Tysons

COUNTY OF FAIRFAX 1742 VIRGINIA

Tysons Circulator Study

Prepared for the Fairfax County Department of Transportation

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STEADMAN HILL CONSULTING, INC.

FOURSQUARE INTEGRATED TRANSPORTATION PLANNING

PARSONS BRINCKERHOFF

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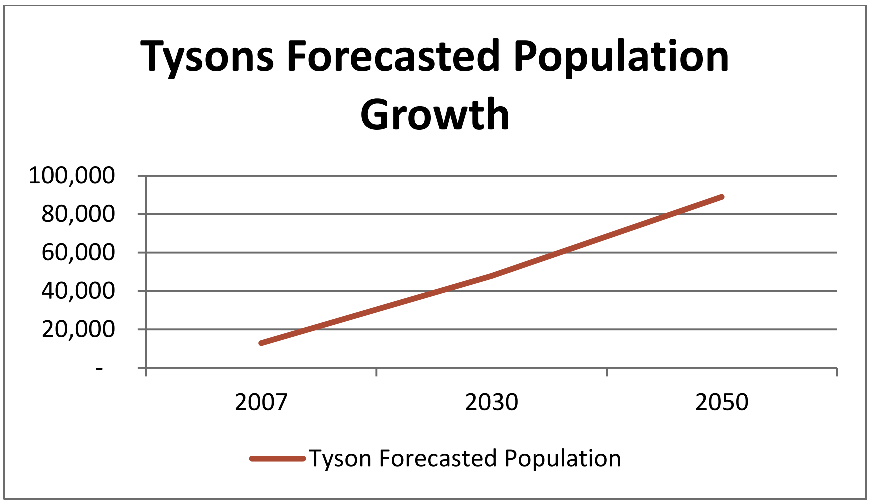
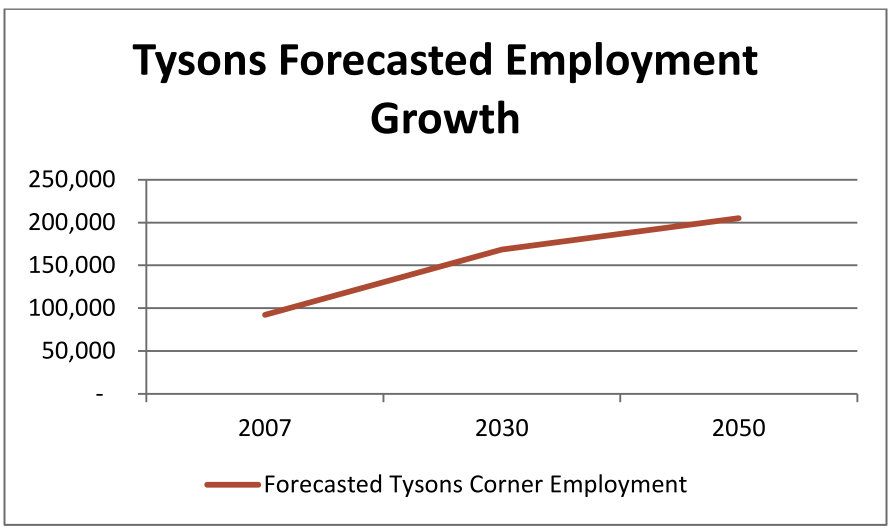
ES.1 Introduction

The Tysons Circulator Study is a **long range** planning study that has been undertaken to support the redevelopment and rezoning of Tysons over the next 40 years (the Circulator planning described here is for a horizon year of 2050 – to provide context, the forecasted growth in population and employment in Tysons through 2050 is shown in Figure ES-1). The purpose of the study is to design a circulator system that will support the County's overall goal of maximizing transit trips and minimizing vehicular trips to, from, and within Tysons.

Figure ES-1: Forecasted Population and Employment Growth in Tysons Through 2050





The key outputs of the study, which will support Fairfax County staff and elected officials in making transportation decisions as the Tysons redevelopment and rezoning process moves forward includes the following:

a. The identification of a circulator network that maximizes transit ridership and provides service to the greatest number of potential riders.

b. The identification of the most appropriate transit mode for each route within the overall recommended network based on ridership demand and required capacity to meet that demand, as well as additional factors such as ease of construction and impacts on pedestrians, bicyclists, and automobiles.

c. The Identification of required transit preferential treatments to support fast and reliable transit service. Preferential treatments include transit exclusive lanes, queue jumps at intersections, and transit signal priority.

The study recommendations in each of these areas are outlined in Section 3 of this Executive Summary.

ES.2 Study Process

Completion of the Tysons Circulator Study relied on a detailed technical planning process in order to develop recommendations in each of the three key areas summarized above. Each step in the planning process is summarized below.

a. **Peer Review –** As a first step in the planning process, a peer review of circulator systems within the United States as well as internationally was completed in order to identify lessons learned on those systems, both negative and positive. The insights provided from this peer review were utilized throughout the Circulator Study planning process.

b. **Project Goals and Objectives** – The project goals and objectives were developed at the beginning of the planning process in order to provide a framework for completing the study, and acted as a foundation for the technical analysis completed in each of the remaining steps of the planning process.

c. **Preliminary Network Development** – This step in the planning process utilized the project goals and objectives as well as a series of route design principles to develop five preliminary circulator networks. This original set of networks was then evaluated for probability of success based on a preliminary evaluation framework and two of these networks were selected to move forward for more detailed evaluation.

d. **Evaluation of Two Networks with Highest Probability of Success** – In this step, the two networks selected for more detailed evaluation based on their assessed probability of success were compared to each other based on a framework that covered a range of performance factors including ridership, productivity, cost-effectiveness, and effectiveness in serving trips within Tysons. The recommended network is described in Section 3 of this Executive Summary.

e. **Mode Option Analysis** – The work in this step yielded one of the key outputs of the study, which was a mode recommendation for each route in the recommended network. The analysis to reach this recommendation relied on an assessment of needed capacity to meet estimated ridership demand on each route in conjunction with the cost of providing this capacity, as well as other factors such as ease of construction, impacts on other modes, and urban design impacts. Three modes were evaluated in this manner: bus (either 40' or 60'), streetcar, and Driverless People Mover. The final mode recommendations are outlined below in Section 3 of this Executive Summary.

f. **Transit Preferential Treatments -** This planning process step yielded the final key recommendation of the study: what transit preferential treatments are required to support a fast and reliable circulator system. Transit preferential treatments include exclusive transit lanes, queue jumps, and transit signal priority. Because exclusive transit lanes and queue jumps will typically require additional right-of-way, which means obtaining property from landowners adjacent to the route alignments, early identification of these requirements was deemed essential. This required right-of-way will be reserved as property owners enter the re-zoning process with the County. The final preferential treatment recommendations are outlined below in Section 3 of this Executive Summary.

g. **Ridership Estimates** – Results from the project ridership estimating process were essential inputs into two of the key planning process steps, the mode option analysis and the network evaluation process. Ridership estimates were based on the "George Mason University (GMU) 2050 High" population and employment forecasts, which were developed in 2008. These population and employment forecasts for 2030 and 2050 were originally developed for Fairfax County by George Mason University for use in the development of the Tysons Comprehensive Plan.

h. **Operating and Capital Costs** – Operating and capital costs were a key input into the network evaluation process and were also utilized in the mode option analysis. To support these analyses costs were calculated in two different formats. In the first instance, operating costs were calculated on an annual basis and capital costs were calculated as a total capital cost. In the second instance, annual operating costs were combined with annualized capital costs to provide a life cycle cost for each mode alternative over 30 years. This approach provides an understanding of total costs over this extended period. These life cycle costs also allow a more accurate and consistent comparison of alternatives that have different upfront capital costs and different operating cost structures (for instance, one alternative may have higher up front capital cost but lower operating costs over the life of the project, or the life of a capital asset may be more expensive to implement upfront but also has a longer life). All costs included in the report are expressed in 2012 dollars.

i. **Guidelines for Interim Circulator Operations** – Because the planning process has such a distant horizon, guidelines for interim circulator alignment and operations prior to 2050 were developed to guide staff in implementation of the early phases of the Circulator as well as to guide how the routes will evolve toward the long term Circulator routes over time.

j. **Public Outreach and Stakeholder Coordination** – Public outreach and stakeholder coordination was a key part of the Circulator planning process, with outreach events occurring throughout the 14 month planning process.

k. **Next Steps –** Identifying how the recommendations developed as part of the Circulator Study will be incorporated into the County's overall Tysons planning process was the final study step.

ES.3 Recommendations

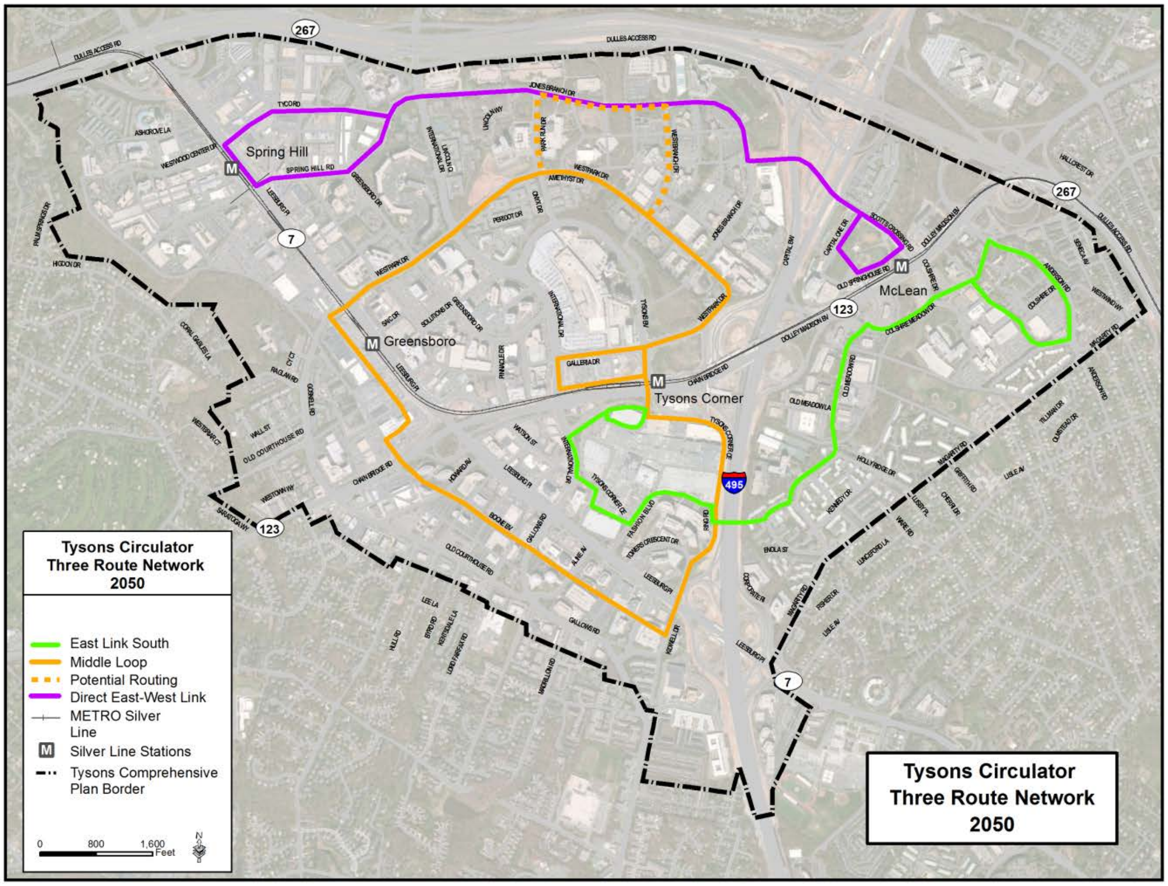
Study recommendations were made in each of the three key areas summarized in Section 1. These are described below.

ES.3.1 Final Network

The final network recommendation is the "Three Route Network". This recommendation is based on the network's consistently higher performance on nearly all of the evaluation criteria utilized to compare the two networks selected from the original five for more detailed evaluation. This includes higher ridership, higher productivity, and higher cost-effectiveness. This recommended network is shown in Figure ES-2 below.

It is important to note that the Circulator will not be the only non-Silver Line transit service in Tysons. Rather, the Circulator, which will be focused on providing circulation within Tysons, will be part of much denser transit network that will include WMATA Metrobus service, Fairfax County Connector service, and long distance bus service from other parts of Northern Virginia. Information on WMATA Metrobus service in Tysons can be found at **http://wmata.com/bus/**; information on Fairfax Connector service in Tysons can be found at **http://www.fairfaxcounty.gov/connector**; information on long distance service to Tysons can be found at **http://www.vamegaprojects.com/commuter-solutions/tysons-bus-services/go-tysons/tysons-express-woodbridge**, **http://prtctransit.org/index.php**, and **http://www.loudoun.gov/index.aspx?NID=228**.

Figure ES-2: Final Recommended Network – Three Route Network



ES.3.2 Mode Recommendation

The mode option analysis indicated that buses can provide sufficient capacity to meet ridership demand under all scenarios evaluated, at a lower cost than streetcar. It is recommended, therefore, in all instances to utilize buses to provide Circulator service given their lower capital and operating cost, their greater flexibility in being adjusted or extended, if required, and their ability to bypass an accident, disabled vehicles, or construction.

Of note is that the County will maintain the flexibility to implement Streetcar on each of the routes in the selected network if future ridership on the route supports Streetcar. Because forecasting future conditions can be imprecise, the County does not want to preclude streetcar if future ridership conditions and the capacity provided by streetcar warrants its implementation.

Finally, a detailed analysis of a Driverless People Mover system identified this mode as infeasible based on the anticipated requirement for additional right-of-way along a significant portion of each route. The model used for the Driverless People Mover analysis was the people mover system installed at Heathrow Airport because of its system characteristics, especially its relatively small footprint and its relatively low capital cost. The right-of-way requirement for the driverless people mover, which would be required to provide the full exclusivity that is necessary on a driverless system, was seen as excessively onerous in an area that is planned for increased urbanization and density (it should be noted that some exclusivity may potentially be provided without additional right-of-way but this can only be identified through detailed design. Based on the anticipated characteristics of Tysons in the future, especially higher future traffic volumes, it was assumed that a significant portion of each route would require new right-of-way in order to avoid impacts on general traffic lanes). In addition, urban design considerations associated with the requirement that the system will likely have to be elevated along a significant portion of the route were deemed to make this mode less attractive than surface modes (it should be further noted that there may be the potential to accommodate some portions of the People Mover at grade but separated from traffic. As with the additional right-of-way, more detailed design would be required to determine if this at-grade configuration is feasible along portions of each route).

ES.3.3 Transit Preferential Treatment Recommendations

The need for queue jumps and transit exclusive lanes were identified based on forecasted slow travel speeds along the alignments of the routes comprising the Three Route network. Three areas were identified for the application of a combination of queue jumps and transit exclusive lanes based on this analysis.

The first of these areas would be along Gosnell Road and Westpark Drive, between the intersection of Gosnell Road and Route 7 and the intersection of Westpark Drive and International Drive. The improvements in this roadway segment would consist of a combination of queue jumps at three intersections (Gosnell Road/Westpark Drive and Route 7, Westpark Drive and Greensboro Drive, and Westpark Drive and International Drive) and transit exclusive lanes between the intersections. This exclusive lane/queue jump combination would be on both sides of this roadway section.

The second area that warrants this combination of queue jumps and transit exclusive lanes would be in the vicinity of the Spring Hill Silver Line station along Spring Hill Road, Route 7, and Tyco Road. This area of transit exclusivity would begin at the intersection of Spring Hill Road and International Drive. An exclusive bus lane would begin on the east side of International Drive and would continue west on Spring Hill Road (crossing Tyco Road in the westbound direction), north on Route 7, and east on Tyco Road. This combination of queue jumps and transit exclusive lanes would be on the north side of Tyco Road, the east side of Route 7, and the south side of Tyco Road and would support the Direct East-West Link as it runs clockwise through this loop.

The third area that would warrant a queue jump and a transit exclusive lane would be on Scott’s Crossing Road between Capital One Drive and Old Springhouse Road. This application would include a queue jump for an eastbound bus on Scott’s Crossing Road at the intersection of Scotts Crossing and Capital One Drive. East of Capital One Drive would be an exclusive bus lane between Capital One Drive and Old Springhouse Road. Since buses would be running only in the eastbound direction in this link, an exclusive lane would be required only on the south side of Scotts Crossing Road. While this recommendation confines the bus only lane to the roadway link between Capital One Drive and Old

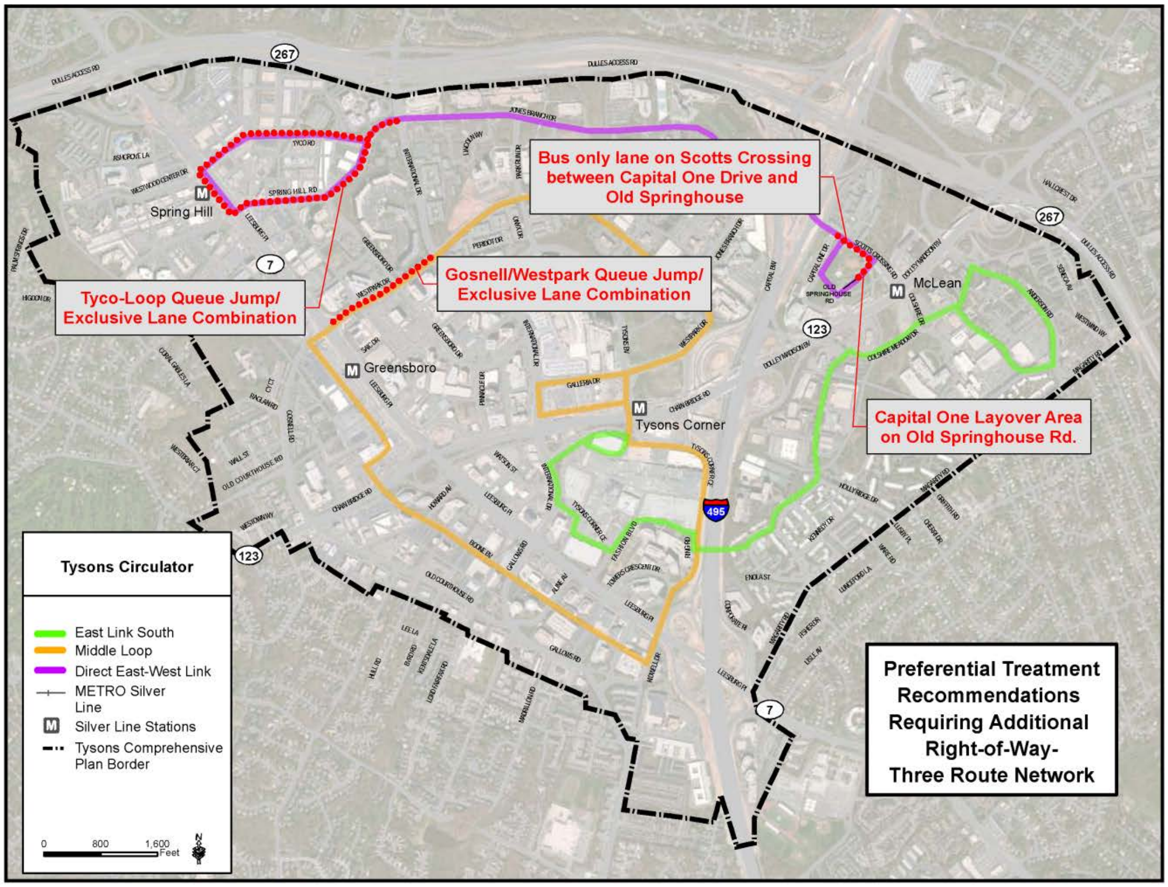
Springhouse Road based on the future forecasted speeds, an exclusive lane of this short distance is not fully optimal and thus future conditions may warrant extending transit exclusivity up to the intersection of the Jones Branch Connector and Jones Branch Drive, on the west side of the I-495 Beltway. To ensure this contingency is addressed, the County is reserving the right-of-way for the entire distance to the east and west side of the Beltway. This contingency also includes the ability to accommodate streetcar on this route if future conditions warrant. This would include exclusive right-of-way of 24' between stations to accommodate two tracks and 36' at stations to accommodate the two tracks as well as station platforms. To this end, the design of the new Beltway crossing is incorporating a cross section wide enough to accommodate exclusivity in the future.

Each of these areas is shown in Figure ES-3.

The final exclusivity recommendation that would require property from an adjacent property owner is on the Capital One campus, along Old Springhouse Road. Buses on the Direct East-West Link would arrive at this point every four to six minutes and would layover here before beginning their westbound trip. Old Springhouse Road also is forecasted for slow travel conditions. Given this combination of bus operating and traffic conditions, two bus bays separated from through traffic are recommended on the north side of Old Springhouse Road. This recommendation is also shown in Figure ES.3 (of note is that this off-street layover facility is also necessitated by the fact that there is only one lane in each direction at this location. Layovers for other routes in the Three Route Network will occur in the street, where two lanes are available, or at Silver Line Stations).

In all instances, the implementation of exclusive lanes would be done through the re-purposing of existing parking lanes wherever feasible. This re-purposing of lanes would minimize the amount of right-of-way that would be required from adjacent property owners.

Figure ES-3: Recommended Transit Preferential Treatments Requiring Additional Property



In addition to the exclusivity recommendations that would require additional right-of-way, transit signal priority at 10 locations is recommended. This signal priority would allow transit vehicles to receive priority at these intersections, either through an extended green as the vehicle approaches the intersection, or a truncated red that allows the transit vehicle to pass through the intersection early. These recommended transit signal priority sites are at locations where there is sufficient intersection delay to warrant priority, but where the application of extended green or truncated red would not have extensive impacts on side street traffic.

ES.4 Tysons Circulator – Comparison to Peer Circulator Systems

This section provides context for the Tysons Circulator's forecasted performance by comparing it to the peer systems evaluated in the project peer review, which was developed at the beginning of the planning process. Table ES-1 shows the forecasted daily ridership and boardings per revenue hour on the Tysons Circulator as well as each of the peer systems evaluated as part of the review.

Table ES-1: Tysons Circulator and Peer System Daily Ridership and Boardings per Revenue Hour

System	Daily Ridership	Boardings per Revenue Hour
Tysons Circulator	17,575*	61.9
Walnut Creek Circulator	863	24.1
Los Angeles Downtown Circulators (DASH)	22,932	38.5
Washington DC Circulator	7,750	29.0
Orlando Lynx LYMMO	3,267	50.0
Miami Metromover	30,700	94
Portland Streetcar	11,916	n/a
Tacoma Link Streetcar	3,053	89.7

*Ridership Scenario #2 – Three Route Network

The data in Table ES-1 show that the forecasted performance of the Tysons Circulator exceeds that of nearly all of the peer circulator systems evaluated. In terms of daily ridership, the two systems that have higher daily ridership are both systems serving dense downtowns in Miami and Los Angeles. When evaluated in terms of boardings per revenue hour, a measure of productivity, only one peer system performs better than the Tysons system, the Tacoma Link Streetcar. This data highlights that when evaluated in terms of its peers, the Tysons Circulator system will be a high performing circulator system, with some of the best performance statistics in the United States. It should be noted that a wide range of factors will ultimately impact ridership, including density of development, the mix of land uses in the service area, and the quality and number of connections to other modes, including other transit modes.

The peer analysis also yielded a number of lessons learned regarding the factors that contributed to a successful circulator system. These include:

a. **High Frequency, Easy to Understand Service** – It is essential that the service be as easy to use as possible, especially to attract choice riders who have other mode options. This includes high service frequency to minimize waits at stops as well as very direct and easy to understand route structures.

b. **Distinct Premium Branding** – A distinct brand coincides with an easy to understand service. Riders, especially infrequent riders, need to feel comfortable with riding the circulator, and a distinct brand helps to provide a level of comfort that the rider is boarding the correct bus that will take them to their destination.

c. **Passenger Amenities** – Passenger amenities make a service more attractive to riders, especially choice riders that have other mode options. In addition, the majority of peer systems provide real-time information on next-trip arrivals, which gives riders an additional level of comfort regarding the system's reliability.

d. **Enhanced Pedestrian Environment and Streetscape** – An attractive pedestrian environment, including attractive streetscaping, provides an overall comfortable atmosphere that supports riders choosing transit versus their automobile.

ES.5. Project Next Steps

The completion of the Tysons Circulator Study has resulted in the specific recommendations on the Circulator network, mode by route, and required transit preferential treatments outlined in this report. As a first next step, these Study recommendations will be incorporated into the Tysons Corner Comprehensive Plan through a plan amendment and will also be included in rezoning applications as appropriate.

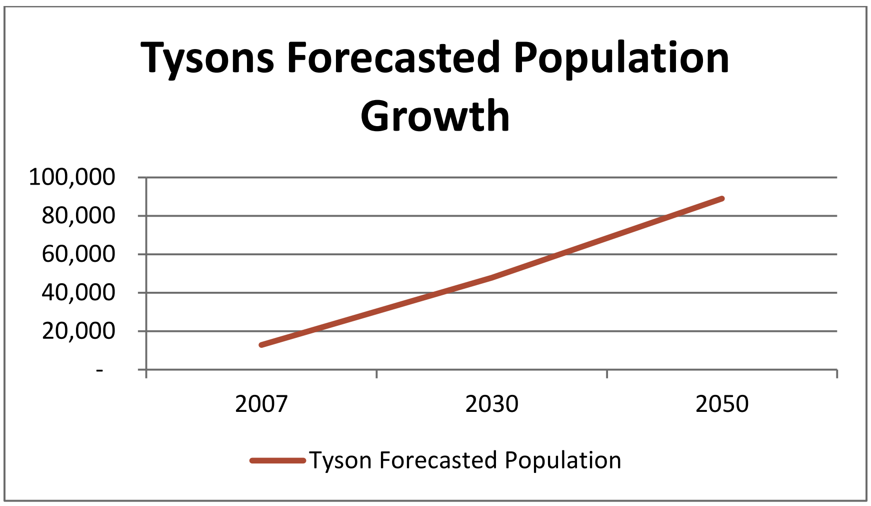
However, even though specific recommendations have been made and will be incorporated into the Comprehensive Plan, the County will maintain flexibility to address conditions that were not anticipated as the Study planning process was completed. Maintaining this flexibility reflects the fact that forecasting into the future can be imprecise and therefore future conditions may change. The County will continue to monitor conditions as Tysons redevelopment occurs. This will include monitoring of traffic conditions, Circulator reliability, Circulator ridership and capacity utilization, and development patterns. If conditions that were not anticipated occur, the County will address these when considering future rezoning requests.

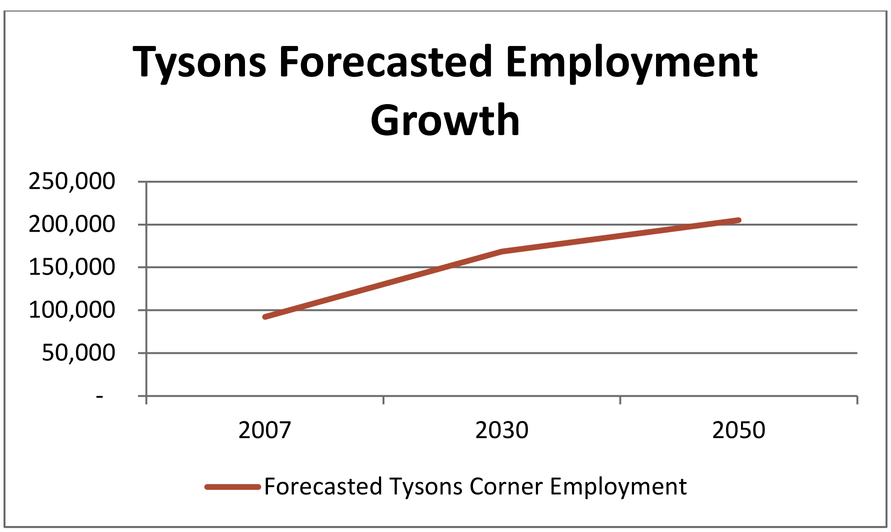
Section 1
Introduction

Introduction

The Tysons Circulator Study is a **long range** planning study that has been undertaken to support the redevelopment and rezoning of Tysons over the next 40 years (the Circulator planning described in this document is for a horizon year of 2050 – the forecasted growth in population and employment in Tysons through 2050 is shown in Figure 1-1). The purpose of the study is to design a Circulator system that will support the overall goal of maximizing transit trips and minimizing vehicular trips to, from and within Tysons.

Figure 1-1: Forecasted Population and Employment Growth in Tysons Through 2050





The key outputs of the study, which will support Fairfax County staff and elected officials in making transportation decisions as the Tysons redevelopment and rezoning process moves forward, include the following:

a. Identification of a circulator network that maximizes transit ridership and provides service to the greatest number of potential riders.

b. Identification of the most appropriate transit mode for each route within the overall selected network based on ridership demand and required capacity to meet that demand, as well as additional factors such as ease of construction and impacts on pedestrians, bicyclists and automobiles.

c. Identification of required transit preferential treatments to support fast and reliable transit service. Preferential treatments, which are the subject of Section 6 of this report, include exclusive transit lanes, queue jumps, and transit signal priority.

The intent of this document is to outline the planning process followed to develop the key outputs summarized above as well the final recommendations in each of these areas. The remainder of this report consists of the following sections:

Peer Review – In addition to the analysis and results outlined in the body of the report and summarized below, the planning process also included, as a first step, the completion of a peer review of other circulator systems both within the United States as well as internationally. The focus of this peer review was the identification of lessons learned on these systems, both in terms of approaches to avoid and approaches to emulate. This peer review, which provided important input throughout the planning process, is included in this document as Appendix H.

