance. 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 (see Figure 22 on the following page).
- 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.

Figure 22: Effect of Scenario C on Auto Travel Times for Key Regional Origin-Destination Pairs



- 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.

5.0 Stakeholder Engagement

The purpose of stakeholder outreach was to engage the region's planning professionals on the links between land use and transit and the impact of policy decisions on congestion, transit operating costs and subsidies, and land development. The CGW Technical Advisory Group (TAG) was briefed on the policy alternatives study in April 2014 and April 2015, and the regional Planning Director Technical Advisory Committee was also briefed on the study by WMATA in March 2014 and February 2015.

In addition, two major outreach efforts – a stakeholder workshop and interactive online survey – involved the region's transportation and land use planning professionals, including staff from each jurisdiction within the WMATA Compact Area and TPB planning area, regional planning agencies, regional transit providers, and professional and advisory groups. The ideas and feedback gathered will help guide the more in-depth public and stakeholder involvement efforts for the CGW plan.

5.1. Stakeholder Workshop

The CGW stakeholder workshop was held at WMATA headquarters on June 24, 2014. The three-hour program included a presentation of key project information followed by breakout work sessions, during which stakeholders discussed land use changes and other policies that could help maximize the effectiveness of the existing transit system. During these sessions, attendees gathered in small groups to discuss the potential impact of policy and land use changes on the performance of the baseline 2040 transit network, focusing specifically on overcrowded and underutilized Metrorail lines. The small groups then reported their findings to the larger group and participants used stickers to vote for land use changes and other policies that WMATA should consider when developing scenarios. Table 12 lists a summary of the top 10 ideas as a result of the workshops.

Table 12: Workshop Results - Top 10 Ideas

Table Idea	Location	Votes
Transit solutions (not Metrorail) – requires bus planning, bike share / bicycle facilities on RTSP loop	Core	9
Congestion Pricing for transit (charging more for peak direction/peak hour travel)	Regional	8
Increased VRE/MARC commuter rail going through region	Regional	8
Increased alternatives to Metrorail for short trips - bike, bus, walk, and wayfinding	Regional	7
Improve bike/walk facilities across the region – more connections across jurisdictions, bike lanes/cycle tracks, wayfinding, and regional bike master plan	Regional	7
More residential housing in DC Core	Regional	7
Metro Station Development: Build out Metro stations – increase reverse commutes to jobs and incentivize employment	Regional	7
Dedicated transit lanes on the Wilson Bridge	Regional	7
Forced capacity management - no land use change (nothing added: no new seats, no Park and Ride at peak, no new fare policy, no TDM, no accessory residential units)	Regional	5
Provide a network of options: Improved VRE service from Manassas to DC, build on Routes 7 and 29, expand round the clock service, and create managed lanes / express bus	VA Orange Line corridor	5

5.2. MetroQuest Survey

In October and November 2014 WMATA hosted an online interactive survey on MetroQuest, an online community engagement platform. WMATA emailed invitations with participation instructions to the stakeholders invited to participate in the June workshop. The MetroQuest activity gave stakeholders the opportunity to provide input on priorities, strategies, and locations that should be considered when WMATA examines how to best utilize the baseline 2040 transit network. There were 61 visitors to the site and over 30 who answered survey questions.

- Slide 1 (Welcome) gave a brief overview of the project, explaining future Metrorail crowding and the need to be responsible stewards of the region's scare financial resources.
- Slide 2 (Priorities) asked participants to rank regional transportation and land use priorities (users could rank up to four).
- Slide 3 (Strategies) asked participants to rank strategies for achieving the priorities they chose on the previous slide.
- Slide 4 (Opportunities) asked participants to identify their preferred future locations in the region for housing, employment, mixed-use development, pedestrian/bicycle facilities, other facilities, and/or a preference for "No changes" by placing markers on a Google map that included the Metrorail system.

Table 13 lists the ranking of the priorities by site participants.

Table 13: MetroQuest Survey Respondent Priority Rankings

Priority	Ranking 1	Ranking 2	Ranking 3	Ranking 4	*Users who ranked in Top 4*
Develop in Activity Centers	17	6	7	2	*32*
Improve Access to Jobs	6	7	6	7	*26*
Reduce Transit Travel Time	5	11	11	3	*30*
Reduce Crowding on Transit	4	3	5	6	*18*
Conserve Open Space	3	2	2	5	*12*
Reduce Traffic Delays	1	5	0	6	*12*
Contain Cost to Taxpayers	0	2	3	5	*10*

Based on these priorities, the strategies awarded the highest number of stars were: improving conditions for biking and walking, building more mixed-income housing near Metrorail stations and jobs, giving priority to buses on roadways, encouraging mixed-use development, and providing real-time transit information and wayfinding.

For the Opportunities mapping exercise, 26 participants placed almost 900 markers.

- The "Mixed Use" marker was placed the greatest number of times (361), followed by Walk-Bike (274), Housing (89), and Jobs (85). Slightly over half of all markers were placed in either Fairfax County or Prince George's County. This does not necessarily indicate that these counties require the most improvements and changes but likely reflects the participation levels of these jurisdictions and other agencies and stakeholders that focus on those jurisdictions.

- Over 70 percent of total markers were placed within 1.5 miles of an existing Metrorail station. Most of the markers placed significantly outside the 1.5 mile Metrorail station radii were located in Virginia, near future Silver Line Metrorail stations, I-66, I-95, or in southern Fairfax County.
- Approximately three quarters of the markers were located within a mile of a RAC that will have high-capacity/high-frequency transit service (Metrorail or other type) in 2040.

6.0 Conclusion

The policy alternatives showed that land use and mobility/accessibility policies can have significant results on transit utilization and performance of the transit system and overall transportation system. However, in a region expected to continue growing in population and employment, some capacity improvements to the transit network would also be needed to address forecast transit crowding and Metrorail core capacity limitations. That said, changes in land use decisions while adding pricing strategies could provide the region with the necessary funds to make expansion possible.

Land Use Findings

Achieving purely balanced passenger loads is difficult considering that most of the land use (existing and land use changes through 2020) is fixed. Increasing population and employment densities generally across the Metrorail and other high-capacity transit stations across the region results in higher ridership throughout the system – in all directions. The scenarios showed how effective land use combined with walkability can be in fostering ridership. Scenario A in particular showed that transit usage can increase significantly through land use policies and improved walking and biking access alone (carrots), even without increases in the cost of driving (sticks). However, the general increase in ridership results in additional crowding on Metrorail and other transit modes, unless additional capacity is provided.

Shifting population and employment growth across jurisdictions was needed to see noticeably higher utilization of Metrorail lines on the east side of the region and in reverse peak-direction trips (Scenario A2). However, these greater overall shifts in population and employment towards transit station areas, compared to just shifting land use within jurisdictions (Scenario A1) also resulted in higher crowding on already crowded Metrorail segments. Shifting population and employment growth only within jurisdictions (Scenarios A1, B1, and C2) was also unable to address long-distance driving commutes from outer suburban locations and these scenarios actually had higher total VMT unless significant driving policies were included, such as the cordon pricing in Scenario B1.

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. However, currently strong travel markets, such as the Orange and Silver Line corridor will remain in high demand and continue to experience congestion without additional capacity, even if future growth in population and employment is more evenly balanced across the region.

MWCOG's designated place types for the RACs served as useful guidelines for shifting land use in a manner consistent with broad regional goals and local visions for their activity centers and station areas. However, these place types also limited the amounts of population and employment that could be reallocated to reduce the spatial mismatch in housing and jobs.

Travel Policy Findings

Non-land use travel policies also showed the potential to significantly affect the transit and overall transportation system performance. Some of the limited policy changes, such as those in Scenario A prime, had very limited effects, but others (Scenarios B and C prime) that included more significant measures, such as cordon pricing and teleworking, had noticeable effects on regional travel patterns.

Cordon pricing produced major travel demand shifts to transit even without any land use changes. A $5 toll (inbound only) was assumed in this analysis and a more optimal charge could be identified depending on the desired outcome and transit ridership levels.

Similarly, the VMT tax rate selected for the C scenarios (1.1 cent/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.

In addition, the policies designed to reduce the overall demand for peak-period motorized travel (teleworking, alternate work hours, non-motorized trips) can help ease congestion on the roadway network without necessarily adding to transit crowding. These policies also reduce Metrorail ridership and revenue as well as auto travel, so their effects on the transit system would need to be considered in addition to their recognized benefits in managing roadway congestion.

Appendix A: Detailed Results for Key MOEs

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

Figure 23 through Figure 32 on the following pages 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 33 through Figure 37 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 23: Metrorail Peak Load Factor 2040 Base (Unconstrained)

