APPENDIX E

Additional Traffic Transportation For Future Land Use Scenarios

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Route 1
Multimodal Alternatives Analysis

ROUTE 1 MULTIMODAL ALTERNATIVES ANALYSIS

ADDITIONAL TRAFFIC ANALYSIS FOR FUTURE LAND USE SCENARIOS

DRAFT January 7, 2015

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1.0 Introduction/Summary

The *Additional Transportation Analysis Report* complements the *Route 1 Multimodal Alternatives Analysis Traffic and Transportation Report* (June 2014) and the *Land Use and Economic Analysis Report* (November 2014). This report extends and enhances the traffic operations analysis summarized in the *Route 1 Multimodal Alternatives Analysis Traffic and Transportation Report*, and develops traffic projections based on the alternative growth scenarios outlined in the *Land Use and Economic Analysis Report*.

1.1 Purpose

Previous traffic analysis focused on intersections in Hybla Valley and Fort Belvoir areas. The purpose of the additional traffic analysis was twofold:

1. Evaluate long-term traffic effects and transit performance at additional key intersections at the northern end of the study corridor, specifically in the Beacon and Penn Daw areas.

2. Estimate potential traffic impacts at key points along the corridor associated with station area development at levels associated with land use Scenarios 2 and 3.

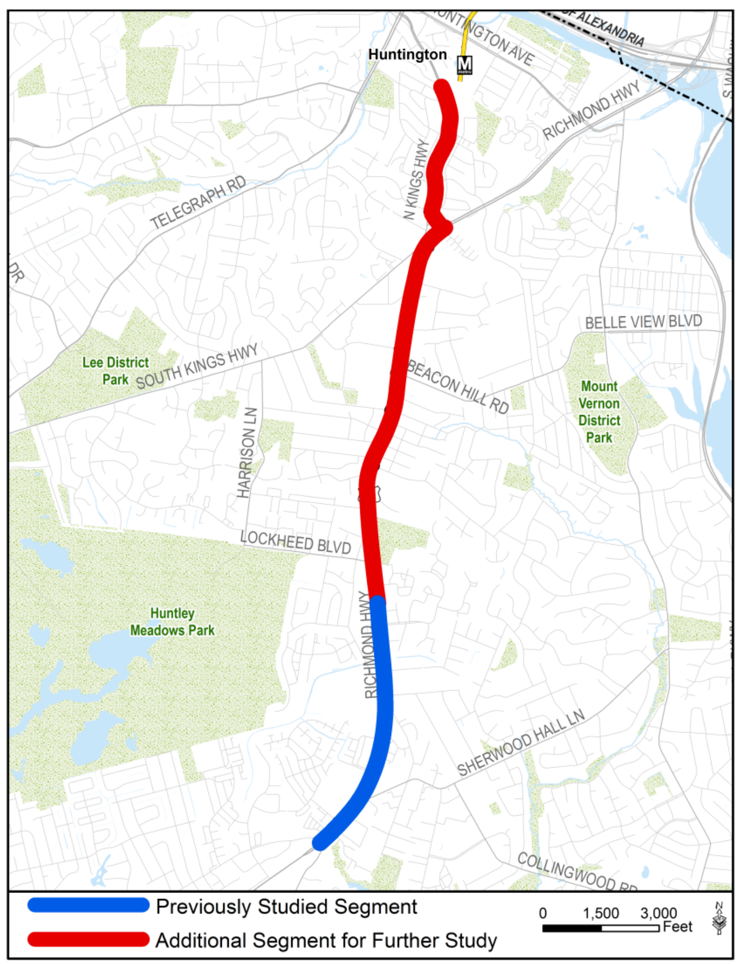
1.2 Level of Analysis

The analysis described in this report provides a general framework for understanding potential traffic levels and intersection performance. Due to the significant levels of assumed growth and the general nature of assumptions regarding the locations and types of land development, outputs from the applied modeling tools have a high degree of variability and must be interpreted as general findings. Future traffic analysis work in the Route 1 corridor will incorporate more specific development plans and more detailed design of proposed transportation investments.

1.3 Scenario 1 Traffic and Transit Operations

The analysis considered 13 additional intersections beyond the seven that were modeled in detail with VISSIM under land use Scenario 1 ("base" land use scenario using the Metpolitan Washington Council of Governments (MWCOG) 2035 regional forecast). The results provide additional information regarding likely performance of a consistent six-lane cross section for general traffic along Route 1.

Figure 1: Segments included in VISSIM Analysis



This work involved expanding the VISSIM network previously prepared for the Hybla Valley segment (see **Figure 1**) to include 13 additional intersections between Hybla Valley and Huntington/North Gateway. This analysis provides further detail and understanding of the interaction of traffic and transit operations and potential traffic impacts along this segment during the AM peak period. The VISSIM tool provides a base model for further refinement in the future to model specific design approaches. In addition to the AM VISSIM analysis, a SYNCHRO analysis was performed to understand the AM and PM peak conditions.

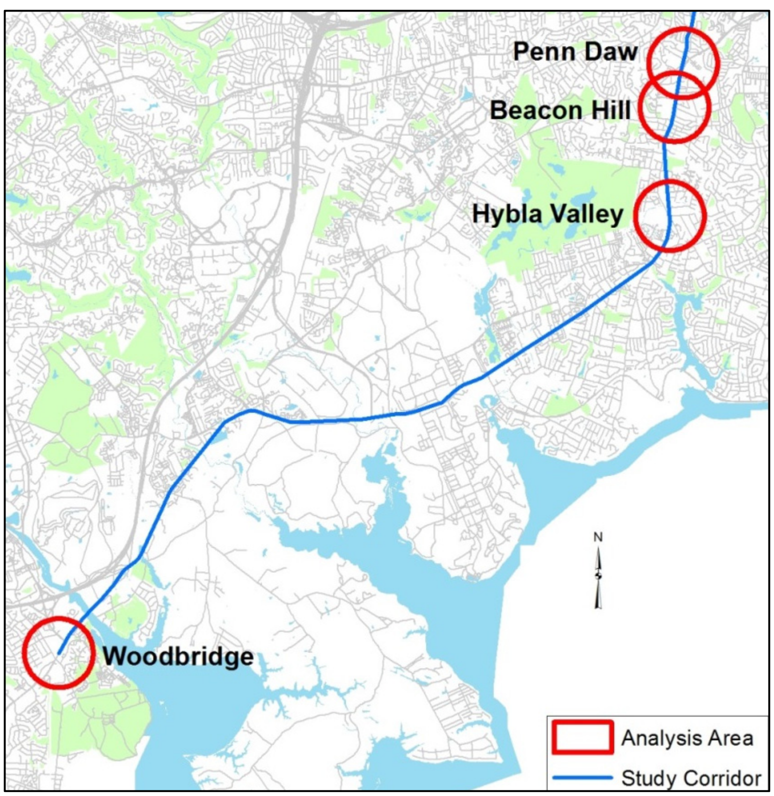
The results of this analysis suggest that operation of a median-running transitway along Route 1 would not significantly degrade traffic delays at intersections. Increases in traffic delays due to projected growth between 2015 and 2035 range from 0 to 35 percent, depending upon the intersection. Additional increases in traffic delays related specifically to transit operations range from 20 to 25 percent.

1.4 Scenarios 2 and 3 Traffic Projections

This analysis considered traffic impacts associated with the levels of new development assumed under land use Scenarios 2 and 3. The new development is assumed to be focused generally within ½-mile of the proposed transit stations. This report examines four example station areas (see **Figure 2**). The evaluation quantifies the projected levels of transportation demand in the proposed station areas, assumes apportionment of that demand according to different modes of travel, and then distributes trips to the roadway and transit network.

The analysis for Scenarios 2 and 3 combines two analytical approaches to understand future traffic conditions:

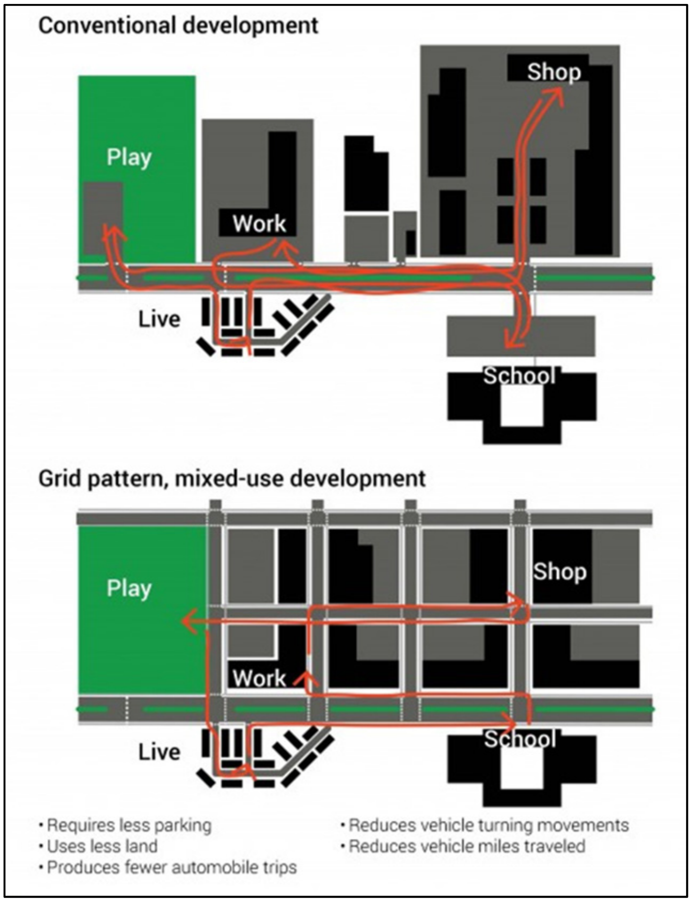
Figure 2: Scenarios 2 and 3 Analysis Areas



First, Scenarios 2 and 3 growth levels are applied within the MWCOG regional model. The model accounts for transit and walk trips, then distributes automobile trips within the network of roadways. This resulting traffic volumes provide a starting point for the analysis, including traffic levels along Route 1.

Second, typical “trip generation” rates are applied to Scenarios 2 and 3 growth levels within a spreadsheet model. Person trips are divided among the range of travel modes, then automobile trips are distributed to the network of existing roadways using factors derived from the MWCOG model. Output includes projected traffic volumes and intersection performance.

Figure 3: Travel Improvements from an Expanded Network of Local Streets



Findings of Scenarios 2 and 3 analyses point to the need for a robust program of local and corridor-wide transportation investment to support the modeled levels of development. Investment in an expanded network of local streets, such as the one demonstrated in the bottom half of **Figure 3**, would be necessary to support the expected traffic levels associated with Scenarios 2 and 3 growth levels . Otherwise, with these growth scenarios, Route 1 traffic volumes would increase and intersection performance would worsen to unacceptable levels.

1.5 General Findings and Recommendations

The analysis described in this report suggests that regardless of the growth scenario, there are deficiencies in the transportation network that should be addressed as the corridor prepares for anticipated growth and invests further in multimodal transportation.

Scenario 1 operations analysis shows that median-running dedicated transit lanes can be accommodated without unduly impacting overall traffic operations. However, delays for left turning vehicles would increase at several locations along Route 1 as a result of median-running transit operation. Likewise, increasing pedestrian volumes over time has the potential to further increase traffic delays along Route 1. A short-term recommendation is to study shorter signal cycle lengths, which will have the effect of reducing queue lengths and delays for turning vehicles.

Traffic analysis for growth Scenarios 2 and 3 indicates that increased traffic volumes would not be adequately accommodated without additional street and intersection capacity along the corridor: a single two- to three-lane facility for Scenario 2, and the equivalent of up to three four-lane facilities for Scenario 3.

Scenario 2 growth level represent a 15 to 25 percent increase in development over the 2035 MWCOG forecast. The growth levels associated with Scenario 3 are more significant, with 100 to 200 percent growth beyond the MWCOG 2035 forecast. These theoretical development densities are representative of existing conditions at such places as Rosslyn or Ballston, and have been evaluated in the Route 1 Alternatives Analysis in connection with a potential future Metrorail investment. Case studies of areas in the region that have experienced similar development densities surrounding Metrorail investments are summarized later.

As anticipated population and employment growth occur in the near future, 2035 population and employment estimates will need to be revised to more accurately evaluate projected traffic conditions. Further study is also recommended to assess the likely development absorption rates, which will provide a better sense of the pace and locations for street network improvements.

Analysis of all scenarios, particularly Scenarios 2 and 3, suggest that traffic operations and growing traffic levels would be best accommodated through a set of targeted, parallel improvements, including the planned roadway widening of Route 1, investment in premium transit service, and refinements to the street networks along the corridor. The refinements to the street network would make additional connections among existing local streets and plan for selected new continuous parallel roadways.

Case Studies

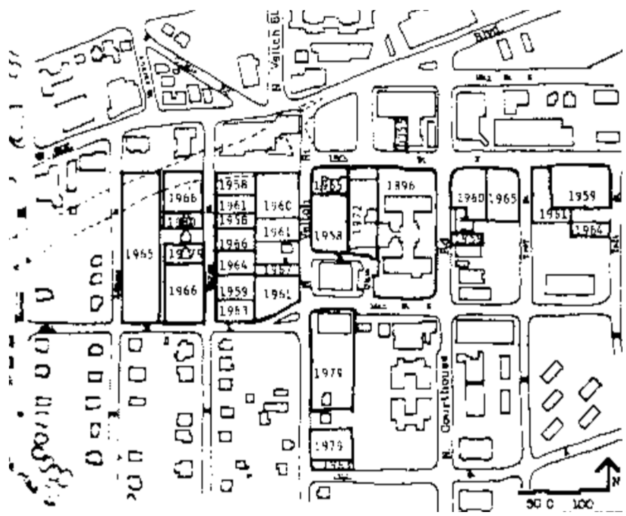
At higher population and employment densities, like those found in Scenarios 2 and 3, an enhanced grid can improve overall accessibility and increase transit and pedestrian mode shares. To evaluate the impacts of growth and the needs for additional roadway infrastructure, two case study areas from other parts of metropolitan Washington DC were reviewed, the Ballston-Rosslyn Corridor and White Flint on Rockville Pike. Both case study locations have developed additional roadways to enhance their grid networks and become more friendly to pedestrians and transit users.

Ballston-Rosslyn Corridor:

Metrorail expanded to the corridor in 1979 and it has since had massive population and employment growth. Since 1990, population within a quarter-mile of these Metrorail stations has increased 107 percent. Between 1970 and 2009, 22 million square feet of office space has been added to the corridor.

In addition to pedestrian-friendly design elements, an enhanced grid was implemented in the Courthouse area following the 1981 sector plan. The addition of Clarendon Boulevard provided additional roadway capacity for employment growth at the Government Center and new office developments, while also providing new pedestrian connections to residential development to the east.

Map of the new Clarendon Blvd and the Government Center (1981)

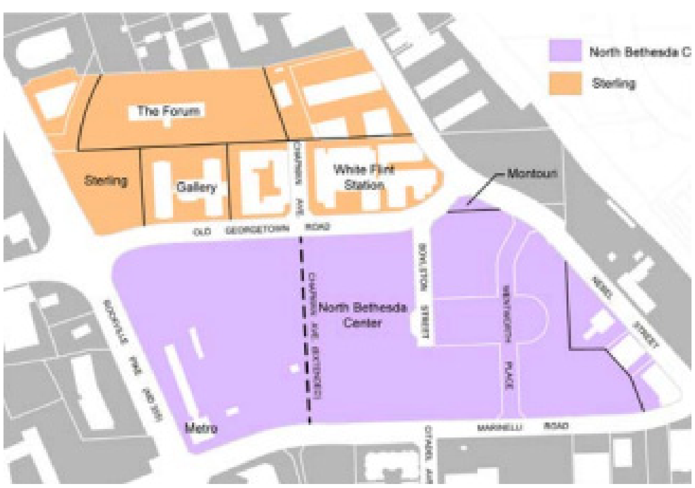


White Flint-Rockville Pike:

Since the opening of the White Flint Metrorail station in 1984, the nearby areas along Rockville Pike have grown from low-density residential uses to a mixed-use district. The current sector plan at White Flint proposes even further growth, with more than triple the existing housing units and doubling of commercial floor area ratio (FAR).

The White Flint Sector Plan (2010) accommodates travel to new commercial uses by developing a street grid that provides more options for pedestrians. For example, in the Metro East district of White Flint, the current commercial FAR limit is 2.0 and the proposed FAR limit for many of the parcels in 3.0 or 4.0. Rather than widening the lanes of existing streets, new parallel streets are proposed for the grid, creating a more inviting space for pedestrians.

