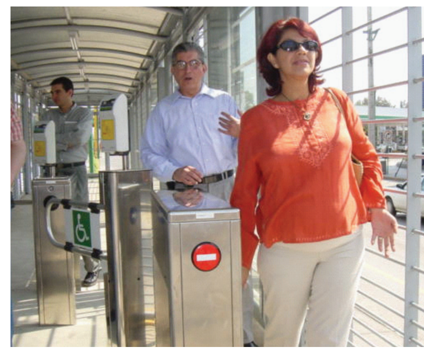

Countywide Bus Rapid Transit Study

Consultant's Report (Final)

July 2011

DEPARTMENT OF TRANSPORTATION

COUNTYWIDE BUS RAPID TRANSIT STUDY

Consultant's Report (Final)

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LIST OF ACRONYMS

APTA	American Public Transportation Association
BRT	bus rapid transit
CCT	Corridor Cities Transitway
CLRP	constrained long-range transportation plan
FTA	Federal Transit Administration
GIS	geographic information system
ICC	Intercounty Connector
LOS	level of service
M-NCPPC	Maryland-National Capital Park and Planning Commission
MCDOT	Montgomery County Department of Transportation
MTA	Maryland Transit Administration
MWCOG	Metropolitan Washington Council of Governments
NCHRP	National Cooperative Highway Research Program
O&M	operations and maintenance
PID	passenger information display
SHA	Maryland State Highway Administration
TAZ	traffic analysis zone
TCRP	Transit Cooperative Research Program
TSP	transit signal priority
WMATA	Washington Metropolitan Area Transit Authority

EXECUTIVE SUMMARY

ES1. Context for the Study

The Montgomery County Department of Transportation (MCDOT) initiated the Countywide Bus Rapid Transit (BRT) Study to identify key corridors within the county that could facilitate premium rapid transit service. The intent of this effort was to complete a planning-level analysis to draw conclusions regarding the feasibility of a network of BRT routes across the county. The background for the study was established through several individual corridor studies exploring BRT service and conducted by the Metropolitan Washington Council of Governments (MWCOG) through a regional premium transit study and by Montgomery County Councilmember Marc Elrich through a BRT system concept.

The consulting team was directed by the MCDOT to explore the feasibility of constructing a set of BRT corridors within the available constrained rights-of-way on county and state roads. The study provided analysis results at a level to allow MCDOT to identify possible BRT routes; determine treatments that would enhance speed, reliability, rider comfort, and convenience; and measure the system's performance in the horizon planning year 2040. This analysis was conducted at a level that indicates relative potential demand for the system and rough estimated costs to build and operate the system. The results should be assessed from that perspective, while also recognizing additional detailed analysis would be required to establish policies or recommendations on specific corridors to include in the final recommended network, the design options to be incorporated along each corridor, and the estimated ridership that would be expected for individual corridors.

The work effort conducted for this study gives the following results:

- About 92,000 daily linked transit trips are estimated on the 150-mile BRT system, with 52,000 being new transit trips.
- The average BRT trip lengths would be 9.3 miles during the peak hour and 8.6 miles daily.
- The system would have approximately 165,000 and 207,000 daily boardings, with annual O&M costs ranging from $150 million to $180 million.
- Construction of the highest capacity BRT system with all recommended improvements would range between $2.3 and $2.5 billion (in 2010 dollars), averaging between 15.8 and $17.1 million/route-mile.

This refined feasibility study serves as the first step toward implementing a BRT system in Montgomery County for individual corridors. Additional work on forecasting of demand, assessing the combination or alterations to proposed BRT routes, further refinement of land-use and parking expectations along the corridors, availability of funding—as well as various combinations of these factors—could yield differing results. These are just a few of many factors that need to be discussed and resolved jointly by the County and neighboring agencies and jurisdictions to further inform final route selection and forecasted system performance, and help drive policy and investment decisions. Routes also need to be weighed for their relative user benefit by developing a phasing plan for the system, and each route must be further refined through an alternatives analysis to verify its feasibility for construction. The results presented in this summary should be considered an initial dialogue to the conversations that will need to be concluded before implementation can begin.

ES2. What is BRT?

The study focused on implementing a BRT system that would emulate light rail operations in terms of the features provided, but would operate on the arterial roadway system in the county. This BRT system would rely on walk access, local bus transfers, and some park-and-ride access, and would combine the most attractive features of light rail with the lower costs of bus technology. Instead of trains and tracks, BRT invests in improvements to vehicles, roadways, rights-of-way, intersections, and traffic signals to speed up bus transit service.

LTD Emx – Eugene, OR

BRT service differs from commuter bus service, which focuses on peak-period service during the weekday with a limited schedule, intermediate stops, and dependence on park-and-ride access. BRT was assumed for this study to be premium bus service operating with the following characteristics:

- All-day service
- Higher frequencies
- Stops at 1/2- to one-mile spacing
- Provision for exclusive lanes
- Transit signal priority and queue jump lanes where appropriate
- Enhanced stations with greater passenger amenities
- Real-time passenger information
- Potential for off-board fare collection
- Efficient boarding and alighting

ES2.1. Key BRT Elements

ES2.1.1 Stylish vehicles

Many BRT vehicles have sleek, modern designs that emulate light rail features. They can be standard, 40-foot or articulated 60-foot buses (as assumed for this study). They should have level floors and multiple wide doors for easy boarding and alighting. Vehicles should have comfortable interiors designed for different configurations, including space for bicycle storage.

Cleveland Healthline Station (with protective shelter, ticket vending, and information kiosk)

ES2.1.2 Attractive stations

BRT stations should reflect the level of investment and permanence of the system. They should welcome passengers and feature a comfortable, attractive design. Stations should provide a variety of passenger amenities, including real-time information displays, benches, substantial shelters, and security features. Station platforms should be at the same level as the floor of the BRT vehicle to accommodate efficient boarding and alighting. This study assumed level-floor boarding for all stations.

WMATA On-Board Smart Card Reader

ES2.1.3 Faster fare collection

On- or off-board fare collection options can help reduce BRT dwell time at stations and increase speed of service. Some on-board fare collection options include exact change payment and pass scanners. Examples of off-board fare collection include the use of ticket vending machines as proof of payment and special prepayment boarding areas. Pass scanners, such as those using the SmarTrip system in the Washington, DC region, provide complete integration with the area-wide transit system.

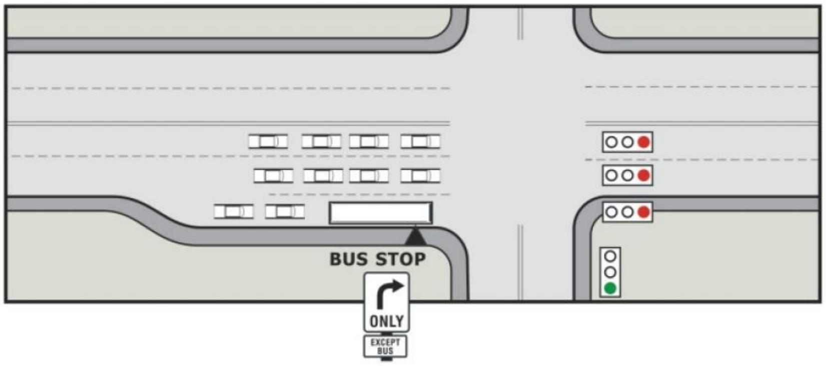
LTD EmX Median Guideway

ES2.1.4 Guideways and rights-of-way

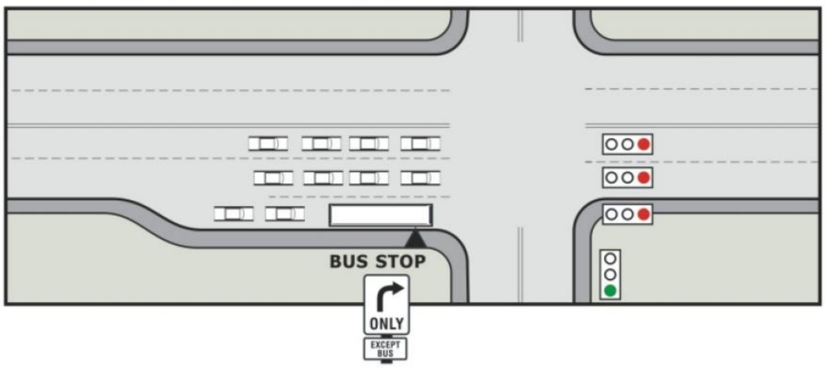
Guideways can serve to increase BRT travel speeds, improve service reliability, and reinforce the system's permanence by separating the vehicles from mixed traffic. Examples of guideways applicable to BRT include median, side-of-road, or separate busways and exclusive bus lanes within the roadway cross section.

BRT vehicles may operate in mixed traffic in areas with constrained rights-of-way. In these conditions, implementing queue jumps can help increase operating speed and service reliability. A queue jump (shown in Figure ES1), as assumed in this study, is when a rapid transit vehicle can use an auxiliary lane (such as a right-turn lane) at a signalized intersection to bypass the general traffic queue at the intersection. An advanced green signal would allow the vehicle to move through the intersection unimpeded ahead of general traffic.

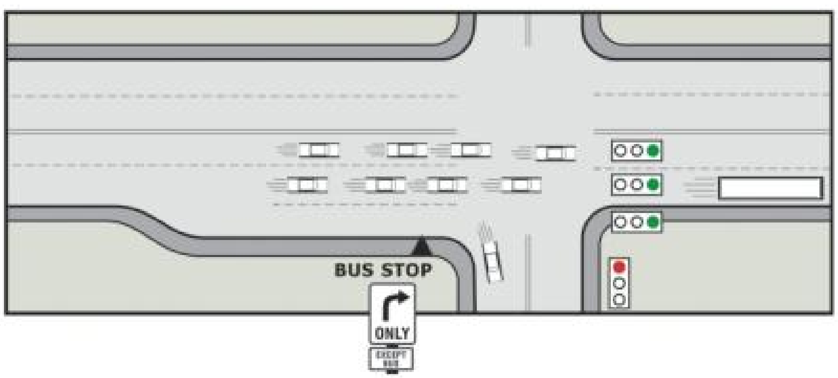
Figure ES1: Queue jump operation example



(a) Bus approaches intersection at red signal



(b) Bus receives green signal before other vehicles



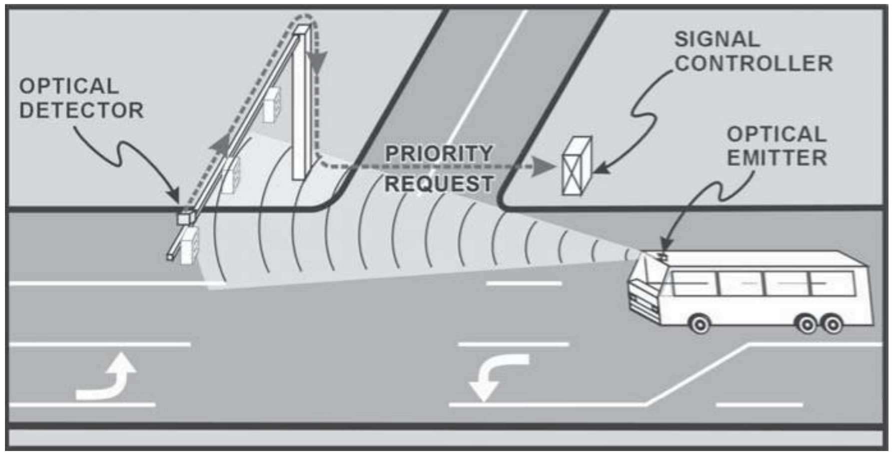
(c) Other vehicles proceed a few seconds later

Source: TCRP Report 118

ES2.1.5 Intelligent transportation systems (ITS)

Using ITS technology can help increase quality of service, improve operations, and provide passengers with timely and reliable information about BRT service. A key ITS application

Figure ES2: Transit signal priority (TSP) example



assumed for this study was transit signal priority (TSP). TSP technology allows a vehicle to request priority through a signalized intersection (shown in Figure ES2) by extending the green phase or truncating the red phase by a few seconds. This is a different application from signal pre-emption, which is often applied at locations of emergency vehicles where signals are controlled to stop all traffic. Typically, TSP saves only a few seconds per intersection. TSP implementation may be conditional, depending on whether the vehicle is behind schedule.

TSP, in this study, was assumed to be feasible where the roadway level of service (LOS) was in the C or D range. LOS A or B represents more free-flow traffic conditions, where priority would not give a BRT vehicle an extra advantage. LOS E or F represents failing traffic conditions, where congestion would be so great a BRT vehicle cannot effectively actuate priority calls. In those cases, BRT would provide minimal benefit to bus operations and increase overall delay to other vehicles.

Other ITS applications can aid passengers with travel decisions by providing timely and reliable information. Riders can learn of the next BRT vehicle to arrive or route delays over the internet, through real-time information displays at BRT stations, or through a user's mobile phone. This study assumed the use of real-time passenger information for the proposed network.

ES2.1.6 Operations

BRT service should provide reliable, frequent service with fewer stops compared to local bus service. It should also provide connectivity to other transportation modes such as local buses, rail, park-and-rides, and bicycle and pedestrian paths. Routes should be easy to understand and designed for passengers to have a one-seat ride to the extent possible. Local transit service should be re-oriented to provide access to BRT corridors.

ES2.1.7 Land use

Dense land use near Cleveland Healthline Station

BRT routes operating along corridors with high concentrations of development that support transit make BRT service more effective as a transportation option. Transit-oriented development is a key component for successful BRT. BRT takes advantage of the pedestrian and customer activity found in areas with higher land use densities and a mixture of types of development, including residential, retail, employment, and entertainment.

Automobile use and parking needs can decrease where there are clusters of such development. BRT corridors require a minimal level of concentrated development. For this study, a threshold of at least six households or five employees per acre was used during early analysis as a method for identifying corridors where BRT service may be appropriate. The planning horizon year of 2040 includes the recently approved White Flint, Great Seneca Science Corridor and the Germantown Plans, all of which focus on transit–oriented communities.

Ensure BRT is accessible to all riders

ES2.1.8 Station access

Improved bicycle, pedestrian and auto access to stations, and the correct placement of the station locations are critical factors in the success of a BRT system. Considerations for station locations in this study included placement at existing bus stops, Metrorail or planned light rail stations, transit centers, and park-and-ride lots. Detailed corridor implementation programs following this study should also consider the surrounding physical environment to enhance or improve access to BRT stations. BRT stations also must be accessible to passengers with varying levels of physical abilities.

ES2.1.9 Strong brand identity

Branding of BRT service conveys to new transit users and users unfamiliar with BRT that they are encountering a premium transit system with enhanced service and amenities. Typical branding methods include:[1]

- Branding stations and terminal features such as bus/BRT stop signs, passenger information boards, fare collection equipment, and media
- Giving vehicles a special styling, unique livery, added passenger amenities, and marketing panels
- Branding running ways by using special paving materials, colors, and markings
- Branding marketing materials such as route maps, route schedules, web sites, and media information

Orange Line BRT Branding - Los Angeles

ES2.2. Study methodology

This feasibility study consisted of several tasks to identify a set of viable BRT routes that could operate along state and county roadways in Montgomery County. These tasks were as follows:

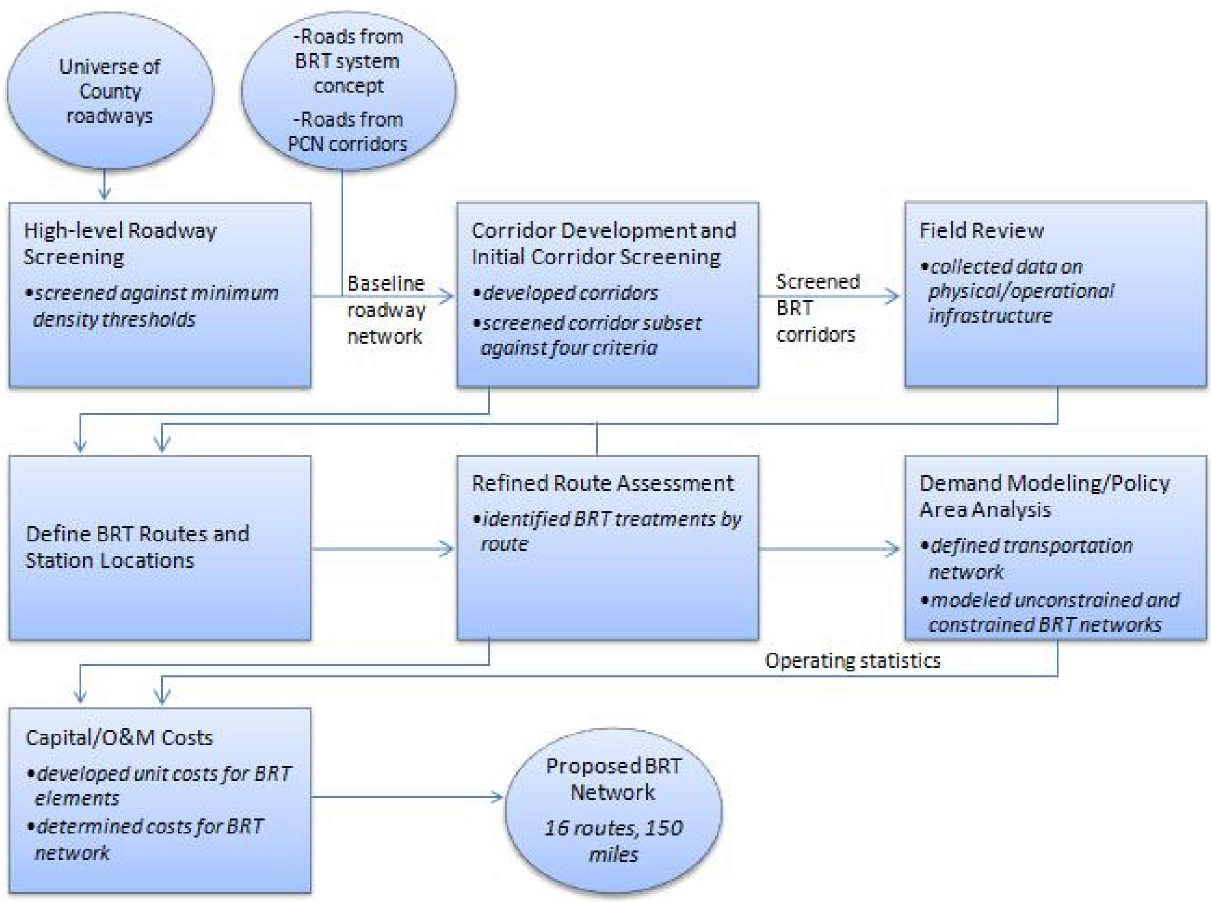
[1] TCRP Report 118: Bus Rapid Transit Practitioner's Guide

1. Conduct an initial screening to identify a set of county roads that exhibit characteristics consistent with BRT operations.
2. Conduct field reviews and planning level right-of-way analysis along potential BRT corridors to determine potential design options, primarily within the existing right of way.
3. Determine travel demand along identified corridors.
4. Determine capital and operating costs for the BRT network.

Figure ES3 depicts the study methodology in flow chart form and identifies the steps taken to determine the final network and analyze that network for viability.

The work conducted for these tasks ultimately produced a network of 16 BRT routes that would incorporate most of the key elements discussed in Section ES2.1 and could be built within the existing right-of-way. The conceptual level of this study did not involve identifying the locations of right-of-way impacts; therefore, this proposed network would involve realigning roadway cross-sections, sometimes beyond the existing right-of-way. For example, exclusive guideways would be constructed through the spaces of existing medians and left-turn lanes at signalized intersections. However, constructing exclusive guideways would include replacing the left-turn lanes to maintain similar levels of traffic operations along the corridors.

Figure ES3: Final corridor analysis and selection process



ES3. Study findings

ES3.1. Proposed BRT network and treatments

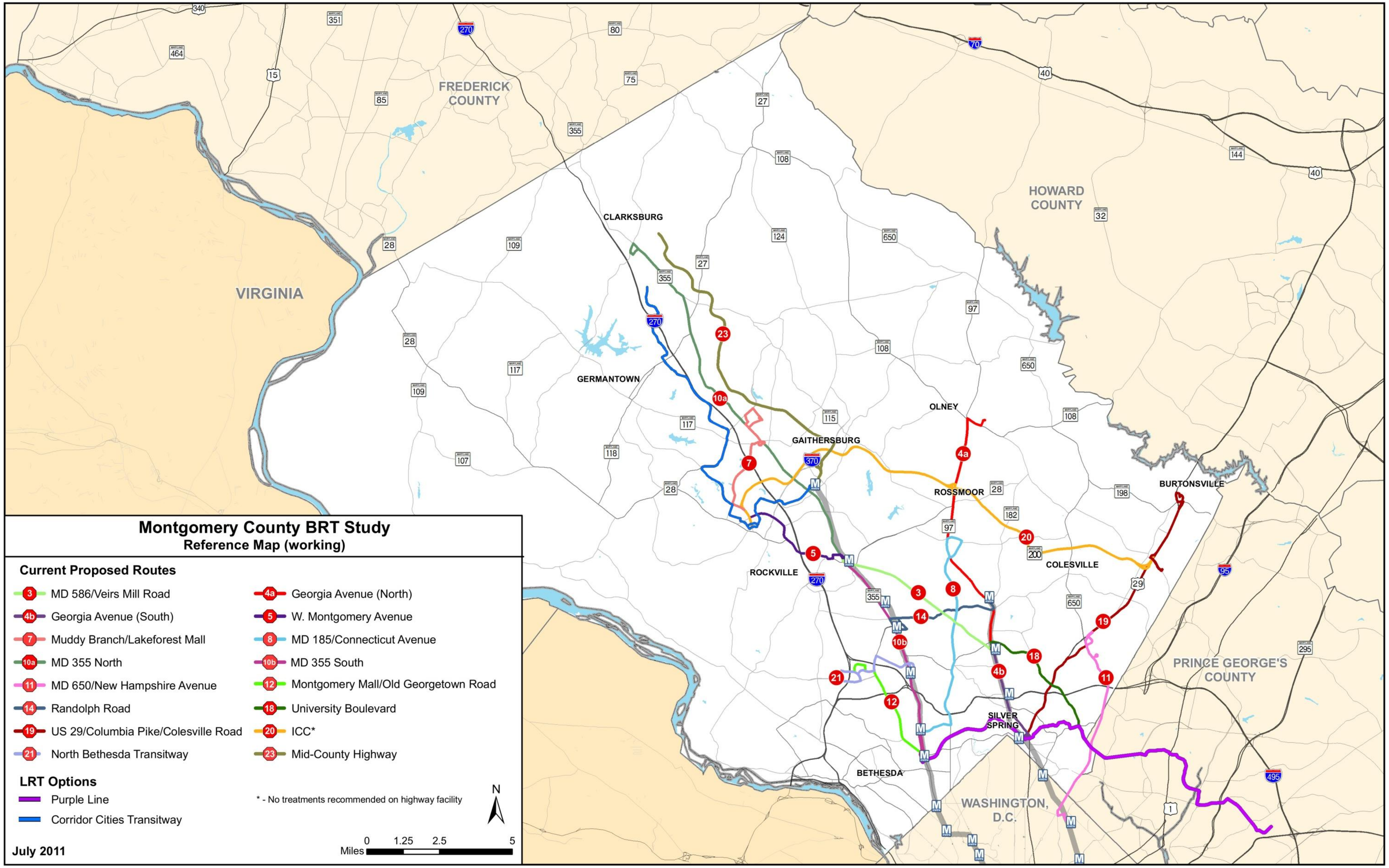
Table ES1 summarizes the proposed BRT network of 16 routes forecasted by 2040 to be viable BRT corridors. Figure ES4 illustrates this network.

The specific guideway and intersection treatment options for each route can be found in the main body of the report.

Table ES1: Proposed BRT routes

Route Number	Corridor	From	To	Route Length (miles)	Number of Stations
3	MD 586/Veirs Mill Road	Rockville Metrorail station	Wheaton Metrorail station	6.7	11
4a	Georgia Avenue North	Montgomery General Hospital	Wheaton Metrorail station	9.8	12
4b	Georgia Avenue South	Wheaton Metrorail station	Silver Spring Transit Center	3.9	6
5	Rockville Metrorail-Life Sciences Center	Life Sciences Center	Rockville Metrorail station	5.3	7
7	MD 124/Muddy Branch Road	Lakeforest Mall	Life Sciences Center	7.2	10
8	MD 185/Connecticut Avenue	Georgia Avenue and Bel Pre Road	Medical Center Metrorail station	9.5	10
10a	MD 355 North	MD 355 and Stringtown Road	Rockville Metrorail station	14.6	16
10b	MD 355 South	Rockville Metrorail station	Bethesda Metrorail station	8.8	13
11	MD 650/New Hampshire Avenue	White Oak Transit Center	Fort Totten Metrorail station	8.8	9
12	Montgomery Mall/Old Georgetown Road	Montgomery Mall Transit Center	Bethesda Metrorail station	6.9	9
14	Randolph Road	White Flint Metrorail station	Glenmont Metrorail station	5.5	7
18	MD 193/University Boulevard	Wheaton Metrorail station	Takoma/Langley Park Transit Center	6.4	9
19	US 29/Columbia Pike/Colesville Road	Burtonsville park-and-ride lot	Silver Spring Transit Center	13.5	11
20	ICC	Life Sciences Center	Briggs Chaney park-and-ride lot	22.9	3
21	North Bethesda Transitway	Montgomery Mall Transit Center	Grosvenor Metrorail station	5.1	7
23	Midcounty Highway	Snowden Farm Parkway and Stringtown Road	Shady Grove Metrorail station	13.4	10

Figure ES4: Proposed BRT network



ES3.2. Ridership and operating costs

Based on the study's proposed implementation of BRT treatments—including exclusive transitways, transit signal priority (TSP) and queue jump lanes, and improved stations—a system of BRT routes could operate effectively within the county. The recommended 150-mile network of BRT routes could significantly increase daily transit use, with 165,000 to 207,000 BRT boardings and 52,000 new and 92,000 total daily linked transit trips[2] in Montgomery County.

The study applied the transit forecasting model developed by the Maryland Transit Administration and accepted by the Federal Transit Administration for use on the Purple Line and Corridor Cities Transitway Alternative Analysis projects. Forecasts were developed for the proposed BRT network, and ridership and operating costs were determined for the planning forecast year of 2040. In addition to the 16 proposed BRT routes, the modeled transportation networks assumed some modified commuter local bus service to reflect enhanced commuter access to the western county and to other regional transit options.

Model outputs used to determine ridership and operating costs were based on travel times developed from field work. Table ES2 identifies the end-to-end travel times for the routes and compares highway and local bus travel times.

[2] A linked transit trip is a trip composing the complete travel between an origin and destination. This can include walking or driving to transit, as well as one or more unlinked trips. An unlinked trip is one in which a passenger boards a transit vehicle

Table ES3 shows a similar comparison based on highway and local bus speeds and BRT speeds, as generated by the forecasting model.

Table ES2: Forecasted (2040) peak-period travel times for highway, local bus, and BRT

Route Number	Average Highway Time (min)	Average Local Bus Time (min)	Average BRT Time (min)	BRT Time Savings over Local Bus (min)	% BRT Time Savings over Local Bus
3	20.5	28.1	19.5	8.6	31%
4a	28.6	35.8	25.6	10.2	28%
4b	15.1	20.7	18.7	2.0	10%
5	19.3	28.8	22.4	6.4	22%
7	30.1	42.1	33.1	9.0	21%
8	31.9	42.6	29.2	13.4	31%
10a	43.1	63.4	45.4	18.0	28%
10b	34.2	50.2	34.7	15.5	31%
11	32.6	45.0	38.1	6.9	15%
12	19.1	26.4	20.5	5.9	22%
14	16.9	22.5	17.3	5.2	23%
18	17.5	24.7	16.1	8.6	35%
19	40.9	55.7	38.2	17.5	31%
20	37.7	41.7	37.7	4.0	10%
21	11.7	16.8	14.5	2.3	14%
23	32.7	42.7	32.7	10.0	23%
Average	***27.0***	***36.7***	***27.7***	***9.0***	***24%***

Table ES3: Forecasted (2040) peak-period travel speeds for highway, local bus, and BRT

Route Number	Average Highway Travel Speed (mph)	Average Local Bus Speed (mph)	Average BRT Travel Speed (mph)	BRT Speed Increase over Local Bus (mph)	% BRT Speed Increase over Local Bus
3	18.8	13.7	19.8	6.1	45%
4a	20.3	16.2	22.7	6.5	40%
4b	13.8	10.1	11.2	1.1	11%
5	14.8	9.9	12.8	2.9	29%
7	11.4	8.2	10.4	2.2	27%
8	15.3	11.5	16.8	5.3	46%
10a	19.1	13.0	18.1	5.1	39%
10b	15.3	10.4	15.1	4.7	45%
11	13.9	10.1	11.9	1.8	18%
12	15.7	11.4	14.7	3.3	29%
14	15.9	12.0	15.6	3.6	30%
18	21.7	15.3	23.6	8.3	54%
19	18.0	13.2	19.3	6.1	46%
20	30.2	27.3	30.2	2.9	11%
21	15.4	10.7	12.4	1.7	16%
23	23.3	17.8	23.3	5.5	31%
Average	***17.7***	***13.2***	***17.4***	***4.2***	***32%***

Detailed analyses of forecasts (highway networks, land use, speeds, etc.) were developed for the year 2040 to determine the functioning of the system in the forecast planning horizon year. In response to a request from MCDOT staff, the consulting team also conducted an analysis of land use projections *only* for the year 2020 (keeping all other factors constant for 2040) as a method to determine information that could be used for later decision making on corridor phasing. This information is presented in Table ES4 to provide context on assumed ridership and operating costs by the year 2040, as well as assumed by 2020. The forecasted ridership for 2040 is about double the ridership for existing Ride On service throughout the county.

Lastly, Table ES5 presents information on the estimated operations and maintenance (O&M) costs and farebox recovery ratios for the network by BRT route.

Table ES4: Daily boarding for BRT network, by daily boardings per route mile (year 2040)

Route Number	Daily Boardings			Daily Boardings/ Route Mile			Required Peak Headway			Percent of 2040 Achieved w/2020 Land Use
14 Randolph Road	13,400	-	16,800	3,000	-	3,700	4.3	-	3.6	80%
10b MD 355 South	23,200	-	29,000	3,000	-	3,700	4.2	-	3.5	70%
4b MD 97/Georgia Avenue South	8,200	-	10,200	2,300	-	2,900	3.5	-	2.9	94%
10a MD 355 North	30,400	-	38,000	2,200	-	2,800	2.5	-	2.1	71%
21 North Bethesda Transitway	6,600	-	8,300	2,200	-	2,800	5.9	-	4.9	80%
18 MD 193/University Boulevard	12,700	-	15,900	2,000	-	2,500	2.9	-	2.5	82%
12 MD 187/Old Georgetown Road	9,000	-	11,300	1,800	-	2,300	6.6	-	5.5	96%
5 Rockville Metro-LSC	6,100	-	7,600	1,300	-	1,600	12.0	-	10.0	78%
11 MD 650/New Hampshire Avenue	9,400	-	11,700	1,300	-	1,600	5.8	-	4.8	83%
4a MD 97/Georgia Avenue North	11,900	-	14,900	1,200	-	1,500	3.9	-	3.2	85%
19 US 29	13,700	-	17,100	1,100	-	1,400	3.7	-	3.1	92%
3 MD 586/Veirs Mill Road	6,200	-	7,700	1,000	-	1,200	12.0	-	10.0	83%
7 Lakeforest Mall/Muddy Branch Rd	4,400	-	5,500	800	-	1,000	12.0	-	10.0	69%
23 Mid-County	5,400	-	6,800	400	-	500	7.2	-	6.0	85%
8 MD 185/Connecticut Avenue	3,400	-	4,200	400	-	500	12.0	-	10.0	95%
20 ICC	1,600	-	2,000	100	-	100	18.0	-	15.0	70%
Total	*165,600*		*207,000*	*1,300*	-	*1,600*	--			*80%*

Table ES5: Annual O&M costs for BRT network, by O&M costs per boarding (year 2040)

BRT Route	Annual O&M Cost	O&M Cost/ Boarding	Farebox Recovery Ratio
14 Randolph Road	$5,974,000 - $7,168,800	$1.19 - $1.43	67% - 54%
21 North Bethesda Transitway	$3,654,000 - $4,384,800	$1.48 - $1.78	54% - 43%
5 Rockville Metro-LSC	$3,432,000 - $4,118,400	$1.51 - $1.81	53% - 42%
3 MD 586/Veirs Mill Road	$3,529,000 - $4,234,800	$1.55 - $1.86	52% - 41%
18 MD 193/University Boulevard	$8,047,000 - $9,656,400	$1.70 - $2.04	47% - 38%
12 MD 187/Old Georgetown Road	$6,357,000 - $7,628,400	$1.88 - $2.26	43% - 34%
4b MD 97/Georgia Avenue South	$5,757,000 - $6,908,400	$1.90 - $2.28	42% - 34%
10b MD 355 South	$16,931,000 - $20,317,200	$1.96 - $2.35	41% - 33%
7 Lakeforest Mall/Muddy Branch Rd	$3,955,000 - $4,746,000	$2.41 - $2.90	33% - 27%
4a MD 97/Georgia Avenue North	$11,383,000 - $13,659,600	$2.57 - $3.09	31% - 25%
11 MD 650/New Hampshire Avenue	$9,832,000 - $11,798,400	$2.81 - $3.37	28% - 23%
10a MD 355 North	$34,584,000 - $41,500,800	$3.06 - $3.67	26% - 21%
8 MD 185/Connecticut Avenue	$4,263,000 - $5,115,600	$3.38 - $4.06	24% - 19%
19 US 29	$18,716,000 - $22,459,200	$3.67 - $4.40	22% - 17%
23 Mid-County	$7,851,000 - $9,421,200	$3.86 - $4.64	21% - 17%
20 ICC	$6,290,000 - $7,548,000	$10.74 - $12.88	7% - 6%
Total	*$150,555,000 - $180,666,000*	-	*33% - 26%*

Note: Farebox recovery ratio is the percentage of annual O&M costs regained from fares, based on an assumed trip fare. BRT O&M cost estimates assume average of 70 persons/bus during peak hour. Farebox recovery assumes an average fare per BRT boarding of $0.80.

ES3.3. Capital costs

The capital costs for the proposed network were derived using estimating methods at a planning analysis level. Unit costs used were taken from Maryland State Highway Administration's 2010 Price Index. Professional experience on other BRT system and corridor studies nationwide, and documentation of unit costs from the FTA *Characteristics of Bus Rapid Transit for Decision-Making* report and TCRP *Report 118: Bus Rapid Transit Practitioner's Guide* also were applied. Projects recently constructed within the county were consulted to identify whether cost estimating methods were reasonable and an adjustment applied based on the costs noted in those projects. The costs do not include right-of-way, utility relocation, or stormwater management costs, as these assessments were beyond the scope of work for this study. Table ES6 summarizes the elements comprising the network.

Table ES6: BRT system element costs (2010 dollars)

System Element	Unit Costs
Guideways and bus lanes	$56-$1,643 per linear foot
TSP	$25,000 per intersection
Queue jumps	$10,000 per approach
Intersection widening	$1.8-$2.9 million for both sides of roadway
Stations	$110,000-$220,000 per station
Concrete pads	$26,728 per pad
Articulated buses	$1.1 million per bus
Maintenance facility	$356,000 per bus
Add-ins	25% of route/system cost (excluding vehicles)

Note: Maintenance facility costs were averaged across the total number of buses in system fleet.

The cost of the system, a network of approximately 150 route-miles including all the elements listed previously, is estimated to range between $2.3 and $2.5 billion (without right-of-way costs) in 2010 dollars. This reflects the cost of incorporating the highest level of design possible for the proposed BRT system. Actual total system costs would vary based on anticipated funding availability and implementation strategy. Table ES7 summarizes the elements comprising the network.

Table ES7: Summary of treatment assumptions for the network

Elements	**Quantity**	
Guideway and bus lane segments	Absolute total	Percentage of network
two-way guideway only	*24 route miles*	*16%*
one-way guideway only	*48 route miles*	*32%*
guideway and bus lane	*27 route miles*	*18%*
bus lane (both directions)	*1 route mile*	*< 1%*
bus lane (one direction)	*7 route miles*	*5%*
no guideway and bus lanes	*44 route miles*	*29%*
Queue jumps		
by location	*26 intersections*	
by direction	*37 queue jumps*	
TSP	174 intersections	
Stations		
by location	*150 sites*	
by platforms	*367 (median and curb)*	
Concrete pads	209 pads	
Articulated vehicles	284 buses (peak period); 347 buses (total fleet)	

A 30 percent contingency was applied to the derived construction costs for guideway and bus lanes treatments, signal priority treatments, intersection widenings, and stations, given the conceptual nature of the study. A 15 percent contingency was applied to maintenance facilities because the unit cost is comparable to estimates from recently constructed facilities. These contingencies do not assume right-of-way purchase. The consulting team allocated a portion of the estimated costs to utility modifications, pavement drainage, and maintenance of traffic. However, refined costs for elements such as major utility relocation and structures (including drainage structures and overhead lane use control structures) and off-roadway stormwater detention were not included in the capital costs but may be covered by the construction contingency. The estimated capital costs derived for this study are to be considered only as a planning level assessment. More detailed studies identifying specific alignments, cross-sections, and roadway characteristics along each of the 16 routes would be required to develop a more specific estimate.