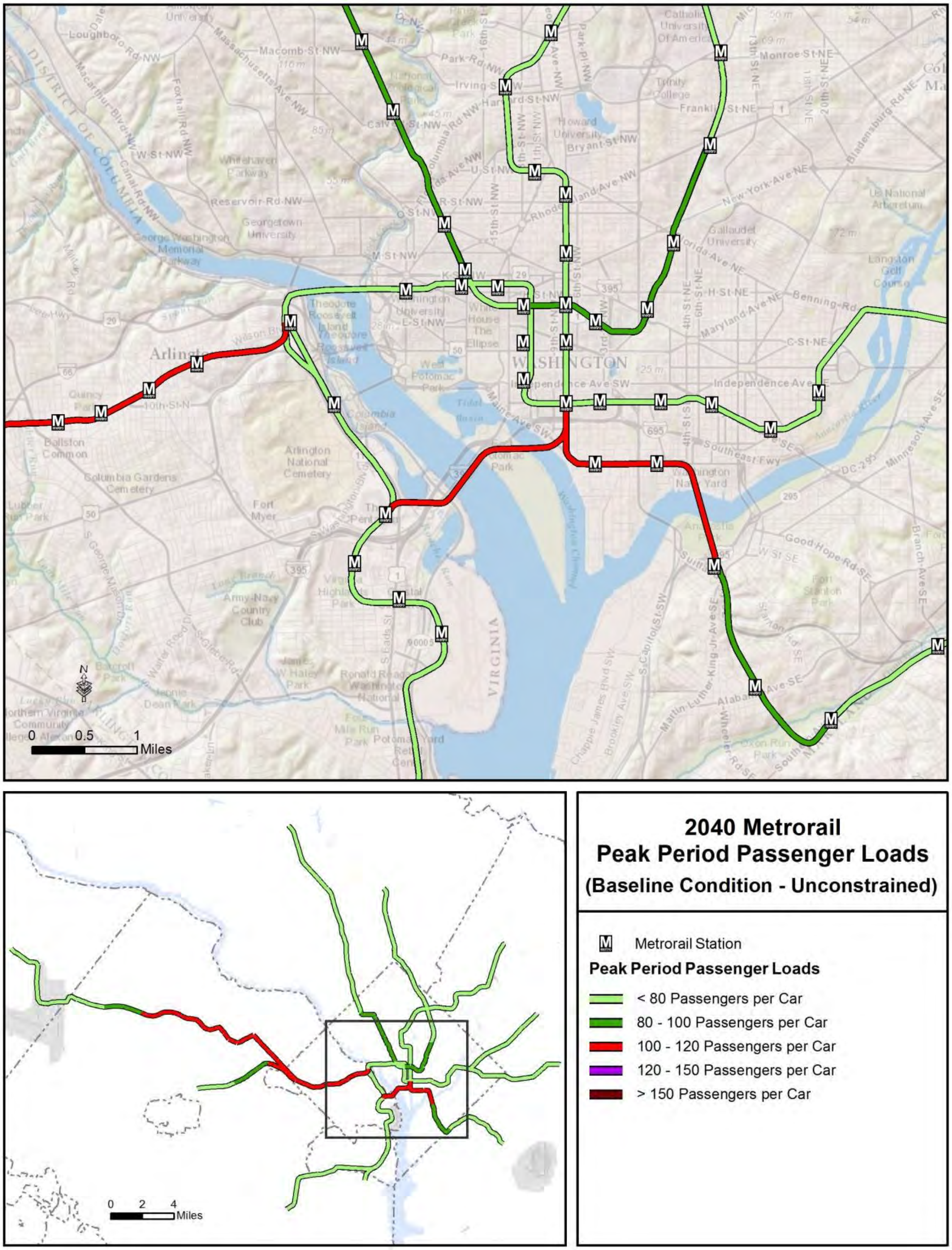


Figure 24: Metrorail Peak Load Factor Scenario A

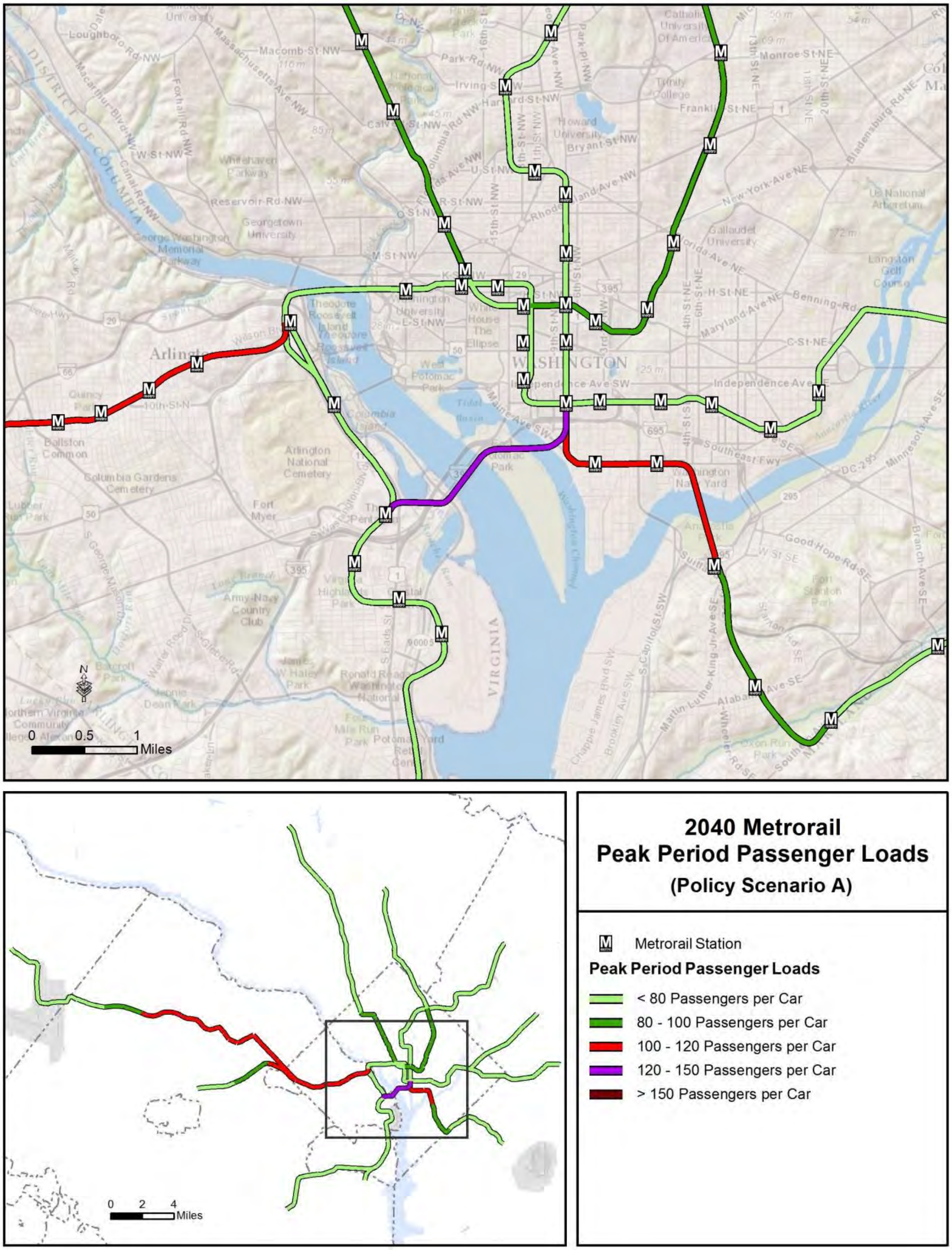


Figure 25: Metrorail Peak Load Factor Scenario A1

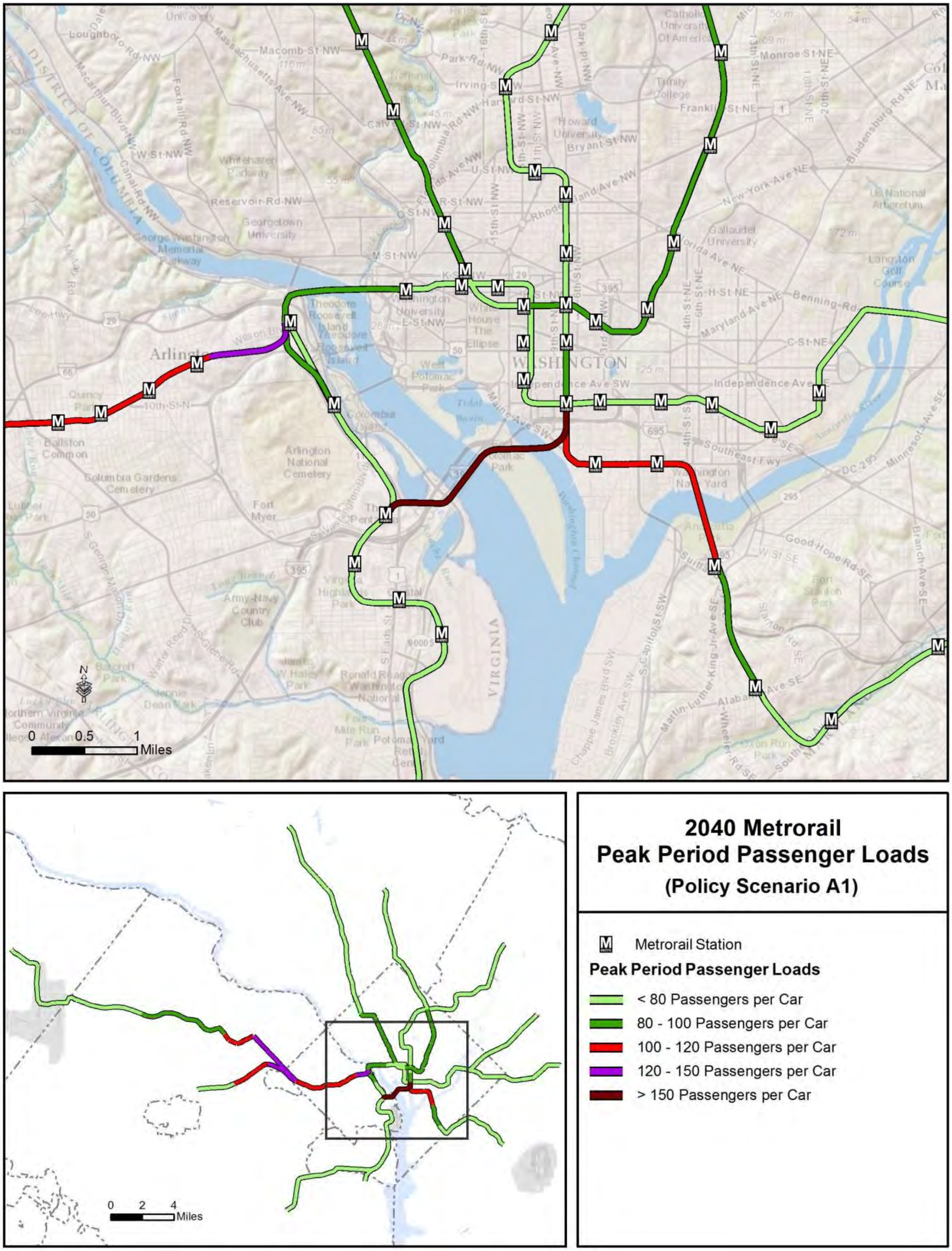


Figure 26: Metrorail Peak Load Factor Scenario A2

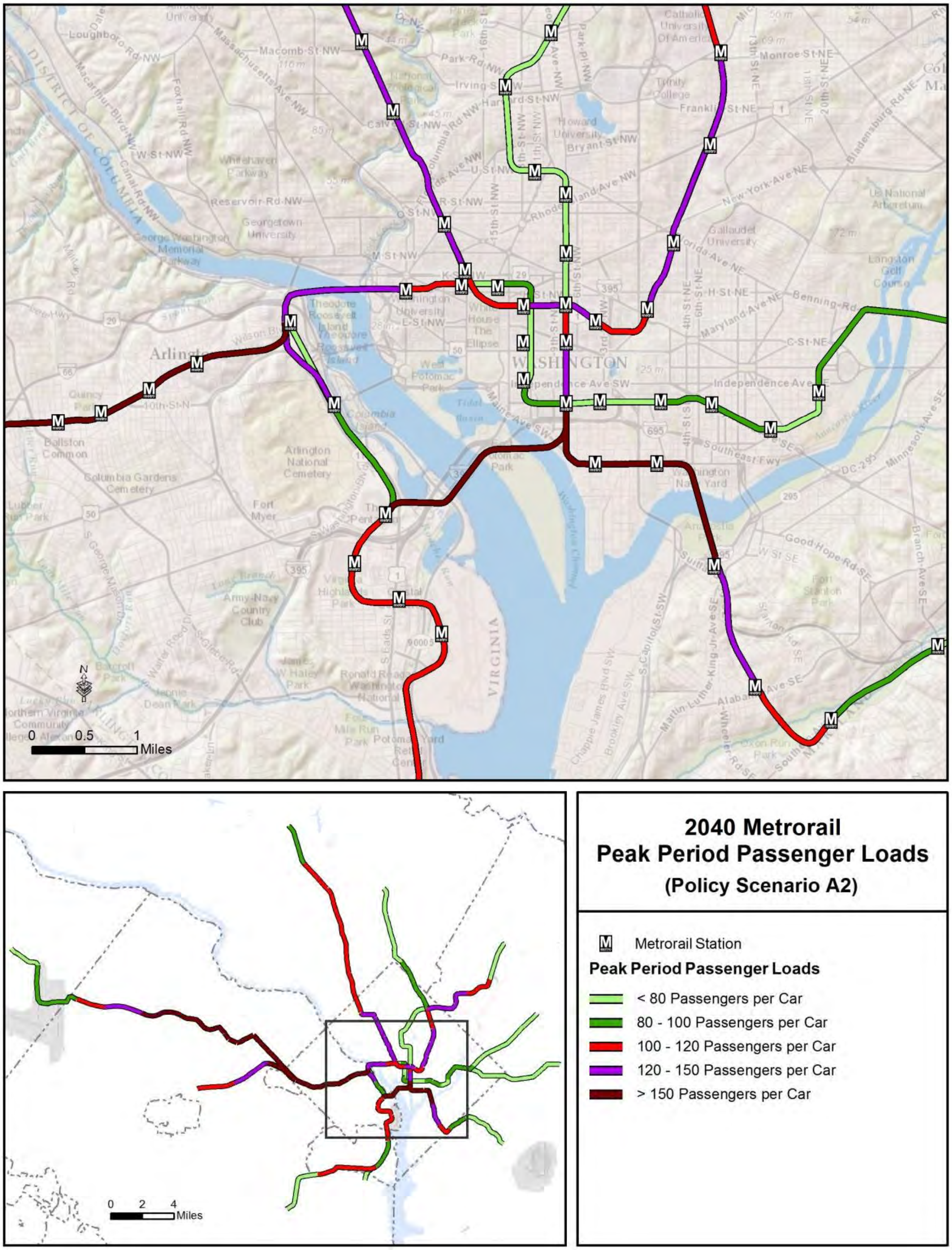


Figure 27: Metrorail Peak Load Factor Scenario B