Metro East District Current Uses



Metro East District Proposed Density and Street Grid

2.0 Scenario 1 Traffic and Transit Operations

This work involves expanding the VISSIM network previously prepared for the seven intersections in the Hybla Valley segment to include 13 additional intersections between Hybla Valley and Huntington/North Gateway (see **Figure 4**). By expanding the VISSIM network, more robust findings related to impacts of traffic and transit operations along this segment can be evaluated and understood. This tool could also be expanded further in the future to model potential street grid enhancements in the proposed station areas.

Key assumptions:

- Traffic growth rates considered both historical trends and the MWCOG forecast growth rate, which ranged from -0.02% to 2.31%. This methodology is described in further detail in the *Route 1 Multimodal Alternatives Analysis Traffic and Transportation Report* (June 2014). The MWCOG growth rates for the relevant segments are provided for reference in **Appendix A**.
- The typical Virginia Department of Transportation (VDOT) and Fairfax County standard for mainline lanes is level of service (LOS) D. For this analysis, LOS E is assumed to be acceptable for Route 1 travel lanes in 2035.
- Traffic signal priority (TSP) is applied only for the peak direction buses (e.g., for northbound buses in the morning peak hour) and only at intersections with available capacity in order to minimize the impact of TSP on non-transit vehicles.
- The Build analysis presented in this report is for Alternative 2, which includes median-running BRT through the corridor.
- VISSIM calibration was performed using field-measured travel times. **Appendix B** provides detailed information on the calibration process.
- Due to scheduling constraints, only morning (AM) peak hour was modeled and analyzed in VISSIM. A separate analysis was conducted for the selected intersections using SYNCHRO for both AM and PM peak hours (see **Appendix C**).

Figure 4 shows the intersections that were studied in the earlier phase of the work and the new intersections that are analyzed in VISSIM. The North Gateway area – the intersections of Route 1 at Huntington Avenue and Fort Hunt Road – is not located directly on the study alignment used for comparing the alternatives at this stage; therefore, these intersections are not included in the current analysis. That area, also being analyzed as part of the Huntington Area Transportation Study (Fairfax County, 2015), would likely be included in a subsequent phase of work.

Figure 5 shows No Build lane configurations at study intersections. The No Build lane configurations include road widening projects on Route 1 from the MWCOG Financially Constrained Long Range Plan (CLRP).

Figure 4: Intersections Added to Scenario 1 VISSIM Analysis

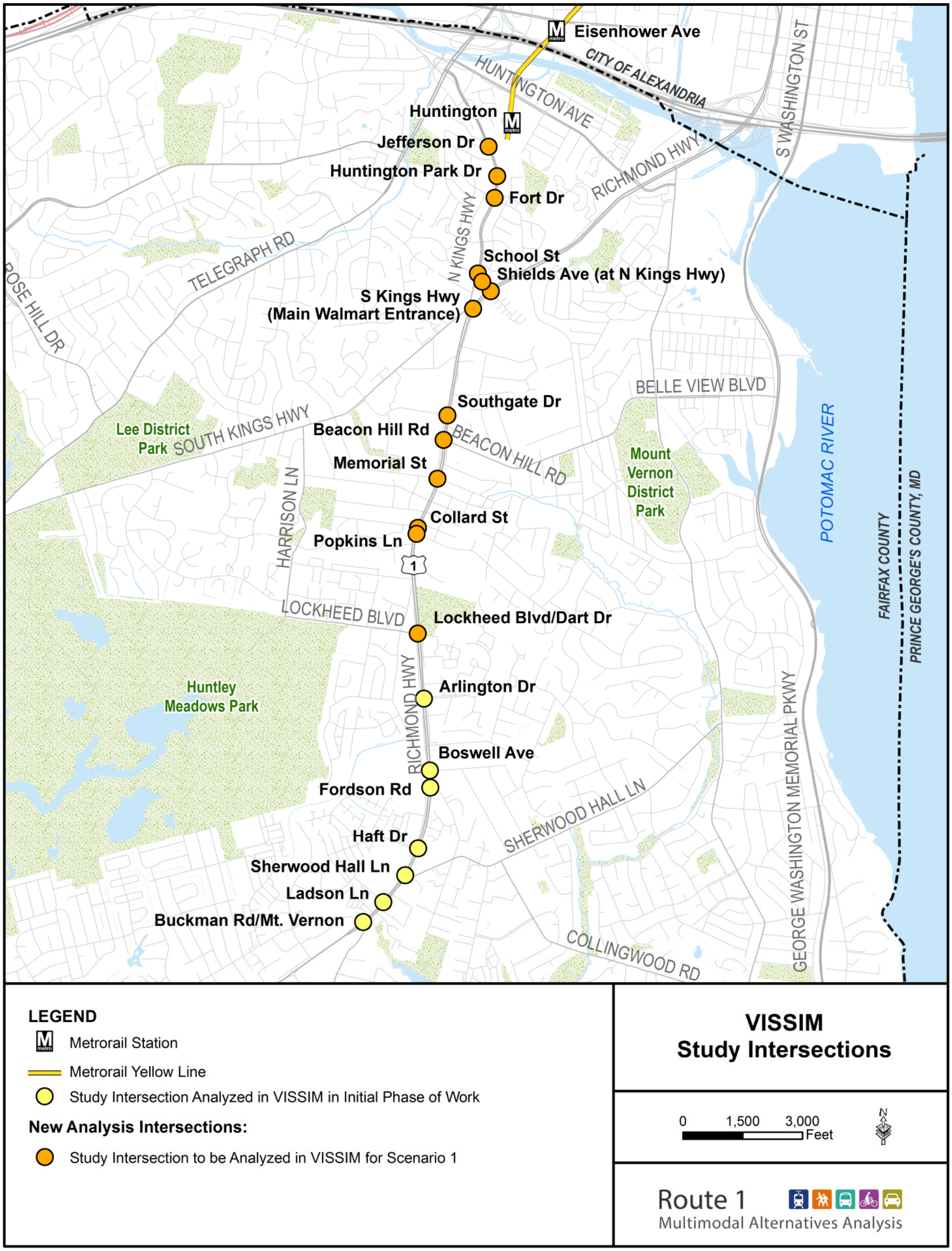
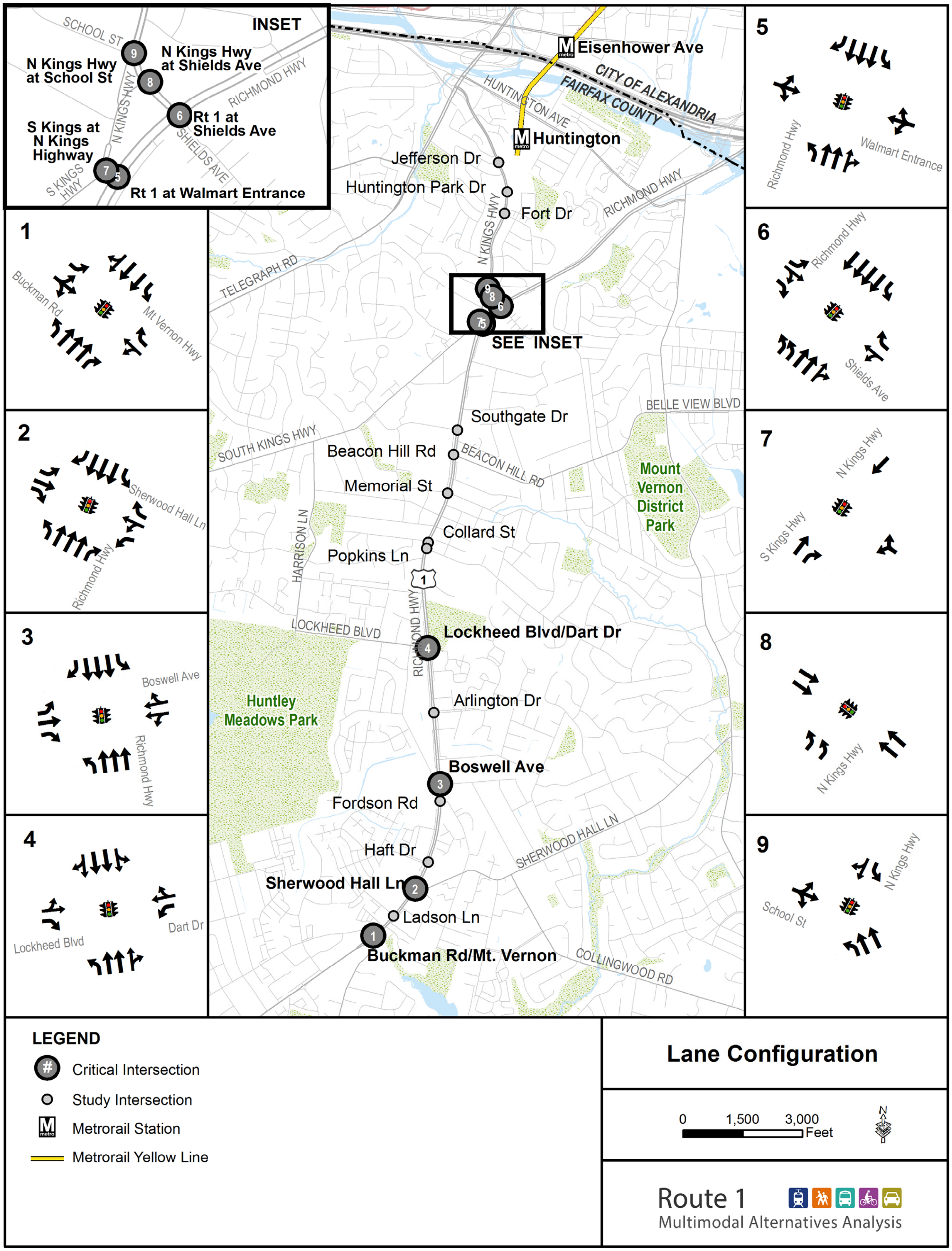


Figure 5: No Build Lane Configurations at Critical Study Intersections



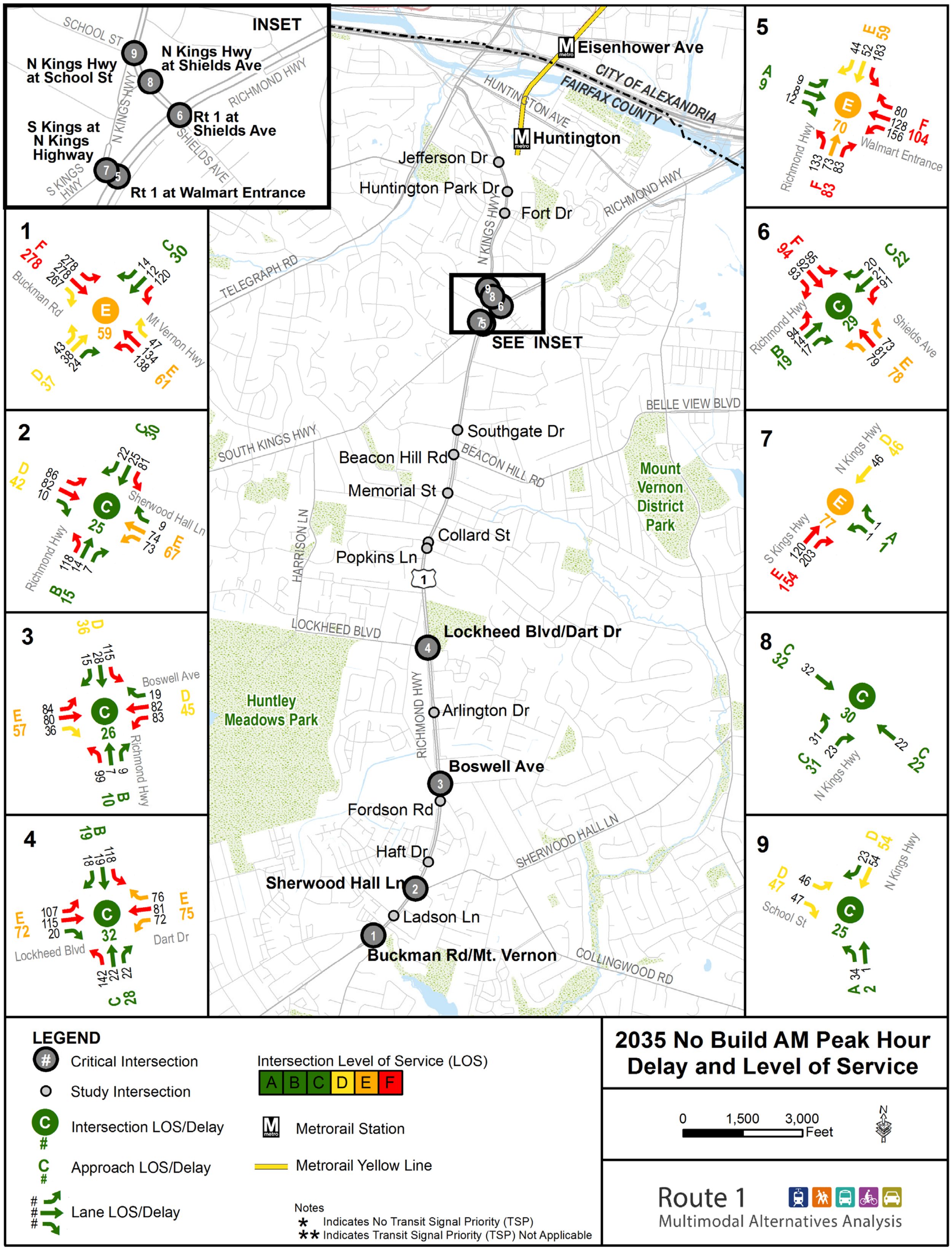
2.1 Findings for key intersections

Figure 6 shows 2035 No Build AM peak hour delay and LOS from VISSIM at critical intersections, defined as those with estimated 2035 intersection delay greater than 25 seconds, identified in **Figure 5**. (The exception is the North Kings Highway/School Street intersection, which is included in the analysis to capture the queue interactions between this intersection and North Kings Highway/ Shields Avenue.)

2.1.1 2035 AM No Build Results

In the 2035 projected conditions, none of the intersections operates at LOS F in the morning peak hour. High levels of congestion and delay, with intersection delays higher than 70 seconds, occur at the Route 1/Walmart Entrance and South Kings Highway/North Kings Highway intersections. The intersection of Route 1 at Mount Vernon Highway/Buckman Road also operates at LOS E. However, this intersection has lower delay as compared to the other two intersections, particularly for the through-movements. Although the through-movement on Route 1 experiences low delays at most intersections, the mainline left turns operate at LOS F. This can be attributed to the long red durations resulting from 180-second cycle length.

Figure 6: VISSIM No Build Delay and Level of Service at Critical Intersections



2.1.2 2035 AM Build Results

Figure 7 shows 2035 Build (median running BRT) VISSIM delay and LOS results for the morning peak hour at critical intersections. The Build Scenario includes median running BRT and TSP for BRT vehicles. TSP is applied only for the peak direction buses (e.g., for northbound buses in the morning peak hour) and only at intersections with available capacity in order to minimize the impact of TSP on non-transit vehicles. The intersections where TSP was not considered due to capacity constraints are denoted by an asterisk (*) in **Figure 7**. **Table 1** provides a summary of the VISSIM delay and LOS results for both the 2035 No Build and Build morning peak hour at critical intersections.

Intersection Operations, General Results

The operation of median running BRT has minor impacts on intersection operations. The findings from the VISSIM analysis can be summarized as follows:

- Because the phasing for the mainline left turn movements are changed from protected plus permissive to protected only operation with median running BRT, left turn delay for the mainline movement is increased. For example, northbound left turn (NBL) delay at Route 1 and Buckman Road/Mt. Vernon Highway intersection (Intersection #1) is increased from 43 seconds to 100 seconds due to the elimination of the permissive phase.

- Due to higher transit ridership, intersections with a BRT station have higher pedestrian volumes crossing Route 1 in the Build Scenario than in the No Build Scenario. With the increase in the number of pedestrian calls, cross-streets typically require longer green times to allow pedestrians to clear the intersection safely. Green time is taken from the mainline movements, resulting in higher delay. This higher delay can be illustrated by looking at delay results at Lockheed Boulevard/Dart Drive intersection (Intersection #4). Delay for the northbound movement is increased from 22 seconds to 44 seconds in the Build Scenario. However, the eastbound and the westbound (cross-street) approach delays are reduced due to changes in signal timing resulting from the increase in pedestrian calls.

- Pedestrian calls were modeled as requests to cross via push button; however, pedestrian volumes were high enough to have a pedestrian call every cycle, resulting in a pattern similar to one with an automatic pedestrian cycle.

