



**NATIONAL CAPITAL REGION  
TRANSPORTATION PLANNING BOARD  
COMMUTER CONNECTIONS PROGRAM**

**TRANSPORTATION EMISSION REDUCTION MEASURE (TERM)  
ANALYSIS REPORT  
FY 2015-2017**

**Covering the period July 2014 – June 2017**

*Prepared for:*



Metropolitan Washington Council of Governments  
777 North Capitol Street, NE, Suite 300  
Washington, DC 20002-4239

Prepared by:

LDA Consulting  
Austin, TX  
202-657-3752

In association with:

CIC Research, Inc., San Diego, CA  
ESTC, San Diego, CA  
Center for Urban Transportation Research, Tampa, FL

November 21, 2017

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## ABSTRACT

- TITLE:** National Capital Region Transportation Planning Board (TPB) Commuter Connections 2015-2017 Transportation Emission Reduction Measure Analysis Report
- DATE:** November 21, 2017
- AUTHORS:** Nicholas Ramfos, Director, Transportation Operations Programs  
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- AGENCY:** The National Capital Region Transportation Planning Board (TPB) is the federally designated Metropolitan Planning Organization (MPO) for the region, and plays an important role as the regional forum for transportation planning. The TPB prepares plans and programs that the federal government must approve in order for federal-aid transportation funds flow to the Washington region. The TPB became associated with the Metropolitan Washington Council of Governments (COG) in 1966. COG was established in 1957 by local jurisdictions to address regional concerns including growth, air quality, public health, transportation, and housing. Although the TPB is an independent body, its staff is provided by COG's Department of Transportation Planning.
- ABSTRACT:** This document provides results of an evaluation of the Transportation Emission Reduction Measures (TERMs) that are voluntary transportation demand measures implemented through the Commuter Connections program in the Washington DC metropolitan region. Data collection efforts and transportation and emission impacts are highlighted for all of the TERMS. Results from the TERMS are used to support the region's air quality goals and congestion management process. The TERMS evaluated include Maryland and Virginia Telework, Guaranteed Ride Home, Employer Outreach, and Mass Marketing. An evaluation is also included for the on-going regional rideshare efforts through the Commuter Operations Center. The evaluation documents the impacts during a three-year period between July 1, 2014 and June 30, 2017.

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## EXECUTIVE SUMMARY

### BACKGROUND

This report presents the results of an evaluation of four Transportation Emission Reduction Measures (TERMs), voluntary Transportation Demand Management (TDM) measures implemented by the National Capital Region Transportation Planning Board's (TPB) Commuter Connections program at the Metropolitan Washington Council of Governments (COG) to support the Washington, DC metropolitan region's air quality conformity determination and congestion management process. This evaluation documents transportation and air quality impacts for the three-year evaluation period between July 1, 2014 and June 30, 2017, for the following TERMs:

- Maryland and Virginia Telework – The Maryland portion of this TERM provides information and assistance to Maryland commuters and employers to further in-home and telecenter-based telework programs. The Virginia portion provides assistance to employers and employees participating in the Telework! VA (TWVA) program.
- Guaranteed Ride Home – Eliminates a barrier to use of alternative modes by providing free rides home in the event of an unexpected personal emergency or unscheduled overtime to commuters who use alternative modes.
- Employer Outreach – Provides regional outreach services to encourage large, private-sector and non-profit employers voluntarily to implement commuter assistance strategies that will contribute to reducing vehicle trips to worksites, including the efforts of jurisdiction sales representatives to foster new and expanded trip reduction programs. The Employer Outreach for Bicycling TERM also is part of this analysis.
- Mass Marketing – Involves a large-scale, comprehensive media campaign to inform the region's commuters of services available from Commuter Connections as one way to address commuters' frustration about the commute. Various special promotional events also are part of this TERM.

COG's National Capital Transportation Planning Board (TPB), the designated Metropolitan Planning Organization (MPO) for the Washington, DC metropolitan region, adopted and continues to support these TERMs, among others, as part of the regional Transportation Improvement Program (TIP). The purpose of the TERMs is to help the region reduce emissions in support of air quality goals for the region and to meet federal requirements for the congestion management process. The Commuter Connections program is considered integral in regional travel demand management and is included in the region's TERMs technical documentation which was updated in October 2015. Travel parameters prior to the year 2010 were captured by the regional travel demand model. Only the effects of the incremental growth of the Commuter Connections program post 2010 will be accounted for in future analysis years in the event the impacts are needed as part of the region's air quality conformity determination.

COG/TPB's Commuter Connections program, which also operates an ongoing regional rideshare program, is the central administrator of the TERMs noted above. Commuter Connections elected to include a vigorous evaluation element in the implementation plan for each of the adopted TERMs to develop information to guide sound decision-making about the TERMs. This report summarizes the results of the TERM evaluation activities and presents the transportation and air quality impacts of the TERMs and the Commuter Operations Center (COC).

This evaluation represents a comprehensive evaluation for these programs. It should be noted, however, that the evaluation is conservative in the sense that it includes credit only for impacts that can be reasonably documented with accepted measurement methods and tools. Note that many of the calculations use data from surveys that are subject to some statistical error, at rates common to such surveys.

A primary purpose of this evaluation was to develop meaningful information for regional transportation and air quality decision-makers, COG/TPB staff, COG/TPB program funding agencies, and state and local commute assistance program managers to guide sound decision-making about the TERMs. The results of this evaluation will provide valuable information for regional air quality conformity and the region's congestion management process, to

improve the structure and implementation procedures of the TERMS themselves, and to refine future data collection methodologies and tools.

## SUMMARY OF TERM IMPACT RESULTS

The objective of the evaluation is to estimate reductions in vehicle trips (VT), vehicle miles traveled (VMT), and tons of vehicle pollutants (Nitrogen Oxides (NO<sub>x</sub>), Volatile Organic Compounds (VOC), Particulate Matter (PM<sub>2.5</sub>), Particulate Matter NO<sub>x</sub> precursors (PM and NO<sub>x</sub>), and Carbon Dioxide (CO<sub>2</sub>)) resulting from implementation of each TERM and compare the impacts against the goals established for the TERMS. The impact results for these measures are shown in Table A for each TERM individually. Results for all TERMS collectively and for the Commuter Operations Center (COC) are presented in Table B.

As shown in Table A, the TERMS combined exceeded the collective goals for vehicle trips reduced by 14% and exceeded the VMT goal by about 18%. The TERMS did not reach the emission goals; the impact for NO<sub>x</sub> was 31% under the goal and VOC impact was 10% under the goal, but these deficits were due largely to changes in the emission factors. The TERM goals were set in 2006, using 2006 emission factors. Goals for some TERMS were re-set since the issuance of the FY2012 – 2014 Commuter Connections TERM Analysis Report. Emission factors used in the 2017 evaluation were considerably lower than the factors from 2014 and lower still than the factors used in 2011, reflecting a cleaner vehicle fleet.

When the COC results are added to the TERM impacts, as presented in Table B, the combined impacts exceeded the vehicle trip and VMT reduction goals by 8% and 9%, respectively. The combined TERM – COC program impacts fell 37% short of the NO<sub>x</sub> goal and were 14% below the VOC goal. Again, the change in the emission factors affected the emission results.

Two TERMS, Telework – Maryland Assistance and Employer Outreach, easily met their individual goals for participation and travel impact. Employer Outreach exceeded vehicle trip and VMT goals by substantial margins. The Employer Outreach for Bicycling TERM component did not meet its goals, but the absolute deficits were small. The Virginia telework component (Telework!VA) also met the goals set for the program.

The impacts for the other two TERMS were below their goals. Vehicle trip reductions and VMT reductions for the Guaranteed Ride Home TERM were about half of the goals set for these impacts, primarily due to declining registrations, compared with 2014 and previous years. The Mass Marketing TERM's vehicle trip and VMT reductions were 6% and 10% short of their respective goals. The Commuter Operations Center and the Software Upgrades TERM also were under their goals for vehicle trips and VMT reduced.

Additional details on the calculations for each TERM and for the Commuter Operations Center are described in individual sections of this report. The reasons for the shortfalls from the goals also are discussed in the individual report sections.

**Table A**  
**Summary of Daily Impact Results for Individual TERMS (July 2014 – June 2017) and Comparison to Goals**

TERM	Participation <sup>1)</sup>	Daily Vehicle Trips Reduced	Daily VMT Reduced	Daily Tons NOx Reduced	Daily Tons VOC Reduced
<b>Maryland Telework Assistance <sup>2)</sup></b>					
2017 Goal	31,854	11,830	241,209	0.122	0.072
Impacts (7/14 – 6/17)	44,350	14,839	361,204	0.096	0.070
<b>Net Credit or (Deficit)</b>	<b>12,496</b>	<b>3,009</b>	<b>119,995</b>	<b>(0.026)</b>	<b>(0.002)</b>
<b>Virginia Telework Assistance – Telework! VA <sup>2)</sup></b>					
2017 Goal	800	155	2,548	0.003	0.001
Impacts (7/14 – 6/17)	1,531	490	9,359	0.003	0.002
<b>Net Credit or (Deficit)</b>	<b>731</b>	<b>335</b>	<b>6,811</b>	<b>0.000</b>	<b>0.001</b>
<b>Guaranteed Ride Home</b>					
2017 Goal	36,992	12,593	355,136	0.177	0.097
Impacts (7/14 – 6/17)	16,742	6,398	181,335	0.040	0.023
<b>Net Credit or (Deficit)</b>	<b>(20,250)</b>	<b>(6,195)</b>	<b>(173,801)</b>	<b>(0.137)</b>	<b>(0.074)</b>
<b>Employer Outreach – all employers participating <sup>3)</sup></b>					
2017 Goal	1,847	82,524	1,393,783	0.561	0.320
Impacts (7/14 – 6/17)	2,046	102,625	1,841,429	0.474	0.350
<b>Net Credit or (Deficit)</b>	<b>199</b>	<b>20,101</b>	<b>447,646</b>	<b>(0.087)</b>	<b>0.030</b>
<b>Employer Outreach – new / expanded employer services since July 2014 <sup>3)</sup></b>					
2017 Goal	91	N/A	N/A	N/A	N/A
Impacts (7/14 – 6/17)	765	25,936	482,153	0.123	0.090
<b>Net Credit or (Deficit)</b>	<b>674</b>	<b>N/A</b>	<b>N/A</b>	<b>N/A</b>	<b>N/A</b>
<b>Employer Outreach for Bicycling <sup>3)</sup></b>					
2017 Goal	590	404	2,421	0.0016	0.0015
Impacts (7/14 – 6/17)	597	373	1,640	0.0008	0.0012
<b>Net Credit or (Deficit)</b>	<b>7</b>	<b>(31)</b>	<b>(781)</b>	<b>(0.0008)</b>	<b>(0.0003)</b>
<b>Mass Marketing</b>					
2017 Goal	23,168	10,809	181,932	0.085	0.025
Impacts (7/14 – 6/17)	23,016	10,133	163,250	0.042	0.019
<b>Net Credit or (Deficit)</b>	<b>(152)</b>	<b>(676)</b>	<b>(18,682)</b>	<b>0.043</b>	<b>(0.006)</b>
<b>TERMS (all TERMS collectively)</b>					
2017 Goal		117,911	2,174,608	0.948	0.515
Impacts (7/14 – 6/17)		134,485	2,556,577	0.655	0.464
<b>Net Credit or (Deficit)</b>		<b>16,574</b>	<b>381,969</b>	<b>(0.293)</b>	<b>(0.051)</b>

1) Participation refers to number of commuters participating, except for the Employer Outreach TERM. For this TERM, participation equals the number of employers participating.