ES4. Key Considerations

This study presents a conceptual high-investment BRT network operating within the rights-of-way of county and state roadway corridors. While it provides a foundation for a viable network, several considerations must be addressed prior to developing final policy and investment level decisions and prior to advancing individual routes for implementation.

ES4.1. Detailed Recommendations

The results presented in this document provide a level of detail appropriate for generating an initial understanding of potential demand in the identified corridors. More refined analysis that informs local bus service changes needed to support the BRT system and include ongoing demand forecasting model adjustments underway for other studies will be required before developing final corridor demand estimates that can then be used to develop implementation policies.

ES4.2. Costs

It is difficult to know all the impacts along a corridor based on the level of analysis consistent with a feasibility study. Constructing a high-investment BRT network affects elements such as right-of-way and utility relocation. While the consulting team allotted some of the capital costs and applied contingencies toward utility reconstruction and pavement drainage systems, detailed corridor studies would extensively document the infrastructure impacts of constructing and implementing BRT treatments. Additionally, detailed field reviews and measurements would identify specific right-of-way impacts expected. Again, right-of-way estimates are not included in the cost estimates generated by this study.

ES4.3. Land use and BRT branding

Two of the key BRT elements—land use and branding—can significantly affect system ridership. Additional studies should consider whether increased transit-oriented development is warranted along individual BRT corridors to help assure the viability of the system. The county should institute a branding campaign should this network advance to implementation. Attracting passengers who associate BRT with a form of premium transit service would be expected to increase the system’s chance of strong, sustained ridership.

ES4.4. Implementation

Next steps toward implementation based upon the findings of this study will be defined by the County Executive, County Council, MCDOT, M-NCPPC, Maryland State Highway Administration, and Maryland Transit Administration. Refined studies focused on specific corridors would identify more factors affecting the success of BRT routes, and consider the refined package of facility and service improvements based on anticipated funding availability.

1 INTRODUCTION

This report outlines the effort to define a viable network of BRT routes that would enhance Montgomery County's diverse existing and planned transportation options. This study was a yearlong effort conducted by the consulting team, with guidance from MCDOT and a multi-agency technical advisory group. It presents a proposed BRT network that provides the highest level of service possible within the constrained transportation rights-of-way, while balancing the importance of regional connectivity and need for a cost-effective transit system.

The study focused on a BRT system that emulates light rail operations in terms of the features provided, but operates on the arterial roadway system in the County and relying on walk access, local bus transfers, and some non-Metrorail park-and-ride access. It combines the most attractive features of light rail with the lower costs of bus technology. Instead of trains and tracks, BRT invests in improvements to roadways, rights-of-way, intersections, and traffic signals to speed up bus transit service.

BRT service differs from commuter bus service, which focuses on peak-period service during the weekday with limited trips, intermediate stops, and dependence on park-and-ride access. Therefore, BRT, when referenced in this study, is premium bus service operating with the following characteristics:

- All-day service
- Higher frequencies
- Stops at 1/2- to one-mile spacing
- Provision for exclusive lanes
- Transit signal priority and queue jumps
- Enhanced stations with greater passenger amenities
- Real-time passenger information
- Potential for off-board fare collection
- Efficient boarding and alighting

The consulting team developed viable BRT routes that could qualify for federal funding. FTA provides funding for "small starts" projects, such as the proposed BRT routes, that meet the following criteria:

- Having substantial transit stations
- Providing traffic signal priority or pre-emption
- Would operate with vehicles with low floors or level boarding
- Targeted branding of the proposed service
- *Operating at 10-minute peak/15-minute off-peak headways or better and for more than 14 hours each weekday*

Developing a network that supports frequent bus service was a major factor in creating the initial BRT corridors. Based on professional experience, the consulting team found it most reasonable to identify those roadways adjacent to or traversing developments with BRT-supportive densities of at least six households or five employees per acre.

In November 2010, MWCOG updated its land-use model to Round 8.0, providing forecasts through the year 2040. The study incorporated this latest land-use model during the demand-modeling phase. It also modified—under the guidance of MWCOG and M-NCPPC— the 2030 highway network to include all new transit and highway projects planned and programmed in MWCOG's 2040 CLRP.

One of the primary means for conveying the fastest possible travel with BRT service is to provide exclusive guideways. The consulting team selected median guideways as a solution because they facilitate higher operating speeds with fewer traffic conflicts compared to bus lanes on curbside or service roadways. Appendix A compares the three transitway types, focusing on their application on a section of MD 355 in Rockville.

This study presents a BRT network based on a level of investment that could generally be implemented within the County's right-of-way, most according to the following investment scenario framework:

- Priority treatment: Mainly roadway segments
- Service levels: Meeting FTA thresholds in all corridors
- BRT facility: Upgraded stations/real-time passenger information at all stops/off-board fare collection

Such a network would consist of exclusive BRT lanes (referred to as guideways in this report) located within roadway medians; general purpose lanes converted into bus-only lanes operating in the peak period; intersection priority treatments; and enhanced stations with fare collection machines, real-time passenger information displays, level-boarding platforms, benches, extended shelters, and other passenger amenities. Most stations would exist within the guideways; curbside stations would exist in locations where median guideways are not possible. Travel times for this network would reflect the high investment in treatments that benefit BRT service. The network also assumes the use of 60-foot articulated buses, stations designed to accommodate two articulated buses at a time, and additional maintenance facilities beyond those already owned and operated by the County.

1.1 Key additional elements of BRT network

This study focused on the feasibility and cost implications of developing and constructing a BRT system within the County's constrained right-of-way. However, other BRT characteristics—namely, relationship to land use, station access, and brand identity—play key roles in a successful system. The following sections briefly discuss these characteristics.

1.1.1 Relationship to land use

BRT routes operating along corridors with high concentrations of development that support transit make BRT service more effective as a transportation option. Transit-oriented development is a key component for successful BRT. BRT takes advantage of the pedestrian and customer activity found in areas with higher land use densities and a mixture of types of development, including residential, retail, employment, and entertainment.

Automobile use and parking needs can decrease where there are clusters of such development. BRT corridors require a minimal level of concentrated development. For this study, a threshold of at least six households or five employees per acre was used during early analysis as a method for identifying corridors where BRT service may be appropriate. The planning horizon year of 2040 includes the recently approved White Flint, Great Seneca Science Corridor and the Germantown Plans, all of which focus on transit–oriented communities.

Figure 1-1: Examples of BRT system elements with respect to surrounding land uses

(a) BRT station in Cleveland

(b) BRT corridor in Curitiba, Brazil (station highlighted by blue circle)

1.1.2 Station access

Improved bicycle, pedestrian and auto access to stations, and the correct placement of the station locations are critical factors in the success of a BRT system. Considerations for station locations in this study included placement at existing bus stops, Metrorail or planned light rail stations, transit centers, and park-and-ride lots. Detailed corridor implementation programs following this study should also consider the surrounding physical environment to enhance or improve access to BRT stations. BRT stations also must be accessible to passengers with varying levels of physical abilities.

Figure 1-2: Ensure BRT is accessible to all riders

Source: www.gobrt.org

1.1.3 Brand identity

Branding of BRT service conveys to new transit users and users unfamiliar with BRT that they are encountering a premium transit system with enhanced service and amenities. Typical branding methods include:[3]

- Branding stations and terminal features such as bus/BRT stop signs, passenger information boards, fare collection equipment, and media
- Giving vehicles a special styling, unique livery, added passenger amenities, and marketing panels
- Branding running ways by using special paving materials, colors, and markings
- Branding marketing materials such as route maps, route schedules, web sites, and media information

[3] TCRP Report 118: Bus Rapid Transit Practitioner's Guide

Figure 1-3: Examples of brand identity – Orange Line BRT in Los Angeles

(a) Orange Line BRT vehicle

Source: www.wikimedia.com

(b) Orange Line station

Source: www.3-b-s.eu

1.2 Organization of report

Chapter 2 of this report covers the processes used to identify a proposed BRT network beginning with initial corridor definition to route modeling. Note that, although it proposed a network operating within the County's rights-of-way, the consulting team also modeled a baseline, unconstrained BRT network that assumed unlimited rights-of-way and funding. Chapter 3 present the proposed BRT network resulting from the efforts outlined in Chapter 2. Chapter 4 shows the capital and operating costs for the BRT network. The appendices provide technical supplements to the report and are excerpts of the memoranda developed during the course of the study.

1.3 Acknowledgments

The consulting team—including Loiederman Soltesz Associates, Inc. and Gallop Corporation, and led by staff from Parsons Brinckerhoff—would like to acknowledge the invaluable contributions of the client agency, core members of the technical advisory group, and many others. The results of this study exist because of the dedication, professional expertise, data, and time given by these contributors.

- City Of Gaithersburg
- City of Rockville
- Howard County Department of Planning and Zoning
- Maryland-National Capital Park and Planning Commission
- Maryland State Highway Administration
- Maryland Transit Administration
- Metropolitan Washington Council of Governments

- Montgomery County Department of Transportation
- Montgomery County Council
- Washington Metropolitan Area Transit Authority

2 STUDY METHODOLOGY

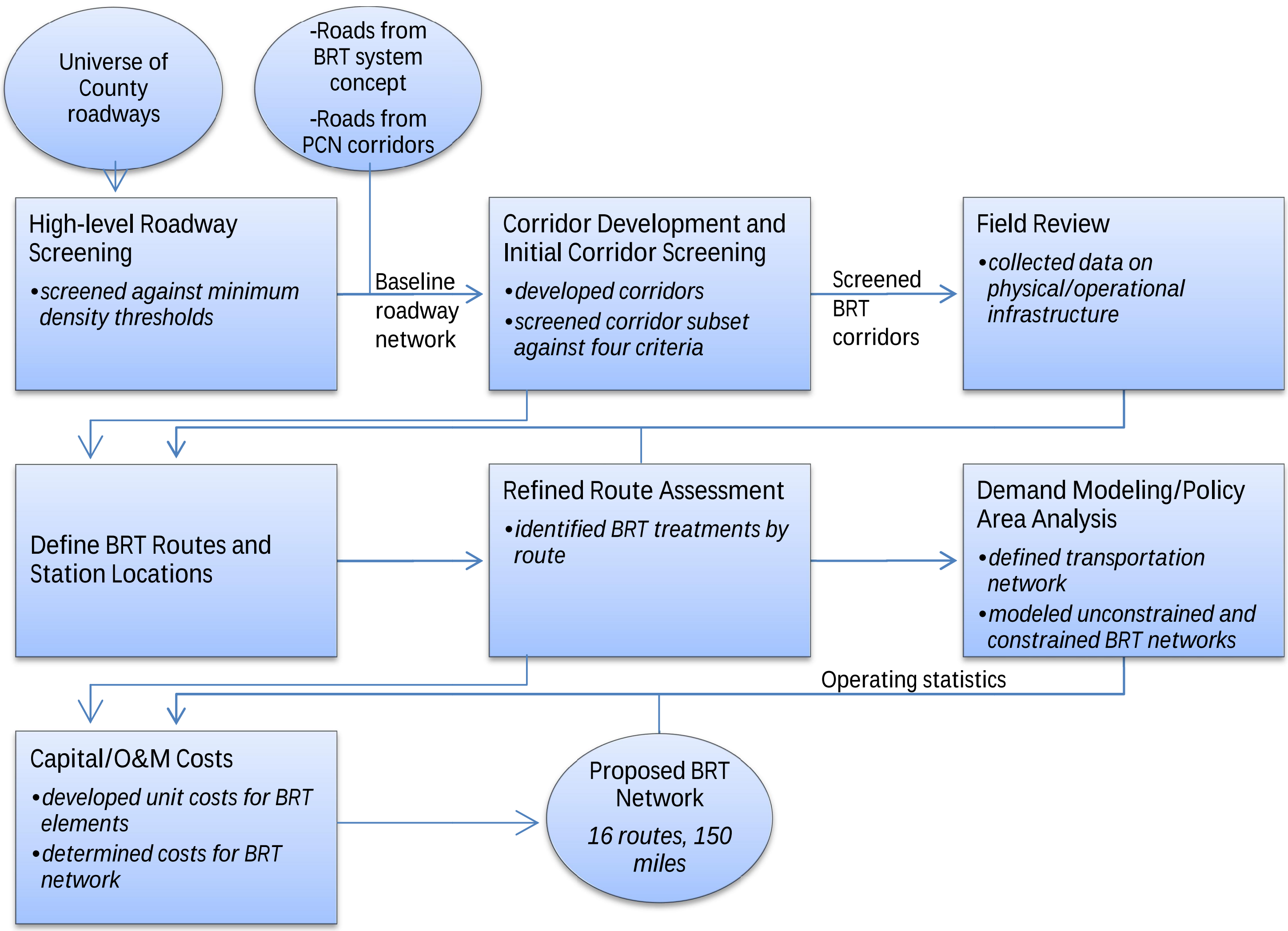
The study consisted of several tasks that led to a set of viable BRT routes that could operate along state and county roadways in Montgomery County, as shown in Figure 2-1. The tasks were as follows:

1. Conduct high-level review of state and county roadways
2. Develop potential BRT corridors
3. Conduct an initial corridor screening to advance viable BRT corridors
4. Conduct field reviews along potential BRT corridors
5. Define potential BRT routes and station locations
6. Conduct refined route assessments to identify applicable BRT treatments
7. Determine travel demand within the BRT network and for other transit modes in the County, as well as testing performance measures
8. Determine capital and operating costs for the BRT network

This chapter discusses Tasks 1 through 7; Task 8 is discussed in Chapter 4.

The study was sensitive to providing a balanced network that accessed not only destinations along the major radial corridors in the County, but also provided cross-County access to key destinations present and planned on the east and west sides of the County. The corridor scoring system emphasized this effort in the preliminary and revised scoring methodologies.

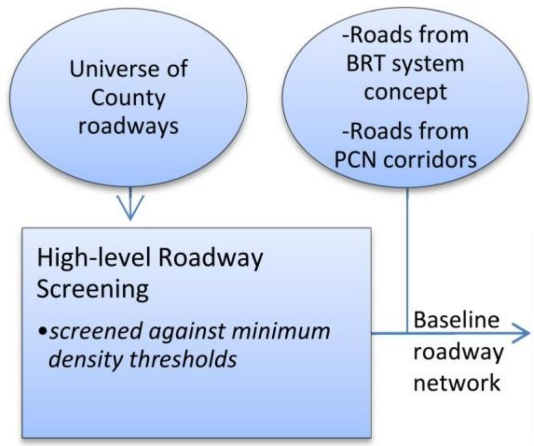
Figure 2-1: Study process and interdependencies



2.1 High-level roadway screening

The team began the study by conducting a high-level screening of all roadways in the County classified as county roads, state roads, and divided highways. The purpose of this initial task was twofold. First, it defined a baseline roadway network that may function as BRT corridors and removed from consideration state and county roadways less likely to support possible BRT corridors, as identified in the Small Starts funding criteria described in Chapter 1. Second, this list limited the analysis to a level that could be accomplished within the scope of this study.

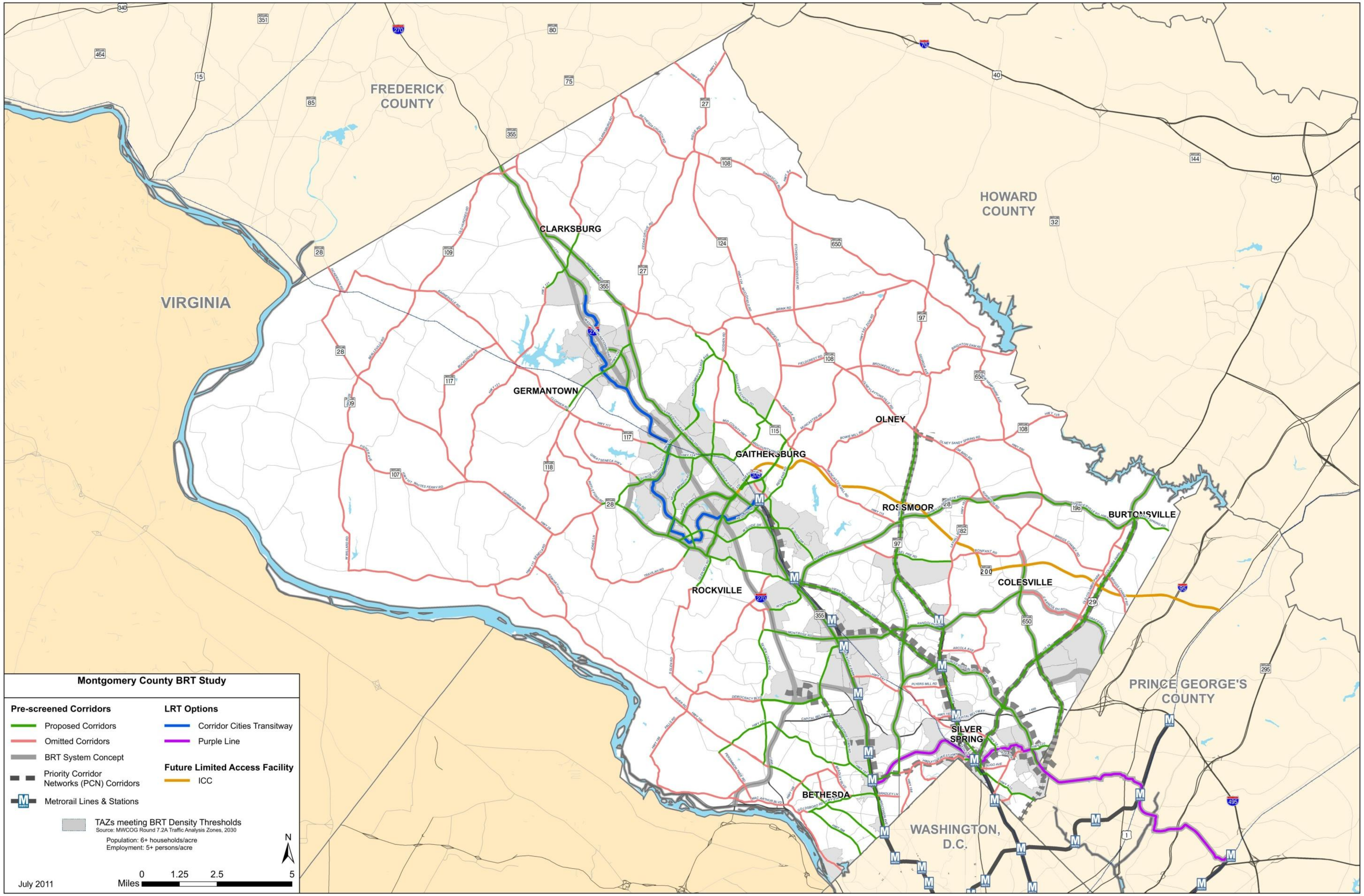
The consulting team assumed that roads providing access to land uses with at least six households or five employees per acre could support BRT service. This was determined by analyzing traffic analysis zones (TAZs) for existing and future (year 2030) conditions within the County. Supplementing this baseline roadway network were the following County roads reviewed by other studies and discussions:



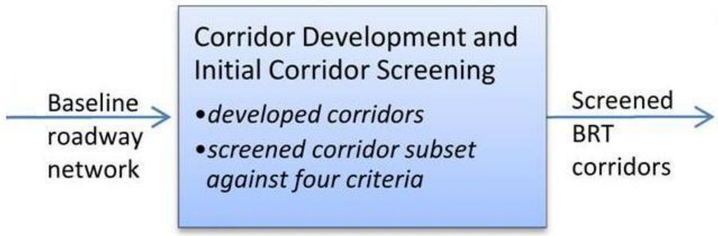
- Roads identified in the 2008 BRT system concept proposed by Councilman Marc Elrich and his staff
- Roads included in the 2010 draft MWCOG report, *An Evaluation of the Metrobus Priority Corridor Networks*, including proposed corridor improvements recently advanced through the federal TIGER grant application

Figure 2-2 highlights the baseline roadway network resulting from this screening.

Figure 2-2: Baseline roadway network



2.2 Corridor development and initial corridor screening



The consulting team used the baseline roadway network and input from the technical advisory group to create 23 BRT corridors on which to conduct an initial corridor screening. The following conditions guided the corridor development.

- Corridors should be at least five miles in length, where possible.
- Corridors should terminate at potential BRT corridors, a major attraction/activity center, premium transit stations, or a county or District border.

Table 2-1 summarizes the initial corridors, and Figure 2-3 shows the initial corridors.

The team conducted the initial corridor screening using four criteria to advance a network of potential BRT corridors for further assessments. The criteria represented characteristics that would facilitate BRT service. The criteria were as follows:

1. Existing daily bus trips
2. Percent of corridor within a 1/2-mile radius having BRT-supportive density under future conditions
3. Presence of major attractors/activity centers
4. Regional transit connectivity

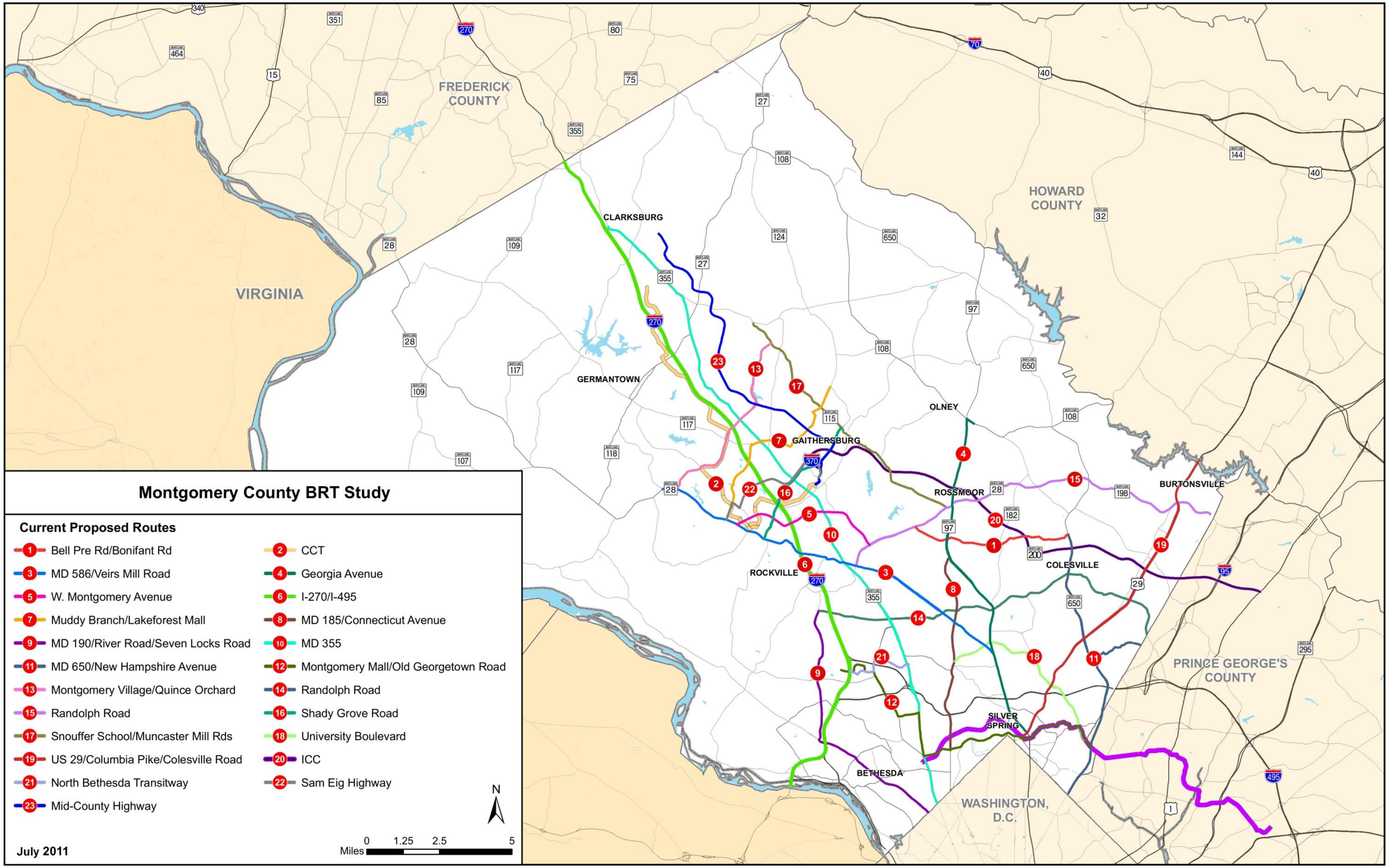
Using these criteria, the consulting team applied two sets of screening methodologies. One was a preliminary methodology and the other was a revised methodology, with each including a weighted scoring system. The revised screening methodology, developed with input from the advisory group, helped reduce the effects of some corridors having a greater concentration of BRT-supportive characteristics compared to others, as well as increased the opportunity for balanced (north-south and east-west) connectivity throughout the County. During the process, several corridors were either shortened or split into multiple corridors. Appendix B provides detailed information for both screening methodologies and the changes made to the initial BRT corridors based on meetings with the advisory group.

Table 2-1: Initial BRT Corridors and Termini

Corridor Number	Corridor	Corridor Length (miles)	From	To
1	Bel Pre Road/Bonifant Road	5.5	Georgia Avenue	New Hampshire Avenue
2	CCT (master plan alignment)	14.8	COMSAT	Shady Grove Metrorail station
3	Darnestown Road/Montgomery Avenue/Veirs Mill Road/MD 586	13.2	Quince Orchard Road	Georgia Avenue
4	Georgia Avenue/Olney Sandy Spring Road[4]	13.6	Olney Sandy Spring Road and Spartan Road	Silver Spring Metrorail station
5	Gude Drive/Key West Avenue	5.2	MD 28/Darnestown Road	Norbeck Road
6	I-270/I-495	24.2	Frederick County border	VA border
7	MD 124/Muddy Branch Road	7.0	Airpark Road	MD 28
8	MD 185/Connecticut Avenue	6.9	Georgia Avenue	East-West Highway
9	MD 190/River Road/Seven Locks Road	9.2	Montrose Road	DC border
10	MD 355[5]	23.7	Comus Road, Clarksburg	DC border
11	MD 650/New Hampshire Avenue	10.2	Bonifant Road	DC border
12	Montgomery Mall/Old Georgetown Road/Rockville Pike/East-West Highway	12.3	Westlake Terrace	University Boulevard
13	Montgomery Village Avenue/Quince Orchard Road	6.5	Snouffer School Road	MD 28
14	Montrose Road/Randolph Road/Cherry Hill Road	12.8	Seven Locks Road	Prince George's County border
15	Norbeck Road	13.9	Rockville Metrorail station	Prince George's County border
16	Shady Grove Road	4.8	MD 28	Muncaster Mill Road
17	Snouffer School Road/Muncaster Mill Road	9.6	Brink Road	MD 28/Norbeck Road
18	University Boulevard	6.6	Connecticut Avenue	University Boulevard
19	US 29/Columbia Pike/Colesville Road	11.7	Burtonsville	Silver Spring Metrorail Station
20	ICC	18.6	MD 355 and I-370	Prince George's County border
21	North Bethesda Transitway	5.1	Westlake Terrace	Grosvenor Metrorail station
22	Sam Eig Highway	14.8	Shady Grove Metrorail station	Belward Farm
23	Midcounty Highway[6]	13.4	Clarksburg	Shady Grove Metrorail station

[4] Later separated into two corridors: 4a: Georgia Avenue North and 4b: Georgia Avenue South
[5] Later separated into two corridors: 10a: MD 355 North and 10b: MD 355 South
[6] Corridor was developed during later stages of the study in response to comments.

Figure 2-3: Initial BRT Corridors



The results of the revised methodology identified the 16 corridors that would ultimately comprise the BRT network tested during demand forecasting activities. These corridors were advanced for refined assessment. Eight corridors advanced without being screened because they had been evaluated for transit enhancements in previous studies. Another eight corridors advanced based on their scores from the revised screening methodology. The CCT corridor was removed from further consideration because it is part of the long-range transportation plan as a separate project.

The results of the initial screening prompted additional corridor changes. Corridor 4 was made into two routes of reasonable lengths. Corridor 4a: Georgia Avenue North would operate between Olney and Wheaton. Corridor 4b: Georgia Avenue South would operate between Wheaton and Silver Spring Metrorail station. Additionally, the Corridor 5 was made a circulator route. Added to it were the segments of Corridor 3 operating along Darnestown Road and Montgomery Avenue, as well as small segments along Great Seneca Highway, Norbeck Road, MD 355, and a few local roads within Rockville Town Center. This formed Corridor 5: Rockville Loop, operating to the Life Sciences Center area by way of Rockville Metrorail station.

Table 2-2 lists the corridors advanced for refined assessment.

Table 2-2: Corridors Advanced for Refined Assessment

Advanced without screening	Advanced with screening (in order of highest scores)
Corridor 3: MD 586/Veirs Mill Road[7]	Corridor 10a: MD 355 North[8]
Corridor 4a: Georgia Avenue North[9]	Corridor 5:Rockville Loop[10]
Corridor 4b: Georgia Avenue South[10]	Corridor 12: Montgomery Mall/Old Georgetown Road
Corridor 10b: MD 355 South[8]	Corridor 13: Montgomery Village Avenue/Quince Orchard Road
Corridor 14: Montrose Road/Randolph Road/Cherry Hill Road	Corridor 16: Shady Grove Road
Corridor 18: University Boulevard	Corridor 7: MD 124/Muddy Branch Road
Corridor 19: US 29/Columbia Pike/Colesville Road	Corridor 8: MD 185/Connecticut Avenue
Corridor 21: North Bethesda Transitway	Corridor 11: MD 650/New Hampshire Avenue

The following four corridors did not advance under either screening methodology.

- Corridor 9: Bel Pre Road/Bonifant Road
- Corridor 13: MD 190/River Road/Seven Locks Road
- Corridor 17: Snouffer School Road/Muncaster Mill Road
- Corridor 18: Norbeck Road

Although Corridors 9 and 18 were desirable for east-west connectivity, their scores suggested they could best be suited for less-frequent service.

[7] This corridor was shortened to operate only along Veirs Mill Road.
[8] This corridor was initially part of Corridor 10: MD 355
[9] This corridor was initially part of Corridor 4: Georgia Avenue/Olney Sandy Spring Road
[10] This corridor was created by combining Gude Drive and Key West Avenue with Great Seneca Highway, Norbeck Road, MD 355, and a few local roads within Rockville Town Center.

The modeled transportation network discussed in Section 2.4 included some modified local bus routes (increased service) to test enhanced commuter access to the across the County that were added in response to stakeholder comments. These modifications were as follows:

- Increased bus frequencies during the peak periods for Ride On Route 52
- Combined Metrobus Routes Z2 and K6 to provide increased bus frequencies between Olney and Ft. Totten Metrorail station
- Combined Metrobus Routes C8 and C9 to provide increased bus frequencies between the White Flint area and Greenbelt Metrorail station

None of these routes performed at a level that would make them viable for BRT routes given the identified assessment criteria.

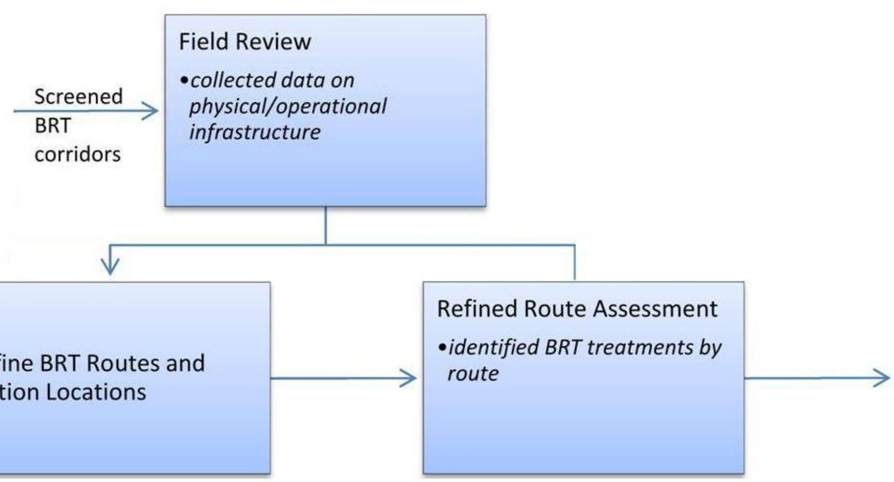
2.3 Field review and refined route assessment

The consulting team conducted a refined assessment of the 17 potential BRT corridors advanced from the initial screening (refer to Table 2-2 in Section 2.2 of this report). This involved a four-day field review creating an inventory of existing physical conditions to highlight opportunities for and constraints to implementing BRT service. The consulting team also supplemented its field survey data with aerials and GIS data to conduct the refined route assessment. This provided a thorough picture of the following conditions along each corridor:

- Roadway cross sections
- On-street parking
- Sidewalks
- Bicycle lanes
- Curbs
- Shoulders
- Medians
- Overhead utilities
- Bus stops
- Bus stop features
- Surrounding development
- Major traffic generators
- Ability to widen the roadway
- Right turn lanes
- Congestion (queuing)
- Density of development

Although the focus was recommending transitway treatments that could be built within the County's right-of-way, this study notes that implementing such a network would involve realigning roadway cross-sections, sometimes beyond the existing right-of-way. For example, exclusive guideways would use the envelopes of existing medians and left-turn lanes at signalized intersections. However, the left-turn lanes would be replaced to maintain similar levels of traffic operations along the corridors. GIS measurements and aerial photographs provided the level of detail needed for this feasibility study.

The inventory helped the consulting team assess the potential to implement guideways, intersection priority, and stations along each corridor. Implementing guideways considered whether they could be built within the roadway median, within the roadway traffic lanes, or alongside the roadway. A guideway alongside the roadway was only considered if the right-of-way currently existed, such as using shoulders for bus-only lanes. Intersections were reviewed to identify possible locations for TSP, queue jump lanes and signals, or special turn signals. Lastly, the inventory helped with identifying station locations to facilitate walk access, passenger drop-off and pickup, bus transfers, and park-n-ride access. Appendix C details the methodology used and assumptions made for locating these system components.



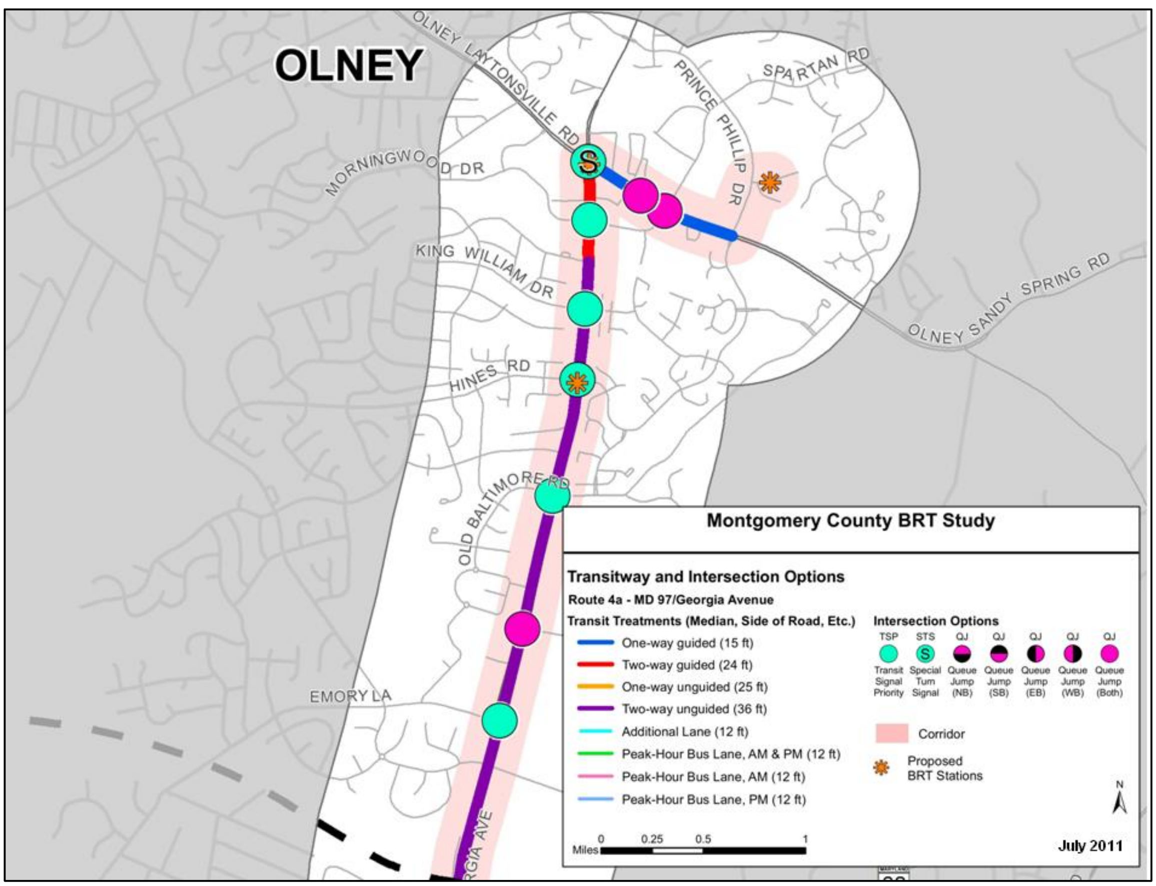
The consulting team packaged guideways, intersection treatments, and station locations for each route. Termini were also clearly defined, as were locations for buses to possibly turn around and restart their routes. Appendix D contains maps illustrating the proposed treatment options and station locations for each route.