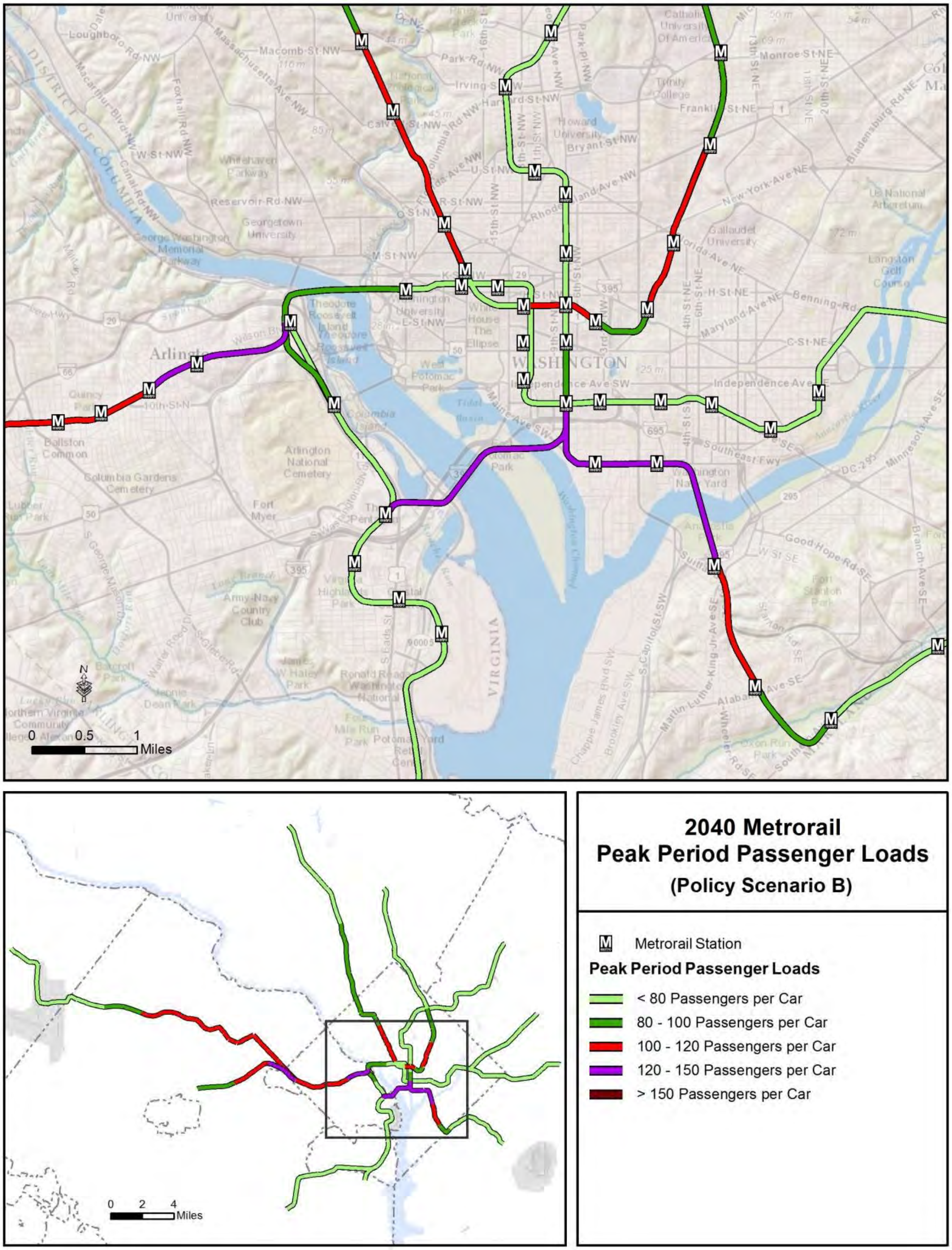


Figure 28: Metrorail Peak Load Factor Scenario B1

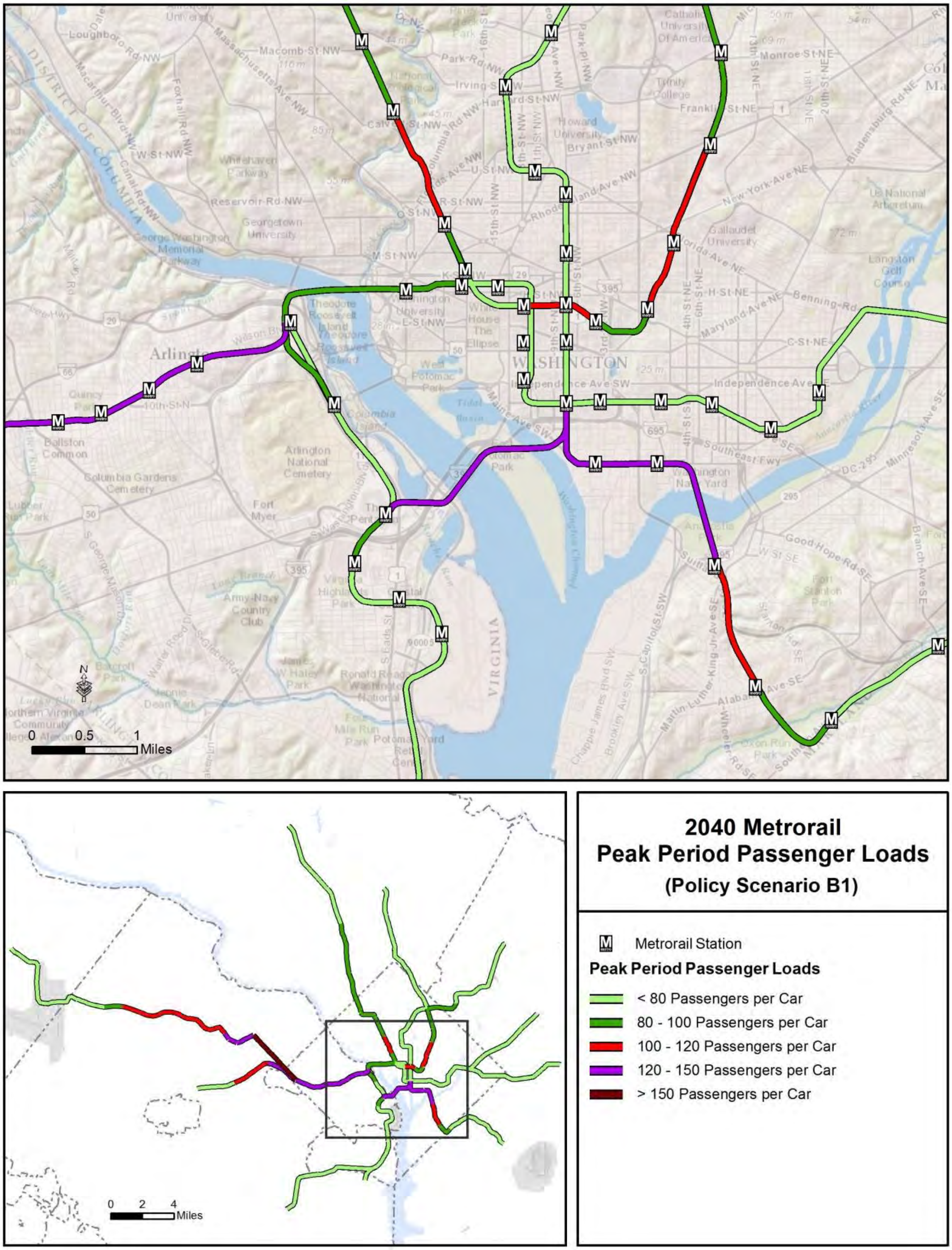


Figure 29: Metrorail Peak Load Factor Scenario B2

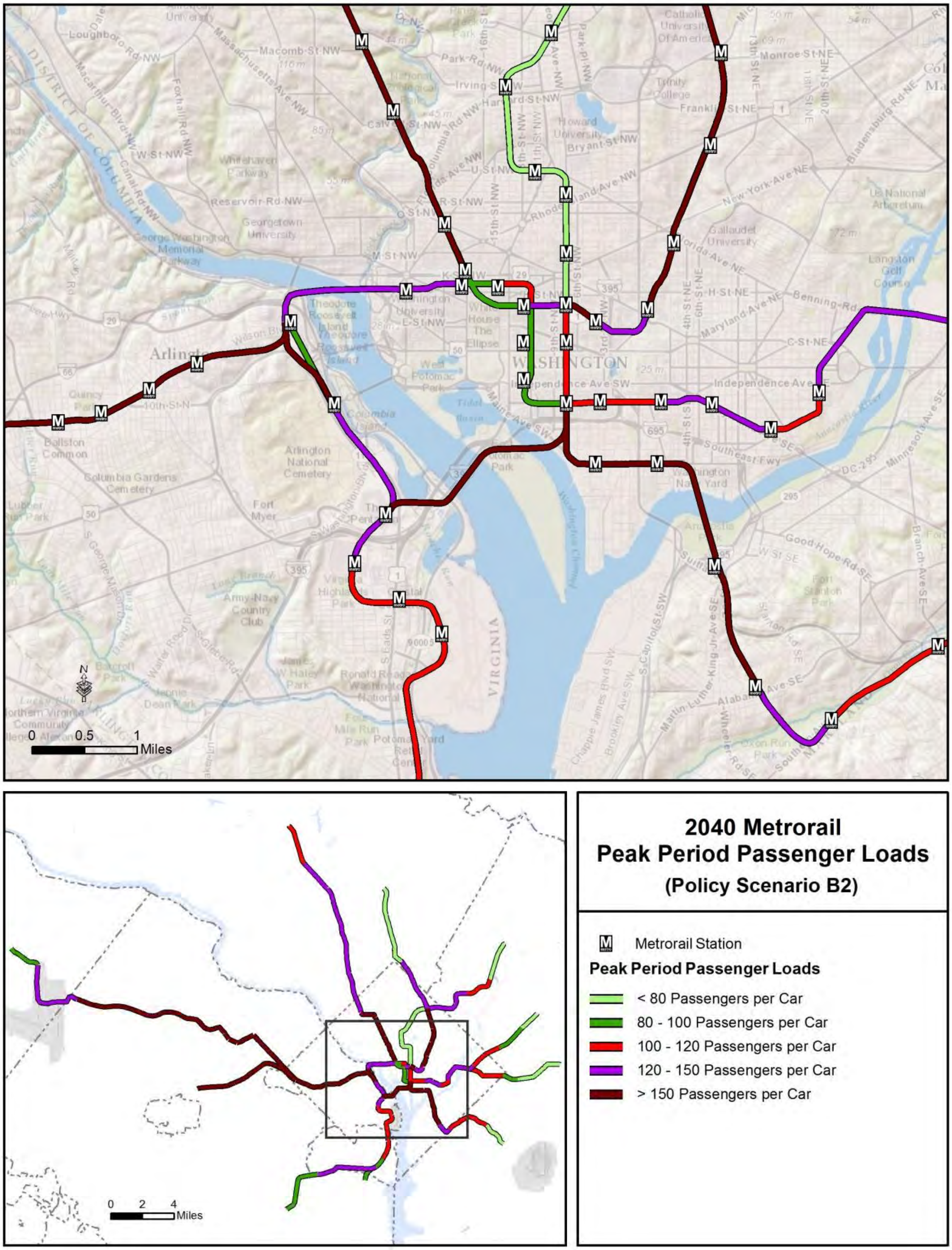


Figure 30: Metrorail Peak Load Factor Scenario C

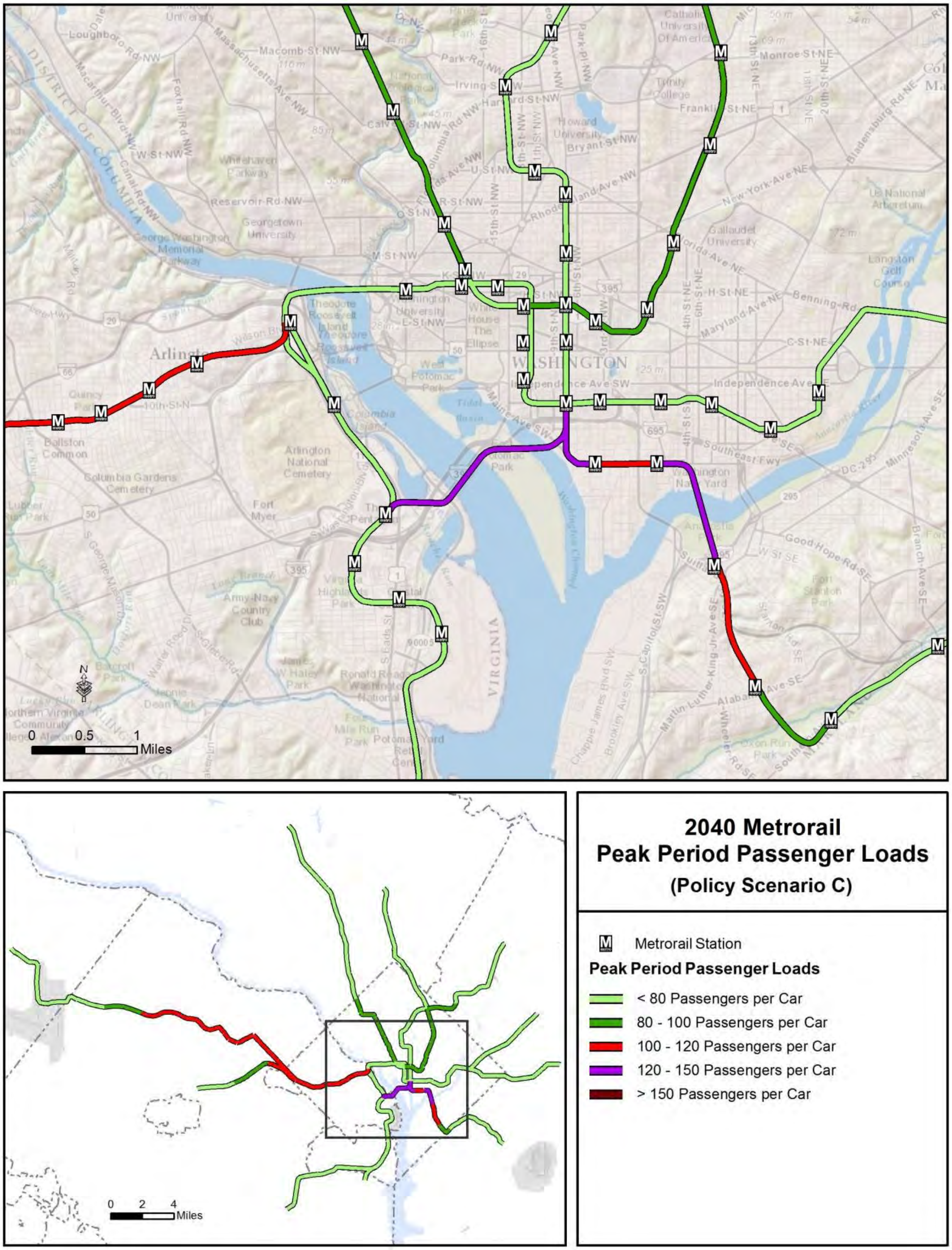


Figure 31: Metrorail Peak Load Factor Scenario C1