2) Maryland impacts represent portion of regional telework attributable to TERM-related activities in Maryland. Virginia impacts represent portion of regional telework attributable to the TW!VA program in Virginia. Total telework credited for conformity is higher than reported for the TERM.

3) Impacts for Employer Outreach - all employers participating includes impacts for Employer Outreach – new / expanded employer services since July 2014 and for Employer Outreach for Bicycling.

**Table B**  
**Summary of TERM and COC Results (July 2014 – June 2017) and Comparison to Goals**

TERM	Participation	Daily Vehicle Trips Reduced	Daily VMT Reduced	Daily Tons NOx Reduced	Daily Tons VOC Reduced
<b>TERMS (all TERMS collectively)</b>					
2017 Goal		117,911	2,174,608	0.948	0.515
Impacts (7/14 – 6/17)		134,485	2,556,577	0.655	0.464
<b>Net Credit or (Deficit)</b>		<b>16,7574</b>	<b>381,969</b>	<b>(0.293)</b>	<b>(0.051)</b>
<b>Commuter Operations Center – Basic Services</b>					
2017 Goal	91,609	24,425	512,637	0.241	0.115
Impacts (7/14 – 6/17)	77,662	19,949	401,327	0.105	0.079
<b>Net Credit or (Deficit)</b>	<b>(13,947)</b>	<b>(4,476)</b>	<b>(111,310)</b>	<b>(0.136)</b>	<b>(0.036)</b>
<b>Commuter Operations Center – Software Upgrades <sup>1)</sup></b>					
2017 Goal	4,681	2,379	66,442	0.028	0.011
Impacts (7/14 – 6/17)	4,178	1,779	51,340	0.011	0.006
<b>Net Credit or (Deficit)</b>	<b>(503)</b>	<b>(600)</b>	<b>(15,102)</b>	<b>(0.017)</b>	<b>(0.005)</b>
<b>All TERMS plus COC</b>					
2017 Goal		144,715	2,753,687	1.217	0.641
Impacts (7/14 – 6/17)		156,213	3,009,244	0.771	0.549
<b>Net Credit or (Deficit)</b>		<b>11,498</b>	<b>255,557</b>	<b>(0.446)</b>	<b>(0.092)</b>

1) Impacts for Commuter Operations Center – software Upgrades are in addition to the impacts for the Commuter Operations Center – Basic Services. This project was previously part of the Integrated Rideshare TERM.

Table C, on the following page, presents annual emission reduction results for PM 2.5, PM 2.5 pre-cursor NOx, and CO2 emissions (Greenhouse Gas Emissions - GHG) for each TERM and for the COC. COG/TPB did not establish specific targets for these impacts for the Commuter Connections TERMS. But COG has been measuring these impacts for other TERMS, thus these results are provided.

As shown, the TERMS collectively reduce 8.7 annual tons of PM 2.5, 175 annual tons of PM 2.5 pre-cursor NOx, and 264,235 annual tons of CO2 (greenhouse gas emissions). When the Commuter Operations Center is included, these emissions impacts rise to 10.2 annual tons of PM 2.5, 206.2 annual tons of PM 2.5 pre-cursor NOx, and 310,982 annual tons of CO2 (greenhouse gas emissions).

**Table C**  
**Summary of Annual PM 2.5 and CO2 (Greenhouse Gas) Emission Results for Individual TERMS**

TERM	Annual Tons PM 2.5 Reduced	Annual Tons PM 2.5 Precursor NOx Reduced	Annual Tons CO2 Reduced
<b>Maryland Telework Assistance</b> <sup>1)</sup>	1.275	25.675	38,820.0
<b>Virginia Telework Assistance (TW!VA)</b> <sup>1)</sup>	0.025	0.700	1,012.5
<b>Guaranteed Ride Home</b>	0.552	10.585	17,664.1
<b>Employer Outreach – all employers</b> <sup>2)</sup>	6.275	126.775	190,093.1
Employer Outreach – new/expanded employers <sup>2)</sup>	1.650	32.975	49,801.5
Employer Outreach for Bicycling	0.000	0.250	195.3
<b>Mass Marketing</b>	0.556	11.369	16,644.8
<b>TERMS (all TERMS collectively)</b>	8.683	175.104	264,234.5
<b>Commuter Operations Center – basic services (not including Software Upgrades)</b>	1.377	28.137	41,766.3
<b>Commuter Operations Center – Software Upgrades</b>	0.150	2.975	4,981.1
<b>All TERMS plus Commuter Operations Center</b>	10.210	206.216	310,981.9

- 1) Maryland impacts represent portion of regional telework attributable to TERM-related activities in Maryland. Virginia impacts represent portion of regional telework attributable to the TW!VA program in Virginia. Total telework credited for conformity is higher than reported for the TERM.
- 2) Impacts for new / expanded employer programs and Employer Outreach for Bicycling are included in the Employer Outreach – all employers.

Finally, Table D shows comparisons of daily reductions in vehicle trips, VMT, NOx, and VOC from the 2017 TERM analysis (July 2014 through June 2017) to results of the 2014 analysis (July 2011 through June 2014). As noted before and as described in the footnotes to the table, the emission factors declined between 2014 and 2017, resulting in decreased emission reductions, even though some of the TERMS achieved greater vehicle trip and VMT reductions in 2017 than in 2014.

The impacts for the Telework TERM and Employer Outreach were substantially higher in 2017 than in 2014. Impacts for GRH and for the Mass Marketing TERMS were lower in the 2017 analysis than in 2014. But the vehicle trip impact for Mass Marketing was only 2% below that for 2014 and the VMT impact was only 6% below 2014. The Commuter Operations Center also had lower impacts in 2017 than in 2014, largely due to a lower than expected application count.



**Table D**  
**Summary of Results for Individual TERMS 7/14– 6/17 Compared with 7/11 – 6/14**

<b>TERM</b>	<b>Daily Vehicle Trips Reduced</b>	<b>Daily VMT Reduced</b>	<b>Daily Tons NOx Reduced</b>	<b>Daily Tons VOC Reduced</b>
<b>Maryland Telework Assistance</b>				
July 2014 – June 2017	14,839	361,204	0.096	0.070
July 2011 – June 2014	9,651	205,511	0.101	0.051
<b>Change <sup>1)</sup></b>	5,188	155,693	(0.005)	0.019
<b>Virginia Telework Assistance – Telework! VA</b>				
July 2014 – June 2017	490	9,359	0.003	0.002
July 2011 – June 2014 <sup>2)</sup>	N/A	N/A	N/A	N/A
<b>Change</b>	490	9,359	0.003	0.002
<b>Guaranteed Ride Home</b>				
July 2014 – June 2017	6,398	181,335	0.040	0.023
July 2011 – June 2014	7,711	212,834	0.087	0.033
<b>Change <sup>1)</sup></b>	(1,313)	(31,473)	(0.047)	(0.011)
<b>Employer Outreach – All services except Employer Outreach for Bicycling</b>				
July 2014 – June 2017	102,252	1,839,789	0.473	0.349
July 2011 – June 2014	78,210	1,325,107	0.533	0.304
<b>Change <sup>1)</sup></b>	24,042	514,682	(0.059)	0.045
<b>Employer Outreach for Bicycling</b>				
July 2014 – June 2017	373	1,640	0.001	0.001
July 2011 – June 2014	323	1,937	0.001	0.001
<b>Change <sup>1)</sup></b>	50	(297)	0.000	0.000
<b>Mass Marketing</b>				
July 2014 – June 2017	10,133	163,250	0.042	0.019
July 2011 – June 2014	10,294	173,269	0.081	0.024
<b>Change <sup>1)</sup></b>	(161)	(10,019)	(0.038)	(0.005)
<b>All TERMS</b>				
July 2014 – June 2017	134,485	2,556,577	0.655	0.464
July 2011 – June 2014	106,189	1,918,658	0.803	0.412
<b>Change <sup>1)</sup></b>	28,296	637,919	(0.148)	0.052
<b>Commuter Operations Center (Basic Services + Software Upgrades)</b>				
July 2014 – June 2017	21,728	452,667	0.116	0.085
July 2011 – June 2014	25,641	554,668	0.258	0.121
<b>Change <sup>1)</sup></b>	(3,913)	(102,001)	(0.142)	(0.035)

1) Change in emissions is due in part to reduction in emission factors from 2014 to 2017.

2) Telework! VA was not included in the FY 2012-14 TERM analysis.

## **SOCIETAL BENEFITS OF FY 2015-17 TRAVEL AND EMISSIONS IMPACTS**

The TERM analysis is undertaken primarily to report TERM performance as compared with regional goals set for air quality conformity determination and conformity and congestion management impacts remain the central focus of the FY 2015-17 Commuter Connections TERM evaluation. The travel and emissions impact indicators shown in Tables 1 and 2 were established for the TERMS by the TPB and the framework established for the FY 2015-17 TERM evaluation did not recommend any official changes to these indicators.

But the TERMS likely do offer other benefit to residents and commuters of the Washington region, in societal objectives such as Greenhouse gas emissions reductions, greater mobility, improved road safety, and enhanced livability/quality of life. One benefit area that is particularly increasing in importance is transportation system performance, as new performance measurement requirements are established by the Federal Highway Administration to comply with FAST Act transportation funding reauthorization.

