APPENDIX E

BIKEWAY PRIORITIZATION METHODOLOGY

INTRODUCTION

The network of bikeways recommended in the Bicycle Master Plan is extensive and is likely to be only partially completed during the 25-year life of this plan. Such a large network is proposed so that opportunities to implement the preferred bicycling network are not lost when unforeseen circumstances arise. At the same time, it is important to identify priorities within the network, so the most important bikeways and facilities are constructed first.

The Bicycle Master Plan creates a new approach to understanding potential bicycle demand by converting the regional travel demand model to a potential demand model for bicycling. This analysis was a primary factor in prioritizing bikeway recommendations and is tied to the goals and objectives of the plan.

Specifically, Goal 2 and Goal 3 include five metrics that measure progress in increasing low-stress connectivity:

- Metric 2.1: Percentage of potential bicycle trips that can be made on a low-stress bicycling network.
- Metric 2.2: Percentage of dwelling units within 2 miles of each Red Line, Brunswick Line, Purple Line and Corridor Cities Transitway station that are connected to the transit station on a low-stress bicycling network.
- Metric 2.3: Percentage of dwelling units within one mile of elementary schools, 1.5 miles of middle schools and 2 miles of high schools that are connected to the schools on a very low-stress bicycling network.
- Metric 2.4: Percentage of dwelling units within 2 miles of public libraries, recreation centers and regional / recreational parks that are connected to the public facility on a low-stress bicycling network.
- Metric 3.1: Percentage of potential bicycle trips that can be made on a low-stress bicycling network in Census tracts where the median income is below 60 percent of the Montgomery County average median income.

DATA INPUTS

An evaluation of the connectivity metrics in the Bicycle Master Plan relies on three major inputs:

- The proposed low-stress bicycling network in Montgomery County.
- A 2040 matrix of all trips focused on areas that are likely to generate the most bicycling in Montgomery County.
- Refined geographic units of analysis by reducing the size of transportation analysis zones (TAZs) into smaller geographic areas.

Input 1: Low-Stress Bicycling Network

In order to attract the broadest segment of the population to bicycle, Montgomery County must create a bicycling network that does not exceed people's tolerance for traffic stress and does not require an excessive level of detour. While currently about 75 percent of street mileage in Montgomery County is low-stress, these streets largely represent "islands of connectivity" that are separated by arterial roads and environmental barriers such that only 16 percent of trips can be made by bicycle.

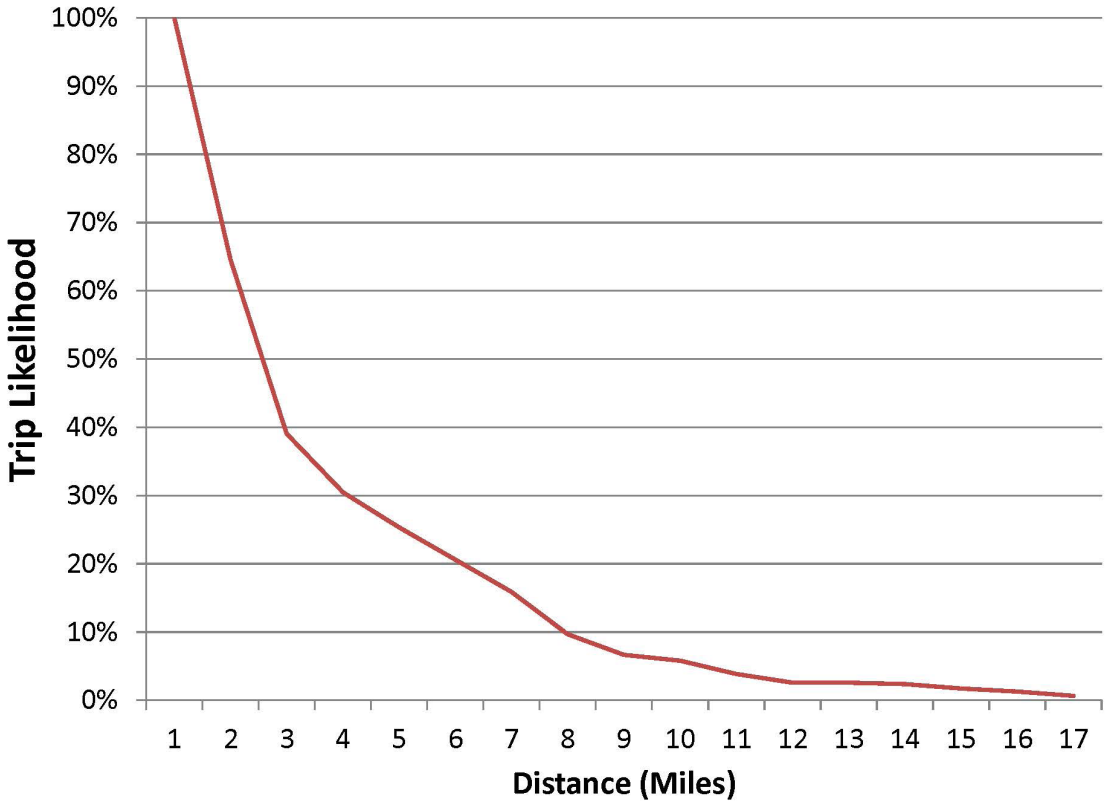
The Bicycle Master Plan recommends a network of low-stress bikeways to connect residential communities to the places in the county where people want to go, including transit stations, employment centers, retail destinations, public facilities and other activity centers. All roads were assigned a level of traffic stress using the methodology explained in Appendix D.