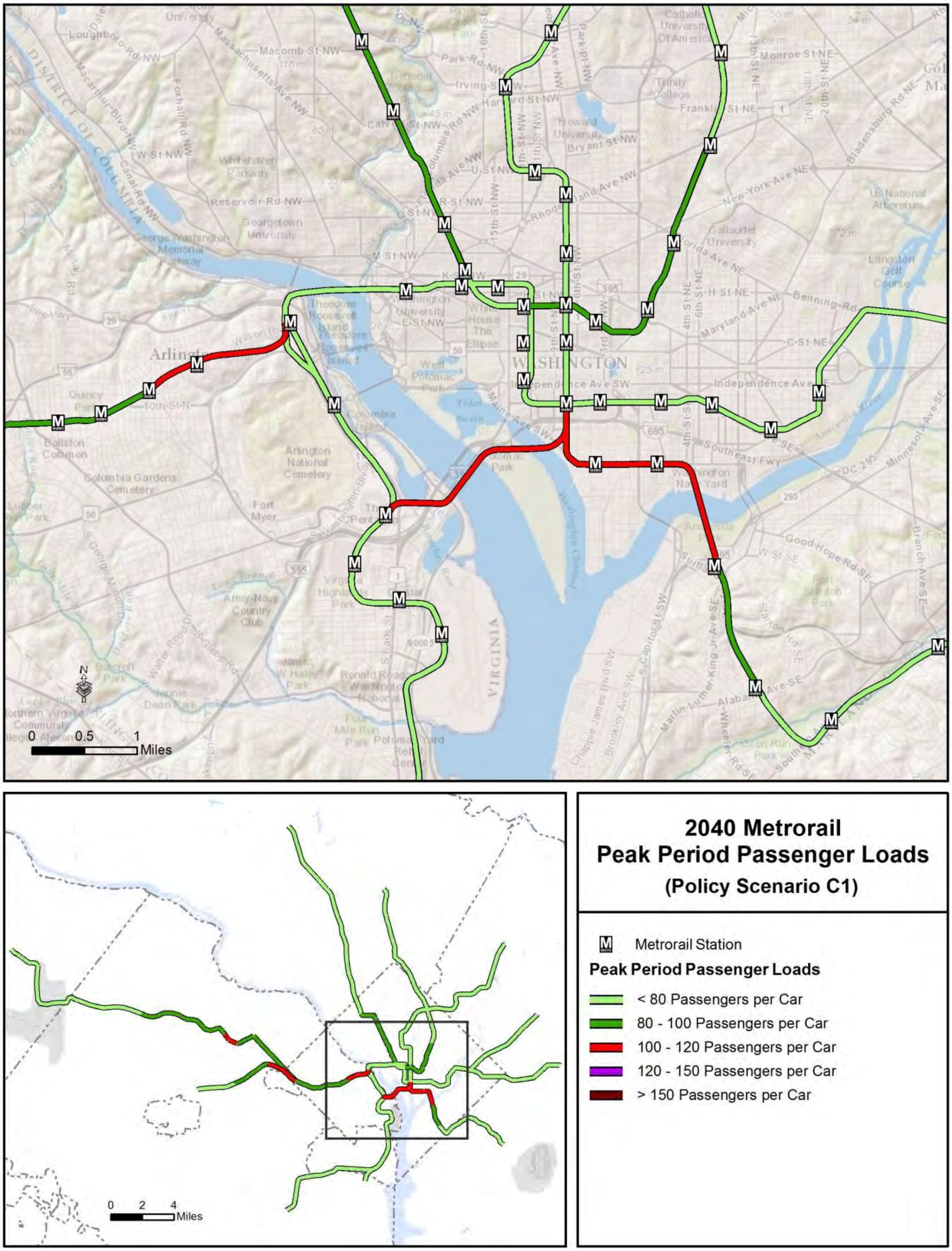


Figure 32: Metrorail Peak Load Factor Scenario C2

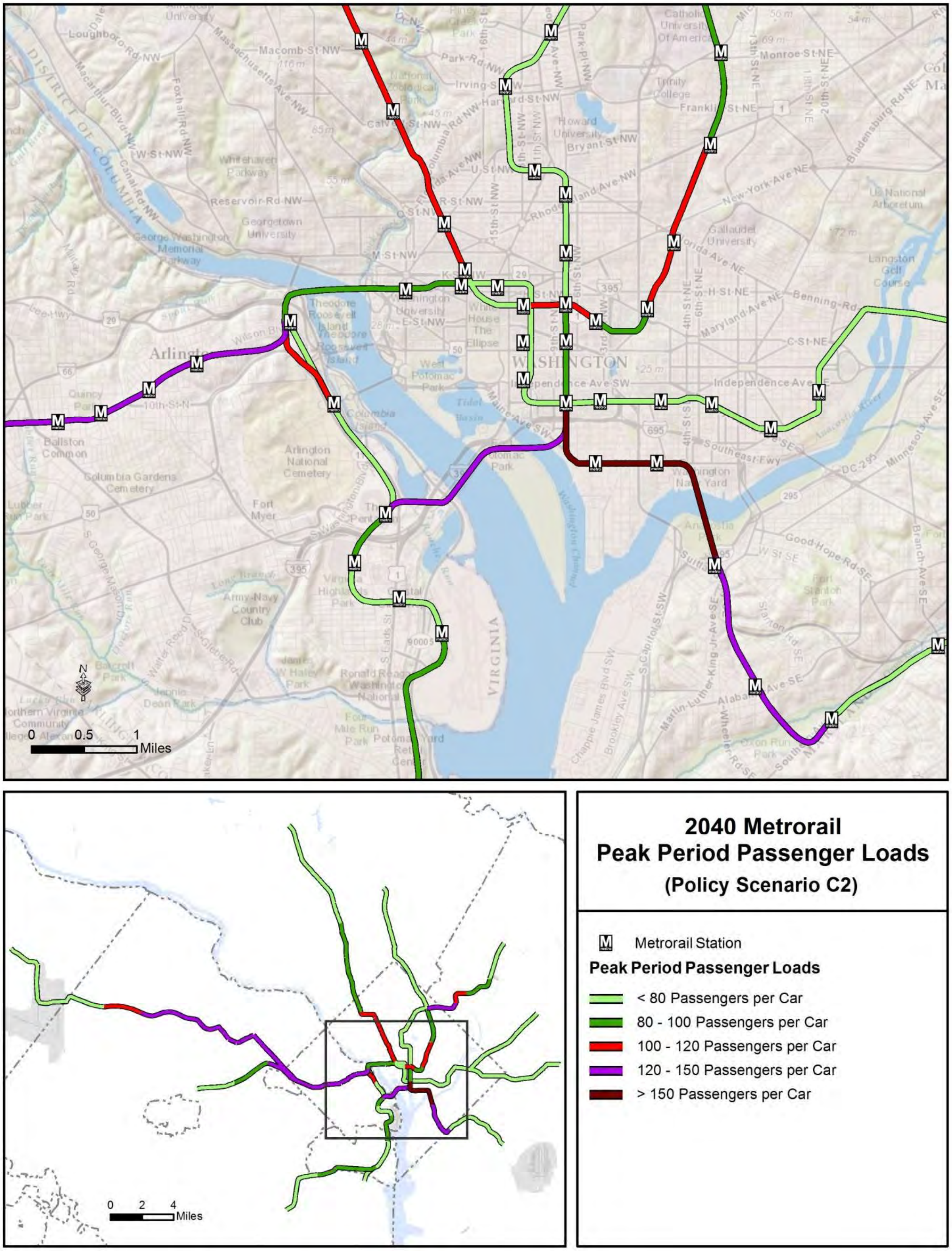


Figure 33: Reverse Peak Direction Peak Period Passenger Loads (2040 Base – Constrained)

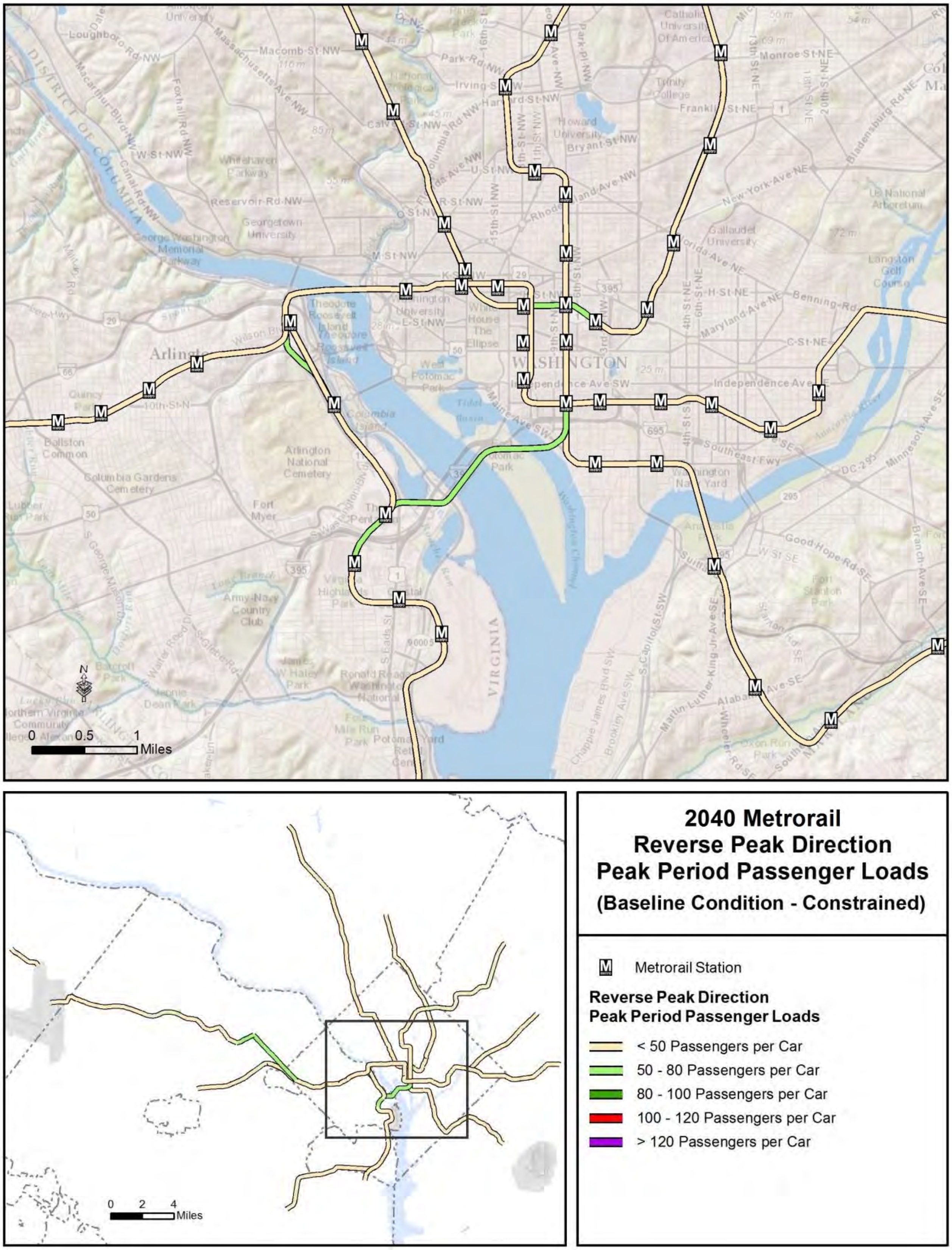


Figure 34: Reverse Peak Direction Peak Period Passenger Loads (2040 Base – Unconstrained)