These benefits are joining congestion and air quality as forces shaping the region's transportation policies, making them also issues relevant to Commuter Connections partners and funders. Documenting the types and magnitude of these benefits demonstrates the broad value of Commuter Connections programs to the community and the value of investments made in the programs.

The FY 2015-17 TERM evaluation added a new analysis component, estimating regional cost savings generated for selected societal benefits of the TERM travel and emissions impacts. These benefits include:

- Air pollution/emissions reductions in NO<sub>x</sub>, VOC, PM 2.5 pollutants
- Reduction in Greenhouse gas emissions/CO<sub>2</sub>
- Reduction in congestion (reduced hours of peak period travel delay)
- Reduction in fuel consumption (gasoline cost saving)
- Improved road safety (accidents reduced per 1 million VMT)
- Noise pollution reduction (reduced motor vehicle noise)

The societal cost savings for each of these benefits was calculated by defining a unit of benefit associated with each type of benefit (e.g., tons of CO<sub>2</sub> reduced, and hours of delay reduced for reduction in congestion) and multiplying the benefit units by a unit cost factor (e.g., cost per ton of pollutant or cost per hour of delay). The conversion to benefit units and the unit cost factors for most benefits were obtained from the Trip Reduction Impacts of Mobility Management Strategies (TRIMMS<sup>TM</sup>) model developed by the Center for Urban Transportation Research. TRIMMS<sup>TM</sup> estimates societal cost saving benefits of TDM actions for the societal benefits shown above. Appendix 9 defines the methodology used for each benefit and the specific sources used to derive unit benefits and unit costs.

Table E presents the cost saving associated with each type of benefit and the overall societal cost saving calculated for the TERMS and the Commuter Operations Center combined. As shown, the combined TERM/Commuter Operations Center impacts generate about \$1.2 million of daily cost saving across the societal benefits included in the calculation. The largest share of the cost saving is in reduction of congestion; reduced hours of travel delay are valued at over \$614,793 per day, or about 51% of the total daily benefits. Reduction in fuel used accounts for about 35% of the total daily benefit (\$419,622). Noise pollution reduction generates about 6% and air pollution/Greenhouse gas reduction benefits and road safety accident reduction benefits each are responsible for about 4% of the total cost saving.

**Table E**  
**Daily Societal Benefit Cost Savings Generated by**  
**FY 2015-17 TERM and Commuter Operations Center Impacts**

Societal Benefit	Benefit Unit	Benefit Base Units	Cost per Unit of Benefit	Total Daily Cost Saving
Air pollution				
- NOx	Tons NOx removed	0.770 T	\$1,612	\$1,241
- VOC	Tons VOC removed	0.548 T	\$133	\$73
- PM 2.5	Tons PM 2.5 removed	0.040 T	\$15,107	\$604
- PM 2.5 NOx	Tons PM 2.5 NOx removed	0.820 T	\$1,612	\$1,322
Greenhouse gases	Tons CO2 removed	1,244 T	\$36	\$44,781
Noise pollution	Total VMT reduced	3,009,244 VMT	\$0.0223	\$67,106
Congestion	Hours of delay reduced	24,464 hours	\$25.13	\$614,793
Excess fuel used	Gallons of fuel saved	167,180 gal	\$2.51	\$419,622
Health/safety <sup>1)</sup>	Accidents avoided/1 M VMT	3.043 acc.	\$15,952	\$48,543
<b>All benefits</b>				<b>\$1,198,085</b>

1) Health and safety benefit base units and cost per unit are weighted averages of accident occurrences by severity.

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## SECTION 1 INTRODUCTION

### PURPOSE OF THE REPORT

This report presents the results of an evaluation of four Transportation Emission Reduction Measures (TERMs), voluntary Transportation Demand Management (TDM) measures implemented by the National Capital Region Transportation Planning Board's (TPB) Commuter Connections program at the Metropolitan Washington Council of Governments (COG) to support the Washington, DC metropolitan region's air quality conformity determination and congestion management process. This evaluation documents transportation and air quality impacts for the three-year evaluation period between July 1, 2014 and June 30, 2017 (FY 2015-17), for the following TERMS:

- Maryland and Virginia Telework – The Maryland portion of this TERM provides information and assistance to Maryland commuters and employers to further in-home and telecenter-based telework programs. The Virginia portion provides assistance to employers and employees participating in the Telework! VA (TWVA) program.
- Guaranteed Ride Home – Eliminates a barrier to use of alternative modes by providing free rides home in the event of an unexpected personal emergency or unscheduled overtime to commuters who use alternative modes.
- Employer Outreach – Provides regional outreach services to encourage large, private-sector and non-profit employers voluntarily to implement commuter assistance strategies that will contribute to reducing vehicle trips to worksites, including the efforts of jurisdiction sales representatives to foster new and expanded trip reduction programs. The Employer Outreach for Bicycling TERM also is part of this analysis.
- Mass Marketing – Involves a large-scale, comprehensive media campaign to inform the region's commuters of services available from Commuter Connections as one way to address commuters' frustration about the commute. Various special promotional events also are part of this TERM.

The TPB, the designated Metropolitan Planning Organization (MPO) for the Washington, DC metropolitan region, adopted these TERMS in the regional Transportation Improvement Program (TIP) to help the region reach emission reduction targets that would maintain a positive air quality conformity determination for the region and to meet federal requirements for the congestion management process.

The United States Environmental Protection Agency has designated the Washington, DC metropolitan region as a "marginal" ozone non-attainment area for the 2008 Ozone Standard. No regional mandates have been adopted that require the reduction of nitrogen oxides (NOx) or the implementation of any specific mitigation measure. But the COG/TPB Travel Management Subcommittee developed and analyzed regional TERMS and the TPB adopted these TERMS in annual TIPs.

COG/TPB's Commuter Connections program, which operates an ongoing regional rideshare program, was given responsibility for implementation of the TDM TERMS noted above. Commuter Connections is the central administrator of these TERMS, but works with partner organizations, such as local jurisdiction commute programs and transportation management associations (TMAs) to implement them.

Commuter Connections also operates the Commuter Operations Center (COC), providing direct commute assistance services, such as carpool and vanpool matching, transit, telework, and Park & Ride information, and other travel information services that are most cost-effectively provided by a central agency, through telephone and internet assistance to commuters. Other services are offered by local organizations and coordinated regionally by the Commuter Connections Subcommittee, a coordinating body comprised of state and local government agencies in the region, several large federal employers, a number of TMAs, and other partner organizations.

At the early stages of implementation of the TERMS, the Commuter Connections Subcommittee elected to include a vigorous evaluation element in the implementation plan for each of the adopted TERMS. The purpose of the evaluation was to develop timely and meaningful information for regional transportation and air quality decision-

makers, COG staff, COG program funders, and state and local commute assistance program managers to guide sound decision-making about the TERMS.

This report summarizes the results of the TERM evaluation activities and presents the transportation and air quality impacts of the TERMS. The report also documents impacts of the commuter assistance activities of the Commuter Operations Center, which COG operates to provide a basic level of commuter information and ridesharing assistance services throughout the Washington metropolitan region. Results from this report will be used to support the region's air quality goals and will be documented in the region's congestion management process.

In June 1997, a consultant team was retained to assist Commuter Connections to define an evaluation methodology. This methodology was used for the first triennial evaluation of five TERMS. In 2001, 2004, 2007, 2010, 2013, and 2016, the consultants, along with Commuter Connections, expanded and enhanced the methodologies, data collection tools, and data sources to expand the coverage, corroborate assumptions, and enhance the reliability of the evaluation estimates. Section 3 presents highlights of the changes made to the methodology in this updated framework. Readers who desire additional details on the methodology are directed to the report entitled, "Commuter Connections' Transportation Demand Management Evaluation Project: Transportation Emission Reduction Measures (TERMs) Revised Evaluation Framework, FY 2015 – FY 2017." This document (*TERM Evaluation Framework, 2015-2017*) is available on-line at [www.commuterconnections.org](http://www.commuterconnections.org).

The data collection activities recommended in the Evaluation Framework report were undertaken by COG/TPB staff or by data collection consultants retained by COG. This report summarizes the results of the evaluation activities and analysis. The report also summarizes the transportation and air quality impacts of commuter assistance activities of the Commuter Operations Center. The COC is not an adopted TERM, but is included in this analysis because its operation supports the operation of most of the regional Commuter Connections TERMS.

## ORGANIZATION OF THE REPORT

This TERM Analysis Report is divided into nine sections following this Introduction section:

- Section 2 Overall Summary of Results
- Section 3 Highlights of Revised Evaluation Methodology
- Section 4 Maryland and Virginia Telework Assistance
- Section 5 Guaranteed Ride Home
- Section 6 Employer Outreach
- Section 7 Mass Marketing
- Section 8 Commuter Operations Center
- Section 9 Summary of TERM Impacts

Section 2 summarizes the overall results for each TERM individually and for all TERMS plus the Commuter Operations Center collectively. Section 3 presents highlights of the revised evaluation methodology developed in 2016 for the FY 2015-17 evaluation period. Sections 4 through 7 present for each individual TERM, a brief description of the TERM and its purpose, an overview of the methodology used to estimate the TERM's impacts and the data used in the analysis, and a comparison of the measured impacts against the goals set for the TERM. Section 8 presents similar information for the Commuter Operations Center. The final section, Section 9, presents general conclusions from the analysis.

Summaries of the calculations of transportation and air quality impacts of individual TERMS also are included in appendices following the body of the report.

## SECTION 2 SUMMARY OF TERM ANALYSIS RESULTS

The objective of the evaluation is to estimate reductions in vehicle trips (VT), vehicle miles traveled (VMT), and tons of vehicle pollutants resulting from implementation of each TERM between July 2014 and June 2017 and to compare these impacts against the goals established for the TERMS. The Revised Evaluation Framework document finalized in March 2016 also recommended that other performance measures be tracked for these TERMS to assess levels of program participation, utilization, satisfaction, and cost-effectiveness. These measures are tracked by Commuter Connections on a monthly and annual basis for the TERMS and are reported in other documents.