Each map shows the locations of all possible BRT treatment options along a route. The legend on each map helps interpret the limits and locations of the treatment options. For example, Figure 2-4 shows the northern portion of Route 4a: Georgia Avenue North. As noted in the legend, the map shows the potential for a one-way guided transitway along Olney-Laytonsville Road between Prince Philip Drive and Georgia Avenue. It is also possible to implement a two-way guided transitway and transition to a two-way unguided transitway along Georgia Avenue starting at Olney-Laytonsville Road. Additionally, the map shows three locations for potential BRT stations, as well as TSP and queue jump options located at numerous signalized intersections along the route.

The consulting team also developed templates of roadway and intersection reconfigurations, with general dimensions for widened roadways. Appendix E contains these templates. Future corridor studies would provide detailed measurements for any required roadways shifts.

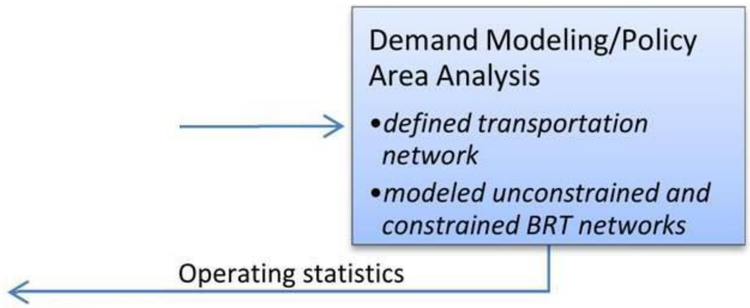
The travel times calculated for each route were based on the information contained within these maps; Section 2.4 of this report discusses the modeling of the network.

Figure 2-4: Example treatment options map – Route 4a: Georgia Avenue North



2.4 Demand modeling/policy area analysis

2.4.1 Background on the forecast model



Analyzing the relative potential of the BRT network in the county required application of a demand forecasting model with a level of detail necessary to determine transit trips along each of the corridors analyzed for this study. This study benefitted from work completed by MTA on a demand forecasting model used for the Purple Line and CCT Alternative Analysis projects. The model, termed the MDAA model—or Maryland Alternative Analysis model—is now in its second phase (MDAAII) and includes a number of improvements to the forecasting model maintained by MWCOG for the specific purpose of generating ridership estimates.

One of the benefits of the MDAAII is that in incorporates very detailed ridership information from the MWCOG 2007 regional bus survey and a Metrorail rider survey funded by MTA. The work to construct the MDAAII model included a number of refinements, including; improving consistency between bus speeds and highway congestion, adding flexibility to the fare model, full implementation of the parking capacity restraint routine, and a corrected defined hierarchy of modes. All of these technical refinements were completed to make the model more reliable for forecasting transit trips.

The forecasting effort conducted for this study was appropriate to help determine whether a BRT system was viable. The scope of the work effort allowed for limited assessments of model coding, transit connectivity, land use or other specific model inputs that can impact ridership forecasts. Additionally, it was the first study in which the MDAAII's transit network included both the Purple Line and Corridor Cities Transitway projects. The results presented in this document should, therefore, be considered a cursory assessment of the viability of the system, applying the results to policy decisions or in setting funding priorities would be an incorrect application of the material presented here.

2.4.2 How models are applied

Demand forecasting models are used to judge the relative benefits of transportation projects when assessed from the perspective of a particular moment in time. They are built from the statistical analysis of travel patterns and use information from current year travel to determine how future travelers would make decisions for choosing a method for travel. Often travel decisions are based on a cost of travel which can include the time spent traveling, costs (vehicle operations or fare), and directness of the trip. Model inputs take into account the type of trip (home to work, home to shopping, work to daycare, etc.) as well as the location of various land use types (employment, shopping, etc.). Models are not prescient and cannot be considered exact ridership estimates for future facilities. Instead they are considered as a tool in determining the relative attractiveness of a travel option when compared to other travel options or other alignments for the same trip type (such as LRT or BRT).

Transportation planning for facilities usually relies on identifying a planning horizon year for analysis to determine how the transportation facilities could function given their construction within an identified period. Typically, a 30-year horizon year is used for transportation projects and regional planning agencies have been tasked with developing long-range transportation plans that extend 30 years out to identify improvements and could reasonably be expected to be funded within that timeframe. These plans are developed typically in five- to 10-year increments to coincide with the release of data from the US Census Bureau and are used to check conformity with air quality emissions targets set for the region.

For this project a horizon year of 2040 was used to determine the operation of the BRT network, with the base year being the 2010 census year. Transportation improvements in this 30-year timeframe are identified by MWCOG in their document *National Capital Region Transportation Planning Board Constrained Long Range Plan* (CLRP) and include those projects that are expected to be built given financial constraints in the region. This 2040 plan for the region is termed the constrained long-range plan for its assessment of financial constraints and the likelihood of transportation facilities being constructed.

2.4.2.1 Comparison to no-build conditions

Analysis of transportation projects is completed by comparing how new or altered facilities would function in an identified future year. For this project the models were used to identify ridership potential along a network of BRT routes which were identified as an output of the screening process identified in the previous section. The analysis is conducted against what is termed the “no build” conditions, which means that none of the BRT network has been built, but that all other projects identified in the CLRP are constructed. For this project this means that the Purple Line and Corridor Cities Transitway projects are assumed to have been built by the year 2040 as have other roadway improvements. Table 2-3 and Table 2-4 identify those projects that are assumed to have been constructed by the year 2040 in Montgomery County and are in the areas near the identified BRT network.

Table 2-3: Constrained long-range plan for 2040 – transit projects

Improvement	Facility	Limits		Lanes		Completion Year
		From	To	From	To	
Construction	Purple Line	Bethesda	New Carrollton			2020
Construction	CCT	COMSAT	Shady Grove Metro			2020
Construction	Veirs Mill Rd Enhancements	Rockville	Wheaton			2015

Note: Veirs Mill Road transit enhancements were included in route recommendations.

Table 2-4: Constrained long-range plan for 2040 – highway projects

Improvement	Facility	Limits		Lanes		Completion Year
		From	To	From	To	
Construction	ICC	I-270	I-95/US 1	0	6	2012
Construction	US 29	Interchange at Musgrove/Fairland Rd.	--	6	6	2025
Upgrade	MD 97	Interchange at MD 28 (Norbeck Rd)	--	6	6	2020
Upgrade	MD 97	Interchange at Randolph Rd	--	6	6	2015
Construction	MD 355	Montrose/Randolph Rds	CSX RR	6	6	2015/2020
Reconstruction	BRAC intersection improvements near NNMC	--	--	--	--	2012
Widen	MD 27	MD 355	A305 (Mid County Hwy ext)	4	6	2020
Construction	MD 28	MD 97	I-95	2/4	4/6	2025
Construction	A305 (Mid County Hwy ext)	MD 355	MD 27	0	4	2010
Construction	Chapman Avenue	Randolph Rd	Old Georgetown Road	0	2	2014
Widen	Father Hurley /Ridge Rd.	I-270	MD 27	4	6	2010
Construction	M83 (Mid County Hwy)	Middlebrook Rd	Montgomery Village Ave	0	4-6	2020
Widen	MD 118 ext	MD 355	Watkins Mill Rd	3	4	2020
Widen	Middlebrook Rd ext	MD 355	M83	3	4	2020
Construction	Montrose Pkwy E	Parklawn Dr	Veirs Mill Rd	0	4	2015
Construction	Nebel Rd ext	Randolph Rd	Target Store site	0	4	2011
Construction	Randolph Rd	Parklawn Dr	Rock Creek Park	4	5	2020
Construction	Watkins Mill Rd ext	I-270	MD 355	0	6	2011

2.4.2.2 Land-use assumptions

A process similar to that used to develop the assumed 2040 transportation network is used by the county and MWCOG to generate land use forecasts for population, households and employment (by type) for geographic units termed traffic analysis zones. These traffic analysis zones are the basis for determining the number of trips into and out of a bounded geographic area, which are then distributed over the transportation network to generate forecasts. Land-use forecasts are developed after careful review of approved master plans and working within a county control total to derive these figures for the future year. This work is done in Montgomery County by M-NCPPC, which then forwards them to MWCOG to determine land use assumptions for the entire Washington region.

This study uses the Round 8 forecasts developed by MWCOG as its baseline land use forecast for the year 2040. This land use forecast includes, among other things, new land use estimates for the White Flint, Germantown, and Life Sciences areas of the county for recently approved master plans for those areas.

2.4.2.3 Travel time assumptions

A critical factor in analyzing a BRT network is the travel time determinations for each route as the relative travel speed of the BRT mode as an option for travel is an important decision point for travel. The effort to determine travel speeds for each corridor was based in the field work and corridor recommendations determined in the field and described in the previous section. Travel times developed for the routes studied as part of this analysis include the following:

- Acceleration and deceleration of transit vehicles near stations and at intersections
- Posted speed limits
- Boarding/alighting time at stations
    - 15 seconds for low volume station, 20 seconds for high volume stations
- Intersection delay, stratified for those intersections where TSP and queue jumper lanes were either assumed or not assumed
    - 42 second average delay assumed for intersections with no treatments
    - 30 second average delay for intersections with TSP
    - 15 second average delay for intersections with queue jump lanes
- Congested speeds

The methodology for determining travel time assumptions along the corridor involved a bottom-up estimating using assumptions noted above. Generally described, travel times for links were calculated and delays for intersections and stations added to develop corridor-level travel times. For links where BRT service was provided in general purpose travel lanes, the congested highway speeds from the forecasting model were used as a method for determining maximum speeds in those segments.

Resulting travel time assumptions for the various corridors were then used to code the transit network used to analyze ridership potential across the county. Table 2-5 identifies the end-to-end travel time and speeds for the routes carried forward into final analysis and shows the comparison between highway speeds, local bus speeds and BRT speeds as generated by the forecasting model.

Table 2-5 Comparison of end-to-end travel times based on forecasting model

Route	Average Highway Time (min)	Average Local Bus Time (min)	% of Route in Busway	Average BRT Time (min)	Average Highway Travel Speed (mph)	Average Local Bus Speed (mph)	Average BRT Travel Speed (mph)
3: Darnestown Road/Montgomery Avenue/Veirs Mill Road/MD 586	20.5	28.1	77%	19.5	18.8	13.7	19.8
4a: Georgia Avenue North	28.6	35.8	95%	25.6	20.3	16.2	22.7
4b: Georgia Avenue South	15.1	20.7	0%	18.7	13.8	10.1	11.2
5: Rockville Loop	19.3	28.8	56%	22.4	14.8	9.9	12.8
7: MD 124/Muddy Branch Road	30.1	42.1	54%	33.1	11.4	8.2	10.4
8: MD 185/Connecticut Avenue	31.9	42.6	79%	29.2	15.3	11.5	16.8
10a: MD 355 North	43.1	63.4	71%	45.4	19.1	13.0	18.1
10b: MD 355 South	34.2	50.2	77%	34.7	15.3	10.4	15.1
11: MD 650/New Hampshire Avenue	32.6	45.0	38%	38.1	13.9	10.1	11.9
12: Montgomery Mall/Old Georgetown Road	19.1	26.4	56%	20.5	15.7	11.4	14.7
14: Montrose Road/Randolph Road/Cherry Hill Road	16.9	22.5	58%	17.3	15.9	12.0	15.6
18: University Boulevard	17.5	24.7	87%	16.1	21.7	15.3	23.6
19: US 29/Columbia Pike/Colesville Road	40.9	55.7	79%	38.2	18.0	13.2	19.3
20 : ICC	37.7	41.7	100%	37.7	30.2	27.3	30.2
21: North Bethesda Transitway	11.7	16.8	34%	14.5	15.4	10.7	12.4
23: Midcounty Highway	32.7	42.7	100%	32.7	23.3	17.8	23.3

2.4.2.4 Headways, fares, and parking

The final inputs to the model to derive forecasts are to specify the headways (how often a bus passes a certain location), fare and parking availability. These factors are obviously important ones to travelers assessing travel options. Initially in this study, a 10-minute headway was applied and a flat fare assumed and significant constraints on parking at Metro stations were assumed.

A 10-minute headway is a typical analysis method, specifying a headway consistent with Small Starts criteria to determine how well the network performs. The model operates with an unconstrained vehicle capacity so testing a 10-minute headway often yields results which identify needs of a more or less frequent headway to handle expected ridership in the corridors. For this study, the majority of the routes tested would require headways more frequent than 10 minutes to handle expected passenger volumes by the year 2040 (see results in Section 4.2). Final ridership forecasts were developed by incorporating a second step and applying reduced headways on those corridors where appropriate to approximate the relative demand for each corridor.

Fare assumptions for the forecasting process assumed a base fare ($1.50 in current dollars) which mirrors Ride-On fares and is consistent with assumptions for the Purple Line and Corridor Cities Transitway projects. Transfers from local bus to BRT, from BRT to local bus, and from BRT-to-BRT were assumed to be a no cost transfer. Transfers to the Metro system assumed a transfer fare consistent with Metro's existing distance based fares.

Parking availability can impact ridership by limiting travel options for those accessing the BRT system. For this study, the parking assumptions included restricted access to Metro station parking (reflecting the limited availability of parking at Metro stations that could be accessed by riders on the BRT system) and unconstrained availability of parking at three park-and-ride lot locations in the study area, including the following:

- Burtonsville Park and Ride lot off Route 29
- Briggs Chaney Park and Ride lot off Briggs Chaney Road
- New ICC Park and Ride lot at the interchange of the ICC and MD 97 (Georgia Avenue)

2.4.2.5 Model runs

A series of model runs were generated to test the network for various investment conditions to help with decision making on selecting corridors as the larger network was assessed for viability and the final network presented in this document was identified. The three model runs used for various analyses included the following:

1. A fully separate, bi-directional BRT facility, termed the "unconstrained scenario" for this project. This model run was conducted to test the viability of various routes in the network for ridership assuming conditions higher than would ever be expected to be built due to right of way constraints. This run was used to screen out most routes that did not meet the 10-minute headway standard for accommodating passenger flows under ideal operating conditions.[11]
2. The BRT network run that assumed assumed no right-of-way needs along the links of the network and combined the various design options in a way that would yield the most efficient BRT network. This scenario included dedicated lanes, TSP, queue jump lanes, additional rights of way at intersections to accommodate a transit lane, and off-board fare collection.
3. A BRT network run with the same assumptions as outlined in Bullet 2, but with year 2020 land uses to test the impact of development on systemwide ridership.

During evaluation of the model runs, the consulting team—with input from the County—made some modifications to the BRT network. The following outlines those considerations.

[11] Those routes presenting headways greater than 10 minutes were retained for evaluation in more detailed corridor studies.

Removals
• Two of the initially screened corridors—those along Montgomery Village Avenue/Quince Orchard Road and Shady Grove Road—were removed from the proposed BRT network due to relatively low daily boardings.
Additions and Modifications
• Although initially removed as a possible BRT corridor, the ICC corridor was retained because of the new facility's future capacity to accommodate premium bus service. It was combined with the Sam Eig Highway corridor to provide cross-County service between Briggs Chaney and the Life Sciences Center. • The Mid-County Highway corridor was added for both additional service for northern County residents and direct access to the planned Clarksburg Town Center.

3 ROUTES IN PROPOSED BRT NETWORK

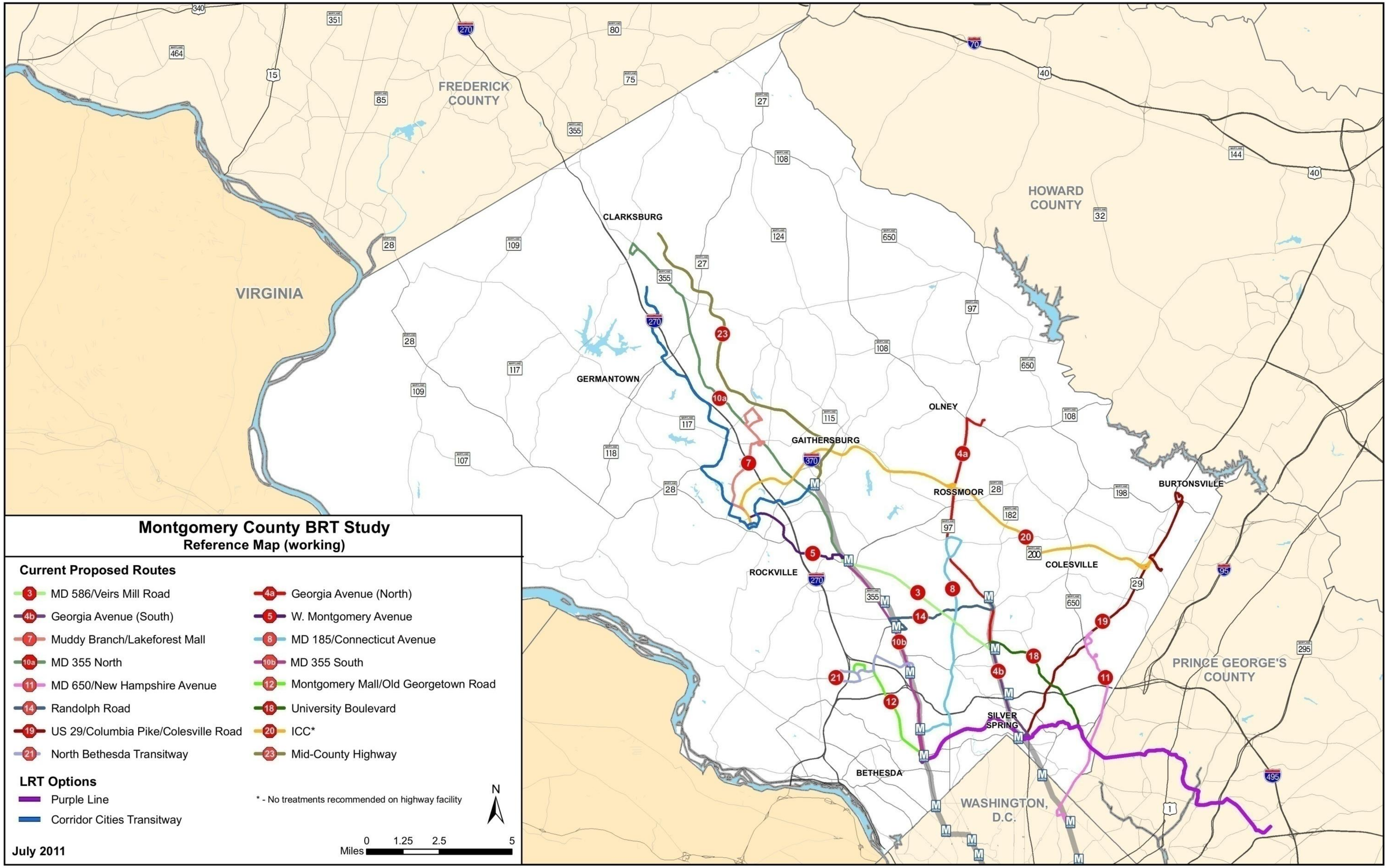
Table 3-1 lists and Figure 3-1 shows the proposed BRT network of 16 routes that performed well under the modeled unconstrained scenario. An additional route, Route 23: Midcounty Highway was added in response to stakeholder comment as it was noted as helping the County achieve its goal of supporting transit-oriented development proposed in the Clarksburg Master Plan, as well as providing northern County residents with an alternate access to destinations in the southern portion of the County and connections to premium transit serving the DC Metropolitan area. Appendix D provides detailed descriptions of each route.[12]

Table 3-1: Proposed BRT routes

Route Number	Corridor	From	To	Route Length (miles)	Number of Stations
3	MD 586/Veirs Mill Road	Rockville Metrorail station	Wheaton Metrorail station	6.7	11
4a	Georgia Avenue North	Montgomery General Hospital	Wheaton Metrorail station	9.8	12
4b	Georgia Avenue South	Wheaton Metrorail station	Silver Spring Transit Center	3.9	6
5	Rockville Metrorail-Life Sciences Center	Life Sciences Center	Rockville Metrorail station	5.3	7
7	MD 124/Muddy Branch Road	Lakeforest Mall	Life Sciences Center	7.2	10
8	MD 185/Connecticut Avenue	Georgia Avenue and Bel Pre Road	Medical Center Metrorail station	9.5	10
10a	MD 355 North	MD 355 and Stringtown Road	Rockville Metrorail station	14.6	16
10b	MD 355 South	Rockville Metrorail station	Bethesda Metrorail station	8.8	13
11	MD 650/New Hampshire Avenue	White Oak Transit Center	Fort Totten Metrorail station	8.8	9
12	Montgomery Mall/Old Georgetown Road	Montgomery Mall Transit Center	Bethesda Metrorail station	6.9	9
14	Randolph Road	White Flint Metrorail station	Glenmont Metrorail station	5.5	7
18	MD 193/University Boulevard	Wheaton Metrorail station	Takoma/Langley Park Transit Center	6.4	9
19	US 29/Columbia Pike/Colesville Road	Burtonsville park-and-ride lot	Silver Spring Transit Center	13.5	11
20	ICC	Life Sciences Center	Briggs Chaney park-and-ride lot	22.9	3
21	North Bethesda Transitway	Montgomery Mall Transit Center	Grosvenor Metrorail station	5.1	7
23	Midcounty Highway	Snowden Farm Parkway and Stringtown Road	Shady Grove Metrorail station	13.4	10

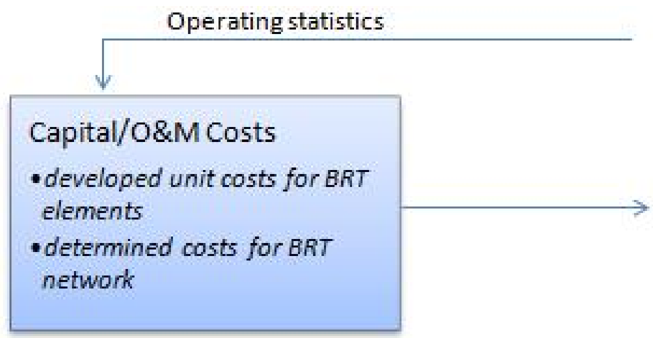
[12] Appendix D also contains the two corridors that included in the refined route assessment: the Montgomery Village Avenue/Quince Orchard Road and Shady Grove Road corridors.

Figure 3-1: Proposed BRT network



4 CAPITAL AND OPERATING COSTS ESTIMATES

4.1 Capital costs estimate



The consulting team determined capital costs for the proposed BRT system using unit costs developed for a number of elements. Unit costs comprised information from SHA's 2010 Price Index, professional experience with developing and applying BRT costs on other BRT system and corridor studies, and documentation of unit costs from the FTA *Characteristics of Bus Rapid Transit for Decision-Making* report and TCRP *Report 118: Bus Rapid Transit Practitioner's Guide*. The unit costs reflect both construction and vehicle acquisition costs, but exclude possible right-of-way acquisition or business/residential relocation costs.

The next several paragraphs describe the costs comprising the following list of elements:

- BRT guideway treatments
- Intersection treatments: TSP and queue treatments, as well as widening of signalized intersections
- Construction of station platforms, concrete bus pads for BRT vehicles serving curb-side stations while operating in mixed traffic
- Articulated, low-floor BRT vehicles
- Maintenance facility
- Add-ins

BRT guideway treatments considered the cost of implementing any of the six options identified in Appendix C of this report. One of the options—a possible side-of-road treatment, which would be implemented on the side of the roadway within the existing right-of-way (such as shoulders)—was applied only to Route 3: MD 586/Veirs Mill Road to take advantage of existing shoulders along the corridor. The consulting team determined the locations of possible guideway treatments for each route, as summarized on route treatment maps in Appendix D.

TSP and queue jump treatments, described in Appendix C of this report, considered the cost of implementing these treatments at specific locations identified on route treatment maps located in Appendix D. These costs also included the widening of signalized intersections based on the type of median guideway treatment.

The consulting team assumed side (as opposed to center) station platforms would be constructed to accommodate a full 120-foot long BRT station (long enough for two 60-foot articulated BRT vehicles). For major stations serving at least 500 daily boardings by the year 2040, construction elements included extended shelter, benches, unique station ID sign, landscaping, lighting, security system, and bicycle storage. The costs also included an off-board fare collection vending machine and two real-time passenger information displays (PIDs). For minor stations serving less than 500 daily boardings, the station would be smaller, not provide for off-board fare collection, have one PID unit, and have reduced shelter and other passenger amenities.

Concrete pads pertain to curbside stations where BRT vehicles would operate in mixed traffic.

Articulated BRT vehicles assume 60-foot low-floor vehicles with hybrid propulsion, as well as automatic vehicle location (AVL), automatic passenger counters (APC), TSP, and security and maintenance monitoring systems.

Maintenance facility costs were based on the total number of vehicles needed, applying an average facility cost per vehicle. This estimate was determined for each BRT route and calculated for the entire system.

Add-ins would address post-planning activities and include preliminary engineering, final design, construction management, insurance, and start-up costs for the system.

Table 4-1 shows the unit costs for each BRT system element in the network.

Table 4-1: BRT system element costs

System Element	Unit Costs
Guideways and bus lanes	$56-$1,643 per linear foot
TSP	$25,000 per intersection
Queue jumps	$10,000 per approach
Intersection widening	$1.8-$2.9 million for both sides of roadway
Stations	$110,000-$220,000 per station
Concrete pads	$26,728 per pad
Articulated buses	$1.1 million per bus
Maintenance facility	$356,000 per bus
Add-ins	25% of route/system cost (excluding vehicles)

Note: Maintenance facility costs were averaged across the total number of buses in system fleet.

Table 4-2 shows individual route and total system costs. The total system cost ranges between $2.3 and $2.5 billion, averaging between $15.8 and $17.1 million per route-mile. These costs include a 30-percent unallocated contingency[13] applied to guideways, intersection treatments, station elements, and maintenance facilities due to the many unknowns associated with

[13] Unallocated contingency covers unknown costs, including changes in project scopes.

developing planning level estimates. Add-ins are 25 percent of system elements, excluding articulated vehicles. The capital costs represents the option of only restriping and signing segments where BRT vehicles would use curb-side lanes exclusively, up to rebuilding the existing bus lanes to accommodate BRT vehicles (as identified in initial capital cost assumptions).

The cost estimate reflects the greatest level investment for the proposed BRT system in existing dollars. Actual total system costs will vary based on anticipated funding availability and implementation strategy. Additionally, this estimated capital cost reflects a BRT network with the removal of duplicative treatments due to route overlaps. The cost of constructing the first set of individual routes would cost more.

Contingency excludes right-of-way costs because assessing right-of-way impacts was beyond the scope of the study. Additionally, this study acknowledges right-of-way costs, stormwater management, and utility relocations can significantly increase the cost of intersection impacts. Individual corridor studies can best quantify those specific needs and develop more refined cost estimates.

Table 4-2: BRT system cost (low end of range)

BRT Route		Guideway Treatment		Intersections		Stations		Vehicles					
		Total Transitway Length	Total Transitway Cost	Total # Intersection Treatments	Total Intersection Cost	Total # Stations	Total Station Cost	Total # Vehicles	Total Vehicle Cost	Maintenance Facility	Add-Ins	Total Route Cost	Cost/Mile
										$356,000	*25%*		
3	MD 586/Veirs Mill Road	42,089	$50,200,000	25	$30,400,000	34	$9,560,000	8	$8,800,000	$3,700,000	$23,500,000	$126,000,000	$19,000,000
4a	MD 97/Georgia Avenue North	58,265	$79,400,000	48	$90,500,000	27	$7,030,000	28	$30,800,000	$13,000,000	$47,500,000	$268,000,000	$27,400,000
4b	MD 97/Georgia Avenue South	12,672	$924,000	11	$341,000	10	$3,210,000	24	$26,400,000	$11,100,000	$3,900,000	$45,900,000	$11,600,000
5	Rockville Metro-LSC	32,627	$22,400,000	21	$24,400,000	12	$3,640,000	8	$8,800,000	$3,700,000	$13,500,000	$76,400,000	$14,500,000
7	Lakeforest Mall/Muddy Branch Rd	22,105	$36,500,000	19	$41,200,000	13	$3,860,000	11	$12,100,000	$5,090,000	$21,700,000	$120,000,000	$16,700,000
8	MD 185/Connecticut Ave	69,808	$45,900,000	29	$43,900,000	32	$9,170,000	10	$11,000,000	$4,630,000	$25,900,000	$141,000,000	$14,900,000
10a	MD 355 North	110,520	$66,800,000	63	$84,100,000	51	$15,700,000	66	$72,600,000	$30,500,000	$49,300,000	$319,000,000	$21,900,000
10b	MD 355 South	54,895	$51,100,000	47	$63,100,000	36	$11,100,000	32	$35,200,000	$14,800,000	$35,000,000	$210,000,000	$24,000,000
11	MD 650/New Hampshire Ave	21,001	$20,400,000	22	$26,900,000	22	$6,280,000	25	$27,500,000	$11,600,000	$16,300,000	$109,000,000	$12,400,000
12	MD 187/Old Georgetown Rd	24,395	$22,300,000	33	$42,900,000	26	$7,990,000	14	$15,400,000	$6,480,000	$19,900,000	$115,000,000	$16,600,000
14	Randolph Road	13,755	$2,330,000	8	$3,680,000	12	$3,850,000	18	$19,800,000	$8,330,000	$4,550,000	$42,500,000	$7,670,000
18	MD 193/University Boulevard	27,117	$33,600,000	23	$36,000,000	28	$7,420,000	26	$28,600,000	$12,000,000	$22,300,000	$140,000,000	$21,800,000
19	US 29	43,695	$78,700,000	27	$46,600,000	23	$7,100,000	39	$42,900,000	$18,000,000	$37,600,000	$231,000,000	$17,200,000
20	ICC	14,329	$25,800,000	9	$18,700,000	4	$1,210,000	8	$8,800,000	$3,700,000	$12,400,000	$70,600,000	$3,080,000
21	North Bethesda Transitway	14,688	$10,700,000	13	$19,400,000	18	$4,710,000	12	$13,200,000	$5,550,000	$10,100,000	$63,700,000	$12,600,000
23	Mid-County	63,252	$122,000,000	25	$58,200,000	19	$4,610,000	18	$19,800,000	$8,330,000	$48,200,000	$261,000,000	$19,500,000
Total Cost Entire Network			$669,000,000		$630,000,000		$106,000,000		$382,000,000	$161,000,000	$392,000,000	$2,300,000,000	$15,800,000

Notes:

- Costs are based on 2010 dollars and excludes escalation and necessary right-of-way acquisition.
- Total system cost reflects removal of overlapping treatments for routes operating along the same segments. Construction of individual routes would represent higher costs for each route.
- Intersection treatments include TSP and queue jump treatments, as well as widening of signalized intersections.
- Station costs include Ticket Vending Machines and Passenger Information.
- Maintenance facility costs exclude right-of-way.
- Add-ins include preliminary engineering, final design, construction management, insurance, and startup costs.

4.2 Operating statistics and costs estimate

The following tables summarize daily operating statistics and O&M costs for the BRT network by the year 2040. Table 4-3 lists the range of daily boardings, daily boardings per route mile, and required peak headway for each route. Overall, the BRT system could expect to provide between 165,000 and 207,000 daily boardings.

The table also shows the percentage of daily boardings achieved by the year 2040, based on the land uses developed by the year 2020. As shown, about 80 percent of the BRT network's daily boardings can be realized by the year 2020.

In addition to the BRT routes, the consulting team modified and modeled three existing local bus routes as express buses to provide enhanced service along corridors in the eastern portion of the County. Table 4-3 also shows these results.

Table 4-3: Daily boarding for BRT network, by daily boardings per route mile (year 2040)

Route Number	Daily Boardings	Daily Boardings/ Route Mile	Required Peak Headway	Percent of 2040 Achieved w/2020 Land Use
14 Randolph Road	13,400 - 16,800	3,000 - 3,700	4.3 - 3.6	80%
10b MD 355 South	23,200 - 29,000	3,000 - 3,700	4.2 - 3.5	70%
4b MD 97/Georgia Avenue South	8,200 - 10,200	2,300 - 2,900	3.5 - 2.9	94%
10a MD 355 North	30,400 - 38,000	2,200 - 2,800	2.5 - 2.1	71%
21 North Bethesda Transitway	6,600 - 8,300	2,200 - 2,800	5.9 - 4.9	80%
18 MD 193/University Boulevard	12,700 - 15,900	2,000 - 2,500	2.9 - 2.5	82%
12 MD 187/Old Georgetown Road	9,000 - 11,300	1,800 - 2,300	6.6 - 5.5	96%
5 Rockville Metro-LSC	6,100 - 7,600	1,300 - 1,600	12.0 - 10.0	78%
11 MD 650/New Hampshire Avenue	9,400 - 11,700	1,300 - 1,600	5.8 - 4.8	83%
4a MD 97/Georgia Avenue North	11,900 - 14,900	1,200 - 1,500	3.9 - 3.2	85%
19 US 29	13,700 - 17,100	1,100 - 1,400	3.7 - 3.1	92%
3 MD 586/Veirs Mill Road	6,200 - 7,700	1,000 - 1,200	12.0 - 10.0	83%
7 Lakeforest Mall/Muddy Branch Rd	4,400 - 5,500	800 - 1,000	12.0 - 10.0	69%
23 Mid-County	5,400 - 6,800	400 - 500	7.2 - 6.0	85%
8 MD 185/Connecticut Avenue	3,400 - 4,200	400 - 500	12.0 - 10.0	95%
20 ICC	1,600 - 2,000	100 - 100	18.0 - 15.0	70%
Total	*165,600 207,000*	*1,300 - 1,600*	--	*80%*
RO52E	800 - 1,000	100 - 100	17.4 - 14.5	
WMZ2K6	600 - 700	- - -	75.9 - 63.3	
WMC8C9	2,000 - 2,500	100 - 100	13.2 - 11.0	

Table 4-4 shows O&M costs and farebox recovery ratios for each route, arranged according to farebox recovery. Total annual operating costs for the BRT system at full build-out by 2040 would be between $150 and $180 million (in existing dollars). Projected farebox recovery ranges between 26 and 33 percent for the entire system. The farebox recovery ratios of many

BRT routes would exceed those of Metrobus routes, which currently range between 30 and 35 percent.

Table 4-4: Annual O&M costs for BRT network, by O&M costs per boarding (year 2040)

BRT Route	Annual O&M Cost	O&M Cost/ Boarding	Farebox Recovery Ratio
14 Randolph Road	$5,974,000 - $7,168,800	$1.19 - $1.43	67% - 54%
21 North Bethesda Transitway	$3,654,000 - $4,384,800	$1.48 - $1.78	54% - 43%
5 Rockville Metro-LSC	$3,432,000 - $4,118,400	$1.51 - $1.81	53% - 42%
3 MD 586/Veirs Mill Road	$3,529,000 - $4,234,800	$1.55 - $1.86	52% - 41%
18 MD 193/University Boulevard	$8,047,000 - $9,656,400	$1.70 - $2.04	47% - 38%
12 MD 187/Old Georgetown Road	$6,357,000 - $7,628,400	$1.88 - $2.26	43% - 34%
4b MD 97/Georgia Avenue South	$5,757,000 - $6,908,400	$1.90 - $2.28	42% - 34%
10b MD 355 South	$16,931,000 - $20,317,200	$1.96 - $2.35	41% - 33%
7 Lakeforest Mall/Muddy Branch Rd	$3,955,000 - $4,746,000	$2.41 - $2.90	33% - 27%
4a MD 97/Georgia Avenue North	$11,383,000 - $13,659,600	$2.57 - $3.09	31% - 25%
11 MD 650/New Hampshire Avenue	$9,832,000 - $11,798,400	$2.81 - $3.37	28% - 23%
10a MD 355 North	$34,584,000 - $41,500,800	$3.06 - $3.67	26% - 21%
8 MD 185/Connecticut Avenue	$4,263,000 - $5,115,600	$3.38 - $4.06	24% - 19%
19 US 29	$18,716,000 - $22,459,200	$3.67 - $4.40	22% - 17%
23 Mid-County	$7,851,000 - $9,421,200	$3.86 - $4.64	21% - 17%
20 ICC	$6,290,000 - $7,548,000	$10.74 - $12.88	7% - 6%
Total	*$150,555,000 - $180,666,000*	-	*33% - 26%*

Note: Farebox recovery ratio is the percentage of annual O&M costs regained from fares, based on an assumed trip fare. BRT O&M cost estimates assume average of 70 persons/bus during peak hour. Farebox recovery assumes an average fare per BRT boarding of $0.80.

Table 4-5 provides systemwide operating information for the proposed BRT system and other transit systems operating in the County—including Ride On and WMATA buses, Metrorail, and the Purple Line and CCT both modeled as light rail. The BRT system would require about 285 articulated buses during peak demand service and a total fleet of 350 articulated buses to accommodate the estimated boardings. Such a fleet size would require additional bus maintenance facilities and/or the modification to existing facilities to service articulated vehicles. (Section 4.1 discussed maintenance facility costs.)

Table 4-5: Operating data for BRT and other transit modes (year 2040)

		% Change from No-build		
	MCBRT	**LRT**	**Ride On**	**Metrobus**
Daily Boardings	206,956	-18%	-31%	-4%
Daily Vehicle Revenue Miles	48,257	-7%	-15%	-4%
Daily Vehicle Revenue Hours	3,029	-6%	-16%	-3%
Daily Train Revenue Hours	--	-6%	--	--
Daily Peak Vehicles	284	-14%	-38%	-6%
Total Fleet	347	-14%	-38%	-6%
Track Miles	--	0%	--	--
Cost/Boarding	$2.44	15%	19%	0%

Table 4-5 also shows implementing the BRT network would result in reduced boardings across all other transit modes and reduced peak vehicle and total fleet needs, in part due to transit mode shifts.