Input 2: 2040 Trip Table

A subset of the regional travel demand model was selected to be included in the connectivity analysis. While there are certainly some daily bike trips between Montgomery County and all jurisdictions in the region, the likelihood that a trip will be made by bicycle decreases with distance. It is therefore possible to remove many areas in the region from the analysis while still creating a useful representation of potential demand.

The likelihood that a trip will be made by bicycle can be approximated by a distance decay function using data from the 2007 – 2008 regional household survey conducted by the Metropolitan Washington Council of Governments. This chart shows that about 40 percent of bicycling trips are three miles or fewer and only 10 percent of bicycling trips are longer than 7 miles.

Distance Decay Function



The geographic areas included in the connectivity analysis include trips that are:

1. Within Montgomery County.
2. Between Montgomery County and the District of Columbia.
3. Between Montgomery County and Prince George's County north of MD 704.

Trips between Montgomery County and the District of Columbia are particularly important to capture because of the large number of transit trips between the two jurisdictions. Bicycling is an important way to expand the catchment area of transit stations without investing in expensive parking garages, and is an approach that WMATA is increasingly using at metrorail stations.

Trips south of MD 704 in Prince George's County were excluded because they are more than 7 miles from the nearest point in Montgomery County and so very few bicycling trips are likely between Montgomery County and these areas.

Similarly, TAZs from Frederick County, Howard County and Fairfax County were not included because their great distances from major activity centers in Montgomery County means that relatively few bicycling trips can be expected to occur between these counties and Montgomery County.

Input 3: Geographic Units for Measuring Bicycle Travel

Just as travel demand models are helpful at understanding future travel patterns via automobile or transit, they can also be used to understand future travel by bicycle. Since their geographic unit of measurement – TAZs – is too large to adequately distinguish areas where barriers to connectivity exist for bicycling, a smaller unit of geography is needed. Census blocks are ideal, since, typically, if people can bicycle to a Census block, they are able to access all of the attractions on that block.

Unfortunately, focusing on Census blocks in this plan would lead to a dataset that is unmanageably large. To keep the size of the dataset manageable, our analysis uses Census blocks in urban areas of Montgomery County, such as Downtown Silver Spring, Bethesda and Wheaton. In suburban and rural Montgomery County, Census blocks are combined into groups of about four to five contiguous blocks. TAZs are retained as units of geography for Washington, DC and Prince George's County.

ADJUSTMENTS TO TRIP TABLE

The 2040 trip table, showing travel patterns in the future, was adjusted to:

- Convert transit trips to potential bicycling trips.
- Disaggregate trip table from TAZs to smaller geographies.