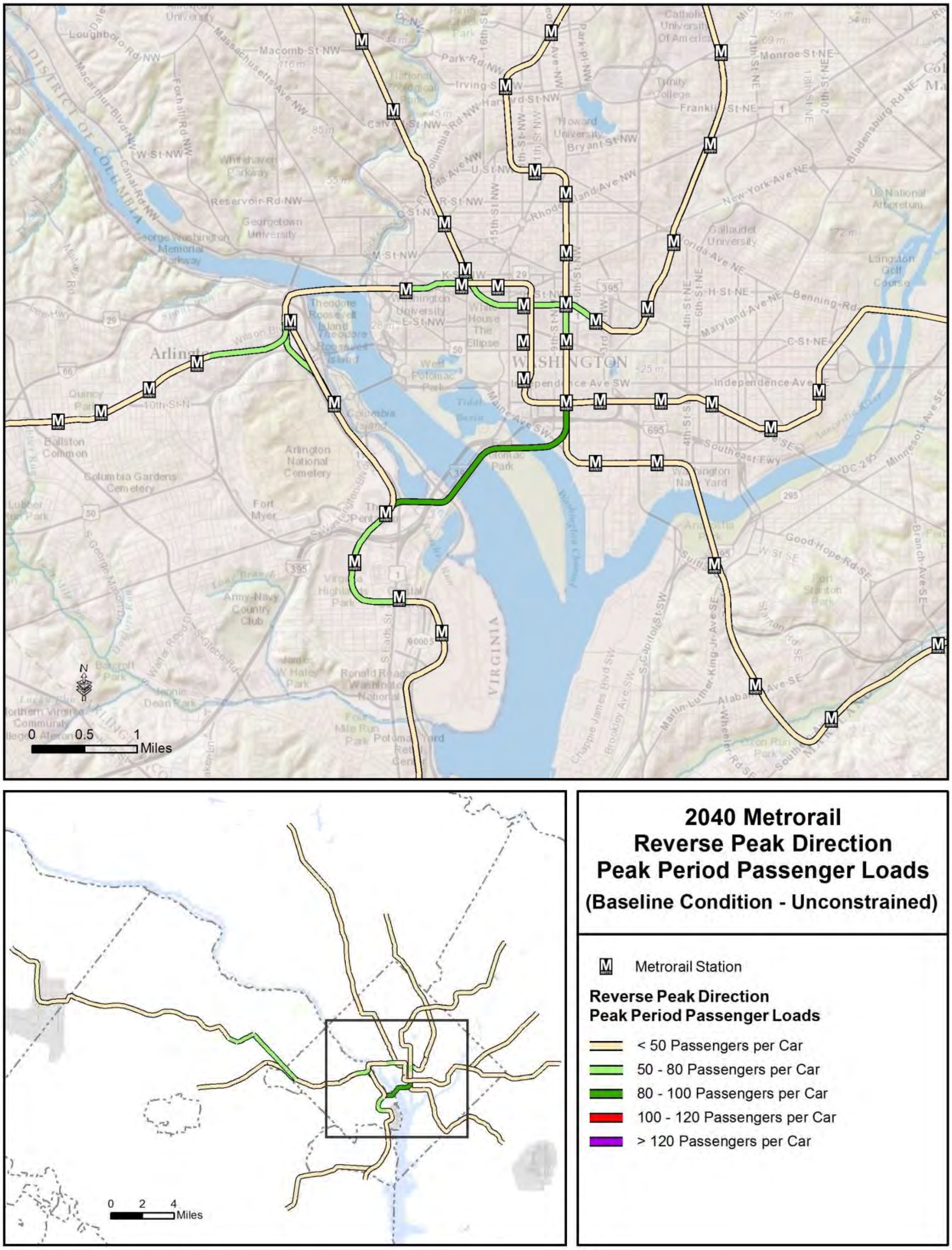


Figure 35: Scenario A Reverse Peak Direction Peak Period Passenger Loads

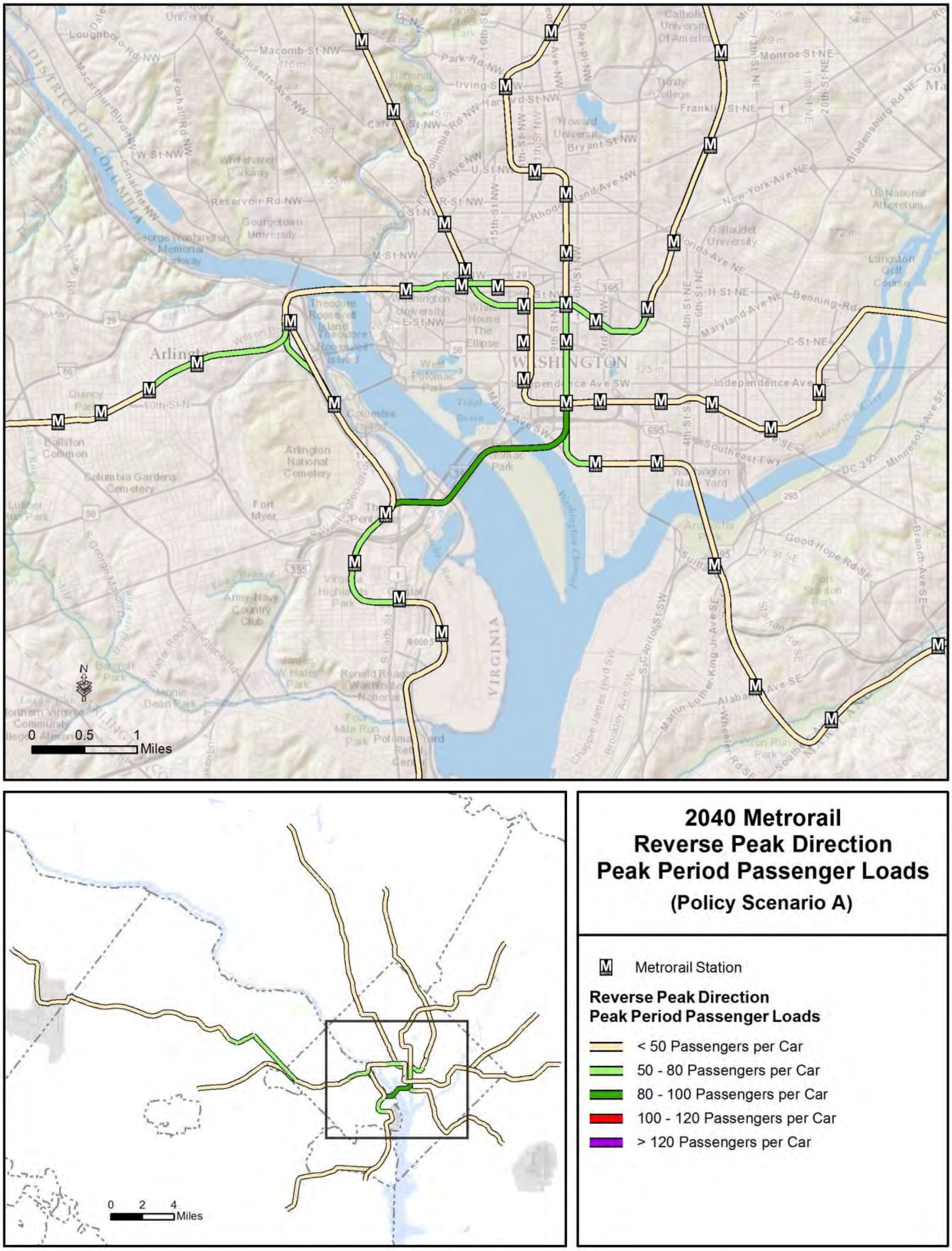


Figure 36: Scenario A1 Reverse Peak Direction Peak Period Passenger Loads

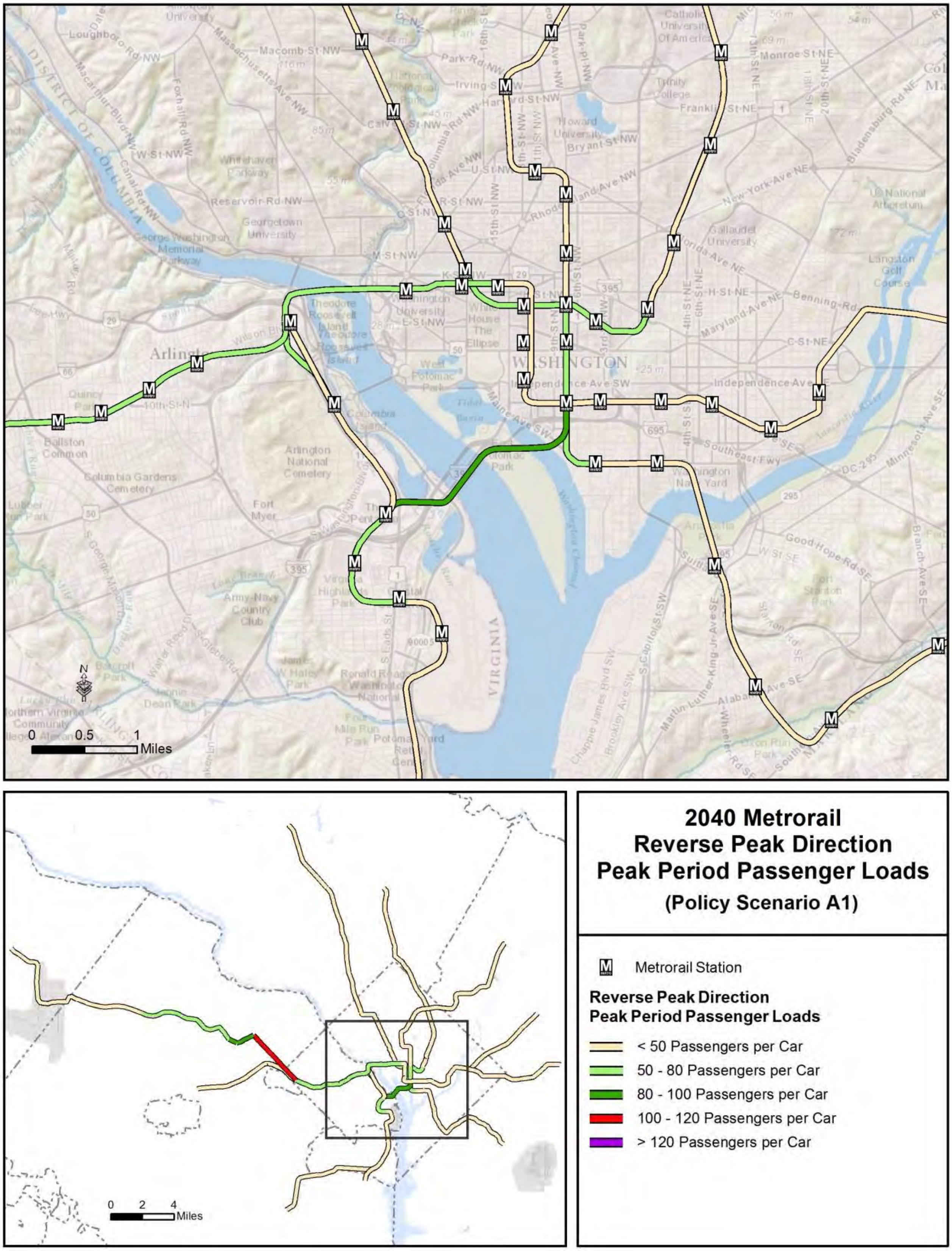
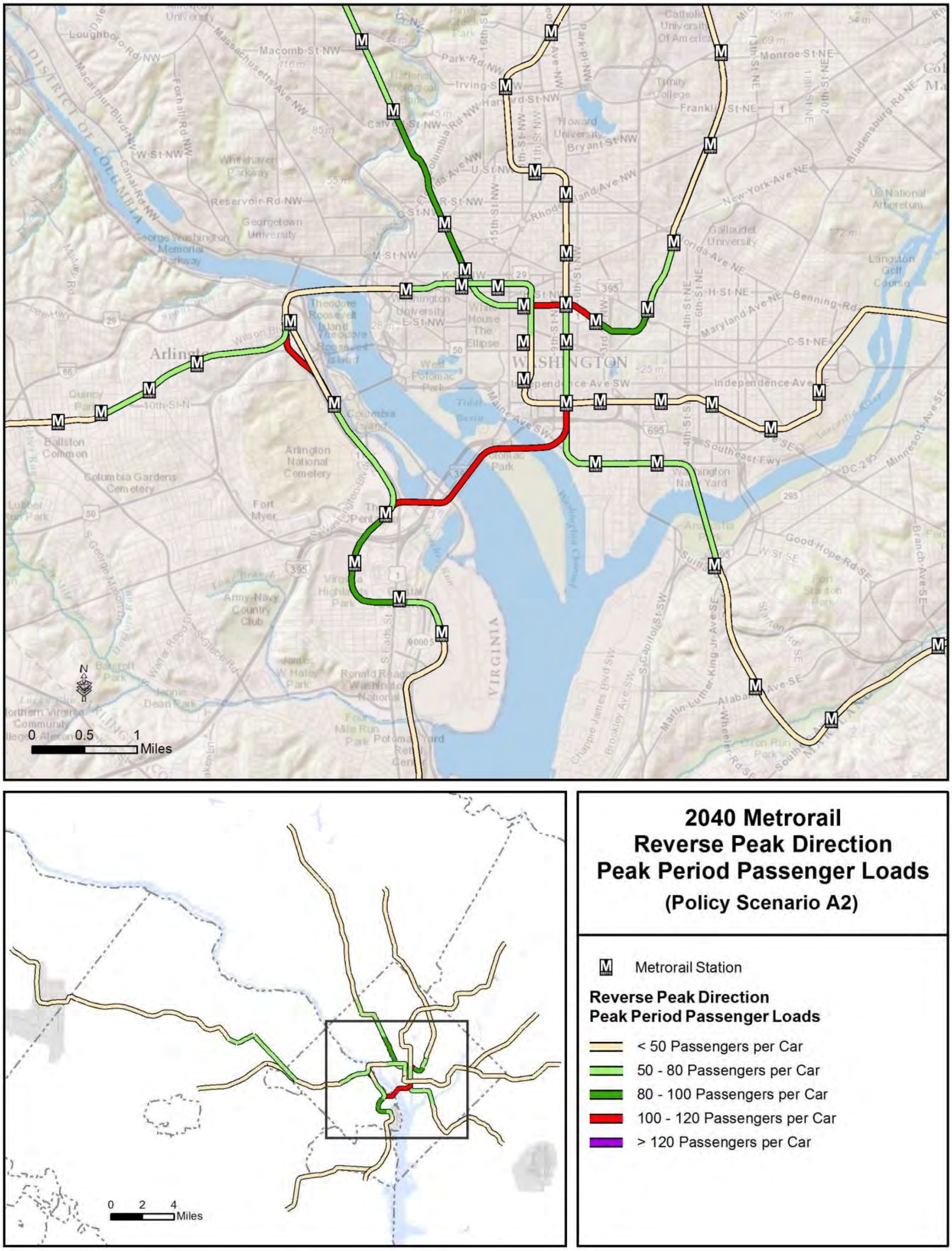


Figure 37: Scenario A2 Reverse Peak Period Passenger Loads



Average Load Factor Deviation (MOE 4.5)

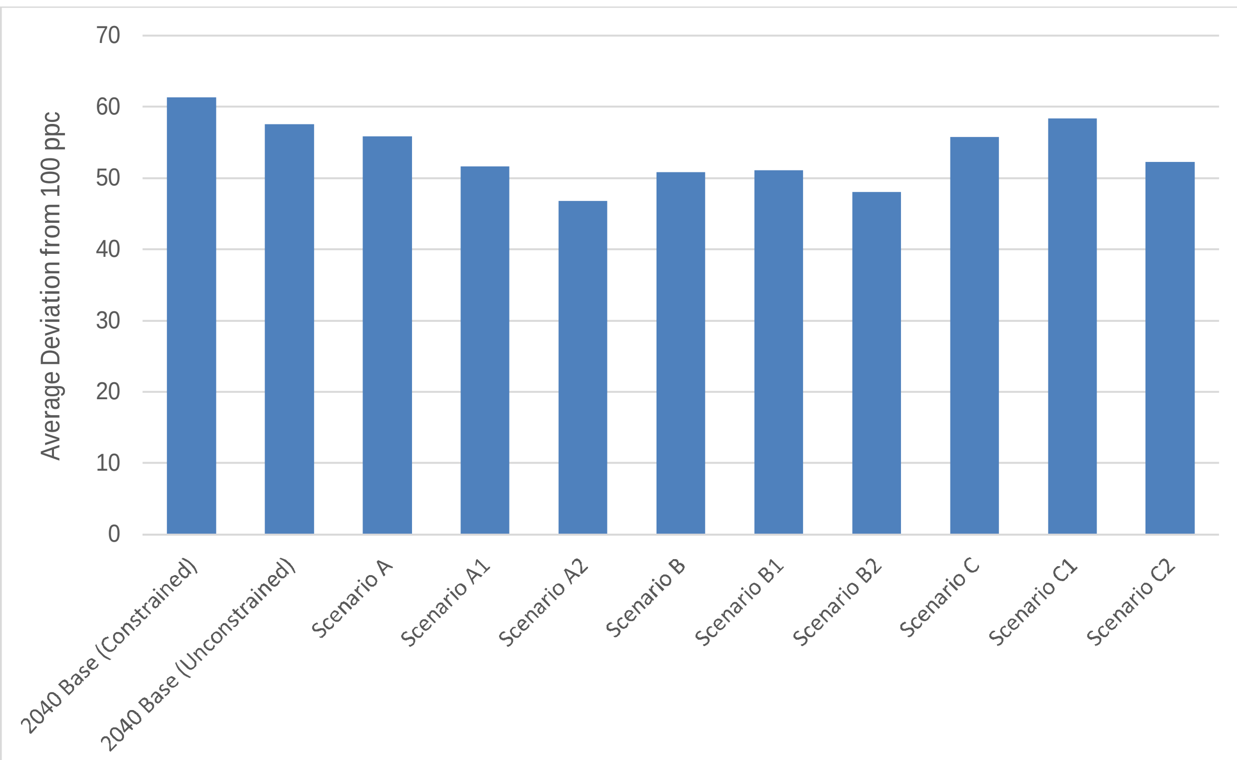
This MOE measures transit service utilization as the average deviation from optimal passenger loads, including both underutilization and overutilization of a transit service. Efficient transit utilization was a key objective for Scenario A. The MOE was calculated for the peak period in all directions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

Metrorail Load Factor Deviation

Figure 38 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.

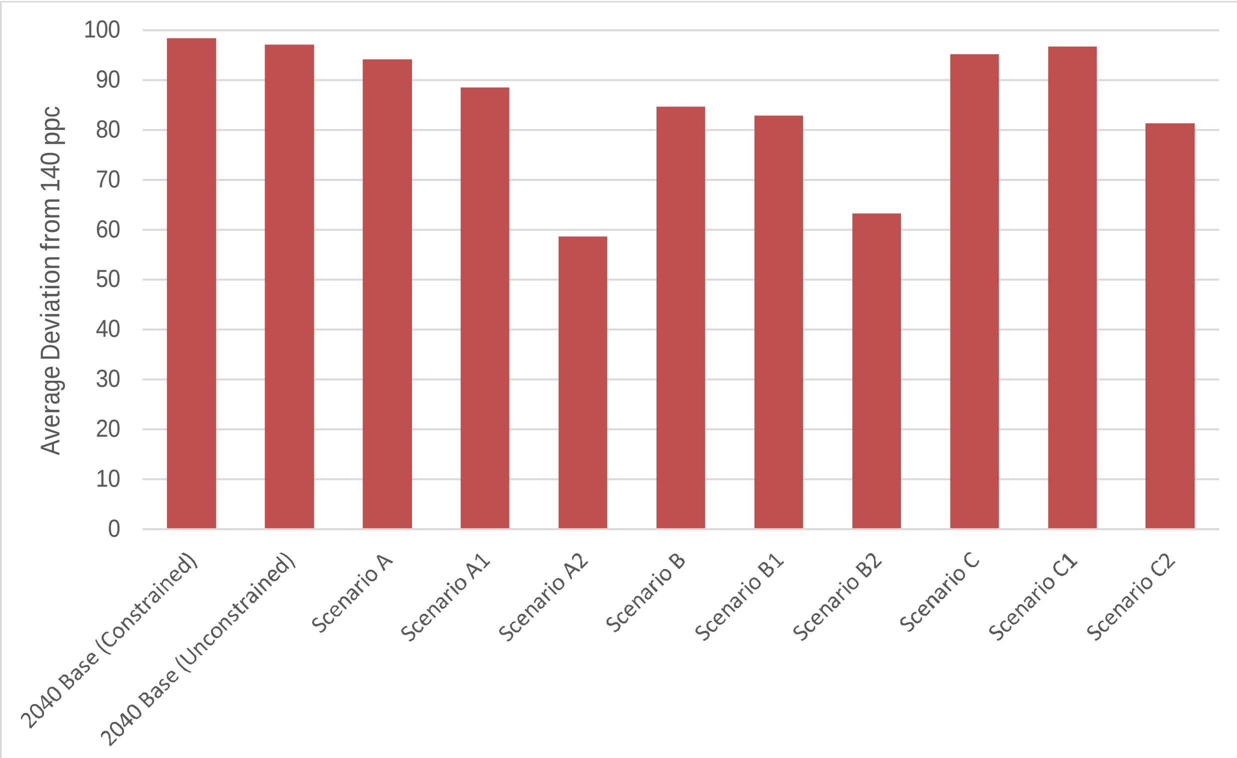
Figure 38: Peak Period Load Factor Deviation - Metrorail



Light Rail Transit (LRT) Load Factor Deviation

Ideal load factors for LRT are higher than Metrorail, at 140 ppc. As shown in Figure 39, 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 39: 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 41 on the following page. The load factor deviation results (below in Figure 40) 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 42, which highlights the Scenario B2 results.

