GetOnBoardBRT MD 355
BUS RAPID TRANSIT IN MONTGOMERY COUNTY

MD 355 BRT Corridor Planning Study

Phase 2

Greenhouse Gas Emissions Technical Memo

June 10, 2019

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1 Introduction

Smart transit-oriented development (TOD) and growth provides a host of environmental and social benefits, including helping to reduce vehicle miles traveled (VMT), fuel use, and emission of greenhouse gases (GHG). GHG primarily consist of carbon dioxide (CO_2) released into the atmosphere from the burning of fossil fuels.

Transit improvements and increased ridership provide direct reductions in GHG emissions through less reliance on driving individual private vehicles. The land use effects of enhanced transit service and resulting TOD community design also support GHG emission reductions, provided that reliable, high-quality transit such as the MD 355 BRT are available and serve to connect key destinations.

Incorporating TOD principles into community master plans and development/redevelopment efforts helps to reduce typical trip distances between homes, jobs, shopping destinations, and community services and attractions. Reduced trip distances result in less VMT and fuel use, and these benefits extend to both transit and non-transit travelers.

Consideration of greenhouse gas emissions associated with the proposed MD 355 BRT Project were assessed using the methodology and tools provided in the Transit Cooperative Research Program (TCRP) publication, "Quantifying Transit's Impact on GHG Emissions and Energy Use, The Land Use Component", TCRP Report 176, 2015.

The outputs of the TCRP model rely on two modeling benefit estimates to calculate overall GHG impacts:

1. GHG reductions associated with transit are based on the extent of existing and planned transit service and ridership to determine regional VMT reductions.
2. GHG reductions associated with TOD land use changes are based on modeled percent reductions in VMT due to compact, mixed use neighborhoods that are anchored by transit system stations, considering urban population density, land use mix, design attributes and travel characteristics of over 300 U.S. urbanized areas.

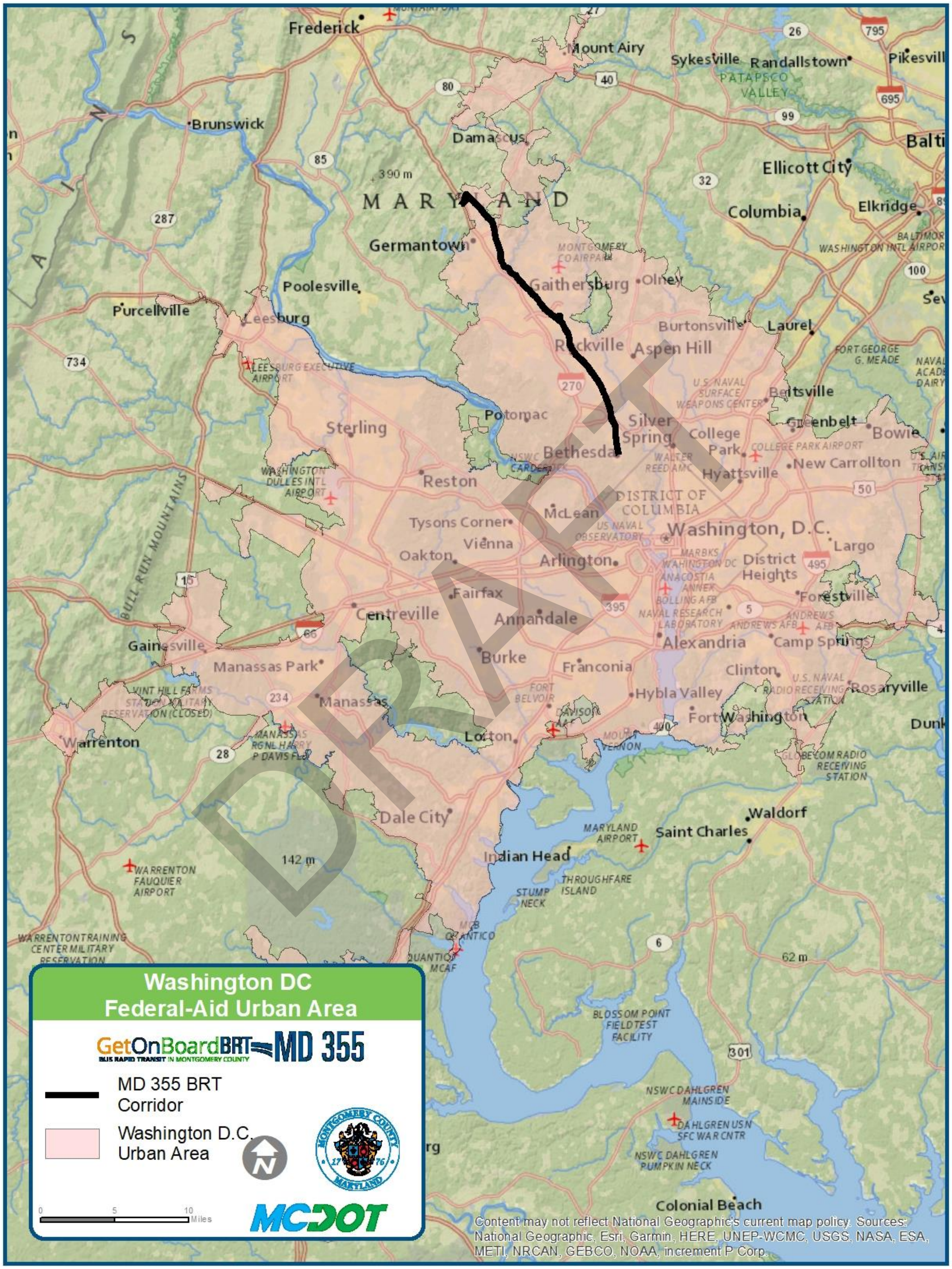
GHG benefits associated with transit improvements and land use improvements are then calculated using comparable fuel consumption and efficiency metrics.