### TRAVEL AND EMISSIONS IMPACTS OVERALL AND BY TERM

Tables 1 and 2 present impact results for reductions in the following impacts and comparisons to the goals set for the impact measures:

- Vehicle trips (VT)
- Vehicle miles traveled (VMT)
- Nitrogen Oxides (NOx)
- Volatile Organic Compounds (VOC)

As shown in Table 1, the TERMS combined exceeded the collective goals for vehicle trips reduced by 14% and exceeded the VMT goal by about 18%. The TERMS did not reach the emission goals; the impact for NOx was 31% under the goal and VOC impact was 10% under the goal, but these deficits were due largely to changes in the emission factors. The TERM goals were set in 2006, using 2006 emission factors. Goals for some TERMS were re-set since the issuance of the FY2012 – 2014 Commuter Connections TERM Analysis Report. Emission factors used in the 2017 evaluation were considerably lower than the factors from 2014 and lower still than the factors used in 2011, reflecting a cleaner vehicle fleet.

When the COC results are added to the TERM impacts, as presented in Table B, the combined impacts exceeded the vehicle trip and VMT reduction goals by 8% and 9%, respectively. The combined TERM – COC program impacts fell 37% short of the NOx goal and were 14% below the VOC goal. Again, the change in the emission factors affected the emission results.

Two TERMS, Telework – Maryland Assistance and Employer Outreach, easily met their individual goals for participation and travel impact. Employer Outreach exceeded vehicle trip and VMT goals by substantial margins. The Employer Outreach for Bicycling TERM component did not meet its goals, but the absolute deficits were small. The Virginia telework component (Telework!VA) also met the goals set for the program.

The impacts for the other two TERMS were below their goals. Vehicle trip reductions and VMT reductions for the Guaranteed Ride Home TERM were about half of the goals set for these impacts, primarily due to declining registrations, compared with 2014 and previous years. The Mass Marketing TERM's vehicle trip and VMT reductions were 6% and 10% short of their respective goals. The Commuter Operations Center and the Software Upgrades TERM also were under their goals for vehicle trips and VMT reduced.

Additional details on the calculations for each TERM and for the Commuter Operations Center are described in individual sections of this report. The reasons for the shortfalls from the goals also are discussed in the individual report sections.



**Table 1**  
**Summary of Daily Impact Results for Individual TERMS (July 2014 – June 2017) and Comparison to Goals**

TERM	Participation <sup>1)</sup>	Daily Vehicle Trips Reduced	Daily VMT Reduced	Daily Tons NOx Reduced	Daily Tons VOC Reduced
<b>Maryland Telework Assistance <sup>2)</sup></b>					
2017 Goal	31,854	11,830	241,209	0.122	0.072
Impacts (7/14 – 6/17)	44,350	14,839	361,204	0.096	0.070
<b>Net Credit or (Deficit)</b>	<b>12,496</b>	<b>3,009</b>	<b>119,995</b>	<b>(0.026)</b>	<b>(0.002)</b>
<b>Virginia Telework Assistance – Telework! VA <sup>2)</sup></b>					
2017 Goal	800	155	2,548	0.003	0.001
Impacts (7/14 – 6/17)	1,531	490	9,359	0.003	0.002
<b>Net Credit or (Deficit)</b>	<b>731</b>	<b>335</b>	<b>6,811</b>	<b>0.000</b>	<b>0.001</b>
<b>Guaranteed Ride Home</b>					
2017 Goal	36,992	12,593	355,136	0.177	0.097
Impacts (7/14 – 6/17)	16,742	6,398	181,335	0.040	0.023
<b>Net Credit or (Deficit)</b>	<b>(20,250)</b>	<b>(6,195)</b>	<b>(173,801)</b>	<b>(0.137)</b>	<b>(0.074)</b>
<b>Employer Outreach – all employers participating <sup>3)</sup></b>					
2017 Goal	1,847	82,524	1,393,783	0.561	0.320
Impacts (7/14 – 6/17)	2,046	102,625	1,841,429	0.474	0.350
<b>Net Credit or (Deficit)</b>	<b>199</b>	<b>20,101</b>	<b>447,646</b>	<b>(0.087)</b>	<b>0.030</b>
<b>Employer Outreach – new / expanded employer services since July 2014 <sup>3)</sup></b>					
2017 Goal	91	N/A	N/A	N/A	N/A
Impacts (7/14 – 6/17)	765	25,936	482,153	0.123	0.090
<b>Net Credit or (Deficit)</b>	<b>674</b>	<b>N/A</b>	<b>N/A</b>	<b>N/A</b>	<b>N/A</b>
<b>Employer Outreach for Bicycling <sup>3)</sup></b>					
2017 Goal	590	404	2,421	0.0016	0.0015
Impacts (7/14 – 6/17)	597	373	1,640	0.0008	0.0012
<b>Net Credit or (Deficit)</b>	<b>7</b>	<b>(31)</b>	<b>(781)</b>	<b>(0.0008)</b>	<b>(0.0003)</b>
<b>Mass Marketing</b>					
2017 Goal	23,168	10,809	181,932	0.085	0.025
Impacts (7/14 – 6/17)	23,016	10,133	163,250	0.042	0.019
<b>Net Credit or (Deficit)</b>	<b>(152)</b>	<b>(676)</b>	<b>(18,682)</b>	<b>0.043</b>	<b>(0.006)</b>
<b>TERMS (all TERMS collectively)</b>					
2017 Goal		117,911	2,174,608	0.948	0.515
Impacts (7/14 – 6/17)		134,485	2,556,577	0.655	0.464
<b>Net Credit or (Deficit)</b>		<b>16,574</b>	<b>381,969</b>	<b>(0.293)</b>	<b>(0.051)</b>

1) Participation refers to number of commuters participating, except for the Employer Outreach TERM. For this TERM, participation equals the number of employers participating.

2) Maryland impacts represent portion of regional telework attributable to TERM-related activities in Maryland. Virginia impacts represent portion of regional telework attributable to the TW!VA program in Virginia. Total telework credited for conformity is higher than reported for the TERM.

3) Impacts for Employer Outreach - all employers participating includes impacts for Employer Outreach – new / expanded employer services since July 2014 and for Employer Outreach for Bicycling.

**Table 2**  
**Summary of TERM and COC Results (July 2014 – June 2017) and Comparison to Goals**

TERM	Participation	Daily Vehicle Trips Reduced	Daily VMT Reduced	Daily Tons NOx Reduced	Daily Tons VOC Reduced
<b>TERMS (all TERMS collectively)</b>					
2017 Goal		117,911	2,174,608	0.948	0.515
Impacts (7/14 – 6/17)		134,485	2,556,577	0.655	0.464
<b>Net Credit or (Deficit)</b>		<b>16,574</b>	<b>381,969</b>	<b>(0.293)</b>	<b>(0.051)</b>
<b>Commuter Operations Center – Basic Services</b>					
2017 Goal	91,609	24,425	512,637	0.241	0.115
Impacts (7/14 – 6/17)	77,662	19,949	401,327	0.105	0.079
<b>Net Credit or (Deficit)</b>	<b>(13,947)</b>	<b>(4,476)</b>	<b>(111,310)</b>	<b>(0.136)</b>	<b>(0.036)</b>
<b>Commuter Operations Center – Software Upgrades <sup>1)</sup></b>					
2017 Goal	4,681	2,379	66,442	0.028	0.011
Impacts (7/14 – 6/17)	4,178	1,779	51,340	0.011	0.006
<b>Net Credit or (Deficit)</b>	<b>(503)</b>	<b>(600)</b>	<b>(15,102)</b>	<b>(0.017)</b>	<b>(0.005)</b>
<b>All TERMS plus COC</b>					
2017 Goal		144,715	2,753,687	1.217	0.641
Impacts (7/14 – 6/17)		156,213	3,009,244	0.771	0.549
<b>Net Credit or (Deficit)</b>		<b>11,498</b>	<b>255,557</b>	<b>(0.446)</b>	<b>(0.092)</b>

1) Impacts for Commuter Operations Center – software Upgrades are in addition to the impacts for the Commuter Operations Center – Basic Services. This project was previously part of the Integrated Rideshare TERM.

Table 3, on the following page, presents annual emission reduction results for PM 2.5, PM 2.5 pre-cursor NOx, and CO2 emissions (Greenhouse Gas Emissions - GHG) for each TERM and for the COC. COG/TPB did not establish specific targets for these impacts for the Commuter Connections TERMS. But COG has been measuring these impacts for other TERMS, thus these results are provided.

As shown, the TERMS collectively reduce 8.7 annual tons of PM 2.5, 175 annual tons of PM 2.5 pre-cursor NOx, and 264,235 annual tons of CO2 (greenhouse gas emissions). When the Commuter Operations Center is included, these emissions impacts rise to 10.2 annual tons of PM 2.5, 206.2 annual tons of PM 2.5 pre-cursor NOx, and 310,982 annual tons of CO2 (greenhouse gas emissions).

**Table 3**  
**Summary of Annual PM 2.5 and CO2 (Greenhouse Gas) Emission Results for Individual TERMS**

TERM	Annual Tons PM 2.5 Reduced	Annual Tons PM 2.5 Precursor NOx Reduced	Annual Tons CO2 Reduced
Maryland Telework Assistance <sup>1)</sup>	1.275	25.675	38,820.0
Virginia Telework Assistance (TW!VA) <sup>1)</sup>	0.025	0.700	1,012.5
Guaranteed Ride Home	0.552	10.585	17,664.1
Employer Outreach – all employers <sup>2)</sup>	6.275	126.775	190,093.1
Employer Outreach – new/expanded employers <sup>2)</sup>	1.650	32.975	49,801.5
Employer Outreach for Bicycling	0.000	0.250	195.3
Mass Marketing	0.556	11.369	16,644.8
<b>TERMS (all TERMS collectively)</b>	<b>8.683</b>	<b>175.104</b>	<b>264,234.5</b>
<b>Commuter Operations Center – basic services (not including Software Upgrades)</b>	<b>1.377</b>	<b>28.137</b>	<b>41,766.3</b>
<b>Commuter Operations Center – Software Upgrades</b>	<b>0.150</b>	<b>2.975</b>	<b>4,981.1</b>
<b>All TERMS plus Commuter Operations Center</b>	<b>10.210</b>	<b>206.216</b>	<b>310,981.9</b>

- 1) Maryland impacts represent portion of regional telework attributable to TERM-related activities in Maryland. Virginia impacts represent portion of regional telework attributable to the TW!VA program in Virginia. Total telework credited for conformity is higher than reported for the TERM.
- 2) Impacts for new / expanded employer programs and Employer Outreach for Bicycling are included in the Employer Outreach – all employers.