Figure 40: Peak Period Load Factor Deviation - Streetcar

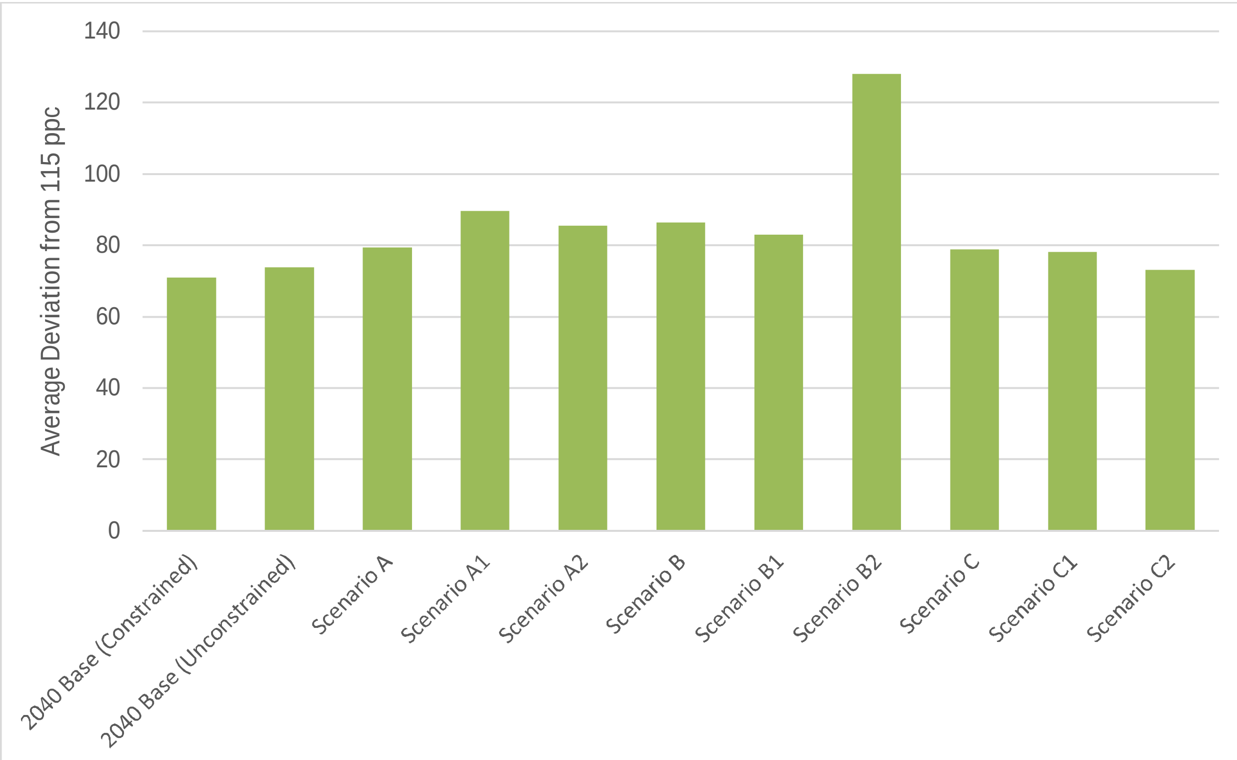


Figure 41: Streetcar Network Peak Period Load Factors – Baseline (Constrained)

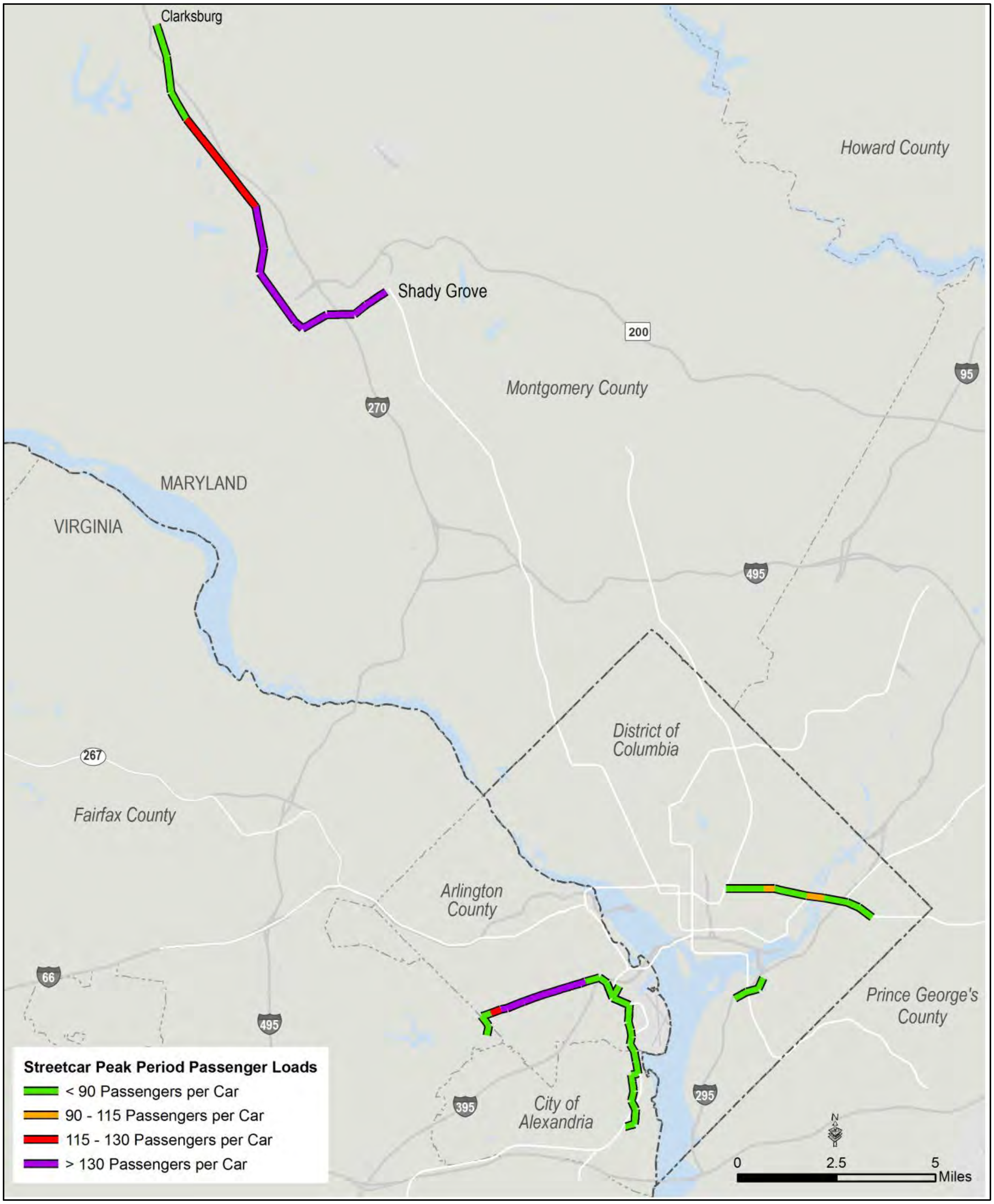
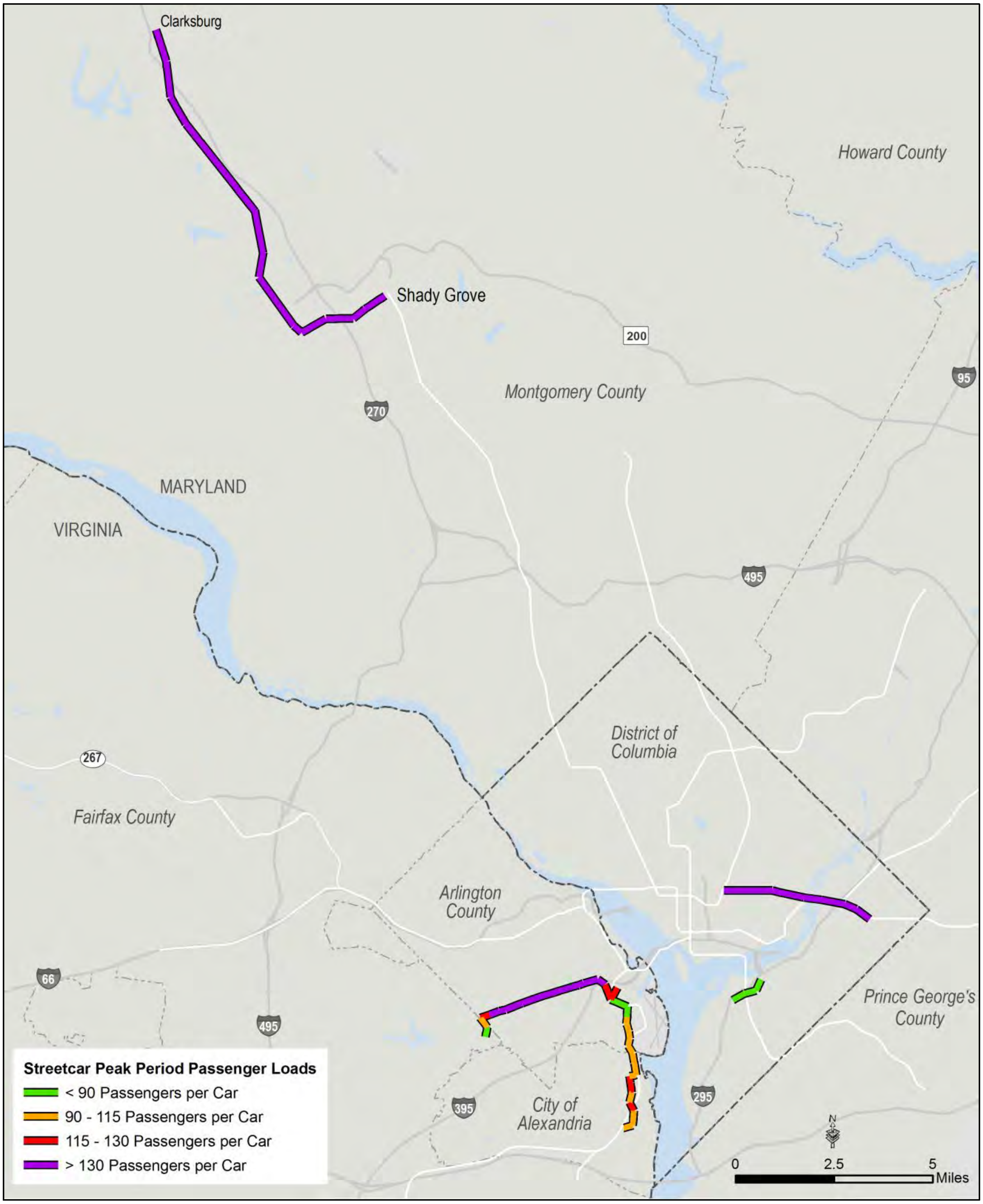


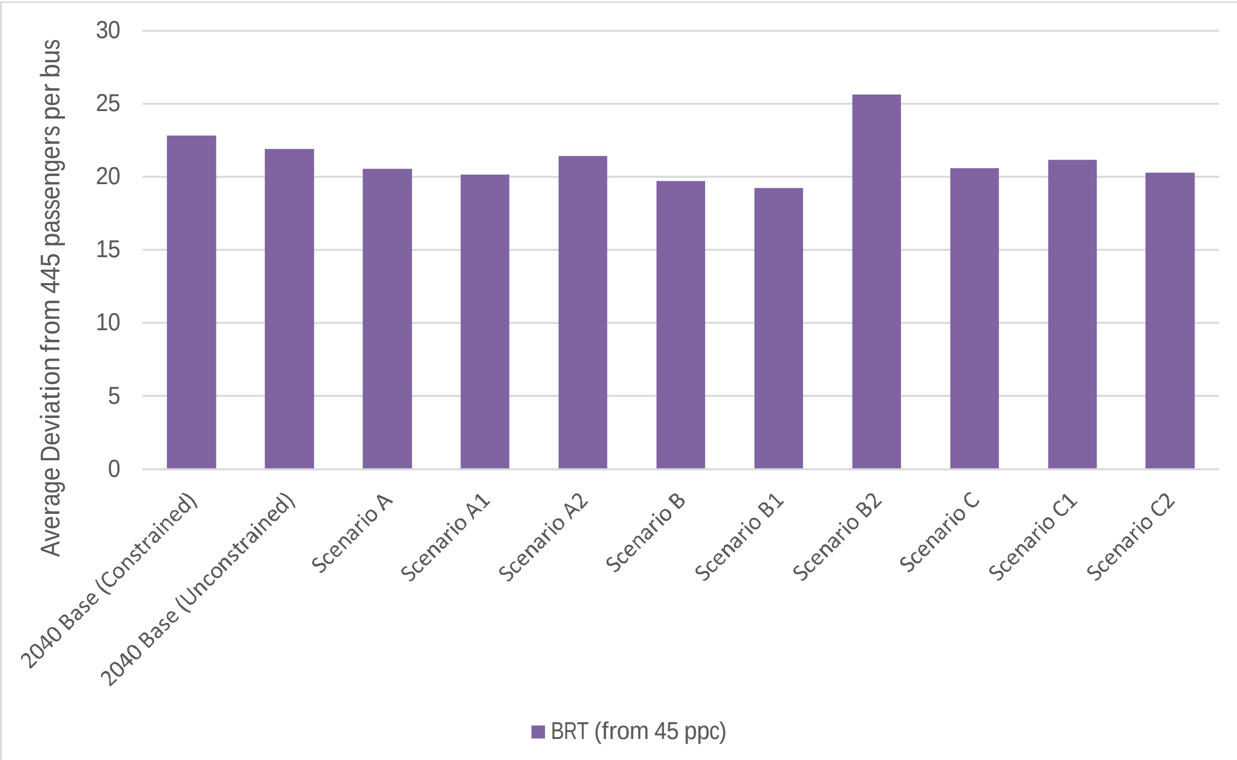
Figure 42: Streetcar Network Peak Period Load Factors – Scenario B2



Bus Rapid Transit (BRT) Load Factor Deviation

The optimal load factor for BRT is 45 passengers per vehicle. As shown in Figure 43, 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 43: Peak Period Load Factor Deviation - BRT



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 44. During the peak period, Scenarios A2 and B2 had utilization higher than 100 percent – particularly on buses, PCN, and streetcar, as shown in Table 14. Overall, average utilization was greater than 100 percent only for Scenario B2.