Considering all Metrobus (including DC and Virginia service), Ride On, and BRT services combined, the net change in operating costs by the year 2040 would be between $104 and $134 million greater than they would for operations under 2040 no-build conditions. Similarly, the net fare revenue would be about $39 to $41 million greater and the net change in operating subsidy would be about $63 and $95 million greater by the year 2040 than they would for 2040 no-build conditions. Table 4-6 through Table 4-8 present this information.

Table 4-6: Change in operating costs due to BRT service (2010 dollars)

	Range (Low	-	High)
BRT (Range of Operating Costs)	$150,555,000	-	$180,666,000
Total 2040 Operating Costs (Buses and BRT)	$748,223,000	-	$778,334,000
Total Net Change in Operations Costs	$104,185,000	-	$134,296,000

Table 4-7: Change in fare revenue due to BRT service (2010 dollars)

	Range (Low	-	High)
BRT (Range of Operating Subsidy)	$101,217,000	-	$133,301,000
Total 2040 Operating Subsidy (Buses and BRT)	$576,439,000	-	$608,523,000
Total Net Change in Operations Subsidy	$63,009,000	-	$95,093,000

Table 4-8: Change in operating subsidies due to BRT service (2010 dollars)

	Range (Low	-	High)
BRT	$47,365,000	-	$49,338,000
Total 2040 Fare Revenue (Buses and BRT)	$169,811,320	-	$171,784,320
Total Net Change in Fare Revenue	$39,203,280	-	$41,176,280

APPENDIX A COMPARISON OF TRANSITWAY OPTIONS: MD 355-ROCKVILLE PIKE

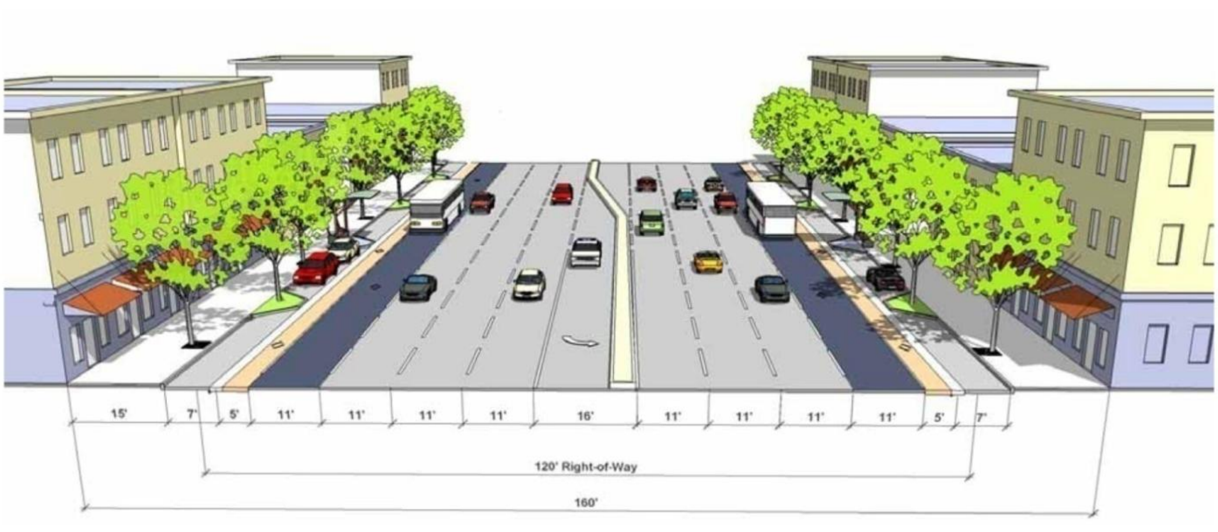
The consulting team evaluated the three conceptual cross-sections for Rockville Pike through the White Flint area (as developed by M-NCPPC, City of Rockville, and the White Flint Partnership). The concepts have been evaluated with respect to facilitating future BRT operations and to overall traffic conflicts among transit, other motor vehicles, pedestrians, and bicycles. Cost was not a major consideration, given the entire Rockville Pike cross section would be reconstructed to develop one of the concepts identified.

A.1 Exclusive bus lanes

This treatment (see Figure A-1) would involve the development of 11-foot bus lanes on the outside of a seven-lane general traffic roadway (six through lanes and a center left turn lane), with bicycle and then parking lanes on the right side of the roadway. With the identified concept, BRT vehicles and local buses would have to cross the bicycle lane to serve curb-side transit stations. Developing a curb extension out to the bus lane to avoid buses from crossing the bicycle lane would end up blocking the bicycle lane, which is not desirable.

Curbside bus lanes are typically difficult to enforce due to the difficulty in identifying whether a general traffic vehicle is using the lane for local access, making a turn, or violating the lane use. In such cases, the shared use of the bus would reduce BRT operating speeds, with the degree of impact dependent on the amount of other vehicles and local buses in the lane. Lastly, parallel parking maneuvers would temporarily block the bus and bicycle lanes. Overall, this concept has a fair number of potential traffic conflicts working against BRT operations.

Figure A-1: Exclusive bus lanes concept along MD 355



Source: Rockville Pike Charette Results Presentation (2008)

A.2 Median transitway

This treatment (see Figure A-2) would develop a median transitway with 10-foot lanes and a raised landscaped median section from the general roadway section on both sides. The 10-foot lanes for the transitway, assuming curbing is provided, reflects lower operating speeds unless the lanes were further narrowed and became truly guided or widened with some shoulder treatment (which could be done if the landscaped median area is narrowed).

This treatment would minimize conflicts between buses and other motor vehicle traffic at signalized intersections. The left turn lanes would be developed to the right of the transitway, and left-turning vehicles would be under protective signal control. This could be done by cutting into the landscaped median area nearside of intersections (assuming stations would be located on the farside of signalized intersections).

A major impact of median transitways is the restriction of local access at unsignalized intersections and driveways. The median transitway acts as a raised median, and it would require restricting vehicles wanting to turn left into and out of local driveways and intersections. Vehicles should not cross a transitway facility at-grade unless under signal control, as it would be difficult for drivers to see and properly interpret bus movements along the transitway.

Figure A-2: Median guideway concept along MD 355

Source: White Flint Redevelopment presentation to WMCOG (2009)

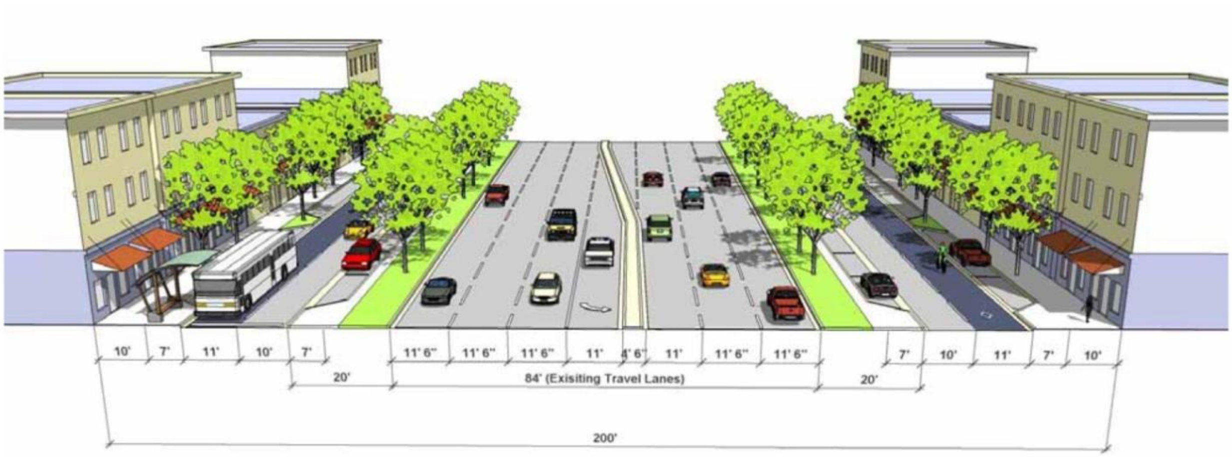
Conceptually, the median transitway would result in higher operating speeds than would curbside bus lanes with the absence of general traffic in the lane. There is sufficient median area to develop a bus bypass lane at stations or in a midblock section to get a BRT vehicle around a local bus (or vice versa) if there were a high number of vehicles using the transitway. Additionally, the identified 15-foot landscaped median on both sides of the transitway would be more than adequate width to accommodate side platforms at designated BRT stop locations (which should be far side if transit signal priority is also applied). Platforms as narrow as 10 feet might be considered, which would reduce the landscaped median area by five feet on both sides and save 10 feet of right-of-way.

With a median transitway, all transit riders would cross half of the street to access a station. However, there must be adequate pedestrian waiting area at the end of the platforms to accommodate transit riders waiting for a pedestrian signal to cross the street.

A.3 Service roads

This treatment (see Figure A-3) would separate the BRT vehicles from through traffic. If parking were located on the left side of the service road, as shown in the concept, parking maneuvers would not conflict with BRT operations. BRT stations could then be provided curbside in an expanded sidewalk area. This concept does identify a 200-foot right-of-way requirement, compared to 162 feet for the previous cross-section options.

Figure A-3: Service roads concept along MD 355



Source: Rockville Pike Charette Results Presentation (2008)

The major problem with this concept is the potential traffic conflicts and delays associated with merging the service road traffic (including BRT) onto the main roadway before signalized intersections. Transit signal priority would be rendered ineffective by potential queue backup with mainline traffic at such intersections. General traffic on the service roads could not take advantage of the limited green associated with individual bus movements out of the service road. This concept would appear to have the most potential for BRT delay and conflicts with through traffic and create some queue backup on the service roads, which would impact parking maneuvers and freight deliveries.

A.4 Conclusions

Table A-1 identifies a rating of each Rockville Pike cross section option with respect to four criteria: 1) BRT operations 2) BRT capacity 3) Conflicts with other motor vehicles and bicycles and 4) Station/pedestrian accessibility (does not reflect the added right-of-way required to develop the service road concept).

Considering 1) the high traffic volume on Rockville Pike, 2) the extent of BRT (and local bus) service envisioned, and 3) the opportunity to integrate a bus bypass lane into the identified median section, a median transitway treatment would provide for both the highest BRT speeds and overall capacity for the corridor and the least conflict with other motor vehicles and bicycles.

Table A-1: Summary of cross-section options

Criterion	Exclusive Bus Lanes	Median Transitway	Service Roads
BRT Operations	2	1	3
BRT Capacity	3	1	2
Traffic Conflicts	2	1	3
Station Access	2	3	1
Total Score	9	6	9

Note: 1 = Highest rating, 3 = Lowest rating

APPENDIX B INITIAL CORRIDOR SCREENING METHODOLOGIES

B.1 Preliminary screening methodology

The consulting team developed and applied a preliminary screening methodology for the first 20 initial BRT corridors listed in Table 2-1 in Section 2.2 of this report. The methodology attempted to normalize certain attributes of some corridors relative to others. The four screening criteria developed for this stage of the study embodied these corridor attributes; they are as follows:

- Existing daily bus trips
- Percent of corridor within a 1/2-mile radius having BRT-supportive density under future conditions
- Presence of major attractors/activity centers
- Regional transit connectivity

Sections B.1.1 through B.1.4 describe the analyses for each criterion in this preliminary screen methodology and the scoring ranges used to select the potential BRT corridors. Section B.1.5 describes the weighting system applied to the final score for each corridor.

B.1.1 Existing daily bus trips

This analysis determined the average number of daily inbound and outbound bus trips along each potential BRT corridor. Daily bus trips was used as a surrogate for daily transit ridership, which, at the time the analysis was initiated, was unavailable for the Ride On, WMATA, and MTA Commuter Bus routes operating within Montgomery County.

The consulting team screened for this criterion using data from the Maryland Alternatives Analysis (MDAA) Phase I model developed in 2007 for both the Purple Line and Corridor Cities Transitway projects. The model output used for this screening was total origin-destination transit trips in the year 2000 for both peak and off-peak travel along each link in network. Based on this data, the average number of daily bus trips per corridor was calculated as the weighted average of the product of the total daily trips per link along a corridor and the length of each corresponding link, divided by the total length of the corridor. Transit trips were not determined for the CCT and ICC alignments because these facilities were in their respective planning stages in the year 2000.

The scores for average number of daily bus trips were as follows:

- 5: More than 35 average daily trips
- 3: Between 20 and 35 average daily trips
- 1: Up to 20 average daily trips

B.1.2 Percent of corridor within a 1/2-mile radius having BRT-supportive density under future conditions

This analysis used GIS software to capture portions of the TAZs within 1/2-mile of each corridor that had BRT-supportive density under future conditions. Corridors such as I-270 and ICC had similar analyses conducted within 1/2-mile of each interchange. The analysis used minimum thresholds of six households per acre or five employees per acre as being supportive of BRT service. Past research and actual experience with BRT systems identified these thresholds as reasonable minimum targets for BRT service.

The scores for BRT-supportive density under future conditions were as follows:

- 5: More than 43 percent density
- 3: Between 31 and 43 percent density
- 1: Up to 31 percent density

B.1.3 Presence of major attractors/activity centers

Information from Montgomery County's Department of Technology Services, the 2005 Ride On system map, and the MWCOG report, Metropolitan Washington Regional Activity Centers and Clusters (2007)—supplemented by professional knowledge of the County—identified the types and locations of major attractors and activity centers. The analysis first identified attractors and activity centers within 1/2-mile of each corridor (within 1/2-mile of the I-270 and ICC interchanges), followed by a review to retain facilities that were considered regionally significant. This reduced set of attractors and activity centers included business parks, colleges and universities, secondary schools, libraries, and hospitals. They also included mixed-use and employment centers identified by MWCOG. Attractors and activity centers not considered regionally significant included community, convenience, and neighborhood shopping centers; the majority of government offices in Montgomery County except district courts, Judicial Center, Executive Office Building, and Rockville Center; and college and universities with very low enrollment, such as health training facilities or those primarily providing online programs.

The scores for major trip attractions/activity centers were as follows:

- 5: More than 29 attractors
- 3: Between 10 and 29 attractors
- 1: Up to 10 attractors

B.1.4 Regional transit connectivity

The analysis for this criterion identified the intersection of potential BRT corridors with local bus routes and major transit facilities, which include Metrorail, MARC commuter rail, future Purple Line service, bus transit centers, and park-and-ride lots. The intersecting connections were verified visually using Google Earth. Potential BRT corridors such as I-270 and ICC were analyzed by considering the number of intersecting transit connections at each interchange within the County.

Each corridor was evaluated to determine the number of times it intersected one of the three types of transit facilities—rail station, bus transit center, and local bus transfer. Weights were assigned to each facility type to emphasize its relative importance to regional connectivity.

- 5: Rail station
- 3: Bus transit center
- 1: Local bus

The final score for this criterion was the total number of transit connections. For example, the total score for a corridor with two rail connections, four connections to a bus transit center, and 11 local bus connections would be calculated as follows:

weights

(2 x 5) + (4 x 3) + (11 x 1) = 33

attractors/centers

The scores for regional transit connectivity were as follows:

- 5: More than 30 connections
- 3: Between 15 and 30 connections
- 1: Up to 15 connections

B.1.5 Weighting of Total Score

The total scores for each corridor were calculated two different ways: 1) assuming equal weights for all four criteria and 2) assuming different weights for each criterion. For the latter calculations, the following assumptions were made on weights:

- Percent future BRT-supportive density: 2
- Presence of major attractors/activity centers: 2
- Regional transit connectivity: 1.5
- Existing bus trips: 1

Population and employment density and the number of major attractors and activity centers received the highest weights because these criteria provide strong justifications for offering and supporting BRT service. Daily bus trips received the lowest weight because data on existing daily ridership was unavailable by corridor segment at the time of the evaluation.

Table B-1 shows the scores for each criterion by route. Table B-2 compares the scores for both the unweighed and weighed criteria, and shows similar rankings of the corridors. The corridors were divided into three tiers based on the range in scores. The Tier 1 and 2 corridors, consisting of the top 10 corridors with the highest scores, comprise about 122 miles (excluding the CCT corridor), which was close to the initial goal of a 120-mile network of corridors for the refined assessment. The CCT corridor was evaluated as part of this exercise and its scoring results are included in the criteria scoring matrix and summary scoring table. As this is a committed transit corridor in MWCOG’s constrained long-range transportation plan, the team did not include it in the top corridors advanced for refined assessments. Tier 3 corridors included those with low scores and fell outside the 120-mile threshold. These corridors excluded the ICC corridor, for reasons similar to those for the CCT corridor.

Table B-1: Results of Initial BRT Corridor Screening: Detailed Scoring Matrix

					Existing Bus Trips		BRT-supportive Density (Future Year)		Presence of Major Activity Centers (1/2-mile area)		Number of Regional Transit Connections					
Corridor Number	Corridor	From	To	Corridor Length (miles)	Avg. # of Daily Bus Trips	Score	% BRT Supportive Density	Score	Reduced # of Major Trip Attractions	Score	# of Metro/MARC/Purple Line Connections	Weighted Rail Connections (5)	# of Major Transit/Transfer Centers/PnR	Weighted Center Connections (3)	# of Intersecting Bus Routes	Score
1	Bel Pre Road/Bonifant Road	Georgia Avenue	New Hampshire Avenue	5.5	12.2	1	35.4%	3	0	1	0	0	0	0	6	1
2	CCT (master plan alignment)	COMSAT	Shady Grove Metrorail station	14.8	--	1	62.3%	5	57	5	2	10	1	3	11	3
3	Darnestown Road/Montgomery Avenue/Veirs Mill Road/MD 586	Quince Orchard Road	Georgia Avenue	13.2	23.5	3	31.1%	3	26	3	2	10	0	0	25	5
4	Georgia Avenue/Olney Sandy Spring Road	Olney Sandy Spring Road and Spartan Road	Silver Spring Metrorail station	13.6	27.9	3	31.2%	3	13	3	3	15	1	3	19	5
5	Gude Drive/Key West Avenue	MD 28/Darnestown Road	Norbeck Road	5.2	6.2	1	75.4%	5	32	5	0	0	0	0	11	1
6	I-270/I-495	Frederick border	VA border	24.2	24.7	3	53.0%	5	41	5	0	0	3	9	11	3
7	MD 124/Muddy Branch Road	Airpark Road	MD 28	7.0	9.6	1	53.5%	5	8	1	1	5	0	0	15	3
8	MD 185/Connecticut Avenue	Georgia Avenue	East-West Highway	6.9	16.0	1	12.2%	1	4	1	1	5	0	0	10	1
9	MD 190/River Road/Seven Locks Road	Montrose Road	DC border	9.2	14.7	1	4.2%	1	2	1	0	0	0	0	12	1
10	MD 355	Clarksburg	DC border	23.7	22.6	3	55.5%	5	51	5	5	25	3	9	40	5
11	MD 650/New Hampshire Avenue	Bonifant Road	DC border	10.2	19.5	1	21.8%	1	5	1	1	5	2	6	16	3
12	Montgomery Mall/Old Georgetown Road/Rockville Pike/East-West Highway	Westlake Terrace	Prince George's County border	12.3	44.1	5	49.4%	5	16	3	3	15	2	6	21	5
13	Montgomery Village Avenue/Quince Orchard Road	Snouffer School Road	MD 28	6.5	15.2	1	51.4%	5	15	3	0	0	1	3	16	3
14	Montrose Road/Randolph Road/Cherry Hill Road	Seven Locks Road	Montgomery County border	12.8	17.6	1	23.5%	1	19	3	0	0	1	3	12	1
15	Norbeck Road/MD 198/Spencerville Road	MD/28/MD 586	Montgomery County border	13.9	6.2	1	8.9%	1	9	1	0	0	2	6	8	1
16	Shady Grove Road	MD 28	Muncaster Mill Road	4.8	21.2	3	60.1%	5	25	3	0	0	1	3	10	1
17	Snouffer School Road/Muncaster Mill Road	Brink Road	MD 28/Norbeck Road	9.6	5.3	1	17.0%	1	1	1	0	0	1	3	9	1
18	University Boulevard	Connecticut Avenue	Montgomery County border	6.6	29.2	3	25.1%	1	5	1	1	5	0	0	11	3
19	US 29/Columbia Pike/Colesville Road	Howard County border	DC border	11.7	54.6	5	15.7%	1	21	3	1	5	2	6	15	3
20	ICC	MD 355 and I-370	Prince George's County border	18.6	--	1	30.1%	1	6	1	0	0	2	6	5	1

Table B-2: Results of Initial BRT Corridor Screening: Final Scores

Corridor Number	Corridor	Unweighted Score	Weighted Score	Number of Miles
1	Bel Pre Rd/Bonifant Rd	6	10.5	6
2	CCT	14	25.5	--
3	Darnestown Rd/Montgomery Ave/Veirs Mill Rd/MD 586	14	22.5	13
4	Georgia Ave/Olney Sandy Spring Rd	14	22.5	14
5	Gude Dr/key West Ave	12	22.5	5
6	I-270/I-495	16	22.5	24
7	MD 124/Muddy Branch Rd	10	17.5	7
8	MD 185 Connecticut Ave	4	6.5	7
9	MD 190/River Rd/Seven Locks Rd	4	6.5	9
10	MD 355	18	30.5	24
11	MD 650/New Hampshire Ave	6	9.5	10
12	Montg Mall/Old Georgetown Rd/Rockville Pike/E-W Hwy	18	28.5	12
13	Montgomery Village Ave/Quince Orchard Rd	12	21.5	6
14	Montrose Rd/Randolph Rd/Cherry Hill Rd	6	10.5	13
15	Norbeck Rd/MD 198/Spencerville Rd	4	6.5	14
16	Shady Grove Rd	12	20.5	5
17	Snouffer School Rd/Muncaster Mill Rd	4	6.5	10
18	University Blvd	8	11.5	7
19	US 29/Columbia Pike/Colesville Rd	12	17.5	12
20	ICC	4	6.5	19
	Tier 1 Corridors - 87 miles (minus CCT)			
	Tier 2 Corridors - 35 miles (122 miles Tiers 1 & 2)			
	Tier 3 Corridors - 76 miles (minus ICC) (198 miles Total)			

B.2 Revised screening methodology

After reviewing the preliminary screening results and receiving feedback from the technical advisory committee, the consulting team made several changes to the corridors and revised the corridor screening methodology.

The first change involved removing the following three corridors from the initial set of potential BRT corridors:

- Corridor 2: CCT
- Corridor 6: I-270/I-495
- Corridor 20: ICC

Corridors 2 and 6 were removed because they were subjects of separate studies under current consideration for transportation enhancements by another agency. Corridor 20 was removed during the initial corridor screening it was designed and in the midst of being constructed as a limited-access toll facility; however, it was reconsidered for inclusion in the final proposed network to help improve east-west connectivity within the County.

Second, the following corridors were added to be screened:

- Corridor 21: North Bethesda Transitway
- Corridor 22: Sam Eig Highway

Next, the MD 355 corridor was split into MD 355 North (Corridor 10a) and MD 355 South (Corridor 10b). Additionally, the advisory group recommended advancing eight of the potential BRT corridors to the refined route assessment without being screened because transit enhancements had been evaluated for them in previous studies. These corridors were as follows:

- Corridor 3: Darnestown Road/Montgomery Avenue/Veirs Mill Road/MD 586
- Corridor 4: Georgia Avenue/Olney Sandy Spring Road[14]
- Corridor 10a: MD 355 South
- Corridor 14: Montrose Road/Randolph Road/Cherry Hill Road
- Corridor 18: University Boulevard
- Corridor 19: US 29/Columbia Pike/Colesville Road
- Corridor 21: North Bethesda Transitway
- Corridor 22: Sam Eig Highway

Finally, the remaining 12 corridors were screened using a revised definition of the criteria. Corridor 12, one of the remaining corridors, was shortened during this step to terminate it in Bethesda instead of running it through Montgomery County and into Prince George's County.

The first two criteria—existing daily bus trips and percentage of BRT-supportive density—did not change from the definition in the preliminary screening methodology. Sections B.2.1 and B.2.2 redefine the last two criteria—presence of attractors/activity centers and regional transit connectivity—and Section B.2.3 describes the overall scoring system applied to all four criteria and used to select corridors for refined assessment.

B.2.1 Presence of major attractors/activity centers

The analysis identified regional activity centers within 1/2-mile of each corridor. Using MWCOG's *Metropolitan Washington Regional Activity Centers and Clusters* (2007) as a guide, the following weights were applied to each type of regional activity center:

- 5: mixed-use activity centers
- 3: employment centers
- 1: all remaining activity centers

The final weight was applied to all remaining activity centers within 1/2-mile of each corridor as identified using GIS data from the County's Department of Technology Services and the advisory committee's knowledge of the County. Attractors and activity centers that were considered regionally significant included the following:

[14] Corridor 4: Georgia Avenue/Olney Sandy Spring Road, was separated into two corridors during the refined route assessment.

- Business parks
- Colleges and universities, except those with very low enrollment
- Secondary schools
- Libraries

The sub-score for each corridor was based on a weighted sum of the total number of attractors and activity centers. For example, the sub-score for a BRT corridor proximate to one mixed-use center, two employment centers, and 14 others attractors was calculated as follows:

weights

(1 x 5) + (2 x 3) + (14 x 1) = 25

attractors/centers

B.2.2 Regional transit connectivity

Using Google Earth, the analysis for this criterion identified the total number of direct intersections of potential BRT corridors with local bus routes. Weights were applied to each facility type to emphasize its relative importance to regional connectivity.

- 5: presence of Metrorail, MARC, and future CCT and Purple Line stations within a 1/4-mile radius of a potential BRT corridor
- 3: presence of park-and-ride lots and bus transit centers within 1/4-mile radius of a potential BRT corridor
- 1: direct intersection of local bus routes to a potential BRT corridor

The sub-scores for transit connectivity were calculated similar to that for major attractors and activity centers.

B.2.3 Corridor Scoring and Results

The thresholds for scoring each of the four criteria were defined based on the following conditions:

- 5: value greater than at least one standard deviation above the average
- 3: value at least equal to the average, but within one standard deviation of the average
- 1: value less than the average

Expanding on the previous example, a potential BRT corridor, and three other corridors scoring 21, 40, and 10 for the presence of major attractors and activity centers would have an average score of 24 with a standard deviation of 12.4. The thresholds would be as follow:

- 5: > 36.4 transit connections
- 3: 24 < x < 36.4 transit connections
- 1: < 24 transit connections

Therefore, the potential BRT corridor scoring 25 for the presence of major attractors and activity centers would receive a threshold score of three. The threshold score finally was multiplied by the criterion weight to determine a final score for the criterion measured along the potential BRT corridor. In this example, the score of 3 would be multiplied by a criterion weight of 1.5 to give a final score of 4.5.

All potential BRT corridors scoring at least a 10 across all criteria were advanced for refined assessment. Table B-3 shows the results of the revised screening analysis. In addition to the eight corridors that were automatically advanced for refined assessment, the following eight corridors were added to the list (in order of highest to lowest score).

- Corridor 10a: MD 355 North
- Corridor 5: Gude Drive/Key West Avenue
- Corridor 12: Montgomery Mall/Old Georgetown Road
- Corridor 13: Montgomery Village Avenue/Quince Orchard Road
- Corridor 16: Shady Grove Road
- Corridor 7: MD 124/Muddy Branch Road
- Corridor 8: MD 185/Connecticut Avenue
- Corridor 11: MD 650/New Hampshire Avenue

Comparing the corridor scores in Table B-2 and Table B-4 show that, under both screening methodologies, four corridors did not advance for refined assessments. They were the following:

- Corridor 9: Bel Pre Road/Bonifant Road
- Corridor 13: MD 190/River Road/Seven Locks Road
- Corridor 17: Snouffer School Road/Muncaster Mill Road
- Corridor 18: Norbeck Road

Table B-3: Results of Revised BRT Corridor Screening: Detailed Scoring Matrix

	Corridor Number	1	5	7	8	9	10a	11	12	13	15	16	17
	Corridor Name	Bel Pre Rd/Bonifant Rd	Gude Dr/Key West Ave	MD 124/Muddy Branch Rd	MD 185/Connecticut Ave	MD 190/River Road/Seven Locks Road	MD 355 North	MD 650/New Hampshire Ave	Mont Mall/Old Georgetown Rd	Montgomery Village/Quince Orchard	Norbeck Rd	Shady Grove Road	Snouffer School/Muncaster Mill Rds
	From	Georgia Ave.	MD 28/Darnestown Rd	Airpark Rd. to Muddy Branch	Georgia Ave.	Montrose Rd	Comus Rd., Clarksburg	US 29	Westlake Terrace	Snouffer School Rd	Rockville Metrorail station	MD 28	Brink Rd
	To	New Hampshire Ave	Norbeck Rd	Hwy 124 to MD 28	East-West Highway	DC border	Rockville Metrorail station	University Boulevard	Bethesda Metrorail station	MD 28	Georgia Avenue/Nobeck Road PnR	Muncaster Mill Rd	MD 28/Norbeck Rd.
	Corridor Length (miles)	5.6	5.5	7.0	6.9	9.2	14.7	6.0	5.0	6.7	4.1	4.9	9.8
Existing Bus Trips	Avg. # of Daily Bus Trips	13.3	13.9	20.2	17.3	11.7	17.1	17.6	12.4	10.6	13.0	15.2	10.4
	Threshold	1	1	5	3	1	3	5	1	1	1	3	1
	Score (Weight=1)	1	1	5	3	1	3	5	1	1	1	3	1
BRT-supportive Density	Future % BRT Supportive Density	35.4%	75.4%	53.5%	12.2%	4.2%	64.2%	27.8%	60.5%	51.4%	21.5%	60.1%	7.0%
	Threshold	1	5	3	1	1	5	1	3	3	1	3	1
	Score (Weight=2)	2	10	6	2	2	10	2	6	6	2	6	2
Presence of Major Attractors/Activity Centers	# of Mixed-use Centers	0	0	0	0	0	0	0	1	0	0	0	0
	Mixed-use Weight (5)	0	0	0	0	0	0	0	5	0	0	0	0
	# of Employment Centers	0	1	2	0	0	4	1	2	1	1	1	0
	Employment Center Weight (3)	0	3	6	0	0	12	3	6	3	3	3	0
	# of Remaining Attractors	1	31	9	8	4	55	6	14	17	6	24	3
	Remaining Attractors Weight (1)	1	31	9	8	4	55	6	14	17	6	24	3
	Total Weighted Regional Attractions	1	34	15	8	4	67	9	25	20	9	27	3
	Threshold	1	3	1	1	1	5	1	3	3	1	3	1
	Score (Weight=2)	2	6	2	2	2	10	2	6	6	2	6	2
Number of Regional Transit Connections	# of Metro/MARC/Purple Line/CCT Connections	0	2	1	2	0	3	1	1	2	1	0	0
	Weighted Rail Connections (5)	0	10	5	10	0	15	5	5	10	5	0	0
	# of Major Transit/Transfer Centers/PnR	0	1	0	0	0	2	2	1	1	1	2	0
	Weighted Center Connections (3)	0	3	0	0	0	6	6	3	3	3	6	0
	# of Intersecting Bus Routes	6	11	15	11	12	21	8	15	16	10	11	10
	Weighted Intersecting Bus Routes (1)	6	11	15	11	12	21	8	15	16	10	11	10
	Total Weighted Transit Connections	6	24	20	21	12	42	19	23	29	18	17	10
	Threshold	1	3	1	3	1	5	1	3	3	1	1	1
	Score (Weight=1.5)	1.5	4.5	1.5	4.5	1.5	7.5	1.5	4.5	4.5	1.5	1.5	1.5

	Averages	Standard Deviation	Threshold = 5	Threshold = 3	Threshold = 1
Existing Bus Trips	14.4	3.1	≥ 19.0	13.8 ≤ x <19.0	< 13.8
BRT-supportive Density	39%	25%	≥ 64%	39% ≤ x < 64%	< 39%
Presence of Major Attractors	18.5	18.5	≥ 37.0	18.5 ≤ x < 37.0	< 18.5
Regional Transit Connectivity	20.1	9.4	≥ 29.4	20.1 ≤ x < 29.4	< 20.1

Table B-4: Results of Revised BRT Corridor Screening: Final Scores

Corridor Number	Corridor	Corridor Length (miles)	Total Score	Ranking
1	Bel Pre Road/Bonifant Road	5.6	6.5	9
5	Gude Drive/Key West Avenue	5.5	21.5	2
7	MD 124/Muddy Branch Road	7.0	14.5	6
8	MD 185/Connecticut Avenue	6.9	11.5	7
9	MD 190/River Road/Seven Locks Road	9.2	6.5	9
10a	MD 355 North	14.7	30.5	1
11	MD 650/New Hampshire Avenue	6.0	10.5	8
12	Montgomery Mall/Old Georgetown Road	5.0	17.5	3
13	Montgomery Village Avenue/Quince Orchard Road	6.7	17.5	3
15	Norbeck Road	4.1	6.5	9
16	Shady Grove Road	4.9	16.5	5
17	Snouffer School Road/Muncaster Mill Road	9.8	6.5	9

APPENDIX C BRT TREATMENTS EVALUATED FOR REFINED ROUTE ASSESSMENT

The consulting team considered several treatment options during the refined route assessment. This appendix describes them and outlines the methodology for each option.

C.1 Guideway assessment

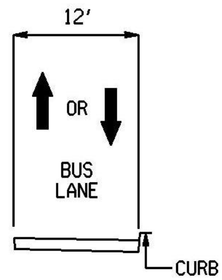
C.1.1 Treatment options

The guideway assessment identified the applicability of the following potential guideway treatment options along each of the current designated BRT routes:

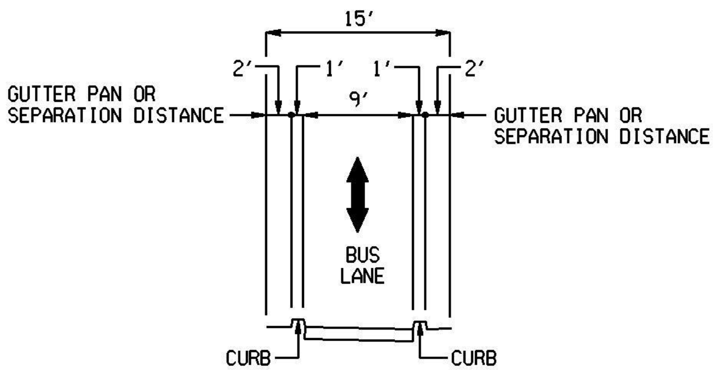
- Operating in travel lane
- One-lane guided busway
- Two-lane guided busway
- One-lane unguided busway
- Two-lane unguided busway
- Side-of-road guided busway

Figure C-1 shows the cross section for the first five of these treatments. The last treatment, the side-of-road guided busway, has dimensions similar to those for the one-lane guided busway. The given busway dimensions are consistent with new BRT guideway planning and design guidelines being developed by APTA.