## **FY 2015-17 IMPACTS COMPARED WITH IMPACTS FROM FY 2012-14 ANALYSIS**

Finally, Table 4 shows comparisons of daily reductions in vehicle trips, VMT, NOx, and VOC from the 2017 TERM analysis (July 2014 through June 2017) to results of the 2014 analysis (July 2011 through June 2014). As noted before and as described in the footnotes to the table, the emission factors declined between 2014 and 2017, resulting in decreased emission reductions, even though some of the TERMS achieved greater vehicle trip and VMT reductions in 2017 than in 2014.

The impacts for the Telework TERM and Employer Outreach were substantially higher in 2017 than in 2014. Impacts for GRH and for the Mass Marketing TERMS were lower in the 2017 analysis than in 2014. But the vehicle trip impact for Mass Marketing was only 2% below that for 2014 and the VMT impact was only 6% below 2014. The Commuter Operations Center also had lower impacts in 2017 than in 2014, largely due to a lower than expected application count.

**Table 4**  
**Summary of Results for Individual TERMS 7/14– 6/17 Compared with 7/11 – 6/14**

<b>TERM</b>	<b>Daily Vehicle Trips Reduced</b>	<b>Daily VMT Reduced</b>	<b>Daily Tons NOx Reduced</b>	<b>Daily Tons VOC Reduced</b>
<b>Maryland Telework Assistance</b>				
July 2014 – June 2017	14,839	361,204	0.096	0.070
July 2011 – June 2014	9,651	205,511	0.101	0.051
<b>Change <sup>1)</sup></b>	5,188	155,693	(0.005)	0.019
<b>Virginia Telework Assistance – Telework! VA</b>				
July 2014 – June 2017	490	9,359	0.003	0.002
July 2011 – June 2014 <sup>2)</sup>	N/A	N/A	N/A	N/A
<b>Change</b>	490	9,359	0.003	0.002
<b>Guaranteed Ride Home</b>				
July 2014 – June 2017	6,398	181,335	0.040	0.023
July 2011 – June 2014	7,711	212,834	0.087	0.033
<b>Change <sup>1)</sup></b>	(1,313)	(31,473)	(0.047)	(0.011)
<b>Employer Outreach – All services except Employer Outreach for Bicycling</b>				
July 2014 – June 2017	102,252	1,839,789	0.473	0.349
July 2011 – June 2014	78,210	1,325,107	0.533	0.304
<b>Change <sup>1)</sup></b>	24,042	514,682	(0.059)	0.045
<b>Employer Outreach for Bicycling</b>				
July 2014 – June 2017	373	1,640	0.001	0.001
July 2011 – June 2014	323	1,937	0.001	0.001
<b>Change <sup>1)</sup></b>	50	(297)	0.000	0.000
<b>Mass Marketing</b>				
July 2014 – June 2017	10,133	163,250	0.042	0.019
July 2011 – June 2014	10,294	173,269	0.081	0.024
<b>Change <sup>1)</sup></b>	(161)	(10,019)	(0.038)	(0.005)
<b>All TERMS</b>				
July 2014 – June 2017	134,485	2,556,577	0.655	0.464
July 2011 – June 2014	106,189	1,918,658	0.803	0.412
<b>Change <sup>1)</sup></b>	28,296	637,919	(0.148)	0.052
<b>Commuter Operations Center (Basic Services + Software Upgrades)</b>				
July 2014 – June 2017	21,728	452,667	0.116	0.085
July 2011 – June 2014	25,641	554,668	0.258	0.121
<b>Change <sup>1)</sup></b>	(3,913)	(102,001)	(0.142)	(0.035)

1) Change in emissions is due in part to reduction in emission factors from 2014 to 2017.

2) Telework! VA was not included in the FY 2012-14 TERM analysis.

## SOCIETAL BENEFITS OF FY 2015-17 TRAVEL AND EMISSIONS IMPACTS

The TERM analysis is undertaken primarily to report TERM performance as compared with regional goals set for air quality conformity determination and conformity and congestion management impacts remain the central focus of the FY 2015-17 Commuter Connections TERM evaluation. The travel and emissions impact indicators shown in Tables 1 and 2 were established for the TERMS by the TPB and the framework established for the FY 2015-17 TERM evaluation did not recommend any official changes to these indicators.

But the TERMS likely do offer other benefit to residents and commuters of the Washington region, in societal objectives such as Greenhouse gas emissions reductions, greater mobility, improved road safety, and enhanced livability/quality of life. One benefit area that is particularly increasing in importance is transportation system performance, as new performance measurement requirements are established by the Federal Highway Administration to comply with FAST Act transportation funding reauthorization.

These benefits are joining congestion and air quality as forces shaping the region's transportation policies, making them also issues relevant to Commuter Connections partners and funders. Documenting the types and magnitude of these benefits demonstrates the broad value of Commuter Connections programs to the community and the value of investments made in the programs.

The FY 2015-17 TERM evaluation added a new analysis component, estimating regional cost savings generated for selected societal benefits of the TERM travel and emissions impacts. These benefits include:

- Air pollution/emissions reductions in NO<sub>x</sub>, VOC, PM 2.5 pollutants
- Reduction in Greenhouse gas emissions/CO<sub>2</sub>
- Reduction in congestion (reduced hours of peak period travel delay)
- Reduction in fuel consumption (gasoline cost saving)
- Improved road safety (accidents reduced per 1 million VMT)
- Noise pollution reduction (reduced motor vehicle noise)

The societal cost savings for each of these benefits was calculated by defining a unit of benefit associated with each type of benefit (e.g., tons of CO<sub>2</sub> reduced, and hours of delay reduced for reduction in congestion) and multiplying the benefit units by a unit cost factor (e.g., cost per ton of pollutant or cost per hour of delay). The conversion to benefit units and the unit cost factors for most benefits were obtained from the Trip Reduction Impacts of Mobility Management Strategies (TRIMMS™) model developed by the Center for Urban Transportation Research. TRIMMS™ estimates societal cost saving benefits of TDM actions for the societal benefits shown above. Appendix 9 defines the methodology used for each benefit and the specific sources used to derive unit benefits and unit costs.

Table 5 presents the cost saving associated with each type of benefit and the overall societal cost saving calculated for the TERMS and the Commuter Operations Center combined. As shown, the combined TERM/Commuter Operations Center impacts generate about \$1.2 million of daily cost saving across the societal benefits included in the calculation. The largest share of the cost saving is in reduction of congestion; reduced hours of travel delay are valued at over \$614,793 per day, or about 51% of the total daily benefits. Reduction in fuel used accounts for about 35% of the total daily benefit (\$419,622). Noise pollution reduction generates about 6% and air pollution/Greenhouse gas reduction benefits and health/safety accident reduction benefits each are responsible for about 4% of the total cost saving.

**Table 5**  
**Daily Societal Benefit Cost Savings Generated by**  
**FY 2015-17 TERM and Commuter Operations Center Impacts**

Societal Benefit	Benefit Unit	Benefit Base Units	Cost per Unit of Benefit	Total Daily Cost Saving
Air pollution				
- NOx	Tons NOx removed	0.770 T	\$1,612	\$1,241
- VOC	Tons VOC removed	0.548 T	\$133	\$73
- PM 2.5	Tons PM 2.5 removed	0.040 T	\$15,107	\$604
- PM 2.5 NOx	Tons PM 2.5 NOx removed	0.820 T	\$1,612	\$1,322
Greenhouse gases	Tons CO2 removed	1,244 T	\$36	\$44,781
Noise pollution	Total VMT reduced	3,009,244 VMT	\$0.0223	\$67,106
Congestion	Hours of delay reduced	24,464 hours	\$25.13	\$614,793
Excess fuel used	Gallons of fuel saved	167,180 gal	\$2.51	\$419,622
Health/safety <sup>1)</sup>	Accidents avoided/1 M VMT	3.043 acc.	\$15,952	\$48,543
<b>All benefits</b>				<b>\$1,198,085</b>

1) Health and safety benefit base units and cost per unit are weighted averages of accident occurrences by severity.

## SECTION 3 HIGHLIGHTS OF REVISED EVALUATION METHODOLOGY

### BACKGROUND

In 1997, consultants selected by COG developed an evaluation framework to guide the collection and analysis of data to estimate travel and air quality impacts of TDM TERMS adopted by COG's TPB. This methodology described evaluation objectives, performance measures for each TERM, data needs and data collection tools and sources, and analysis and calculation steps to be used to estimate travel, air quality, energy, and consumer cost impacts of the TERMS. The framework also presented recommendations for the evaluation schedule, responsibilities, and reporting of results to maintain and utilize information produced through the evaluation process.

The methodology was designed to collect sufficient data, using recognized and accepted survey and tracking techniques, to allow COG to measure TERM effectiveness with confidence. But it also was designed to be efficient to undertake. The first TERM analysis, conducted in 1999, reinforced the view that data collection and evaluation for TDM programs can be challenging, especially when the programs are voluntary. Reliable data can be difficult to assemble, as assumptions may need to be made using proxy data, and factors outside the program can influence results.

The first evaluation made recommendations for several data collection changes that could enhance the accuracy, rigor, coverage, and reliability of future TERM evaluations. A revised methodology was prepared in 2001, reflecting these recommendations. The methodology was updated again, in 2004, 2007, 2010, 2013, and 2016, following subsequent triennial TERM evaluations, to enhance the analysis results for several TERMS.

This section identifies key enhancements that were made to the methodology since the 2014 TERM Analysis Report was completed and discusses the overall rigor of the evaluation framework as compared to other regions. Overall, the Transportation Demand Management evaluation process employed for this analysis is among the most rigorous and comprehensive in the United States.