Section 2 - Project Goals and Objectives – Project goals and objectives were developed at the beginning of the planning process to provide a framework for the development of preliminary route networks as well as to select a final network for long term implementation. These goals and objectives acted as a foundation for the remaining steps of the planning process. This report section outlines the final project goals and objectives.

Section 3 - Preliminary Network Development and Evaluation – This step in the planning process utilized the project goals and objectives as well as route design principles to develop five preliminary route networks. These networks were evaluated and compared based on a preliminary evaluation framework that utilized existing and readily available data in order to identify those networks that had the highest probability of success. Two networks were selected from this original group of five for additional evaluation before selection of the final recommended network. This section describes the process behind the development of the five preliminary networks as well as the process utilized to narrow the original five networks to two based on this preliminary assessment of probable success.

Section 4 – Evaluation of Two Networks – This section describes the detailed network evaluation process that was used to compare the two networks selected from the original five based on their higher probability of success, as well as the evaluation results. These evaluation results were used to support the selection of the recommended network, which is also identified in this section.

Section 5 - Mode Option Analysis – As noted above, one of the key outputs of the Circulator Study was the identification of the most appropriate mode on each route within the selected overall Circulator network. This report section describes the detailed technical process utilized in the identification of the recommended mode on each route as well as the final results of the analysis. This section also identifies the recommended mode by route.

Section 6 - Transit Preferential Treatments – A key final output of the Circulator study is the identification of transit preferential treatments that are needed to support a fast and reliable Circulator system. Transit preferential treatments include exclusive transit lanes, queue jumps, and transit signal priority. Because exclusive transit lanes and queue jumps will typically require additional right of way, which means obtaining property from landowners adjacent to the route alignments, early identification of these requirements was deemed essential. This required right of way will be reserved as property owners enter the re-zoning process with the County. This report section describes the process followed to identify required transit preferential treatments as well as final recommendations.

Section 7 - Ridership Estimates – Ridership estimates were used in the detailed evaluation of the two networks that were selected after the preliminary network evaluation, and were also key inputs into the identification of the most appropriate mode by route within the overall selected network. This section describes the process used to estimate ridership as well as ridership results.

Section 8 - Operating and Capital Costs – Operating and capital costs were an essential input into the evaluation of the remaining networks and were also utilized in the mode option analysis. This section describes the process followed to calculate operating and capital costs as well as the final estimated costs. Costs were calculated in two different ways in order to support the two evaluations. In the first instance operating costs were estimated on an annual basis in conjunction with the calculation of total capital costs. In the second instance, annual operating costs were combined with annualized capital costs to provide a life cycle cost over thirty years in order to understand total costs over an extended period. These two cost calculation methods were used to support the mode option analysis and the detailed evaluation of the remaining networks. **Of note is that all costs included in this report are 2012 costs.**

Section 9 - Guidelines for Interim Circulator Operations – This report section outlines guidelines for Circulator alignment and operations in the interim period before 2050, which is the horizon year for the Circulator planning and the recommendations made in this document.

Section 10 - Public Outreach and Stakeholder Coordination – Public outreach and stakeholder coordination was a key part of the Circulator planning process, with outreach events occurring throughout the 14 month planning process. This section describes the outreach and stakeholder coordination process.

Section 11 – Summary and Conclusions – This report section summarizes the final Study recommendations as well as the next steps in incorporating the recommendations into the County's planning process.

Section 2
Project Goals and Objectives

Project Goals and Objectives

2.1 Introduction

The development of project goals and objectives was one of the first steps in the Tysons Circulator Study planning process. The purpose of the project goals and objectives was to help define the purpose of the final recommended Circulator system and therefore to provide a framework for completing the subsequent steps in the planning process. The project team felt strongly that setting expectations for the final Circulator system at the very beginning of the study was essential to support a transparent and efficient planning process. The final goals and objectives presented below reflect an iterative review process that included County technical staff, the Tysons Partnership, senior management at the Fairfax County Department of Transportation, and County elected officials.

The development of the goals and objectives relied on the original Tysons Circulator Study scope of work, a review of the goals and objectives of the Tysons Comprehensive Plan, and feedback from County technical staff participating as members of the project team.

In developing this project framework, goals were defined as a broad statement of what is to be achieved by the Circulator system and are generally qualitative in nature. Objectives are specific, achievable, measurable statements of what will be done to achieve each of the goals.

The final project goals and objectives are outlined below.

2.2 Project Goals and Objectives

Goal 1 – The Tysons Circulator will support the comprehensive plan vision to transform Tysons into a walkable transit oriented urban environment.

<u>Goal 1 Objectives</u>

1.1 Develop a system that incorporates context sensitive solutions and the urban design principles and elements provided in the comprehensive plan for all aspects of the Circulator.

1.2 Develop a system that enhances walkability in Tysons by reducing the dominance of auto travel, while not hindering pedestrian movements.

1.3 Develop a system that supports the land use goals outlined in the comprehensive plan.

Goal 2 – The Circulator will provide high quality transit that will contribute to a reduction in auto dependence and an increase in the transit share of total trips.

Goal 2 Objectives

2.1 Provide efficient, reliable, fast, and high-frequency service that is competitive with automobile travel.
2.2 Provide dedicated transit right-of-way where required and appropriate.
2.3 Utilize a mix of modes as appropriate.
2.4 Attract new transit riders and increase transit mode share for commuters and internal trips within Tysons.
2.5 Provide convenient access to a variety of high trip generating destinations to serve commuters as well as workers and residents.
2.6 Provide coverage to serve the most destinations in Tysons while maintaining service efficiency and directness of travel.

Goal 3 – The Circulator will support a multimodal transit transportation network within Tysons and provide a convenient link to the regional transportation network.

Goal 3 Objectives

3.1 Provide simple, convenient, and coordinated connections with Metrorail, High Occupancy Toll (HOT) lanes, Bus Rapid Transit (BRT)/Express bus service, and local bus service.
3.2 Develop a system that allows for phased implementation of routes and modes that works within the transportation and development context of Tysons.
3.3 Provide a system that ensures the safety and security of the passengers as well as pedestrians, bicyclists, and automobile users.

Goal 4 – The Circulator will be constructed and operated in a cost effective manner.

Goal 4 Objectives

4.1 Maximize ridership and return on capital investment by taking into consideration all capital costs in the determination of initial and final mode.
4.2 Achieve a high operating performance for interim and final Circulator mode(s) and route(s) by taking into consideration all operating costs associated with different options.
4.3 Provide service at a fare that balances the need for financial sustainability with other project objectives.

Section 3
Preliminary Network Development

Preliminary Network Development

3.1 Introduction

The purpose of this report section is to document the route design and preliminary evaluation process that was used first to develop an original universe of potential Circulator networks and then second to select a subset of those networks for more detailed evaluation (the subject of the next report section).

The process described in this report section was based on being as comprehensive as possible in identifying and evaluating all potentially feasible routes and routing sub-options. The process also included incorporating the final selected individual routes developed in the first step of the process into viable network alternatives incorporating different individual routes, and then evaluating those network alternatives relative to both qualitative and quantitative evaluation criteria.

The remainder of this section outlines the process followed to develop route and network alternatives as well as the evaluation process utilized to select the networks that were moved forward for more detailed evaluation.

3.2 Determination of Route Alignments

In developing the possible Circulator routes and overall Circulator route network alternatives outlined below, the project team utilized a number of general guiding principles. These guiding principles started with the project planning objectives defined earlier in the planning process, which in turn became the foundation for the identification of a set of route design principles. Several of these route design principles were highlighted by other circulator systems during the Peer Review task of this study (see Appendix H). Overall, the peer review yielded a consistent theme among the successful circulators evaluated: high frequency and simple to understand service. In addition, speed and exclusive right-of-way were desirable features of the peer circulators, an aspect of overall route design that was considered in determining the alternative Tysons Circulator alignments contained in this document.

3.3 Circulator Planning Objectives Incorporated into Route Design

The design of the Circulator routes incorporated the careful consideration of several of the planning objectives that had been defined early in the planning process and agreed upon by the study team. These objectives then became the basis for the development of the route design principles that were followed during the development of the route and network alternatives outlined in the following sub-sections. The planning objectives utilized in this process include:

a. Provide efficient, reliable, fast, and high-frequency service that is competitive with automobile travel.

b. Attract new transit riders and increase transit mode share for commuters and internal trips within Tysons.

c. Provide convenient access to a variety of high trip generating destinations to serve commuters as well as workers and residents.

d. Provide coverage to serve the most important destinations in Tysons while maintaining service efficiency and directness of travel.

e. Provide simple, convenient, and coordinated connections with Metrorail, HOT lanes, BRT/Express bus service, and local bus service.

3.4 Design Principles for Tysons Circulator Route Design

Outlined below are the design principles that became the foundation for the design of the routes described later in this section, as well as the network alternatives that resulted from the combination of these individual routes.

a. **Keep the system as easy to understand as possible** – In order to attract riders who are not used to using public transportation and make it easy for visitors to the area to circulate within Tysons without the use of a car, it is essential that the system be easy to understand. There are two corollaries to this principle:

   1. **Maintain consistent routing at all times** – While it is possible to design different services for different times of day, with peak period services focused on moving people to and from jobs and midday services focused on non-work (primarily lunch and shopping) trips, the added degree of passenger confusion resulting from having to learn two different systems and knowing when each one operates, overwhelms any benefit resulting from more finely targeting routes to particular travel markets by time of day.

   2. **Minimize total number of routes in the Circulator system** – This corollary is at odds with the other principles of directness and coverage (see below), since directness is enhanced by having more routes (so that each individual route does not need to cover too much territory), as is coverage (since more routes offers the ability to cover more areas). Nonetheless, too many routes increases passenger confusion. There is no strict limit to the number of routes, but for an area the size of Tysons, it should likely not exceed five.

b. **Find optimal balance between directness and coverage** – The goal of the Circulator service is to provide convenient access to all parts of the Tysons area, both as connections to the Silver Line as well as for internal trips. In order to be seen as convenient, the Circulator routes must be as direct as possible between the Silver Line station, the Tysons workplace destination, and other major trip attractors in Tysons.

c. **Minimize duplication of Circulator route mileage** – In order to minimize cost while at the same time maximizing coverage, the various routes in the Circulator system should be kept separate from each other, with overlap only at their Silver Line station terminals. This approach also has the benefit of reducing passenger confusion, since passengers will not have to choose between (or have knowledge of) different routes serving the same stop.

Note that a corollary of this principle is that transfers between Circulator routes are assumed to be a non-issue; the system should be designed so that the great majority of trips are able to be accomplished with a one-seat ride within Tysons and if a transfer is necessary, it would be between the Silver Line and the Circulator system.

d. **Minimize use of busiest through roadways** – In order to operate the Circulator in a fast, reliable, and efficient manner, all routes were planned with minimal to no mileage on Routes 7 and 123. These primary arterials were viewed more as through travel routes, with their primary function as transporting cars and longer distance and feeder buses into and through Tysons. The smaller roads through Tysons are less congested currently and will likely be in the future, and therefore are more likely to be able to provide some type of priority to the Circulator. Even with the anticipated changes occurring in Tysons in the future, Routes 7 and 123 will very likely continue to be the primary through routes through the area and therefore will be the most congested. Based on the final route design, the Circulator routes will primarily use Avenues, as defined in the Tysons Comprehensive Plan, within the service area.

e. **Utilize both existing and future roadways** – To allow for the greatest flexibility in planning the eventual routes, the route structure was not limited to operations on the existing roadways in Tysons but also included the future street grid. To the extent possible, the future network acted as the basis for the route design and thus routing decisions were not limited to existing roadway network or network characteristics.

3.5 Route Design – Individual Routes

As noted, the Circulator objectives in combination with the route design principles were utilized to develop a series of individual Circulator routes that were mode and priority neutral (these routes were then combined into route networks, which is discussed in more detail in sub-section 3.6). In some cases, several slight variations to a given individual route were developed to ensure that all potential routing sub-options for an overall route were considered. The routes were then evaluated based on the route design principles, the route length (a proxy for route operating cost), and the percent of productions and attractions within Tysons (in 2050) that are within one-quarter mile of the route (a proxy for route coverage and demand potential). The design considerations for each individual route (and in some cases several routing sub- options for an overall route) are discussed in greater detail in Appendix A.

Of note is that for all loops within an individual route that serve as a way to turn a vehicle around but are otherwise just a small part of the route, it was assumed the service would operate in a clockwise direction to minimize confusion and maximize right turns.

3.6 Route Networks

Once individual routes alternatives were defined, several alternative networks of routes were then developed through the combination of different individual routes. Each of these networks was then evaluated based on a set of both qualitative and quantitative criteria, the results of which are summarized in Section 3.7.

While not formally evaluated in this document, the project team did review the network of Circulator routes identified in the Tysons Comprehensive Plan. The Plan proposed a network of routes composed of three overlapping loops. This network was not carried forward for more detailed evaluation in this document because it did not meet key design principles established for this analysis:

a. The three loop routes in the Comprehensive Plan have a large amount of overlap, which results in inefficiencies and which can be confusing to passengers.

b. Because each of the loops is relatively large, many trips within Tysons would not be served in the most direct and convenient manner.

c. The Comprehensive Plan network consists entirely of loop routes. While loop routes do not violate the design principles per se, the three overlapping routes can confusing for passengers, and thus do not fully meet the principle of keeping the network as easy to understand as possible.

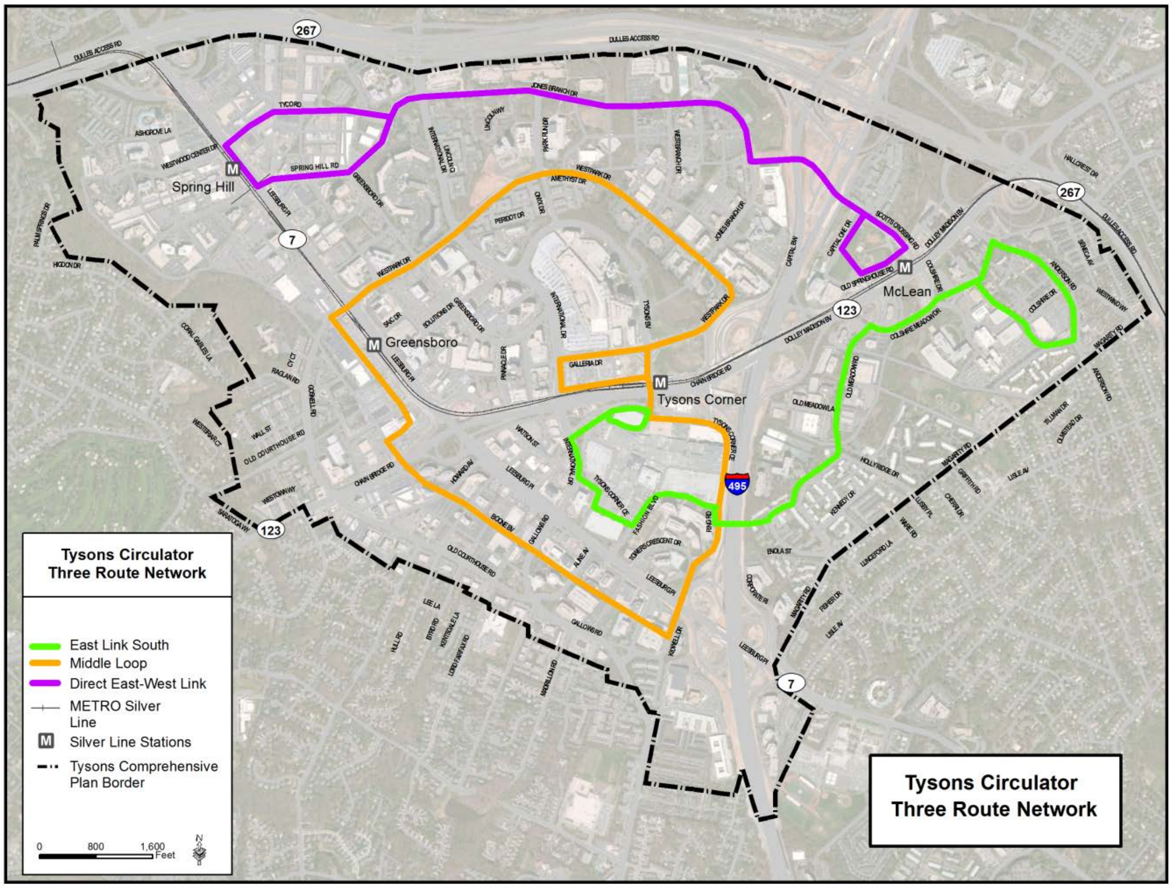
Each of the network alternatives developed in this analysis is described in greater detail below. Maps of each network alternative follow the descriptions

3.6.1 Three Route Network

This network alternative consists of three routes that complement each other by each serving a distinct purpose. The first route distributes Silver Line riders east and west along Jones Branch Drive from the two stations at the edges of Tysons (McLean and Spring Hill); the second route provides a loop connecting several employment locations with the Tysons Corner Silver Line station and its surrounding commercial opportunities; and the third route provides a link between the eastern part of Tysons and the hub of activity around the Tysons Corner Station. A summary of network coverage of productions and attractions is provided below (all productions and attractions within ¼ mile of a Circulator route). A map of this network is shown in Figure 3.1.

Percent Productions Served: 90%	Percent Attractions Served: 92%

Figure 3-1: Three Route Network

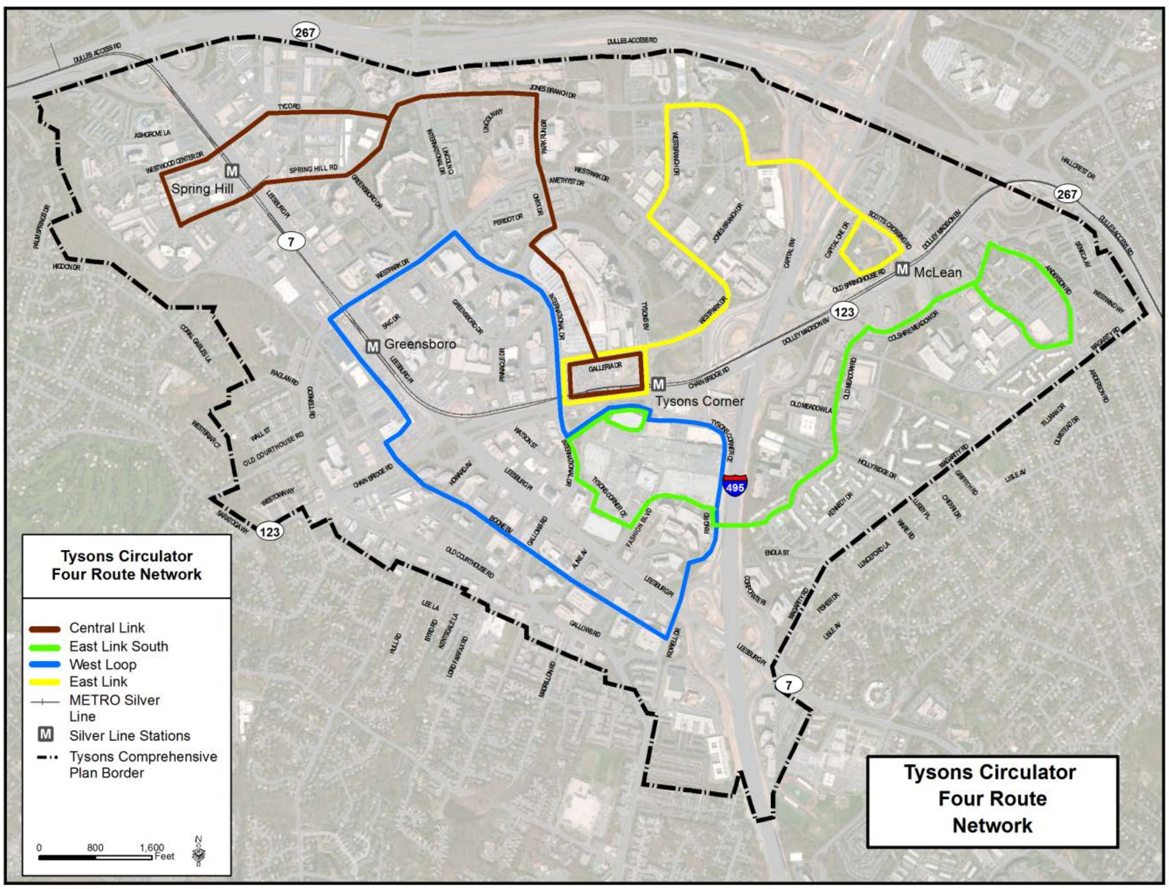


3.6.2 Four Route Network

This network alternative consists of four routes that together most directly serve the most areas within Tysons, providing a structure that would accommodate midday and non-work trips through an orientation toward the Tysons Corner station. The "hub" of the Tysons Corner station would also potentially accommodate commuters arriving in Tysons by other regional transit services, though the final terminal location for regional services is still being determined. A summary of the network production and attraction statistics are shown below. A map of this network is shown in Figure 3.2.

Percent Productions Served: 94%	Percent Attractions Served: 95%

Figure 3-2: Four Route Network

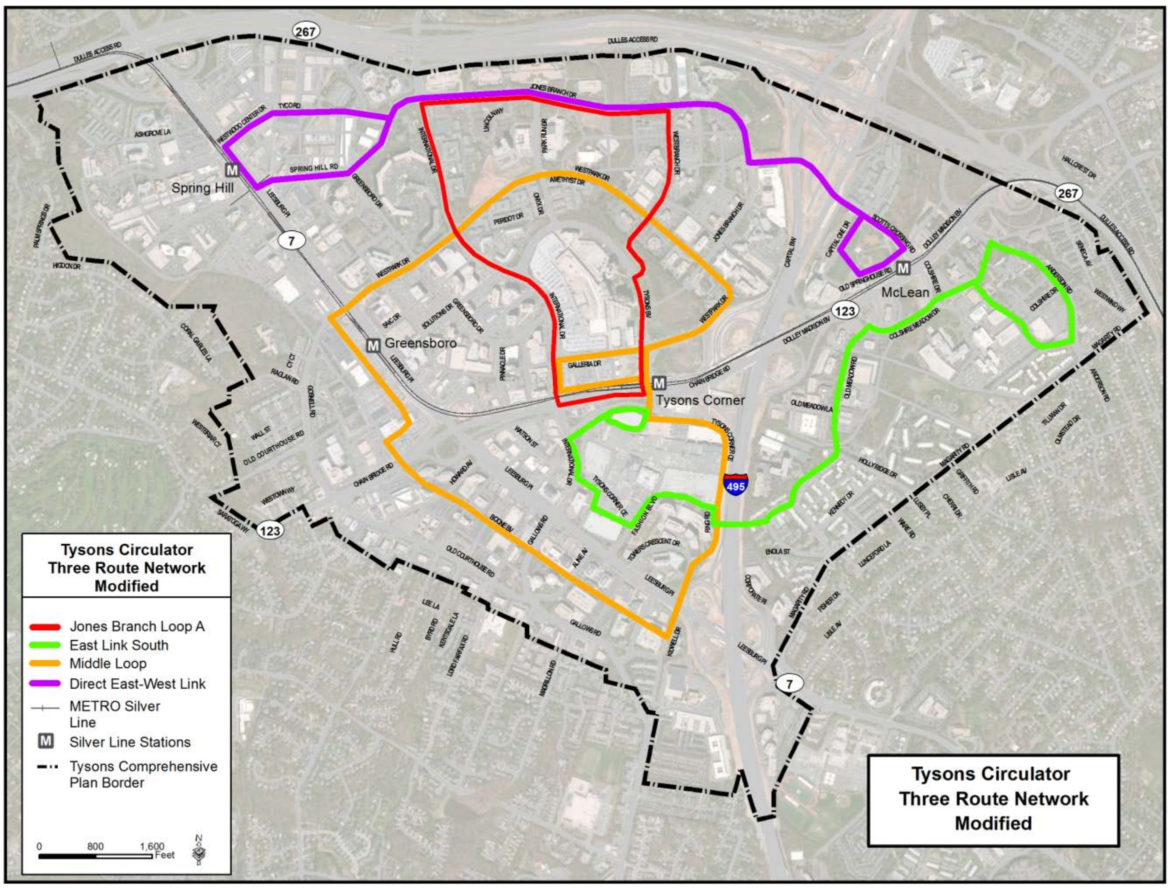


3.6.3 Three Route Network Modified

This network is similar to the Three Route Network but with the addition of a loop in the central part of Tysons to connect Jones Branch Drive with the Tysons Corner station. This loop was added to the original Three Route Network because without this loop, there is no convenient way for people along the Jones Branch corridor to reach the mall area of Tysons without utilizing the Silver Line. A summary of network coverage statistics for this network is provided below. A map of this network is shown in Figure 3.3.

Percent Productions Served: 90%	Percent Attractions Served: 92%

Figure 3-3: Three Route Network Modified

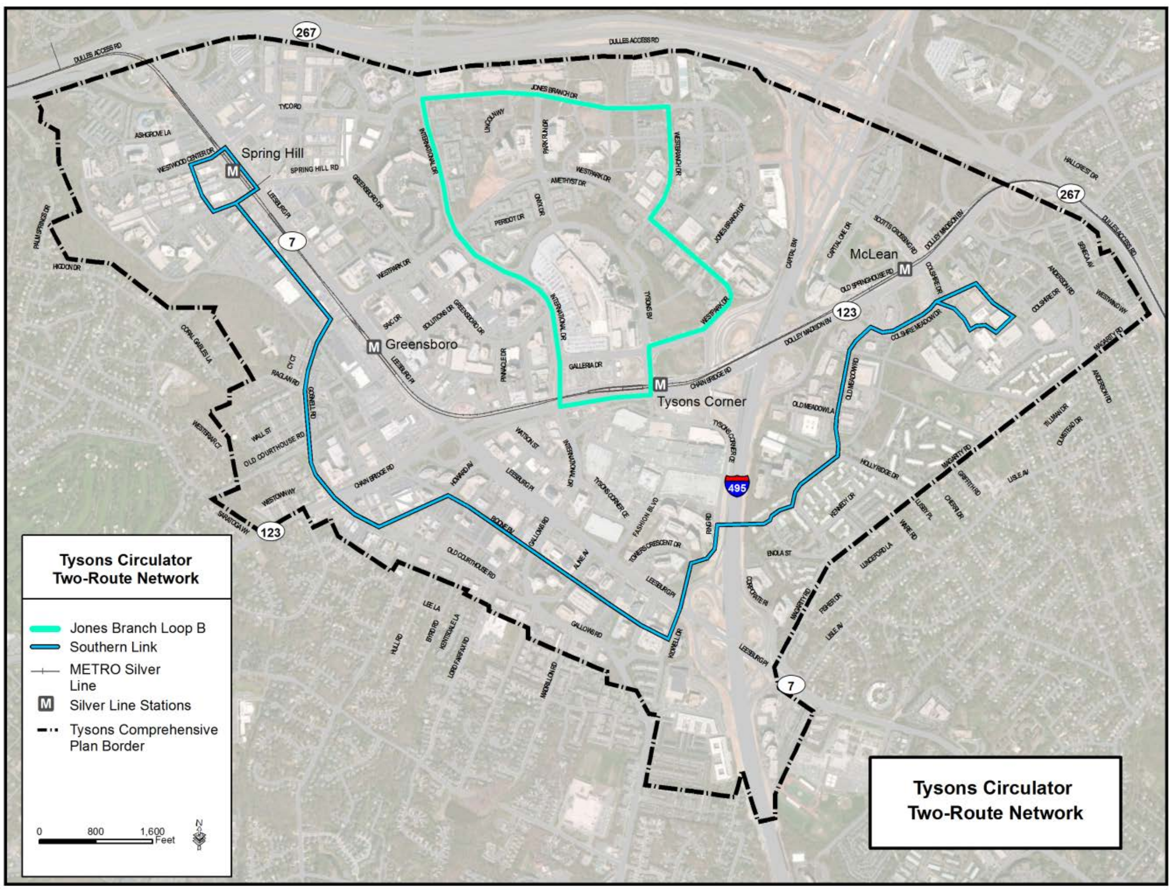


3.6.4 Two-Route Network

This network alternative attempts to provide as much coverage as possible with only two routes. It does so by focusing on those areas that are beyond a short walk from the Silver Line stations and not providing comprehensive connections for internal trips within Tysons. It thus assumes that Silver Line riders will be willing to walk up to 5-10 minutes to get to their destination, and that a sizable portion of internal trips would involve a transfer between the Circulator and the Silver Line. The Jones Branch loop provides distribution to many of the locations on the north side of Tysons from the Tysons Corner Station while the South Link provides connections to locations south and west of Routes 123 and 7 from the Spring Hill and McLean stations. A summary of network coverage statistics for this network is provided below. A map of this network is shown in Figure 3.4.