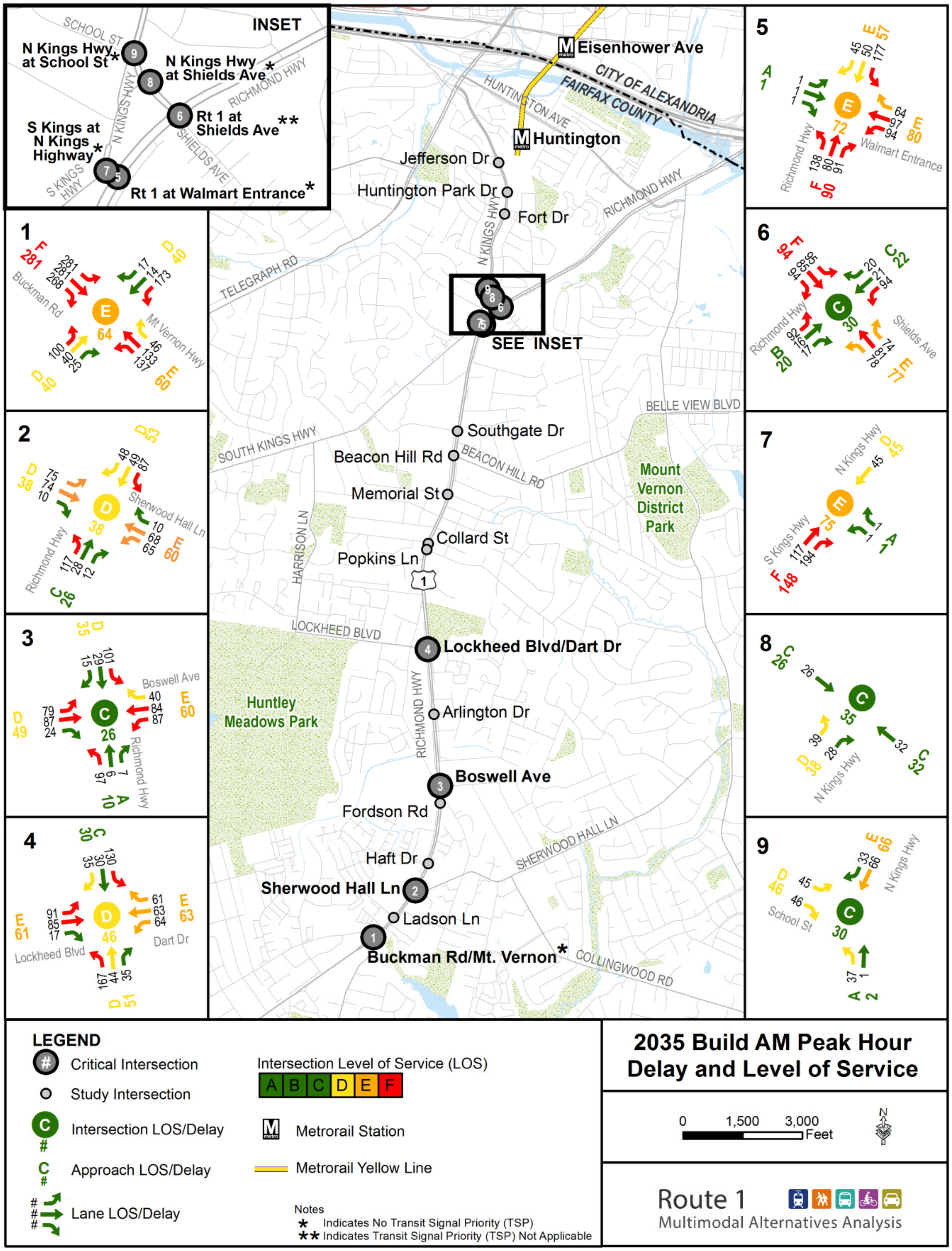
- The application of transit signal priority (TSP) increases delay for the conflicting movements. However, the impact of TSP is relatively small since limited priority was applied.

Note that the VISSIM analysis was limited to AM peak conditions. To understand future PM conditions of intersections in the northern end of the corridor, a SYNCHRO analysis was performed. The SYNCHRO results show that except for the Richmond Highway and Walmart Entrance intersection (#1), all other intersections operate with LOS D or better in 2035 during the morning and evening peak hours. Similar to the VISSIM findings, movements that are unable to take advantage of signal coordination, including the turning traffic from the mainline movement and the cross street traffic, experience relatively higher delays and degraded LOS. Detailed SYNCHRO findings for the AM and PM peak hours are provided in **Appendix C**.

Table 1: Summary of Estimated Delay and LOS in Intersections in VISSIM (2035)

#	Intersection	No Build		Build	
		LOS	Delay (s)	LOS	Delay (s)
1	Buckman Road/Mount Vernon Highway	E	59	E	64
2	Sherwood Hall Lane	C	25	D	38
3	Boswell Avenue	C	26	C	26
4	Lockheed Boulevard/Dart Drive	C	32	D	46
5	Walmart Entrance	E	70	E	72
6	Shields Avenue	C	29	C	30
7	South Kings Highway at North Kings Highway	E	77	E	75
8	North Kings Highway at Shields Avenue	C	30	C	35
9	North Kings Highway at School Street	C	25	C	30

Figure 7: VISSIM Build Delay and Level of Service at Critical Intersections



2.2 Corridor and Network Level Transit Findings

Median-running BRT affects traffic operations at the corridor and network levels. **Figure 8** shows the extents of the corridor study in this analysis. **Figures 9** and **10** show estimated peak direction auto and transit corridor travel times during the morning peak hour under the No Build and Build scenarios for 2035. The No Build transit travel time is calculated based on the current operation of REX Service, adjusted to account for the proposed BRT routing.

Peak direction auto travel time increases by 20 to 25 percent with the median running BRT alternative, with the average auto travel time in the corridor increasing from 12.1 minutes in the No Build scenario to 14.6 minutes in the Build scenario and average auto network speed decreasing from 18.6 mph in the No Build scenario to 16.3 mph in the Build scenario. Auto travel time increases can primarily be attributed to the increase in the number of pedestrian calls, reducing the green time for Route 1 through-movement. Total auto network delay also increases by 25 percent due to the elimination of permissive left turns and application of TSP. However, the median running BRT alternative reduces transit travel time by more than 3 minutes, nearly a 20 percent reduction. Given the estimated 9,400 estimated daily passengers in 2035 for this segment, this reduction in transit travel time would save 500 passenger hours on an average weekday. Modeled BRT travel time is shorter than the auto travel time (13.6 vs. 14.6 minutes), indicating the efficiency of median running BRT service.

Figure 8: Extents of Auto and Transit Travel Time Analysis

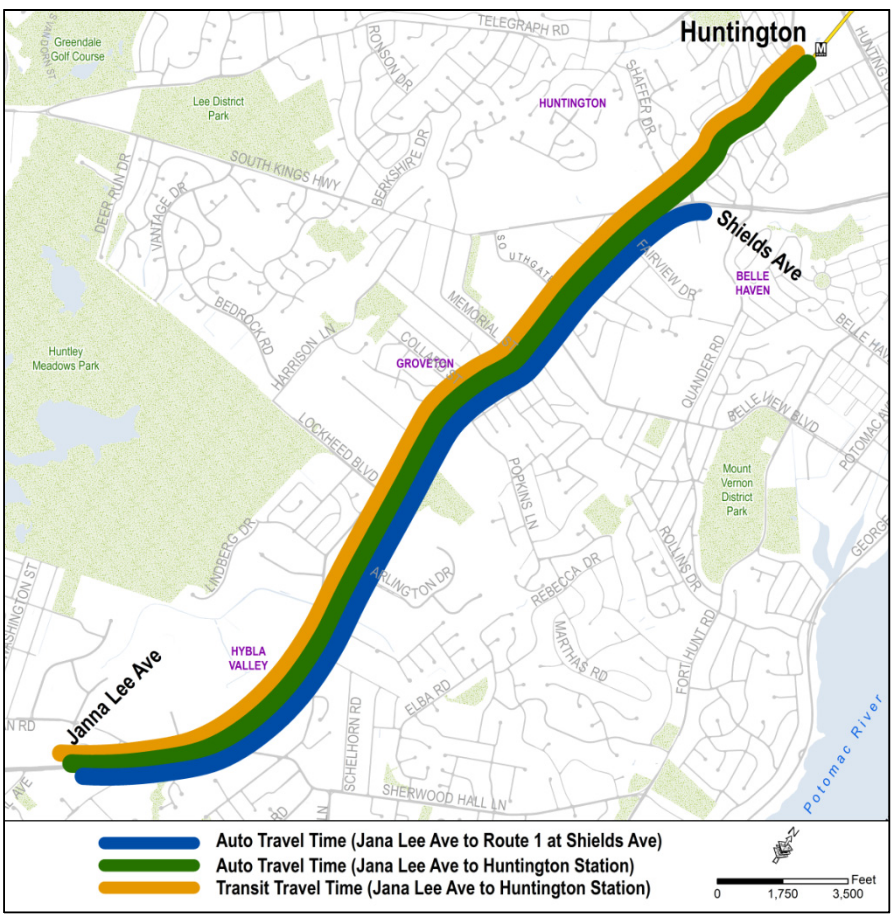


Figure 9: 2035 Estimated Auto and Transit Travel Times

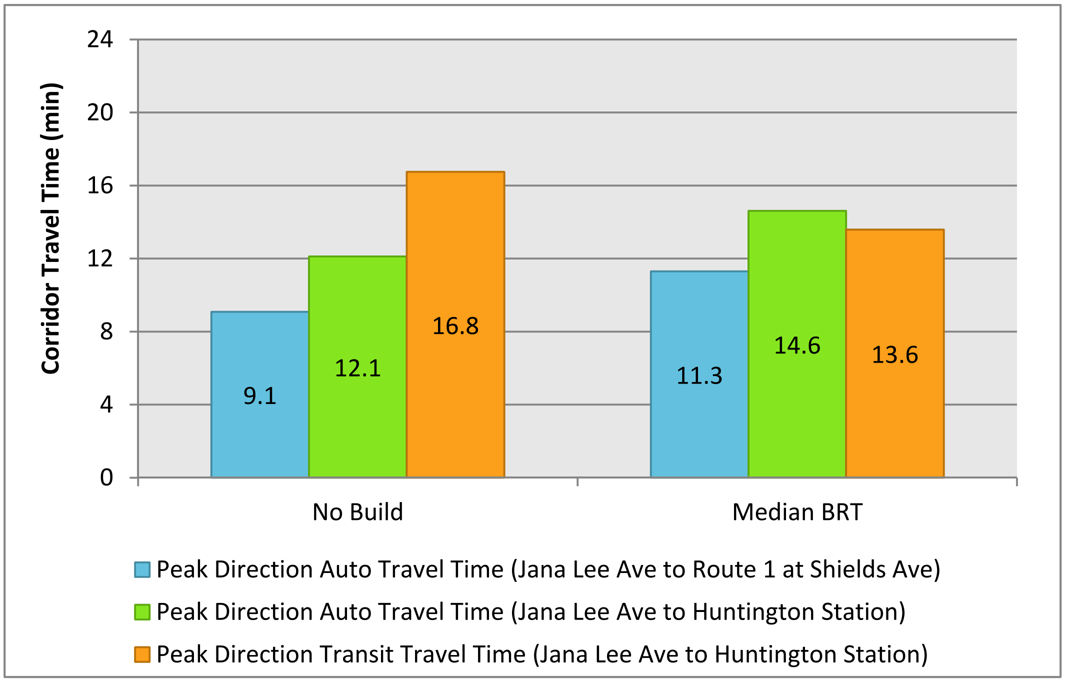
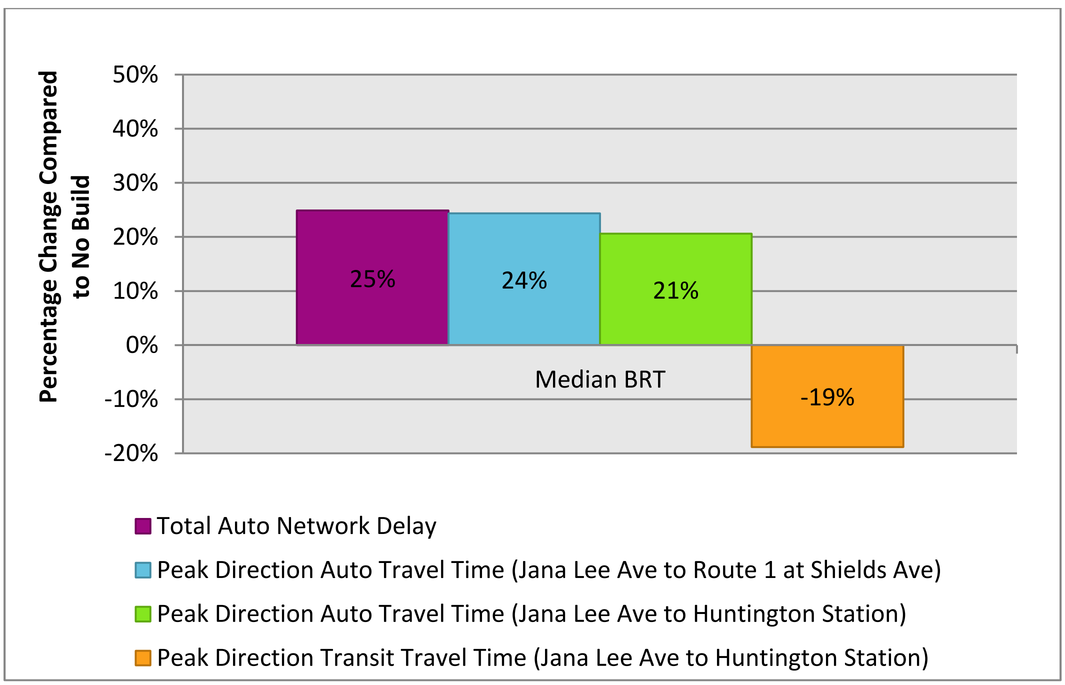


Figure 10: No Build versus Build Travel Times (2035)



3.0 Scenarios 2 and 3 Traffic Projections

This analysis projects traffic impacts of station area development levels assumed under land use Scenarios 2 and 3. The purpose of this effort is to quantify in general terms the levels of transportation demand in the areas around selected proposed stations and test the resulting performance of the transportation network. This analysis focuses on the proposed Penn Daw, Beacon Hill, Hybla Valley, and Woodbridge station areas (see **Figure 11**). More detailed maps of these areas is shown in **Figures 12** through **15**. These areas were selected as representative "worst case" traffic impacts to help define the need for roadway and intersection capacity.

Figure 11: Scenarios 2 and 3 Analysis Areas

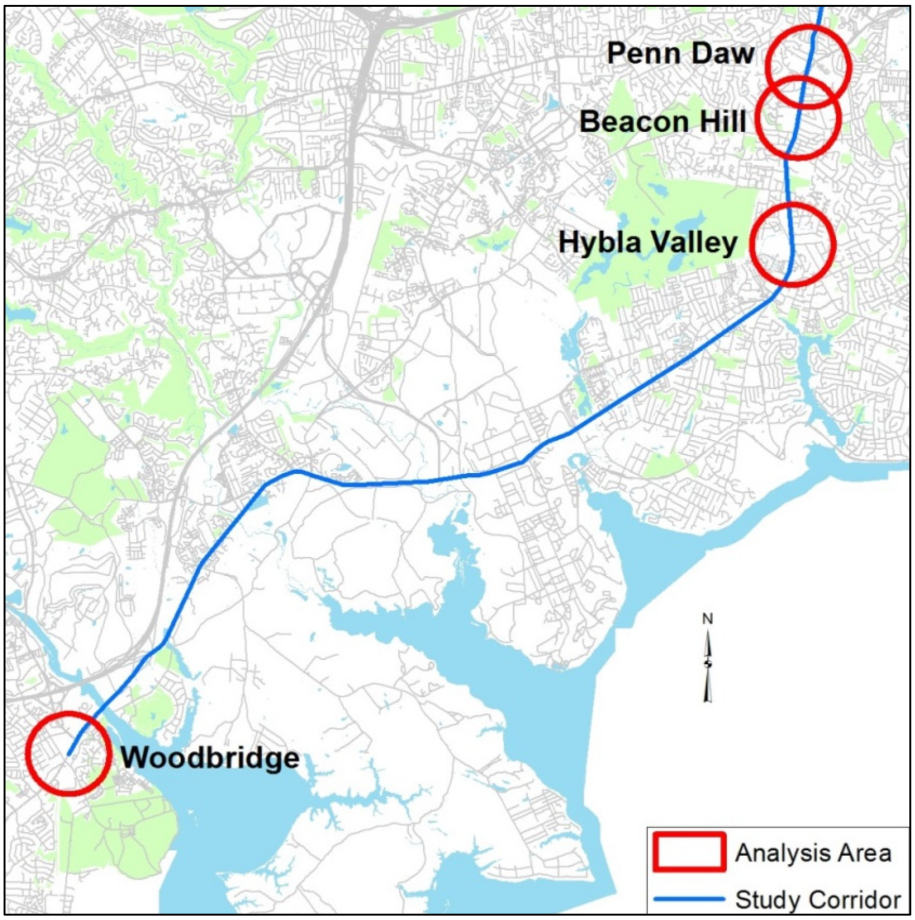


Table 2 shows the intersections analyzed as part of this task. These intersections were chosen for their proximity to potential transit stations, and thus the likelihood that they would need to accommodate increased traffic with the alternative growth scenarios.