Adjustment 1: Converting Transit Trips to Potential Bicycling Trips

Many trips in the travel demand model that are transit trips could include bicycle trips as the mode of access to the transit station. Since the travel demand model does not identify where transit was accessed, assumptions where made to determine which portion of the overall trip could be made by bicycle:

- For transit trips produced in Montgomery County where the attraction is in the District of Columbia or Prince George's County, the attraction location was converted to the Census block for the Montgomery County rail station that is closest to the production location. For example, for trips that are produced in Aspen Hill and attracted to Union Station in the District of Columbia, the production remains Aspen Hill and the attraction becomes the Glenmont Metrorail Station.

- For transit trips where the production is in the District of Columbia or Prince George's County and the attraction is in Montgomery County, the production location was converted to the Census block for the Montgomery County rail station that is closest to the attraction location. For example, for a trip that is produced in Georgetown and is attracted to Rock Spring area of Bethesda, the production becomes the Grosvenor Metrorail Station and the attraction remains Rock Spring.

What are Productions and Attractions?

For home-based trips, the production is always at the home end of the trip, whether home is the starting point or the ending point. In trips without a home end (non-home-based trips), productions are defined as the starting point of the trip. For home-based trips, the attraction end of the trip is the non-home end of the trip, whether that location is the starting or ending point of the trip. For non-home-based trips, attractions are defined as the ending point of the trip.

- For transit trips where both the production and attraction are in Montgomery County, the production and attraction were converted to the Census blocks for the closest rail stations in Montgomery County and became two potential bicycle trips. For example, for a trip that starts at Aspen Hill and ends at the Montgomery County Planning Department, one potential bicycling trip became from Aspen Hill to the Glenmont Metrorail Station and the second potential bicycling trip became from the Silver Spring Metrorail Station to the Montgomery County Planning Department.

Adjustment 2: Trip Table Disaggregation

The travel demand model was from TAZs to smaller geographic units within Montgomery County. Trips between TAZs were disaggregated based on the number of productions and attractions in each geographic unit.

A. Trip productions were distributed based on the forecast number of households in the geographic unit in the year 2040.
B. Trip attractions were distributed based on a summation of the following equations for different area types in the Metropolitan Washington Council of Governments Version 2.3 travel forecasting model calibration report:

HBW_Attr_1-2 = 1.118 x TOTEMP
HBW_Attr_3+ = 0.8546 x TOTEMP
HBS_Attr_1-2 = 1.995 x RETEMP + 0.301 x TOTPOP
HBS_Attr_3+ = 3.102 x RETEMP + 0.221 x TOTPOP
HBO_Atttr_1-2 = 0.425 x NONRETEMP + 1.012 x TOTPOP
HBO_Attr_3+ = 1.084 x NONRETEMP + 0.588 x RETEMP + 0.777 x TOTEMP
NHW_Attr_1-2 = 0.944 x RETEMP + 0.557 x OFFEMP + 0.656 x OTHEREMP
NHW_Attr_3+ = 0.807 x RETEMP + 0.522 x OFFEMP + 0.507 X OTHEREMP
NHO_Attr_1-2 = 0.097 x NONRETEMP + 1.498 x RETEMP + 0.300 x TOTPOP
NHO_Attr_3+ = 0.178 x NONRETEMP + 2.784 x RETEMP + 0.184 x TOTPOP

Total population (TOTPOP) is included in the MWCOG cooperative land use forecasts Round 8.3). Employment for retail (RETEMP), non-retail (NONRETEMP), office (OFFEMP) and other (OTHEREMP) was calculated by converting the square footage for each land use type in the Montgomery County Planning Department's parcel file to office, retail, industrial and other land use jobs using the following job factors:

a. Office: 250 square feet job
b. Retail: 400 square feet per job
c. Industrial: 450 square feet per job
d. Other: 500 square feet per job

The above equations also require assumptions about the area type, based on its population and employment densities. (For example, 1-2 refers to areas types 1 and 2; 3+ refers to area types 3, 4, 5 and 6.) Each block was assigned an area type from 1 to 6 using Table 24 from the MWCOG Version 2.3 travel forecasting model calibration report:

Table 24: Area Type Definitions (1-7) as a function of population and employment density