Percent Productions Served: 83%	Percent Attractions Served: 84%

Figure 3-4: Two Route Network

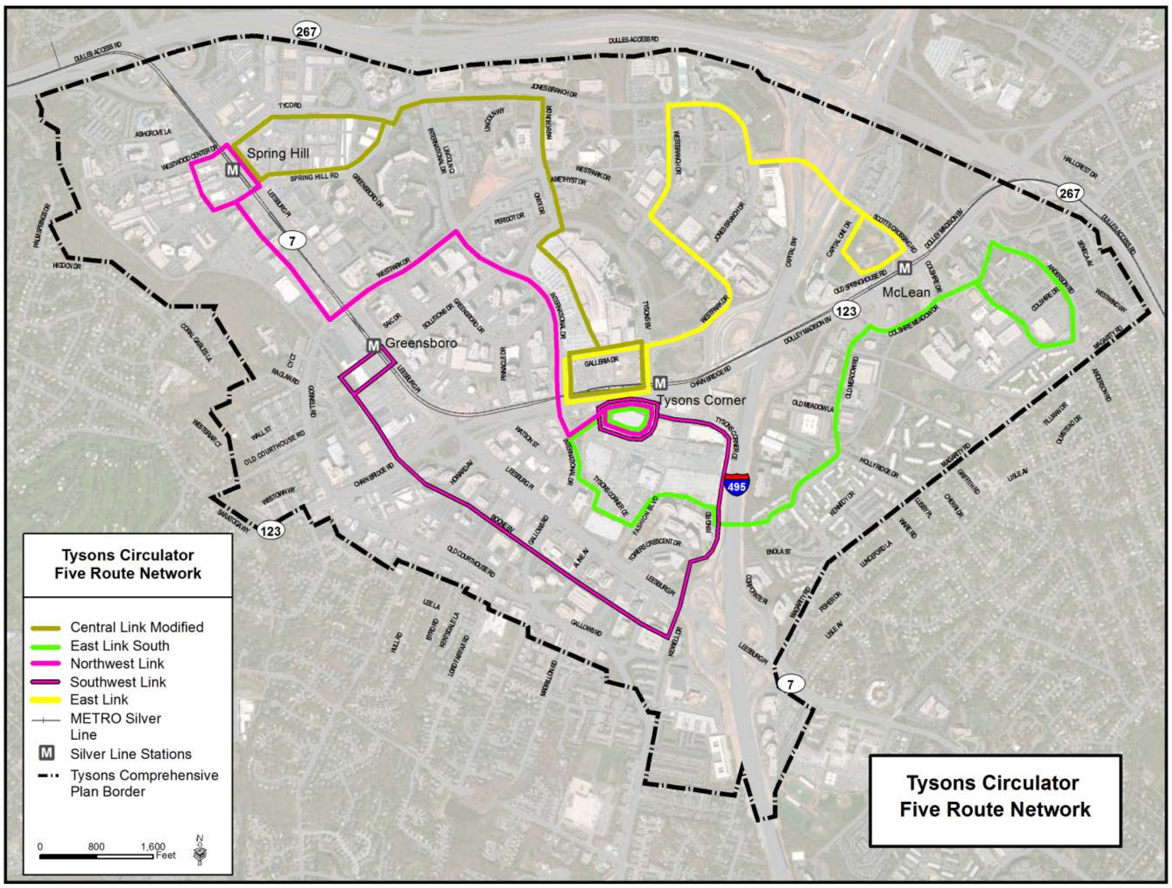


3.6.5 Five Route Network

This network varies from the Four Route Network only in that it replaces the West Loop with two routes, the Southwest Link and the Northwest Link, in order to increase directness and the confusion passengers may have with loop service. The network route mileage is comparable between the two alternatives; however it does necessitate an additional route over the Four Route network. A summary of network statistics is provided below. A map of this network is shown in Figure 3.5.

Percent Productions Served: 92%	Percent Attractions Served: 95%

Figure 3-5: Five Route Network



3.7 Circulator Network Evaluation

This section contains an evaluation of the network alternatives outlined above based on two sets of parameters. The first set of parameters involves a qualitative evaluation of each of the network alternatives relative to the route design principles outlined above in Section 3.4. The second set of parameters involves a quantitative analysis that evaluates each network alternative relative to the total market potential of each network, network mileage, and system coverage. More detail on each evaluation, including results is outlined below. The evaluation included here is a preliminary analysis that was used to narrow the number of alternatives by selecting the two that appeared to have the greatest probability of success for more detailed evaluation. The results of the more detailed evaluation are the subject of Section 4 of this report.

3.7.1 Qualitative Evaluation – Adherence to Route Design Principles

Table 3-1: Qualitative Assessment of Route Design

Criterion	Three Route	Four Route	Three Route Modified	Two Route	Five Route
Easy to Understand (Proxy: total routes in system)	Good	Fair	Fair	Excellent	Poor
Route directness	Fair	Good	Fair	Poor	Excellent
Minimal Duplication of route mileage	Excellent	Good	Fair	Excellent	Good
Avoidance of busiest roads	Good	Good	Good	Excellent	Good

Rating: Poor, Fair, Good, Excellent

The qualitative analysis of adherence to route design principles, as summarized in Table 3.1 above, shows how well each network meets each individual design principle. The Three Route Network, with good or excellent ratings in three of four categories, excelled in the avoidance of route mileage duplication. The Four Route Network also had good ratings in three categories, while the Five Route Network had good or excellent ratings in three of four categories, excelling in the route directness category, although at the expense of the number of routes being greater.

The Two Route Network received excellent ratings in three of four categories; however because its route directness rating is due to the fact that it has only two routes, it received a poor rating in this category. The Three Route Network Modified received the poorest overall rating, with only one category receiving a good or better score.

3.7.2 Quantitative Evaluation

The quantitative analysis in this section is a companion piece to the qualitative analysis contained in Section 3.7.1. Each of the quantitative measures used to evaluate each network is shown in Table 3.2. This quantitative analysis relied on readily available data derived from County population and employment forecasts for Tysons in 2050.

Table 3-2: Quantitative Analysis of Route Networks[1]

Criterion	Three Route	Four Route	Three Route Modified	Two Route	Five Route
Productions within ¼ mile of Network*	391,600	409,100	392,750	361,000	404,300
System coverage of Productions	90%	94%	90%	83%	92%
Productions per Mile of Network (total system mileage)	45,500	39,900	34,700	53,700	37,300
Attractions within ¼ mile of Network	587,800	605,300	591,300	538,800	605,300
System coverage of Attractions	92%	95%	92%	84%	95%
Attractions per Mile of Network (total system mileage)	68,300	59,000	52,200	80,200	55,800

Green shading indicates top performer for that criterion, pink indicates second best performer for that criterion.
*All analysis utilized 2050 productions and attractions

The quantitative analysis summarized in Table 3.2 reveals, relative to each of the quantitative criterion used in this analysis, the following findings:

a. **Productions Within ¼ Mile of the Network** – The Four Route Network has the highest number of productions within ¼ mile of the network, followed by the Five Route network. The Three Route Modified and the Three Route networks follow with approximately 16,300 and 17,500 fewer productions within ¼ mile than the best performing network (Four Route Network), respectively. The poorest performing network relative to this criterion is the Two Route Network.

b. **System Coverage of Productions** – As with the previous quantitative criterion, the Four Route Network and the Five Route Network are the best performers relative to this criterion. Both the Three Route Network and the Three Route Network Modified have 4%

[1] Year 2050 Productions and Attractions were used in all cases.

less coverage than the best performer, the Four Route Network. The Two Route Network is last, with 83% coverage of productions.

c. **Productions Per Mile of Network –** This criterion is a proxy for productivity, and measures how much service (as measured by network miles) is required to serve the absolute number of productions within ¼ mile of the network. In this instance, the Two Route Network, given its short length performs best (even though the overall absolute number of productions covered within Tysons is less than the other network alternatives). The Three Route Network comes in second relative to this criterion. The order of the remaining networks relative to this criterion is the Four Route Network, the Five Route Network, and the Three Route Network Modified.

d. **Attractions within ¼ Mile of the Network** – As with the "Productions within ¼ Mile of the Network" criterion, the Four Route Network and the Five Route Network are the highest performing networks relative to this criterion. In this instance, the total absolute number of attractions within ¼ mile of the network is the same, at 605,300. The Three Route Network Modified was ranked third, with 14,000 fewer attractions within ¼ mile than the two best performing networks. The Three Route Network was fourth relative to this criterion and the Two Route Network was ranked last.

e. **System Coverage of Attractions –** The best performing networks relative to this criterion were the Four Route Network and the Five Route Network, with 95% coverage of attractions for both network alternatives. The Three Route and Three Route Network Modified both came in second, with 92% coverage of attractions.

f. **Attractions Per Mile of Network** – As with the "Productions per Mile of Network" criterion the best performing networks are the Two Route Network, ranking first, and the Three Route Network. The order of the remaining networks is the Four Route Network, the Five Route Network and the Three Route Network Modified.

g. **Total One Way System Mileage** – This measure is a proxy for operating cost. The highest mileage network is the Three Route Modified Network, followed by the Five Route Network, the Four Route Network, the Three Route Network, and the Two Route Network. One way mileage for each network is as follows: Three Route – 8.6; Four Route – 10.25; Three Route Modified – 11.32; Two Route – 6.72; Five Route – 10.84.

3.8 Circulator Network Recommendation

Based on the results of the qualitative and quantitative evaluations of the five network alternatives, the Three Route Network and the Four Route Network were identified as those having the greatest probability of success based on the combination of evaluation factors, and therefore were recommended to be carried forward for more detailed analysis.

The specific findings that led to these recommendations are summarized below.

a. **Productions and Attractions within ¼ Mile and Productions and Attractions per Mile of Network** –The Productions and Attractions with ¼ mile measures provide a sense of the demand potential for each network. The Four Route Network performs the best of all networks and the Five Route Network comes in second for both productions and attractions. However, when evaluating these networks relative to productions and attractions per route mile (a proxy for productivity) the Three Route Network performs better than both the Four Route and Five Route networks, with the Four Route Network performing better than the Five Route Network on this measure. It was this combination of total demand potential in conjunction with the higher productivity on the Three Route Network that made the Three Route and Four Route networks the most attractive relative to these measures. While the Two Route Network performed well relative to these measures, the Network's much lower coverage of productions and attractions resulted in it not being recommended.

b. **System Coverage of Productions and Attractions** – The Four Route and Five Route Networks performed best on these measures, with the Three Route and Three Route Modified Networks falling slightly behind the best performers. Of note, however, is when these coverage percentages are compared against the one way mileage measure (a proxy for operating cost). When that additional comparison is done, the Three Route Network increases in attractiveness given that this network's coverage is met with a lower route mileage than the other two. This combination of coverage and the efficiency in providing that coverage again made the Three Route and Four Route Networks the most the attractive relative to the coverage measures.

Qualitative Measures – The Three Route and Five Route Networks each had one excellent rating and two good ratings, while the Four Route Network had three good ratings. The Five Route Network had one poor rating, on "easy to understand". These qualitative results for each network are close enough together that the recommendations based on the quantitative analysis were left to stand.

Section 4
Detailed Evaluation of Two Networks Assessed as Having Highest Probability of Success

Detailed Evaluation of Two Networks Assessed as Having Highest Probability of Success

4.1 Introduction

The network development and preliminary evaluation process of the original five networks described in report Section 3 resulted in the identification of two networks for more detailed analysis: the Three Route Network and the Four Route Network. These networks are shown in Figures 4.1 and 4.2 respectively. The purpose of this report section is to outline the process that was used to compare these two remaining networks, the final results of the evaluation process, and the recommended final network based on the results of the evaluation.

The remainder of this report section contains the following subsections:

a. Evaluation Factors Utilized in Comparison of Networks – This subsection provides a general description of the evaluation factors that were utilized to compare each of the networks.

b. Network Comparison Results – By Evaluation Factor – This subsection outlines the network comparison results by evaluation factor.

c. Final Network Recommendation – This subsection outlines the proposed network for implementation.

d. Potential Additions to Selected Network – This subsection outlines some potential additions to the selected network based on an analysis of high volume origin-destination pairs (all trips) and some gaps in the selected network in serving these origin-destination pairs. These additions are not recommended at this time but exist for the consideration of the people who will be implementing the Circulator system in future years.

Figure 4-1: Three Route Network

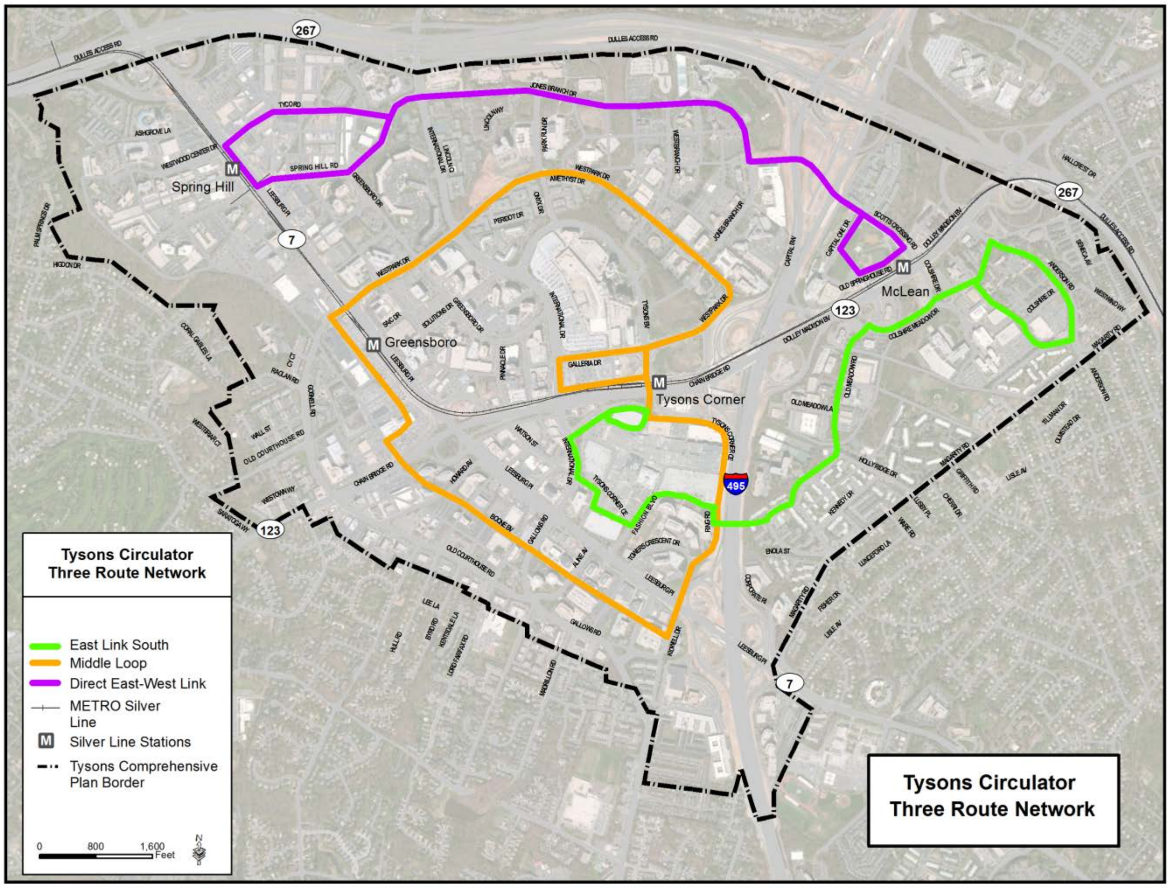
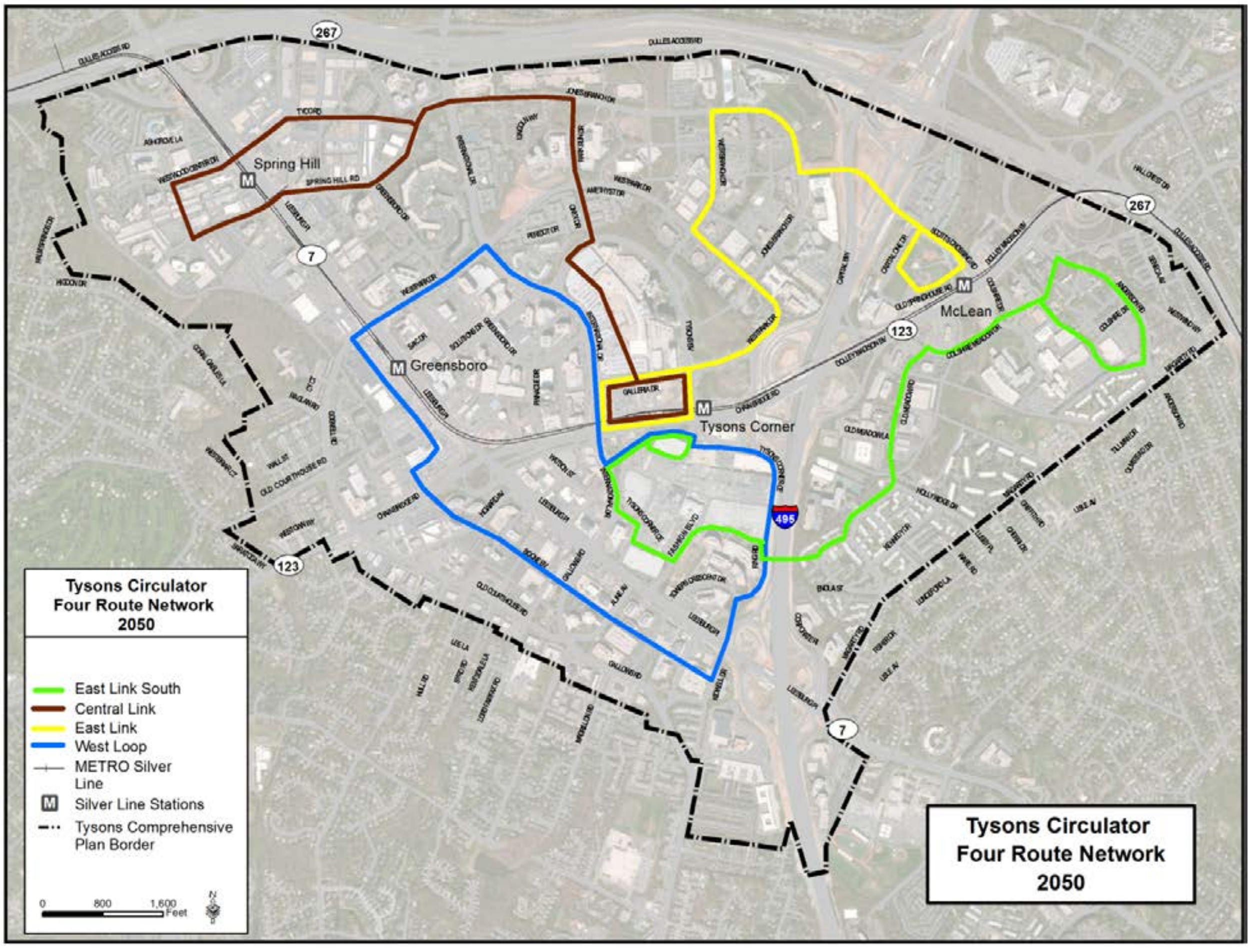


Figure 4-2: Four Route Network



4.2 Evaluation Factors Utilized in Comparison of Networks

Six evaluation factors were utilized to compare the two networks selected, from the original five, for more detailed evaluation. Together, these factors comprise a framework with which to assess each network's overall potential success by providing an understanding of each network's cost effectiveness, productivity, overall ridership, effectiveness in serving key origins and destinations within Tysons, and a proxy for understanding overall service reliability. Outlined below is a description of each evaluation factor utilized in the network comparison.

a. Daily Ridership – This evaluation factor is a straightforward measure of ridership demand on each network, and is an important indicator of how effective each network is in providing a transit alternative for people traveling to, from and within Tysons.

b. Boardings Per Revenue Hour – Boardings per revenue hour is a standard productivity measure utilized by transit agencies when evaluating their routes. This productivity measure assesses how much each unit of service provided, as measured by revenue hours, is utilized. The higher the measure, the more each unit of service provided is utilized, and thus also the higher the productivity.

c. Daily Operating Cost Per Daily Boardings – This evaluation factor, which is a measure of the cost effectiveness of the service provided, assesses the operating cost of the service relative to the number of people who use it. The higher the cost per rider, the less cost effective the service is.

d. Annualized Capital Cost Per Daily Boardings – This evaluation factor also measures cost effectiveness but evaluates cost effectiveness based on capital costs rather than operating costs.

e. Potential Run Time Variability and Impact on Reliability – This factor acts as a proxy for service reliability by evaluating the percentage of each network that consists of links with forecasted travel speeds less than 10 miles per hour (a measure of congestion).

f. Circulator Travel Times between Select Origins/Destinations within Tysons – This evaluation factor is a measure of the ease with which the Circulator can be used to travel between select origins and destinations within Tysons.

The network evaluation results are outlined below.

4.3 Network Comparison Results – By Evaluation Factor

This section outlines the comparison of each network relative to each of the evaluation factors summarized above. The results of the network comparison contained here acted as the foundation for the recommended network outlined in sub-section 4.4.

a. Daily Ridership – A comparison of forecasted daily ridership by route network and ridership scenario scenarios are included below in Table 4.2 (as part of the project ridership analysis, three ridership scenarios were developed with different assumptions regarding the factors that drive ridership. A summary of assumptions for each ridership scenario is provided in Table 4.1, with Scenario #1 being the most conservative and Scenario #3 being the most aggressive).

Table 4-1: Ridership Scenario Assumptions

Ridership Factors	Scenario #1	Scenario #2	Scenario #3
Service Frequency	10 minutes, peak, 15 minutes off-peak	6 minutes peak, 10 minutes off-peak	4 minutes peak, 6 minutes off-peak
Fare	$1.25	$1.00	Free
Transit Exclusivity	Mixed Traffic	Dedicated lanes with ½ mile of Metrorail stations	50% Dedicated Lanes
Tysons Parking Fees	Current Tysons Parking Fees	Parking Fees in the Arlington Orange Line Corridor, as incorporated in the regional forecasting model	Parking Fees in the Arlington Orange Line Corridor, as incorporated in the regional forecasting model
Mode	Bus	Bus	Streetcar

Table 4-2: Total Daily Ridership by Network and Ridership Scenario

Network	Peak Ridership	Off-Peak Ridership	Total Ridership
Ridership Scenario #1			
Three Route	3,456	2,241	**5,697**
Four Route	2,069	1,212	**3,281**
Ridership Scenario #2			
Three Route	10,007	7,658	**17,575**
Four Route	9,439	7,024	**16,463**
Ridership Scenario #3			
Three Route	16,440	15,306	**31,746**
Four Route	16,322	16,988	**33,310**

The data in Table 4.2 show that the Three Route Network performs better than the Four Route Network under ridership scenarios #1 and #2. The Four Route Network actually performs better under ridership scenario #3; with the most significant difference coming from off-peak ridership (the Three Route Network actually has higher peak ridership).

b. Daily Boardings per Daily Revenue Hour – A comparison of daily boardings per daily revenue hour is included below in Table 4.3.

Table 4-3: Boardings per Revenue Hour by Ridership Scenario and Service Frequency Scenario

Network	Boardings per Revenue Hour – 10 minute peak service frequency scenario	Boardings per Revenue Hour – 6 minute peak service frequency scenario	Boardings per Revenue Hour – 4 minute peak service frequency scenario
Ridership Scenario #1			
Three Route	31.65	20.06	12.66
Four Route	13.84	9.43	6.08
Ridership Scenario #2			
Three Route	97.64	61.88	39.06
Four Route	69.46	47.31	30.49
Ridership Scenario #3			
Three Route	176.37	111.78	70.55
Four Route	140.55	95.72	61.69

The data in Table 4.3 shows that the Three Route Network performs better than the Four Route Network in terms of productivity, as measured by daily boardings per daily revenue hours, under all combinations of daily ridership and service frequencies.

c. Daily Operating Cost per Daily Boarding – A comparison of the daily operating cost per weekday daily boardings between the two networks is included below in Table 4.4, for bus.

Table 4-4: Daily Operating Cost per Weekday Daily Boarding by Ridership Scenario and Service Frequency Scenario (bus)

Network	Operating Cost per Boarding – 10 minute peak service frequency scenario	Operating Cost per Boarding – 6 minute peak service frequency scenario	Operating Cost per Boarding - – 4 minute peak service frequency scenario
Ridership Scenario #1			
Three Route	$3.48	$5.48	$8.69
Four Route	$7.95	$11.67	$18.10
Ridership Scenario #2			
Three Route	$1.13	$1.78	$2.82
Four Route	$1.58	$2.33	$3.61
Ridership Scenario #3			
Three Route	$.62	$.98	$1.56
Four Route	$.78	$1.15	$1.78

As with the boardings per revenue hour, the data in Table 4.4 shows that the Three Route Network performs better than the Four Route Network in terms of cost-effectiveness, as measured by daily operating cost per daily boarding, under all combinations of daily ridership and service frequency.

d. Annualized Capital Cost per Daily Boarding – Because annualized capital costs will vary by mode across each of the service frequency scenarios (see Section 5 for more detail on service frequency scenarios), the data outlined below in Table 4.5 is provided only for the 40' bus mode in order not to present excessive amounts of data. It is important to note that the relationship between networks, which is the focus of this analysis, will be the same for the 60' bus and streetcar as it is for the 40' bus.

Annualized capital cost per daily rider data is outlined in Table 4.5.

Table 4-5: Annualized Capital Cost per Daily Boarding by Ridership Scenario and Service Frequency Scenario (40' Bus Mode)

Network	Annualized Capital Cost per Boarding – 10 minute peak service frequency scenario	Annualized Capital Cost per Boarding – 6 minute peak service frequency scenario	Annual Capital Cost per Boarding – 4 minute peak service frequency scenario
Ridership Scenario #1			
Three Route	$1,620	$2,350	$3,520
Four Route	$2,810	$4,070	$6,120
Ridership Scenario #2			
Three Route	$530	$760	$1,140
Four Route	$560	$810	$1,220
Ridership Scenario #3			
Three Route	$290	$420	$630
Four Route	$280	$400	$600

The data in Table 4.5 show that annualized capital cost per boarding is lower for the Three Route network under ridership scenario #1 and #2 while the cost is slightly lower for the Four Route network under ridership scenario #3.

e. Potential Run Time Variability and Impact on Reliability – Potential run time variability, which can impact service reliability, is measured as a proxy by the percentage of each route's distance that have travel speeds less than 10 mph (a measure of congestion). This percentage is shown in Table 4.6.

   The speed data that was used in this analysis was derived from the Consolidated Traffic Impact Analysis (CTIA) that was underway during the same time frame as this study and which involved detailed traffic impact analysis for the east, central, and western portions of Tysons. The purpose of the CTIA was to provide an understanding of the traffic impacts of the entire proposed rezoning request in Tysons. This consolidated approach was undertaken to address the weakness of individual Traffic Impact Analyses, which focus on individual rezoning applications but do not take into account the cumulative impacts of adjacent rezoning requests.

   The data in Table 4.6 show varying percentages of total route distance that run at congested speeds on both networks. This reflects the varying characteristics of the areas that the different routes run through as well as the different roadways that the routes run on. Of note in comparing the different networks is that the percentages are relatively comparable between networks. Based on this, there is little to distinguish between networks relative to this measure.

Table 4-6: Percent of Each Route that Has Travel Speeds Under 10 mph

Route/Direction/Time Period	% of Total Route Distance Under 10 MPH
Three Route Network	
East Link South EB AM	12.4%
East Link South EB PM	28.2%
East Link South WB AM	14.7%
East Link South WB AM	14.7%
Direct E-W Link EB AM	32.1%
Direct E-W Link EB PM	35.8%
Direct E-W Link WB AM	33.8%
Direct E-W Link WB PM	30.1%
Middle Loop Clockwise AM	16.9%
Middle Loop Clockwise PM	21.9%
Middle Loop Counterclockwise AM	24.7%
Middle Loop Counterclockwise PM	22.3%
Four Route Network	
Central Link EB AM	33.4%
Central Link EB PM	32.5%
Central Link WB AM	47.9%
Central Link WB PM	42.0%
East Link EB AM	32.8%
East Link EB PM	26.6%
East Link WB AM	35.1%
East Link WB PM	36.9%
East Link South EB AM	12.4%
East Link South EB PM	28.2%
East Link South WB AM	14.7%
East Link South WB PM	14.7%
West Link Clockwise AM	12.4%
West Link Clockwise PM	21.1%
West Link Counter Clockwise AM	24.8%
West Link Counter Clockwise PM	25.6%

f. Circulator Travel Times between Select Origins/Destinations within Tysons - This evaluation criterion focuses on the travel time between different origins and destinations within Tysons via the two different Circulator networks. This evaluation is a non-model based approach to assessing the convenience of the two networks for serving internal trips within Tysons. Because the measure focuses on convenience, the assumption was that the trip should be made without a transfer. If a transfer is required to make the trip between select origin-destination pairs, it is noted. This origin destination analysis is outlined in Table 4.7.

Table 4-7: Trip Time between Select O/D Pairs via the Three Route and Four Route Networks

Origin	Destination	O/D Travel Time – Three Route Network (minutes)	O/D Travel Time – Four Route Network (minutes)
Tysons Galleria	Tysons Corner Metro Station	10.1	10.4
Location off of Old Meadow Road	McLean Metro Station	10.5	10.5
Location off of Old Meadow Road	Tysons Corner Metro Station	15.1	15.1
Location off of Old Meadow Road	Tysons Corner Center	11.7	11.7
Capital One Campus	Tysons Galleria	Requires Transfer	19.3
Location off Jones Branch Road, near West Branch	McLean Metro Station	12.2	12.2
Location off Jones Branch Road, near West Branch	Tysons Corner Metro Station	Requires Transfer	11.6
Location off Jones Branch Road, near West Branch	Spring Hill Metro Station	12.3	Requires Transfer
Location off Jones Branch Road, near West Branch	Tysons Galleria	Requires Transfer	13.9
Location off Westpark, west of International Drive	Tysons Corner Metro Station	Requires Transfer	11.0
Location off Westpark, west of International Drive	Spring Hill Metro Station	Requires Transfer	12.7
Location off Westpark, west of International Drive	Tysons Galleria	Requires Transfer	10.6
Location off Greensboro Drive, south of Spring Hill	Tysons Galleria	19.6	12.8
Spring Hill Road, west of Route 7	Tysons Corner Metro Station	Requires Transfer	17.4
Spring Hill Road, west of Route 7	Tysons Galleria	Requires Transfer	17.0
SAIC Drive	Greensboro Metro Station	11.9	11.9
SAIC Drive	Tysons Galleria	20.5	13.6
Boone Blvd., West of Gallows	Tysons Corner Metro Station	16.3	15.7
Boone Blvd., West of Gallows	Greensboro Metro Station	8.8	8.8
Boone Blvd., West of Gallows	Tysons Corner Center	15.9	15.9

The data in Table 4.7 point to the greater coverage afforded by the Four Route Network, including the ability to access a larger number of destinations within Tysons via the Circulator without making a transfer.