### EVALUATION METHODOLOGY OVERVIEW

#### Evaluation Principles

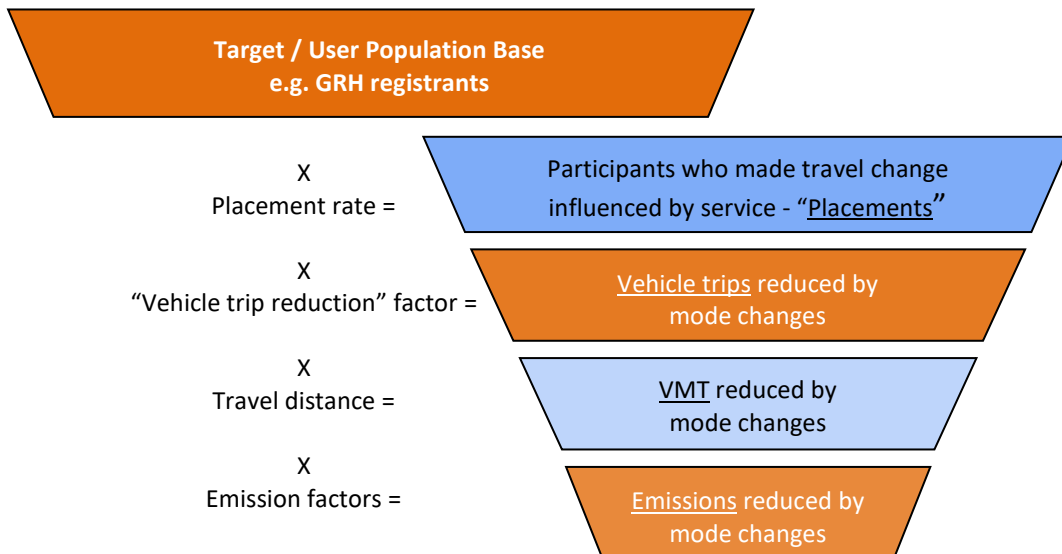
Before discussing the methodology changes in the Revised Evaluation Methodology, it is useful to review several elements of the methodology developed in 1997. The TERM evaluation process was founded on several key evaluation principles that formed the foundation for the Evaluation Framework that has guided the process since 1997. Some of those principles, which have since been adopted by other regions evaluating TDM programs, include:

- Provide sound, definitive, and useful information about the results of the program
- Assure objective evaluation by using a third-party (other than a funding or implementing agent)
- Avoid double counting by separating out the impacts of individual program elements or TERMS
- Report only those impacts associated with the TERMS, and not the combined impacts of the TERMS and the basic commuter services that were in place prior to the adoption of the TERMS
- Follow accepted and recognized evaluation techniques
- Be rigorous, ongoing, resource efficient, unobtrusive for COG partners, and compatible with regional, state, and national practices

### Evaluation Methodology Steps

The calculation of Commuter Connection’s TERM program impacts is based on a step-by-step methodology that estimates program impact measures related to transportation and air quality benefits generated by the TERMS. The methodology calls for a series of “multiplier factors,” derived primarily from survey data, to be applied to a known number of commuters who might be influenced or assisted by the TERM to make a travel pattern change (population base). The result of these step-by-step calculations is an estimate of the numbers of vehicle trips, VMT, and emissions reduced through commute changes made by commuters after contact with the TERM programs or services (Figure 1).

**Figure 1: Impact Calculation Multipliers Series**



For most TERMS, the population base is commuters who participate in or use the TERM service, although in a few cases, the population is all regional commuters. The methodology requires an accurate documentation of the participation in each TERM program and an accurate count of other population bases. This is accomplished primarily by program participant tracking performed by Commuter Connections staff and survey results.

The methodology then applies five primary calculation factors, derived from surveys of the populations of interest, to the population base. Each TERM has a unique set of factors, depending on the characteristics of the TERM and users, but the basic calculation method is the same for all TERMS. The calculation factors and the calculation steps are briefly described below.

1. Estimate “placement rate” and “influenced placement rate”

Placement rate refers to the percentage of the population base “placed” in an alternative mode after receiving a service. Placement rates are typically estimated from survey data of a sample of the population and vary from one service to another, depending on the characteristics of the service and population.

To collect placement rate data, service users are asked several questions:

- How do you travel now—what modes do you use and how many days per week do you use them?
- Did you make any changes in your travel since you received “X” service?
- How did you travel before you received this service?
- Did the service encourage or assist you to make this change?



Users who made a travel change are considered “placements.” For most TERMS, two rates were estimated, distinguished by the time the service user used the new mode after shifting. The *Continued* rate represents users who shifted to a new alternative mode and continued using the new mode. The *Temporary* rate represents users who tried a new alternative mode but returned to original mode within the evaluation period. Temporary changes are credited only for the duration of time the new mode was used.

2. Estimate the number of new alternative mode placements

Step 2 estimates the number of TERM users who started or increased use of alternative modes as a result of the TERM. It was calculated as:

$$\text{Total Population base} \times \text{Placement rate (from Step 1)}$$

3. Estimate the vehicle trip reduction factor for new placements

Next, the vehicle trip reduction (VTR) factor is estimated for each TERM. The VTR factor is equal to the average daily vehicle trips reduced per placement, taking into account three types of changes:

- 1) Shifts to an alternative mode, either from driving alone or from another alternative mode
- 2) Increased use of alternative modes
- 3) Increase in the number of riders in an existing carpool or vanpool



The VTR factor combines the trip reduction results of all placements into an average reduction per placement. Note that shifts from alternative modes to drive alone were not included in the VTR factor, since these changes are typically unrelated to the TERM.

4. Estimate vehicle trips reduced

The number of daily vehicle trips reduced for the TERM was estimated by multiplying the number of alternative mode placements by the TERM’s VTR factor:

$$\text{Total placements (from Step 2)} \times \text{VTR factor (from Step 3)}$$

5. Estimate vehicle miles traveled (VMT) reduced

The daily VMT reduced was calculated by multiplying the number of daily vehicle trips reduced by the average travel distance for TERM users who made a travel change.

$$\text{Total vehicle trips reduced (from Step 4)} \times \text{one-way travel distance}$$

6. Adjust vehicle trips and VMT for access mode

This step adjusts the vehicle trip and VMT reductions to account for commuters who drive alone to where they meet a rideshare partner or board a bus or train. This step eliminates “cold starts” from the emission analysis. The “adjusted” vehicle trips reduced and VMT reduced, rather than the initial totals, were used to calculate emissions reduced.

7. Estimate emissions reduced

Daily emissions reduced by mode shifts were estimated by multiplying regional emission factors by the number of vehicle trips and VMT reduced. The emissions factors were obtained from Commuter Connections for FY 2017 and were consistent with the regional planning process. The emissions factors account for emissions created from a “cold start,” when a vehicle is first started, a “hot soak,” that occur when the vehicle is later turned off, and the emissions generated per mile of travel by a warmed-up vehicle. Daily emissions reductions

were calculated for NOx and VOC emissions in grams and converted to tons by dividing by 907,185 grams per ton. Annual emissions reductions were calculated for PM 2.5, PM 2.5 pre-cursor NOx, and CO2.

***Adjusted vehicle trips reduced (from Step 6) x Trip emission factor***  
***Adjusted VMT reduced (from Step 6) x VMT (running) emission factor***

8. Estimate the energy savings

Energy savings is reported as gallons of gasoline saved and was estimated by multiplying the VMT reduced by an average fuel consumption factor for the regional mix of light duty vehicles.

These steps were established in the evaluation framework developed in 1997 and remained largely unchanged for the subsequent evaluations conducted for FY 2000-02, FY 2003-05, FY 2006-08, FY 2009-11, and FY 2012-14. They also will be applied to the FY 2015-17 evaluation described in this report.

Key Evaluation Issues

Several other issues should be noted as background, because they are critical to understanding the high level of rigor build into the evaluation process:

- Avoid Double Counting – The evaluation separates the impacts of individual Commuter Connections programs to avoid double counting benefits. For example, carpools might be formed as a joint result of online ridematching and GRH program benefits. These impacts must either be credited to one of the two TERMS or divided between the TERMS. Program benefits are not necessarily additive.
- Separate Impacts of Program Elements – Similarly, the evaluation separates the baseline impacts of Commuter Operations Center “basic” services from the impacts of the new TERM programs. This is especially important for the Mass Marketing TERM, because its impacts can be “direct,” meaning the marketing effort alone motivated use of alternative modes, or “referred,” meaning the marketing effort influenced commuters to utilize another Commuter Connections program, such as ridematching. In such cases, the travel and air quality impacts will be assigned to the TERM or to the Commuter Operations Center, based on their respective influences.
- Account for Commute Mode Prior to Change – Prior mode is an important variable in this evaluation, because a shift to an alternative mode does not always mean a vehicle trip was eliminated. Vehicle trips are reduced only in three cases: 1) the commuter shifts from driving alone to an alternative mode, 2) the commuter increases the frequency of use of an alternative mode, or 3) the commuter shifts to a higher-occupancy mode (e.g., from carpool to vanpool). But some commuters who make shifts within alternative modes increase their vehicle trips, such as if they shift from transit to carpool and these would be valid shifts under the TERM analysis. The calculation of the vehicle trip reduction (VTR) factor converts the number of valid alternative modes placements into the number of vehicle trips reduced, taking into account various types of before-after alternative mode combinations.
- Account for Access Mode to Transit and Carpool/Vanpool – For air quality evaluation purposes, it is necessary to know the access mode of carpoolers, vanpoolers, and transit riders. Access mode refers to how carpoolers, vanpoolers, and transit riders travel from home to bus stops, train stations, Park & Ride lots, or other places where they meet rideshare partners or board a bus or train. Access mode is a minor issue in the evaluation of VMT impacts, because access trips generally account for a very small portion of the total miles traveled and the alternative mode generally is used for the most congested and longest portion of the trip. However, commuters who drive alone to the meeting point still make a vehicle trip and accumulate some drive-alone VMT, which must be subtracted from the vehicle trips reduced and VMT reduced in the air quality analysis.
- Apply Life-cycle Assessment to Mode Shifts to Capture the Full Duration of Benefits for TERM Impacts – In previous TERM evaluations, mode shifts motivated by TERMS during the evaluation period were not carried over to the next evaluation cycle. But numerous surveys conducted for past TERM analyses suggested that

mode shifts extended beyond three years, so additional impacts could be retained from one 3-year evaluation cycle to the next. To address this opportunity, in 2016, Commuter Connections conducted a new “Retention Rate” survey to estimate the share of past service users who continued to use alternative modes. The survey interviewed Commuter Connections online system users and GRH users who last participated in these programs prior to the start of the evaluation period. Users were asked about their current modes, how long they had used their current modes, what Commuter Connections services they received, and how those services influenced them to continue to use alternative modes. The survey data were used to develop “retained” placement rates and other factors for the GRH TERM and for the Commuter Operations Center. More details on these factors are provided in the GRH and Commuter Operations Center sections of this report and in the appendices detailing the calculations of those Commuter Connections programs.

## FY 2015-17 REVISED EVALUATION FRAMEWORK

In general, the TERM analysis approaches documented in the FY 2012-14 TERM Analysis Report were used as the basis for the TERM evaluation methods applied in the FY 2015-17 evaluation. But the Revised Evaluation Framework for FY 2015-17 identified a few enhancements for the current evaluation period. A brief summary of key methodology issues and approaches is presented below for each TERM. More details of each approach are presented in Sections 4 – 7 for each individual TERM.