Figure 44: Peak Transit Utilization (passenger miles per seat mile)

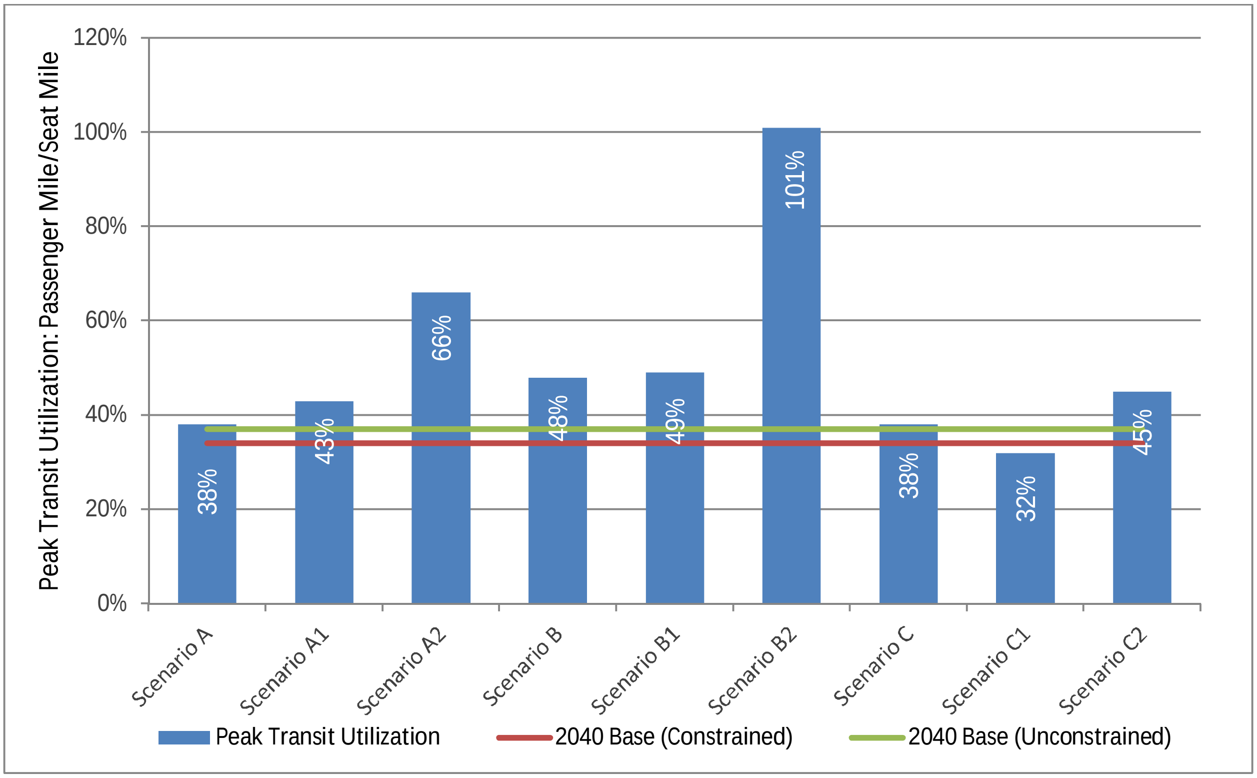


Table 14: Peak Transit Utilization by Mode (passenger miles per seat mile)

	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%

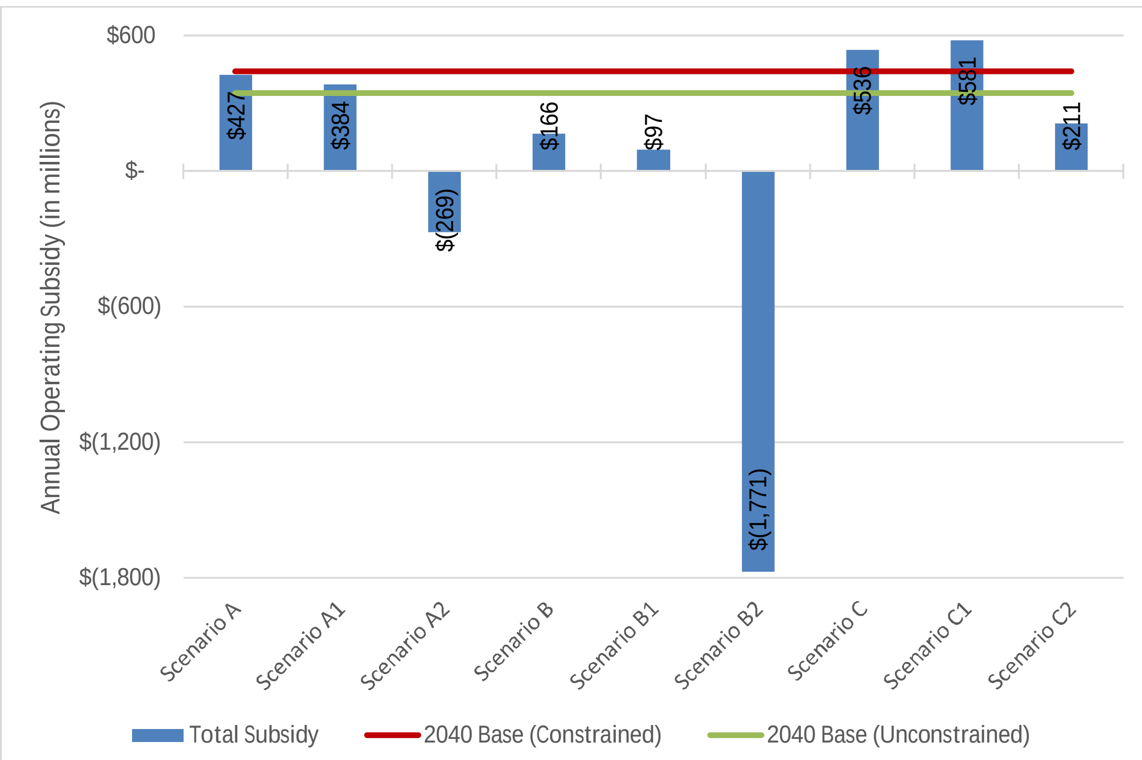
Metrorail Operating Subsidy (MOE 5.6)

The Metrorail Operating Subsidy is the amount of subsidy required by each jurisdiction, and is calculated using a set formula[3] 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 45, Scenarios A2 and B2 would remove the need for any operating subsidy, with revenues exceeding the operating costs (assuming they could accommodate the extremely high passenger loads). However, these levels of ridership, especially Scenario B, 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 45: Metrorail Annual Operating Subsidy



Note: Subsidy amounts are in year of expenditure dollars for 2040.

[3] 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 15 – 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 15: Annual Metrorail Operating Subsidy by Jurisdiction (in millions)

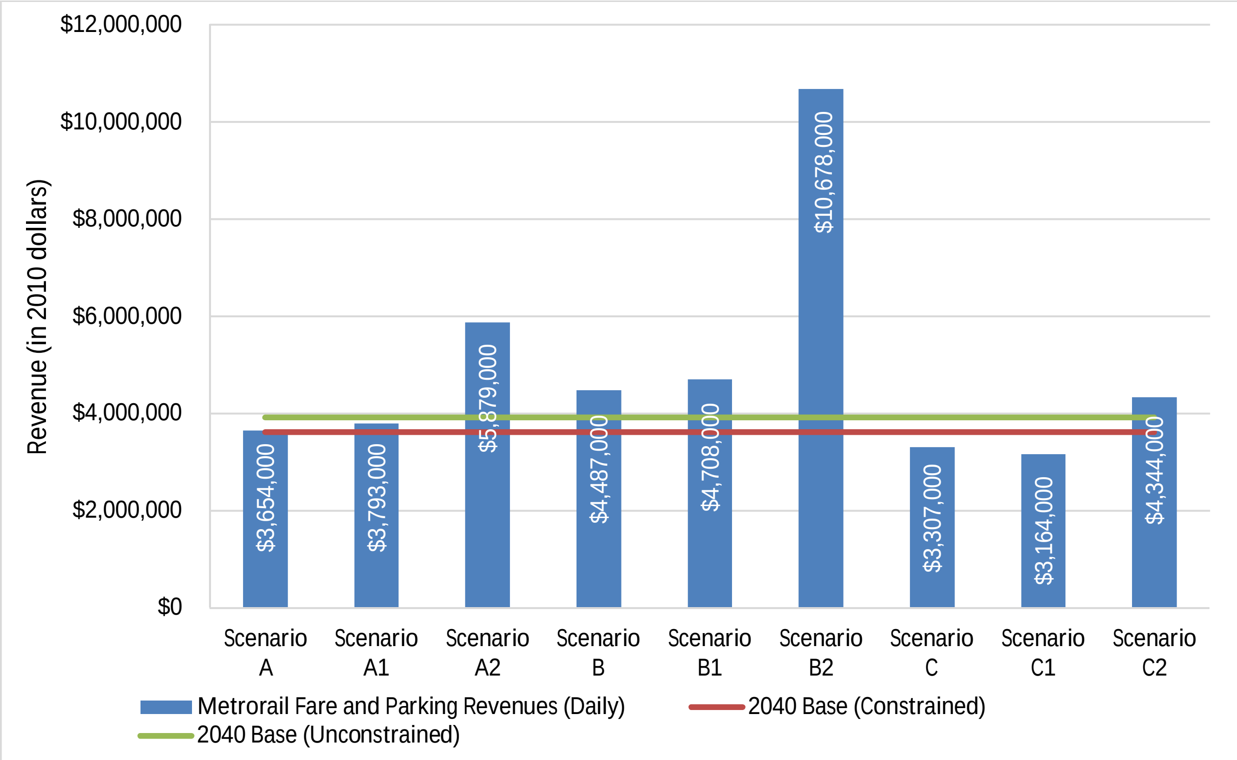
	2040 Const	2040 Unconst	A	A1	A2	B	B1	B2	C	C1	C2
District of Columbia	$138.20	$105.40	$144.70	$117.80	$0.00	$44.40	$21.90	$0.00	$169.30	$188.80	$72.70
Montgomery County	$98.60	$78.50	$90.80	$87.90	$0.00	$41.30	$24.50	$0.00	$119.80	$128.70	$41.90
Prince George's County	$61.00	$47.20	$57.70	$50.70	$0.00	$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

Note: Subsidy amounts are in year of expenditure dollars for 2040.

Metrorail Fare and Parking Revenues (MOE 5.5)

This MOE calculates the average weekday revenues from fares and parking fees as shown in Figure 46. All A and B scenarios increased daily fare revenues through a combination of increased ridership and increased Park & Ride use. 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 46: Metrorail Total Daily Fare and Parking Revenues



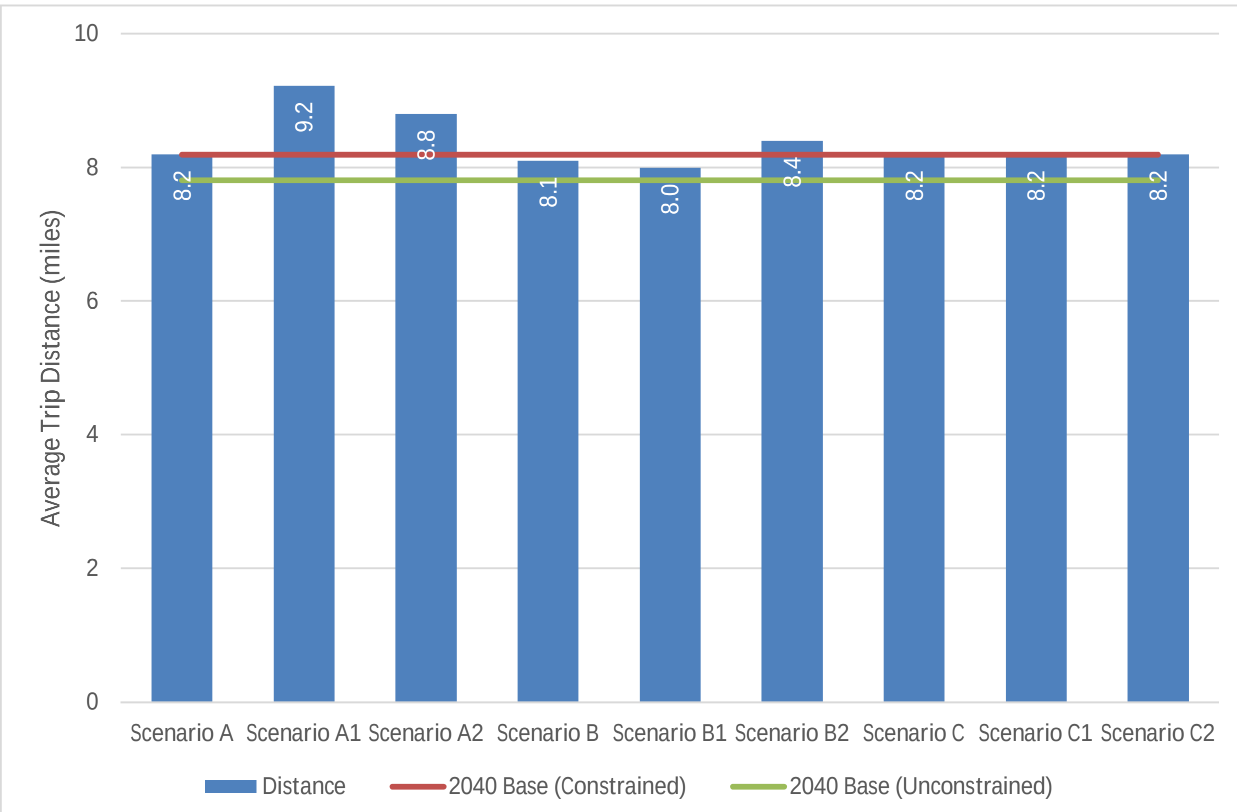
Note: Revenues are in year of expenditure dollars for 2040.