4.4 Final Network Recommendation

Based on the results of the evaluation analysis outlined above, the final network recommendation is the Three Route Network. This recommendation is based on the Three Route network's consistently higher performance on all of the evaluation criteria except the travel time between origin- destination pairs. While convenience for moving between origins and destinations within Tysons is important, the superior performance of the Three Route Network in all other performance areas outweighs this one shortfall.

4.5 Potential Additions to Selected Network

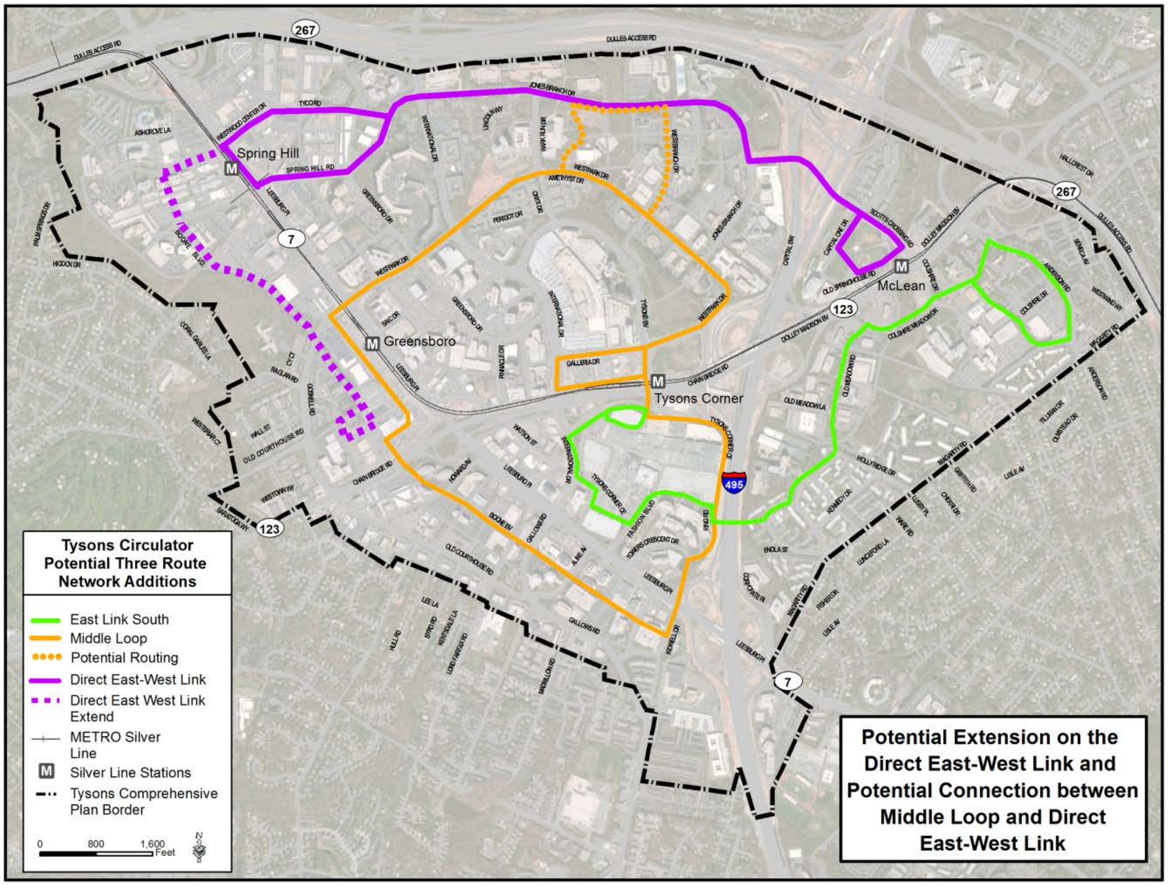
In order to ensure the final network effectively serves as many trip movements as possible within Tysons, a review of heavy total trip movements between origins and destinations within Tysons was completed as a supplement to the ridership analysis. Two heavy trip movements within Tysons that might warrant additions to the Three Route network were identified:

a. **Trip Movements between the Jones Branch Corridor and the Galleria/Tysons Corner Center Area** - The potential addition to the Three-Route Network to address this heavy trip movement is shown in Figure 4.3. This addition is a potential modification to the Middle Loop so that the route would run up and connect to Jones Branch Drive before completing its trip to the Galleria.

b. **Trip Movements on the West Side of Route 7**- There are heavy total trip movements on the west side of Route 7 between the Spring Hill and Greensboro stations. The potential addition to the Three Route network to address this trip movement is shown in Figure 4.3 below and would involve an extension of the Direct East-West Link south to serve the area west of Route 7 around the Greensboro Silver Line station.

These additions would not change the County's request for additional right-of-way to support transit operations and therefore final decisions regarding these additions can be made as implementation of the Circulator moves forward.

Figure 4-3: Potential Addition to the Direct East-West Link and Connections between the Middle Loop and Direct East-West Link



Section 5
Mode Option Analysis

Mode Option Analysis

5.1 Introduction

The purpose of the Mode Option Analysis step of the Tysons Circulator Study planning process was to identify the most appropriate transit mode on each route within the selected Circulator network. The analysis to complete this identification was based on an analytic framework that includes a number of evaluation factors, outlined in more detail below.

The most important factor in the evaluation framework relates to the amount of transit capacity each mode would provide at a given service frequency (three different service frequency scenarios were utilized in the analysis) relative to ridership demand.

Because each mode being considered has different size vehicles, capacity between each mode will differ when running at the same service frequency. The intent when running a service is to utilize a mode that will not result in too much excess capacity relative to ridership demand (vehicles are only partially filled and thus unproductive) or not enough capacity relative to demand (vehicles are too crowded).

Additional factors beyond capacity that were also considered in the Mode Option analysis include:

a. Right of way requirements for each mode evaluated.
b. Roadway congestion levels along each route.
c. Constructability of required infrastructure to support each mode.
d. The transit mode's impacts on other modes sharing the roadway network, including automobiles, bicycles, and pedestrians.
e. Maintenance facility requirements for each mode evaluated.

The remainder of this section outlines the technical analysis carried out to evaluate each mode as well as the final mode recommendations by route.

5.2 Modes Evaluated

Three transit modes were evaluated as part of the mode option analysis. These modes are:

a. Streetcar
b. Bus (40' in length and 60' in length)
c. Driverless People Mover

(**Note:** The model used for the Driverless People Mover analysis was the people mover system installed at Heathrow Airport. The choice of this system as the basis of this analysis was its system characteristics, especially its relatively small footprint and its relatively low capital cost. Two additional driverless technologies were considered but not carried forward for analysis. The first of these technologies was larger capacity people mover systems. This technology was not carried forward because of its larger size and thus also its inconsistency with a dense urban environment. The second technology, considered but not carried forward, was a driverless surface mode (cybercars or cyberbuses), which is a relatively new untested technology with minimal real world deployment. However, because this technology is a surface mode just like bus, only driverless, it would operate in the same environment and rely on the same transit exclusivity recommendations as the surface bus mode considered in this document, if it ever becomes feasible).

An example of each of the modes evaluated is shown in Figure 5.1

As surface modes, streetcar and bus were compared and evaluated relative to each other, with a focus on determining which was most appropriate as a surface mode. Driverless People Mover was evaluated with a focus on determining its overall feasibility as a Circulator mode option within Tysons.

Figure 5-1: Mode Examples

Standard Bus – 40'

Streetcar

Driverless People Mover

5.3 Surface Mode - Required Capacity to Meet Ridership Demand

As noted above, the fundamental factor considered when identifying the most appropriate surface mode was the transit capacity required to meet estimated passenger demand on each of the routes being evaluated. In evaluating modes, the focus was to provide enough capacity so that demand is met without significant crowding while not providing so much capacity that the vehicle is only partially loaded and thus the service is unproductive. Outlined first below is the process followed for evaluating the most appropriate surface mode (streetcar versus bus as well as the most appropriate sized bus).

The analysis is outlined in detail in Appendix B, and summarized below in Table 5.2. The analysis begins with the estimated peak hour, peak direction passenger demand (it is this demand which will dictate the amount of capacity required in the peak hour). This peak hour, peak direction, calculation was derived from daily passenger demand, which was forecasted for each route in the two final networks (more detail on the ridership estimating process is contained in Section 7). Further, daily ridership on each route was estimated under three different ridership scenarios with each scenario reflecting different assumptions about the variables that influence ridership (see Section 7 for more detail on the ridership scenarios). The variables impacting ridership that were varied between each ridership scenario include:

a. Circulator fare
b. Parking fees in Tysons
c. Circulator service frequency
d. Level of transit exclusivity
e. Circulator mode

The calculated peak hour, peak direction demand by route, by ridership scenario is shown in Table 5.1 (of note is that ridership scenario 1 is the most conservative in terms of the assumptions relative to each variable while ridership scenario 3 is the most aggressive). Peak period, peak direction demand on each route was factored down from total peak period ridership based on the following steps.

a. Total peak period ridership (Both AM and PM peak ridership combined as derived from the ridership model) is factored into AM peak ridership by taking 50% of total peak period ridership.

b. Total AM peak ridership is further factored into AM peak hour ridership by taking 45% of total AM peak ridership.

c. Total AM peak hour ridership is factored into AM peak hour, peak direction ridership by taking 70% of AM peak hour ridership.

As noted, it is this AM peak hour, peak direction ridership that will dictate the amount of transit capacity that is required to meet passenger demand.

Table 5-1a: Peak Hour, Peak Direction Ridership Demand (Three Route Network)

Route	Ridership
Ridership Scenario #1	
Middle Loop	131
Direct East-West	365
Tysons Link South	47
Ridership Scenario #2	
Middle Loop	572
Direct East-West	658
Tysons Link South	347
Ridership Scenario #3	
Middle Loop	832
Direct East-West	1,081
Tysons Link South	676

Table 5-1b: Peak Hour, Peak Direction Ridership Demand (Four Route Network)

Route	Ridership
Ridership Scenario #1	
Central Link	52
East Link South	48
West Loop	69
East Link	157
Ridership Scenario #2	
Central Link	215
East Link South	487
West Loop	198
East Link	587
Ridership Scenario #3	
Central Link	391
East Link South	883
West Loop	429
East Link	869

Once demand was calculated, the second step in the analysis was to calculate capacity utilization for each surface mode based on three different service frequency assumptions. This capacity utilization was measured by the mode's load factor, which measures the number of passengers on board compared to the number of seats on the vehicle (a load factor of 1.0 means the number of passengers on board equals the number of seats on board. A load factor less than 1.0 means that not all seats on a vehicle are occupied and a load factor greater than 1.0 means that there are standees). This load factor calculation takes into account the seating capacity of each mode as well as the peak hour, peak direction ridership estimates outlined above.

The actual calculation to determine load factor as well as load factors by mode and service frequency scenario is outlined in Appendix B.

The final step in the capacity analysis is to use the capacity utilization data, as measured by load factor (shown in Appendix B) to determine the most appropriate surface mode under each service frequency. In identifying the most appropriate surface mode, it was determined that the ideal load factor should fall in a range between .8 and 1.2. The lower number in the range indicates that 80% of seats would be utilized, which indicates a productively utilized vehicle. A load factor below .8 indicates a less than ideal productivity. The higher number in the range indicates that there would be some standees but not excessive crowding. A load factor exceeding 1.2 would mean there is the start of excessive crowding.

The results of this analysis are summarized in Table 5.2, which shows which mode best meets the load factor criterion under each ridership and service frequency scenario (as noted the more detailed data showing all load factor calculations is shown in Appendix B).

Since the data in Table 5.2 show that peak hour, peak direction ridership demand can be met with different mode types depending on service frequency, the Table also provides two sets of cost data by service frequency and mode. The first is the daily operating cost of the selected mode for that service frequency and the second is the annualized capital cost of vehicles and guideway per rider for the selected mode for that service frequency.

The purpose of this information is to provide an understanding of the most cost-effective mode/service frequency combination to meet a route's demand. For instance, streetcar may provide sufficient capacity to meet demand at a 10-minute service frequency but a more cost effective solution may be to run buses at a more frequent headway. This outcome would reflect the lower operating cost per hour of bus as well as the lower capital costs of a bus versus streetcar.

It should be noted that in some instances the load factors for each mode under a specific service frequency/ridership combination all fell outside the ideal range of .8 to 1.2. In this instance, the mode with the highest load factor, if all of the load factors were less than .8, was identified as the most appropriate mode. This highest load factor reflects the highest level of productivity. In those instances where all modes had a load factor greater than 1.2, the mode with the lowest load factor was identified as the most appropriate mode based on the fact that the lowest load factor would represent the least crowded vehicle.

As one example of how to interpret the results shown in the Table, see the Middle Loop under Ridership Scenario #2 in Table 5.2a. The data in the Table show that the Middle Loop's peak hour, peak direction ridership under ridership scenario 2 can be met with a streetcar running every 10 minutes, a 60' bus running every six minutes or a 40' bus running every four minutes. An evaluation of the cost data for each of these mode/service frequency scenarios show that the 60' bus running every six minutes would have the lowest weekday daily operating cost ($15,600 versus $24,000 for 40' bus and $25,900 for streetcar). A review of the annualized guideway and vehicle cost per rider data show that the 60' bus cost per rider is slightly higher than the 40' bus cost ($270 versus $260 for the 40' bus) but much lower than the streetcar cost ($850). In this instance, the 60' bus mode would be the most ideal mode for the Middle Loop under ridership scenario #2.

The final mode and service frequency recommendation for each route under each ridership scenario is shown below in Table 5.3.

Note: All costs presented in Section 5 are in 2012 dollars

Table 5-2a: Most Appropriate Mode by Ridership Scenario/Service Frequency Combination – Three Route Network

Route	Service Frequency – Vehicle Every 4 minutes	Service Frequency – Vehicle every 6 minutes	Service Frequency – Vehicle Every 10 minutes
Ridership Scenario #1			
Middle Loop	40' Bus (.22) $24,000 $1,180	40' bus (.34) $15,600 $1,060	40' bus (.56) $9,900 $910
Direct East-West Link	40' bus (.62) $12,800 $250	40'bus (.94) $7,800 $200	60' bus (1.01) $5,000 $190
East Link South	40' bus (.08) $12,800 $1,760	40' bus (.12) $7,800 $1,450	40' bus (.2) $5,000 $1,250
Ridership Scenario #2			
Middle Loop	40' bus (.98) $24,000 $260	60' bus (.95) $15,600 $270	Streetcar (.73) $25,900 $850
Direct East-West Link	40' bus (1.12) $12,800 $120	60' bus (1.10) $7,800 $110	Streetcar (.84) $13,000 $360
East Link South	40' bus (.59) $12,800 $260	40' bus (.89) $7,800 $220	60' bus (.96) $5,000 $200
Ridership Scenario #3			
Middle Loop	60' bus (.92) $24,000 $170	Streetcar (.64) $40,900 $520	Streetcar (1.07) $25,900 $470
Direct East-West Link	60' bus (1.20) $12,800 $90	Streetcar (.83) $20,400 $260	Streetcar (1.39) $13,000 $240
East Link South	40' bus (1.16) $12,800 $110	60' bus (1.13) $7,800 $100	Streetcar (.87) $30,400 $340

Note:
1. Number in parentheses represents the load factor
2. The middle number in each cell represents the daily operating cost of the mode under that service frequency scenario
3. The lower number in each cell represents the annualized capital cost of guideway and vehicles per daily rider

Table 5-2b: Most Appropriate Mode by Ridership Scenario/Service Frequency Combination – Four Route Network

Route	Service Frequency – Vehicle Every 4 minutes	Service Frequency – Vehicle every 6 minutes	Service Frequency – Vehicle Every 10 minutes
Ridership Scenario #1			
Central Link	40' bus (.09) $14,100 $1,000	40' bus (.13) $9,900 $940	40' bus (.22) $7,000 $770
East Link South	40' bus (.08) $12,800 $907	40' bus (.12) $7,800 $749	40' bus (.21) $5,000 $643
West Loop	40' bus (.12) $19,800 $2,500	40' bus (.18) $12,800 $2,300	40' bus (.29) $9,100 $1,900
East Link	40' bus (.27) $12,800 $1,120	40' bus (.40) $7,800 $980	40' bus (.67) $5,000 $840
Ridership Scenario #2			
Central Link	40' bus (.37) $14,100 $270	40' bus (.55) $9,900 $260	40' bus (.92) $7,000 $210
East Link South	40' bus (.83) $12,800 $160	60' bus (.81) $7,800 $150	Streetcar (.62) $13,000 $450
West Loop	40' bus (.34) $19,800 $300	40' bus (.51) $12,800 $270	40' bus (.85) $9,100 $230
East Link	40' bus (1.00) $12,800 $350	60' bus(.98) $7,800 $340	Streetcar (.75) $1,000 $1,110
Ridership Scenario #3			
Central Link	40' bus (.67) $14,100 $161	40' bus (1.00) $9,900 $152	60' bus (1.09) $7,000 $139
East Link South	60' bus (.98) $12,800 $100	Streetcar (.68) $20,400 $300	Streetcar (1.13) $13,000 $270
West Loop	40' bus (.73) $19,800 $120	40' bus (1.10) $12,800 $110	60' bus (1.19) $9,100 $100
East Link	60' bus (.97) $12,800 $180	Streetcar (.67) $20,400 $520	Streetcar (1.11) $13,000 $500

Note:
1. Number in parentheses represents the load factor
2. The middle number in each cell represents the daily operating cost of the mode under that service frequency scenario
3. The lower number in each cell represents the annualized capital cost of guideway and vehicles per daily rider

Table 5-3: Surface Mode Recommendations – by Ridership Scenario and Route

Route	Mode Recommendation	Required Service Frequency
Ridership Scenario #1 – Three Route Network		
Middle Loop	40’ Bus	10 Minutes
Direct East-West Link	60’ Bus	10 Minutes
East Link South	40’ Bus	10 Minutes
Ridership Scenario #2 – Three Route Network		
Middle Loop	60’ Bus	6 minutes
Direct East-West Link	60’ Bus	6 minutes
East Link South	60’ Bus	10 minutes
Ridership Scenario #3 – Three Route Network		
Middle Loop	60’ Bus	4 minutes
Direct East-West Link	60’ Bus	4 minutes
East Link South	60’ Bus	6 minutes
Ridership Scenario #1 – Four Route Network		
Central Link	40’ Bus	10 minutes
East Link South	40’ Bus	10 minutes
West Loop	40’ Bus	10 minutes
East Link	40’ Bus	10 minutes
Ridership Scenario #2 – Four Route Network		
Central Link	40’ Bus	10 minutes
East Link South	60’ Bus	6 minutes
West Loop	40’ Bus	10 minutes
East Link	60’ Bus	6 minutes
Ridership Scenario #3 – Four Route Network		
Central Link	60’ Bus	10 minutes
East Link South	60’ Bus	4 minutes
West Loop	60’ Bus	10 minutes
East Link	60’ Bus	4 minutes

The data in Table 5.3 show that, with regard to surface modes, demand can be met most cost-effectively in all instances with either a 40' bus or a 60' bus.

5.4 Capacity Evaluation of Driverless People Mover

In addition to the surface modes evaluated above, an evaluation of a Driverless People Mover technology was also completed. The first step in this evaluation was to develop an understanding of the number of trips that would be required to meet ridership demand. Table 5.4 below shows the number of peak hour trips that would be required based on demand on each route and an assumed vehicle capacity of 8 persons (8 persons is the standard vehicle size for the prototypical system used for this analysis (system currently deployed at Heathrow Airport); expanding vehicle size would require a heavier guideway, thus increasing construction cost per mile). The data shows that under ridership Scenario #3, over 100 trips per hour would be required on the Middle Loop and the Direct East-West Link routes on the Three Route Network and on the East Link South route on the Four Route Network.

Table 5-4a: Required People Mover Trips Based on Peak Hour, Peak Direction Demand – Three Route Network

	Peak Hour, Peak Direction Ridership	Vehicle Capacity - People Mover	Required Number of Trips to Meet Demand
Ridership Scenario #1			
Middle Loop	131	8	16
Direct East-West	365	8	46
Tysons Link South	47	8	6
Ridership Scenario #2			
Middle Loop	572	8	72
Direct East-West	658	8	82
Tysons Link South	347	8	43
Ridership Scenario #3			
Middle Loop	832	8	104
Direct East-West	1081	8	135
Tysons Link South	676	8	85

Table 5-4b: Required People Mover Trips Based on Peak Hour, Peak Direction Demand – Four Route Network

	Peak Hour, Peak Direction Ridership	Vehicle Capacity - People Mover	Required Number of Trips to Meet Demand
Ridership Scenario #1			
Central Link	52	8	7
East Link South	48	8	6
West Loop	69	8	9
East Link	157	8	20
Ridership Scenario #2			
Central Link	215	8	27
East Link South	487	8	61
West Loop	198	8	25
East Link	587	8	73
Ridership Scenario #3			
Central Link	391	8	49
East Link South	883	8	110
West Loop	429	8	54
East Link	869	8	109

5.5 Life Cycle Cost Comparison – Surface vs. Driverless People Mover

The second component of the Driverless People Mover technology evaluation is a comparison of costs between the surface modes and the driverless mode. It should be noted that the cost drivers of the operations and maintenance portion of life cycle costs differ between the surface modes and the driverless modes. For the surface mode the operations and maintenance portion of life cycle costs vary by service frequency while ridership rather than frequency will directly affect the operations and maintenance portion of the life cycle cost of the Driverless People Mover. With that proviso, a comparison of life cycle costs for the surface modes and driverless mode is shown below in Tables 5.5 and 5.6. Table 5.5 contains data on annualized cost that combines operations and maintenance and annualized capital costs over a 30 year period while Table 5.6 contains total 30 year period costs (the detail on Driverless People Mover operations and maintenance costs is included in Appendix G. The capital cost and annualized capital cost detail for Driverless People Mover is shown in report Section #8).

Table 5-5: Annual Life Cycle Cost Comparison – Surface Modes vs. Driverless People Mover

Surface Modes				Driverless People Mover	
Service Frequency Scenario (Surface Modes)	**40' Bus annualized cost**	**60' Bus annualized cost**	**Streetcar annualized cost**	**Ridership Scenario (Driverless People Mover)**	**Driverless People Mover annualized cost**
Three Route Network					
10 minutes	$9,218,200	$9,478,200	$28,460,700	Scenario #1	$6,468,400
6 minutes	$13,365,900	$13,755,900	$39,399,100	Scenario #2	$10,804,700
4 minutes	$20,077,300	$20,613,600	$57,086,500	Scenario #3	$16,781,500
Four Route Network					
10 minutes	$11,907,700	$12,234,700	$36,303,100	Scenario #1	$6,434,800
6 minutes	$16,390,100	$16,877,600	$48,064,500	Scenario #2	$10,606,000
4 minutes	$23,984,900	$24,602,400	$68,167,400	Scenario #3	$16,141,300

Table 5-6: Total Life Cycle Cost Comparison – Surface Modes vs. Driverless People Mover

Surface Modes				Driverless People Mover	
Service Frequency Scenario (Surface Modes)	**40' Bus total 30 year cost**	**60' Bus total 30 year cost**	**Streetcar total 30 year cost**	**Ridership Scenario (Driverless People Mover)**	**Driverless People Mover total 30 year cost**
Three Route Network					
10 minutes	$276,547,400	$284,347,400	$853,822,100	Scenario #1	$194,052,700
6 minutes	$400,976,100	$412,676,100	$1,181,973,100	Scenario #2	$324,141,900
4 minutes	$602,320,100	$618,407,600	$1,712,594,400	Scenario #3	$503,444,500
Four Route Network					
10 minutes	$357,229,900	$367,042,400	$1,089,092,200	Scenario #1	$193,043,000
6 minutes	$491,702,600	$506,327,600	$1,441,934,400	Scenario #2	$318,179,400
4 minutes	$719,547,300	$738,072,300	$2,045,022,200	Scenario #3	$484,239,400

The data in Tables 5.5 and 5.6 shows that the Driverless People Mover technology has lower costs than the surface modes in all instances, with the smallest difference being between the driverless mode and the 40' bus surface mode.

5.6 Other Evaluation Factors

Table 5.7 below summarizes each mode relative to the other evaluation factors utilized as part of the mode comparison evaluation framework (these factors are identified above).

Table 5-7: Summary – Mode Evaluation – Other Evaluation Factors

Evaluation Factor	Streetcar	Bus	People Mover
Right of Way Required by Mode	1. Operates most effectively in exclusive median right-of way. a. Lack of flexibility to bypass stalled or illegally parked vehicles. b. Exclusivity reflects level of capital investment associated with streetcar. c. Curb running requires streetcars to share the curb lane with vehicles making right turns and exiting from driveways, even if running in exclusive lane. d. Exclusivity should be consistent along entire route (e.g. – median running should be consistent along entire length of route).	1. More flexibility to run in curb lane and in mixed traffic. a. More flexibility to bypass stalled or illegally parked cars. b. Can utilize curb or median exclusive lanes. c. Due to fact that it is less capital intensive, exclusivity would potentially have more rigorous warrants – congestion and transit volumes.	1. Because technology is driverless, it must be fully exclusive both horizontally and vertically. a. Vertical exclusivity means the technology must be elevated above street level. b. Support pillars require that guideway must be in own right-of-way along entire length of route.
Roadway Congestion Levels along Route	1. Operates most effectively in exclusive median right-of-way regardless of congestion. Lower congestion could potentially support mixed operations.	1. Can more effectively operate in mixed traffic than streetcar. a. Higher congestion levels provide support for exclusive lanes. b. Higher delay at intersections provide support for queue jumps at congested intersections.	1. Requires exclusive right-of-way regardless of levels of congestion.

Evaluation Factor	Streetcar	Bus	People Mover
Constructability	1. Complex level of constructability even if runs in mixed traffic. Significant impact on traffic operations during construction.	1. Implementation of mixed traffic service will have limited impact. Implementation of exclusive lanes and queue jumps will impact current operations.	1. Complex Level of constructability including guideway and guideway supports.
Impacts on other Modes/Urban Design Considerations	1. Impacts can be significant. a. Transition from one street to another – may require transit only phase, impacting other movements. b. Exclusive lanes will widen cross-section, impacting pedestrians and overall walkability. c. Bicyclists will also be impacted by the wider required cross-section. Mitigation for both bicyclists and pedestrians will need to be addressed in design, with a specific focus on urban design elements. Mitigation approaches will include median refuges for pedestrians and bicyclists, pedestrian/bicyclist protected signal phases, protected mid-block crossings, and safety oriented signing and crosswalk treatments. Bike paths and other non-auto amenities included as part of Comprehensive Plan will also facilitate safe and convenient bike and pedestrian movements	1. Exclusive lane operation will have same impact on other modes as streetcar. 2. Non-exclusive lane operation will result in fewer impacts.	1. Full exclusivity means limited impacts on other modes. 2. Elevated nature of operation can have urban design impacts. a. Different technologies will have different cross-sections and pillar widths. Urban design impacts could vary fairly significantly between different technologies.

Evaluation Factor	Streetcar	Bus	People Mover
Maintenance Facility Requirements	1. Maintenance and storage facility within Tysons would be required. Track access to facility would also be required. Location would depend on which routes are implemented as streetcar.	1. Greater flexibility with regard to location of maintenance and storage facility. Does not have to be in Tysons.	1. Maintenance and storage facility within Tysons would be required. Elevated track access to facility would also be required. Location would depend on which routes are implemented as People Mover.

5.7 Recommendations

On all routes under both networks, sufficient capacity to meet demand can be achieved through the use of a 40' or 60' bus. It is recommended in all instances, therefore, to utilize buses to provide Circulator service given their lower capital and operating cost as well as their greater flexibility in being re-routed as required. In those instances where capacity can be provided with a 40' bus at lower frequencies versus a 60' bus at higher frequencies, it is proposed that the mode/frequency combination that provides the lowest daily operating cost be selected. This is summarized in Table 5.3.

The cost evaluation for a the prototypical Driverless People Mover used for this analysis does show the mode to be somewhat less costly than the surface mode, though the cost presented here is for the guideway and vehicles only and does not include the cost of additional right-of way. In addition, construction costs per mile would also increase if larger vehicles were used or if more vehicles per hour were required to provide service. Despite lower costs, Driverless People Mover was not recommended as the Circulator mode because it was determined that the characteristics of a People Mover system make it infeasible for implementation in Tysons. The most important of these characteristics is the fact that because a People Mover system is driverless, it requires complete horizontal and vertical exclusivity. In order to provide this exclusivity the system must be elevated, which in turn requires support pillars, which would require new right-of-way along a significant portion of each route (it should be noted that some exclusivity may be potentially provided without additional right-of-way, though based on the anticipated characteristics of Tysons in the future, especially higher future traffic volumes, it is assumed that a significant portion of the route would require new right-of-way in order to avoid impacts to general traffic lanes). Obtaining this required right-of-way in an urbanized Tysons would have extensive impacts on adjacent property owners and thus would be extremely difficult, if not impossible to implement.