2 Existing Conditions

Within the Washington DC-VA-MD metropolitan urbanized area **(Figure 2-1)** which includes the entire MD 355 BRT corridor, existing transit services have been estimated to provide an overall 20.4 percent benefit, or reduction, in regional VMT **(Table 2-1)**. Approximately 43 percent of this VMT reduction has been attributed directly to transit ridership, with approximately 57 percent attributed to TOD land use patterns which help to promote transit use and/or provide shorter auto trips through mixed use development.

GHG emission benefits of the existing regional transit system provide:

Figure 2-1: Washington D.C. Federal Aid Urbanized Area (2010)



- 3,069,333,392 pounds CO_2 equivalent reduction attributable to transit use. This is equivalent to operation of 295,589 passenger vehicles driven for one year.
- 4,116,442,238 pounds CO_2 equivalent reduction attributable to transit-oriented land use patterns. This is equivalent to operation of 396,430 passenger vehicles driven for one year.

Table 2-1: Modeled GHG Benefits of Current Regional Transit System (Washington D.C Federal-Aid Urbanized area)

Measure	Current Condition	Without transit
Difference between current conditions and a hypothetical scenario without transit		
Daily per capita VMT	22.0	27.6
Gross population density (persons/square mile)	3,431	2,189
Land area needed to house current population (square miles)	1,291	2,024
Measure	**Per capita per day**	**Annual for total regional population**
Benefits of current transit services		
Benefits derived from Land Use Patterns		
Percent reduction in VMT	11.7%	11.7%
Reduction in VMT (miles)	3.225	5,214,510,577
Reduction in gasoline used (gallons)	0.129	209,235,421
Reduction in GHG emissions (lbs. CO_2e)	2.546	4,116,442,238
Benefits derived from Transit Ridership		
Percent reduction in VMT	8.7%	8.7%
Reduction in VMT (miles)	2.405	3,888,083,571
Reduction in gasoline used (gallons)	0.096	156,011,727
Reduction in GHG emissions (lbs. CO_2e)	1.898	3,069,333,392

Note: CO_2e = carbon dioxide equivalent, a standard unit measure used to compare emissions from various greenhouse gas sources
Source: Transit Cooperative Research Program (TCRP) Land Use Benefit Calculator, TCRP Report 176, 2015

3 Alternatives Evaluation

Each of the MD 355 BRT Alternatives would provide a supplemental premium transit service to the existing conditions. Each Alternative also would differ in the location and length of additional revenue service in Segment 7, from Middlebrook Road to Clarksburg. The characteristics of each BRT alternative would therefore have unique potential to affect the master plan visions that generally seek to enhance transit-oriented development and redevelopment patterns along the corridor.