ONE-MILE "FLOATING" POPULATION DENSITY (POP/SQ MI)	ONE-MILE "FLOATING" EMPLOYMENT DENSITY (EMP/SQ MI)						
	0-100	101-350	351-1,500	1,501-3,550	3,551-13,750	13,751-15,000	15,001+
0-750	6	6	5	3	3	3	2
751-1,500	6	5	5	3	3	3	2
1,501-3,500	6	5	5	3	3	2	2
3,501-6,000	6	4	4	3	2	2	1
6,001-10,000	4	4	4	2	2	2	1
10,001-15,000	4	4	4	2	2	2	1
15,001+	2	2	2	2	2	1	1

Once productions and attractions were determined for each geographic unit in Montgomery County, they were disaggregated to better represent potential bicycle travel. For example, the Travel / 4[2] travel demand model shows that there will be approximately 21 trips produced in TAZ 3724 and attracted to TAZ 3726 in 2040:

PRODUCTION TAZ	PRODUCTION TAZ	TRIPS
3724	3726	20.73

TAZ 3724 and 3726 are each composed of two Census block groups. Within TAZ 3724, block group 240317047001 comprises 14.9 percent of productions and 14.7 percent of attractions, while block group 240317047002 comprises 85.1 percent of productions and 85.3 percent of attractions. All possible combinations of the block groups result in the following table:

BLOCK GROUP	TAZ	PRODUCTION %	ATTRACTION %
240317047001	3724	14.9%	14.7%
240317047002	3724	85.1%	85.3%
240317048041	3726	13.4%	95.0%
240317048052	3726	86.6%	5.0%

[2]Travel / 4 is an adaptation of the Metropolitan Washington Council of Governments (MWCOG) regional travel demand model used by Montgomery County.

To disaggregate the TAZ-to-TAZ trips to block group-to-block group trips, the production percentages and the attraction percentages for each block group were multiplied by the number of trips between TAZs using a query in Microsoft Access. For example, there were assumed to be 2.94 trips between 240317047001 and 240317048041. This total was calculated by multiplying 20.73 trips x 14.9 percent of productions and 95.0 percent of attractions.

PRODUC-TION TAZ	ATTRAC-TION TAZ	TRIPS	PRODUCTION BLOCK GROUP	ATTRACTION BLOCK GROUP	PRODUC-TION %	ATTRAC-TION %	TRIPS DISAGGRE-GATED
3724	3726	20.73	240317047001	240317048052	14.9%	5.0%	0.15
3724	3726	20.73	240317047002	240317048041	85.1%	95.0%	16.77
3724	3726	20.73	240317047002	240317048052	85.1%	5.0%	0.87
3724	3726	20.73	240317047001	240317048041	14.9%	95.0%	2.94
TOTAL							**20.73**

POTENTIAL DEMAND MODEL

The Montgomery County Planning Department created a GIS-based digital model to determine the potential for bicycling trips on all segments of the bicycling network using the three major inputs described above. The process assigns trips to the network based on the shortest distance between two points. Future versions could consider elevation change and delay at crossings.

Please note that the potential demand model is primarily intended to compare relative future bicycling among bikeway scenarios (existing, prioritized and full-build) and at comparing how well each bikeway project contributes to increasing connectivity. The model does not forecast actual demand.

The model includes two adjustments to the data:

- **Travel distance adjustments** on trails and breezeways.
- Travel flow adjustments based on trip distance using a **bicycle decay function.**

Travel Distance Adjustments on Trails and Breezeways

Two types of bikeways – trails and breezeways – are likely to be more attractive to bicyclists than other types of bikeways since they tend to allow faster travel (less delay due to crossings) and are much less stressful than other bikeways. As a proxy for these characteristics, travel distances on trails and breezeways were reduced to simulate the prioritized bicycling environment. The travel distances on bikeways classified as trails was reduced by 30 percent, since these bikeways feature few delays and are largely separated from traffic. The travel distance on bikeways classified as part of the Breezeway Network was reduced by 15 percent, since these routes will also prioritize bicycle travel, enabling faster speeds, though not as fast as trails, since trails typically have fewer road crossings. For example, if a bicycle trips is 3 miles long, including 1 mile on the Breezeway Network and 2 miles on a trail, the trip would be modeled as 2.25 miles. This includes 0.85 miles on the Breezeway Network (1 mile x 0.85) and 1.4 miles on the trail (2 miles x 0.70).