Urban design elements also make a Driverless People Mover system less attractive. The first of these elements is the fact that riders would have to access an elevated station via elevator or escalator, which requires a longer and less direct access path (it should be noted that there may be potential to accommodate some portions of the People Mover at grade but separated from traffic. More detailed design would be required to determine if this at-grade configuration is feasible along portions of each route). This could be especially onerous for people transferring from elevated Silver Line Stations. The second urban design element that makes an elevated people mover system less attractive is the potential impact on the desired walkable and accessible urban street system, including impacts to pedestrians and to street level businesses. For these various reasons a Driverless People Mover system was not recommended as the mode for the Tyson Circulator system.

One final note with regard to mode is that the County is reserving the option of implementing streetcar on each of the routes in the Three Route network. While the analysis included in this report indicates that the capacity that would be provided by streetcar would be not be fully utilized and therefore unproductive, maintaining mode flexibility on these routes reflects the fact that forecasting future conditions can be imprecise and that the capacity provided by streetcar may be required based on actual long-range conditions.

Section 6
Transit Preferential Treatments

Transit Preferential Treatments

6.1 Introduction

As noted earlier in the document, one of the key purposes of the Tysons Circulator Study is the identification of required transit preferential treatments to support a fast and reliable Circulator system. The purpose of this report section is threefold:

a. Describe the process and analysis that was used to identify required transit preferential treatments along each proposed Circulator route.

b. Outline the recommendations for preferential treatments based on the process noted above.

c. Identify the additional right-of-way that would be required to implement these treatments (an understanding of these right-of-way requirements is essential so that the County can reserve this right-of-way as re-zoning requests are made to the County during the Tysons redevelopment).

The discussion below assumes that bus will be the final mode on each of the routes in the network, based on the mode option analysis as outlined in the previous report section.

The remainder of this report section consists of the following subsections:

a. Transit Preferential Treatments Evaluated – This subsection contains a general description of each of the transit preferential treatments evaluated for implementation in Tysons.

b. Transit Preferential Treatment Identification Process – This subsection outlines the process and analysis followed to identify where transit preferential treatments are warranted within Tysons.

c. Transit Preferential Treatment Recommendations – This section outlines the recommendations for implementation of transit preferential treatments based on the analysis described above.

6.2 Transit Preferential Treatments Evaluated

There are three primary transit preferential treatments that have been evaluated as part of the Tysons Circulator Study planning process. A general description of each of these treatments is provided below.

a. Queue Jump Lanes – Queue jump lanes are bus only bypass lanes at congested intersections that allow buses to bypass, or “jump” past long queues backed up at signals. This configuration allows buses to avoid general traffic congestion and move more quickly through the intersection. A conceptual intersection configuration with a queue jump lane is shown in Figure 6.1.

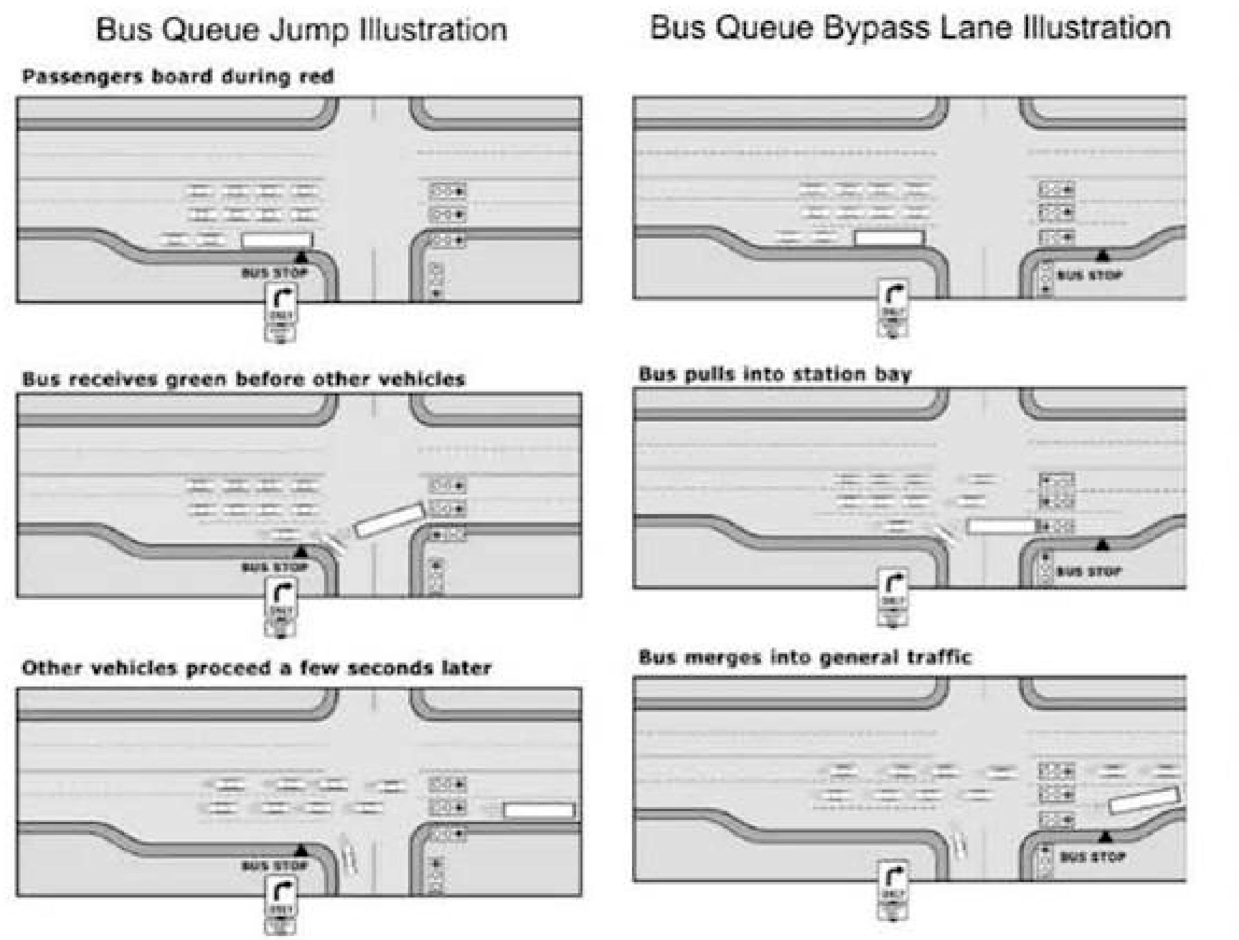
   On the approach to the intersection the queue jump lane can utilize an intersection right turn only lane, if this type of lane exists or a new lane if the intersection configuration does not include a right turn only lane. In both instances, the recommendation is that the bus shares the lane with vehicles making a right turn. This recommendation is based on the fact that there would be a conflict between a bus passing through an intersection and cars to the left of the bus that would have to make a right turn in front of the bus. It is important to note, however, that a bus only lane to the right of a vehicle right turn lane is feasible, but the intersection operation would be more complex. In this instance, the bus would require its own phase that would allow it to pass through the intersection separately from right turning cars.

   In a queue jump, the far side of the intersection will require a receiving lane for the bus as it crosses the intersection. In some instances a right turn from the cross street of the intersection will include a merge lane on the street being utilized by the Circulator. In those instances where a merge lane exists it can be used as a receiving lane, though it may require modification so that it can handle buses (this modification may include widening or lengthening as well as additional signing warning right turning vehicles to watch for buses). When there is no existing lane on the far side of the intersection, a new receiving lane will be required. This receiving lane will likely require new right-of-way from the adjacent property owner.

   The receiving lane on the far side of the intersection can consist of one of two general configurations, depending on the level of congestion and travel speeds on the intersection-to- intersection link the bus is entering. If link congestion is not significant and speeds are reasonable, the bus would merge back into general traffic and the receiving lane would end. If link congestion is significant and travel speeds slow, the receiving lane may continue as a bus only lane to the next intersection (more detail on exclusive lanes is provided below).

   The final consideration in the queue jump design is the intersection signal phasing. Since the bus, under the approach proposed above, is sharing the queue jump lane with right turning vehicles, it typically will cross the intersection during the same green phase as the vehicular traffic (this green will also allow vehicles sharing the queue jump with the bus to turn right). In this instance, if the bus merges into traffic on the far side of the intersection, it will merge when a break in traffic occurs. If traffic volumes are high enough that the bus merges back into general traffic on the far side of the intersection is too difficult, a short transit only green phase may be warranted. This would allow buses to merge into general traffic lanes ahead of the vehicles passing through the intersection.

Figure 6-1: Conceptual Intersection Configuration – With Queue Jump Lane



Source: Transit Cooperative Research Program Report 118 – Bus Rapid Transit Practitioner's Guide

b. Bus Only Lanes between Intersections - Bus only lanes on links between intersections allow buses to bypass congested and slow traffic on the adjacent general traffic lanes by providing bus exclusivity. Bus only lanes can be stand-alone lanes not connected to queue jumps or they can be a continuation of a queue jump receiving lane. If they are stand-alone lanes, buses would transition into the bus only lane on the far side of the intersection and then transition back to general traffic at the next intersection. To avoid delay associated with transitioning into and out of the bus only lane and thus also provide a speed benefit relative to adjacent general traffic, the bus only lane without queue jumps should be of a fairly long distance in order to avoid excessive transitioning into and out of traffic. Stand-alone bus lanes not tied to queue jumps would likely require additional right-of-way from adjacent property owners.

Where intersection to intersection roadway links are relatively short, to avoid excessive transitioning, the exclusive lanes should be tied to queue jump lanes. Typically this configuration would start with the queue jump lane on the near side of the intersection. On the far side of the intersection the receiving lane would continue as a bus only lane to the next intersection. The bus only lane would then become the queue jump lane for this next intersection and the receiving lane on the far side of the intersection would then transition to the bus only lane. This configuration would continue as far as slow speeds and congestion warrant. Bus only lanes that are continuations of queue jumps would, like stand-alone bus lanes, very likely require additional right-of-way from adjacent property owners.

In all instances where transit exclusive lanes are proposed, a re-purposing of parking lanes will be utilized, wherever feasible. This re-purposing of existing lanes will minimize the amount of additional right-of-way that will have to be obtained from adjacent property owners.

c. Transit Signal Priority – Transit signal priority is a component of the roadway signaling system that provides advantages to transit in order to increase transit speeds and minimize delays at intersections. The most typical example of transit signal priority would be an extended green phase for a bus arriving at an intersection just as the bus is to receive a red light. This extended green would allow the bus to pass through the intersection and avoid waiting through an entire signal cycle. Another form of priority is a truncated red, which would shorten the length of the red phase and allow the bus to pass through the intersection early. Transit signal priority requires no physical right-of-way. Because the use of transit signal priority affects the green time provided to traffic on the intersection side streets, typically the operation is conditional, meaning priority will be provided only if a bus is running late or running too close to the bus in front of it based on scheduled headway.

6.3 Transit Preferential Treatment Identification Process

This section focuses on the data and criteria (or warrants) that were used to identify where along the Circulator networks transit preferential treatments should be installed in order to support fast and reliable Circulator service.

Two criteria were used to identify where queue jumps and exclusive lanes are warranted. The first of these is congestion and travel speeds and the second is bus volumes per hour.

Two additional criteria were used to identify where transit signal priority is warranted. The first of these is approach delay and the second is delay on the side streets of each intersection.

All four criteria are described in greater detail below.

a. Congestion and Travel Speeds – The key purpose of the transit preferential treatments described above is to provide buses a speed and reliability benefit by either separating them from congested general traffic or providing them priority at signals in order to avoid signal related delay. Since queue jumps and exclusive lanes widen the roadway cross section, they will have impacts on adjacent property owners as well as on pedestrian crossings. Transit signal priority does not require additional right-of-way but does have an impact on vehicular traffic on the intersection side streets, which will receive less green time when signal priority to the bus is provided.

   Because of these impacts, a warrant system was utilized to identify locations along the route networks where preferential treatments are warranted. The first of these warrants was roadway congestion levels, as measured by travel speeds by link. These speed levels by link were derived from the Consolidated Traffic Impact Analysis currently being completed. These traffic analyses will support the development of traffic mitigation strategies to address increased traffic associated with increased development densities. The speed data by link is calculated by taking the total travel time from the approach side of the link's upstream intersection to the approach side of the link's downstream intersection and dividing that travel time by the distance of the link. The inclusion of the upstream intersection incorporates intersection delay into the link average speeds. Travel speeds, as calculated in this manner, are shown graphically in Appendix C. There are four maps for the Three Route Network: AM peak eastbound direction, AM peak westbound direction, PM peak eastbound direction, and PM peak westbound direction. The congestion and travel speed warrant is that any link where travel speeds are less than 10 miles per hour is a candidate for queue jumps and exclusive lanes. This warrant was used in conjunction with the "Bus Volumes per Hour" warrant to identify the proposed queue jump/exclusive lane recommendations outlined in the next subsection.

b. Bus Volumes Per Hour – A review of academic literature on transit preferential treatments indicates that transit exclusive lanes are warranted at bus volumes of 30 buses per hour, or a bus running every two minutes, which also corresponds to a bus utilizing the exclusive lane during every 120 second signal cycle (source: Transit Capacity and Quality of Service Manual). It should be noted, however, that this volume would generally relate to the removal of a general traffic lane for use as an exclusive bus lane. Because it was never the intention of this study to recommend the removal of a general traffic lane to provide transit exclusivity, and because a two minute service frequency is simply not required on any of the proposed Tysons Circulator routes based on demand, this study utilized a less rigorous bus volume requirement as its warrant. The bus volume warrant utilized for the identification of exclusive lane/queue jump applications was 10 to 15 buses per hour, or a bus running every four to six minutes. This would result in a bus arriving every second or third signal cycle. This warrant was applied in conjunction with the "Travel Speeds and Congestion" warrant to identify the proposed queue jump/exclusive lane recommendations outlined in the next section.

c. Approach Delay and Side Street Delay – Because transit signal priority does not require additional right-of-way, its application is not constrained in the same manner as queue jumps and exclusive transit lanes. Instead, it can be relatively easily implemented. The first warrant utilized for the identification of transit signal priority was an approach delay of 35 seconds or greater, which represents a level of service D or worse. Given the relative ease of transit signal priority implementation, this warrant is relatively loose in identifying potential intersection candidates for the application of transit signal priority.

   While transit signal priority can be relatively easily applied, there is an effect of its application. This effect comes from the impact its application has on side street traffic movement, given that providing priority to a bus will take green time away from this side street traffic. Therefore, the second warrant used to determine where transit signal priority should be implemented is actually focused on intersections where it should not be installed because of its impacts on side street traffic operations. This second warrant, therefore, is that any side street with a delay greater than 60 seconds is not a candidate for transit signal priority because the impacts of the extra green time for buses would be too significant.

Based on the warrants described in this subsection, actual recommendations for transit preferential treatments are outlined in the next subsection.

6.4 Transit Preferential Treatment Recommendations

6.4.1 Queue Jump/Exclusive Lane Recommendations

A review of the speed maps contained in Appendix C show three areas of slow speeds that meet the speed and congestion warrants described above and thus are recommended for a combination of queue jumps and exclusive lanes. Each of these areas is described below.

a. Gosnell Road/Westpark Drive and Route 7 intersection to Westpark Drive and International Drive intersection – A review of the speed maps contained in Appendix C show that the roadway between Gosnell Road at the new proposed street running parallel to Route 7 (south of Route 7) and the intersection of Westpark Drive and International Drive has combined travel speeds less than 10 miles per hour along the entire length at least once during one of the peak periods and at least in one direction (on most portions of this link, the less-than-10- miles per hour condition happens more than once). Since, for operational purposes, queue jumps and exclusive lanes would be implemented in both directions and would be operational at least during the peak period, it is recommended that a combination of queue jumps and exclusive bus lanes be implemented along this entire length of roadway, in both directions. The proposed configuration of this combination is shown, at a conceptual level, in Figure 6.2.

Starting at the western end of the proposed link, and running in the eastbound direction, the bus would utilize the right-turn only at the intersection of Gosnell and Route 7 lane as a queue jump and would cross the Gosnell/Westpark/Route 7 intersection utilizing the same green phase as the through traffic. The bus would continue to run in the exclusive bus lane up to Greensboro Drive. At Greensboro, the bus-only lane would act as a queue jump and the receiving lane on the far side of the intersection would continue up to International Drive as a bus only lane. The bus-only lane would act as queue jump at International. There would be a receiving lane on the far side of International and then buses would merge into the general traffic lanes. To allow for effective merging back into general traffic, a transit only phase at this intersection may be required.

This recommendation would require additional right-of-way on the south side of Westpark Drive from Route 7 to International Drive.

In the westbound direction a comparable operation would occur. Of note is the transit only signal phase in the westbound direction at the Route 7/Westpark intersection; this phase will be necessary in order to allow the bus to quickly position itself to make the left turn onto the proposed new roadway running parallel to Route 7. Without the transit only phase, the bus would not be able to cross traffic quickly enough to make the left turn. This recommendation would also require additional right-of-way on the north side of Westpark Drive between International Drive and Route 7.

These transit preferential treatments would support the Middle Loop under the Three Route Network. Based on the mode option analysis for the Three Route Network, the most likely operating scenario would be a 60' articulated bus running every six minutes, or 10 buses per hour.

Of note is that the exclusive bus lanes identified here and at other locations below will result in wider street cross sections, thus impacting pedestrian and bicycle crossings at intersections. Mitigation for both bicyclists and pedestrians will be addressed in design, with a specific focus on urban design elements. Mitigation approaches may include median refuges for pedestrians and bicyclists, pedestrian/bicyclist protected signal phases, protected mid-block crossings, and safety oriented signing and crosswalk treatments. Bike paths and other non-auto amenities included as part of the Comprehensive Plan will also facilitate safe and convenient bike and pedestrian movements.

Figure 6-2: Proposed Queue Jumps and Exclusive Bus Lane - Gosnell Road/Westpark Drive and Route 7 intersection to Westpark Drive and International Drive intersection – Gosnell/Westpark and Route 7 Intersection Section

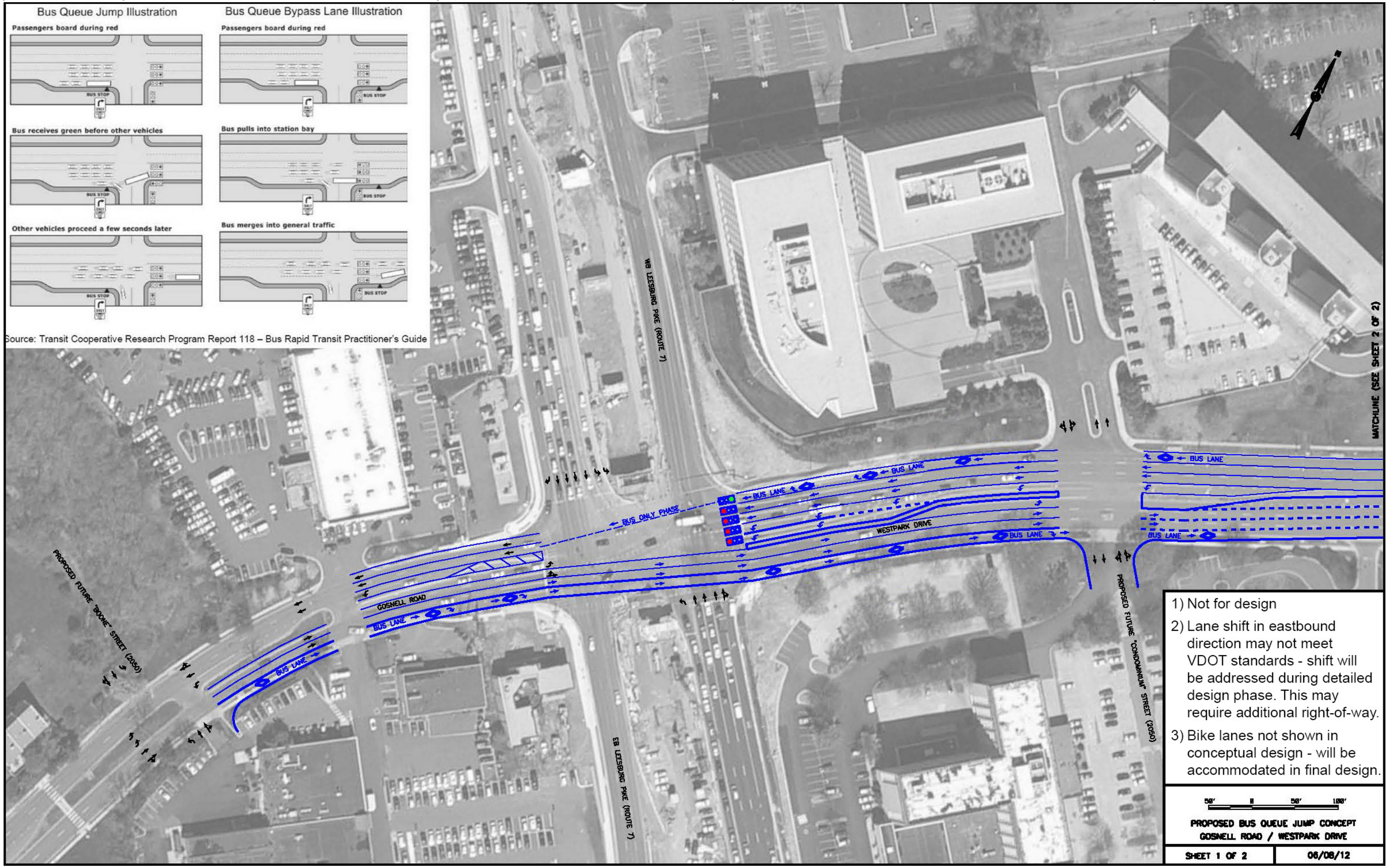


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Figure 6-2 (cont.): Proposed Queue Jumps and Exclusive Bus Lane - Gosnell Road/Westpark Drive and Route 7 intersection to Westpark Drive and International Drive intersection – Greensboro to International Section

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b. Spring Hill Road/Route 7/Tyco Road Loop – The second area of concentrated slow speeds and congestion is in the loop comprised of Spring Hill Road, Route 7, and Tyco Road. This loop would be served by the Direct East-West link in the Three Route network, which would run through the loop in a clockwise direction (Spring Hill Road, Route 7, and Tyco Road). The most likely service mode and frequency on this route will be a 60' bus running every six minutes.

While there are sections of this loop that do not display speeds under 10 mph during any time of the day, for efficient operations, the recommended transit preferential treatment would be a combination of queue jumps and bus only lanes through the entire clockwise loop and extending to the intersection of Spring Hill Road and International Drive. This configuration is shown, at a conceptual level, in Figure 6.3.

This recommendation would require additional right of way on the inside of the entire loop (north side of Spring Hill Road, east side of Route 7, south side of Tyco Road) as well as on both sides of Spring Hill Road between Tyco Road and International Drive.

Starting in the westbound direction at the intersection of International Drive and Spring Hill Road, the bus only lane would begin at the same point along Jones Branch Drive where the three right turn lanes from Jones Branch Drive to International Drive would begin. The bus lane would be located in the right turn lane located closest to the through traffic lanes. The bus lane would act as queue jump at the intersection of International Drive and Spring Hill Road and the receiving lane on the far side of the intersection would continue as a bus only lane. Continuing west on Spring Hill Road, the bus only lane would act as a queue jump at the intersection of Spring Hill Road and Tyco Road. The bus only lane would continue on Spring Hill Road to the intersection of Spring Hill Road and Route 7. The bus would turn right into a bus only lane running parallel to Route 7 and would share the right turn lane from Route 7 to Tyco Road. Once on Tyco, the bus only lane would continue back to the intersection of Tyco Road and Spring Hill Road (as shown in Figure 6.3, this would be a continuous clockwise loop). At the intersection of Tyco Road and Spring Hill Road, the bus would need to transition to Spring Hill Road to run back in the eastbound direction. A potential transit-only signal phase may be warranted for this move. This transition would be into a bus lane running eastbound which would also act as a queue jump at International Drive. A bus only phase at this intersection may also be warranted to allow the bus to transition back into general traffic lanes.

Figure 6-3: Proposed Queue Jump and Exclusive Bus Lane – Spring Hill Road, Route 7, Tyco Road Loop – Spring Hill to International

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Figure 6-3 (cont): Proposed Queue Jump and Exclusive Bus Lane – Spring Hill Road, Route 7, Tyco Road Loop – Spring Hill Road Section

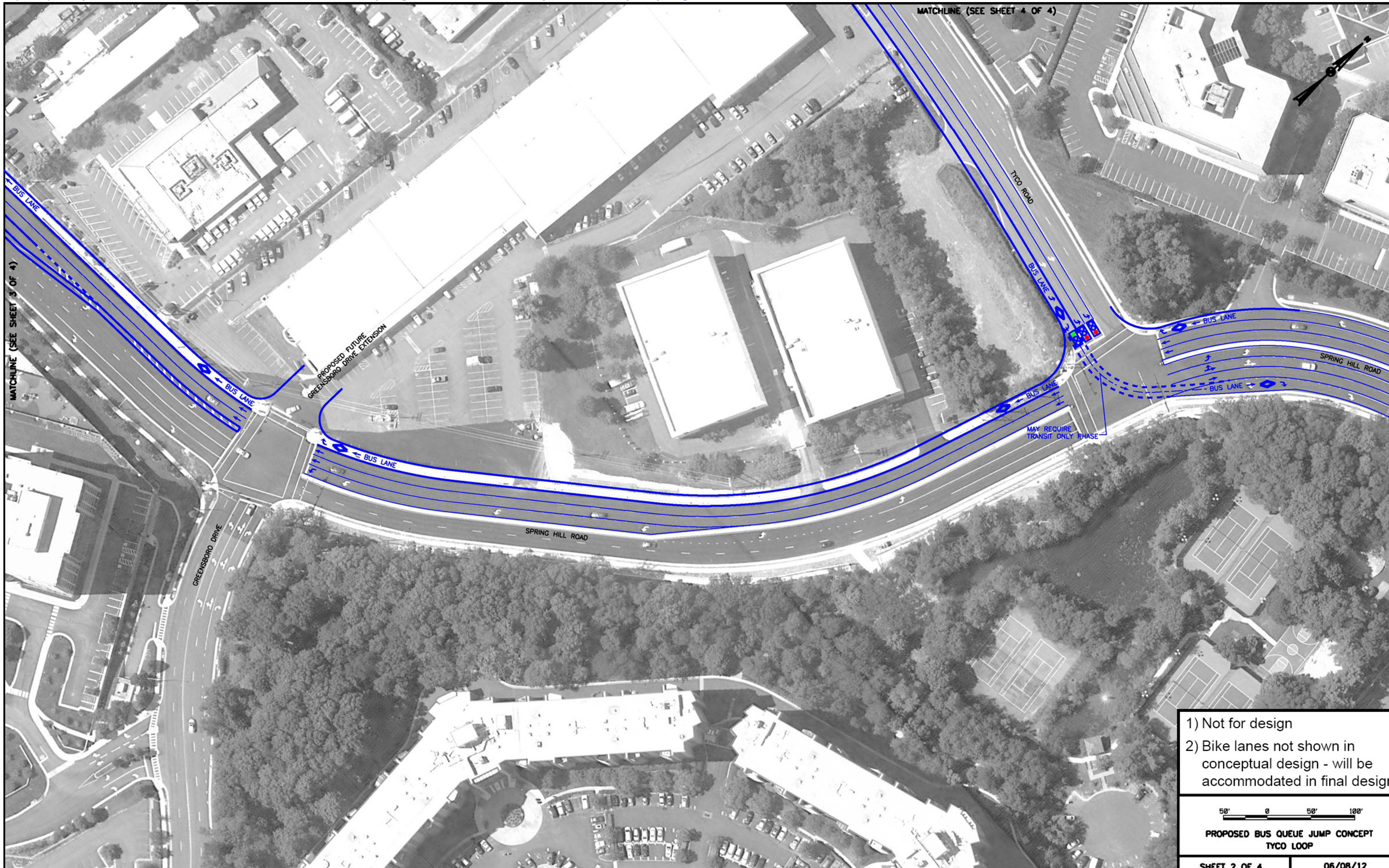

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Figure 6-3 (cont.): Proposed Queue Jump and Exclusive Bus Lane – Spring Hill Road, Route 7, Tyco Road Loop – Spring Hill Road/Route 7/Tyco Road Section