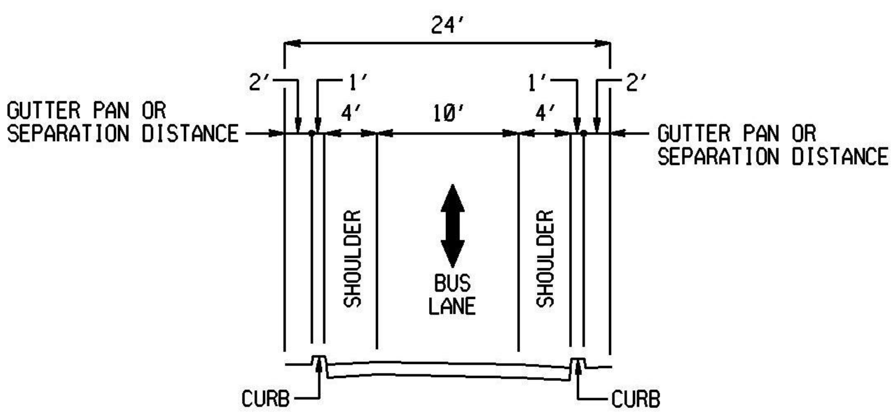
Figure C-1: Cross-sections of possible BRT guideway treatments



(a) Bus Lane on Street

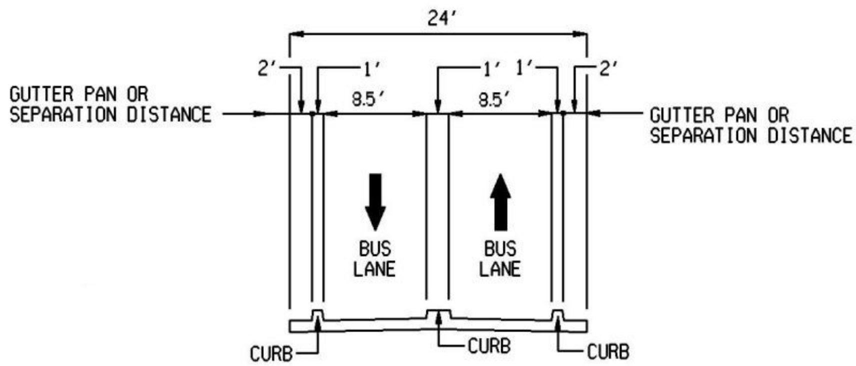


(b) One-lane Guided

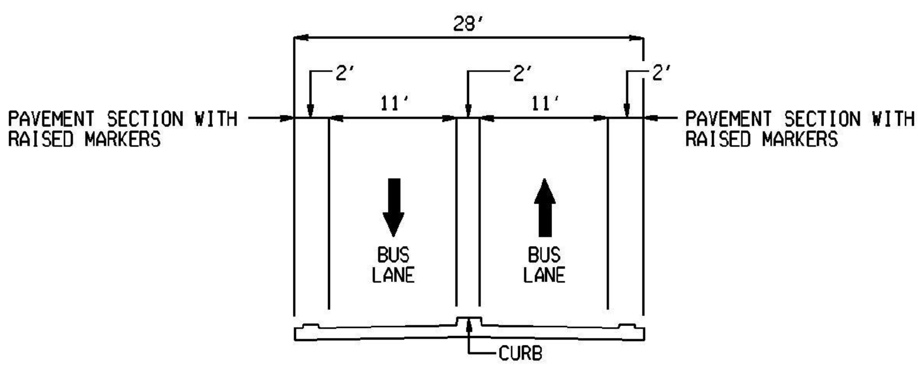


(c) One-lane Unguided

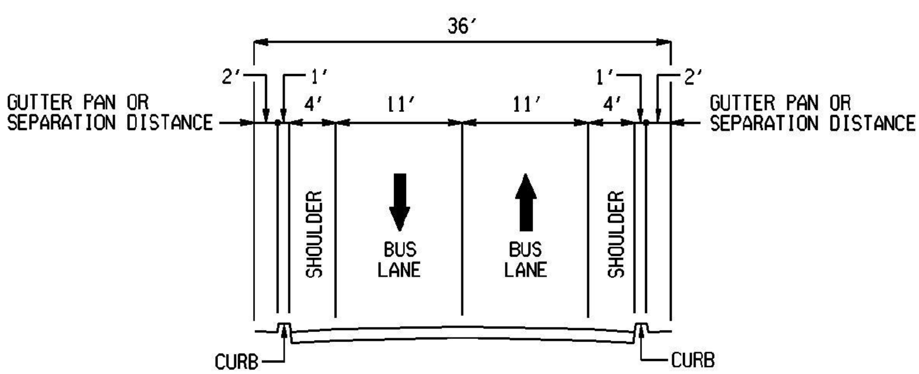
Figure C-1 (continued)



(d) Two-lane Guided



(e) Two-lane Unguided: open concept



(f) Two-lane Unguided: closed concept

C.1.1.1 Operating in travel lane

This treatment would involve either widening a roadway and operating in a new lane (assumed to be in the same direction as general traffic) or converting an existing general traffic lane to an exclusive bus lane. In the case of widening a roadway to provide an added lane(s), a 12-foot lane width was assumed in the evaluation.

C.1.1.2 Guided busway

A guided busway would allow some reduction in cross section width because of the greater ability to steer a vehicle. Guide wheels typically would be mounted on the vehicle, though a driver could also operate a bus without guide wheels if under a lower speed. This represents the narrowest cross-section for a potential busway treatment.

In this assessment, both one-lane and two-lane guided busways were evaluated. A one-lane guided busway was assumed to have a cross section requirement of 15 feet, including nine feet for the operating lane, one-foot curbing on both sides, and a two-foot separation distance to an adjacent traffic lane or adjacent off-road feature. If developed in the median, it could be reversible, operating in the peak direction during the peak period. If it were developed along the side of the roadway, a one-lane guided busway would operate only in the direction of travel on that side of the roadway all of the time.

A two-lane guided busway was also evaluated, which would provide two-directional operation at all times, and was assumed to have a cross section width of 24 feet, two 8.5-foot lanes, three one-foot curbs for separation, and two feet separation distance on both sides.

C.1.1.3 Unguided busway

With an unguided busway, narrow shoulders would be included in the busway section, with the buses operating unguided. This is to provide some latitude for drivers to maneuver past other vehicles or to be able to have a maintenance or tow vehicle service a disabled vehicle. Thus, a wider cross section width was identified, assumed to be 24 feet for a one-lane section and 36 feet for a two-lane section. The one-lane unguided section would have a single 10-foot lane, four-foot shoulders, one-foot curbing on both sides, and a two-foot separation from an adjacent traffic lane or off-road feature. The two-lane unguided section would have dual 11-foot lanes, four-foot shoulders, one-foot curbing on both sides, and a two-foot separation distance.

Although not assessed during this study, an added narrower cross section for a two-lane unguided median busway was identified. This would consist of 11-foot lanes in each direction, separated by a two-foot raised median, and a two-foot pavement separation on both sides from adjacent general traffic lanes, with raised markers in those transition areas. This cross-section would have a total width of 28 feet.

C.1.2 Median assessment

Using GIS mapping for each BRT route, the existing median width along each BRT route for different segments was identified. Changes in median widths were recorded. The median width in each segment was then related to the width required to develop each of the busway options between intersections. It was recognized that at intersections, particularly signalized intersections, where turn lanes have been developed, that a narrower median width typically exists compared to midblock sections. Thus, the applicability of developing one or more of the median busway options at intersections would be based on the ability to widen approaches to replace turn lanes, and even widen further where BRT stations would be located (the extent of widening to accommodate stations based on the station platform configuration and overall platform width identified). As a surrogate for this impact, the number of signalized intersections along each BRT route was identified. With a median guideway treatment, all vehicle crossings of such a corridor would have to be signalized.

C.1.3 Take-a-lane assessment

This assessment involved using both years 2005 and 2030 weekday peak-hour and off-peak-hour model volumes and roadway capacities to identify whether a general traffic lane in a particular direction could be converted to an exclusive bus lane. This option could occur along roadway sections with two or more lanes in a particular direction. The volume to capacity ratio was calculated in the remaining general traffic lanes after a lane removal for a bus lane, for different segments of the route where the volume and/or capacity varied. If the volume to capacity ratio was assumed to be 1.0 or greater, representing overcapacity conditions in the remaining general traffic lane (s), then the take a lane option was not considered applicable.

C.1.4 Side-of-road assessment

GIS mapping was also used to identify what right-of-way was available outside of the existing roadway along each BRT route to either widen a roadway in a particular direction to develop an added lane which could be devoted to bus-only use, or the development of one or two-lane guided or unguided busways. The analysis was conducted assuming that space would need to be available within the existing right-of-way to replace on-street parking, sidewalks, and overhead utility lines, if a widened roadway or separate busway were provided. It was also assumed that there would be a minimal five-foot separation between the back of sidewalk or utility pole locations and the start of the busway treatment. This assessment only applied to Route 3: MD 586/Veirs Mill Road to take advantage of existing shoulders alongside the roadway in each direction.

C.1.5 Packaging of treatments

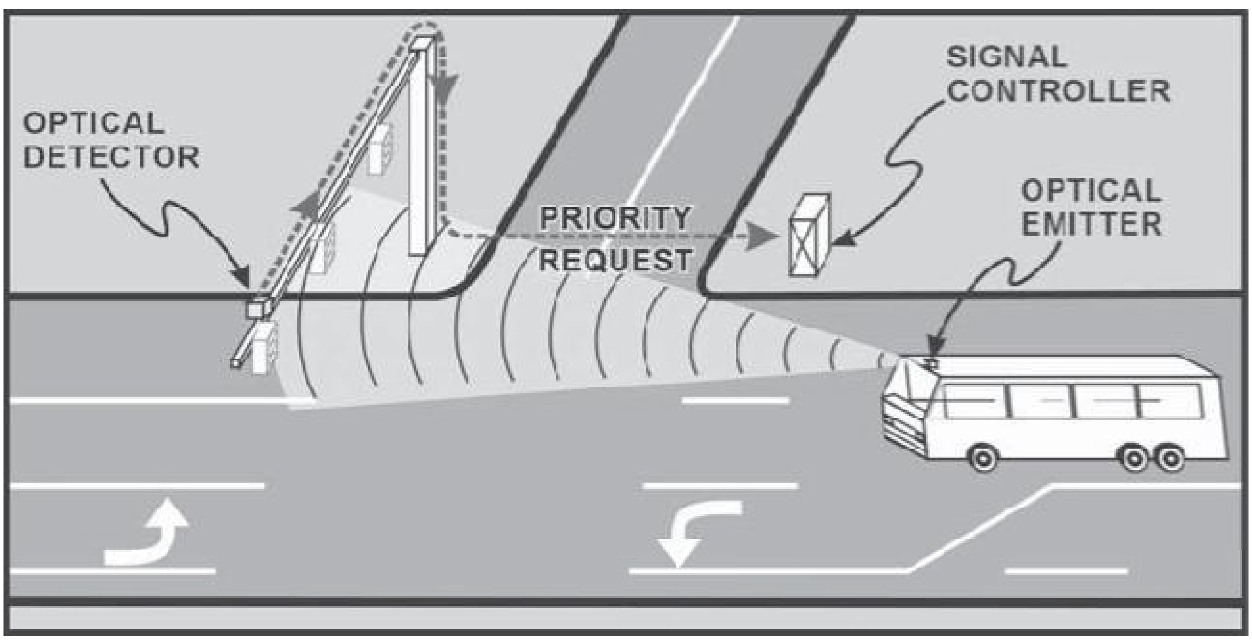
Once the different guideway assessments were completed, the applicability and continuity of the different potential BRT cross sections were evaluated to identify where possible a logical continuous guideway treatment could be developed along all or a segment of the corridor. This included keeping one particular treatment over as long a stretch as possible, and transitioning to another treatment only at signalized locations where, through special signal phasing, safe transitions could be made from one treatment to another. In general, a guideway treatment was considered applicable if it could extend at least one mile. A few exceptions were made where shorter guideways were acceptable, related to a BRT route pulling off its main corridor onto a cross street to serve a station (such as the US 29 route serving the Briggs Chaney Road park-n-ride).

C.2 Intersection assessment

C.2.1 Transit signal priority

At this stage of the study, an overview assessment of TSP applicability at the signalized intersections along each BRT route was conducted. TSP was considered to represent green extension and/or red truncation for BRT vehicles operating straight through at intersections, as illustrated in Figure C-2. In such cases, LOS was used as the measure to determine potential TSP applicability. Existing conditions were assessed, as intersection LOS data was only available related to existing conditions. In particular, if the intersection LOS during a particular weekday peak period was “C” or “D”, TSP was assumed to have a benefit to transit operations and a negligible impact on traffic operations, and hence potentially applicable. Using LOS C and D was considered a conservative assumption for TSP applicability. A more detailed assessment of TSP applicability using Synchro models or other detailed operations analysis data, and the possibility of TSP being feasible in certain cases under LOS E, was not possible within the study budget.

Figure C-2: Example of TSP application



Source: TCRP Synthesis 83

Intersection level of service information was available from SHA for about 70 percent of the signalized intersections along the BRT routes. For the other intersections, critical lane volume and volume to capacity information from M-NCPPC was used, where available, to convert to LOS using the relationships relating critical lane volumes to LOS in the NCHRP Circular 212 report from 1980. Table C-1 shows the relationship of volume to capacity ratio to LOS described in Circular 212.

Table C-1: Relationship of LOS to v/c ratios for signalized intersections

LOS	V/C Ratio
A	0.00-0.59
B	0.60-0.69
C	0.70-0.79
D	0.80-0.89
E	0.90-0.99
F	1.00+

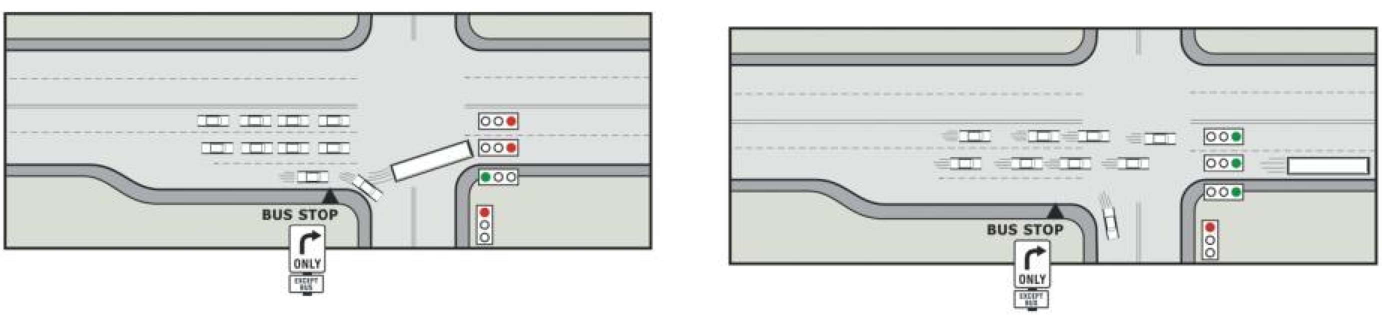
Source: NCHRP Circular 212

C.2.2 Queue jumps

An alternate priority treatment to TSP at signalized intersections is a queue jump treatment. This is where a bus could use an auxiliary lane at a signalized intersection to bypass the adjacent general traffic queue, and then have an advance green signal to move through the intersection unimpeded ahead of the general traffic. Figure C-3 illustrates this application. In this study, the queue jump assessment considered the following factors:

- If there was an existing right turn lane available on a particular intersection approach which could be used for a queue jump, and
  - o If there was not an excess number of right turns and heavy adjacent through traffic volumes that would hinder the ability of a BRT vehicle to access the right turn lane, or
  - o Be substantially delayed in the lane by right turn traffic

Figure C-3: Example of queue jump application



(a) Bus receives green signal before other vehicles

(b) Other vehicles proceed a few seconds later

Source: TCRP Synthesis 83

Given the absence of detailed intersection operations data, a qualitative assessment of potential queue jump applicability was undertaken, with rough queue lengths estimated during weekday AM and PM peak periods based on assumed signal cycle lengths and knowing right turn volumes and adjacent through traffic volumes on approaches from intersection turning movement counts. The assessment was only undertaken for existing/recent conditions, as year 2030 intersection turning movements were not available.

C.2.3 Special turn signals

For locations where BRT left or right turning movements would be made from one major road to another, revised or new left turn or right turn phasing was assumed to be possible if the overall intersection LOS was “C” or” D.”

C.2.4 Packaging of treatments

Once the TSP, queue jump, and special turn signal applicability assessments were completed, each signalized intersection along each bus route was evaluated to identify the most appropriate treatment for initial system modeling. It was assumed that TSP (for BRT through movements) or special turn signal phasing (for BRT turning movements) would take precedent over a queue jump treatment, and that queue jumps would be applied on an intersection approach only if TSP was deemed not feasible. Additionally, if TSP and queue jumps were only feasible during one of the weekday peak periods, it would still be considered in the subsequent modeling effort.

C.3 Station locations

Potential station locations along each BRT route were identified based on the application of a hierarchical set of criteria:

1. Route termini
2. Intermediate locations with existing Metrorail, MARC, and/or bus transit center access
3. Intermediate locations with intersecting bus routes
4. Intermediate locations with major activity centers not served by Item 2 or 3 in this list

Once all potential station locations along a BRT route applying the above criteria were identified, refinements to station locations were made with an objective of achieving an overall average 1/2-mile to one mile spacing of stations. In some cases where an intersecting bus route crossed a BRT route close to a major intersection, it was assumed that the bus route could be relocated to the major cross street.

APPENDIX D BRT ROUTE DESCRIPTIONS AND TREATMENT OPTIONS

Eighteen potential BRT routes[15] were developed to advance to the demand modeling phase of this study. (During modeling activities, Routes 13 and 16 were removed due to relatively low daily boardings.) The team made a couple of changes during the course of the study. The first change combined Route 22: Sam Eig Highway with the previously eliminated Corridor 20: ICC, to provide a cross-County connection between Briggs Chaney and planned development in the Life Sciences Center area. The second change added Route 23: Midcounty Highway to the list of proposed routes. The consulting team made assumptions about the unconstructed roadways for this route based on input from MCDOT.

This appendix will describe the routes and provide information gathered during field reviews—roadway cross-sections, surrounding development, regional connectivity—that helped determine guideway and intersection options, as well as proposed station locations. Maps of treatment options for all routes are placed toward the end of this appendix.

D.1 Route 3: Veirs Mill Road

Route Overview

The Veirs Mill Road route would be about 6.7 miles in length, anchored by the Rockville Metrorail station at the western terminus and the Wheaton Metrorail station at the eastern terminus. Heading east from Rockville Metrorail station toward Wheaton Metrorail station, the route would begin by heading south on MD 355. It then would head east along MD 586/Veirs Mills Road before entering Wheaton Metrorail station. For westbound travel starting at Wheaton Metrorail station heading toward Rockville Metrorail station, the route would replicate the eastbound travel in the opposite direction.

Cross-section

The route's cross-section has a range in existing right-of-way (ROW) width of 65 to 160 feet. It is predominantly a four-lane roadway, with five through lanes and an eastbound continuous right-turn lane south of MD 185/Connecticut Avenue. There are service roads along sections of Veirs Mill Road that provide for access to residential development, as well as allow for on-street parking. Other on-street parking opportunities exist along one block near the Wheaton Metrorail station. Between First Street and Nimitz Avenue, the profile of the main roadway is typically higher than that of the adjacent service roads. There is a continuous right-turn lane in the eastbound direction between Connecticut Avenue and University Boulevard that permits through travel to transit vehicles. Additionally, there are shoulders between Twinbrook Parkway and Randolph Road that are currently used as bus-only lanes. Through this and most other sections of the Veirs Mill Road corridor, a grassy median is provided. Wrought-iron fencing is installed along Veirs Mill Road between Reedie Drive and Wheaton Metrorail Station access road to promote pedestrian safety.

[15] Seventeen routes from the refined assessment; one route (Mid-County Highway) added during modeling activities

Potential BRT Stations

There are 11 BRT station locations identified along the route.

1. Rockville Metrorail station (west entrance)
2. MD 586/Veirs Mill Road and MD 28/Norbeck Road
3. MD 586/Veirs Mill Road and Broadwood Drive
4. MD 586/Veirs Mill Road and Twinbrook Parkway
5. MD 586/Veirs Mill Road and Aspen Hill Road
6. MD 586/Veirs Mill Road and Parkland Drive
7. MD 586/Veirs Mill Road and Randolph Road
8. MD 586/Veirs Mill Road and MD 185/Connecticut Avenue
9. MD 586/Veirs Mill Road and Newport Mill Road
10. MD 586/Veirs Mill Road and MD 193/University Boulevard
11. Wheaton Metrorail station

The station at each terminus would serve both directions of travel; the remaining nine stations would have individual stations in each direction of travel. There is an average station spacing of about 0.7 miles in each direction.

Five of the stations—Twinbrook Parkway, Randolph Road, Connecticut Avenue, Newport Mill Road, and MD 586/University Boulevard—were included as proposed stations because they were previously recommended in the 2005 report, Veirs Mill Road Bus Rapid Transit Facility Planning-Phase 1. The report also recommends a “super shelter” at Randolph Road. The stations would serve a number of major attractions along Veirs Mill Road—including the Rockville CBD and County and City offices, Westfield Wheaton Shopping Center and the Wheaton CBD. They would also serve eleven transfer opportunities to premium transit service, including two Metrorail stations (Rockville and Wheaton), MARC commuter rail (Rockville), and eight other BRT routes (4a, 4b, 5, 8, 10a, 10b, 14, and 18) being assessed.

D.2 Route 4a: Georgia Avenue North

Route Overview

The Georgia Avenue North route would be about 9.8 miles in length, anchored by Montgomery General Hospital and a future transit center at the northern terminus and Wheaton Metrorail station at the southern terminus. Initially, this route was combined with Route 4b: Georgia Avenue South, but was split during this refined assessment. The study could consider combining these two routes once again following the initial modeling of the BRT network to understand the effect on ridership along the Georgia Avenue corridor.

From Montgomery General Hospital, the Georgia Avenue North route would head south along Prince Philip Drive, then west on MD 108/Olney Sandy Spring Road. It then would head south along Georgia Avenue before heading west onto Veirs Mill Road. It then would turn into and terminate at Wheaton Metrorail station.

In the northbound direction from Wheaton Metrorail station, the route would head north to Reedie Drive, then east to Georgia Avenue. The route then would head north on Georgia Avenue, east on Olney-Sandy Spring Road, then north on Prince Philip Drive to enter and terminate at Montgomery General Hospital.

Cross-section

The route's cross-section has a range in existing ROW width of 60 to 270 feet. It is a four-lane roadway north of Emory Lane, transitioning into a six-lane roadway to the south until its southern terminus. Wide medians exist along most of this route and at several intersections—primarily north of May Street—and transition to narrower, grassy and tree-lined medians through residential areas south toward its terminus. There is no on-street parking along this route.

Potential BRT Stations

There are 12 station locations identified along the route.

1. Montgomery General Hospital
2. MD 108/Olney-Sandy Spring Road and MD 97/Georgia Avenue
3. MD 97/Georgia Avenue and Hines Road
4. MD 97/Georgia Avenue and ICC—eastbound interchange
5. MD 97/Georgia Avenue and Rossmoor Boulevard (Leisure World)
6. MD 97/Georgia Avenue and Bel Pre Road
7. MD 97/Georgia Avenue and MD 185/Connecticut Avenue
8. MD 97/Georgia Avenue and Hewitt Avenue
9. Glenmont Metrorail station
10. MD 97/Georgia Avenue and Randolph Road
11. MD 97/Georgia Avenue and Arcola Avenue
12. Wheaton Metrorail station

The station at each terminus would serve both directions of travel; the remaining 10 stations would have individual stations in each direction of travel. There is an average station spacing of about 0.9 miles in each direction.

The stations would serve a large community hospital, the Leisure World retirement community, Wheaton CBD, Westfield Wheaton Shopping Center, clusters of shopping centers, and a number of residential communities along the route. They would also provide ten connections to premium transit service, including two Metrorail stations (Glenmont and Wheaton), a future park-and-ride facility at the ICC eastbound interchange, a future transit center sited at Montgomery General Hospital, and six BRT routes (3, 4b, 8, 14, 18, and 20) being assessed.

D.3 Route 4b: Georgia Avenue South

Route Overview

The Georgia Avenue South route would be about 3.9 miles in length, anchored by Glenmont Metrorail station at the northern terminus and the future Silver Spring Transit Center at the southern terminus. In the southbound direction starting at Wheaton Metrorail station, the route would head east on Veirs Mill Road very briefly before merging onto Georgia Avenue heading south toward Colesville Road. It then would head south on Colesville Road and east on Wayne Avenue before heading into and terminating at the future Silver Spring Transit Center. In the northbound direction starting at Silver Spring Transit Center, the route would head east on Wayne Avenue. It then would head north along Georgia Avenue. It would merge onto Veirs Mill Road before entering and terminating at Wheaton Metrorail station.

Cross-section

The route's cross-section is predominantly a six-lane roadway along Georgia Avenue, with a range in existing ROW width from 80 to 130 feet. The route has concrete medians with raised curbs and grass/tree treatments. From I-495 eastbound to Sixteenth Street, there is a six-lane reversible section of roadway to accommodate a 4+2 configuration during weekday peak periods. There is some off-peak on-street parking provided within the Silver Spring CBD along this route.

Potential BRT Stations

There are six station locations identified along the route.

1. Wheaton Metrorail station
2. MD 97/Georgia Avenue and Dexter Avenue
3. MD 97/Georgia Avenue and Forest Glen Road
4. MD 97/Georgia Avenue and Seminary Road
5. MD 97/Georgia Avenue and Cameron Street
6. Silver Spring Transit Center

The station at each terminus would serve both directions of travel; the remaining seven stations would have individual stations in each direction of travel. There is an average station spacing of about 0.8 miles in each direction.

The stations would serve a variety of land uses along the route, including the Wheaton CBD, Holy Cross Hospital, the Silver Spring CBD, Westfield Wheaton Shopping Center, City Place Mall, and clusters of office development. They would also provide nine transfer opportunities to premium transit, including three Metrorail stations (Wheaton, Forest Glen, and Silver Spring), MARC commuter rail (Silver Spring), the future Purple Line at Silver Spring, and four BRT routes (3, 4a, 18, and 19) being assessed.

D.4 Route 5: Rockville Metrorail-Life Sciences Center

Route Overview

This began as the Rockville Loop route and was 11.3 miles in length. Following initial model results, it was truncated to a 5.3-mile route. The Rockville Metrorail-Life Sciences Center route would terminate at Rockville Metrorail station and operate eastbound toward the Life Sciences Center development. Departing Rockville Metrorail station, the route would head north along MD 355 for a short segment before heading west along East Middle Lane. It would then head south along South Washington Street and west along MD 28/West Jefferson Street, which becomes MD 28/West Montgomery Avenue at Great Falls Road and MD 28/Key West Avenue at Shady Grove Road. The route would continue west along Key West Avenue and head south along Great Seneca Highway, where it would terminate at the Life Sciences Center development at Medical Center Way. It would follow the reverse operation in the eastbound direction.

Cross-section

The route's cross-section varies between four and six lanes along the entire length, with relatively short segments of two-lane roadways. The treatments along MD 28 vary from grassy medians with more narrowed concrete tapers to striped medians with two-way left-turn lanes. The existing ROW width along the route ranges from 50 to 170 feet. There are no on-street parking opportunities along the entire length of the route.

Potential BRT Stations

There are seven station locations identified along the route.

1. Rockville Metrorail station
2. East Middle Lane and Gibbs Street
3. MD 28/West Montgomery Avenue and Laird Street
4. MD 28/West Montgomery Avenue and Research Boulevard
5. MD 28/Key West Avenue and Shady Grove Road
6. MD 28/Key West Avenue and Broschart Road
7. Medical Center Way near MD 119/Great Seneca Highway— Life Sciences Center

The station at Life Sciences Center and Rockville Metrorail station would serve both directions of travel. The remaining station locations would have individual stations in each direction of travel. There is an average station spacing of about 0.9 miles around the route.

The stations would serve many of the medical facilities in the Rockville/Gaithersburg area; colleges and universities such as Johns Hopkins, University of Maryland, and University of Phoenix; and office developments on the west side of the route and the Rockville CBD and its cluster of office buildings in the center of the route. The route would also serve numerous biotechnology offices, some of the light industrial facilities, single-family residences, Rockville Historic District, and clusters of office development heading back toward the Life Sciences Center development. The stations would also provide seven transfer opportunities to premium transit, including a Metrorail and MARC commuter service (both at Rockville) and five BRT routes (3, 7, 10a, 10b, and 16) being assessed. The route may also connect to the Corridor Cities Transitway at the route's terminus, depending on the locally-preferred route alternative selected.

D.5 Route 7: Muddy Branch Road/Lakeforest Mall

Route Overview

The Muddy Branch Road/Lakeforest Mall route would be about 7.2 miles in length, anchored by Lakeforest Mall and its transit center at its northern terminus and the Life Sciences Center development at its southern terminus. Heading southbound, the route would begin at Lakeforest Transit Center and head west along Odendhal Avenue. It then would head south along MD 355 before taking the service ramp toward West Diamond Avenue. It then would head west on West Diamond Avenue, then south along Muddy Branch Road before heading south on Great Seneca Highway. The route would cross Key West Avenue and then head west onto Medical Center Drive to its terminus within Life Sciences Center. This terminus may also be the site of a potential station for the future CCT.

In the northbound direction, the route would travel along Medical Center Drive to head north along Great Seneca Highway. It then would head north along Muddy Branch Road and east along West Diamond Avenue, where it would cross beneath the MD 355 overpass and turns into Old Towne Avenue. It then turns onto Fulk's Corner Avenue very briefly before heading north along MD 355. Passing Odendhal Avenue, the route continues for one block before heading east along Lakeforest Boulevard. It then heads north along Russell Avenue, north along Montgomery Village Avenue, and south along Lost Knife Road. The route then would terminate at the Lakeforest Transit Center.

Cross-section

The existing ROW width along the route ranges from 65 to 220 feet. At the north end of the route, along MD 355, Lost Knife Road, and Odendhal Avenue, the roadway cross-section is either a four- or six-lane roadway. On Muddy Branch Road and Great Seneca Highway, the route's cross-section is a four-lane roadway. There is no on-street parking available along this route.

Potential BRT Stations

There are 10 BRT stations identified along the route.

1. Lakeforest Transit Center
2. Montgomery Village Avenue and Lost Knife Road
3. MD 355 and Perry Parkway/Lakeforest Boulevard
4. MD 355 and Odendhal Avenue
5. MD 355 and Brookes Avenue
6. Muddy Branch Road and West Diamond Avenue
7. Muddy Branch Road and West Side Drive
8. Muddy Branch Road and Diamondback Drive
9. Great Seneca Highway and Decoverly Drive
10. Life Sciences Center (Great Seneca Highway and Medical Center Drive)

The station at each terminus would serve both directions of travel; the remaining eight stations would have individual stations in each direction of travel. There is an average station spacing of about 0.8 miles in each direction.

The route would largely operate within two regional activity centers: North Frederick Avenue and Shady Grove/King Farm/Life Sciences Center. As such, stations would serve a number of business parks within Life Sciences Center and toward the center of the route surrounding the West Diamond Avenue/Muddy Branch Road intersection. Additionally, Lakeforest Mall—a regional shopping center—would be served by this route. The stations would also provide six connections to premium transit service, including a potential CCT station at the southern terminus of this route, park-and-ride facility (Lakeforest Transit Center), and three BRT routes (5, 10a, and 13) being assessed. The station at MD 355 and Brookes Avenue would be within walking distance of the MARC Gaithersburg station and Old Towne Gaithersburg.

D.6 Route 8: MD 185/Connecticut Avenue

Route Overview

The MD 185/Connecticut Avenue route would be about 9.5 miles in length. It would terminate at MD 97/Georgia Avenue and Bel Pre Road—with a transfer opportunity to the MD 97/Georgia Avenue North route—in the north and extend to Medical Center Metrorail station in the south, by way of Jones Bridge Road. In the southbound direction, the route would begin at Bel Pre Road and Georgia Avenue, heading south along Georgia Avenue and then south along Connecticut

Avenue. The route would travel several miles along Connecticut Avenue and then head west along Jones Bridge Road. It would then travel north for a brief segment along MD 355 and terminate at the Medical Center Metrorail station. In the northbound direction, the route would depart the Metrorail station, heading south along MD 355 and east along Jones Bridge Road. It would then head north along Connecticut Avenue for several miles, crossing Georgia Avenue before heading west on Bel Pre Road, where it would terminate.

Cross-section

The route is primarily a six-lane roadway along Connecticut Avenue and is a four-lane roadway along Jones Bridge Road. There are raised grass/tree-lined medians along most of the route. Narrow concrete medians exist along Connecticut in Kensington. Along Jones Bridge Road, the median changes between a grassy/tree-lined median to a striped median with two-way-left-turn lanes. The existing ROW width ranges from 80 to 240 feet. On-street parking exists on service roads generally located between Dean Road and Brightview Street. On-street parking is not available along the remainder of the route.

Potential BRT Stations

There are 10 station locations identified for this route.

1. Bel Pre Road and MD 97/Georgia Avenue
2. MD 185/Connecticut Avenue and Georgia Avenue/Aspen Hill Road
3. MD 185/Connecticut Avenue and Kelsey Street/Dean Road
4. MD 185/Connecticut Avenue and Randolph Road
5. MD 185/Connecticut Avenue and Veirs Mill Road
6. MD 185/Connecticut Avenue and Howard Avenue
7. MD 185/Connecticut Avenue and Saul Road
8. MD 185/Connecticut Avenue and Jones Bridge Road
9. MD 185/Connecticut Avenue and Glenbrook Pkwy
10. Medical Center Metrorail station

The station at each terminus would serve both directions of travel. Six of the remaining eight stations would have individual stations in each direction of travel. Two of the remaining eight stations would have modified locations. The Georgia Avenue/Aspen Hill Road stations would be placed at a convenient midpoint location. For the Kelsey Street/Dean Road stations, one station would be located at MD 185/Connecticut Avenue and Dean Road for northbound trips, and the other station at MD 185/Connecticut Avenue and Kelsey Road for southbound trips. At Connecticut and Georgia Avenues, the route would be merging onto Connecticut Avenue, causing the BRT vehicle to enter a channelized right-turn lane. This would not be conducive to a bus stop in the southbound direction. Therefore, a bus stop would be provided at this intersection only in the northbound direction. There is an average station spacing of about 1.1 miles in each direction.

The stations would serve the Leisure World retirement community at its southern boundary, clustered retail development surrounding the intersection at MD 97/Georgia Avenue and near Howard Avenue, schools and libraries, various residential communities, and the National Institute of Health (NIH) and National Naval Medical Center (NNMC) campuses near Medical Center Metrorail station. They also would provide seven transfer opportunities to premium transit, including a Metrorail station (Medical Center), MARC commuter rail (Kensington station) within 1/4-mile of Howard Avenue, and four BRT routes (3, 4a, 10b, and 14) being assessed.

D.7 Route 10a: MD 355 North

Route Overview

The MD 355 North route would be about 14.6 miles in length. It would terminate at MD 355 and Stringtown Road—within the developing Clarksburg Town Center—at its northern terminus and at Rockville Metrorail station at its southern terminus. In the southbound direction, the route would turn around by heading south along Gateway Center Drive, and west along Stringtown Road to MD 355. The route would then travel south along MD 355 for its remainder until it terminates at Rockville Metrorail station. In the northbound direction, the route would depart the Metrorail station and replicate the southbound travel in the opposite direction.

Cross-section

The route's existing ROW ranges from 60 to 160 feet. Its cross-section varies as a four-lane roadway from Milestone Manor Lane to Middlebrook Road and transitions to a six-lane roadway from Middlebrook Road to the end of the route. It operates along a two-lane MD 355 between Stringtown Road and Milestone Manor Lane. The route varies between having striped medians to no medians along MD 355 north of Milestone Manor Way. South of this intersection, there are raised, grassy and tree-lined medians until Montgomery Village Avenue. From this point through to the terminus, the median treatments range from striped, two-way left-turn lanes to medians that are wide at mid-block locations with concrete tapers. There is no on-street parking available for the entire route.

Potential BRT Stations

There are 16 station locations identified along the route.

1. MD 355 and Stringtown Road
2. MD 355 and Shawnee Lane
3. MD 355 and Little Seneca Parkway
4. MD 355 and Shakespeare Boulevard
5. MD 355 and MD 118/Germantown Road
6. MD 355 and Middlebrook Road
7. MD 355 and Game Preserve Road
8. MD 355 and MD 124/Montgomery Village Avenue
9. MD 355 and Odendhal Avenue
10. MD 355 and Brookes Avenue
11. MD 355 and Education Boulevard
12. MD 355 and Shady Grove Road
13. MD 355 and King Farm Road
14. MD 355 and West/East Gude Drive
15. MD 355 and Mannakee Street
16. Rockville Metrorail station-west entrance

The station at the southern terminus would serve both directions of travel; the remaining 15 station locations would have individual stations in each direction of travel. There is an average station spacing of about 1.0 miles in each direction.

The stations would serve a variety of business parks and office development, schools, several clusters of local and regional shopping centers—including Neelsville Shopping Center and Lakeforest Mall—two campuses for Montgomery College, Montgomery County offices within the heart of the Rockville CBD, and a number of residential communities along the route. They also provide ten transfer opportunities to premium transit services, including a park-and-ride lot in Germantown, Metrorail and MARC station (Rockville), and seven BRT routes (3, 5, 7, 10a, 10b, 13, and 16) being assessed.

D.8 Route 10b: MD 355 South

Route Overview

The MD 355 South route would be about 8.8 miles in length. It would terminate at Rockville Metrorail station at its northern terminus and at Bethesda Metrorail station at its southern terminus. In the southbound direction, the route would travel south along MD 355 and then south along Woodmont Avenue. It would head east along Edgemoor Lane and terminate at Bethesda Metrorail station. In the northbound direction, the route would depart Bethesda Metrorail station along Commerce Lane and head north along MD 355. The route would travel on MD 355 until its terminus at Rockville Metrorail station.

Cross-section

The route's existing ROW width ranges from 45 to 165 feet. Its primary cross-section is a six-lane roadway along MD 355. Woodmont Avenue is a four-lane roadway. There is no on-street parking available for majority of the route except for two small segments between Cordell Avenue and Old Georgetown Road and between Battery Lane/Rosedale Avenue and Commerce Lane, which are about 0.3 miles and 0.5 miles in length, respectively. Along MD 355, the medians range from narrow, concrete medians to medians that are wide at mid-block locations with concrete tapers. Striped, two-way left-turn medians exist along Woodmont Avenue.

Potential BRT Stations

There are 13 station locations proposed along the route.

1. Rockville Metrorail station-west entrance
2. MD 355 and Wootton Parkway/First Street
3. MD 355 and Halpine Road
4. MD 355 and Hubbard Drive
5. MD 355 and Marinelli Road/White Flint Metrorail station
6. MD 355 and Edson Lane
7. MD 355 and Tuckerman Lane north/Grosvenor Metrorail station
8. MD 355 and Pooks Hill Road
9. MD 355 and Cedar Lane
10. MD 355 and South Drive/Wood Road/Naval Center Metrorail Station access
11. MD 355 and Norfolk Avenue/Cheltenham Drive

12. Bethesda Metrorail station
13. MD 355 and Norfolk Avenue/Cheltenham Drive

The station at each terminus would serve both directions of travel; the remaining 11 stations would have individual stations in each direction of travel. There is an average station spacing of about 0.7 miles in each direction.