Bicycle Decay Function

As discussed previously, the likelihood that a trip will be made by bicycle decreases with distance. The following equation was fitted to the bicycle decay function mentioned previously and was used to convert travel flows into potential bicycling trips, where x is the distance between the centroids of two geographies.

$$y = 1.0747e-0.289x$$

Once the potential bicycling trips were determined for each pair of geographies, the trips were cumulatively assigned to the individual network segments comprising each route.

For example, each trip that is two miles in length would represent 0.60 potential bicycling trips and each trip that is five miles long would represent 0.25 potential bicycling trips. In other words, a two-mile long trip is 2.4 times as likely as a five-mile long trip.

Additionally, only trips that are 0.5 miles or greater could represent potential bicycling trips. Distances shorter than 0.5 miles were assumed to be walking trips.

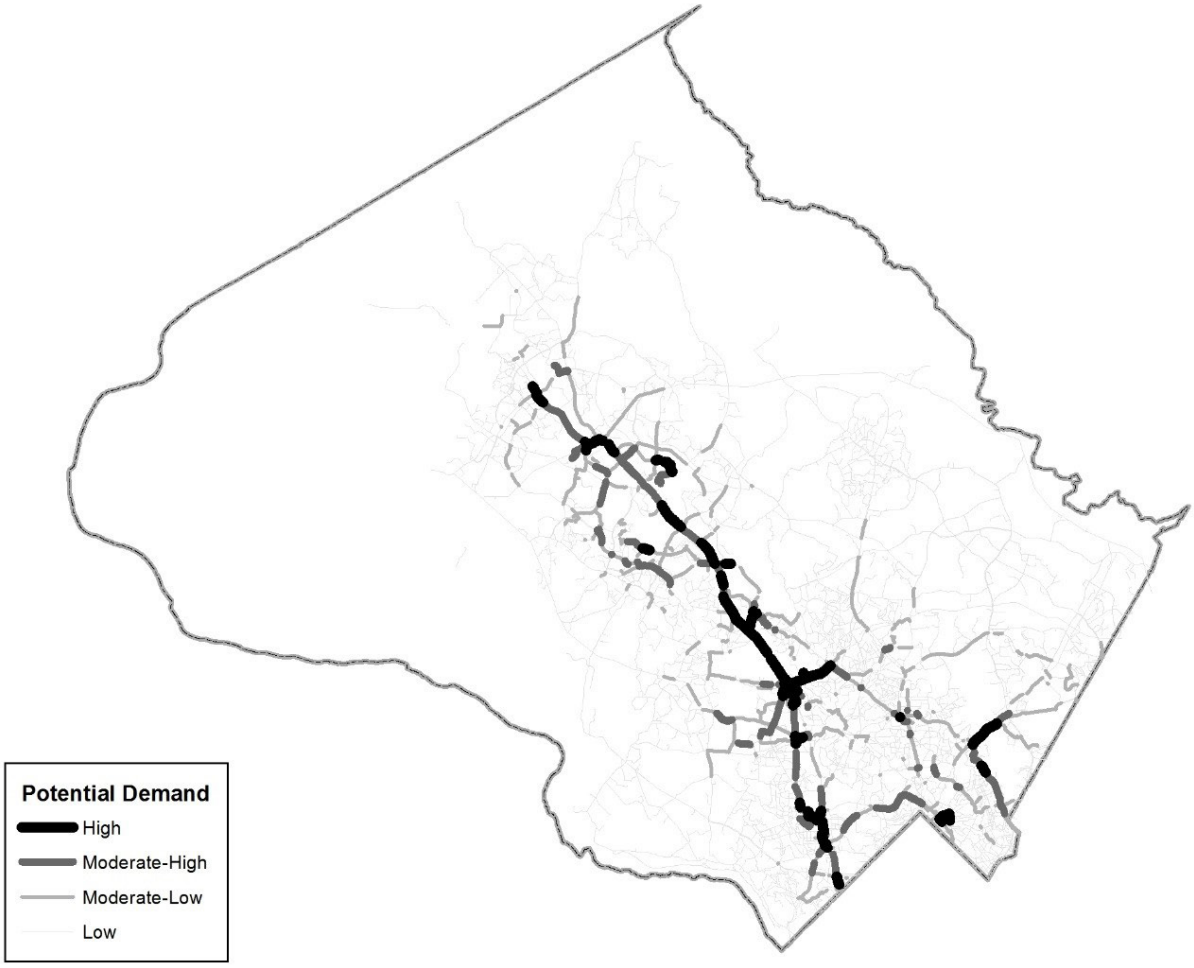
PRIORITIZATION OF BIKEWAYS

The network of bikeways recommended in the Bicycle Master Plan is extensive and is likely to be only partially completed during life of this plan. The first step in the prioritization process is, therefore, to identify those bikeways that are most important to implement to meet the overarching goals of the Plan. To develop a list of prioritized bikeways, segments were grouped into potential projects. Those bikeways that are most important to implement include one or more of the following conditions:

1. Are in the top 25 percent of bikeways with the highest potential demand.
2. Located in one of the 31 locations in the county designated as Bicycle Pedestrian Priority Areas.
3. Fill in a gap within the existing bikeway network.
4. Are low in cost to construct, including most neighborhood greenways.

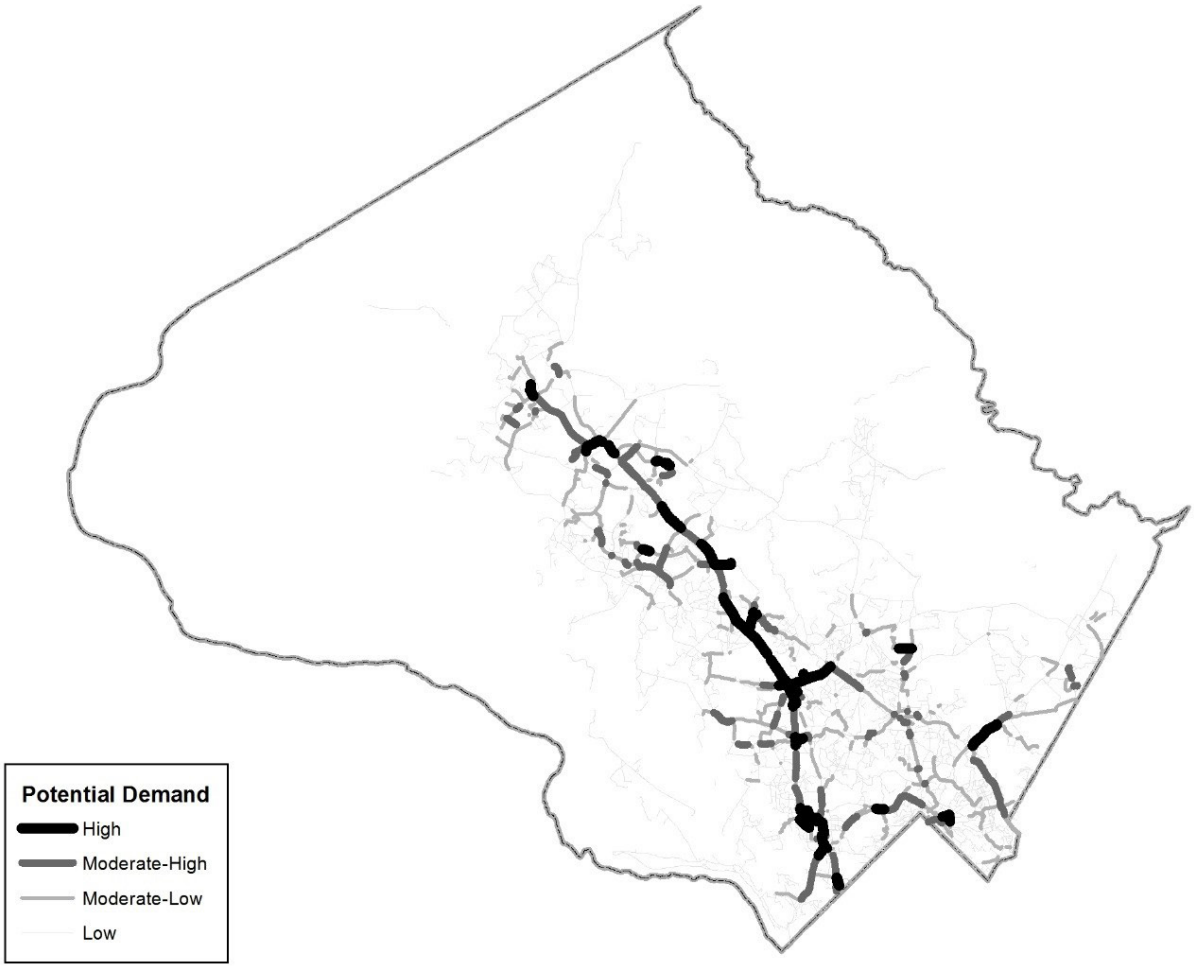
Potential Demand for the Full Build-Out Bicycling Network