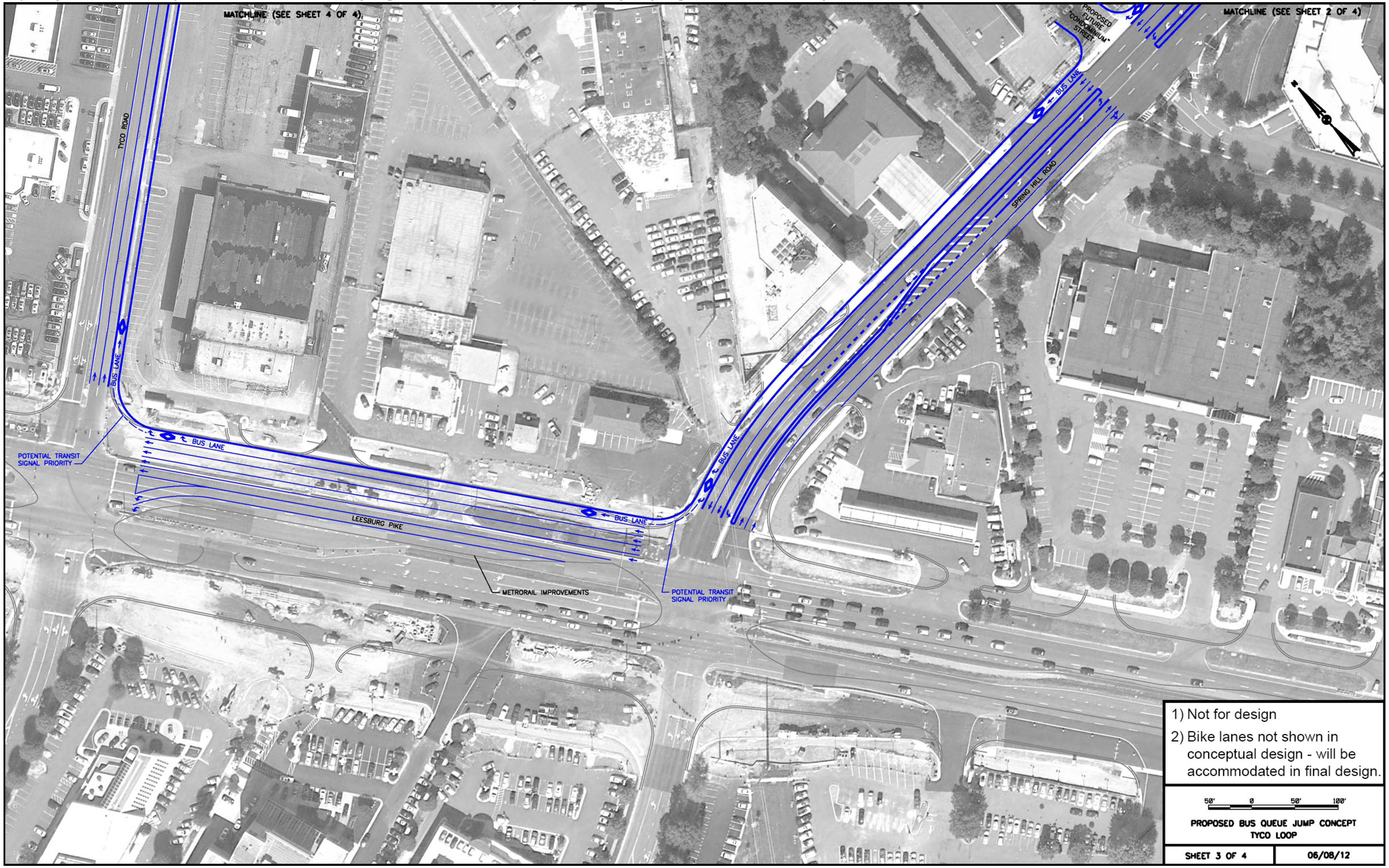

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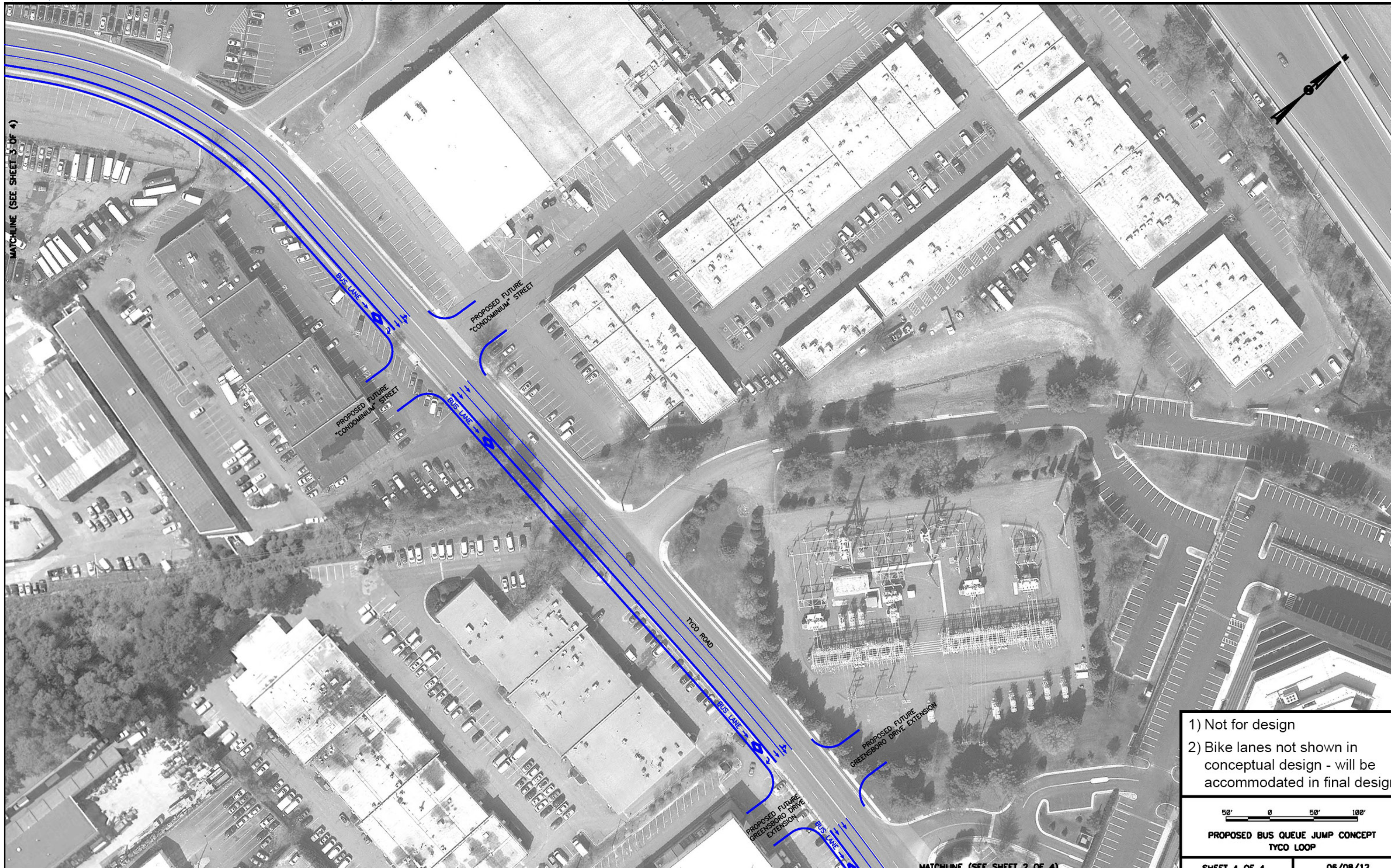
Figure 6-3 (cont.): Proposed Queue Jump and Exclusive Bus Lane – Spring Hill Road, Route 7, Tyco Road Loop – Tyco Road Section



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c. Scotts Crossing Road between Capital One Drive and Old Springhouse Road – The third area of concentrated slow speeds is on Scotts Crossing Road between Capital One Drive and Old Springhouse Road in the eastbound direction. In this instance a bus only lane on the south side of Scotts Crossing Road that would also be shared with right turning vehicles would be provided to allow buses to separate from general traffic congestion along Scotts Crossing Road. This bus only lane is shown in Figure 6.4.

While this recommendation confines the bus only lane to the roadway link between Capital One Drive and Old Springhouse Road based on future forecasted speeds, an exclusive lane of this short distance is not fully optimal and thus future conditions may warrant extending transit exclusivity up to the intersection of the Jones Branch Connector and Jones Branch Drive, on the west side of the I-495 Beltway. This exclusivity would be on both sides of the Jones Branch Connector and Scotts Crossing Road alignment between Capital One Drive and Jones Branch Drive. To ensure this contingency is addressed, the County is reserving the right-of-way for the entire distance to the east and west side of the Beltway along the Jones Branch Connector. This contingency also includes the ability to accommodate streetcar on this route if future conditions warrant. This would include exclusive right-of-way of 24' between stations to accommodate two tracks and 36' at stations to accommodate the two tracks as well as station platforms. To this end, the design of the Jones Branch Connector is incorporating a cross section wide enough to accommodate exclusivity if it is deemed appropriate in the future.

As noted, in all instances where transit exclusive lanes are proposed, a re-purposing of parking lanes will be utilized, wherever feasible. This re-purposing of existing lanes will minimize the amount of additional right-of-way that will have to be obtained from adjacent property owners.

Two additional locations within Tysons show slow speeds during at least a portion of the day, but were not proposed for queue jumps and/or transit only lanes. The first of these is in the area south of the Galleria, comprised of the loop of Tysons Boulevard, Route 123, International Drive, and Westpark Drive. More detailed conceptual design was not completed for this area because the re-zoning request for this area was approved prior to the start of this study and therefore right-of-way for preferential treatments would not be available.

The second area where slow speeds occur during some portions of the day are along Boone Boulevard between Gallows Road and Route 123. This roadway segment, however, was not recommended for queue jumps or exclusive lanes because speeds and congestion vary significantly by direction and during different times of the day. Because of these variances, there are times of the day when congestion is not an issue at all, and therefore overall it did not appear that queue jumps and transit only lanes were warranted at this location.

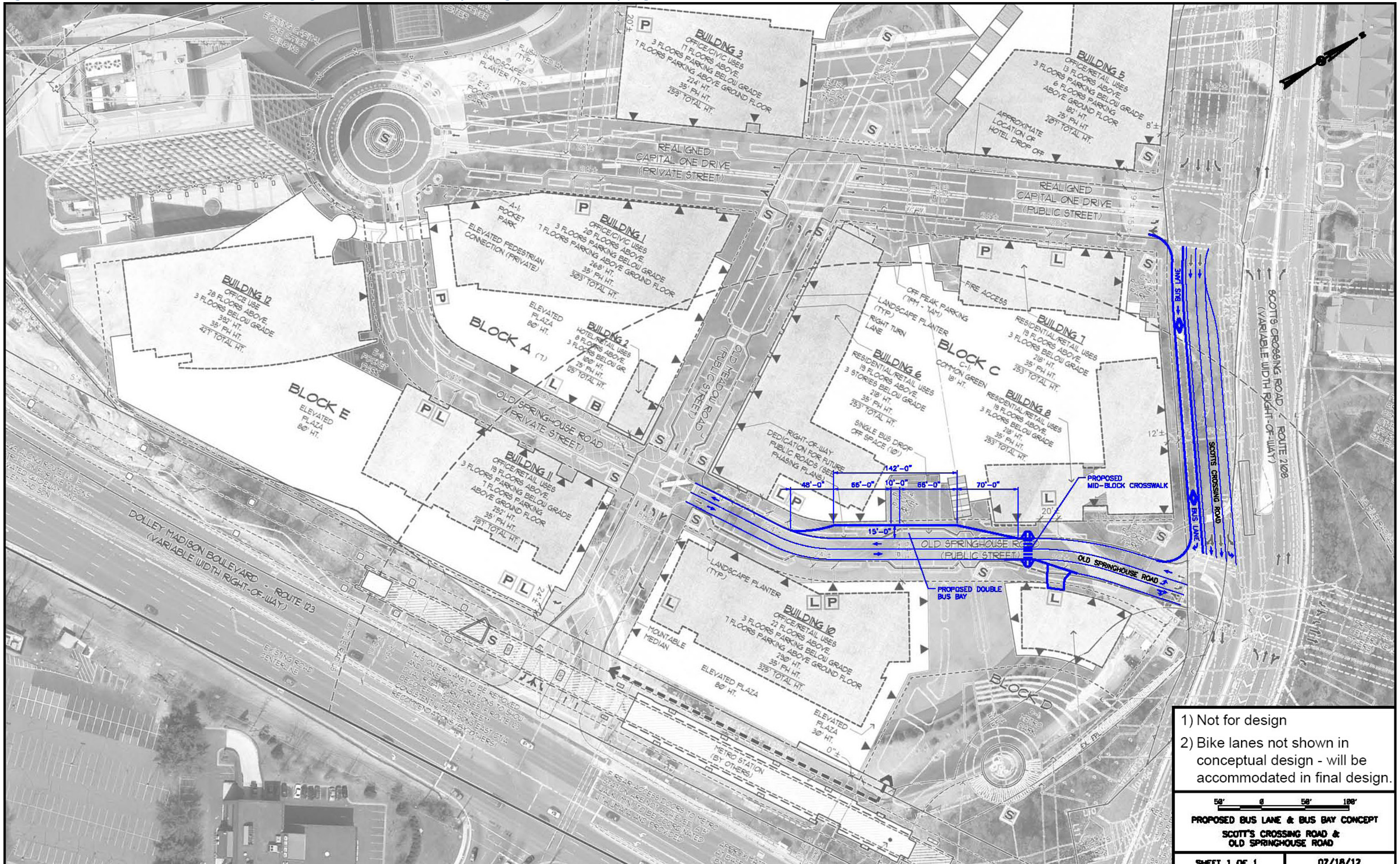
6.4.2 Bus Layover Recommendation

One additional recommendation that would require property from an adjacent property owner would be within the Capital One Campus, on Old Springhouse Road. This location would be the terminal point for the Direct East-West Link under the Three Route network. If 60’ articulated buses are utilized on the route, a bus would arrive at this location every six minutes. If 40’ buses are utilized, a bus would arrive at this location every four minutes. Old Spring House Road also shows congestion during both peak periods and in both directions. Given these bus operating and traffic conditions, two bus bays separated from through traffic are recommended along Old Spring House Road (of note is that this off-street layover facility is also necessitated by the fact that there is only one lane in each direction at this location. Layovers for other routes in the Three Route Network will occur in the street, where two lanes are available, or at Silver Line Stations).

A conceptual layout of these bays is shown in Figure 6.4, below. This recommendation would require additional right-of-way on the north side of Old Springhouse Road.

In the proposed operation of these bays, an eastbound bus ending its trip would pull into the first bay and drop off passengers. Once the bus is empty, it would then pull forward into the second bay where it would layover prior to its westbound trip (and leaving space for the next arriving bus). Passengers for the next westbound trip would then board at the second bay.

Figure 6-4: Exclusive Bus Lane on Scotts Crossing Road and Two Bus Bay Configuration on Old Spring House Road



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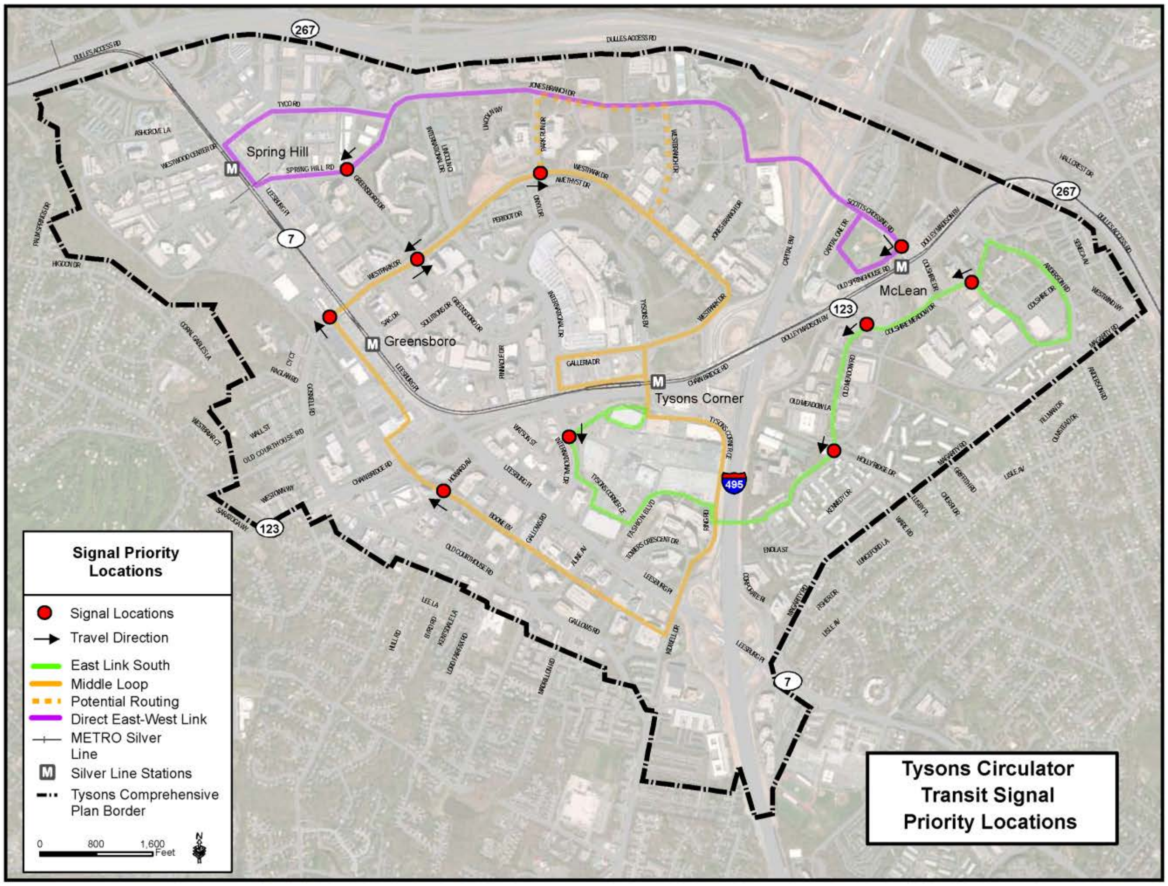
6.4.3 Transit Signal Priority Recommendations

Based on the transit signal priority warrants outlined above as well as delay data from the Consolidated Traffic Impact Analysis, intersections along each route in the Three Route Network that are potential candidates for transit signal priority have been identified. Specifically, these are intersections along the route where the approach delay is greater than 35 seconds and the delay on side streets is less than 60 seconds. These intersections are summarized below in Table 6.1 by route and the direction transit signal priority would be applied. They are also shown graphically in Figure 6.5.

Table 6-1: Transit Signal Priority Recommendations

Route	Intersection	Direction
East-West Link	Old Spring House Road and Capital One Drive	Right turn from Old Spring House Road to Capital One Drive(clockwise direction)
	Spring Hill Road and Greensboro Drive	Westbound
East Link South	Colshire Meadow Drive and Colshire Drive	Westbound/Southbound
	Colshire Meadow Drive and Old Meadow Drive	Westbound/Southbound
	Old Meadow Drive and Holly Ridge Drive	Westbound/Southbound
	Mall Ring Road and International Drive	Southbound
Middle Loop	Boone Boulevard and Howard Avenue	Westbound
	New Road Parallel to Route 7 and Gosnell Road	Right Turn onto Gosnell Road
	Westpark Drive and Greensboro Drive	Northbound and Southbound
	Westpark Drive and Park Run Drive	Eastbound

Figure 6-5: Transit Signal Priority Locations



Section 7
Ridership Estimates

Ridership Estimates

7.1 Introduction

Ridership estimates were an essential input into a number of the analyses described throughout this document, as well the final recommendations that were made based on this analysis. The purpose of this report section is to outline the ridership forecasting process and its results. Addressed in this section is:

a. A description of the forecasting model utilized in this effort.
b. The assumptions that were incorporated into the forecasting model.
c. The different ridership scenarios that were run as part of the planning process.
d. The final forecasting results.

Examples of how the ridership data was utilized for analysis purposes exist throughout the document, especially in the Mode Option Analysis and Network Evaluation sections.

Outlined first below is a description of the model utilized for the forecasting process.

7.2 Forecasting Model Description

To complete the project ridership forecasting, the study technical team utilized a variant of the Metropolitan Washington Council of Government's (MWCOG) regional transportation forecasting model called the WMATA post-processor model. The WMATA post-processor model variant was developed with a specific focus on evaluating potential **transit** investments in the region. The advantage of the post-processor variant of the MWCOG model is that it more accurately reflects the factors that influence the choice of transit as a mode when making a trip (this revised mode choice model has been approved by the Federal Transit Administration). This new mode choice model utilizes a measure of street network density to quantify the pedestrian friendliness of a particular area. This variable is used directly in the post-processor mode choice model as an explanatory variable to estimate overall transit utilization. It was felt that use of the post-processor model variant would most accurately reflect the anticipated changes in Tysons associated with more dense development as well a denser street network and a more pedestrian friendly environment. This approach is in contrast to the native current MWCOG model mode choice model, which uses a series of geographic mode-specific constants to predict transit utilization.

7.3 Model Assumptions

This section outlines the key underlying assumptions coded into the forecasting model that remained consistent for all network alternatives and all ridership scenarios (the ridership scenarios are described in greater detail in sub-section 7.4 below). These assumptions relate to the Tysons Transportation Analysis Zone Structure, the 2050 population and employment assumptions and the baseline 2050 transportation network (each of these areas is described in greater detail below).

7.3.1 Transportation Analysis Zone Structure

The MWCOG model is based on a regional zone system consisting of 2,191 zones with a total of 8 zones within Tysons. The 2050 population and employment data (GMU 2050 High Forecast – completed in 2008) that was provided to the study team by Fairfax County was based on 29 zones that were also further disaggregated into 89 subzones for land use analysis. The study forecasting effort utilized the Fairfax County 29 zone structure. Additional model changes to support the zone splits included the addition of roadway network detail that was compatible with the refined zone system and an updating of the transit line files for consistency with the updated roadway network.

7.3.2 Population and Employment Forecasts – 2030 and 2050

The forecasting process utilized 2030 and 2050 population and employment forecasts that reflected the GMU 2050- High Forecast completed in 2008 and which were provided to the project team by Fairfax County. These forecasts, in turn, were originally developed for use in the development of the Tysons Corner Comprehensive Plan.

7.3.3 Transportation Network

The 2050 baseline transportation network that underlies the model includes the following elements:

a. The Metrorail Silver Line running between Stadium-Armory in Washington DC and the Route 772 Station in Loudoun County, with the following four stations within Tysons:

   1. McLean
   2. Tysons Corner
   3. Greensboro
   4. Spring Hill

b. HOT Lanes on the Capital Beltway, including associated transit improvements.

c. The extension of the Orange Line from Vienna to Centreville, with an additional three stations – Fair Oaks Mall, Stringfellow Road, and Route 28.

d. A new high capacity urban rail corridor running between Bethesda and Centreville via Tysons. The line would follow I-495 to Tysons, and would stop at all four Tysons stations. The line would then follow Route 123 to the extended Orange Line at the Fair Oaks Mall. In addition to the stops within Tysons, stops would include River Road and Clara Barton Parkway in Maryland, Georgetown Pike in Virginia before Tysons Corner and Oakton (Hunter Mill Road) prior to entering the Orange Line. Parking at the three stations other than Clara Barton were assumed to have 500 parking spaces.

e. The full proposed 2050 street network within Tysons.

This network represents the "No-Build" alternative with no Circulator in the network. The Build Alternatives (Three-Route Network and Four-Route Network) include this transportation network as well as the respective Circulator networks incorporated into the overall transportation network.

7.4 Ridership Scenarios

Three ridership forecast scenarios were developed for study analysis purposes. Each scenario, in turn, reflected assumptions about the key factors that drive transit ridership. The three scenarios for which forecasts were completed ranged from a scenario that incorporated a conservative set of assumptions regarding the "ridership drivers" to a scenario with an aggressive set of assumptions. The intent in utilizing these three scenarios was to provide an understanding of ridership over a range of potential operating and fare combinations in order to support analysis and decision making.

The factors impacting ridership include:

a. Transit service frequency
b. Transit fares
c. Level of transit exclusivity
d. Parking fees in Tysons
e. Transit mode

Table 7.1 contains a summary of the assumptions utilized in each scenario, with scenario #1 being the most conservative and scenario #3 being the most aggressive.

Table 7-1: Ridership Scenario Assumptions

Ridership Factors	Scenario #1	Scenario #2	Scenario #3
Service Frequency	10 minutes, peak, 15 minutes off-peak	6 minutes peak, 10 minutes off-peak	4 minutes peak, 6 minutes off-peak
Fare	$1.25	$1.00	Free
Transit Exclusivity	Mixed Traffic	Dedicated lanes with ½ mile of Metrorail stations	50% Dedicated Lanes
Tysons Parking Fees	Current Tysons Parking Fees	Parking Fees in the Arlington Orange Line Corridor as currently incorporated in the regional forecasting model.	Parking Fees in the Arlington Orange Line Corridor as currently incorporated in the regional forecasting model.
Mode	Bus	Bus	Streetcar

The ridership forecasting results are outlined below in Section 7.5.

7.5 Ridership Forecasting Results

The daily weekday ridership forecasting results, by scenario, are outlined below in Table 7.2.

Table 7-2: Daily Weekday Ridership by Route Network and Ridership Scenario

Route	Peak Period Ridership	Off-Peak Ridership	Total Ridership	Riders Transferring from Metrorail	Riders Starting trip on Circulator or Transferring from Non-Metrorail Mode
RIDERSHIP SCENARIO #1					
Ridership Scenario #1 – Three Route Network					
Middle Loop	835	562	1,397		
Direct East-West Link	2,320	1,450	3,770		
East Link South	301	229	530		
Total	3,456	2,241	5,697	1,636	4,061
Ridership Scenario #1 – Four Route Network					
Central Link	330	606	936		
East Link	998	29	1,027		
East Link South	306	232	538		
West Loop	435	345	780		
Total	2,069	1,212	3,281	1,348	1,933
RIDERSHIP SCENARIO #2					
Ridership Scenario #2 – Three Route Network					
Middle Loop	3,632	2,662	6,294		
Direct East-West Link	4,175	3,566	7,731		
East Link South	2,200	1,350	3,550		
Total	10,007	7,568	17,575	6,195	11,380
Ridership Scenario #2 – Four Route Network					
Central Link	1,364	2,182	3,546		
East Link	3,730	2,178	5,908		
East Link South	3,090	1,423	4,513		
West Loop	1,255	1,241	2,496		
Total	9,439	7,024	16,463	7,355	9,108
RIDERSHIP SCENARIO #3					
Ridership Scenario #3 – Three Route Network					
Middle Loop	5,283	6,145	11,428		
Direct East-West Link	6,865	5,042	11,907		
East Link South	4,292	4,119	8,411		
Total	16,440	15,306	31,746	12,323	19,423
Ridership Scenario #3 – Four Route Network					
Central Link	2,481	3,483	5,964		
East Link	5,516	5,128	10,644		
East Link South	5,604	5,491	11,095		
West Loop	2,721	2,886	5,607		
Total	16,322	16,988	33,310	14,362	18,948

Of interest in Table 7.2 are the large increases in ridership across the different ridership scenarios. This shows the impacts of changing the assumptions regarding the ridership drivers such as fare and service frequency. Also of interest is the fact that there are more Circulator trips that have no connection to Metrorail than trips which involves a transfer to or from Metrorail, under all three ridership scenarios and for both route networks.

7.6 Changes in Transit Mode Share

One of the primary goals of the Circulator system is to shift people out of their automobiles and into transit, with the Circulator being a key link in a rider's overall trip. Outlined below in Table 7.3 is data on the change in transit mode share with the Circulator as part of the transportation network versus a network with the Silver Line but no circulator. The data in Table 7.3 is presented for home-based work trips for both networks and for all three ridership scenarios. The data is further stratified by trips that start in Tysons and trips that end in Tysons.

Table 7-3: Change in Transit Mode Share Due to Circulator

Network	2050 Mode Share – Without Circulator	2050 Mode Share with Circulator	Change in Transit Mode Share	Change in Actual Number of Transit Trips
TRIPS BEGINNING IN TYSONS				
Ridership Scenario #1 – Trips Beginning in Tysons				
Three Route Network	40.4%	41.9%	1.5%	918
Four Route Network	40.4%	41.4%	1.0%	593
Ridership Scenario #2 – Trips Beginning in Tysons				
Three Route Network	40.4%	43.7%	3.4%	2,006
Four Route Network	40.4%	43.2%	2.9%	1,725
Ridership Scenario #3 – Trips Beginning in Tysons				
Three Route Network	40.4%	45.2%	4.8%	2,934
Four Route Network	40.4%	44.9%	4.5%	2,751
TRIPS TERMINATING IN TYSONS CORNER				
Ridership Scenario #1 – Trips Terminating in Tysons				
Three Route Network	26.2%	26.6%	.4%	797
Four Route Network	26.2%	26.4%	.2%	455
Ridership Scenario #2 – Trips Terminating in Tysons				
Three Route Network	26.2%	27.5%	1.3%	2,969
Four Route Network	26.2%	2.7.5%	1.3%	2,902
Ridership Scenario #3 – Trips Terminating in Tysons				
Three Route Network	26.2%	28.3%	2.1%	4,704
Four Route Network	26.2%	28.2%	2.0%	4,612

The data in Table 7.3 show that the highest percentage transit mode share changes occur for trips beginning in Tysons, and the highest percentage mode share changes occur under ridership scenario #3, the most aggressive in terms of the assumptions about the factors that drive ridership. Further, the Three Route network results in a higher percentage transit mode share shift in nearly all instances (the only instance where this not the case is where the changes are the same).

Section 8
Capital and Operating Cost Estimates

Capital and Operating Cost Estimates

8.1 Introduction

Operations and maintenance and capital costs were important inputs into two of the key evaluations completed as part of the Circulator planning process; 1) the detailed evaluation of the two networks selected for more detailed analysis (report Section 4) and; 2) the analysis and selection of the most appropriate mode by route (report Section 5). The purpose of this report section is to describe the process followed to estimate both operations and maintenance and capital costs for two different surface modes, bus and streetcar, and a Driverless People Mover mode. Because costs were important inputs into the evaluation of networks and modes, the costs presented here are for the two networks that were evaluated in greater detail, and are also presented for all three modes evaluated. Specific recommendations for network and mode are presented in earlier sections of the document.