The stations would serve libraries, White Flint mixed center, Bethesda CBD, several federal facilities—including NIH, NNMC, and Federal Energy Regulatory Commission—business parks, Richard Montgomery High School, clusters of local and regional shopping centers such as Mid-Pike Shopping Center and White Flint Mall, Rockville Town Center, and numerous residential communities along the route. They would also provide 16 transfer opportunities to premium transit, including six Metrorail stations (Rockville, Twinbrook, White Flint, Grosvenor, Medical Center, and Bethesda), a MARC station (Rockville), a park-and-ride facility (Mid-Pike Plaza), a future Purple Line station (Bethesda), and seven BRT routes (3, 5, 8, 10a, 12, 14, and 21) being assessed.

D.9 Route 11: New Hampshire Avenue

Route Overview

The New Hampshire Avenue route began as 5.0 miles in length. Prior to initial model results, it was extended into northeast DC for a route length of 8.8 miles. It would terminate at White Oak Transit Center at its northern terminus and the Fort Totten Metrorail station at its southern terminus. In the southbound direction, the route would depart White Oak Transit Center traveling west along Lockwood Drive, then south along New Hampshire Avenue. It would travel this road into DC, then head south on North Capitol Street. The route would then head east on Riggs Road NE and then south on First Place NE before terminating at the Fort Totten Metrorail station. In the northbound direction, the route would replicate the southbound travel in the opposite direction.

Cross-section

The route's cross-section is primarily that of six-lane roadway, with an existing ROW width ranging from 75 to 280 feet. It widens to seven lanes along New Hampshire Avenue near the FDA-White Oak campus. Between Lockwood Drive and I-495, New Hampshire has primarily narrower medians that widen at mid-block. They transition to primarily wider, grassy medians with narrower concrete tapers up to Ruatan Street. From this intersection to the southern terminus, there are narrow, concrete medians along the route. Wrought-iron fencing is installed along New Hampshire Avenue between Lockwood Drive and Michelson Road and between Lebanon Street and University Boulevard to promote pedestrian safety. On-street parking opportunities exist only along service roads between Oakview Drive/Mt. Pisgah Lane and Fox Street in the northbound direction and in both directions between Ruatan Road and Lebron Street.

Potential BRT Stations

There are nine station locations identified along the route.

1. White Oak Transit Center
2. New Hampshire Avenue and Schindler Drive/Mahan Road (FDA-White Oak campus)

3. New Hampshire Avenue and Powder Mill Road
4. New Hampshire Avenue and Oakview Drive/ Mount Pisgah Lane
5. New Hampshire Avenue and Northampton Drive
6. Takoma/Langley Park Transit Center
7. New Hampshire Avenue and MD 410/Ethan Allen Avenue/East-West Highway
8. New Hampshire Avenue and Eastern Avenue NE
9. Fort Totten Metrorail station

The station at each terminus would serve both directions of travel; the remaining four stations would have individual stations in each direction of travel. There is an average station spacing of about 1.1 miles in each direction.

The stations would serve the FDA-White Oak campus, local and regional shopping centers including White Oak Shopping Center and the cluster of retail development at the Takoma/Langley Crossroads, and a number of residential communities along the route. The route would provide a key connection to riders heading toward the DC core. Stations would provide seven connections to premium transit service, including one Metrorail station (Fort Totten), three transit centers (White Oak, Hillandale, and Takoma/Langley Park), future Purple Line station at Takoma/Langley Park, and two BRT routes (18 and 19) being assessed.

D.10 Route 12: Old Georgetown Road

Route Overview

The Old Georgetown Road route would be about 6.9 miles in length. It would terminate at Montgomery Mall Transit Center—with transfer opportunities to several local bus routes—at its northern terminus and at Bethesda Metrorail station—with connections to the Red Line and future Purple Line—at its southern terminus. In the southbound direction, the route begins at Montgomery Mall Transit Center. It would head east on Westlake Terrace/Fernwood Road, then north on Rockledge Drive. Here it would loop through Rock Spring Business Park along Rockledge Drive and Rockledge Boulevard before reaching Rock Spring Drive. It would then head east on Rock Spring Drive up to Old Georgetown Road. The route then would head south along Old Georgetown Road up to Woodmont Avenue, where it would head south on Woodmont Avenue, then east on Edgemoor Lane to terminate at Bethesda Metrorail station.

In the northbound direction, the route would depart Bethesda Metrorail station to head east north along Old Georgetown Road. It then heads west along Rock Spring Drive up to Fernwood Road. At Fernwood Road, the route would head south to Democracy Boulevard, then head west toward Westlake Drive, where it would head north up to Westlake Terrace. The route then would head east along Westlake Terrace to terminate at Montgomery Mall Transit Center.

Cross-section

In the northern end surrounding Montgomery Mall and Rock Spring Business Park, route segments along Westlake Terrace/Fernwood Road, Westlake Drive, Rockledge Drive, Rockledge Boulevard, and Rock Spring Drive are four-lane roadways; while route segments along Democracy Boulevard are six-lane roadways. The median treatments along these route segments include striped medians; narrow, concrete medians; and wide, grassy medians. Along Old Georgetown Road, the cross-section is six lanes up to Greentree Road/South Drive and transitions to four lanes through to the CBD. Old Georgetown Road has medians of varying widths, with trees lining the wider portions of the median and narrow concrete medians at intersections. Between Glenwood Road and Woodmont Avenue, the median is a two-way turn lane that becomes a directional third lane during peak periods. The existing ROW width ranges from 75 to 220 feet. There is no on-street parking along this route.

Potential BRT Stations

There are nine station locations identified along the route.

1. Montgomery Mall Transit Center
2. Rockledge Drive and Rockledge Center
3. Rockledge Road and Rock Spring Drive
4. Rock Spring Drive and Old Georgetown Road
5. Old Georgetown Road and Ryland Drive
6. Old Georgetown Road and West Cedar Lane
7. Old Georgetown Road and Lincoln Drive
8. Old Georgetown Road Del Ray Avenue/Cordell Avenue
9. Bethesda Metrorail station

The station at each terminus would serve both directions of travel; the remaining seven stations would have individual stations in each direction of travel. There is an average station spacing of about 0.9 miles in each direction.

The stations would serve Montgomery Mall west of I-270, Rock Spring Business Park along Fernwood Road (including Marriott's headquarters), single-family homes, neighborhood shopping centers, Walter Johnson High School, Suburban Hospital, the National Institute of Health, and the Bethesda CBD on Old Georgetown Road. They would also provide five connections to premium transit service, including a Metrorail and future Purple Line station (Bethesda), a park-and-ride facility sited at a transit center (Montgomery Transit Center), and two BRT routes (10b and 21) being assessed.

D.11 Route 13: MD 124/Quince Orchard Road/Montgomery Village Avenue

Route Overview

The MD 124/Quince Orchard Road/Montgomery Village Avenue route would be about 6.1 miles in length, Montgomery Village Shopping Center at its northern terminus and the Kentland community at its southern terminus. Heading southbound, the route would begin at Montgomery Village Shopping Center and travel south along Montgomery Village Avenue, which turns into Quince Orchard Road after I-270. The route would travel toward Great Seneca Highway, heading south Great Seneca Highway and terminating at Main Street to serve the Kentland Shopping Center and a potential CCT station.

Heading northbound, the route would have to turn around by traveling south on Great Seneca Highway, west along Kentlands Boulevard, and north along Quince Orchard Road. It then would travel along Quince Orchard Road, which becomes Montgomery Village Avenue at I-270 and head to and terminate at Montgomery Village Shopping Center.

Cross-section

The route's existing ROW width ranges between 80 to 170 feet. Its cross-section is a four-lane roadway along Quince Orchard Road. It becomes a six-lane roadway once the road becomes Montgomery Village Avenue, and then goes back to being a four-lane roadway starting at Mid County Highway through the end of the route. North of Mid County Highway, the route has grassy and tree-lined medians through to the northern terminus, with its widest median between Mid County Highway and Lake Landing Road. South of Mid County Highway to Dosh Drive, the route transitions from grassy medians with raised curbs to undivided roadways with left-turn lanes approaching each intersection. Wider grassy medians return from Dosh Drive through to Kentlands Boulevard. Great Seneca Highway and Kentlands Boulevard also have wider, grassy medians; however, Kentlands Boulevard has two roundabouts at Market and Main Streets. There are no on-street parking opportunities along most of the route, with the exception of the section along Kentlands Boulevard between Great Seneca Highway and Quince Orchard Road.

Potential BRT Stations

There are nine proposed stations along the route.

1. Montgomery Village Avenue and Centerway Drive
2. MD 124/Montgomery Village Avenue and Lost Knife Road
3. MD 124/Montgomery Village Avenue and MD 355
4. Gaithersburg PnR (MD 124/Quince Orchard Road and I-270 SB)
5. MD 124/Quince Orchard Road and West Diamond Avenue
6. Sound Rd and MD 124/Quince Orchard Road
7. MD 124 and Sioux Lane/Orchard Ridge Drive
8. MD 119/Great Seneca Highway and Main Street
9. Kentlands Boulevard and Main Street

The station at each terminus would serve both directions of travel. One station would serve Kentlands Boulevard and Main Street in the northbound direction; the remaining six stations would have individual stations in each direction of travel. There is an average station spacing of about 0.7 miles in each direction.

The stations would serve a large planned unit development community in Montgomery Village at its north end, including a mixture of residential, commercial (including Montgomery Village and Kentlands Shopping Center), business parks such as the IBM, Lockheed Martin, and National Institutes of Standards and Technology (NIST) facilities, as well as higher density residential development within the Kentlands traditional residential development. The stations would also provide five connections to premium transit service, including two potential CCT stations (Kentlands and NIST), a park-and-ride facility (Gaithersburg park-and-ride), and two BRT routes (7 and 10a) being assessed.

D.12 Route 14: Randolph Road

Route Overview

The Randolph Road route would be about 5.5 miles in length. It would terminate at White Flint Metrorail station at its western terminus and at Glenmont Metrorail station at its eastern terminus, providing transfer opportunities to both rail and local buses at either end. In the eastbound direction, the route would begin at White Flint Metrorail station and head north along MD 355. It then would follow the Montrose Parkway access ramp and operate along Randolph Road for most of the route. It would head north on Georgia Avenue and terminate at Glenmont Metrorail station. In the westbound direction, the route would begin at Glenmont Metrorail station and essentially operate in the opposite direction up to Randolph and Nebel Roads. At Nebel Road, the route would head south to Marinelli Road, where it would head west and terminate at White Flint Metrorail station.

Cross-section

The route's existing ROW width ranges from 90 to 125 feet. Its cross-section varies between four to six lanes along Randolph Road: the road is four lanes at its western end up to Galena Road, where it begins its transition to six lanes. Both MD 355 and Georgia Avenue are six-lane roadways. The route is an undivided roadway with a two-way left turn lane from MD 355 to Gaynor Road. The eastbound roadway separates over a short distance from the westbound roadway to intersect with Parklawn Drive. Over Rock Creek, the roadway has narrow concrete median. East of Rock Creek, the roadway has grassy medians between intersections and narrow concrete median at intersections. Most of the roadways along the route do not have on-street parking. The exceptions are sections of on-street residential parking along Randolph Road during the off-peak hours and between Dewey and Selfridge Roads and between Veirs Mill Road and Georgia Avenue.

Potential BRT Stations

There are seven station locations identified along the route.

1. White Flint Metrorail station
2. Randolph Road and Lauderdale Drive
3. Randolph Road and MD 586/Veirs Mill Road
4. Randolph Road and MD 185/Connecticut Avenue
5. Randolph Road and Bluhill Road
6. Randolph Road and MD 97/Georgia Avenue
7. Glenmont Metrorail station

The station at each terminus would serve both directions of travel; the remaining five stations would have individual stations in each direction of travel. There is an average station spacing of about 0.9 miles in each direction.

Four of the seven stations are recommended stations from the 2002 report, Randolph Road Bus Transit Improvement Study. The report proposes a "super shelter" at Veirs Mill Road. The stations would serve a number of land uses and attractions, including development existing and proposed within the White Flint mixed-use center; retail centers such as Loehmanns Plaza, Colonia Veirs Mill Shopping Center, and Glenmont Shopping Center; and the campus serving both Thomas Edison High School Institute of Technology and Wheaton High School. There are also six transfer opportunities to premium transit service, including two Metrorail stations (White Flint and Glenmont) and four BRT routes (3, 4a, 8, and 10b) being assessed.

D.13 Route 16: Shady Grove Road

Route Overview

The Shady Grove Road route would be about 9.1 miles in length. It would terminate at MD 124/Woodfield Road and Airpark Road—central to the business parks near Montgomery County Airpark—at its northern terminus and Traville Transit Center at its southern terminus. In the southbound direction, the route would head south along Woodfield Road, circle through Lindbergh Drive, and head north on Woodfield Road back to Airpark Road to create a bus turn-around. The route then would travel south along Airpark Road, which becomes Shady Grove Road after MD 115/Muncaster Mill Road. The route would travel several miles before heading east on Blackwell Road, then south on Fallsgrove Drive to serve the Fallsgrove Regional Transit Center. Continuing along Fallsgrove Road, it would head west on Fallsgrove Boulevard and then south back onto Shady Grove Road. The route would head west at Darnestown Road and then south at Traville Gaetway Drive, terminating at Traville Transit Center. In the northbound direction, the route would head south along Traville Gateway Drive and then north along Shady Grove Road, following the path of travel in the opposite direction.

Cross-section

The route's existing ROW width ranges from 65 to 140 feet. Its cross-section is primarily a six-lane roadway along Shady Grove Road between Darnestown Road and Muncaster Mill Road. Airpark Road is a four-lane roadway for its section of the route. The route has raised medians that vary from medium to wide widths. Shady Grove Road separates briefly as it crosses the CSXT railroad tracks. The only opportunities for on-street parking are along Blackwell Road, Fallsgrove Drive, Fallsgrove Boulevard, and Traville Gateway Drive.

Proposed Stations

There are 10 station locations proposed along the route:

1. Airpark Road and MD 124/Woodfield Road
2. Airpark Road and Antares Drive
3. Airpark Road/Shady Grove Road and MD 115/Muncaster Mill Road
4. Shady Grove Road and Mid-County Highway
5. Shady Grove Road and Oakmont Avenue
6. Shady Grove Road and MD 355
7. Shady Grove Road and Gaither Road
8. Shady Grove Road and Key West Avenue
9. Fallsgrove Regional Transit Center (at Oak Knoll Terrace and Fallsgrove Drive)
10. Traville Transit Center

The station at the southern terminus would serve both directions of travel; the remaining nine station locations would have individual stations in each direction of travel. There is an average station spacing of about 0.9 miles in each direction.

The stations would serve various retail development centers and single-family residential development along the route. Additionally, they would serve numerous office parks/medical facilities—including the Shady Grove Executive Center, Key West Corporate Center, and Shady Grove Life Sciences Center. They would also provide three transfer opportunities to premium transit service, including two transit centers (Traville and Fallsgrove Regional) and one BRT route (5) being assessed.

D.14 Route 18: MD 193/University Boulevard

Route Overview

The MD 193/University Boulevard route began as 8.3 miles in length. Following initial model results, it was truncated to a 6.4-mile route. It would terminate at Wheaton Metrorail station at its western terminus and at the planned Takoma/Langley Park Transit Center at its eastern terminus. Starting at the Wheaton Metrorail station in the eastbound direction, the route would head west along Veirs Mill Road, east along Reedie Drive, north along Georgia Avenue, then east onto University Boulevard. The route would continue along University Boulevard and terminate at the Takoma/Langley Park Transit Center. In the westbound direction, the route would replicate the eastbound travel in the opposite direction.

Cross-section

The route's existing ROW width ranges from 50 to 125 feet. Its cross-section is primarily a six-lane roadway along the major arterials, including Connecticut Avenue, University Boulevard, and Georgia Avenue. The portion of the route operating along Veirs Mill Road is a four-lane roadway. University Boulevard has narrow medians that are typically concrete at intersections, with some grass median in certain midblock sections. The roadway separates between Lorain Avenue and St. Lawrence Drive, where there are retail and religious developments. Wrought-iron fencing is installed along Veirs Mill Road between Reedie Drive and Wheaton Metrorail Station access road to promote pedestrian safety. There are opportunities for on-street parking along the locals roads that would facilitate a bus turn-around (Knowles Avenue, Armory Road, and Warner Street), a short one-block section along Veirs Mill Road, and service roads along University Boulevard between Merrimac Drive and Lebanon Road. There is no on-street parking available for the majority of the route.

Potential BRT Stations

There are nine station locations identified along the route.

1. Wheaton Metrorail station
2. MD 193/University Boulevard and Amherst Avenue
3. MD 193/University Boulevard and Inwood Avenue
4. MD 193/University Boulevard and Arcola Avenue
5. MD 193/University Boulevard and Dennis Avenue
6. MD 193/University Boulevard and US 29
7. MD 193/University Boulevard and East Franklin Avenue
8. MD 193/University Boulevard and Gilbert Street
9. Takoma/Langley Transit Center

The station at each terminus would serve both directions of travel; the remaining seven stations would have individual stations in each direction of travel. There is an average station spacing of about 0.8 miles in each direction.

The stations would serve various commercial clusters at Veirs Mill Road, US 29, and New Hampshire Avenue. They would also serve two high schools and one middle school, as well as single-family residential interspersed with multi-family development. There are also nine transfer opportunities to premium transit services, including one Metrorail station (Wheaton), two future Purple Line stations (Gilbert Street and Takoma/Langley Park), and six BRT routes (3, 4a, 4b, 8, 11, and 19) being assessed.

D.15 Route 19: US 29

Route Overview

The US 29 route would be about 13.5 miles in length. It would terminate at the Burtonsville Park-and-Ride at its northern terminus and the future Silver Spring Transit Center at its southern terminus. In the southbound direction, the route would travel through the park-and-ride facility using a slip ramp to access US 29. It would exit US 29 to get to Briggs Chaney Road, heading east toward Briggs Chaney Park-and-Ride. Leaving the facility, it would head west along Briggs Chaney Road and re-enter US 29, heading south up to Stewart Lane. It would then head east very briefly, travel south along Old Columbia Pike and behind White Oak Shopping Center to serve White Oak Transit Center. The route would then travel south along Lockwood Drive and merge into US 29 heading south. It would then travel that roadway until it terminates at Silver Spring Transit Center.

In the northbound direction, the route would exit Silver Spring Transit Center and travel north before bearing onto Lockwood Drive, heading north to White Oak Shopping Center. It would then travel behind the shopping center, north along Old Columbia Pike and west very briefly along Stewart Lane before heading north along US 29. At Briggs Chaney Road, the route would head east toward Briggs Chaney Park-and-Ride. Leaving the facility, it would head west along Briggs Chaney Road and re-enter US 29, heading north and exiting at MD 198/Spencerville Road. The route would head west along Spencerville Road, north along Old Columbia Pike, and finally entering and terminating at Burtonsville Park-and-Ride.

Cross-section

The route's existing ROW width ranges from 80 to 300 feet. Its cross-section is primarily a six-lane roadway along US 29, with short segments of four lanes in either the northbound or southbound direction between Timberwood Avenue and the I-495 eastbound ramp. US 29 also has a reversible lane in a 4+2 configuration between Fenton Street and Sligo Creek Parkway. The Briggs Chaney Road cross-section is four lanes and Lockwood Drive's cross-section is two lanes. North of Stewart Lane, the roadway has grassy medians plus inside and outside shoulders, with the outside shoulders intended to be used by buses during peak periods. From just north of Stewart Lane to south of I-495, the roadway has narrower grass medians provided between intersections and a narrow concrete median at intersections; the inside and outside shoulders are largely dropped in this section. There are wider, grassy medians along Briggs Chaney Road. The median along Lockwood Drive drops from a narrow concrete median to no median. On-street parking opportunities are very limited along the route and exist along Lockwood Drive between New Hampshire Avenue and US 29, as well as along US 29 between Cedar Street/Spring Street and Wayne Avenue.

Potential BRT Stations

There are 11 station locations identified along the route.

1. Burtonsville Park-and-Ride
2. Briggs Chaney Park-and-Ride
3. US 29 and Fairland Road
4. US 29 and Tech Road
5. White Oak Transit Center
6. Lockwood Drive and Oak Leaf Drive
7. US 29 and Hillwood Drive
8. US 29 and University Boulevard
9. US 29 and Sligo Creek Parkway
10. US 29 and Fenton Street
11. Silver Spring Transit Center

The station at each terminus would serve both directions of travel; the remaining nine station locations would have individual stations in each direction of travel. There is an average station spacing of about 1.4 miles in each direction.

The stations would serve numerous business parks along the route; commercial activity including White Oak Shopping Center, City Place Mall, and other retail clusters at Four Corners and Burnt Mills Shopping Center; Silver Spring CBD; and Montgomery Blair High School. It would also provide ten transfer opportunities to premium transit services, including three park-and-ride facilities (Burtonsville, Briggs Chaney, and Tech Road) served by commuter bus service, one station for Metrorail, MARC, and future Purple Line services (Silver Spring), and four BRT routes (4b, 11, 18, and 20) being assessed.

D.16 Route 20: ICC

Route Overview

The ICC route began as 17.5 miles in length. Following initial model results, it was extended to serve the Life Sciences Center area instead of terminating at Shady Grove Metrorail station; its route length would be 22.9 miles. It would terminate at Life Sciences Center at its western terminus and Briggs Chaney Park-and-Ride at its eastern terminus. In the eastbound direction, the route would travel from Life Sciences Center heading north on MD 119/Great Seneca Highway and west onto Sam Eig Highway, continuing onto I-370 and then the ICC. It would then head east along the ICC and exit at Georgia Avenue heading south. The route would serve the planned ICC park-and-ride facility located at the southwest corner of the ICC/Georgia Avenue interchange. The route could either circulate within the park-and-ride lot or turn around by way of the planned interchange at Georgia Avenue and Norbeck Road. It would return north along Georgia Avenue and enter the ICC heading east. The route would then exit at US 29 northbound and exit at Briggs Chaney Road to head east. The route would finally terminate at Briggs Chaney Park-and-Ride. It would follow the reverse operation in the westbound direction.

Cross-section

The route’s cross-section is primarily a six-lane highway along the ICC. It is also six lanes along Georgia Avenue and US 29. Briggs Chaney Road is a four-lane roadway for its section of the route. The majority of the ICC route is on a limited-access highway; ROW widths focus on arterials used to access potential BRT stations. For the portions of the route operating on state and county roadways, the existing ROW widths are about 200 feet along Georgia Avenue, between 190 and 200 feet along US 29, and between 135 and 150 feet along Briggs Chaney Road. There are no opportunities for on-street parking along this route.

Potential BRT Stations

There are three station locations identified along the route.

1. Life Sciences Center
2. ICC Park-and-Ride
3. Briggs Chaney Park-and-Ride

The station at each terminus would serve both directions of travel and the intermediate station location would have individual stations in each direction of travel. There is an average station spacing of about 11.5 miles in each direction.

The route would primarily function as a means of connecting riders to other premium transit services, at three locations, including a Metrorail station (Shady Grove) and park-and ride facilities (ICC and Briggs Chaney) with access to existing and planned ICC bus routes operated by MTA.

D.17 Route 21: North Bethesda Transitway

Route Overview

The North Bethesda Transitway route would be about 5.1 miles in length, anchored by Montgomery Mall at its western terminus and Grosvenor Metrorail station at its eastern terminus. In the eastbound direction, the route would begin at Montgomery Mall Transit Center. It would head east on Westlake Terrace/Fernwood Road, then east along Rock Spring Drive up to Old Georgetown Road. The route would head north along Old Georgetown Road up to Tuckerman Lane, where it would then head east and terminate at Grosvenor Metrorail station.

In the westbound direction, the route would depart Grosvenor Metrorail station and head west north along Tuckerman Lane. It would then head south along Old Georgetown Road. The route would head west along Rock Spring Drive up to Fernwood Road. At Fernwood Road, the route would head south to Democracy Boulevard, then west toward Westlake Drive, where it would head north up to Westlake Terrace. The route would then head east along Westlake Terrace to terminate at the Montgomery Mall Transit Center.

Cross-section

The route's existing ROW width ranges from 75 to 160 feet. Its cross-section varies between four to seven lanes. In the northern end surrounding Montgomery Mall and Rock Spring Business Park, route segments along Westlake Terrace/Fernwood Road, Westlake Drive, Rockledge Drive, Rockledge Boulevard, and Rock Spring Drive are four-lane roadways; while route segments along Democracy Boulevard are six-lane roadways. The median treatments along these route segments include striped medians; narrow, concrete medians; and wide, grassy medians. Along Old Georgetown Road, the route is about seven lanes wide with raised, grassy medians that taper to a narrow concrete median at Tuckerman Lane. Along Tuckerman

Lane, the roadway is four lanes wide and medians are primarily striped, two-way left-turn lanes. There is a limited section of on-street parking along Tuckerman Lane between the northern and southern entrances to Grosvenor Metrorail station.

Potential BRT Stations

There are seven station locations proposed along the route.

1. Montgomery Mall Transit Center
2. Fernwood Road and Rock Spring Drive
3. Rockledge Drive and Rock Spring Drive
4. Rock Spring Drive and Old Georgetown Road
5. Old Georgetown Road and Tuckerman Lane
6. Tuckerman Lane and Sugarbush Lane
7. Grosvenor Metrorail station

The station at each terminus would serve both directions of travel; the remaining five stations would have individual stations in each direction of travel. There is an average station spacing of about 0.9 miles in each direction.

The stations would serve Montgomery Mall west of I-270, Rock Spring Business Park along Fernwood Road (including Marriott's headquarters), Walter Johnson High School, neighborhood shopping centers, and single-family homes. It would also provide four transfer opportunities to premium transit services, including a park-and-ride facility (Montgomery), one Metrorail station (Grosvenor), and two BRT routes (10b and 12) being assessed.

D.18 Route 23: Midcounty Highway

Route Overview

The Midcounty Highway route was created following the initial modeling results. The route would be about 13.4 miles in length. It would terminate in Clarksburg Town Center at its northern terminus and Shady Grove Metrorail station at its southern terminus. In the southbound direction, the route would depart the town center from Snowden Farm Parkway and Stringtown Road; it would travel along Snowden Farm Parkway, which will transition into the planned Midcounty Highway extension (designated as M-83) and then connect to the existing Midcounty Highway at Montgomery Village Avenue. The route would continue south along Midcounty Highway, then west along Shady Grove Road to the I-370 eastbound entrance toward Shady Grove Metrorail station, where it would terminate. In the northbound direction, the route would replicate the southbound travel in the opposite direction.

Cross-section

The northern end of the route along Snowden Farm Parkway is a four-lane divided highway with wide grassy medians. Toward the southern end of the route, the existing Midcounty Highway has a similar cross-section. Shady Grove Road is a six-lane roadway with medians that vary from medium to wide widths. Midcounty Highway extended would be a six-lane divided highway with medians wide enough to accommodate bi-directional dedicated bus lanes. Along this section, the route would travel beneath the newly constructed Intercounty Connector. This is no on-street parking available along this entire route.

Potential BRT Stations

There are 10 station locations along the route.

1. Snowden Farm Parkway and Stringtown Road
2. Snowden Farm Parkway and Foreman Boulevard
3. Midcounty Highway and Ridge Road
4. Midcounty Highway and MD 118 Extended/Watkins Mill Road
5. Midcounty Highway and Middlebrook Road
6. Midcounty Highway and Watkins Mill Road
7. Midcounty Highway and Montgomery Village Avenue
8. Midcounty Highway and Goshen Road
9. Midcounty Highway and MD 124/Woodfield Road
10. Shady Grove Metro Station

The station at each terminus would serve both directions of travel; the remaining eight stations would have individual stations in each direction of travel. There is an average station spacing of about 1.5 miles in each direction.

The stations would serve Clarksburg Town Center and the residential communities along this route. It would also provide a transfer opportunity to premium transit service at Shady Grove Metrorail station.