The potential demand model was run to forecast future potential demand on the full build-out of the bicycling network. The figure below shows the results of the full build-out model and categorizes each road segment as having a high, moderate-high, moderate-low or low potential bicycling demand. The darker and thicker the line, the higher the potential bicycling demand. The bikeway recommendations that have the highest potential demand include segments of MD 355, Montrose Parkway, Woodmont Avenue, US 29 and several areas in downtown Silver Spring.



Potential Demand for the Prioritized Bicycling Network

The potential bikeway demand model was then analyzed with only those bikeways that are included in the list of projects as most important to be implemented over the life of the Bicycle Master Plan. The figure below shows the results of the prioritized bikeway model and similarly categorizes each road segment as having high, moderate-high, moderate-low, or low potential bicycling demand.



Those bikeways that are most important to implement over the life of the Bicycle Master Plan were categorized into four levels of priority: high, moderate-high, moderate-low, and low.

Tier 1 includes:

- Bikeways located in seven Bicycle Pedestrian Priority Areas (Bethesda CBD, Friendship Heights CBD, Life Sciences Center, Silver Spring CBD, Wheaton CBD, White Flint and White Oak).
- Neighborhood greenways feeding into these BPPA areas (such as the Cornish Rd / Elm St neighborhood greenway).
- Bikeways with high demand that are included in the capital improvement program (such as the Montrose Parkway East project).
- Other county priorities (such as the Germantown – Grosvenor Breezeway, aka the PEPCO Trail).

Tier 2 includes:

- Bikeways located in the remaining Bicycle Pedestrian Priority Areas.

Tier 3 includes:

- Remaining neighborhood greenways.
- Highest demand bikeways located outside of the Bicycle Pedestrian Priority Areas.
- High demand recreational bicycling routes.

Tier 4 includes:

- All remaining bikeways that are important to implement over the life of the plan.
- Several heavily-used recreational bicycling routes.

The full build-out and prioritized bicycling networks were evaluated based on the connectivity metrics in the Bicycle Master Plan. The results are shown in the table below.

OBJECTIVE	METRIC		EXISTING (2018)	FUNDED	IMMEDIATE	TIER 1	TIER 2	TIER 3	TIER 4	BUILD OUT
GOAL 2: CREATE A HIGHLY-CONNECTED, CONVENIENT AND LOW-STRESS BICYCLING NETWORK										
2.1	Countywide Connectivity		16%	N/A	20%	30%	40%	50%	50%	80%
2.2	Connectivity to Transit Stations	Red Line	10%	15%	20%	35%	55%	60%	65%	80%
		Brunswick Line	14%	25%	30%	35%	60%	60%	65%	80%
		Purple Line	4%	10%	20%	30%	60%	70%	70%	75%
		Corridor Cities Transitway	0%	0%	0%	35%	40%	40%	40%	75%
2.3	Connectivity to Public Schools	Elementary Schools	38%	40%	40%	40%	45%	45%	45%	60%
		Middle Schools	25%	25%	25%	30%	30%	35%	35%	55%
		High Schools	12%	15%	15%	15%	20%	20%	25%	35%
2.4	Connectivity to Public Facilities	Public Libraries	8%	10%	15%	20%	40%	50%	55%	85%
		Recreation Centers	16%	15%	20%	25%	30%	35%	40%	70%
		Recreational and Regional Parks	28%	30%	30%	30%	35%	45%	50%	75%
GOAL 3: PROVIDE EQUAL ACCESS TO LOW-STRESS BICYCLING FOR ALL MEMBERS OF THE COMMUNITY										
3.1	Connectivity to Low Income Areas		0%	N/A	0%	0%	0%	0%	0%	0%