In general, the analysis assumes the future street grid resembles the existing street grid; growth in traffic volumes would be distributed across today's street network. In reality, future conditions associated with growth scenarios would likely distribute traffic across a more robust grid of local street connections.

Table 2: Intersections for Scenarios 2 and 3 Traffic Assessment

Station Area	Intersection for Land Use Scenarios 2 & 3 Traffic Assessment
Penn Daw (see Figure 11)	Route 1 at South Kings (Walmart Entrance)
	Shields Avenue
Beacon Hill (see Figure 12)	Beacon Hill Road
	Memorial Street
Hybla Valley (see Figure 13)	Boswell Avenue
	Sherwood Hall Lane
	Buckman Road
North Woodbridge (see Figure 14)	Annapolis Way
	Gordon Blvd

Figure 12: Intersections in Penn Daw for Scenarios 2 and 3 Traffic Assessment

Figure 13: Intersections in Beacon Hill for Scenarios 2 and 3 Traffic Assessment

Figure 14: Intersections in Hybla Valley for Scenarios 2 and 3 Traffic Assessment

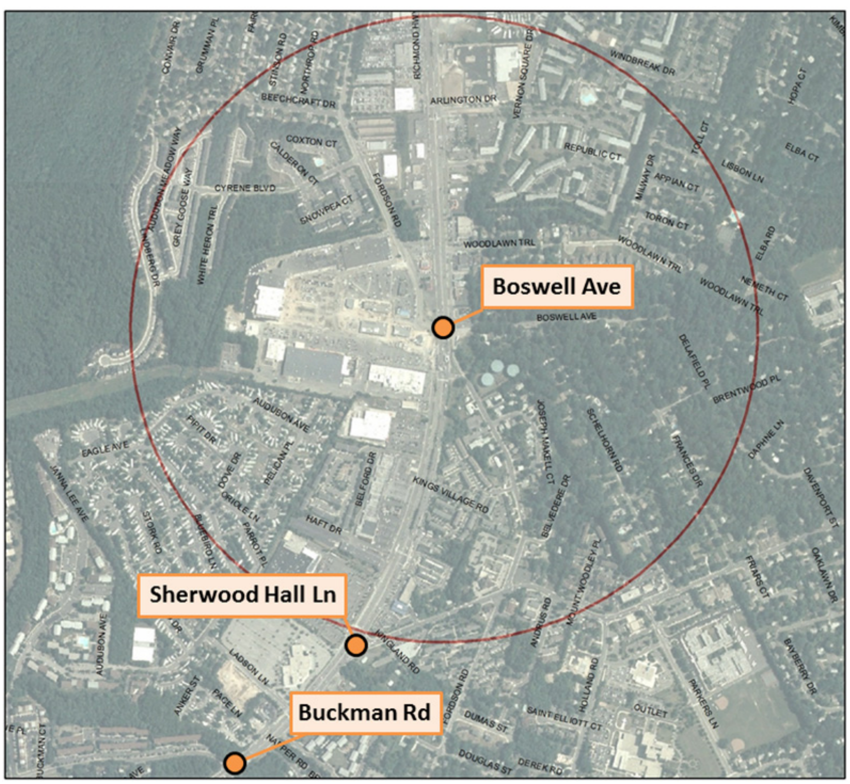


Figure 15: Intersections in North Woodbridge for Scenarios 2 and 3 Traffic Assessment

3.1 Applicability of Findings

This analysis presents projected traffic performance in terms of roadway capacity and intersection LOS because these are typical ways of understanding traffic levels. However, given the significant growth associated with each potential land use scenario and the complexity of travel patterns in a congested transportation network, the findings must be understood not as specific tests of intersections or of corridor segments, but rather as a general assessment of the Route 1 corridor capacity to accommodate additional travel.

3.1.1 Key General Assumptions

The methodologies and findings are described in detail below. Several general assumptions apply to both approaches:

- The traffic assessment assumes Multimodal Alternative 2 (i.e., median running BRT) for land use Scenario 2, and Multimodal Alternative 4 (i.e., hybrid BRT and Metrorail) for land use Scenario 3.
- The mix of residential and commercial/office land uses for each growth scenario is consistent with the Fairfax County Comprehensive Plan (2013) and Prince William County Comprehensive Plan (2008) for the study station areas in question.

- “No Build” traffic volumes are based on recent traffic counts, observed traffic growth rates, and the calibrated MWCOG model.

3.1.2 Distribution of Trips to the Street Network

The key questions in the assessment are: a) How to translate the land use scenario growth levels into trips using a range of travel modes? and b) How to apply vehicular trips to the network of streets?

To provide perspectives on these questions, the analysis was conducted in two interrelated ways:

1) Traffic assignment to the street network using outputs of the MWCOG model; and

2) Application of Institute of Transportation Engineers (ITE) Trip Generation rates and Fairfax and Prince William County mode share assumptions related to transit-oriented development patterns.

3.2 MWCOG Model Process and Outputs

The MWCOG regional model to generate traffic growth rates and transit ridership forecasts was applied in the *Route 1 Multimodal Alternatives Analysis Traffic and Transportation Report* (June 2014). In the analysis found in this report, the MWCOG model is applied to test impacts on the transportation system—and specifically the street network—associated with Land Use Scenarios 2 and 3.

The analysis included the following steps:

1. A detailed review of the areas slated for the large increases in land use intensity in Scenarios 2 and 3: As inputs to the ridership forecasting effort, the study team applied growth associated with Land Use Scenarios 2 and 3 along the corridor and tabulated growth according to the current TAZ structure.

2. Running the MWCOG model to generate person-trips and levels of use by transportation mode: This step reflects the existing and proposed transit services associated with the Build alternatives.

3. Assigning automobile trips to the MWCOG highway network for each of the growth scenarios: The result of this step includes estimated traffic volumes and assumed annual growth rates along each modeled link or roadway segment.

3.2.1 Transit and Pedestrian Mode Share

The purpose of the MWCOG approach is to make an initial estimate of future traffic volumes with concentrated new growth along the corridor. The MWCOG model was run two different ways:

First, with pedestrian and transit mode shares typical for areas within the Washington DC metropolitan area. This provided an “upper limit” on traffic volumes of “unadjusted” assignment of automobile trips to the roadway network.

Second, transformative land use changes are reflected in adjustments to the model inputs:

- Larger internal capture rates by non-motorized modes. Moving to a stronger mixed use development pattern shifts some portion of travel from motorized to non-motorized, as people can access more activity centers (attractions) without an automobile.

- Mode shift driven in part by availability and cost of parking. With higher levels of development density, there will be more structured parking and paid parking which tend to discourage vehicle trips.

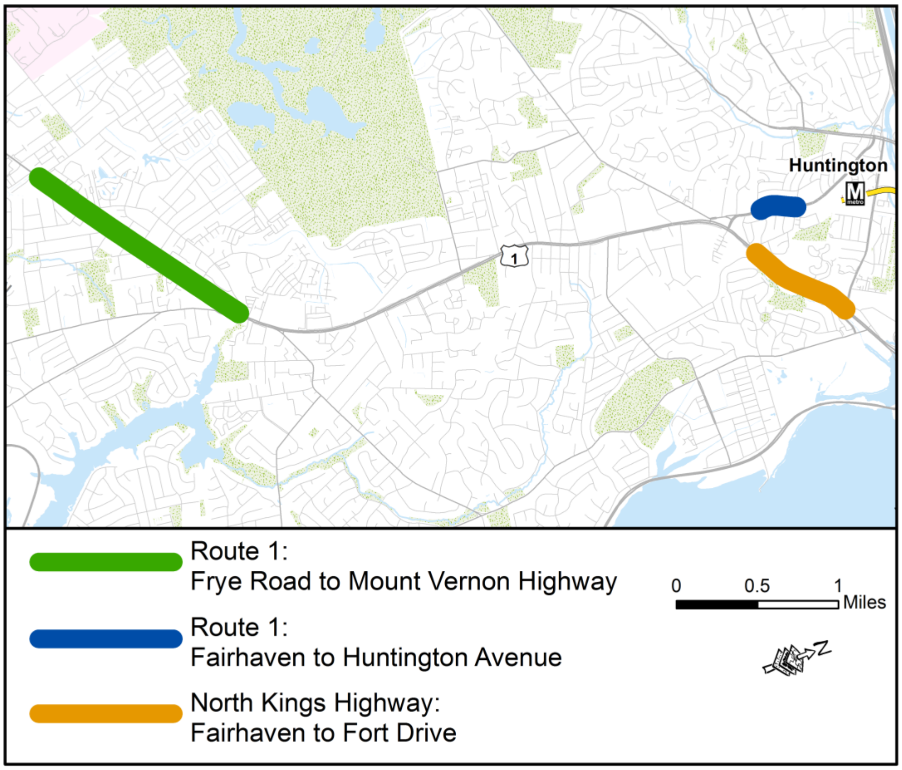
The MWCOG automobile trip table is adjusted based on the “factored” trip generation rates, then the refined estimates of automobile trips are assigned to the network. **Table 3** shows projected daily traffic volumes at selected locations (see **Figure 16**) and compares the unadjusted roadway network assignment to the factored network assignment. Detailed information regarding the projected daily and peak period traffic volumes at a range of locations for each scenario is provided in **Appendix D**.

Table 3: Comparison of MWCOG Network Volumes

	A-Route 1: Frye to Mt Vernon Highway		B-North Kings Highway: Fairhaven to Fort Drive		C-Route 1: Fairhaven to Huntington Av	
	Southbound	Northbound	Southbound	Northbound	Southbound	Northbound
2010 Average Daily Traffic (ADT)	16,275	16,893	18,095	16,535	16,945	21,170
Scenario 1						
Scen. 1 ADT	24,300	24,530	15,880	15,095	22,785	24,765
Avg. Annual Growth 2010-2035	1.62%	1.50%	-0.52%	-0.36%	1.19%	0.63%
Scenario 2						
Scen. 2 ADT	25,660	26,255	17,565	16,390	19,575	22,505
Avg. Annual Growth 2010-2035	1.84%	1.78%	-0.12%	-0.04%	0.58%	0.24%
Scen. 2 ADT Factored	25,270	26,100	17,576	16,247	19,096	22,288
Avg. Annual Growth 2010-2035	1.78%	1.76%	-0.12%	-0.07%	0.48%	0.21%
Scenario 3						
Scen. 3 ADT	27,200	28,715	19,250	18,515	25,269	26,385
Avg. Annual Growth 2010-2035	2.08%	2.14%	0.25%	0.45%	1.61%	0.88%
Scen. 3 ADT Factored	26,130	27,885	19,010	18,110	24,325	25,575
Avg. Annual Growth 2010-2035	1.91%	2.03%	0.20%	0.36%	1.46%	0.76%

Note: Factored ADT assumes greater pedestrian and transit mode shares.

Figure 16: Selected Locations for Comparison of MWCOG Network Volumes



3.2.2 Findings

The MWCOG approach to assessing the traffic growth associated with Scenarios 2 and 3 development levels shows that:

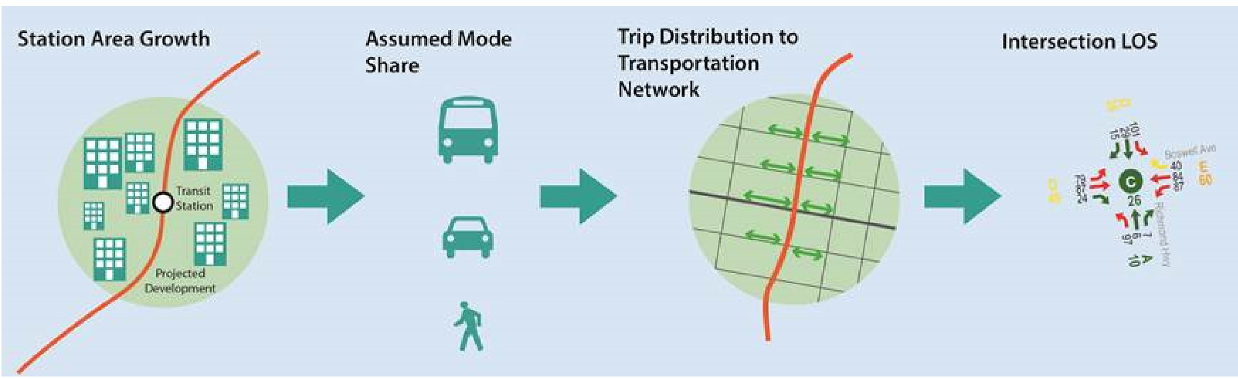
- Traffic levels for Scenario 2 would grow by 10 to 20 percent over Scenario 1.
- Traffic levels for Scenario 3 would grow by 20 to 30 percent over Scenario 1.

Factored model inputs have a modest effect on traffic growth projections; this is likely due to the already congested modeled roadway network. Overall, these findings establish a range of the potential growth in traffic volumes that is constrained by the capacity of the planned highway network. The trip generation approach, detailed below, provides a way of estimating "unconstrained" traffic volumes associated with Route 1 corridor growth scenarios.

3.3 Station Area Trip Generation Process and Outputs

The trip generation approach uses background growth levels along Route 1 as supplied by the MWCOG forecast, then adds finer detail related to trip making within the study station areas. As compared to the findings based on the MWCOG model alone, trip generation provides an unconstrained estimate of the capacity needed to accommodate the Scenario projected growth levels. **Figure 17** summarizes the steps involved in estimating trips generated by changes in land use, population, and employment. The approach uses the ITE Trip Generation methodology in conjunction with assumed shares of transit and walk/bike trips based on Fairfax County experience and transportation demand management goals.

Figure 17: Trip Generation Approach Methodology



3.3.1 Transit and Pedestrian Mode Share

Fairfax County staff provided guidance on the range of reasonable levels of non-automobile travel for transit-oriented development areas. The main source was the *Fairfax County Comprehensive Plan*, 2013 Edition – Tysons Corner Urban Center, Amended Through 4-9-2014.

Other sources for non-auto mode shares included:

- *WMATA Development Related Ridership Survey* (2005)
- *Arlington County Residential Building Transportation Performance Monitoring Study* (2013)

In general, each of these sources suggest a combined share of transit and walk/other trips in TOD areas of 15 to 40 percent. A description of each of the studies reviewed is provided in **Appendix E**.

Table 4 presents the current population, dwelling units, employees, and office space for the four station areas and demographic projections for all three scenarios. Population and employment estimates were based on MWCOG Land Use Round 8.2. The calculation of dwelling units assumes 2.14 persons per dwelling unit. The calculation of office square footage assumes 300 square feet per employee.

Table 4: Demographics by Station and Land Use Scenario

Station Name	Scenario	Population	Dwelling Units	Employees	Office (sf)
Penn Daw	Current	4,661	2,178	2,272	681,600
	Scenario 1	7,820	3,654	4,393	1,317,900
	Scenario 2	10,284	4,806	4,983	1,494,900
	Scenario 3*	10,284	4,806	4,983	1,494,900
Beacon	Current	3,736	1,746	2,809	842,700
	Scenario 1	9,098	4,251	4,570	1,371,000
	Scenario 2	9,300	4,346	7,787	2,336,100
	Scenario 3	19,164	8,955	16,046	4,813,800
Hybla	Current	5,010	2,341	2,387	716,100
	Scenario 1	5,948	2,779	3,549	1,064,700
	Scenario 2	6,414	2,997	5,456	1,636,800
	Scenario 3	19,025	8,890	16,185	4,855,500
Woodbridge	Current	2,793	1,305	1,632	489,600
	Scenario 1	8,363	3,908	3,283	984,900
	Scenario 2	9,011	4,211	5,547	1,664,100
	Scenario 3	11,520	5,383	7,091	2,127,300

*Penn Daw area does not include a proposed Metrorail station in Scenario 3, however considered in the analysis at Scenario 2 development levels.