The TCRP Land Use Benefits Calculator uses linear structural equation modeling to estimate transit and land use effects on emissions based on sample research involving over 300 U.S. urbanized areas. Key data attributes sampled included urban area size, demographic characteristics including population and income, and transit route and revenue miles. Supplemental information from national and regional transportation agencies were used to determine attributes such as per capita VMT and transit ridership.

The TCRP model uses a corridor consisting of the area within 1 mile on either side of the route served by one or more transit lines. Corridor-level projects increase transit frequency or add service along a portion or the entirety of a route. Model inputs based on the proposed project include transit route miles, revenue miles, corridor length, and existing population.

Ridership effects in the model correspond with travelers shifting from driving to riding transit, based on corridor factors and the general percentage of transit use within the region. The calculator estimates the reduction in VMT due to ridership effects, a reduction that is roughly proportional to the increase in transit passenger miles due to improved transit service.

Land use effects in the model**,** whereby transit stations anchor development that is more compact, mixed use, or walkable, considers the corridor population and the potential change in population density. The land use effect of transit is realized when new development occurs, but the development process can be long and complex. If new development takes decades to happen around new transit investments, the land use benefits of transit will likewise take decades to be realized.

Analysis of modeled BRT Alternative GHG benefits are provided in **Tables 3-1 through 3-4**.

Table 3-1: Modeled GHG Benefits of TSM Alternative

Measure	Per capita per day	Annual for total corridor population
Additional GHG Benefits of TSM Alternative		
Benefits derived from Land Use Patterns		
Percent reduction in VMT of corridor residents	0.0%	0.0%
Reduction in VMT of corridor residents (miles)	0.001	267,272
Reduction in gasoline used by corridor residents (gallons)	0.000	10,724
Reduction in GHG emissions by corridor residents (lbs. CO_2e)	0.001	210,990
Benefits derived from Transit Ridership		
Percent change in corridor transit passenger miles	0.1%	0.1%
Percent reduction in VMT by corridor residents	0.0%	0.0%
Reduction in VMT by corridor residents (miles)	0.000	77,235
Reduction in gasoline used by corridor residents (gallons)	0.000	3,099
Reduction in GHG emissions by corridor residents (lbs. CO_2e)	0.000	60,971

Note: CO_2e = carbon dioxide equivalent, a standard unit measure used to compare emissions from various greenhouse gas sources.

Table 3-2: Modeled GHG Benefits of BRT Alternative A

Measure	Per capita per day	Annual for total corridor population
Additional GHG Benefits of Alternative A		
Benefits derived from Land Use Patterns		
Percent reduction in VMT of corridor residents	0.0%	0.0%
Reduction in VMT of corridor residents (miles)	0.004	721,085
Reduction in gasoline used by corridor residents (gallons)	0.000	28,934
Reduction in GHG emissions by corridor residents (lbs. CO_2e)	0.001	569,240
Benefits derived from Transit Ridership		
Percent change in corridor transit passenger miles	0.3%	0.3%
Percent reduction in VMT by corridor residents	0.0%	0.0%
Reduction in VMT by corridor residents (miles)	0.001	208,262
Reduction in gasoline used by corridor residents (gallons)	0.000	8,357
Reduction in GHG emissions by corridor residents (lbs. CO_2e)	0.001	164,406

Note: CO_2e = carbon dioxide equivalent, a standard unit measure used to compare emissions from various greenhouse gas sources.