Further, in order to support evaluation needs, operations and maintenance costs were calculated and reported in two different forms: on an annual basis and also in combination with annualized capital costs to develop life cycle costs over a 30 year time period. Capital costs were calculated as total capital costs and on an annualized basis.

A description of the step-by-step process used in the calculation of costs for the surface modes is outlined below. The calculation process for the Driverless People Mover mode follows the surface mode description.

NOTE: ALL OPERATIONS AND MAINTENANCE AND CAPITAL COSTS PRESENTED IN THIS SECTION ARE IN 2012 DOLLARS

8.2 Calculation Process - Operations and Maintenance Costs – Surface Modes (Bus and Streetcar)

Surface mode operations and maintenance costs were calculated based on a standard method utilized by transit agencies when estimating the operations and maintenance costs of a new service or when modifying existing service. The approach is based on the change in revenue hours resulting from the new service and the per hour cost of each of these additional revenue hours. The step-by-step process for calculating revenue hours is outlined below. Operations and maintenance costs were calculated for both the bus mode and the streetcar mode. The actual detailed calculations are contained in Appendix D and summarized below in Table 8.2.

Step 1 – Calculate Number of Buses Required for Service- By Time Period - The first step in calculating revenue hours is identifying the number of vehicles (bus or streetcar) that will be required to provide revenue service during different periods of the day. The calculation of the number of revenue vehicles, in turn, is based on two inputs: service frequency and trip travel time. Costs were calculated for three different service frequency scenarios (these service frequency scenarios correspond to the three service frequency scenarios that were utilized as part of the ridership forecasting effort, described in greater detail in report section 7). The three service frequency scenarios for which costs were calculated include:

a. Weekday - 10 minute peak period service frequency and a 15 minute off-peak service frequency.

   Saturday and Sunday – 15 minute service frequency all day.

b. Weekday - 6 minute peak period service frequency and a 10 minute off-peak service frequency.

   Saturday and Sunday – 15 minute service frequency all day.

c. Weekday - 4 minute peak period service frequency and a 6 minute off-peak service frequency.

   Saturday and Sunday – 15 minute service frequency all day.

Overall trip times are based on two components. The first component is actual vehicle run times while a vehicle is in service picking up passengers. These run times are based on an estimated travel speed and the two way route distance. The second component of overall trip time is recovery time at the end of each one-way trip. This recovery time allows a driver to get back on schedule if he is running late and is calculated as 10% of actual run time. Actual two-way run time in conjunction with recovery time at the end of the trip is called round trip cycle time.

The number of vehicles required for a service at a given frequency is calculated by dividing the round trip cycle time for a route by the service frequency. Since service frequencies will vary by time of day, the number of vehicles in service will also vary by time of day.

Step 2 – Calculate Revenue Hours by Time Period – The first step in this calculation is to break down the service day into different time periods, based on differing service frequencies during the day. The breakdown of the service day into time periods is shown in Table 8.1 below.

Table 8-1: Weekday Time Period Breakdown

Hours of Service Breakdown		
	Peak	Off-Peak
5 AM - 6 AM		1
6 AM - 9 AM	3	
9 AM - 3 PM		6
3 PM - 7 PM	4	
7 PM - 12 AM		5
Total	7	12

As an example of how this time period data relates to the service frequency data discussed above, under the first service frequency scenario, there would be seven hours of service when vehicles run every 10 minutes (peak period service frequency) and 12 hours when vehicles run every 15 minutes (off-peak service frequency).

Actual revenue hours are calculated by multiplying the number of vehicles in service during each time period by the length of that time period (see Appendix D for more detail). Total daily revenue hours are calculated by adding the revenue hours from each time period together.

Step 3 – Calculate Daily Operations and Maintenance Costs – The final step in calculating daily operations and maintenance costs is simply to multiply the number of daily revenue hours by the cost per revenue hour. For buses, the cost per revenue hour utilized in this calculation is the cost per revenue hour paid by Fairfax County to its contract operator for the Fairfax County Connector system. For streetcar, the cost per revenue hour is the same as that used in the calculation of operations and maintenance costs for the Columbia Streetcar project in Arlington.

Step 4 – Annualize Daily Operations and Maintenance Costs – In this final step, the daily operations and maintenance costs are annualized to arrive at an annual cost estimate. Annualizing factors utilized in this estimate were: 250 days of weekday service, 57 days of Saturday service, and 58 days of Sunday service.

All calculations are shown in Appendix D. A summary of bus and streetcar operations and maintenance costs is included in Table 8.2 below.

Table 8-2: Annual Operations and Maintenance Cost Estimate by Service Frequency Scenario

Service Frequency Scenario	Annual Weekday O&M Costs	Annual Saturday O&M Costs	Annual Sunday O&M Costs	Total Annual O&M Costs
BUS OPERATIONS AND MAINTENANCE COSTS				
Three Route Network				
10 minutes peak, 15 minutes off-peak	$4,950,000	$852,700	$756,600	$6,559,300
6 minutes peak, 10 minutes off-peak	$7,810,000	$1,279,100	$1,148,400	$10,237,500
4 minutes peak, 6 minutes off-peak	$12,375,000	$2,131,800	$1,914,000	$16,420,800
Four Route Network				
10 minutes peak, 15 minutes off-peak	$6,517,500	$1,172,500	$1,052,700	$8,742,700
6 minutes peak, 10 minutes off-peak	$9,570,000	$1,598,900	$1,410,800	$12,579,600
4 minutes peak, 6 minutes off-peak	$14,850,000	$2,558,200	$2,296,800	$19,705,000
STREETCAR OPERATIONS AND MAINTENANCE COSTS				
Three Route Network				
10 minutes peak, 15 minutes off-peak	$12,960,000	$2,232,600	$2,004,500	$17,197,100
6 minutes peak, 10 minutes off-peak	$20,448,000	$3,348,900	$3,006,700	$26,803,600
4 minutes peak, 6 minutes off-peak	$32,400,000	$5,581,400	$5,011,200	$42,992,600
Four Route Network				
10 minutes peak, 15 minutes off-peak	$17,064,000	$3,069,800	$2,756,200	$22,890,000
6 minutes peak, 10 minutes off-peak	$25,056,000	$4,186,100	$3,758,400	$33,000,500
4 minutes peak, 6 minutes off-peak	$38,880,000	$6,697,700	$6,013,400	$51,591,200

8.3 Calculation Process – Total Capital Cost – Surface Modes

There are three drivers of capital costs for the surface modes evaluated as part of the study. The first is the number of vehicles required to provide service, the second is the length of the alignment and the third is the size of the required maintenance facility.

The number of vehicles required for service reflects the vehicle peak pull-out, or the number of vehicles required when service frequencies are highest during the day. This vehicle requirement was calculated as part of the O&M cost estimates, and is shown in Appendix D under the "peak buses in service" column. In addition to the vehicles actually required to meet service, there is a requirement for spare vehicles. These additional spare vehicles ensure that enough vehicles are available for service while vehicles are pulled for different types of required maintenance. The standard industry spare ratio is an additional 15% of the peak pull-out.

The calculation of total required vehicles is shown in Appendix E.

The second capital cost driver is the length of the alignment. Utilizing general cost per mile factors from research completed for the Columbia Pike Transit Initiative project, the assumed guideway cost per mile for bus is $10 million per mile and $50 million per mile for streetcar. This is based on an average of multiple bus and streetcar projects with a varying range of characteristics in terms of exclusivity. The detailed total guideway distance and cost is included in Appendix E. The costs are summarized in Table 8.4 below.

The final capital cost driver is the size of the maintenance facility, and the mode for which the facility is designed. This capital cost estimate assumes that a new maintenance facility would be required regardless of the mode selected. Key inputs into the estimates of maintenance facility cost include the number of vehicles that would be handled at the facility as well as an estimated cost per vehicle. It is important to note that these factors are planning level inputs to allow for the evaluation of alternatives, and are based on cost inputs from other comparable projects. These are not meant to provide estimates detailed enough to make funding decisions. This work would require more detailed conceptual design based on final facility size and site characteristics.

The inputs utilized for this analysis assumed a cost-per-bus figure based on work completed on the new WMATA Cinder Bed Bus Maintenance and Storage facility. The cost-per-streetcar figure was based on capital cost estimates completed for the Columbia Pike Transit Initiative. Total capital costs are outlined below in Table 8.3 by surface mode, service frequency scenario and network.

Table 8-3: Total Capital Cost – By Route Network, Service Frequency Scenario and Mode

Service Frequency Scenario	Total Capital Cost
THREE ROUTE NETWORK	
Three Route Network – 40' Bus	
40' Bus – 10 minute peak headway	$101,819,500
40' Bus – 6 minute peak headway	$109,729,200
40' Bus – 4 minute peak headway	$118,627,700
Three Route Network – 60' Bus	
60' Bus – 10 minute peak headway	$104,939,500
60' Bus – 6 minute peak headway	$114,409,200
60' Bus – 4 minute peak headway	$125,062,700
Three Route Network – Streetcar	
Streetcar – 10 minute peak headway	$521,728,000
Streetcar – 6 minute peak headway	$567,592,000
Streetcar – 4 minute peak headway	$619,189,000
FOUR ROUTE NETWORK	
Four Route Network – 40' Bus	
40' Bus – 10 minute peak headway	$121,285,600
40' Bus – 6 minute peak headway	$132,161,500
40' Bus – 4 minute peak headway	$140,071,200
Four Route Network – 60' Bus	
60' Bus – 10 minute peak headway	$125,210,600
60' Bus – 6 minute peak headway	$138,011,500
60' Bus – 4 minute peak headway	$147,481,200
Four Route Network – Streetcar	
Streetcar – 10 minute peak headway	$621,427,000
Streetcar – 6 minute peak headway	$679,078,000
Streetcar – 4 minute peak headway	$730,354,000

8.4 Calculation Process – Life Cycle Cost – Surface Modes

Life cycle costs provide an opportunity to combine operating and maintenance and annualized capital costs into a single life cycle cost that allows a consistent comparison across alternatives. This approach also allows a more accurate comparison of an alternative that may have high capital costs but low operating costs to other alternatives that may have a different capital cost/operating cost ratio. Finally, life cycle costs allow for an accounting of the life of a capital asset. For instance, a bus must be replaced every 12 years while a streetcar has a 30 year life. While the lower upfront capital costs of a bus will result in lower total initial capital costs, life cycle costing will allow for a more accurate accounting of a streetcar's longer life. To calculate life cycle costs, annual operating costs and annualized capital costs, based on the useful life of each capital asset, are combined. A total life cycle over a certain time frame, in this case 30 years, is calculated and an annual cost of total life cycle costs can also be calculated. The detailed estimates are included in Appendix F and a summary is included in Table 8.4 below.

Table 8-4: Surface Mode Life Cycle Costs by Service Frequency Scenario

Service Frequency Scenario	40' Bus		60' Bus		Streetcar	
	Annual Cost – 30 Year Cycle	Total 30 Year Cost	Annual Cost – 30 Year Cycle	Total 30 Year Cost	Annual Cost – 30 Year Cycle	Total 30 Year Cost
3 Route Network						
10 Minutes	$9,218,200	$276,547,400	$9,478,200	$284,347,400	$28,460,700	$853,822,100
6 Minutes	$13,365,900	$400,976,100	$13,755,900	$412,676,100	$39,399,100	$1,181,973,100
4 Minutes	$20,077,300	$602,320,100	$20,613,600	$618,407,600	$57,086,500	$1,712,594,400
4 Route Network						
10 Minutes	$11,907,700	$357,229,900	$12,234,700	$367,042,400	$36,303,100	$1,1089,092,200
6 Minutes	$16,390,100	$491,702,600	$16,877,600	$506,327,600	$48,064,500	$1,441,934,400
4 Minutes	$23,984,900	$719,547,300	$24,602,400	$738,072,300	$68,167,400	$2,045,022,200

8.5 Calculation Process – Driverless People Mover System – Capital Costs, Operations and Maintenance Costs and Life Cycle Costs

Capital costs for a Driverless People Mover system were estimated utilizing general capital cost per mile data provided by Ultra Global Limited, the manufacturer and operator of the People Mover System at Heathrow Airport (this system represents the prototypical Driverless People Mover system utilized for analysis in this study). This overall cost per mile figure includes guideway, vehicles, and the maintenance facility but does not include right-of-way costs, which can vary significantly depending on the environment in which the system is being implemented. Based on discussions with representatives from Ultra Global Limited, they indicated that the cost per mile will increase with the number of vehicles in service (this reflects a larger required vehicle fleet and a larger maintenance facility). Based on data provided by Ultra Limited, a cost per mile figure of $18 million per mile, minus right-of-way costs, was utilized in calculating capital cost estimates. This cost per mile reflects fairly heavy vehicle trips (see Section 5, Mode Option Analysis) and thus a large vehicle fleet. This cost per mile would increase if more vehicles are required for service or if larger vehicles are utilized.

The calculation of capital costs, by route and route network, is shown in Table 8.5.

Table 8-5: Estimated Capital Costs – Driverless People Mover System

Route	Route Distance	Cost Per Route Mile	Total Capital Cost
Three Route Network			
Middle Loop	4.17	$18,000,000	$75,060,000
Direct E-W Link	2.21	$18,000,000	$39,780,000
East Link South	2.22	$18,000,000	$39,960,000
Total Capital Costs			**$154,800,000**
Four Route Network			
Central Link	2.37	$18,000,000	$42,660,000
East Link South	2.22	$18,000,000	$39,960,000
West Loop	3.48	$18,000,000	$62,640,000
East Link	2.18	$18,000,000	$39,240,000
Total Capital Costs			**$184,500,000**

Operations and maintenance costs were based on an estimated number of people mover trips required to meet ridership demand, the average length of a trip, and the cost per revenue mile of service. The detailed calculations for each route network and ridership scenario is shown in Appendix G.

The number of required People Mover trips by route was calculated by dividing estimated total daily ridership by the capacity of the Heathrow People Mover System vehicles (this approach assumes every trip leaves fully loaded). The average length of each trip, by route, was assumed to be 33% of the length of the route the trip is operating on. This assumption reflects an assumed relatively short trip. Total daily revenue miles were calculated simply by multiplying the average trip length by the number of trips made. To calculate operations and maintenance costs, total revenue miles were multiplied by a cost per revenue mile.

Cost per revenue mile data for a system comparable to the Heathrow system was difficult to find and therefore cost per revenue mile was derived from the National Transit Database for Driverless People Mover systems in the United States. Cost per revenue mile for the Detroit and Miami systems was collected. The average cost per revenue mile for those two systems was $22.33. Because these systems run larger vehicles than the Heathrow system and thus have a heavier guideway to maintain and a more intensive vehicle maintenance requirement, an assumed cost per revenue mile for the Tysons system was half the average of the Detroit and Miami systems, or $11.00 per revenue mile.

A summary of the Operations and Maintenance costs by route network, route and ridership scenario is outlined below in Table 8.6. As noted, the detailed calculations are provided in Appendix F.

Table 8-6: Driverless People Mover Operations and Maintenance Cost Estimates

Route	Annual O&M Cost
Ridership Scenario #1	
3 Route Network	
Middle Loop	$777,100
Direct E-W	$1,111,500
East Link South	$157,000
Total	**$2,045,600**
Four Route Network	
Central Link	$296,200
East Link South	$159,300
West Loop	$362,100
East Link	$298,700
Total	**$1,116,300**
Ridership Scenario #2	
3 Route Network	
Middle Loop	$3,501,300
Direct E-W	$2,279,300
East Link South	$1,051,300
Total	**$6,831,900**
Four Route Network	
Central Link	$1,121,100
East Link South	$1,336,500
West Loop	$1,158,700
East Link	$1,718,100
Total	**$5,334,400**
Ridership Scenario #3	
3 Route Network	
Middle Loop	$6,357,300
Direct E-W	$3,510,400
East Link South	$2,490,900
Total	**$12,358,600**
Four Route Network	
Central Link	$1,885,600
East Link South	$3,285,800
West Loop	$2,603,000
East Link	$3,095,500
Total	**$10,869,900**

Life cycle costs for the Driverless People Mover system are summarized below in Table 8.7. Detailed calculations are shown in Appendix F.

Table 8-7: Driverless People Mover System – Life Cycle Costs

Network	Total 30 Year Cycle Costs	Annual Cost over 30 Year Cycle
Ridership Scenario #1		
Three Route Network	$194,052,700	$6,468,400
Four Route Network	$193,043,400	$6,434,800
Ridership Scenario #2		
Three Route Network	$324,141,900	$10,804,700
Four Route Network	$318,179,400	$10,606,000
Ridership Scenario #3		
Three Route Network	$503,444,600	$16,781,500
Four Route Network	$484,239,400	$16,141,300

Section 9
Guidelines for Interim Circulator Alignments

Guidelines for Interim Circulator Alignments

9.1 Introduction

Because the planning for the Circulator is long range, an important element of the study was to develop interim guidelines for a Circulator system that could be implemented prior to the 2050 planning horizon that was used in this study planning process. In addition, because there is the possibility that on some routes there would be a mode transition between bus and streetcar, a second important element of the study was to develop an understanding of the factors that should be considered as this potential change in modes occurs. These two areas are the subject of this report section, and will provide support to future Fairfax County staff that are tasked with implementing interim Circulator alignments.

9.2 Interim Circulator Alignment Guidelines

With the implementation of Tysons Link bus routes in conjunction with the opening of the four Silver Line stations in Tysons in 2013, Fairfax County begins a process of building toward its future Circulator system (these Link Routes are shown in Figure 9.1. Also shown in Figure 9.2 are the existing bus routes in and adjacent to Tysons). Over the coming decades, it is envisioned that Tysons will become more urbanized and more walkable, with a grid street network and higher-density mixed-use development. The purpose of this section of the report is to provide guidelines to the County so that steps toward the future Circulator can be coordinated with changes in land use and development as they occur. A summary of the proposed guidelines is outlined later in this subsection.

There are three potential triggers that could warrant changes in the Tysons Link bus system as it is transformed to the future Circulator:

a. Changes in the roadway network that offer new connections and street mileage.

b. Changes in land use that increase the density and mix of destinations along a corridor as well as improving the pedestrian environment.

c. Degradation of service on the existing Link routes due to traffic congestion and/or excess demand.

The first two triggers are both necessary for a transition to future Circulator service to be successful. Obviously, the Circulator cannot operate on the planned alignment until all of the necessary roadway segments and bridges are in place. But it is also the case that it should not be operated until development has occurred to a sufficient extent to support the desired level of service. The Circulator needs to operate at a high frequency to attract riders who have the option to drive, as they will be very sensitive to waiting time and reliability. However, if there is not enough density along the Circulator corridors, it will be an unproductive service and could potentially lose support.

The short-term Tysons Link routes are designed to serve present land uses and development patterns. The transition from these routes to the Circulator, whether in stages or more precipitously, will depend

Figure 9-1: Proposed Tysons Link Routes – After Opening of Silver Line

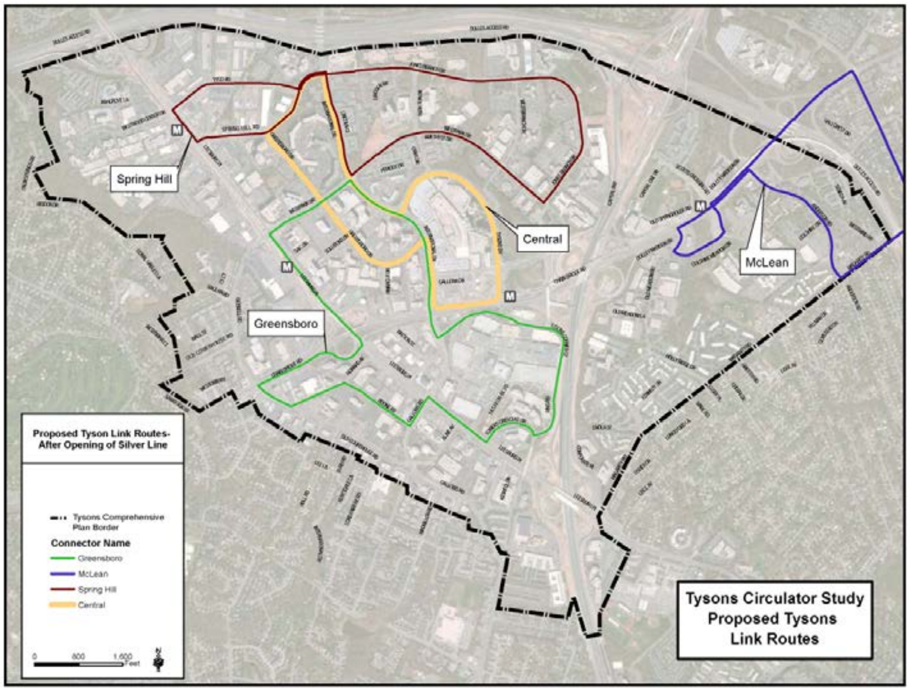
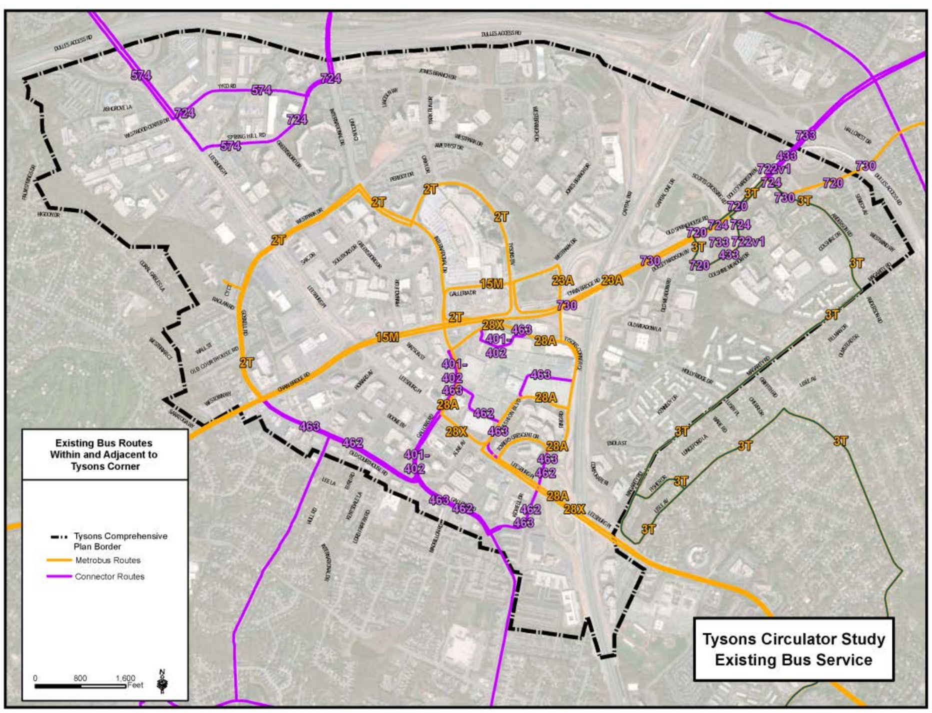


Figure 9-2: Existing Bus Routes within and Adjacent to Tysons



on the pace of redevelopment of parcels along the Circulator alignment and the construction of supporting infrastructure.

Among many potential land uses, there are three broad categories that are most relevant to the implementation of Circulator service and which have implications for the span of service and frequency of service on the Circulator routes.

a. Residential development – Housing development along the Circulator will generate two types of travel demand: access/egress trips to the Silver Line to reach other destinations within the Washington metropolitan area; and internal trips within Tysons to reach employment, shopping, and recreational destinations.

b. Office development – Commercial space devoted to offices will also generate two types of travel demand: access/egress trips to the Silver Line so that commuters from around the metropolitan area can reach their jobs in Tysons; and internal trips within Tysons to commute to home locations in the area and for lunchtime and evening trips for shopping and entertainment purposes.

c. Regional and local attractors – Shopping and entertainment destinations within Tysons will attract people from around the region, as well as from local residences within the Tysons area. Depending on their proximity to the Silver Line stations, these attractors could generate demand for intra-Tysons trips from local residents, or both intra-Tysons trips and access/egress trips from residents of other parts of the metro area.

To the extent that the Circulator corridors have a mix of all three types of development, demand will exist at all times of day and on weekends. If a corridor is dominated by office development, demand is likely to be highly peaked during traditional commuting periods and substantially lower in the evening and on weekends. A predominantly residential corridor will have demand during commuting periods, as well as during midday, evening and weekend periods, though with a lower peak than would be seen with office development.

When new developments are proposed in the Tysons area that will have a significant impact on the density (residential, employment, or attractor) of a transit route corridor (either one served by a Link route or by a planned Circulator route), increasing the corridor density by 10% or more, the County should evaluate if the transit service should be changed in response. Potential changes could include an increase in the level of service on the existing route, an alteration of the alignment to serve the new development, or the transition from a Link alignment to a planned Circulator alignment, including potential roadway preferential treatments. Of course, as mentioned earlier, a transition to the Circulator alignment will require that the necessary road segment is in place.

The third trigger mentioned above is a degradation of service along the Tysons Link routes. Like the future Circulator, the Tysons Link routes must provide efficient connections between the Silver Line stations and the many destinations within the Tysons area. As Tysons is developed, the level of service on the Link routes will increase over time to accommodate the increased demand, and larger vehicles will be operated on the routes. The initial routes are designed to avoid the most congested roadway segments, but they will inevitably face congested conditions and delays at peak times.

Fairfax County will monitor the ridership and running times of the Link routes on a continuous basis. As development density increases in Tysons, a significant increase in bus running times for the Link routes (and their successors as new roadway segments become available) will be an indicator toward implementation of the Circulator and its associated preferential roadway treatments such as queue jumps, exclusive lanes, and transit signal priority.

Changes to the Tysons Link routes and the transition to the future Circulator routes should be guided by the same principles that were used to develop the future Circulator system:

a. Keep the system as easy to understand as possible.

    1. Maintain consistent routing at all times.
    2. Minimize total number of routes in the Circulator system.

b. Find optimal balance between directness and coverage.

c. Minimize duplication of Circulator route mileage.

d. Minimize use of busiest through roadways.

The underlying goal of these principles is to make the connection between the Silver Line and all Tysons destinations as seamless and hassle-free as possible. For an area that has been historically dominated by automobile travel, it is necessary for new transit service to remove all possible obstacles to riders and to try to match the convenience of driving. Many of the principles recognize a balance that needs to found between convenience, simplicity, and cost. This balance needs to be maintained through all phases of Circulator development.

9.3 Summary of Principles

9.3.1 Response to New Developments

a. Does a new development increase the density (residential, employment or attractor) of a transit corridor by 10% or more?

    1. Transit corridor includes the current Tysons Link routes and the planned Circulator routes.

b. If new development is not served by an existing Link route, will it generate sufficient demand to warrant direct service?

c. Are the necessary roadway links in place to serve the new development efficiently (avoiding circuitous routing, congested roadway segments, and/or duplication of other Link service)?

d. Does the development include necessary infrastructure to support transit service?

    1. Pedestrian accommodations
    2. Room for bus stops and shelters, including lighting

9.3.2 Response to Road Network Changes

a. Does the new road segment offer a more efficient travel path for the transit route?

   1. Reduced mileage
   2. Reduced congestion
   3. Potential for preferential treatment

b. Does the new road segment connect to an area with sufficient density to support transit service?

9.3.3 Response to Degradation of Service on Tysons Link Routes

a. Has the average peak running time increased by two minutes or more since the previous year?

b. Has there been a significant decrease in reliability?

c. Have there been passenger overloads resulting in a peak-30 minute load factor greater than 1.2?

A "Yes" answers to at least one of the questions listed under the three trigger areas should prompt an evaluation of potential service changes. Possible responses include the following:

a. No action at this time.

b. Increase capacity on existing Tysons Link route through increased frequency or use of larger vehicle.

c. Investigate implementation of roadway preferential treatments.

d. Investigate alterations to alignment to avoid congested roadway segments.

e. Investigate alterations to alignment to serve new developments.

f. Investigate alterations to alignment to take advantage of new roadway segments.

g. Investigate transition to planned Circulator alignment.

9.4 Evolution of Modes

In addition to the transition between the Tysons Link Routes and the Circulator system as the Tysons area urbanizes, the other factor that must be considered by the staff that will be responsible for implementing the Circulator will be a potential transition from bus to streetcar on heavier ridership routes. This section provides a summary of the factors that will have to be evaluated and addressed if this transition to streetcar occurs.

9.4.1 Utility Relocation and Construction

Utilizing buses on Circulator routes would not require extensive utility relocation, if any. While streetcar implementation in other cities such as Portland has shown that most streets can handle the additional weight associated with a streetcar, placement of streetcar tracks in relation to subterranean infrastructure such as water and power lines can be an issue. Required utility work, in conjunction with track construction, will require detours and lane closures, leading to temporary modifications to Circulator routes and stop locations as well as to general traffic operations. Standard maintenance-of-traffic approaches, in conjunction with detailed communication of the temporary modifications to the public, will be essential elements in mitigating construction impacts to the greatest degree possible.

9.4.2 Transition in Levels of Exclusivity

As envisioned in this plan, buses will run in curb lanes with specific areas of exclusivity which were identified based on locations of slow travel speeds and high levels of congestion. A transition to streetcar would require an evaluation of the level of exclusivity the streetcar route would be provided. In the first instance, the streetcar could operate in the same manner as the bus, with streetcars utilizing the same areas of exclusivity utilized by the bus. A second option to be evaluated as the potential transition is to occur is full exclusivity in curb lanes. This approach has the advantage of pivoting off of the exclusivity in place to support buses. In this instance, the streetcar would share right turn lanes with general vehicular traffic and would utilize re-purposed parking lanes to the greatest degree possible in order to minimize taking of property from adjacent land owners. The final level of exclusivity would be full exclusive median running. This would lead to the most effective operations because interactions between vehicular traffic and streetcar would be minimized. This median running could, however, require additional right-of-way beyond that required by curb running operations because the re-purposing of traffic lanes may not be feasible. One final consideration in median running is that transitions from street to street under median running would likely require a separate transit signal phase, which would impact other movements through that intersection.