The assumed mode shares for each scenario are provided in **Table 5** below. Relatively lower transit and walk/bike shares are used for Woodbridge Station since it would be served by BRT, while the other stations would be served by Metrorail in land use Scenario 3. A similar methodology is applied in estimating the generated trips associated with land use Scenario 2. However, to account for lower land use intensity and BRT service (all stations will be served by BRT in land use Scenario 2), a lower non-auto mode share is assumed. The analysis for Scenarios 2 and 3 was conducted for a likely mode share and an "enhanced mode share" to establish a potential range of impacts

Table 5: Mode Share Assumptions for Scenarios 1,2,3

	Beacon and Hybla Valley Stations (served by Metro)			Woodbridge Station (served by BRT)		
	Transit	Walk & Other	Auto	Transit	Walk & Other	Auto
Scenario 1	10%	5%	85%	10%	5%	85%
Scenario 2	15%	5%	80%	15%	5%	80%
Scenario 3	29%	11%	60%	15%	5%	80%

Table 6 shows the additional dwelling units and office space for Scenario 2 (compared to Scenario 1) as well as the daily and peak hour auto trips that would be generated.

Table 6: Additional Vehicular Trips Generated for Land Use Scenario 2

Area	Land Use (ITE Category)	Units (Change Compared to Scenario 1)	Total Generated Trips			Total Auto Trips	
			Daily	AM Peak Hour	PM Peak Hour	AM Peak Hour	PM Peak Hour
PENN DAW STATION	High Rise Apartment 222	1,151 DU	4,836	345	403	276	322
	General Office 710	177 ksf	1,952	276	264	221	211
	Total		***6,788***	***621***	***667***	***497***	***533***
BEACON STATION	High Rise Apartment 222	94 DU	396	28	33	23	26
	General Office 710	965 ksf	10,645	1,506	1,438	1,204	1,150
	Total		***11,042***	***1,534***	***1,471***	***1,227***	***1,177***
HYBLA STATION	High Rise Apartment 222	218 DU	915	65	76	52	61
	General Office 710	572 ksf	6,310	892	852	714	682
	Total		***7,225***	***958***	***929***	***766***	***743***
WOODBRIDGE STATION	High Rise Apartment 222	303 DU	1,272	91	106	73	85
	General Office 710	679 ksf	7,492	1,060	1,012	848	810
	Total		***8,763***	***1,150***	***1,118***	***920***	***894***

Table 7 provides the additional dwelling unit and office space for Scenario 3 as compared with Scenario 1, and the associated vehicular trips that would be generated in the morning and evening peak hours.

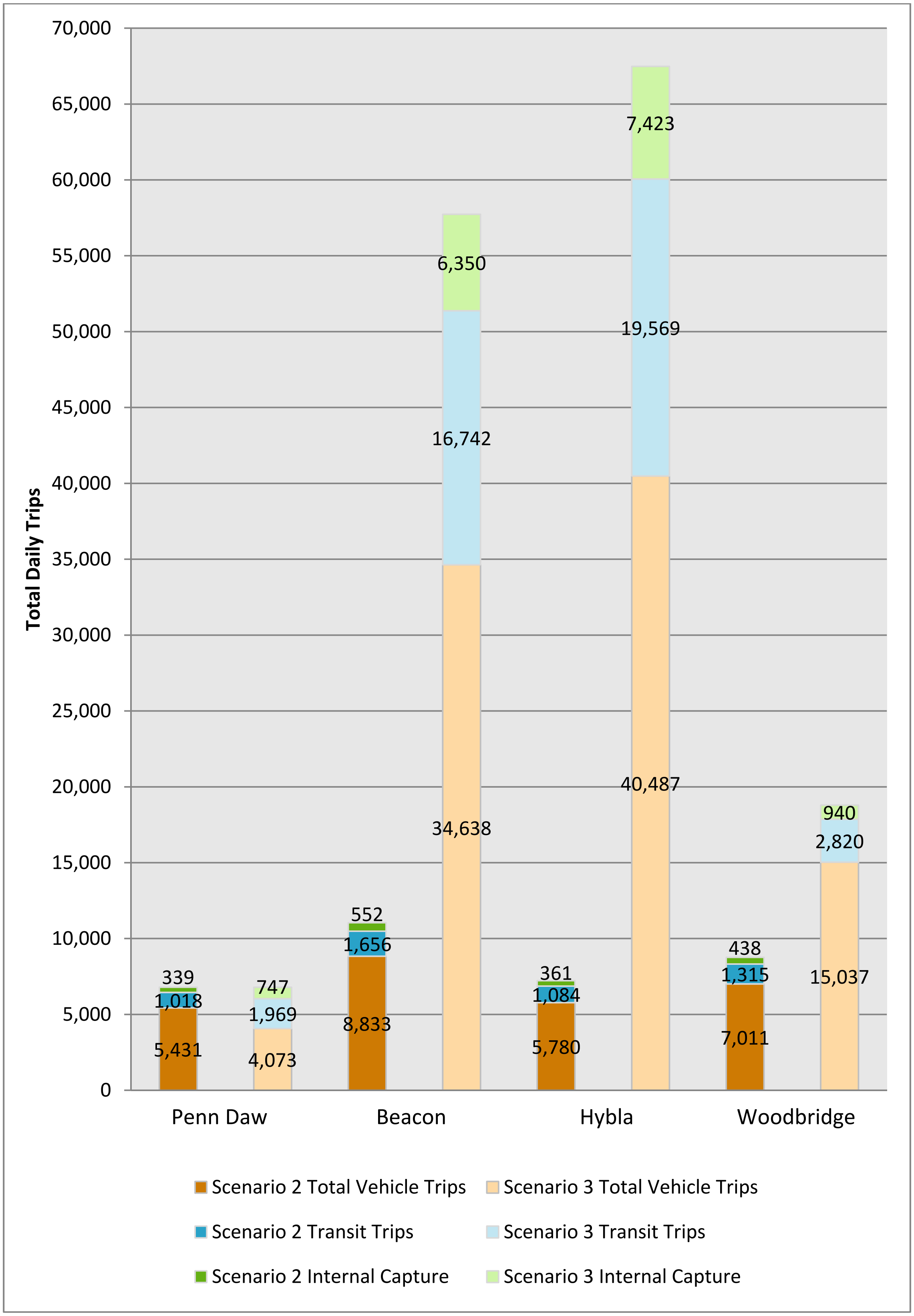
Table 7: Additional Vehicular Trips Generated for Land Use Scenario 3

Area	Land Use (ITE Category)	Units (Change Compared to Scenario 1)	Total Generated Trips			Total Auto Trips	
			Daily	AM Peak Hour	PM Peak Hour	AM Peak Hour	PM Peak Hour
PENN DAW STATION	High Rise Apartment 222	1,151 DU	4,836	345	403	207	242
	General Office 710	177 ksf	1,952	276	264	166	158
	Total		***6,788***	***621***	***667***	***373***	***400***
BEACON STATION	High Rise Apartment 222	4,704 DU	19,756	1,411	1,646	847	988
	General Office 710	3,443 ksf	37,974	5,371	5,129	3,223	3,078
	Total		***57,730***	***6,782***	***6,776***	***4,069***	***4,065***
HYBLA STATION	High Rise Apartment 222	6,111 DU	25,665	1,833	2,139	1,100	1,283
	General Office 710	3,791 ksf	41,813	5,914	5,648	3,548	3,389
	Total		***67,478***	***7,747***	***7,787***	***4,648***	***4,672***
WOODBRIDGE STATION	High Rise Apartment 222	1,475 DU	6,196	442	516	354	413
	General Office 710	1,142 ksf	12,601	1,782	1,702	1,426	1,362
	Total		***18,797***	***2,225***	***2,218***	***920***	***1,775***

Figure 18 shows additional daily trips generated with land use Scenarios 2 and 3 compared to Scenario 1 and the breakdown of the additional trips by transit, internal capture (walk and bike), and auto trips.

Scenario 3 growth levels generate significantly larger numbers of trips (auto, transit, and internal) than Scenario 2. Even with the high transit and walk/other modal splits, Scenario 3 is estimated to generate about 4,500 additional vehicular trips during the AM and PM peak hours within each potential Metrorail station area.

Figure 18: Additional Daily Trips Generated by Mode for Land Use Scenarios 2 and 3



3.3.2 Station Area Trip Distribution Approach

No Build traffic volumes are used as the baseline for estimating additional, scenario-related trips. Residential trips are assumed to originate from each station area and office trips would be destined to the study area in the morning peak. Symmetry was assumed between the morning and evening trips (i.e., the number of trips leaving the area in the morning peak hour is equal to the number of trips entering the area during the evening peak hour). Directional distributions of trips for the proposed Beacon Hill Metrorail Station for residential and office trips are shown in **Figure 19** and **Figure 20.** A similar approach was used at other stations.

- Scenario growth is applied to the exising roadway network to assess “worst case” intersection LOS.
- The number of theoretical through lanes needed to provide an “acceptable” intersection LOS is calculated. “Acceptable” volume is defined as lower than 85 percent of design capacity (generally better than operating at LOS E).
- The typical 6-lane Route 1 cross section was assumed, operating at “acceptable” levels due to enhanced transit and walk mode share and expanded theoretical local street capacity. The local street capacity is assumed as 600 vehicles per hour per lane.

Once the additional trips at each station area are generated, their impacts on other stations (external or through-trips) are also considered in the analysis. The Woodbridge station was analyzed independently and the impact of external trips beyond the Scenario 1 baseline was not considered due to its relatively long distance from other stations.

Figure 19: Residential Trip Distribution for Beacon Hill Metro Station

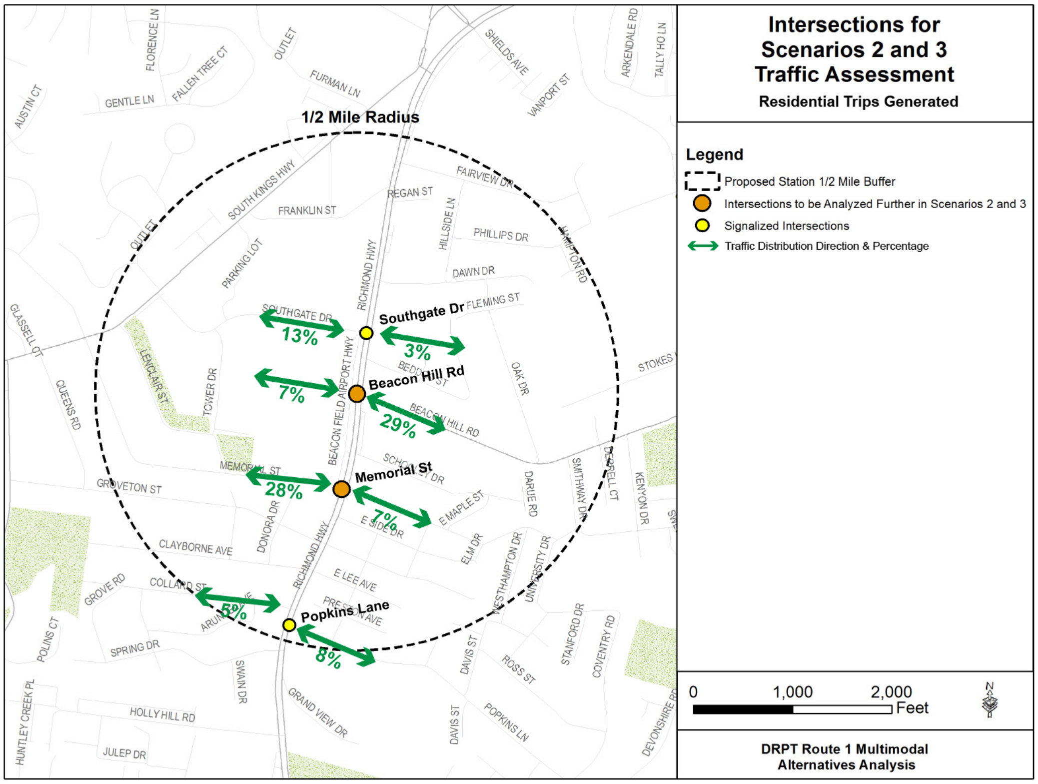
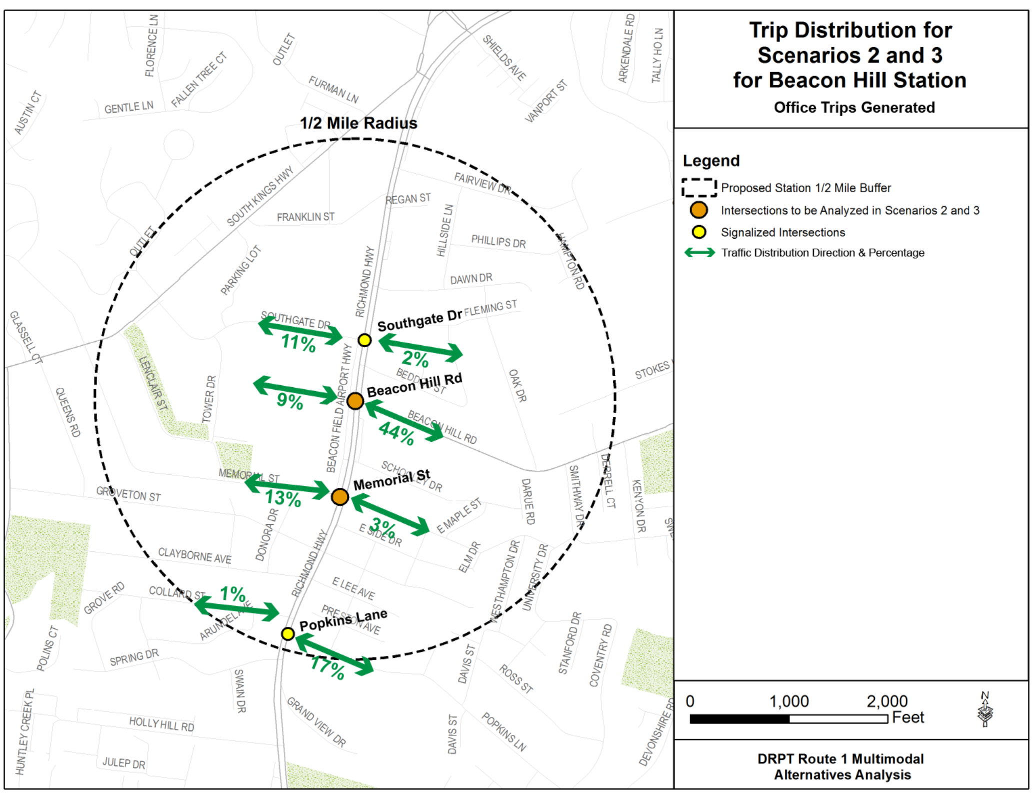


Figure 20: Office Trip Distribution for Beacon Hill Metro Station



3.3.3 Intersection-specific Results

Tables 8, 9, 10, and 11 below summarize intersection LOS for the key study intersections.

Overall, these findings must be understood not as specific tests of intersections or of corridor segments, but rather as a general assessment of the Route 1 corridor capacity to accommodate additional travel demand associated with the potential growth scenarios.