Figure D-1: Route 3: Veirs Mill Road treatment options

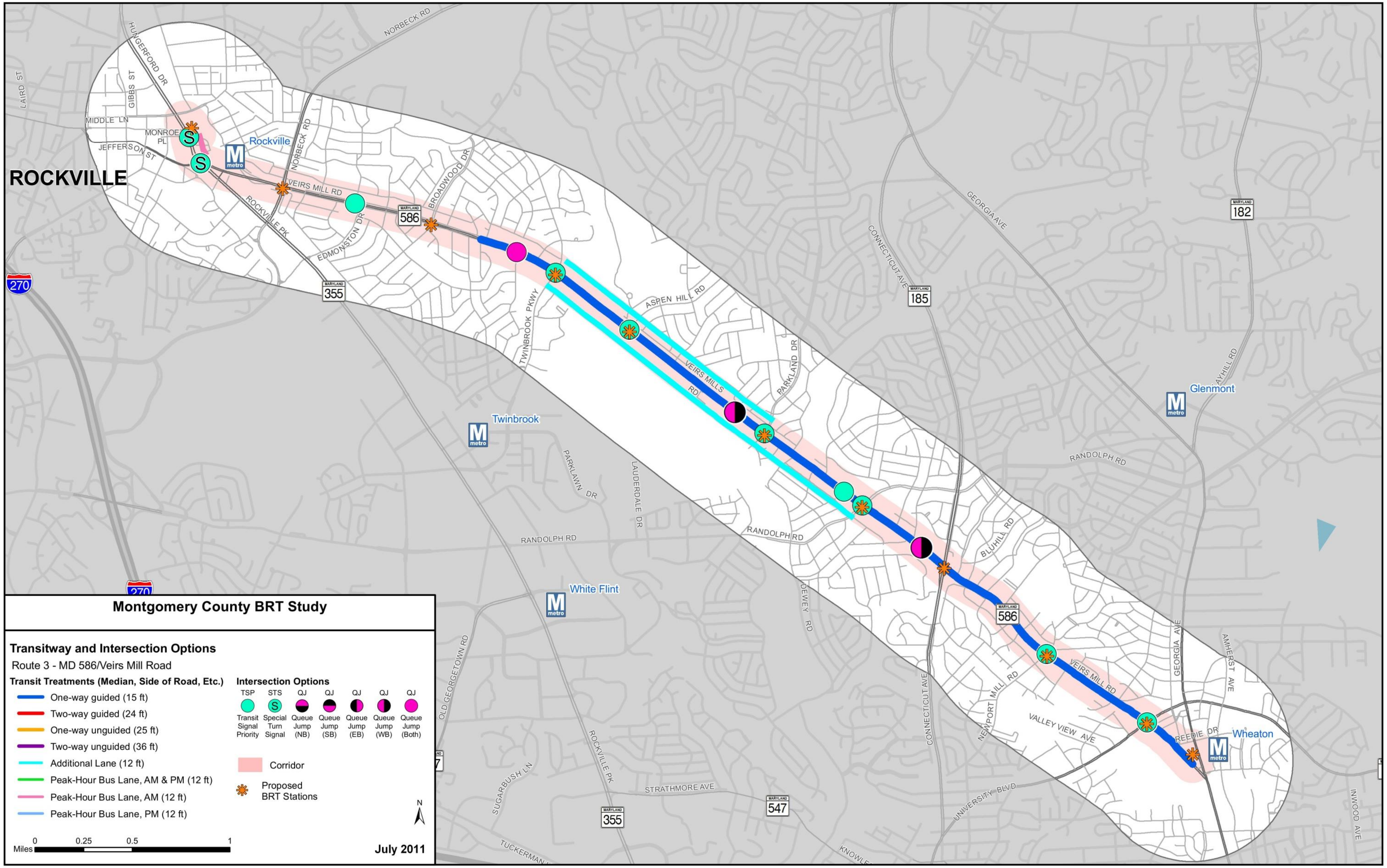


Figure D-2: Route 4a: Georgia Avenue North

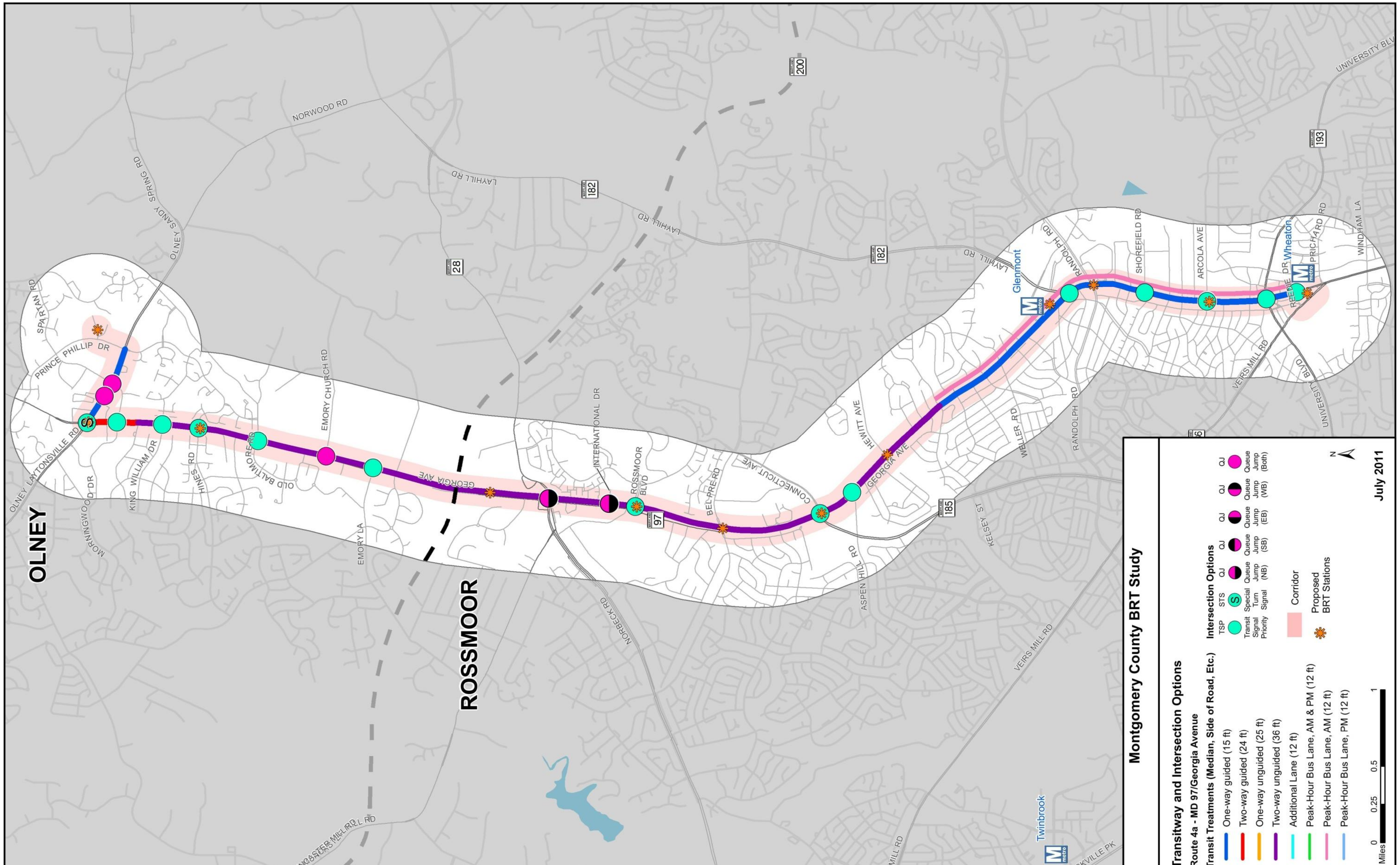


Figure D-3: Route 4b: Georgia Avenue South

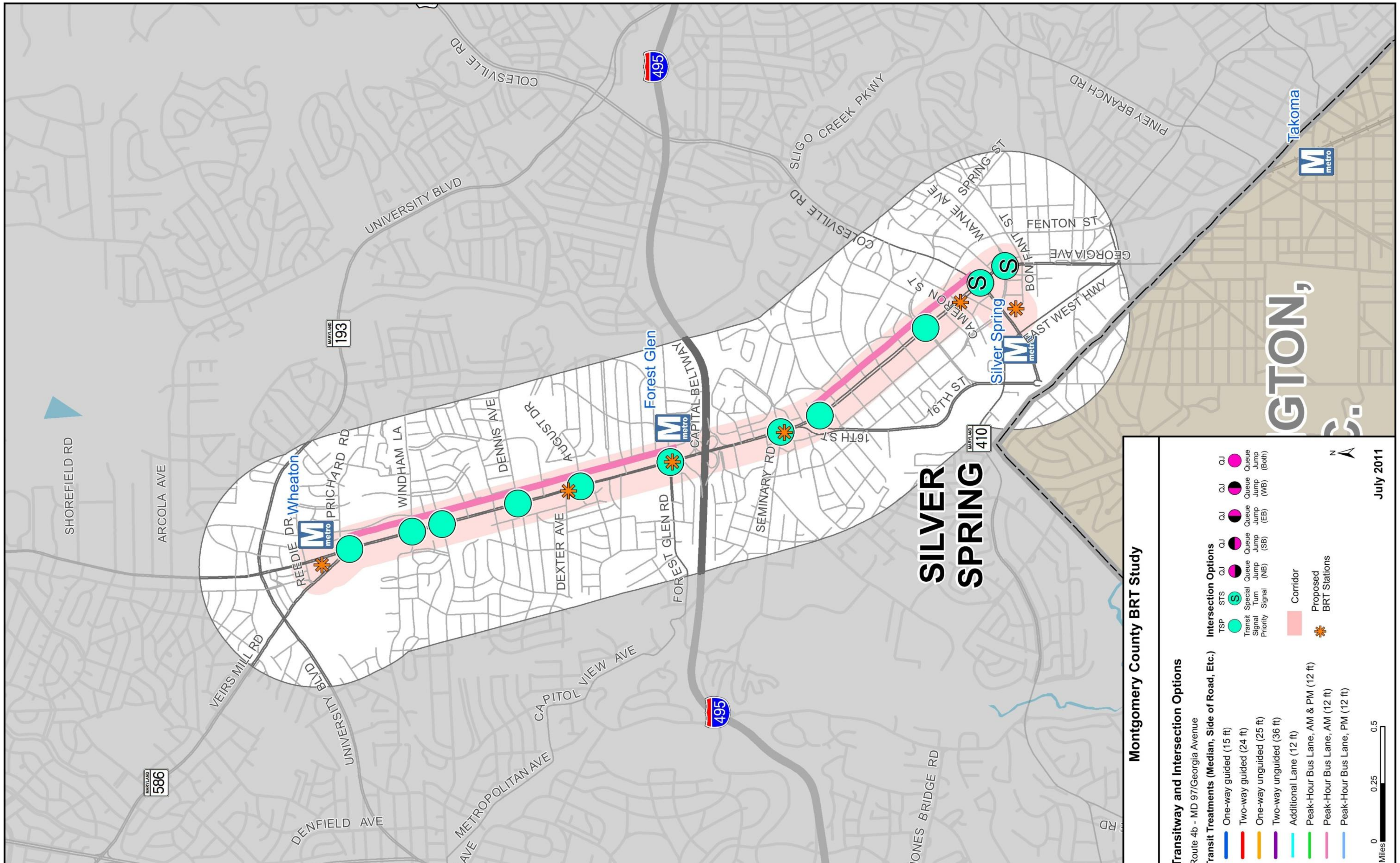


Figure D-4: Route 5: Rockville Metrorail-Life Sciences Center treatment options

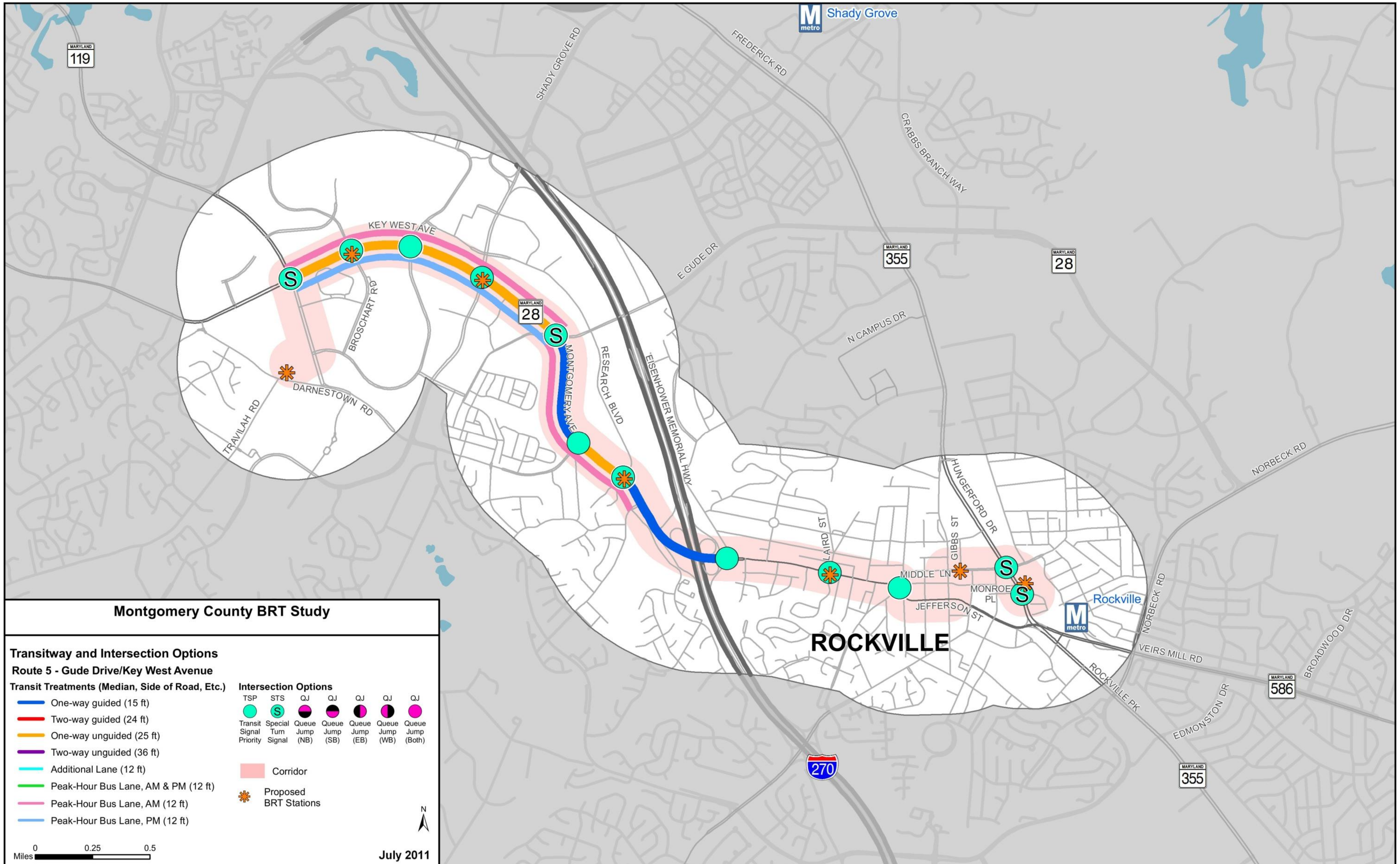


Figure D-5: Route 7: MD 124/Muddy Branch Road treatment options

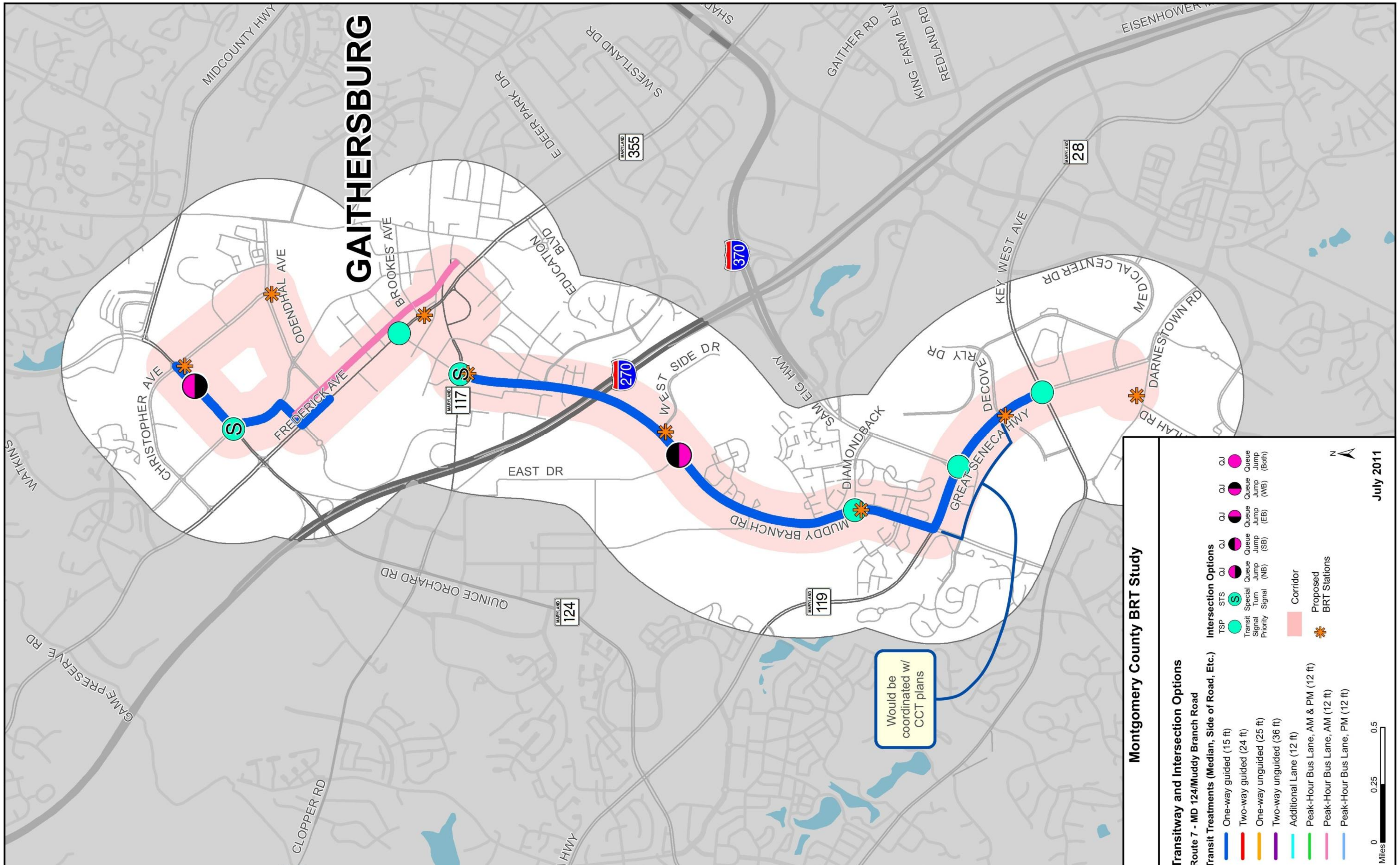


Figure D-6: Route 8: MD 185/Connecticut Avenue treatment options

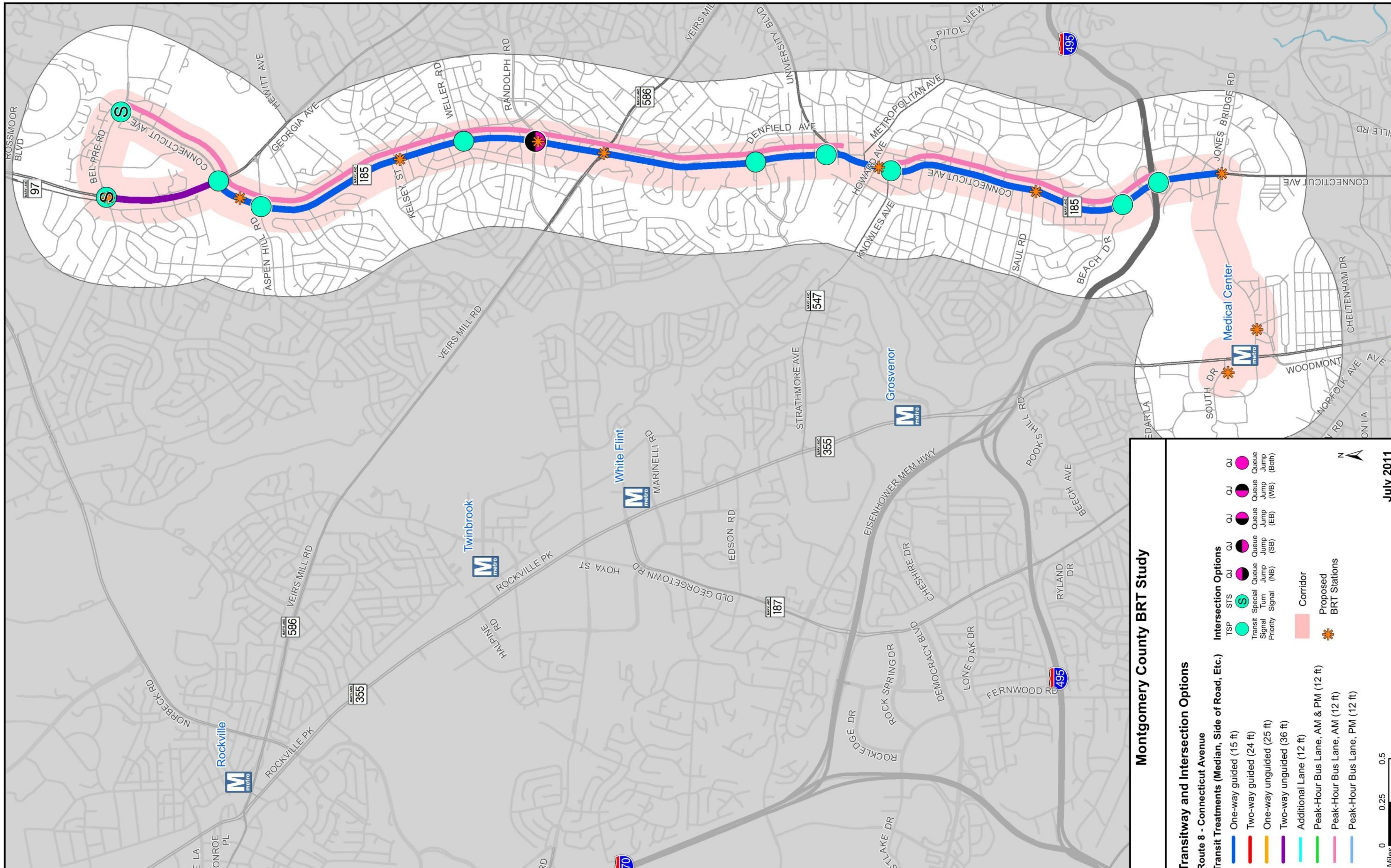


Figure D-7: Route 10a: MD 355 North treatment options

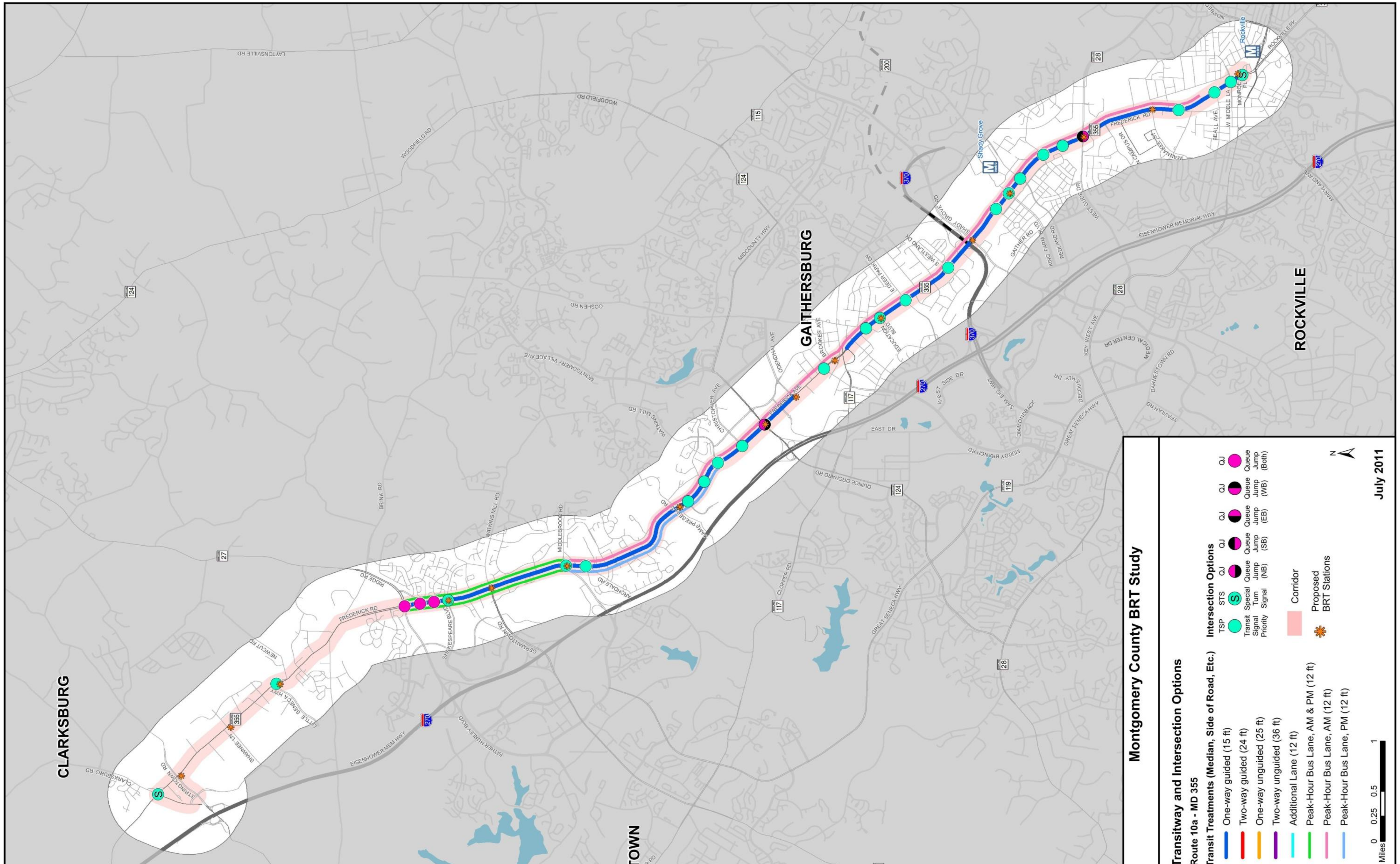


Figure D-8: Route 10b: MD 355 South treatment options

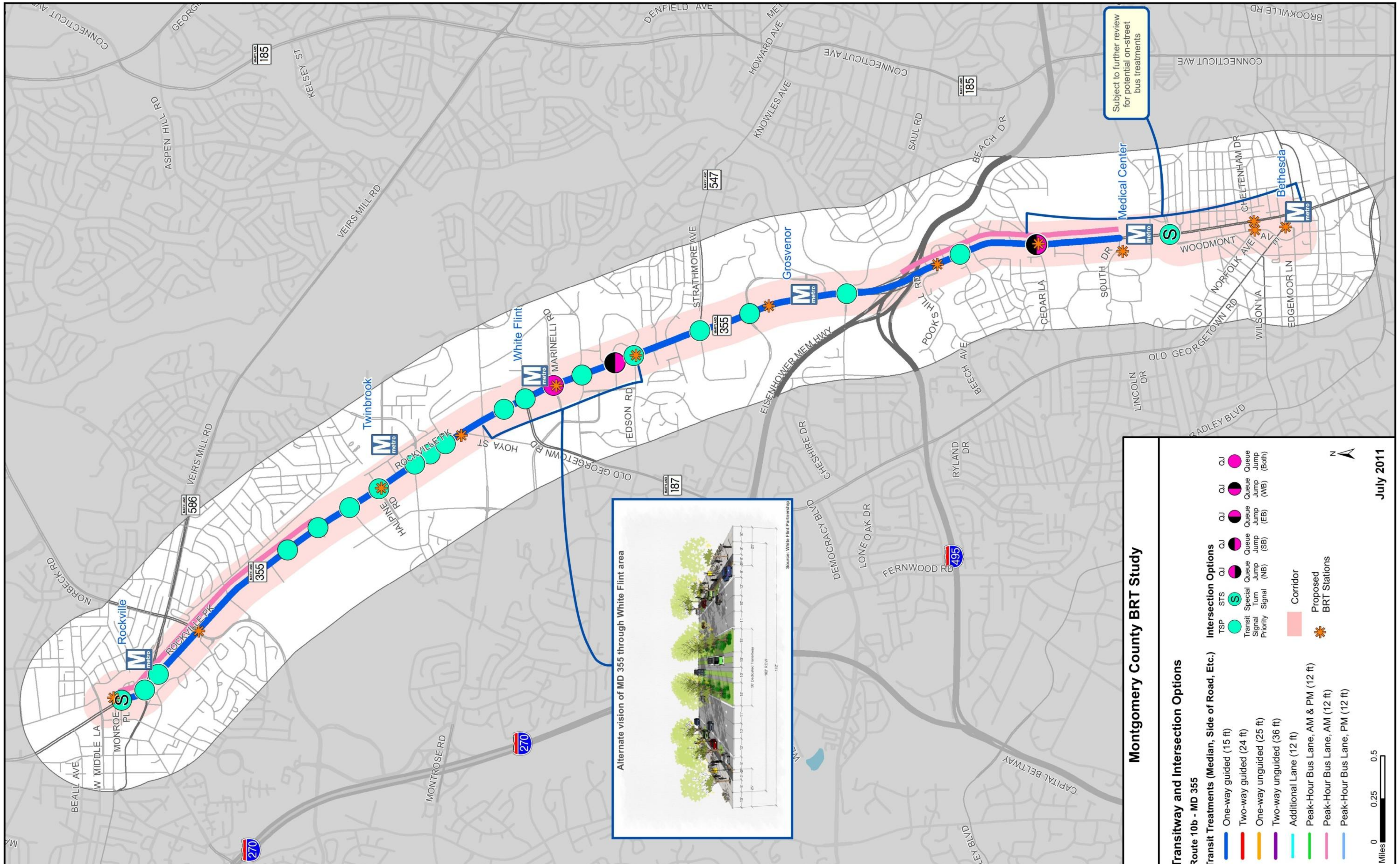


Figure D-9: Route 11: MD 650/New Hampshire Avenue treatment options

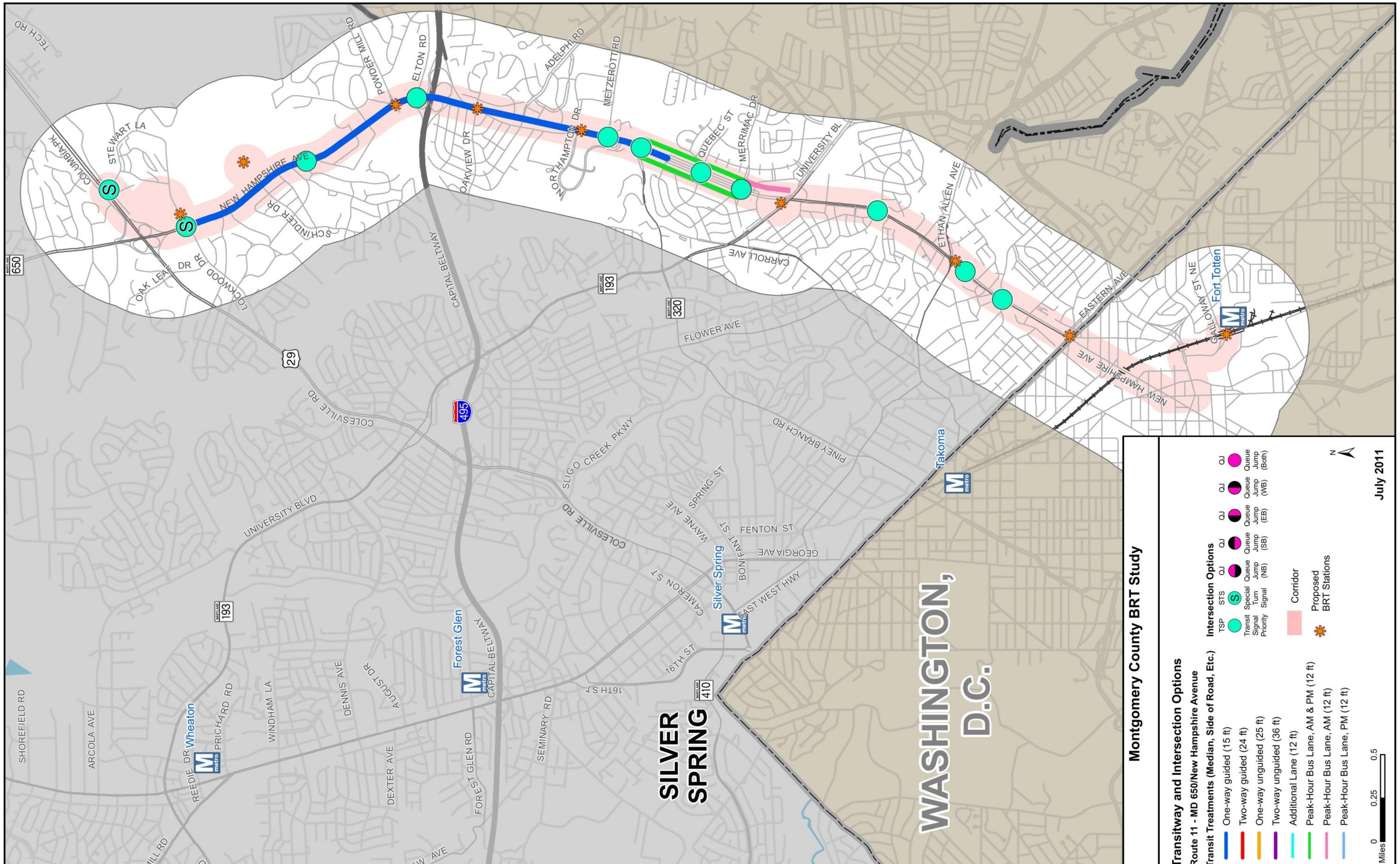


Figure D-10: **Route 12: Montgomery Mall/Old Georgetown Road treatment options**

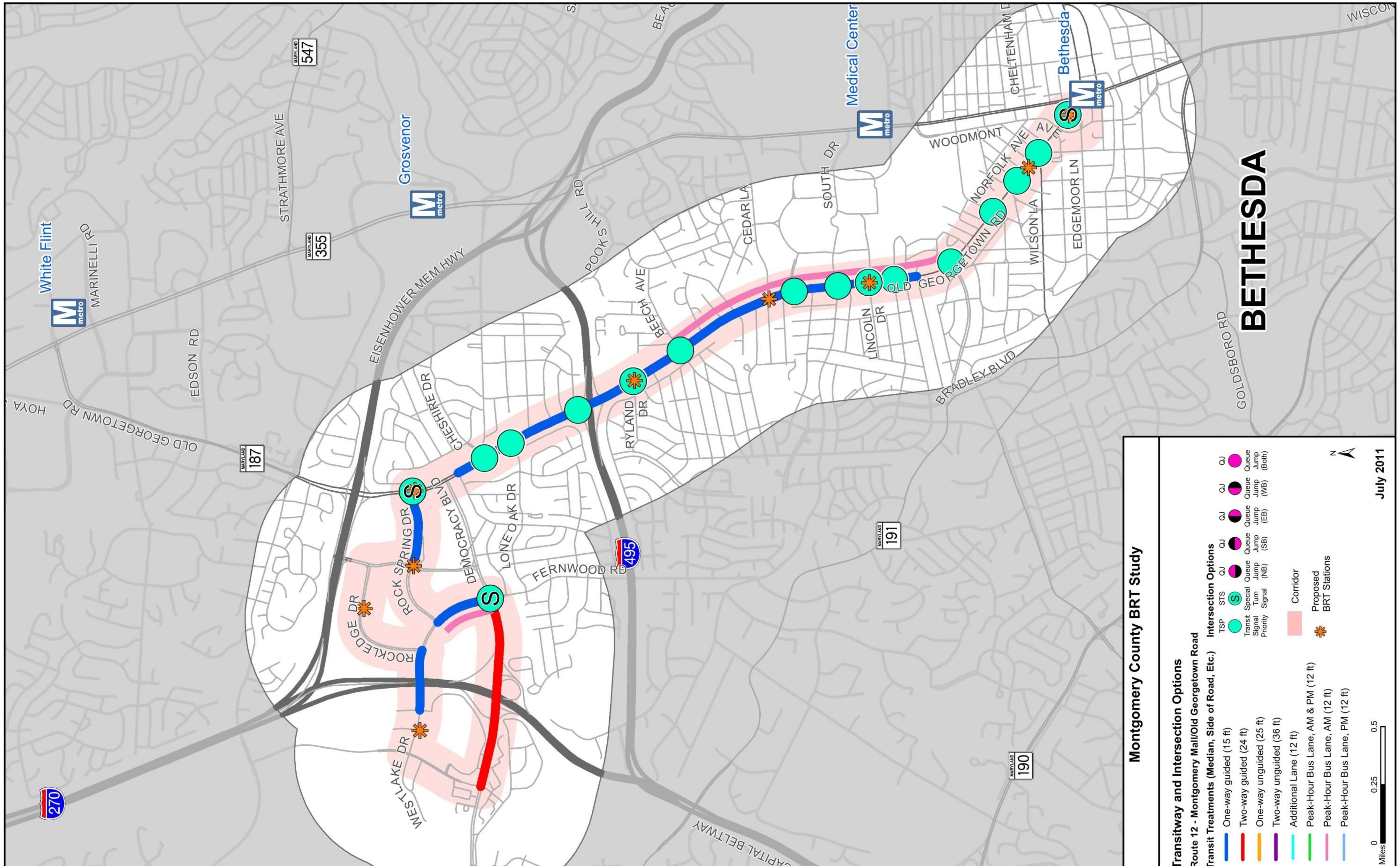


Figure D-11: Route 13: MD 124/Quince Orchard Road/Montgomery Village Avenue treatment options