9.4.3 Traction Power Substations and Overhead Catenary System

Streetcars will require the installation of traction power substations to provide power via an overhead catenary system. The location of these substations will have to take into account the power requirements of the system as well as environmental and urban design considerations. In addition to the traction power substations, implementation of streetcar service will also require the installation of an overhead catenary system to provide power to streetcars. Installation of this system will entail the addition of significant infrastructure to the existing built environment and will likely require additional right of way beyond what is required for the streetcar guideway. The impacts of the overhead system will also vary depending on the type of operation that is ultimately implemented (curb running versus median running).

9.4.4 Maintenance and Storage Facility Requirements

The transition to streetcar from bus will result in a significant loss of flexibility in terms of the location of the maintenance and storage facility. Because buses can utilize the existing roadway network to access their beginning terminal point, a bus storage and maintenance facility supporting Circulator vehicles does not have to be located within Tysons, providing greater location flexibility. Because streetcars utilize fixed guideway, the maintenance and storage facility must be located within close proximity to the tracks, thus necessitating the location of the facility within Tysons. In addition, in order to minimize the distance of the lead tracks from the facility, the facility should be located closely adjacent to the streetcar revenue tracks. This constrains flexibility even more.

9.4.5 Change in Passenger Facility Requirements

The transition to streetcar on selected routes may require changes to stops/stations. However, because the intent is to equip the Circulator bus routes with Bus Rapid Transit like elements, including stops that are more substantial than a standard bus stop, the transition between bus and streetcar passenger stops may not be overly significant. This will be addressed during the more detailed design process but considerations in this design should include effective integration with adjacent land uses, visibility, passenger comfort, ADA accommodations and station access, and the accommodation of effective information, including the potential for real time arrival information.

Section 10
Public Outreach Process

Public Outreach Process

10.1 Introduction

The Tysons Circulator Study planning process incorporated a wide range of public outreach efforts in order to inform different stakeholder groups of the findings of the planning process at different stages of the study, as well as to receive feedback from these stakeholders. The purpose of this report section is to provide a brief summary of the different outreach efforts undertaken during the planning process.

10.2 Planning Process Outreach Efforts

This report section provides a brief summary of the different planning process outreach efforts, by event.

a. Tysons Open House – (June 2011) – Members of the project team attended this event as participants. The event was a public open house at which different groups involved in the Tysons redevelopment presented information and answered questions regarding their specific area. The event included different developers as well as different Fairfax County Departments, including the Department of Transportation. The Circulator team provided attendees information on the Circulator planning process and answered questions. This event was held at the beginning of the planning process so the focus was on the scope of work and what would be completed during the study.

b. Tysons Partnership Meetings – (June 2011, February 2012, October 2012) – Three discussions were held with the Tysons Partnership during the planning process. In the first meeting, held in June 2011, the project team presented the proposed goals and objectives and received feedback on them. In the second meeting, held in February 2012, the project team provided a status update on the planning process. This update included a summary of the route networks that were carried forward for more detailed evaluation, preliminary results of the network evaluation, ridership results, and information on next steps in the planning process. In the final meeting, the recommendations included in this report were presented and discussed. This provided a final opportunity to receive feedback from the Partnership prior to the report being posted to the project website for public review.

c. Transportation Advisory Commission Briefing – (March 2012) – This meeting involved a general progress update on the Tysons Circulator and included a summary of the route networks being evaluated in greater detail, the progress of the network evaluation, ridership results, and an update on the work completed on transit preferential treatments.

d. Public Meeting – (April 2012) – A public meeting for Fairfax Connector route changes was also utilized by the Tysons Circulator team to present study progress to that point. Subjects covered in the presentation included the scope of work, the network development and evaluation process, ridership forecasting results, an update on transit preferential treatments, preliminary recommendations, and next steps for completion of the study. A number of questions were asked by meeting attendees and an information handout was also made available. The presentation was also posted to project website.

e. Planning Commission Tysons Committee Briefing – (May 2012) – This briefing had many of the same elements as meetings held in the Spring of 2012, including progress to date, preliminary recommendations on network, mode, transit preferential treatments, and next steps for the completion of the study.

f. Tysons Open House – (June 2012) – This open house had the same structure as the open house held in June 2011, with information stations manned by different groups involved in the Tysons redevelopment. The Tysons Circulator Study had its own information station and information was provided on study progress. Handout materials were made available, which were also put on the project website. The handout package included the study purpose and scope of work, the route network evaluation process and the proposed network, a summary of the mode option analysis and the proposed modes, and a discussion of transit preferential treatments.

g. Board of Supervisors Transportation Committee Meeting – (June 2012) – Fairfax County staff presented study status and preliminary findings during this meeting. This meeting was open to the public.

h. Posting of Draft Report on Tysons Website for Public Comment – (November 2012) – The draft final study report was posted on the County's Tysons website during November 2012 to provide members of the public an opportunity to read the report and provide comments.

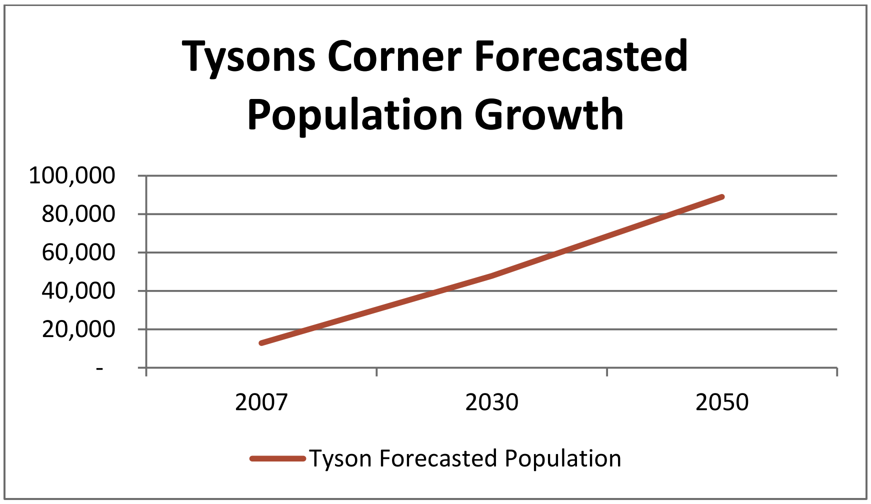
Section 11
Summary and Conclusions

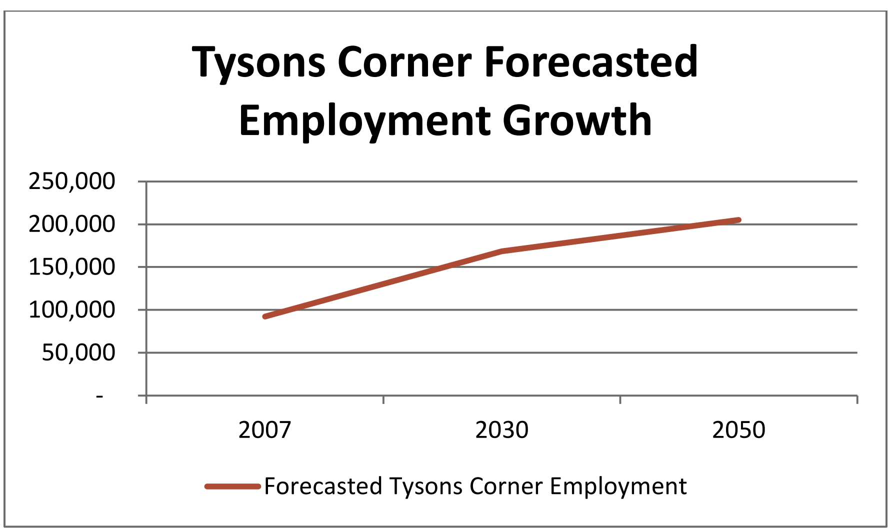
Summary and Conclusions

11.1 Introduction

As was noted in the Introduction to this report, the Tysons Circulator Study is a **long range** planning study that has been undertaken in order to support the redevelopment and rezoning of Tysons over the next 40 years (anticipated growth in population and employment in Tysons through 2050 is shown in Figure 11-1). The purpose of the study is to design a Circulator system that will support the County's overall goal of maximizing transit trips and minimizing vehicular trips to, from, and within Tysons.

Figure 11-1: Forecasted Population and Employment Growth in Tysons to 2050





The key outputs of the study, which will support Fairfax County staff and elected officials in making transportation decisions as the Tysons redevelopment and rezoning process moves forward, include the following:

a. The identification of a Circulator network that maximizes transit ridership and provides service to the greatest number of potential riders.

b. The identification of the most appropriate transit mode for each route within the overall recommended network based on ridership demand and required capacity to meet that demand, as well as additional factors such as ease of construction and impacts on pedestrians, bicyclists, and automobiles.

c. The identification of required transit preferential treatments to support fast and reliable transit service. Preferential treatments include transit exclusive lanes, queue jumps at intersections, and transit signal priority.

The remainder of this report section outlines the recommendations made in each of these three areas, including a summary of the data analysis that was used to reach these recommendations. This section also includes a description of how the results of the Tysons Circulator plan will be used as the Tysons redevelopment and rezoning processes move forward.

11.2 Final Circulator Network Recommendation

The selection of a final recommended Tysons Circulator network followed a three step process. In the first step a set of route design principles were utilized to develop a series of individual routes that were then incorporated into a series of potential Circulator networks. Five preliminary networks were developed in this manner. The route design principles used in the route design covered areas such as route directness, service coverage, ease of use, and route length.

In the second step of the process, the original five potential route networks were compared to each other to determine each network's effectiveness in serving potential riders, each network's estimated productivity and cost-effectiveness, and how well each network met the project's goals and objectives. This evaluation was a preliminary assessment of the networks utilizing available data and was focused on selecting a subset of networks for more detailed evaluation. Two networks were identified as having the greatest potential for success and were selected for more detailed evaluation.

The third process step was a detailed evaluation of the two networks that were selected from the original group of five (these two networks were the Three Route Network and the Four Route Network). Based on the detailed evaluation of the two networks selected to move forward, the **Three Route Network** was selected as the recommended Circulator network. This recommendation was based on the Three Route Network's superior performance on the majority of the evaluation criteria that were used to compare the two route networks. The evaluation criteria utilized in the network comparison, as well as summary of how each network performed, is included in Table 11-1.

Table 11-1: Highest Performing Network by Evaluation Criterion

Evaluation Criterion	Highest Performing Network	
	Three Route Network	Four Route Network
Daily Ridership	X	
Boardings per Revenue Hour	X	
Daily Cost per Daily Boarding	X	
Annualized Capital Cost per Daily Boarding	X	
Run Time Variability and Potential Impact on Reliability	Networks are Similar Relative to this Criterion	
Circulator Travel Times Between Origin-Destination Pairs within Tysons (convenience in making intra-Tysons trips)		X

A map of the Three Route Network is shown in Figure 11-1.

11.3 Final Mode Recommendation

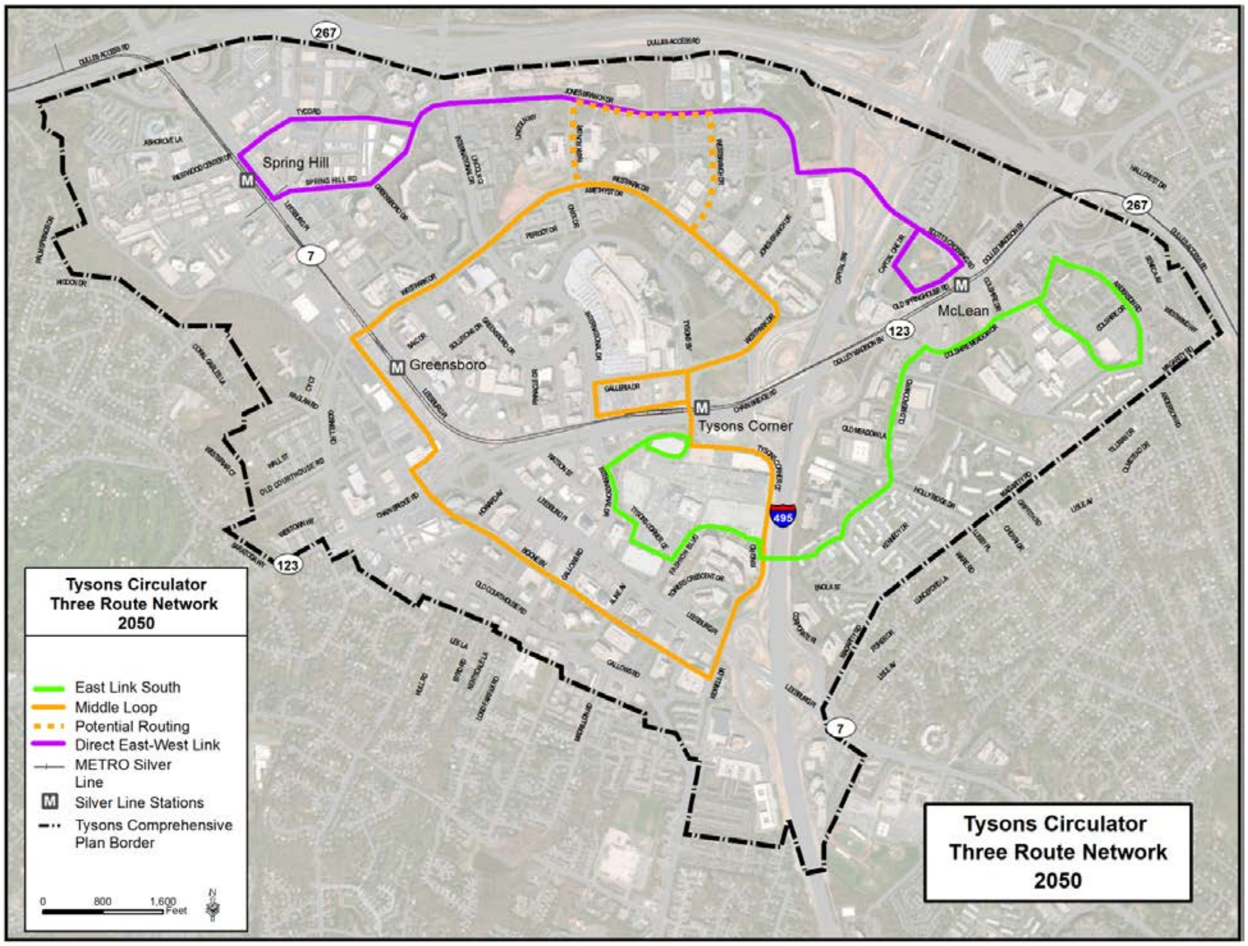
The selection of the most appropriate mode for each route within the Three Route Network was based on an evaluation framework that considered the full range of factors that would impact a mode's effectiveness in providing service within Tysons. The foremost of these factors was a mode's ability to provide sufficient capacity to meet ridership demand in conjunction with the cost of providing this capacity. Additional factors beyond capacity and cost that were also part of the evaluation framework included:

a. Right-of-way requirements for each mode evaluated.
b. Roadway congestion levels along each route.
c. The ease of construction of the required infrastructure to support each mode.
d. The transit mode's impact on other modes sharing the roadway network, including automobiles, bicycles, and pedestrians.
e. Maintenance facility requirements for each mode evaluated.

The modes considered for implementation in Tysons included Streetcar, Bus (40' or 60' in length), and a Driverless People Mover system.

On all routes in the Three Route Network bus (either a 40' bus or a 60' bus) can provide sufficient capacity to meet ridership demand, at a lower cost than streetcar, and therefore bus is the recommended mode on all routes within the Three Route Network.

Figure 11-2: Final Selected Network – Three Route Network



Driverless People Mover systems actually have a lower estimated combined annual operating and capital cost than bus but was not recommended because it was determined that the characteristics of a People Mover system make it infeasible for implementation in Tysons. The most important of these characteristics is the fact that because a People Mover system is driverless, it requires complete horizontal and vertical exclusivity. In order to provide this exclusivity the system must be elevated (some at grade running may be feasible, though detailed design would be required to identify how much), which in return requires support pillars in their own right-of-way (some exclusivity may potentially be provided without additional right-of-way though because of the anticipated characteristics of a future Tysons, especially higher future traffic volumes, it was assumed that a significant portion of each route would require new right-of-way In order to avoid impacts to general traffic lanes). Obtaining this required right-of-way in a more urbanized Tysons would have extensive impacts on adjacent property owners and thus would be extremely difficult, if not impossible to implement.

Urban design elements also make a Driverless People Mover system less attractive. The first of these elements is the fact that riders would have to access an elevated station via elevator or escalator, which requires a longer and less direct access path. This could be especially onerous for people transferring from elevated Silver Line Stations. The second urban design element that makes an elevated people mover system less attractive is the potential impact on the desired walkable and accessible urban street system, including impacts to pedestrians and to street level businesses. For these various reasons a Driverless People Mover system was not recommended as mode for the Tysons Circulator system.

One final note with regard to mode is that the County is reserving the option of implementing streetcar in future, if future conditions warrant. While the analysis included in this report indicates that the capacity that would be provided by streetcar would be not be fully utilized and therefore unproductive, maintaining mode flexibility reflects the fact that forecasting future conditions can be imprecise and that the capacity provided by streetcar may be required based on actual long-range conditions.

11.4 Transit Preferential Treatments Recommendations

Three types of transit preferential treatments were considered for implementation as part of the Circulator Study. These include queue jumps, which allow a transit vehicle to bypass a queue waiting at an intersection, transit exclusive lanes between intersections, and transit signal priority. Queue jumps and transit exclusive lanes require additional right-of-way to implement.

The need for queue jumps and transit exclusive lanes were identified based on forecasted slow travel speeds along the alignments of the routes comprising the Three Route network. Three areas along these route alignments were identified for the application of a combination of queue jumps and transit exclusive lanes based on this analysis.

The first of these areas would be along Gosnell Road and Westpark Drive, between the intersection of Gosnell Road and Route 7 and the intersection of Westpark Drive and International Drive. The improvements in this roadway segment would consist of a combination of queue jumps at three intersections (Gosnell Road/Westpark Drive and Route 7; Westpark Drive and Greensboro Drive; and Westpark Drive and International Drive) and transit exclusive lanes between the intersections. This exclusive lane/queue jump combination would be on both sides of Westpark Drive in this roadway section.

The second area that warrants this combination of queue jumps and transit exclusive lanes would be in the vicinity of the Spring Hill Silver Line station along Spring Hill Road, Route 7, and Tyco Road. This area of transit exclusivity would begin at the intersection of Spring Hill Road and International Drive. An exclusive bus lane would begin on the east side of International Drive and would continue west on Spring Hill Road (crossing Tyco Road in the westbound direction), north on Route 7, and east on Tyco Road. This combination of queue jumps and transit exclusive lanes would be on the north side of Tyco Road, the east side of Route 7, and the south side of Tyco Road and would support the Direct East-West Link as it runs clockwise through this loop.

The third area that would warrant a queue jump and a transit exclusive lane would be on Scott's Crossing Road between Capital One Drive and Old Springhouse Road. This application would include a queue jump for an eastbound bus on Scott's Crossing Road at the intersection of Scotts Crossing and Capital One Drive. East of Capital One Drive would be an exclusive bus lane between Capital One Drive and Old Springhouse Road. Since buses would be running only in the eastbound direction in this link, an exclusive lane would be required only on the south side of Scotts Crossing. While this recommendation confines the bus only lane to the roadway link between Capital One Drive and Old Springhouse Road based on forecasted speeds, an exclusive lane of this short distance is not fully optimal and thus future conditions may warrant extending transit exclusivity up to the intersection of the Jones Branch Connector and Jones Branch Drive, on the west side of the I-495 Beltway. This exclusivity would be on both sides of the Jones Branch Connector and Scotts Crossing Road alignment between Capital One Drive and Jones Branch Drive. To ensure this contingency is addressed, the County is reserving right-of-way for the entire distance to the west and east side of the Beltway. This contingency also includes the ability to accommodate streetcar on this route if future conditions warrant. This would include exclusive right-of-way of 24’ between stations to accommodate two tracks and 36’ at stations to accommodate the two tracks as well as station platforms. To this end, the design of the Beltway Crossing is incorporating a cross section wide enough to accommodate exclusivity in the future.

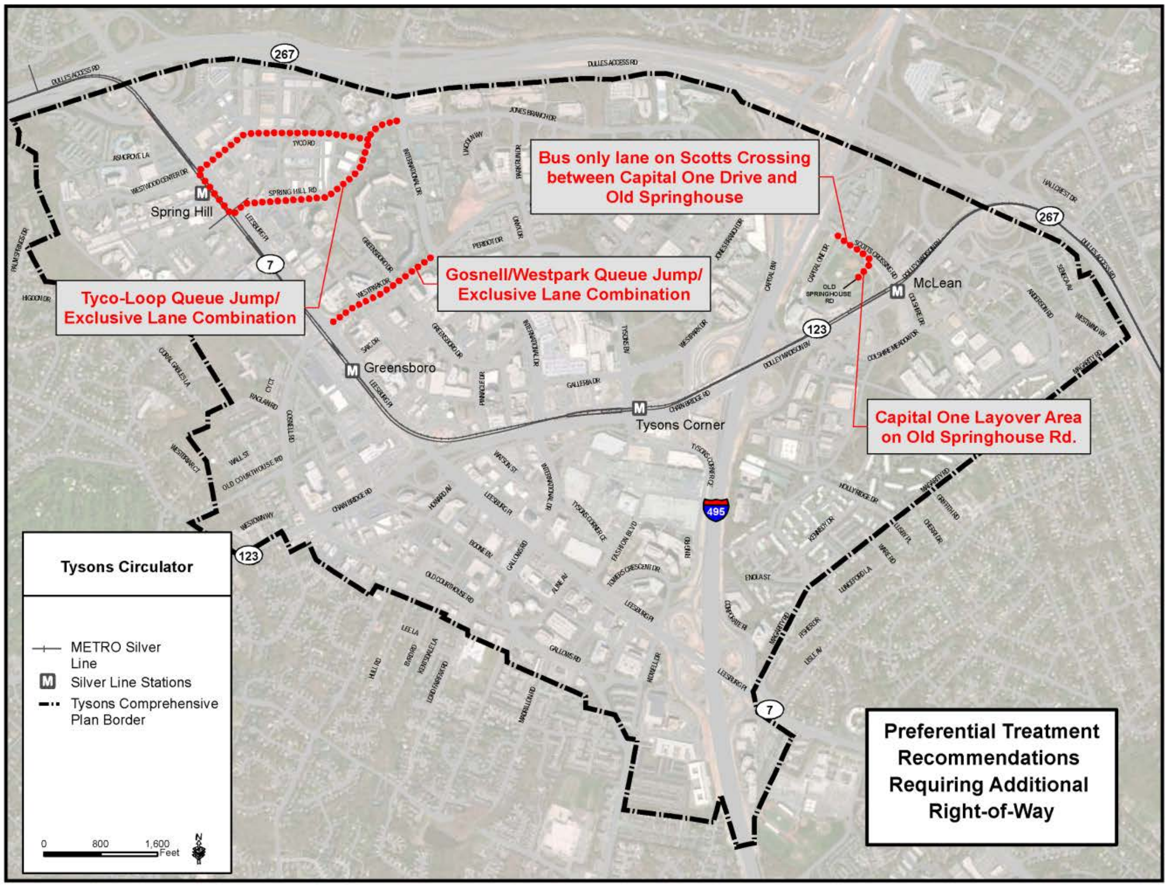
Each of these areas is shown in Figure 11-2.

In all instances where transit exclusive lanes are proposed, a re-purposing of parking lanes will be utilized, wherever feasible. This re-purposing of existing lanes will minimize the amount of additional right-of-way that will have to be obtained from adjacent property owners.

The final exclusivity recommendation that would require property from an adjacent property owner is on the Capital One campus, along Old Springhouse Road. Buses on the Direct East-West Link would arrive at this point every four to six minutes and would layover here before beginning their westbound trip. Old Springhouse Road also is forecasted for slow travel conditions. Given this combination of bus operating and traffic conditions, two bus bays separated from through traffic are recommended on the north side of Old Springhouse Road (of note is that this off-street layover facility is also necessitated by the fact that there is only one lane in each direction at this location. Layovers for other routes in the Three Route Network will occur in the street, where two lanes are available, or at Silver Line Stations).

This recommendation is also shown in Figure 11-2.

Figure 11-3: Recommended Transit Preferential Treatments Requiring Additional Property



The final set of recommended transit preferential treatments is transit signal priority. The intersections proposed for transit signal priority were identified as those intersections along the Three Route Network route alignments where approach delay is greater than 35 seconds and delay on the side streets is less than 60 seconds. This reflects intersection locations where bus movements would receive a run time benefit, but not at the expense of vehicular traffic on intersection side streets. The intersections recommended for transit signal priority are summarized below in Table 11-2.

Table 11-2: Intersections Proposed for Transit Signal Priority

Route	Intersection	Direction
East-West Link	Old Spring House Road and Capital One Drive	Right turn from Old Spring House Road to Capital One Drive(clockwise direction)
	Spring Hill Road and Greensboro Drive	Westbound
East Link South	Colshire Meadow Drive and Colshire Drive	Westbound/Southbound
	Colshire Meadow Drive and Old Meadow Drive	Westbound/Southbound
	Old Meadow Drive and Holly Ridge Drive	Westbound/Southbound
	Mall Ring Road and International Drive	Southbound
Middle Loop	Boone Boulevard and Howard Avenue	Westbound
	New Road Parallel to Route 7 and Gosnell Road	Right Turn onto Gosnell Road
	Westpark Drive and Greensboro Drive	Northbound and Southbound
	Westpark Drive and Park Run Drive	Eastbound

11.5 Tysons Circulator – Comparison to Peer Circulator Systems

This section provides context for the Tysons circulator's forecasted performance by comparing it to the peer systems evaluated in the project peer review, which was developed at the beginning of the planning process. Table 11.3 shows the forecasted daily ridership and boardings per revenue hour on the Tysons Circulator as well as each of the peer systems evaluated as part of the review.

Table 11-3: Tysons Circulator and Peer System Daily Ridership and Boardings per Revenue Hour

System	Daily Ridership	Boardings per Revenue Hour
Tysons Circulator	17,575*	61.88
Walnut Creek Circulator	863	24.1
Los Angeles Downtown Circulators (DASH)	22,932	38.5
Washington DC Circulator	7,750	29.0
Orlando Lynx LYMMO	3,267	50.0
Miami Metromover	30,700	94
Portland Streetcar	11,916	n/a
Tacoma Link Streetcar	3,053	89.7

*Ridership Scenario #2 – Three Route Network

The data in Table 11.3 show that the forecasted performance of the Tysons Circulator exceeds that of nearly all of the peer circulator systems evaluated. In terms of daily ridership, the two systems that have higher daily ridership are both systems serving dense downtowns in Miami and Los Angeles. When evaluated in terms of boardings per revenue hour, a measure of productivity, only one peer system performs better than the Tysons system, the Tacoma Link Streetcar. This data highlights that when evaluated in terms of its peers, the Tysons Circulator system will be high-performing circulator system, with some of the best performance statistics in the United States.

The peer analysis also yielded a number of lessons learned regarding the factors that contributed to a successful circulator system. These include:

a. **High Frequency, Easy to Understand Service** – It is essential that the service be as easy to use as possible, especially to attract choice riders who have other mode options. This includes high service frequency to minimize waits at stops as well as very direct and easy to understand route structures.

b. **Distinct Premium Branding** – A distinct brand coincides with an easy to understand service. Riders, especially infrequent riders, need to feel comfortable with riding the Circulator, and a distinct brand helps to provide a level of comfort that the rider is boarding the correct bus that will take them to their destination.

c. **Passenger Amenities** – Passenger amenities make a service more attractive to riders, especially choice riders that have other mode options. In addition, the majority of peer systems provide real-time information on next-trip arrivals, which gives riders an additional level of comfort regarding the system's reliability.

d. **Enhanced Pedestrian Environment and Streetscape** – An attractive pedestrian environment, including attractive streetscaping, provides an overall comfortable atmosphere that supports riders choosing transit versus their automobile.

11.6 Next Steps

The completion of the Tysons Circulator Study has resulted in the specific recommendations on the Circulator network, mode by route, and required transit preferential treatments outlined in this report. These recommendations will provide a road map of improvements required to support an effective Circulator system as Tysons redevelops into a more urban area in the future. As a first next step, these Study recommendations will be incorporated into the Tysons Corner Comprehensive Plan through a plan amendment and will also be included in rezoning applications as appropriate.

However, even though specific recommendations have been made and will be incorporated into the Comprehensive Plan, the County will maintain flexibility to address conditions that were not anticipated as the Study planning process was completed. Maintaining this flexibility reflects the fact that forecasting into the future can be imprecise and therefore future conditions may change.

The County will maintain flexibility to address unanticipated future conditions through the rezoning application process. The County will continue to monitor conditions as Tysons redevelopment occurs. This will include monitoring of traffic conditions, Circulator reliability, Circulator ridership and capacity utilization, and development patterns. If conditions that were not anticipated occur, the County will address these when considering future rezoning requests. These considerations as part of rezoning may include additional right-of-way for transit exclusivity, layover space, or a transit station.