Table 8: Findings for Scenario 2 Traffic Assessment - AM Analysis

Station Area	Intersection	Scenario 1		Scenario 2 Existing Grid		Scenario 2 Enhanced Mode Share and Expanded Through-Capacity	
		LOS	Delay (s)	LOS	Delay (s)	LOS	Delay (s)
Penn Daw	Shields Avenue	B	18	D	55	D	35
	Walmart Entrance	D	45	F	91	D	47
Beacon	Beacon Hill	C	31	F	98	E	70
	Memorial Road	B	16	C	25	B	16
Hybla Valley	Boswell Avenue	C	31	E	62	D	37
	Sherwood Hall Ln	C	34	E	80	C	34
	Buckman Road	E	65	F	134	E	75
Woodbridge	Annapolis Road	A	4	A	5	A	5
	Gordon Boulevard	D	46	F	87	D	51

Table 9: Findings for Scenario 2 Traffic Assessment- PM Analysis

Station Area	Intersection	Scenario 1		Scenario 2 Existing Grid		Scenario 2 Enhanced Mode Share and Expanded Through-Capacity	
		LOS	Delay (s)	LOS	Delay (s)	LOS	Delay (s)
Penn Daw	Shields Avenue	D	36	D	45	D	37
	Walmart Entrance	E	60	F	91	E	68
Beacon	Beacon Hill	D	48	F	156	E	74
	Memorial Road	C	32	F	102	D	42
Hybla Valley	Boswell Avenue	D	43	F	111	D	52
	Sherwood Hall Ln	E	57	F	124	E	68
	Buckman Road	D	48	F	104	E	64
Woodbridge	Annapolis Road	A	8	B	15	B	10
	Gordon Boulevard	C	25	E	74	C	32

Table 10: Findings for Scenario 3 Traffic Assessment- AM Analysis

Station Area	Intersection	Scenario 1		Scenario 3 Existing Grid		Scenario 3 Enhanced Mode Share and Expanded Through-Capacity	
		LOS	Delay (s)	LOS	Delay (s)	LOS	Delay (s)
Penn Daw	Shields Avenue	B	18	F	176	D	40
	Walmart Entrance	D	45	F	266	D	54
Beacon	Beacon Hill	C	31	F	275	E	72
	Memorial Road	B	16	F	275	C	23
Hybla Valley	Boswell Avenue	C	31	F	286	C	33
	Sherwood Hall Ln	C	34	F	347	D	36
	Buckman Road	E	65	F	344	E	73
Woodbridge	Annapolis Road	A	4	A	6	A	5
	Gordon Boulevard	D	46	F	158	E	59

Table 11: Findings for Scenario 3 Traffic Assessment- PM Analysis

Station Area	Intersection	Scenario 1		Scenario 3 Existing Grid		Scenario 3 Enhanced Mode Share and Expanded Through-Capacity	
		LOS	Delay (s)	LOS	Delay (s)	LOS	Delay (s)
Penn Daw	Shields Avenue	D	36	F	113	D	49
	Walmart Entrance	E	60	F	253	E	68
Beacon	Beacon Hill	D	48	F	491	D	49
	Memorial Road	C	32	F	330	D	44
Hybla Valley	Boswell Avenue	D	43	F	308	D	49
	Sherwood Hall Ln	E	57	F	259	D	51
	Buckman Road	D	48	F	221	E	57
Woodbridge	Annapolis Road	A	8	C	22	B	12
	Gordon Boulevard	C	25	F	166	D	39

3.4 Summary of Results

The overall traffic levels include baseline growth derived from the MWCOG model, plus Scenario 2 or 3 station area growth as calculated through the trip generation method described above. With the assumed trip distribution factors and mode splits, the intersections in each station area are evaluated. To calculate design capacity the analysis uses a Highway Capacity Manual (HCM) approach, which considers the total number of through lanes and green to cycle ratio (g/C).

Table 12 summarizes findings for worst performing intersection in each station area, in either the AM or PM. Additionally, the analysis in **Table 12** first assesses the number of additional theoretical Route 1 lanes required to maintain "acceptable capacity". Recognizing that building up to ten additional lanes on Route 1 is not feasible, the analysis assesses the number of lanes required in a parallel street network to maintain "acceptable capacity" on Route 1 with its current amount of planned lanes and with enhanced transit and walk mode shares.

Table 12: Growth Scenario Results- LOS and Additional Lanes

	Penn Daw			Beacon			Hybla Valley			Woodbridge		
Scenarios	*1*	*2*	*3*	*1*	*2*	*3*	*1*	*2*	*3*	*1*	*2*	*3*
Station area growth with no new roadway capacity												
Planned Route 1 through lanes	7	7	7	7	7	7	6	6	6	6	6	6
Assumed transit mode share*	10%	15%	29%	10%	15%	29%	10%	15%	29%	10%	15%	15%
Assumed walk trips*	5%	5%	11%	5%	5%	11%	5%	5%	11%	5%	5%	5%
"Worst case" intersection LOS (6-lane Route 1 section)	E	F	F	D	F	F	E	F	F	D	F	F
Expanded corridor through-capacity												
Additional theoretical Route 1 through-lanes for "acceptable" capacity (v/c = 0.85)	0	1	4	0	1	7	0	4	10	0	2	2
Enhanced mode share and expanded corridor through-capacity												
Enhanced transit mode share	10%	18%	35%	10%	18%	35%	10%	18%	35%	10%	18%	18%
Enhanced walk trips	5%	7%	15%	5%	7%	15%	5%	7%	15%	5%	7%	7%
Resulting Route 1 intersection LOS	E	E	E	D	E	E	E	E	E	D	D	E
Theoretical through-lanes on parallel local streets	0	2	2	0	3	10	0	2	12	0	2	4

*Mode share percentages based on input from Fairfax County and Prince William County staff.

3.4.1 Scenario 2

Scenario 2 results in LOS F at several locations, though not as many locations as Scenario 3. Of the eleven study intersections, two operated with LOS F in the AM peak and three operated with LOS F in the PM peak under Scenario 2. While conditions in most locations worsen in comparison to Scenario 1, results show that acceptable volumes can be achieved with relatively lower transit and walk/bike mode splits and fewer parallel local streets compared to Scenario 3.

3.4.2 Scenario 3

For Scenario 3, the "worst case" analysis shows that at least one of the study intersections in each area operates with LOS F during both the AM and PM peak hours. Of the eleven study intersections, ten operated with LOS F in the AM peak and nine operated with LOS F in the PM peak. With an enhanced grid and transit mode split, only four of the study intersections reach LOS E in the AM peak, with the rest at LOS D or better, and in the PM peak, five study intersections operate with LOS E, with the remaining intersections operating at LOS D or better.

The results indicate that other measures would be required to maintain acceptable traffic volumes assuming the current proposed Route 1 cross-section.

- **An enhanced mode shift to transit and walk trips would be required.**
  The assumptions included in this analysis align with high performing, non-downtown TOD areas from the Washington DC region. Refinements to the mode shift assumptions would affect traffic performance and required roadway capacity.

- **An enhanced secondary street network would be required.**
  This analysis acknowledges that the secondary, local street network along Route 1 is currently limited in terms of continuity and capacity. More street network capacity should be created to provide improved access and accommodate growth, particularly near planned transit stations. Further analysis is required to assess the required capacity of additional street infrastructure.

3.4.3 Findings

The results in **Table 12** show that expanded traffic capacity would be necessary to ensure the required LOS on Route 1 and estimated needs for expanded capacity to maintain required LOS, both with and without enhanced transit and walking mode shares. Recognizing that expanding Route 1 beyond the current planned number of lanes is not desirable or feasible, the analysis focuses on the capacity of potential theoretical parallel through-streets. Under Scenario 2, the parallel streets would need two to four lanes in addition to the existing lanes. Under Scenario 3, ten to twelve lanes would need to be built in a parallel street network to maintain acceptable capacity on Route 1.

ATTACHMENTS

Attachment A: Growth Rates for Scenario 1 VISSIM Analysis

Attachment B: VISSIM Calibration

Attachment C: PM SYNCHRO Results

Attachment D: MWCOG Model Methodology

Attachment E: Trip Generation Methodology

Attachment A: Growth Rates for Scenario 1 VISSIM Analysis

Table A-1 below presents the growth factors used to project 2035 No-Build traffic volumes along North Kings Highway.

Table A-1: Projected Average Annual Growth Rates for North Kings Highway (2015 to 2035)

	Morning Peak Hour	Evening Peak Hour
NB Annual Growth Rate	0.25%	0.75%
SB Annual Growth Rate	0.75%	0.75%

Tables A-2 and **A-3** below show MWCOG Model annual percent growth rates for the AM and PM peak periods at various locations, including North Kings Highway segments based on 2010 and 2035 link volumes. MWCOG Model results indicate higher growth rates south of Mt. Vernon Memorial Highway, however the growth rate is relatively small north of South Kings Highway (Walmart Entrance) and show even negative numbers on North Kings Highway.

Table A-2: MWCOG Model Annual Growth Rates for Route 1 (2015 to 2035)

	ANNUAL GROWTH RATE (%) (SCENARIO 1) ALONG ROUTE 1											
	Gunston Cove to Armistead		Telegraph Road to Fairfax County Parkway		Frye to Mt Vernon Highway		South Kings Hwy (Walmart Entrance) to Fairhaven		Fairhaven to Huntington		Huntington to 495	
	SB	**NB**	**SB**	**NB**	**SB**	**NB**	**SB**	**NB**	**SB**	**NB**	**SB**	**NB**
AM	2.31	1.02	2.24	1.44	1.36	1.39	0.91	0.01	1.48	0.50	1.21	-0.02
PM	1.20	1.45	1.59	1.86	1.94	1.74	1.44	0.83	0.95	1.18	0.65	0.47
24 hr	1.36	1.32	1.51	1.39	1.62	1.50	0.95	0.41	1.19	0.63	1.05	0.29

Table A-3: MWCOG Model Annual Growth Rates for North Kings Highway (2015 to 2035)

	ANNUAL GROWTH RATE (%) (SCENARIO 1) ALONG NORTH KINGS HIGHWAY					
	Route 1 to Fairhaven		Fairhaven to Fort Dr		Fort Dr to Hungtinton	
	SB	**NB**	**SB**	**NB**	**SB**	**NB**
AM	-0.71	-0.08	-0.77	-0.33	-0.59	-0.19
PM	-0.65	-0.38	-0.70	-0.71	0.07	-0.51
24 hr	-0.50	-0.18	-0.52	-0.36	-0.17	-0.15

Attachment B: VISSIM Calibration

In order to calibrate the existing VISSIM model, travel time along Route 1 (between Jana Lee Avenue to Shields Avenue) was used as the performance measure. VISSIM travel time in the northbound direction (i.e., the peak direction) was compared to the VDOT and AECOM field travel times.

VDOT field travel time results were based on three runs collected in May 2011 while AECOM performed a single field travel time run in September 2013. Ten simulation runs were initially performed in VISSIM. To determine the necessary number of simulation runs, a standard statistical "t-Test", as explained in *VDOT Traffic Operations Analysis Tool Guidebook* (2013) was performed. The necessary number of runs can be calculated using the following equation

$$N = \frac{Z^2 * S^2}{E^2} \qquad (1)$$

where *N* is the necessary simulation runs, *Z* is the number of standard deviations away from the mean corresponding to the required confidence interval (corresponds to 1.96 assuming a normal distribution and 95th percentile confidence interval), and *E* is the margin of error. The default confidence interval and margin of error assumed by the Federal Highway Administration (FHWA) are 95 percent and 10 percent, respectively, which were also used in this analysis. **Table B-1** shows the mean travel time and standard deviation of VISSIM travel time results as well as the necessary simulation runs calculated using equation (1).

Table B-1: Necessary Simulation Runs

Mean Travel Time (s)	499.1
S - Standard Deviation of Travel Time (s)	15.5
N – Necessary Simulation Runs	9.3

The results indicate that at least 9.3 runs are required in order to achieve the required confidence interval with the specified margin of error. Therefore, ten simulation runs were concluded to be adequate.

Table B-2 provides travel time comparison during the morning peak hour based on VDOT, AECOM, and VISSIM travel time runs. Results show that VISSIM travel time is 6 percent higher than the VDOT travel time and approximately 8 percent lower the AECOM travel time. Moreover, VISSIM total travel time (497.4 s) is almost the same as the average of VDOT and AECOM field travel time runs (505.5 s).

Table B-2: Travel Time Comparison in the Morning Peak Hour

	VDOT Field Travel Time (s) – 3 Runs	AECOM Field Travel Time (s) – 1 Run	VISSIM Travel Time (s)
Jana Lee Ave to Mt Vernon Highway	50.7	26.6	56.3
Mt Vernon Highway to Ladson Ln	11.7	31.5	17.7
Ladson Ln to Sherwood Ln	36.7	21.3	26.5
Sherwood Ln to Bedford Dr	14.0	12.4	15.9
Bedford Dr to Fordson Rd	30.3	25.1	34.4
Fordson Rd to Boswell Ave	10.7	7.2	12.0
Boswell Ave to Arlington Dr	62.7	97.5	54.3
Arlington Dr to Lockheed Blvd	30.3	33.4	43.9
Lockheed Blvd to Collard St	70.3	67.3	48.0
Collard St Memorial St	33.0	25.5	25.1
Memorial St to Beacon Hill Rd	31.7	15.1	25.2
Beacon Hill Rd to Southgate Dr	12.3	10.8	11.7
Southgate Dr to South Kings Hwy	62.7	154.6	96.6
South Kings Hwy to Shields Avenue	12.3	13.4	29.7
Total	**469.3**	**541.7**	**497.4**

Attachment C: SYNCHRO Findings

Figures C-1 to **C-4** show the 2013 and 2035 AM and PM Synchro results.