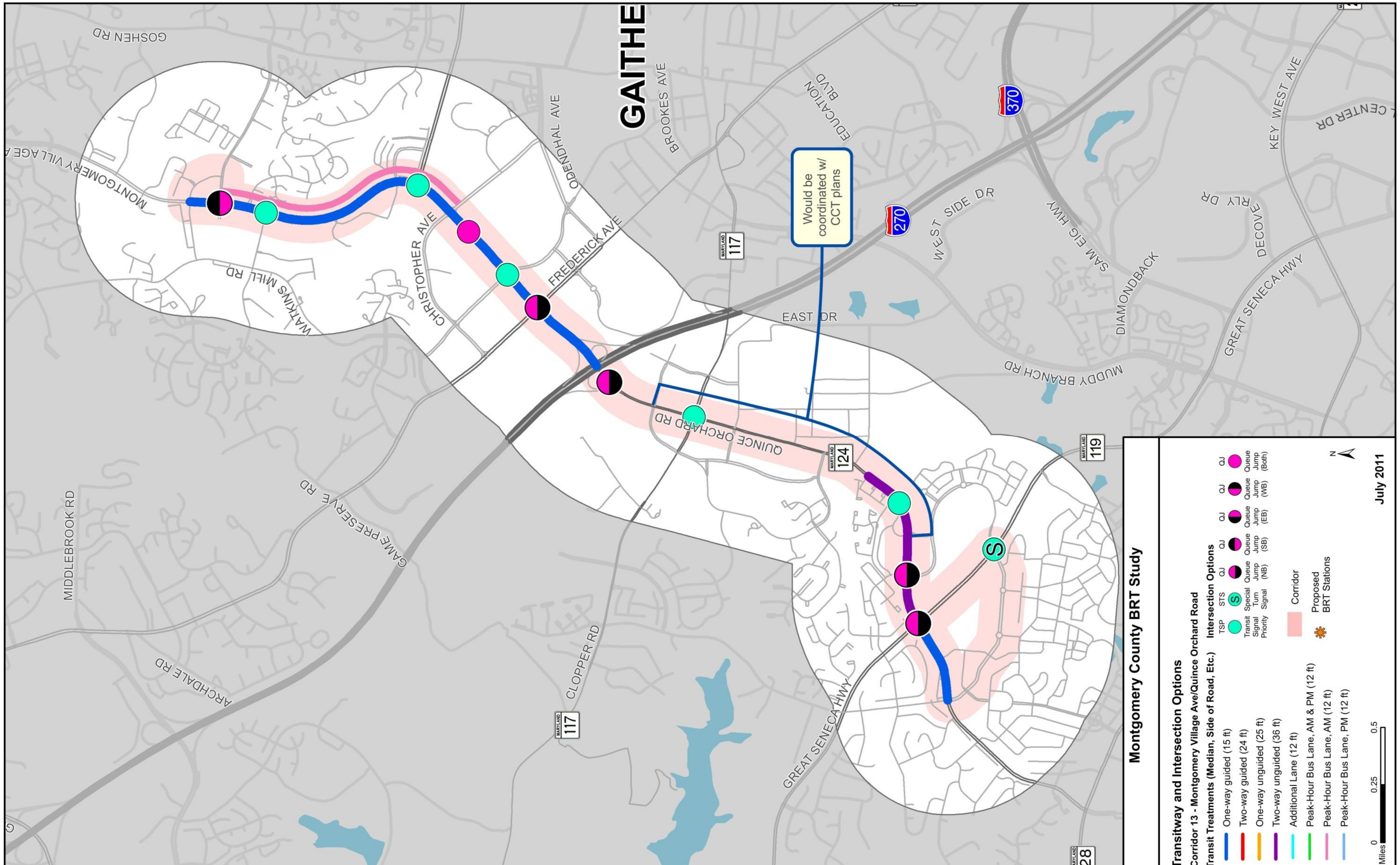


Figure D-12: Route 14: Randolph Road treatment options

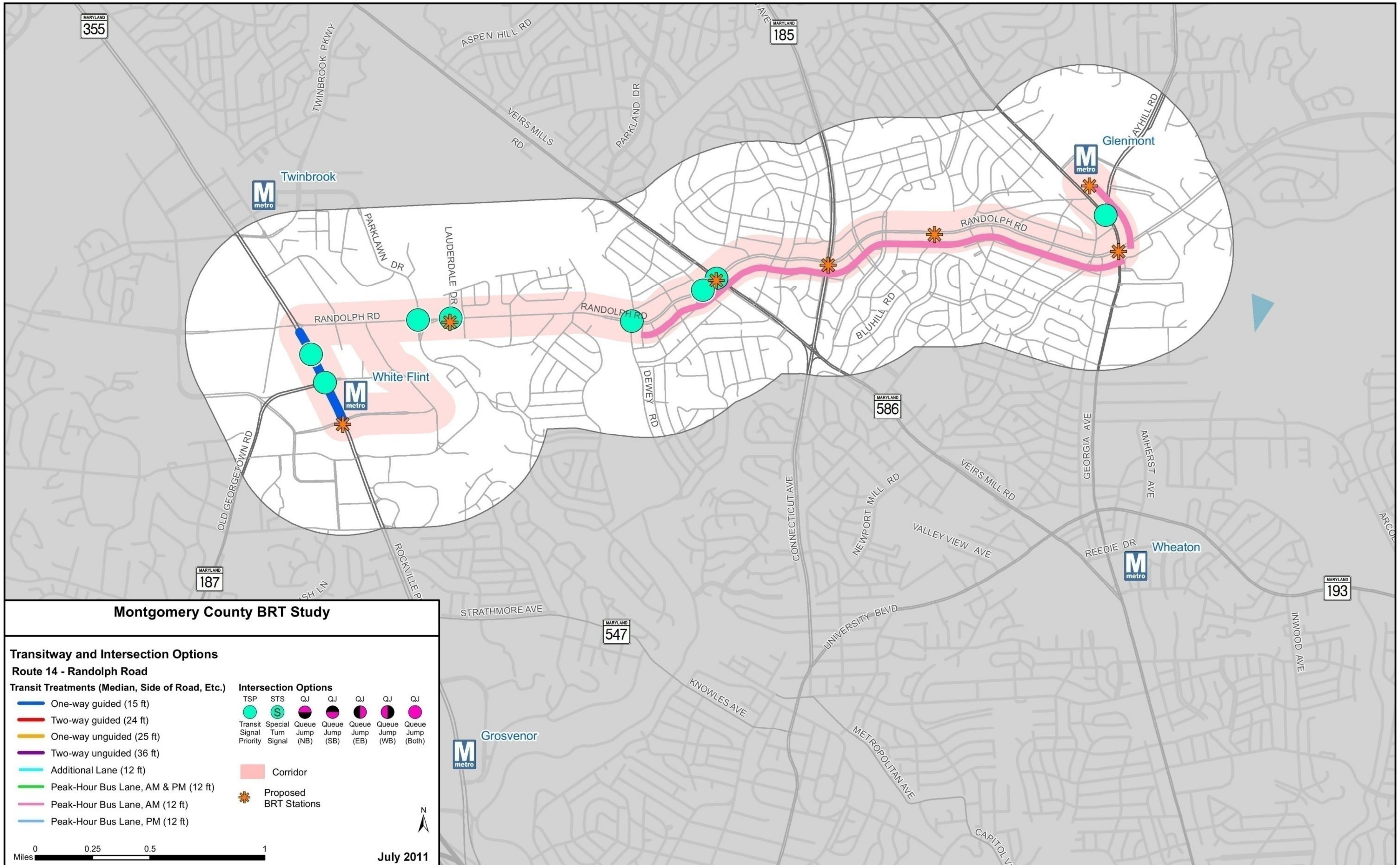


Figure D-13: Route 16: Shady Grove Road treatment options

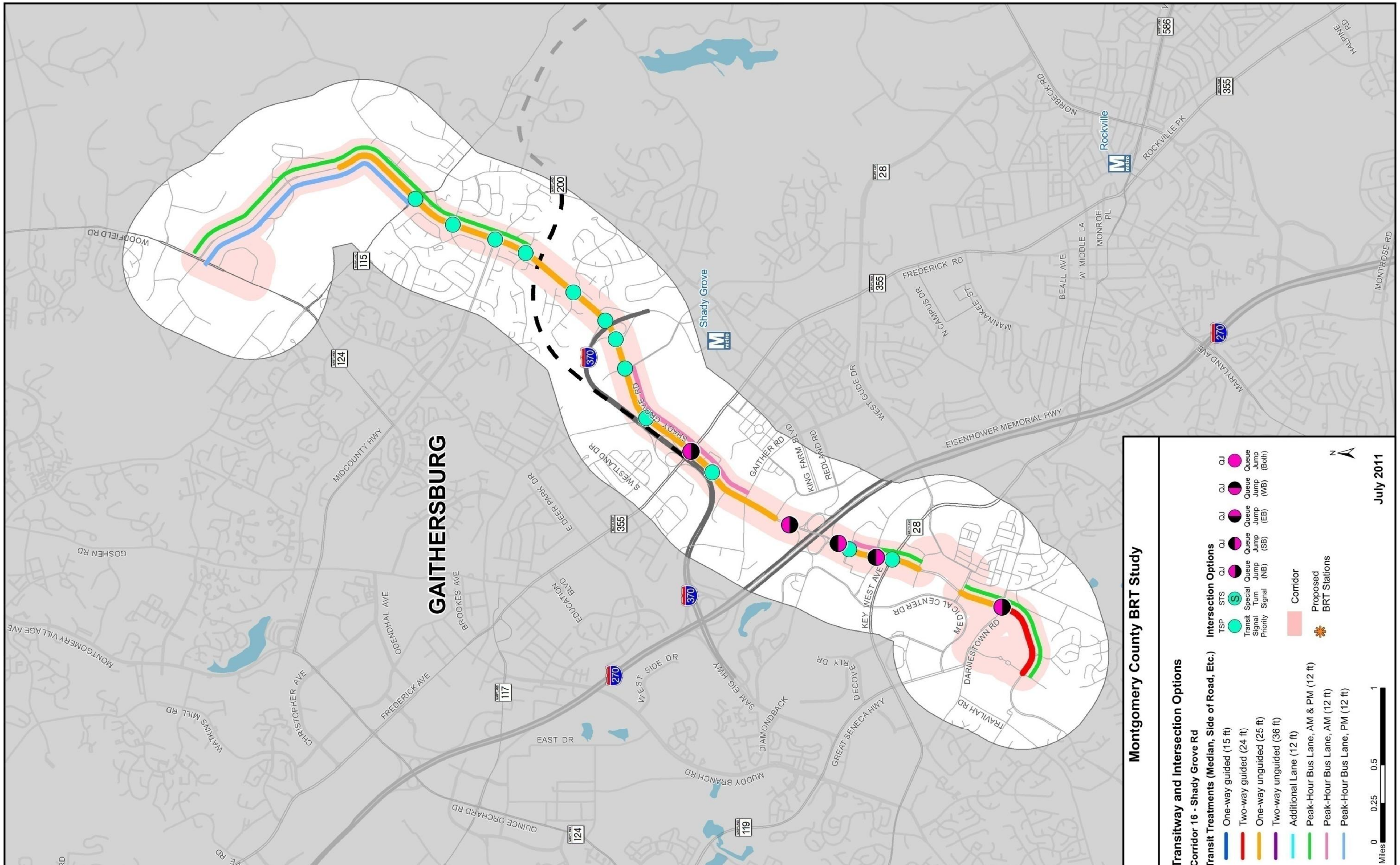


Figure D-14: Route 18: MD 193/University Boulevard treatment options

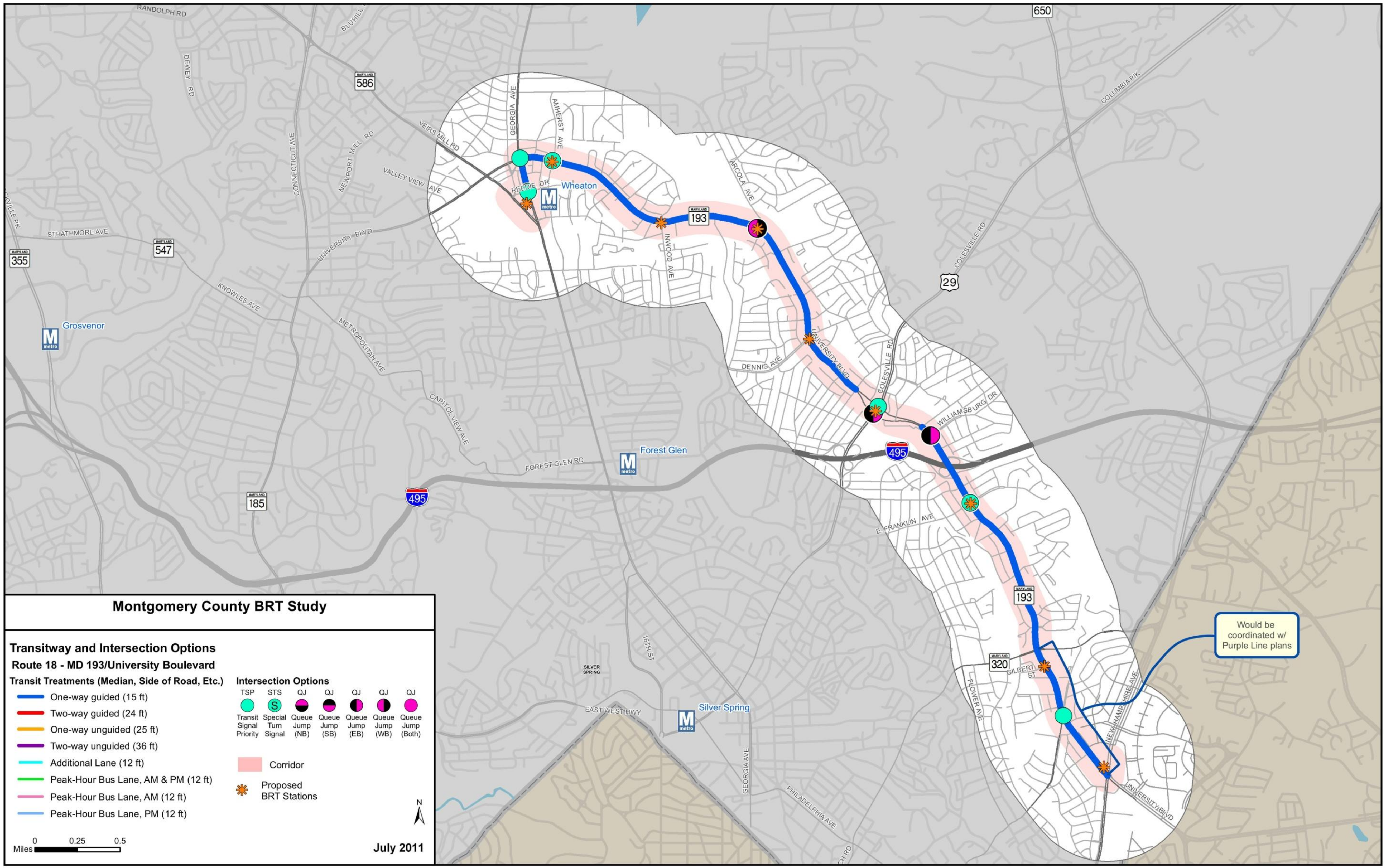


Figure D-15: Route 19: US 29/Columbia Pike/Colesville Road treatment options

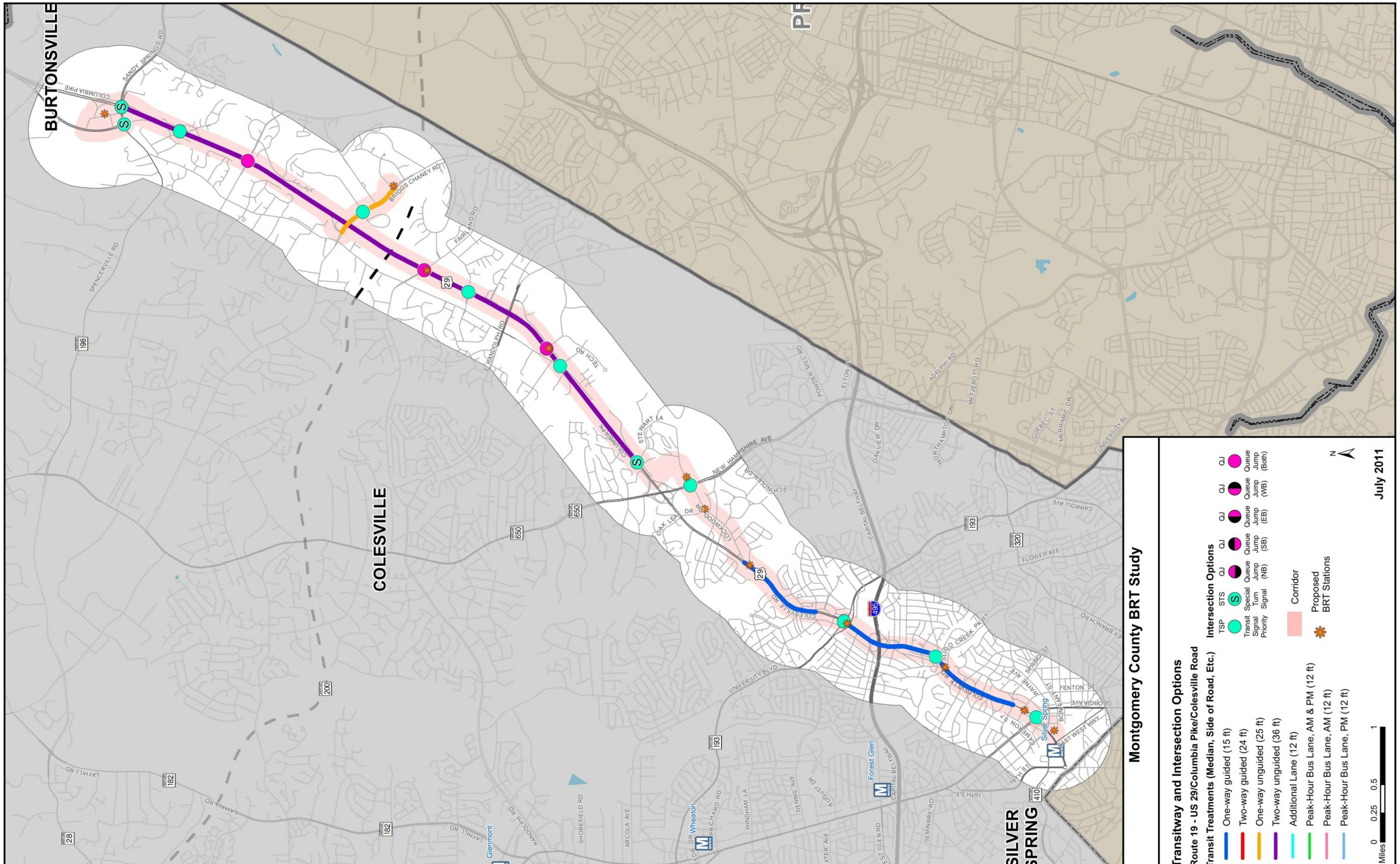


Figure D-16: Route 20: ICC treatment options

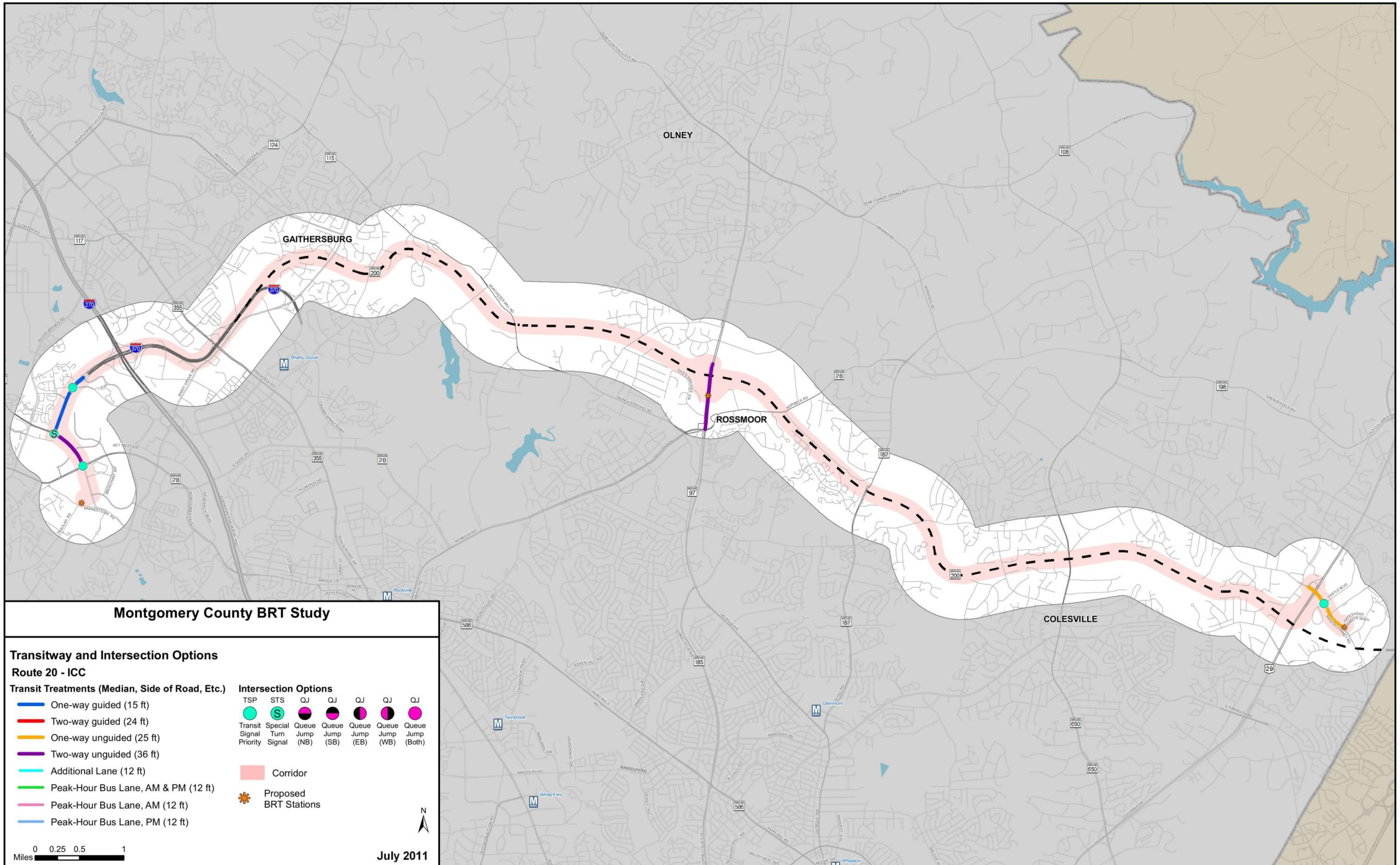


Figure D-17: Route 21: North Bethesda Transitway treatment options

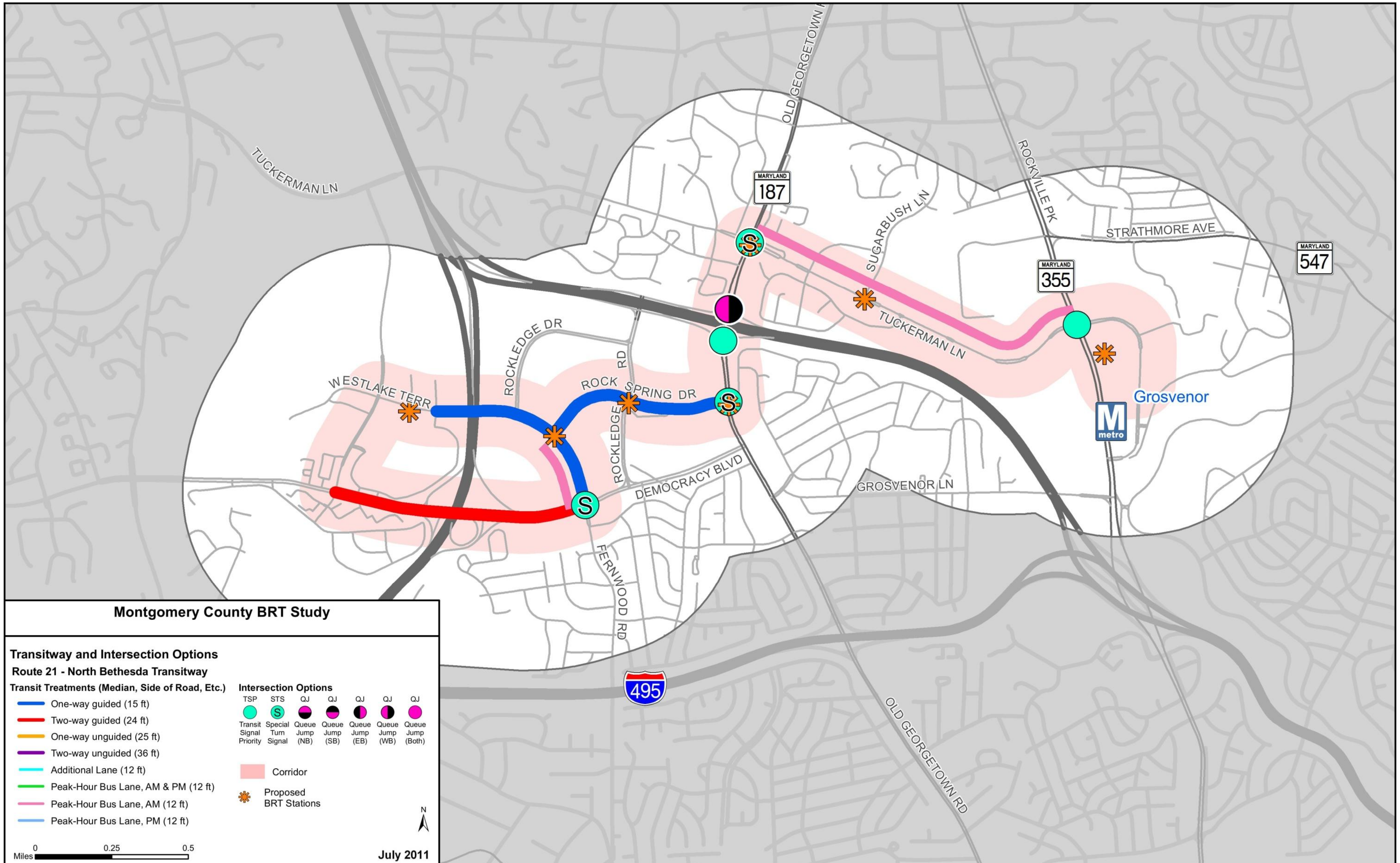
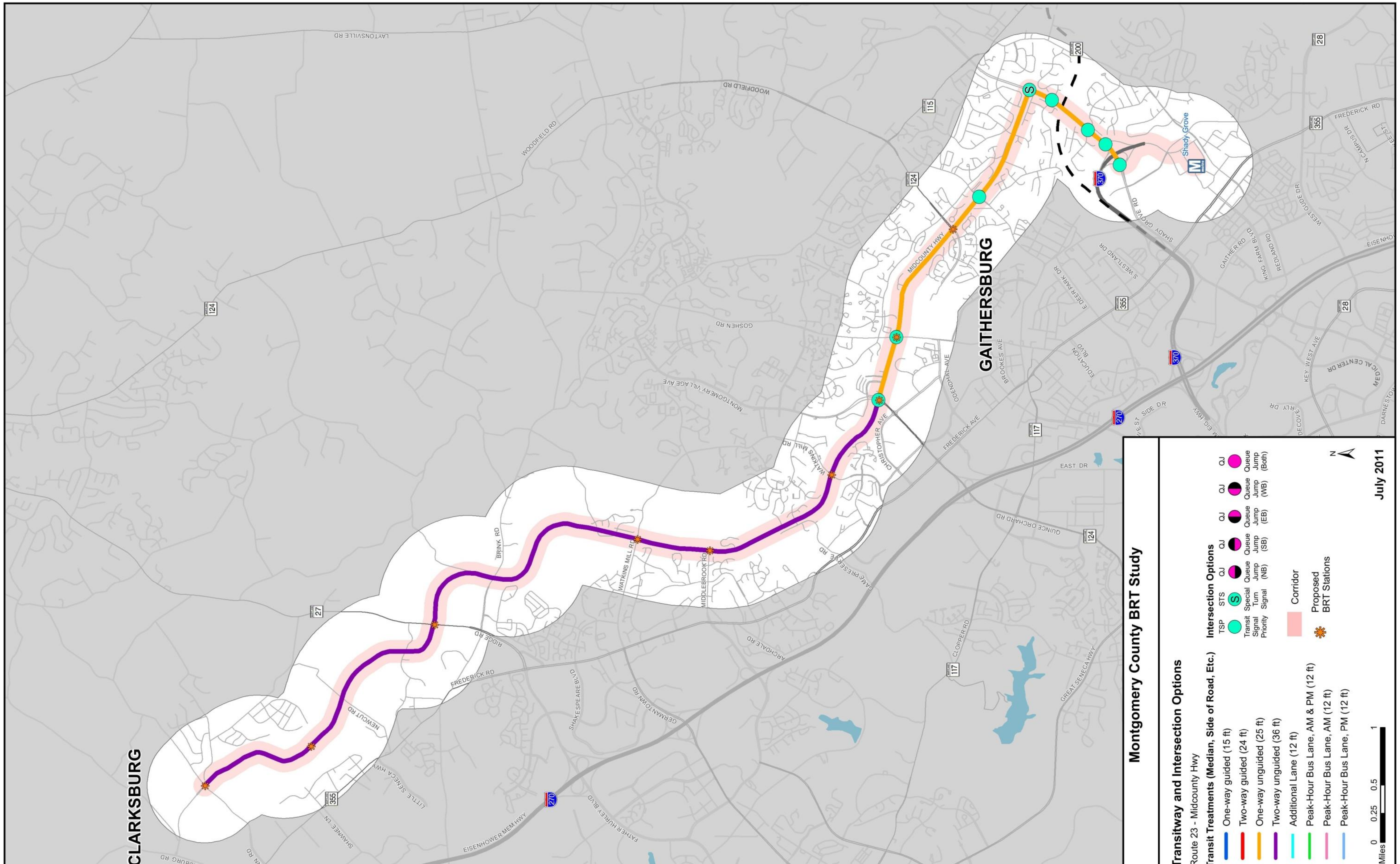


Figure D-18: Route 23: Midcounty Highway treatment options



APPENDIX E METHODOLOGY FOR BRT SYSTEM UNIT COST ESTIMATES

E.1 Guideway

Several potential configurations were identified initially for a BRT guideway, based on the assumed cross sections for on-street, guided, and unguided busway treatments shown in Figure C-1 of Appendix C. These configurations were as follows:

- Mixed traffic
- Existing roadway or parking lane converted to transit use
- Median, one-lane guided busway
- Median, two-lane guided busway
- Median, one-lane unguided busway
- Median, two-lane unguided busway
- Side-of-road guided busway

Basic guideway and intersection cost estimates were assumed to include combinations of the following components:

- Clearing and grubbing
- Finish grading
- Excavation with haul
- Pavement drainage
- Aggregate base
- Concrete pavement (8")
- Concrete curb
- Roadway lighting
- Miscellaneous signing and striping
- Utility modification allowance
- Maintenance of traffic allowance

The following sections describe each guideway capital cost component.

E.1.1 BRT in mixed traffic

For BRT in mixed traffic, the only cost identified is installation of concrete bus pads at designated BRT stations. Assuming each BRT station would have a length of 120 feet (long enough to accommodate two 60-foot articulated buses), a concrete pad was assumed to have a 120' x 10' dimension. Assuming an 8" concrete depth, the estimated unit cost per pad is $26,728.

E.1.2 BRT in exclusive roadway lane

For BRT operating in a roadway lane, options include dedicating an existing travel or parking lane to BRT operations, or widening the roadway and dedicating one or more lanes to BRT use. For dedicating an existing travel or parking lane for BRT use, capital costs would include special pavement markings, side of road signing, and overhead signing (signs spaced every 1/4-mile) to identify the dedicated lane use, along with concrete pads at each station. The assumption is there would be no pavement replacement or overlay, or special drainage modifications. For new lanes, assumed to be 12 feet in width, costs would include grading and paving costs in addition to the pavement marking and signing costs. It is assumed under any new lane construction that the terrain is level and that no substantial cut or fill sections would be required.

The assumed per linear foot construction cost for the BRT in exclusive roadway lane (not including concrete bus pads at stations) is as follows:

- Existing travel or parking lane - $56 per linear foot
- New lane - $699 per linear foot

E.1.3 Median Busway

Either a one- or two-lane busway could be developed along certain sections of the identified refined BRT corridors. In most corridors, width is only available for a guided busway vs. an unguided busway. In any location where sufficient width is available, a typical at-grade busway treatment has been costed. The costs for busway development itself that have been developed reflect maintaining a constant cross section through intersections for either a guided or unguided busway, plus the added cost of intersection modifications to reflect replacing turn lanes which would have to be moved outward to accommodate a busway through an intersection. It should also be noted that there were no assumptions for itemized cost of overhead lane use control signals.[16]

E.1.3.1 Guided Busway

A guided busway involves operating a bus in a guided trackway, which allows some reduction in cross section width because of the greater ability to steer a vehicle. Guide wheels typically would be mounted on the vehicle, though a driver could also operate a bus without guide wheels if under a lower speed. This represents the narrowest cross-section for a potential busway treatment.

In this study, both one-lane and two-lane guided busways were evaluated. A one-lane guided busway was assumed to have a cross section requirement of 15 feet, including nine feet for the operating lane, one-foot curbing on both sides, and a two-foot separation distance to an adjacent traffic lane or adjacent off-road feature. If developed in the median, it could be reversible, operating in the peak direction during the peak period. A two-lane guided busway was also evaluated, which would provide two-directional operation at all times, and was assumed to have a cross section width of 24 feet, two 8.5-foot lanes, three one-foot curbs for separation, and two feet separation distance on both sides.

The busway pavement section was assumed to be concrete with an eight-inch depth. For the one-lane guided busway, added overhead signs were assumed to assist with lane control, spaced at 1/4-mile.

The resulting assumed capital cost per linear foot for a guided busway is as follows:

- One-lane guided (15'): $954 per linear foot
- Two-lane guided (24'): $1,192 per linear foot

[16] For overhead signage, it is assumed that a portion of the 30 percent contingency could cover these costs.

E.1.3.2 Unguided Busway

With an unguided busway, narrow shoulders would be included in the busway section, with the buses operating unguided. This is to provide some latitude for drivers to maneuver past other vehicles or to be able to have maintenance or tow truck service a disabled vehicle. Thus, a wider cross section width was initially identified, assumed to be 24 feet for a one-lane section and 36 feet for a two-lane section. The one-lane guided section would have a single 10-foot lane, four–foot shoulders, one-foot curbing on both sides, and a two-foot separation from an adjacent traffic lane or off-road feature. The two-lane unguided section would have dual 11-foot lanes, four-foot shoulders, one-foot curbing on both sides, and a two-foot separation distance.

Subsequent to the initial cross-section assessment, an added narrower cross section for a two-lane unguided median busway was identified, which would develop 11-foot lanes in each directions, separated by a two-foot raised median, and a two-foot pavement separation on both sides from adjacent general traffic lanes, with raised markers in those transition areas. This cross section would have a total width of 28 feet.

As for the guided busway, the unguided busway pavement section was assumed to be concrete with an eight-inch depth.

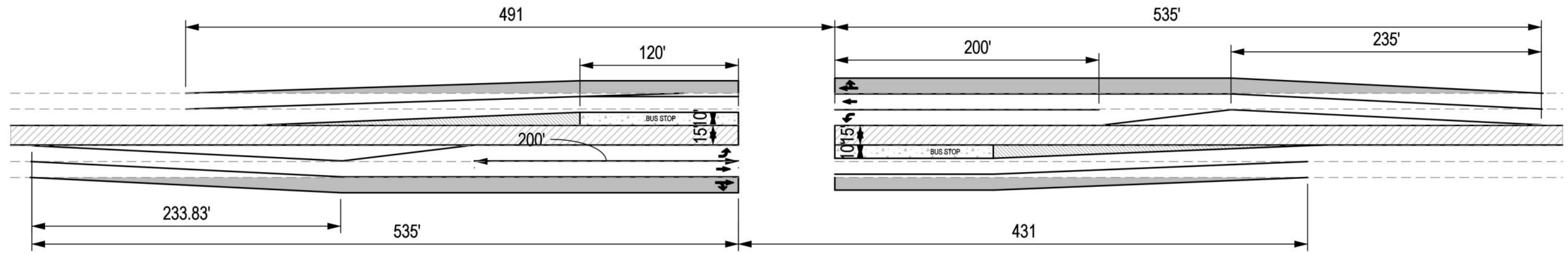
The resulting assumed capital cost per linear foot for an unguided busway is as follows:

- One-lane unguided (24’): $1,281 per linear foot
- Two-lane unguided (28’): $1,399 per linear foot
- Two-lane unguided (36’): $1,583 per linear foot

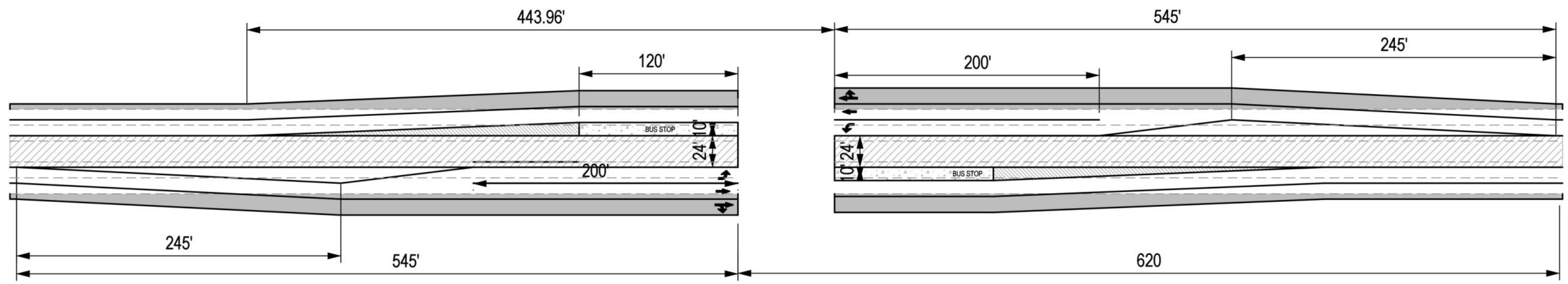
E.1.3.3 Intersection Modifications

In addition to the basic median busway cross section costs, an added intersection modification cost was developed for a median busway treatment assuming that each signalized intersection approach would need to be widened by the corresponding width of the identified busway treatment. This assumed at least a four-foot wide concrete median would remain on each approach, that all auxiliary and through lanes would still be provided, and that there would only be further intersection widening to put back added pavement to account for the amount taken up by the busway cross section. It was also assumed that at intersections where BRT stations would be located, they would be located far side and shadow the near side innermost left-turn lane. A 120-foot platform length was assumed. For intersection widening cost purposes, only providing an added space for a platform was assumed, with actual built-up platform/station development unit costs estimated separately. In general, a roadway reconstruction/widening envelope was identified that assumed a 200-foot average length for a left turn lane and 150-foot length for a right turn lane, with 10:1 entrance tapers. Figure E-1 illustrates the possible roadway and intersection reconfigurations for each guideway option.

Figure E-1: Options for roadway and intersection reconfigurations

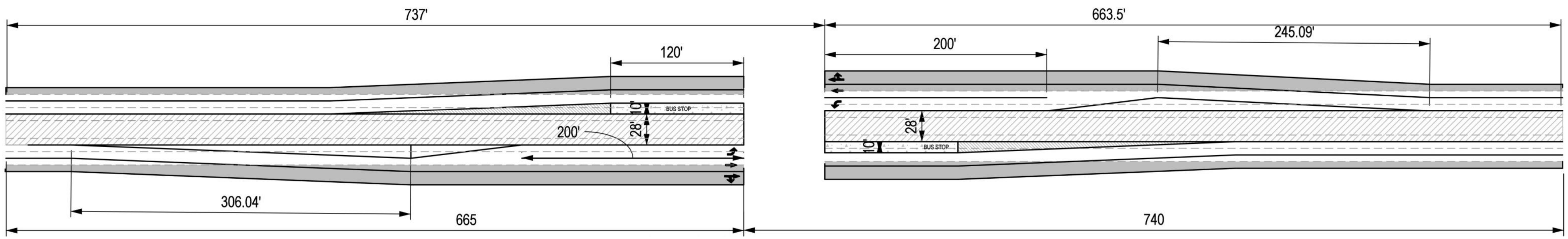


(a) Option 1: 15-foot bus lane, one-way guided
Additional pavement area: 14,467 square feet

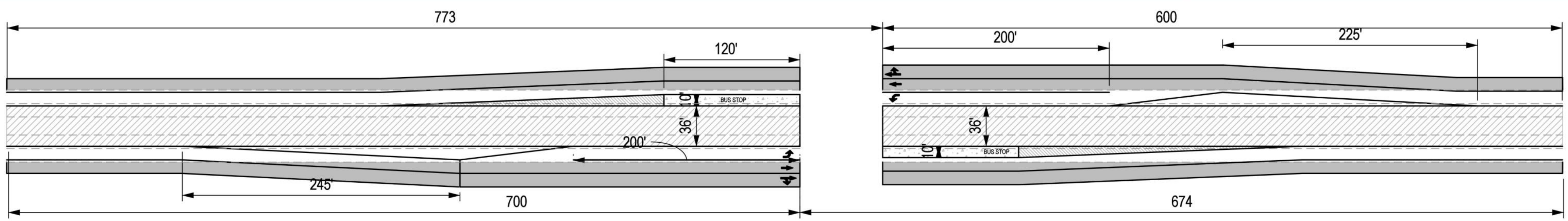


(b) Option 2: 24-foot bus lane, one-way unguided/two-way guided
Additional pavement area: 23,858 square feet

Figure E-1 (continued)



(c) Option 3: 28-foot bus lane, two-way unguided
Additional pavement area: 30,272 square feet



(d) Option 4: 36-foot bus lane, two-way unguided
Additional pavement area: 41,023 square feet

It is important to realize that the added roadside modifications could vary significantly from intersection to intersection, and thus the roadside allowance cost at this time should be interpreted as a generic cost. The assumed unit cost also does not reflect any potential right-of-way acquisition costs. These cost estimates would be further assessed in follow-up corridor/alternatives analysis studies.

Given the identified capital cost components, the following unit cost estimates were derived for the four basic median busway configurations (both intersection approaches):

- One-lane guided busway (15-foot) - $1.8 million
- Two-lane guided/one-lane unguided busway (24-foot) - $2.3 million
- Two-lane unguided busway (28-foot) - $2.7 million
- Two-lane unguided busway (36-foot) - $2.9 million

E.1.4 Side-of-Road Busway

For the side-of-road busway, it was assumed in this study that only a one-way, 11-foot guided busway would be developed, completely outside of the existing roadway cross section. Only half of the signal reconstruction cost was assumed as the side-of-road busway would impact each signalized intersection. The resulting capital costs were developed for the side-of-road busway option:

- One-lane guided (11-foot): $885 per linear foot
- Intersection modifications (signal): $900,000

As for the median busway intersection impact scenarios, side-of-road busway construction could have some added roadside modification and right-of-way acquisition costs that would have to be assessed in more detailed studies.

E.2 Stations

For BRT stations, two levels of station development and passenger amenities were assumed for cost purposes. In either case, it was assumed that side platforms would be developed. The first would be a full BRT station with extended shelter, benches, unique station ID sign, landscaping, lighting and security system, and bicycle storage. This station is assumed to be long enough (120 feet) to accommodate upwards of two BRT vehicles at the same time. This station would be provided where there are estimated higher boardings. Based on the initial corridor "screening" model run, it was assumed that year 2040 daily boardings of over 500 would justify this level of station development. The second station prototype would be a smaller BRT station with reduced shelter and other passenger amenities, with year 2040 daily boardings under 500.

The assumed station capital cost (based on station development costs for other BRT systems) is as follows:

- Major station: $150,000 (single direction)
- Minor station: $100,000 (single direction)

E.3 Intersection priority treatments

The two intersection transit priority treatments considered in the BRT study are 1) TSP, involving extension of the green signal phase from BRT operating in an approach through lane, and 2) queue jump signal, where BRT vehicles would bypass through traffic and trigger an advance green from a right turn lane. In the refined screening evaluation, analysis was conducted that identified at which intersection approaches queue backups would not be long enough to preclude effective utilization of a right turn lane for a queue bypass and signal.

For estimating capital costs, it was assumed that for TSP, an average cost would be appropriate assuming some degree of signal hardware and software modifications would be required. This would be in addition to whatever traffic signal modifications would be needed to accommodate any widened roadway for a particular BRT guideway treatment. For a queue bypass and signal, it was assumed that BRT would use existing right turn lanes where available (and where TSP was not deemed feasible), with only a new queue jump signal required.

The assumed intersection transit priority unit cost (based on the above assumptions) is as follows:

- Transit signal priority: $25,000 per intersection
- Queue jump signal: $10,000 per intersection approach

E.4 Off-board fare collection

Off-board fare collection equipment was assumed where there are estimated to be high daily boardings at a BRT station. Using the same 500 daily boarding threshold to identify where expanded stations and passenger amenities should be provided, at these locations it was assumed that one off-board ticket vending machine would be provided. The estimated cost of a vending machine is $50,000.

E.5 Real-time passenger information

In addition to the identified station cost, an additional $20,000 per station location was assumed at high boarding locations (500 or more per day) to install two real-time passenger information signs. At smaller stations, an added $10,000 was assumed for one real-time passenger information sign. The electrical costs localized to the station were assumed in the broader station cost. Any corridor fiber installation was assumed covered in the contingency assigned to the overall BRT corridor development cost.

E.6 Vehicles

BRT vehicles which could be applied include standard 40-foot length buses or 60-foot articulated buses. It was assumed in either case that hybrid propulsion would be integrated into the vehicles, as well as Automatic Vehicle Location (AVL), Automatic Passenger Counters (APC), TSP, and security and maintenance monitoring systems. Based on recent BRT vehicle purchases for other systems, a cost of $1.1 million for a 60-foot vehicle was assumed.

E.7 Application

The unit capital costs were applied to the identified BRT treatments to develop overall system costs. It is important to recognize that the costs are very conceptual, and will be updated and further detailed as a corridor undergoes further study and eventual design to integrate BRT facility and vehicle improvement.