Table 3-3: Modeled GHG Benefits of BRT Alternative B

Measure	Per capita per day	Annual for total corridor population
Additional GHG Benefits of Alternative B		
Benefits derived from Land Use Patterns		
Percent reduction in VMT of corridor residents	0.0%	0.0%
Reduction in VMT of corridor residents (miles)	0.004	719,069
Reduction in gasoline used by corridor residents (gallons)	0.000	28,853
Reduction in GHG emissions by corridor residents (lbs. CO_2e)	0.003	567,648
Benefits derived from Transit Ridership		
Percent change in corridor transit passenger miles	0.3%	0.3%
Percent reduction in VMT by corridor residents	0.0%	0.0%
Reduction in VMT by corridor residents (miles)	0.001	207,693
Reduction in gasoline used by corridor residents (gallons)	0.000	8,334
Reduction in GHG emissions by corridor residents (lbs. CO_2e)	0.001	163,957

Note: CO_2e = carbon dioxide equivalent, a standard unit measure used to compare emissions from various greenhouse gas sources.

Table 3-4: Modeled GHG Benefits of BRT Alternative C

Measure	Per capita per day	Annual for total corridor population
Additional GHG Benefits of Alternative C		
Benefits derived from Land Use Patterns		
Percent reduction in VMT of corridor residents	0.0%	0.0%
Reduction in VMT of corridor residents (miles)	0.004	716,673
Reduction in gasoline used by corridor residents (gallons)	0.000	28,757
Reduction in GHG emissions by corridor residents (lbs. CO_2e)	0.003	565,757
Benefits derived from Transit Ridership		
Percent change in corridor transit passenger miles	0.3%	0.3%
Percent reduction in VMT by corridor residents	0.0%	0.0%
Reduction in VMT by corridor residents (miles)	0.001	207,007
Reduction in gasoline used by corridor residents (gallons)	0.000	8,306
Reduction in GHG emissions by corridor residents (lbs. CO_2e)	0.001	163,416

Note: CO_2e = carbon dioxide equivalent, a standard unit measure used to compare emissions from various greenhouse gas sources.

4 Alternatives Comparison

To compare BRT alternatives, the resulting total GHG emissions reductions (including both transit and land use-derived characteristics) were combined and used to calculate "equivalent" benefits to allow for a comparison of alternatives **(Table 4-1)**. Generally, the TSM Alternative, which provides the lowest level of additional transit service (i.e. less revenue miles), would provide the least overall benefit in regard to regional reduction of GHG emissions, as this alternative would have the lowest impact on VMT and furtherance of corridor TOD land use policies.

Each of the other build alternatives would conceptually have similar benefits on GHG reductions resulting from greater transit ridership and a more substantial impact on VMT. The effect of increased transit service and additional stations under Alternatives A, B, and C would also help to realize greater land use pattern benefits in comparison to the TSM Alternative, increasing the potential for development and redevelopment along the MD 355 corridor using TOD principles of mixed use and closer integration of housing and employment uses.

Table 4-1: GHG Benefit Comparison

Measure	TSM	Alt A	Alt B	Alt C
Benefits derived from Land Use Patterns				
Annual reduction in GHG emissions by corridor residents (lbs. CO_2e)	210,990	569,240	567,648	565,757
Benefits derived from Transit Ridership				
Annual reduction in GHG emissions by corridor residents (lbs. CO_2e)	60,971	164,406	163,957	163,416
Total Annual GHG Emission Benefit	271,961	733,646	731,605	729,173
BRT Alternative GHG reductions equivalent to:				
	Emissions from operating 26.2 vehicles for one year	Emissions from operating 70.7 vehicles for one year	Emissions from operating 70.5 vehicles for one year	Emissions from operating 70.2 vehicles for one year
	Energy emissions from 14.8 homes for one year	Energy emissions from 39.8 homes for one year	Energy emissions from 39.7 homes for one year	Energy emissions from 39.6 homes for one year

Equivalencies derived from U.S. EPA Greenhouse Gas Equivalencies Calculator, https://www.epa.gov/energy/greenhouse-gas-equivalencies-calculator
Note: CO_2e = carbon dioxide equivalent, a standard unit measure used to compare emissions from various greenhouse gas sources.