Figure C-1: 2013 AM Peak Hour Delay and LOS

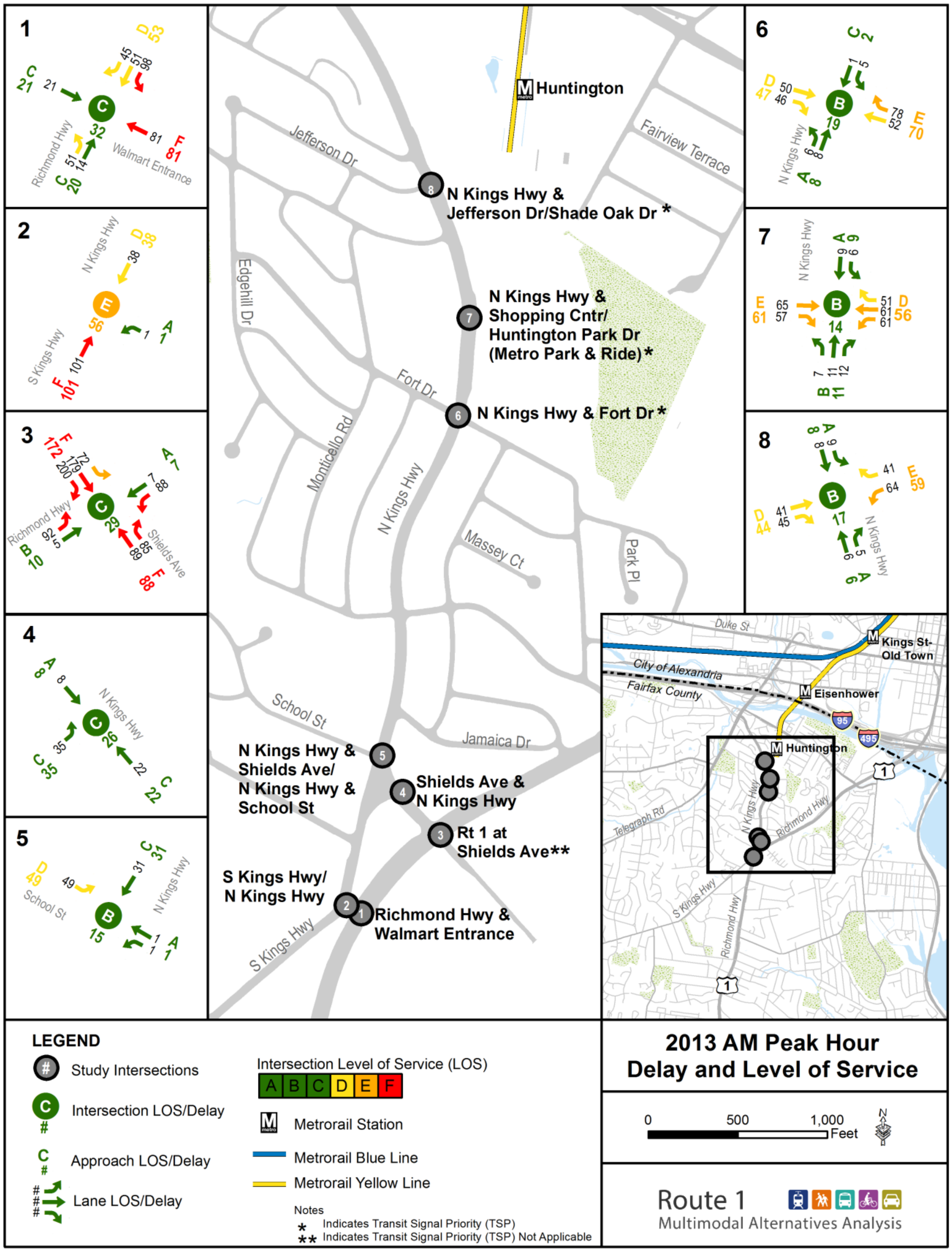


Figure C-2: 2013 PM Peak Hour Delay and LOS

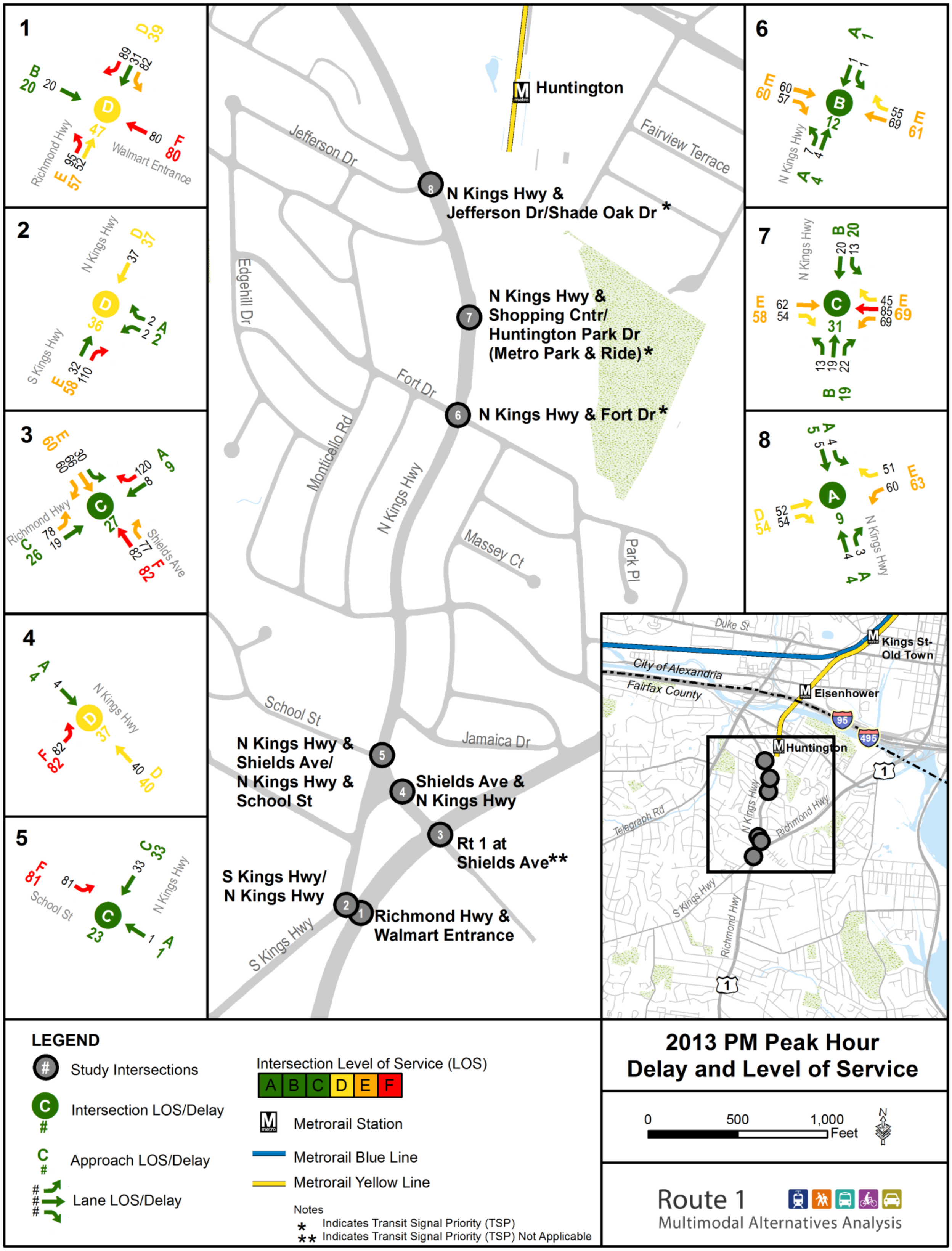


Figure C-3: 2035 AM Peak Hour Delay and LOS

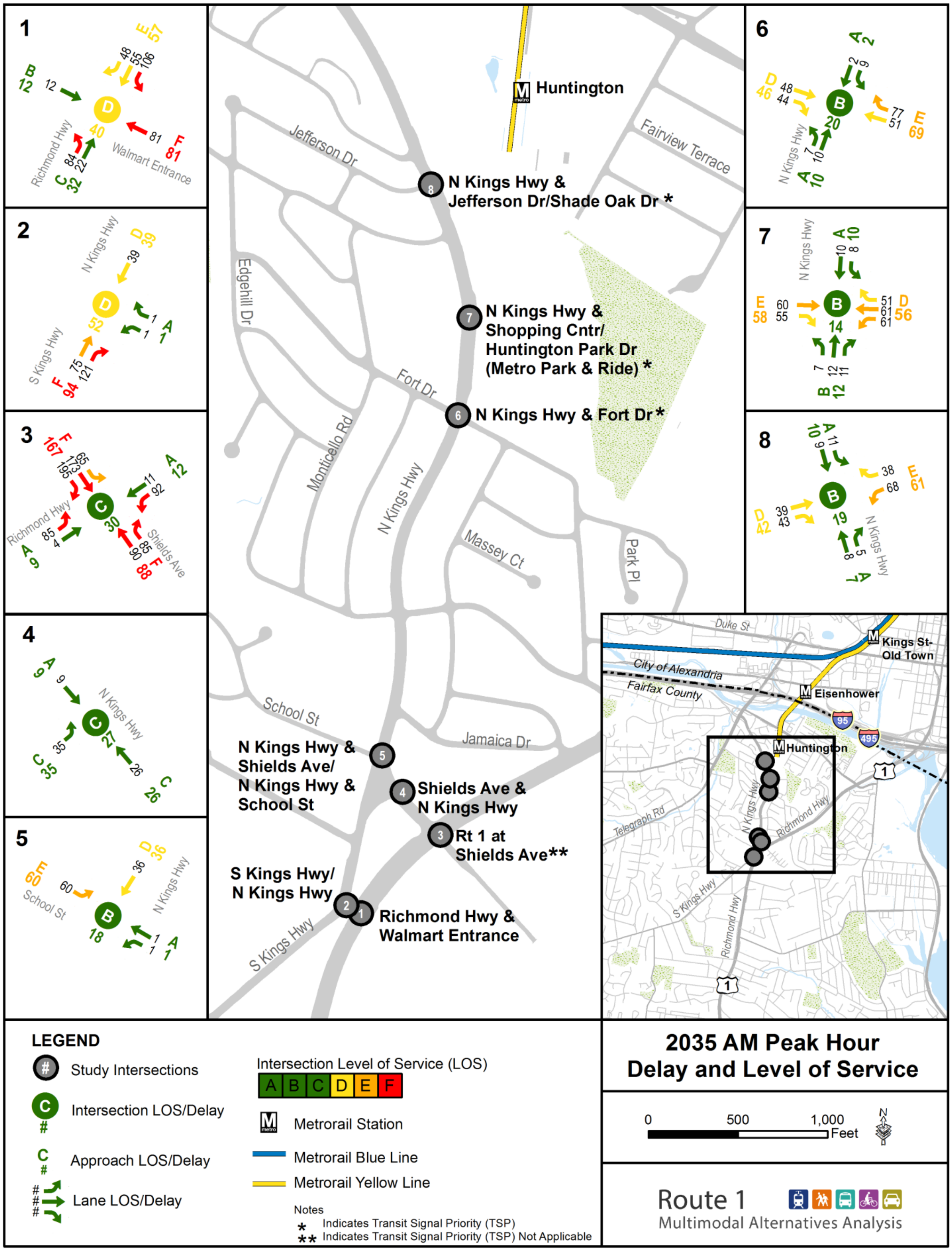
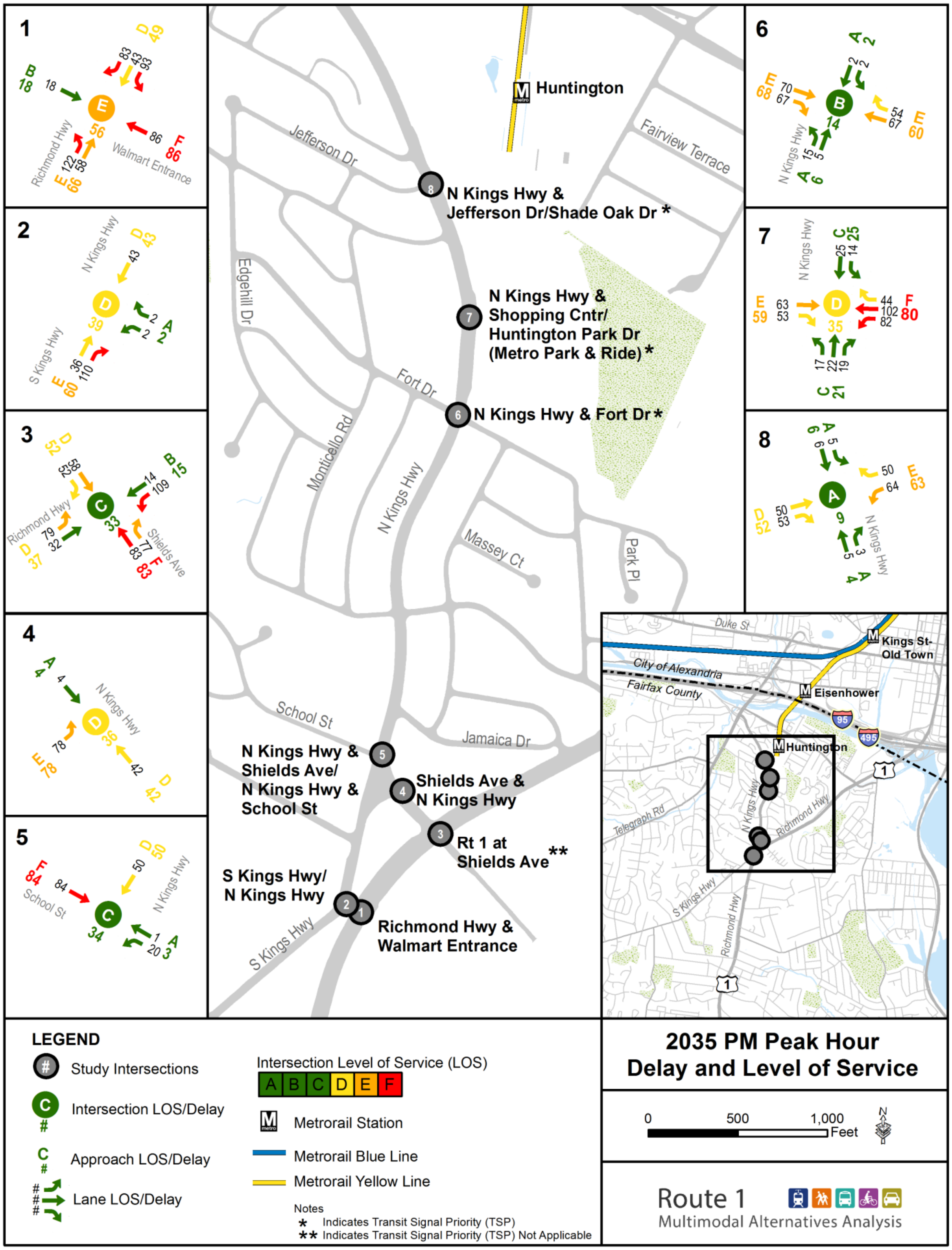


Figure C-4: 2035 PM Peak Hour Delay and LOS



Attachment D: MWCOG Model Methodology

MWCOG Model Validation

The MWCOG/TPB Travel Forecasting Model Version 2.2 used for the Route 1 Alternatives Analysis was validated for both highway and transit. The MWCOG model is a regional tool, and the link volumes that it generates, while generally close to the observed volumes, are subject to the limitations of a regional model: aggregate access/egress due to centroids, poor traffic signal representations, aggregate 4-hour volume delay functions, etc.

As such, off-model traffic analysis is important to ensure applicability to real, observed traffic conditions. The MWCOG model is best used to establish traffic growth rates. This has the advantage of basing the traffic analysis in actual data and applying the growth implied by the MWCOG process.

MWCOG Model Application

The traffic growth forecasts for Scenarios 2 and 3 require post-processing of MWCOG model outputs, due to models generally offering crude aggregate trip generation rates that may/may not understand the impacts of transformational land use impacts.

In revisiting the MWCOG Travel Model 2.2 trip generation procedures, the models use a typical cross-classification structure for trip rates (income by auto ownership) to estimate production end (home) trip rates and very simple attraction models (generally employment based). In addition, the MWCOG Travel Model 2.2 makes a crude statement for non-motorized trips, based on area type.

To establish network traffic growth rates, the following inputs are introduced as “factors” to the regional model: expected changes to internal capture rates, trip making, and automobile ownership between projected Scenario 1 versus Scenarios 2 and 3 development patterns.

Tables D-1 through **D-5** show the annual growth rates by scenario and segment along Route 1.

Table D-1: Annual Growth Rates (%) Projected for Scenario 1

	Gunston Cove to Armistead		Telegraph Road and Fairfax County Parkway		Frye to Mt Vernon Highway	
	SB	NB	SB	NB	SB	NB
AM Vol	2.31	1.02	2.24	1.44	1.36	1.39
PM Vol	1.20	1.45	1.59	1.86	1.94	1.74
24 hr vol	1.36	1.32	1.51	1.39	1.62	1.50

	S Kings Hwy to Fairhaven		Fairhaven to Huntington		Huntington to 495	
	SB	NB	SB	NB	SB	NB
AM Vol	0.91	0.01	1.48	0.50	1.21	-0.02
PM Vol	1.44	0.83	0.95	1.18	0.65	0.47
24 hr vol	0.95	0.41	1.19	0.63	1.05	0.29

	Route 1 to Fairhaven		Fairhaven to Fort Dr		Fort Dr to Hungtinton	
	SB	NB	SB	NB	SB	NB
AM Vol	-0.71	-0.08	-0.77	-0.33	-0.59	-0.19
PM Vol	-0.65	-0.38	-0.70	-0.71	0.07	-0.51
24 hr vol	-0.50	-0.18	-0.52	-0.36	-0.17	-0.15

Table D-2: Annual Growth Rates (%) Projected for Scenario 2

	Gunston Cove to Armistead		Telegraph Road and Fairfax County Parkway		Frye to Mt Vernon Highway	
	SB	NB	SB	NB	SB	NB
AM Vol	2.51	1.24	2.64	1.55	1.46	1.87
PM Vol	1.36	1.68	1.69	2.15	2.20	1.98
24 hr vol	1.47	1.31	1.88	1.80	1.84	1.78

	S Kings Hwy to Fairhaven		Fairhaven to Huntington		Huntington to 495	
	SB	NB	SB	NB	SB	NB
AM Vol	0.19	-0.69	0.94	-0.28	1.21	-0.31
PM Vol	0.97	0.65	0.12	0.94	0.43	0.65
24 hr vol	0.45	0.05	0.58	0.24	0.94	0.29

	Route 1 to Fairhaven		Fairhaven to Fort Dr		Fort Dr to Hungtinton	
	SB	NB	SB	NB	SB	NB
AM Vol	0.12	-0.09	-0.23	-0.40	0.25	-0.21
PM Vol	-0.62	-0.01	-0.74	-0.26	0.11	0.03
24 hr vol	-0.08	0.15	-0.12	-0.04	0.22	0.20

Table D-3: Annual Growth Rates (%) Projected for Scenario 2 with Post-Processed Outputs

	Gunston Cove to Armistead		Telegraph Road and Fairfax County Parkway		Frye to Mt Vernon Highway	
	SB	NB	SB	NB	SB	NB
AM Vol	2.42	1.04	2.48	1.56	1.37	1.89
PM Vol	1.22	1.39	1.76	2.00	2.12	1.94
24 hr vol	1.44	1.31	1.82	1.73	1.78	1.76

	S Kings Hwy to Fairhaven		Fairhaven to Huntington		Huntington to 495	
	SB	NB	SB	NB	SB	NB
AM Vol	0.18	-0.77	0.82	-0.36	1.07	-0.31
PM Vol	0.84	0.66	0.00	0.87	0.35	0.62
24 hr vol	0.32	0.04	0.48	0.21	0.82	0.25

	Route 1 to Fairhaven		Fairhaven to Fort Dr		Fort Dr to Hungtinton	
	SB	NB	SB	NB	SB	NB
AM Vol	0.06	-0.09	0.05	-0.40	0.20	-0.25
PM Vol	-0.64	-0.02	-0.73	-0.30	0.07	0.00
24 hr vol	-0.09	0.12	-0.12	-0.07	0.20	-6.29

Table D-4: Annual Growth Rates (%) Projected for Scenario 3

	Gunston Cove to Armistead		Telegraph Road and Fairfax County Parkway		Frye to Mt Vernon Highway	
	SB	NB	SB	NB	SB	NB
AM Vol	2.46	0.50	2.17	1.61	0.58	2.21
PM Vol	0.66	1.25	1.87	2.08	2.16	1.88
24 hr vol	1.21	1.14	2.04	1.96	2.08	2.14

	S Kings Hwy to Fairhaven		Fairhaven to Huntington		Huntington to 495	
	SB	NB	SB	NB	SB	NB
AM Vol	1.51	-1.54	3.02	-0.43	2.90	-0.13
PM Vol	0.69	1.29	0.25	1.43	0.94	1.38
24 hr vol	0.92	0.30	1.61	0.88	1.92	0.94

	Route 1 to Fairhaven		Fairhaven to Fort Dr		Fort Dr to Hungtinton	
	SB	NB	SB	NB	SB	NB
AM Vol	-0.71	-0.08	-0.77	-0.33	-0.59	-0.19
PM Vol	-0.65	-0.38	-0.70	-0.71	0.07	-0.51
24 hr vol	-0.50	-0.18	-0.52	-0.36	-0.17	-0.15

Table D-5: Annual Growth Rates (%) Projected for Scenario 3 with Post-Processed Outputs

	Gunston Cove to Armistead		Telegraph Road and Fairfax County Parkway		Frye to Mt Vernon Highway	
	SB	NB	SB	NB	SB	NB
AM Vol	2.41	0.42	2.06	1.52	0.43	2.11
PM Vol	0.62	1.16	1.77	1.97	2.03	1.77
24 hr vol	1.15	1.06	1.92	1.86	1.91	2.03

	S Kings Hwy to Fairhaven		Fairhaven to Huntington		Huntington to 495	
	SB	NB	SB	NB	SB	NB
AM Vol	1.40	-1.57	2.90	-0.56	2.76	-0.20
PM Vol	0.41	1.09	0.04	1.35	0.75	1.28
24 hr vol	0.76	0.16	1.46	0.76	1.76	0.84

	Route 1 to Fairhaven		Fairhaven to Fort Dr		Fort Dr to Hungtinton	
	SB	NB	SB	NB	SB	NB
AM Vol	0.42	-0.39	0.49	-0.52	0.84	-0.71
PM Vol	-0.67	0.29	-0.84	-0.01	0.49	0.86
24 hr vol	0.11	0.19	0.20	0.36	0.74	0.79

Attachment E: Trip Generation

Options for Trip Generation Methodology

Case studies and previous research were used to determine the most appropriate method in estimating trips generated by land use in Scenarios 2 and 3.