- The Telework TERM is comprised of resources to help employers, commuters, and program partners initiate and expand telework programs. In evaluating teleworking, several travel changes need to be examined, including telework frequency, the mode on non-telework days, and mode and travel distance to telework locations other than home. The Telework TERM includes impacts for two programs, one in Maryland and a second in Virginia.
  - The *Maryland component* of the impacts includes assistance directly to commuters who live and/or work in Maryland and assistance to employers with Maryland worksites. These impacts are estimated, respectively, from the State of the Commute survey and from surveys conducted with Maryland employers that received telework information or assistance from Commuter Connections.
  - The *Virginia component* of the impacts includes extensive telework development consulting provided to selected Virginia employers that participate in the Telework! VA program. Impacts for this component of the TERM are estimated from baseline and follow-up surveys of employees at participating Virginia worksites.
  - Commuter Connections also continues to provide telework information to commuters who live and/or work outside Maryland and who work for employers that do not participate in TW!VA. Impacts of this assistance are included in the Commuter Operations Center impacts.
- Guaranteed Ride Home (GRH) – The basic methodology for GRH follows the format used for FY 2012-14. However, the FY 2015-17 methodology adds a new “retained” component for registrants who ended their participation in GRH prior to the start of the current evaluation period, made a commute change related to the GRH program, and who continued to use alternative modes to commute into the FY 2015-17 evaluation period. This is accomplished by estimating the number of past GRH participants and applying a “retention” placement rate and other multiplier factors to the past participant count.
- Employer Outreach – No changes to the methodology for FY 2015-17.
- Mass Marketing – The basic methodology for Mass Marketing follows the format used for FY 2012-14 and includes the same TERM activities of commute program/service advertising, promotional events, and ‘Pool Rewards incentive program. One new element in the FY 2015-17 evaluation is the addition of vanpools to the ‘Pool Rewards evaluation. In FY 2012, Commuter Connections expanded the program to include newly-formed vanpools that originate in either the District of Columbia or Maryland and are destined for job locations in the Washington metro region non-attainment area. Vanpools that participate in this program are included in the FY 2015-17 TERM analysis.

- Commuter Operations Center (COC) and Integrated Rideshare-Software Upgrades – The basic methodologies for the COC and the Integrated Rideshare-Software Upgrades follows the format used for FY 2012-14, with two exceptions:
  - The FY 2015-17 methodology adds a “retained” component for COC online applicants whose last contact with Commuter Connections was prior to the start of the current evaluation period, who made a commute change related to their COC assistance, and who continued to use alternative modes to commute into the FY 2015-17 evaluation period. This is accomplished by estimating the number of past COC participants and applying a “retention” placement rate and other multiplier factors to the past participant count.
  - The FY 2015-17 methodology also will count telework impacts generated in Virginia from the Telework! VA program under the Maryland and Virginia Telework TERM; these impacts were counted under the COC in the FY 2012-14 analysis.

## **NATURE OF THE EVALUATION APPROACH AS COMPARED TO OTHER REGIONS**

The evaluation approach used in the Washington DC region to assess the impact of the TERMS implemented by Commuter Connection has become recognized as among the most comprehensive and rigorous in the nation. Several regions of a similar size and complexity have looked to this evaluation as a model and adopted similar approaches. For example:

- The evaluation of voluntary trip reduction strategies in Atlanta is using a similar “bottom-up” approach to measure the impact of various program elements individually and carefully sum the results while avoiding double counting from overlapping program influences. Data are collected and analyzed to evaluate regional ridesharing, transit and vanpool subsidy programs, and marketing campaigns. The TERM analysis served as the basic model for this approach and the data collection and analysis methods used are similar to those used in the MWCOG evaluation.
- A comprehensive evaluation of TDM services in Los Angeles County derived unique placement rates and VTR factors for the programs being evaluated and estimated the cost per person placed and cost per trip reduced of the overall TDM program. This evaluation also explicitly drew from the evaluation experience in Washington DC.
- Triangle J Council of Governments, in the Raleigh-Durham region of North Carolina, also uses an evaluation system that applies placement rates and VTR factors derived from survey data to assess impacts of trip reduction strategies funded by the Department throughout the region. Some elements of this system are based on Commuter Connections’ evaluation method.

The key characteristics of the evaluation approach used in metropolitan Washington that have elevated or enhanced the state of the practice in TDM evaluation include:

- The careful avoidance of double counting between program elements
- The derivation of unique placement rates for each program element and mode
- The inclusion of placement duration in the calculation of impacts
- The derivation of empirically-based Vehicle Trip Reduction (VTR) factors to avoid the document mistaken assumption that every new placement reduces a full vehicle trip every day
- The consideration of access mode to a shared ride arrangement to account for cold starts

For these reasons, the users of these evaluative results should feel confident that the reported impacts are as accurate and reliable as is reasonably possible and are based on what is widely accepted as one of the most comprehensive and rigorous evaluation approaches being used today in the US.

## SECTION 4 MARYLAND AND VIRGINIA TELEWORK ASSISTANCE

### BACKGROUND

The TPB adopted a telework-oriented TERM in the FY 1995-2000 TIP and in June 1996, the Metropolitan Washington Telework Resource Center (TRC) was implemented. This TERM was renamed as Telework Assistance (Telework) in the FY 2012-14 TERM analysis when its scope was reduced to focus solely on Maryland employers and on commuters who either lived or worked in Maryland, but its purpose remained the same: to provide information, training, and assistance to individuals and businesses to further in-home and non-home telework programs. Telework activities during the past few years have included assistance to employers to start or expand telework programs, development of employer telework case studies, distribution of telework information included in a telework information kit, and ongoing marketing and initiatives.

In 2016, the Virginia Department of Rail and Public Transportation and the Virginia Department of Transportation requested that the Virginia-based Telework! VA assistance program be added to the FY 2015-17 TERM analysis, to document its results. Telework! VA, which was originally adopted as a separate TERM for Northern Virginia, is an online resource to help employers start or expand a formal telework program. In Northern Virginia, the program also offers free expanded technical assistance, in which telework experts provide on-site guidance to company managers and teleworkers tailored to the individual needs and situations of the company. This component of the Commuter Connections Telework TERM is comprised of impacts generated at Northern Virginia worksites that receive on-site technical assistance.



### EVALUATION METHODOLOGY AND DATA SOURCES

The goal of Telework Assistance is to increase the number of telecommuters in the region, whether full-time or part-time telecommuters. For FY 2015-17, Telework TERM impacts were evaluated by calculating the number of telecommuters who used or were influenced by Telework Assistance services and estimating the number of vehicle trips and VMT they eliminated by use of telework and the tons of emissions that were reduced by the trip and VMT reductions. Through this method, only impacts that could be traced directly to Telework TERM actions were counted in the TERM analysis. In other words, it was recognized that some telework would have occurred even if the Telework TERM was not in place. As described below, the Maryland and Virginia components of the Telework TERM impacts are analyzed similarly, but using different data.

#### Three Telework Assistance Populations

Three Telework populations were analyzed, two for Maryland and one for Virginia, including:

- Maryland – Regional telecommuters who live and/or work in Maryland who were influenced by Telework services/assistance to begin telecommuting
- Maryland – Telecommuting employees at Maryland worksites that were assisted by Commuter Connections
- Virginia – Telecommuting employees at Virginia worksites that received on-site Telework! VA assistance

Evaluation data for these populations were obtained from several sources, each briefly described below:

**State of the Commute Survey** (regional commuters) – Data from the SOC survey were analyzed to estimate the:

- Number of regional telecommuters
- Telecommuters' home and work locations (45% lived and/or worked in Maryland and 55% had both home and work outside of Maryland)
- Telecommute locations – the mix between home-based and non-home-based
- Average telecommute frequency, telecommuters' travel modes on non-telework days, and commute distance they traveled on non-telecommute days
- Telecommuters' travel patterns to telecommute locations outside the home
- Information sources used to learn about telework (COG/Commuter Connections or other)

**Maryland Assisted Employer Telework Survey** (new telecommuters at Maryland worksites that received assistance from Commuter Connections) – This survey interviewed assisted employers about telework at their worksites before and after they received assistance and the role assistance played in telework changes at the worksite. The survey data were analyzed to estimate the:

- Percentage of assisted employers with telework programs before and after receiving telework assistance
- Percentage of telecommuters at assisted sites before and after receiving assistance

**Telework! VA Baseline and Follow-up Employee Surveys** (new telecommuters at Virginia worksites that received on-site Telework! VA assistance) – These surveys interviewed employees at assisted worksite before Telework! VA assistance was provided (baseline survey) and after assistance was provided (follow-up survey). Fifteen employers, representing 4,938 employees, were participating in the Telework! VA program in June 2017. All of these employers had completed baseline surveys and seven had completed post-assistance surveys. The survey data were analyzed to estimate the:

- Percentage of telecommuters at assisted sites before and after receiving assistance
- Percentage of employees who started or increased teleworking as a result of telework assistance
- Average telecommute frequency, telecommuters' travel modes on non-telework days, and commute distance they traveled on non-telecommute days

#### Calculation Factors and Impacts

**Placement Rates and Placements** – Using results from the surveys and Commuter Connections and Telework! VA records on assisted employers, the numbers of new telecommuters who had either direct or indirect (through their employers) contact with the Telework TERM during the evaluation period were estimated.

Maryland Telework – As shown below, 44,350 placements were calculated for Maryland Telework, 44,316 from direct commute assistance and 34 from assisted worksites. Maryland telecommuters were further divided into “home-based” (98% of total = 43,463) and “non-home-based” (2% of total = 887).

Telework! VA –Using data from the baseline and post-assistance surveys, the analysis estimated a placement rate of 31% (5% new teleworkers and 26% employees with increased telework), equating to 1,531 placements. All of these Virginia telecommuters were home-based.

	<u>Population base</u>	<u>Placement Rate</u>	<u>Placements</u>
Maryland Telework			
• Maryland-based commuters	399,241 x	11.1% =	44,316
• Assisted Maryland worksites	4,219 x	0.8% =	34
Virginia – Telework! VA			
• Assisted Virginia worksites	4,938 x	31.0% =	1,531

**VTR Factors and Vehicle Trips Reduced** – The three groups of new/increased telecommute placements were then multiplied by average VTR factors, as identified by the appropriate survey data, to obtain the number of vehicle trips reduced by their telecommuting. Telework TERM VTR factors accounted for both the average telecommute frequency of the groups as well as their travel modes on non-telecommute days and the travel modes on telecommute days of commuters who traveled to a telecommute location other than home.