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 47); 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.

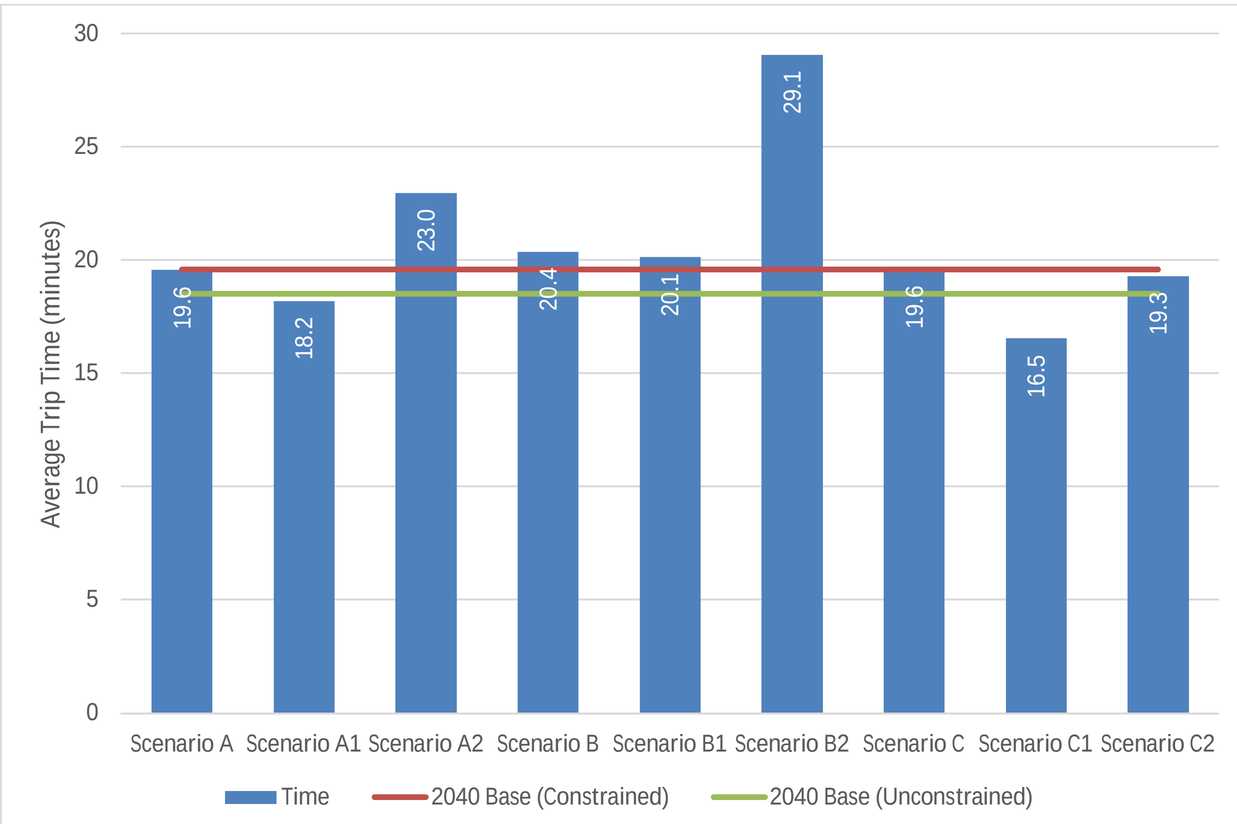
Figure 47: Average Daily Trip Distance



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 48, 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 48: Average Daily Trip Time



Change in Highway Travel Times (MOE 2.5)

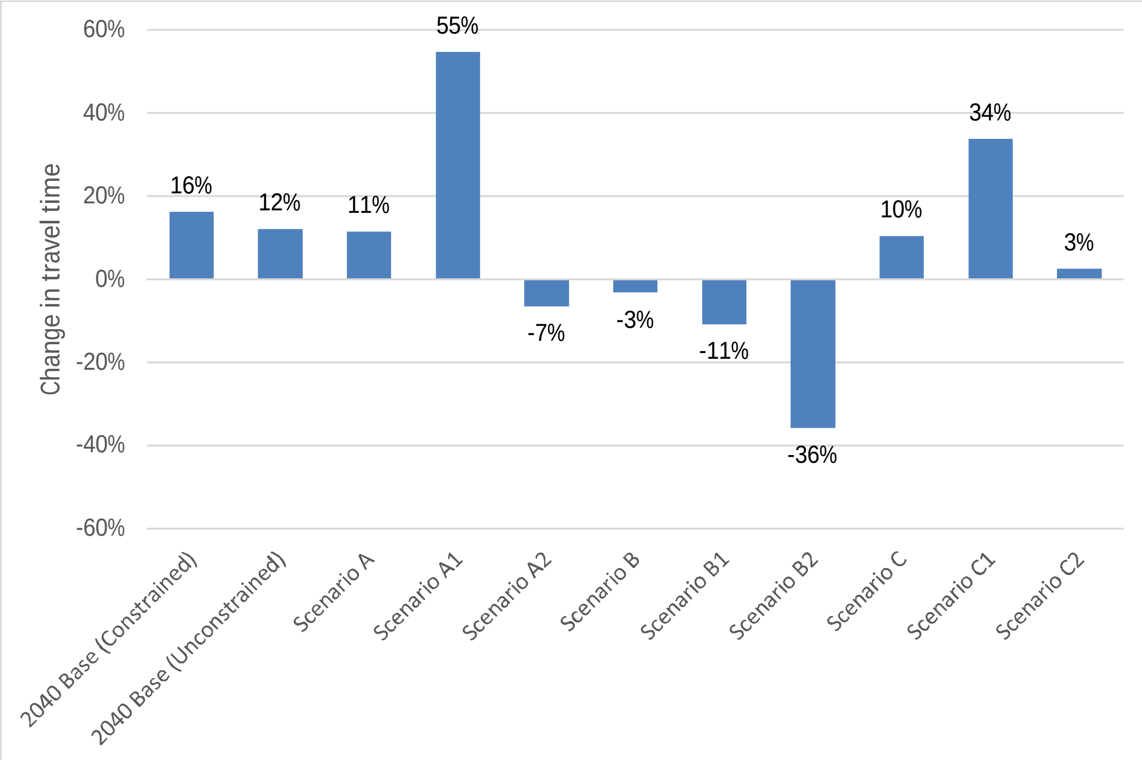
This MOE shows the change in morning peak period highway travel times between the regional destinations listed below compared to 2010 conditions. This MOE summed the total travel times between the origin-destination pairs listed in Table 16 as a representative measure for travel time in the region. As shown in Figure 49, 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 49 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 16: 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

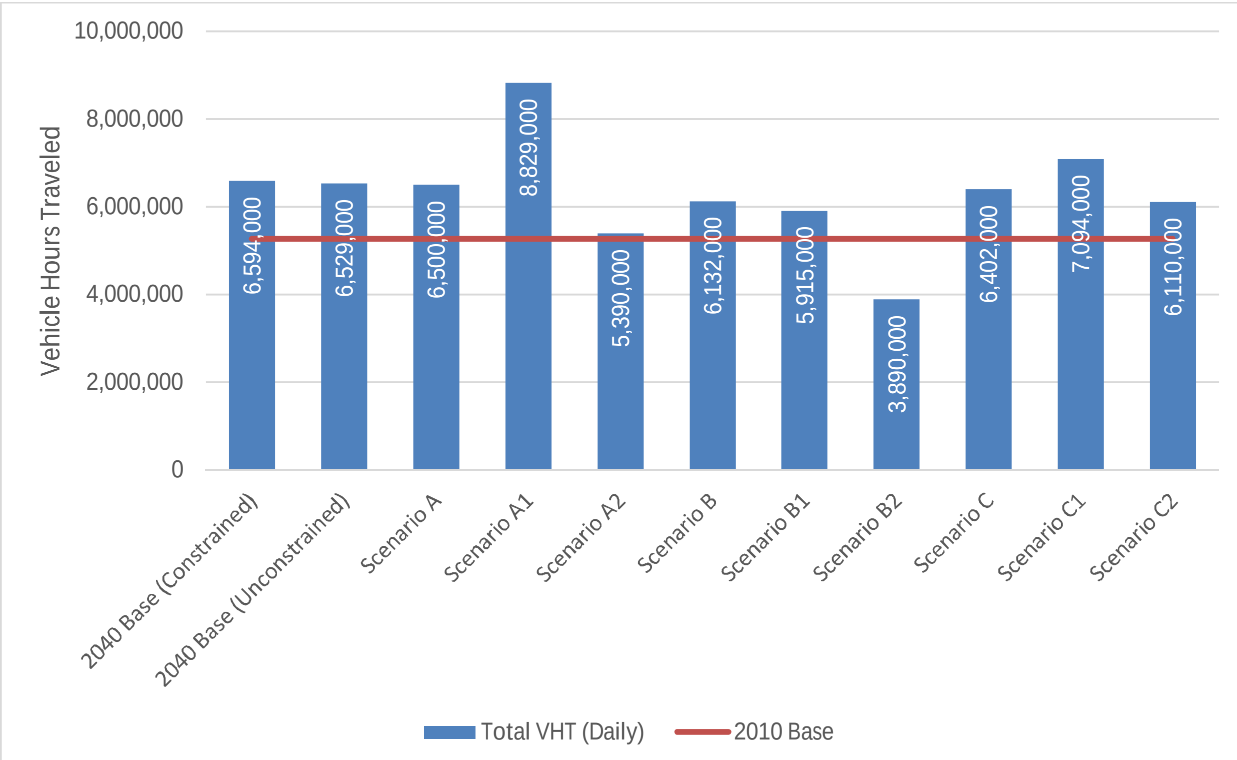
Figure 49: Change in Highway Travel Times Compared to 2010 Existing Conditions (Morning Peak)



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 50, 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 50: Total Vehicle Hours Traveled (Daily)



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 51, 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 17 shows the variation in average speeds by jurisdiction – there is some variation depending on changes to localized traffic patterns and congestion levels.

Figure 51: Average Morning Peak Travel Speed

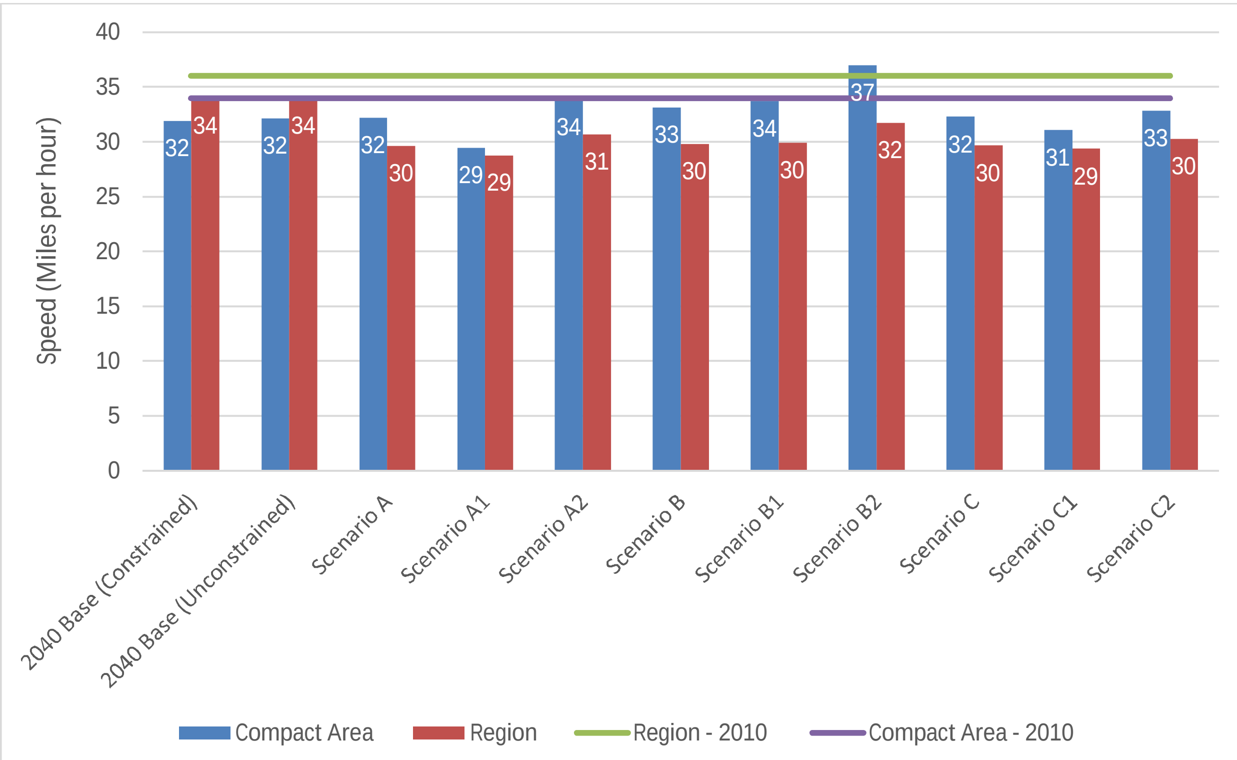


Table 17: Average Travel Speed during Morning Peak – by Jurisdiction

	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