The Institute of Transportation Engineers (ITE) Trip Generation model[1] uses manual numbers, based on corresponding land uses, to generate a total number of daily trips as well as morning and evening peak hour trips. However, the ITE method typically reflects isolated, suburban developments with poor transit service, limited walking and cycling accessibility. The Route 1 study area under the proposed land use scenarios, in particular under land use Scenario 3, will be well-serviced by multiple transit options and be accessible to walkers and cyclists. Therefore, the direct application of ITE Trip Generation Manual will result in significant overestimation of the number of trips generated.

The US Environmental Protection Agency (EPA) Trip Generation[2] tool was developed with mixed-use developments in mind and land use data from household travel surveys, GIS databases, and other sources to calculate resulting travel from areas with more than one land use. This model is able to estimate internal capture as well as transit use for trips that start and end in mixed-use developments based on the mix and densities of the land uses in the site. However, the EPA method involves a large data input that is complex to collect. Moreover, the model has size and density limitations based on the range of data used to develop the model. Since the level of development in our study area has data that surpassed the model's maximum inputs and since the details regarding the future development that is required for the EPA analysis is not available, the EPA model was not considered in the analysis.

A six-region study[3], conducted by a diverse group of stakeholders, researched to what extent the ITE method understated the traffic benefits of mixed-use developments. The findings suggested that TOD with diverse activities on-site captured a larger share of trips internally, while walkable areas with transit access generated a significant share of walking and transit trips. A different report by the Texas Transportation Institute[4] (TTI) studied the estimation of trip generation for mixed-use developments with a focus on sufficiently capturing internal site trips. The National Cooperative Highway Research Program (NCHRP)[5] also published a report on ways to improve the methodologies used to estimate the extent to which trips made within mixed-use developments are internalized or satisfied with both origin and destination within the development.

WMATA Development Related Ridership Survey[6] conducted by Washington Metropolitan Area Transit Authority (WMATA) in 2005 surveyed the travel behavior of persons traveling to and from office and residential sites near Metrorail stations. Thirteen Metrorail stations participated in the study. The goal of the study was to estimate modal splits for certain physical site characteristics.

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[1] http://www.ite.org/tripgeneration/trippubs.asp
[2] http://www.epa.gov/dced/mxd_tripgeneration.html
[3] http://www.reconnectingamerica.org/assets/Uploads/trafficmixedusedevelopments2009.pdf
[4] http://tti.tamu.edu/documents/5-9032-01-1.pdf
[5] http://onlinepubs.trb.org/onlinepubs/nchrp/nchrp_rpt_684.pdf
[6] https://www.wmata.com/pdfs/planning/2005_Development-Related_Ridership_Survey.pdf

The WMATA study reflects numbers from the Washington Metropolitan Area and offers insights regarding mode splits based on different typologies (e.g., station located in central business district); consequently, the project team decided to use the ITE method in conjunction with the WMATA study findings. The combined method essentially uses standard ITE rates first to compute daily trip estimates and then considers the WMATA study to capture transit as well as walk and other mode splits on similar transit oriented developments in the region. Once modal splits were determined, trip generation for vehicular trips were calculated.

Table E-1 summarizes the results from the *WMATA Development Related Ridership Survey* (2005). This report provides mode share data for stations inside and outside the beltway. Stations inside the beltway include Ballston, Court House, Eisenhower Avenue, King Street, and Silver Spring. These do not include stations in the urban core. Outside the beltway stations include Dunn-Loring, Grosvenor, and New Carrollton.

Table E-1: WMATA Development Related Ridership Survey (2005)

Typology	Trip Type	Transit	Walk & Other	Auto
Suburban – Inside the Beltway	Residential Mode Share for All Trips	49%	14%	37%
	Commute Mode Share at Office Sites	30%	6%	64%
Suburban – Outside the Beltway	Residential Mode Share for All Trips	32%	6%	62%
	Commute Mode Share at Office Sites	11%	0%	89%

Source:http://www.reconnectingamerica.org/assets/Uploads/2005developmentrelatedridershipstudy

The study team also referred to the *Fairfax County Comprhensive Plan, 2013 Edition – Tysons Corner Urban Center, Amended Through 4-9-2014, Vision for Tysons*. To support the level of development in Tysons, Fairfax County developed transit mode split values for the Tysons area for different future years as a strategy to meet a target automobile trip reduction level. These mode split values assume future investment in high-quality transit and TOD development. **Table E-2** summarizes mode share goals for Tysons, and **Table E-3** shows trip reduction goals for Tysons.

Table E-2: Mode Share Targets for Tysons Area

Required Transit Mode Share During Peak Periods to Meet Target Auto Trip Reduction Level			
Year	TOD Areas	Non-TOD Areas	All of Tysons
2040	29%	15%	25%

Source: *Fairfax County Comprhensive Plan, 2013 Edition – Tysons Corner Urban Center, Amended Through 4-9-2014, Vision for Tysons*

Table E-3: Trip Reduction Targets for Tysons Area

Development		0 to 1/4 Mile from Station	1/4 to 1/2 Mile from Station	Non-TOD Locations (More than ½ Mile from Station)
Office	Baseline	30%	25%	20%
	Transportation Demand Management Goal	45% - 35%	40% - 30%	35% - 25%
Residential	Baseline	30%	25%	15%-10%
	Transportation Demand Management Goal	45% - 35%	40% - 30%	25% - 15%

Source: *Fairfax County Comprhensive Plan, 2013 Edition – Tysons Corner Urban Center, Amended Through 4-9-2014, Vision for Tysons*

Trip Generation Process

In order to determine the trip generation numbers associated with land use in Scenarios 2 and 3, population and employment estimates were converted into units that are compatible with the ITE method. Dwelling units (DU) were calculated from population size, based on the average persons per household (pph) number for high-rise multi-family units in Fairfax County (2.14 pph) divided by the projected population. For the employment numbers, the average square feet needed per employee (300 ft) was multiplied by the employment projections to determine the amount of new office space needed in the future.

Once the inputs for the three transit-oriented stations were determined, ITE Trip Generation (9th edition) rates were used to calculate the daily or hourly trip estimates. For the dwelling units, land use designation 222, "High-Rise Apartments", was used based on the assumption the proposed development will be needed to achieve high densities to support transit. For the office space, land use designation 710, "General Office", was assumed as there is little information available at this stage of the study regarding what type of employment will be located around these stations.

Based on input from Fairfax County and Prince William County staff, the modal splits assumptions used for Scenario 3 were finalized. The residential mode share numbers are for all trips; therefore, the mode share numbers for residential during the peak hours can actually be higher than what is shown below. Relatively lower transit and walk and other modal split values are used for Woodbridge Station since it will be served by BRT, while the other two stations will be served by Metrorail in land use Scenario 3.

Table E-4: Assumed Mode Share for Current Route 1 Analysis

Station	Transit	Walk & Other	Auto
Beacon and Hybla Valley Stations (served by Metro)	29%	11%	60%
Woodbridge Station (served by BRT)	15%	5%	80%

A similar methodology is applied in estimating the generated trips associated with land use in Scenario 2. However, to account for lower land use intensity and BRT service (all stations will be served by BRT in Scenario 2), a lower non-auto mode share is assumed. Using the MWCOG Travel Model Scenario 2 results and *NCHRP Report 758*[7], transit and walk & other mode shares were assumed to be 14 percent and 4 percent, respectively.

The mode split assumptions also considered *Arlington County Residential Building Transportation Performance Monitoring Study* (2013). The report presents survey results of commuting and mode share patterns in TOD and non-TOD areas in Arlington. The TOD areas within Arlington County include both bus and Metrorail corridors. Results of the study are below in **Table E-5**.

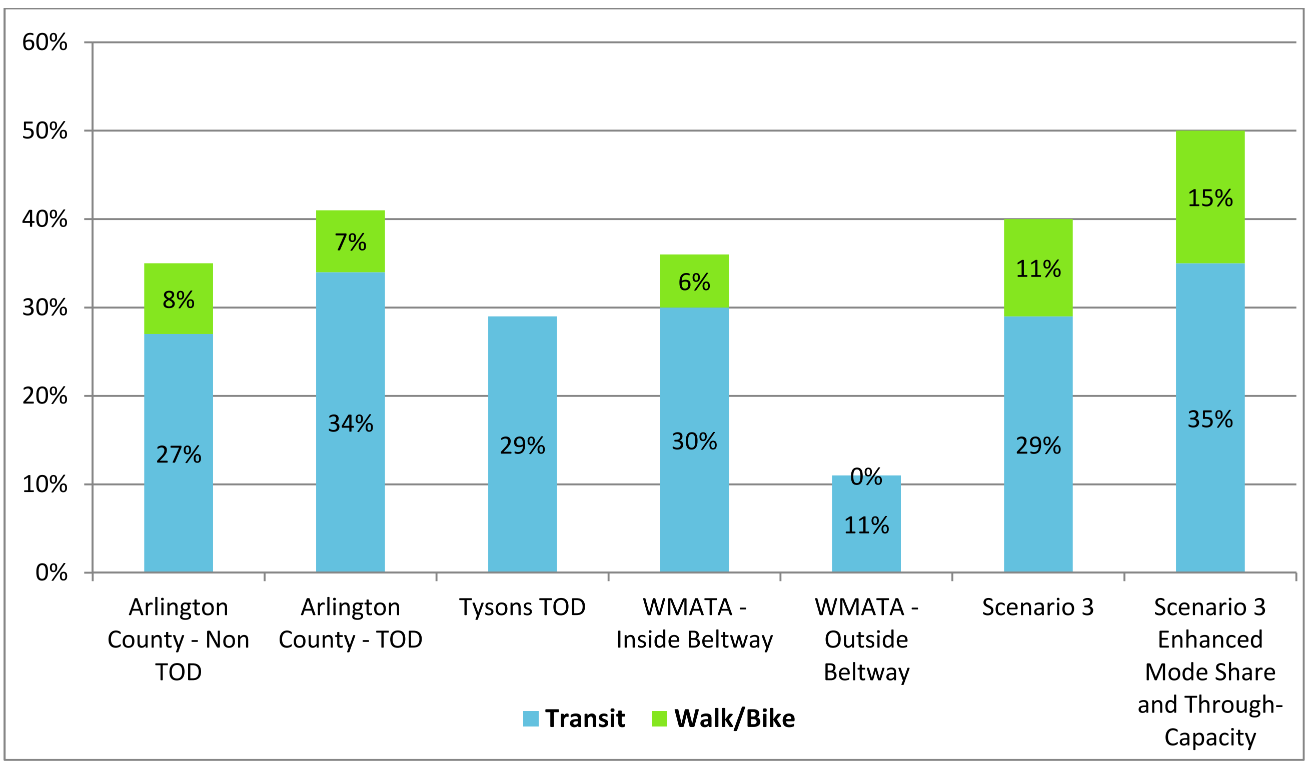
Table E-5: Arlington County Survey Results: Non-Auto Mode Split

	TOD Areas	Non-TOD Areas
Commute Trips	43%	35%
Non-Work Trips	39%	33%

Source: http://mobilitylab.org/wp-content/uploads/2013/10/ACCS_ResidentialBuildingStudy_Presentation17Sept2013.pdf

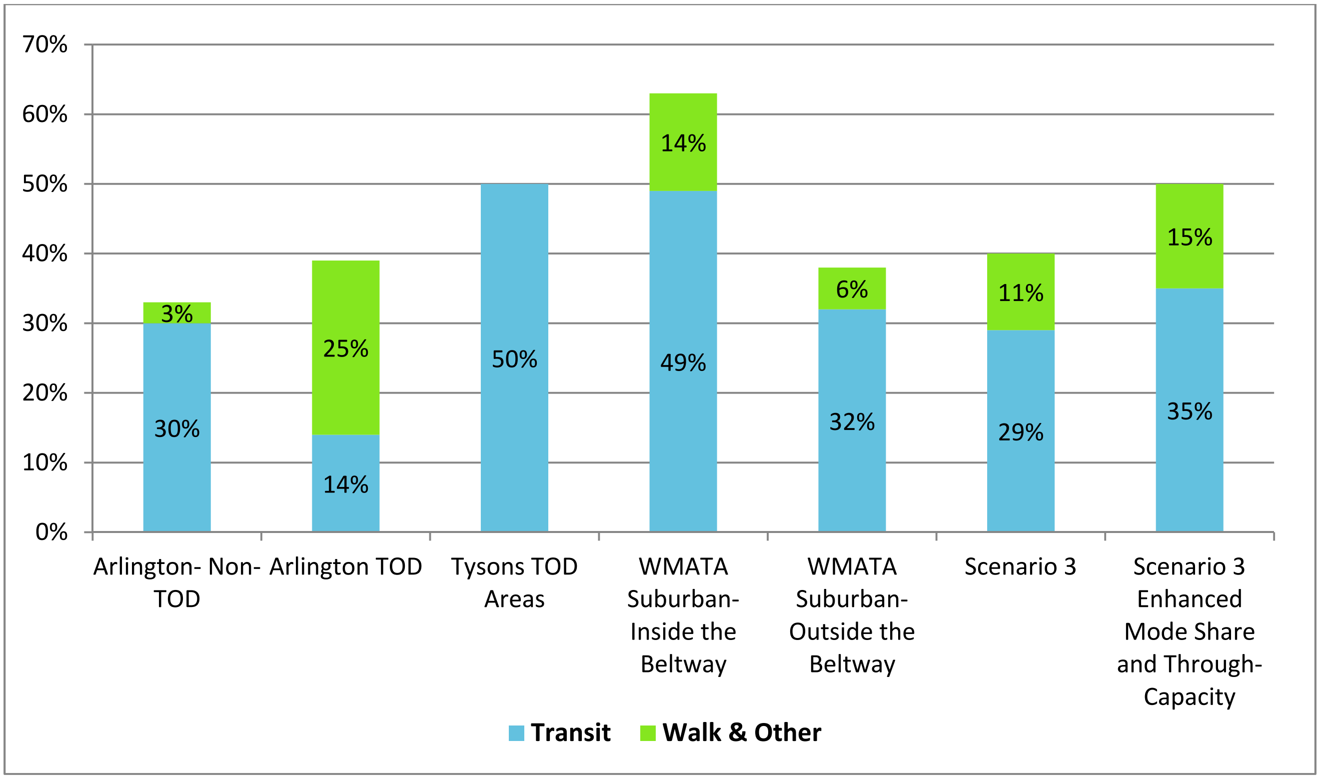
Figures E-1 and E-2 show Scenario 3 internal capture rate assumptions with the other case studies for both commute trips and non-work trips.

Figure E-1: Commute Trips Mode Share



7 http://onlinepubs.trb.org/onlinepubs/nchrp/nchrp_rpt_758.pdf

Figure E-2: Non-Work Trips Mode Share



Once transit and internal capture percentages were determined, vehicular trips are calculated as follows:

$$VehicularTrips = TotalTrips \times (100 - P_{Transit} - P_{Walk\&Other})$$

where $P_{Transit}$ and $P_{Walk\&Other}$ represent transit and walk & other modal splits in percentages, respectively.