- Maryland home-based telecommuters – The VTR factor was 0.34 daily trips reduced per telecommuter, reflecting the part-time (1.38 days per week average) telework frequency and the elimination of vehicle trips for the 61% of telecommuters who drove alone, carpooled, or vanpooled on non-telecommute days.
- Maryland non-home-based telecommuters – The VTR factor for this group was much lower (0.07) because the majority of these telecommuters drove alone to the telecommute locations. Thus, they did not reduce (and in some cases increased) the number of vehicle trips they made on an average day. However, the benefit of their telecommuting was in the reduction of VMT on telecommute days.
- Telework! VA telecommuters – The VTR factor for Telework! VA telecommuters was 0.32 daily trips reduced per telecommuter. This factor accounted for both an increase in total telework days due to a higher percentage of (83% total teleworkers post program vs 78% baseline) and a higher overall telework frequency (0.93 days per week post program vs 0.64 days per week baseline). The VTR factor was adjusted to include only the 88% of telecommuters who drove alone, carpooled, or vanpooled on non-telecommute days.

**Commute Distance and VMT Reduced** – The VMT reduced by telecommuting was calculated by multiplying the daily vehicle trips reduced for each population by the average commute miles reduced per teleworker:

- Maryland home-based telecommuters – Average miles reduced (24.4 miles) equals the one-way commute distance to the main workplace on non-telework days.
- Maryland non-home-based telecommuters – Average miles reduced (10.4 miles) was calculated as the one-way commute distance to main work location minus the distance to the outside telework location (15.1 – 4.7).
- Telework! VA telecommuters – Average miles reduced (19.1 miles) equals the one-way commute distance to the main workplace on non-telework days.

**Emissions Reduced** – Tons of emissions removed were calculated by multiplying vehicle trip and VMT reductions by 2017 emission factors developed by MWCOG staff for the Washington metropolitan region, using the MOVES emission model. Daily emissions were calculated for the TERMS for NO<sub>x</sub> and for VOC. Annual impacts for PM 2.5, PM 2.5 pre-cursor NO<sub>x</sub>, and CO<sub>2</sub> also were calculated. Appendix 2 details the calculations made to estimate Telework TERM impacts.

## TELEWORK ASSISTANCE SUMMARY OF GOALS AND IMPACTS

The results of the calculations for Telework are shown in Table 6 below for all regional telework (6a), for the Maryland component of the Telework TERM (6b) and for the Telework! VA program (6c). Tables 6b and 6c also show the goals established for the TERM. The net credits or deficits, which were equal to the impacts minus goals also are shown.

**Table 6**  
**Regional Telework Impacts and**  
**Telework Goals and Estimated Telework TERM Impacts for Maryland Telework and Telework! VA**

**Table 6a – Regional Telework****Regional TW Impacts**

• Number of telecommuters	887,202
• Daily vehicle trips reduced	306,493
• Daily VMT reduced	5,970,004
• Daily tons NOx reduced	1.6688 T
• Daily tons VOC reduced	1.3256 T
• <u>Annual</u> tons PM 2.5 reduced	21.55 T
• <u>Annual</u> tons PM 2.5 pre-cursor NOx reduced	447.15 T
• <u>Annual</u> tons CO2 reduced	645,500 T

**Table 6-b – Maryland Telework**

	<b>Telework Goal – MD</b>	<b>Telework Impact – MD</b>
• Number of telecommuters	31,854	44,350
• Daily vehicle trips reduced	11,830	14,839
• Daily VMT reduced	241,209	361,204
• Daily tons NOx reduced	0.1222 T	0.0958 T
• Daily tons VOC reduced	0.0723 T	0.0696 T
• <u>Annual</u> tons PM 2.5 reduced	N/A	1.275 T
• <u>Annual</u> tons PM 2.5 pre-cursor NOx reduced	N/A	25.675 T
• <u>Annual</u> tons CO2 reduced	N/A	38,820.0 T

**Impacts vs Goals – Maryland Telework**

<b>Participation Benefit</b> (net over or (under) goal):	Telecommuters: 12,496
<b>Transportation Benefit</b> (net over or (under) goal):	Vehicle Trips: 3,009 VMT: 119,995 miles
<b>Emission Benefit</b> (net over or (under) goal):	NOx: (0.0264) tons per day VOC: (0.0024) tons per day

**Table 6-c – Telework! VA Telework**

	<b>Telework Goal – TW!VA</b>	<b>Telework Impact – TW!VA</b>
• Number of telecommuters	800	1,531
• Daily vehicle trips reduced	155	490
• Daily VMT reduced	2,548	9,359
• Daily tons NOx reduced	0.0028 T	0.0027 T
• Daily tons VOC reduced	0.0014 T	0.0021 T
• <u>Annual</u> tons PM 2.5 reduced	N/A	0.025 T
• <u>Annual</u> tons PM 2.5 pre-cursor NOx reduced	N/A	0.700 T
• <u>Annual</u> tons CO2 reduced	N/A	1,012.5 T



**Impacts vs Goals – Telework! VA**

<b>Participation Benefit</b> (net over or (under) goal):	Telecommuters: 731
<b>Transportation Benefit</b> (net over or (under) goal):	Vehicle Trips: 335 VMT: 6,808 miles
<b>Emission Benefit</b> (net over or (under) goal):	NOx: (0.0001) tons per day VOC: 0.0007 tons per day

**Regional Telework** – In 2016, approximately 887,202 regional workers teleworked at least occasionally, representing about 30% of the total regional workforce and 32% of all workers who are not self-employed, working only at home (Table 6a). This number of regional telecommuters represented a 31% increase over the 2013 count of 675,000, 48% of the 2010 count of 600,000, and nearly six times the 1996 baseline of 150,900 telecommuters.

Telework growth is likely the result of several factors, including the use of telework by employers to recruit and retain employees. Increasing traffic congestion in the Washington region also might have prompted some commuters to work at home to avoid traffic. Emergency preparedness, with a focus on continuity of operation, also has been a catalyst in the growth of telework. Finally, the desire of employees for a better balance of work and family, a trend occurring nationally, and greater affordability of sophisticated technology, also might have contributed to the growth in telecommuting.

**Maryland Telework TERM** – Table 6b shows the expected contribution of the Maryland Telework TERM component to regional teleworking (Telework Goal – MD) and the impacts for this TERM component (Telework TERM Impacts – MD). The number of Maryland telecommuters estimated for the TERM was 39% over the number of telecommuters expected from this TERM activities. The TERM also exceeded the reduction goals for vehicle trips (25%) and VMT (50%). Maryland telecommuters accounted for approximately 45% of regional telecommuters.

The Maryland portion of the Telework TERM was responsible for about 5% of regional telecommuters and telework impacts. In the 2016 State of the Commute Survey, 11% of Maryland telecommuters mentioned Commuter Connections or MWCOC as a source of telework information. These telecommuters were credited to the Telework TERM contribution.

One possible area in which the Telework TERM's contribution to the regional telework impacts could have been undercounted is in the area of regional employer outreach. More than seven in ten (73%) telecommuters said they learned of teleworking from their employer. While employers could have learned of telework from many sources, the Commuter Connections Employer Outreach TERM also promotes telework to employers. Thus, this response likely indicates additional telecommuters who learned about teleworking indirectly from Commuter Connections. Because this cannot be clearly documented, no additional credit is attributed for these employees to the Telework TERM. But these impacts are included in the Employer Outreach calculation for employers that offer telework.

**Telework! VA** – Table 6c presents the impact for the Telework! VA program and the comparison of impacts to goals established for the program. The count of 1,531 employees who started or increased teleworking at assisted sites was nearly twice the 800-teleworker goal set for the program. Telework! VA also substantially exceeded the vehicle trip and VMT goals for the program. As a result of these significant impacts compared with the goals, the Telework! VA program also met its emission reduction goals.

## SECTION 5 GUARANTEED RIDE HOME

### BACKGROUND

The regional Guaranteed Ride Home (GRH) program was adopted by the TPB in the Fiscal Year 1995-2000 TIP to eliminate a major barrier to using alternative modes, commuters' fear of being without transportation in the case of an emergency. The program provides up to four free rides home per year in a taxi or rental car in the event of an unexpected personal emergency or unscheduled overtime.



When the program was implemented, it was offered to commuters who used alternative modes three or more times per week and who would register with Commuter Connections for GRH. In January 1999, to encourage additional participation, the program guidelines were changed to require use of alternative modes only two days per week. This rule was in place throughout the entire FY 2015-17 evaluation period.

### EVALUATION METHODOLOGY AND DATA SOURCES

Transportation and emissions impacts of the GRH program were measured through two surveys, the 2016 GRH Survey and the 2016 Retention Rate survey, both conducted in 2016. The GRH survey assessed commute travel for commuters who participated in the GRH program during the 2017 evaluation period. The Retention Rate survey examined commute travel for commuters who participated in GRH prior to the 2017 evaluation period.

#### GRH Survey

The 2016 GRH Survey polled 2,171 commuters who had registered for the Washington Regional GRH Program between March 16, 2013 and March 15, 2016 (FY 2015-17). Both commuters who were currently registered at the time of the survey and those who had been registered at some point during the three-year period but whose registrations had expired were eligible to participate in the survey. Additionally, commuters who had not registered for the program, but had taken a “one-time exception trip” were included in the survey sample.

The survey asked detailed questions to define travel behavior changes commuters made immediately before or during their participation in GRH and the influence of GRH on these changes. Information collected from all respondents, included, among other elements:

- Commute patterns: Current mode and previous mode (if commuter made a mode shift), frequency of mode use, travel distance, access mode to rideshare/transit pick-up point, and pool occupancy
- Permanence of mode changes: Whether change was continued (still in effect) or temporary (commuter had stopped using the new mode)
- Motivation: Importance of GRH to decisions to start or continue use of alternative modes

Data from the GRH survey were used to derive the placement rate, VTR factor, and travel distance calculation multipliers for the current/recent GRH participants. Multipliers were estimated for two GRH sub-populations: 1) participants who both lived and worked in the Washington, DC Metropolitan Statistical Area (MSA); that is within the 11 jurisdictions covered by the TERM evaluation, and 2) respondents who worked in the MSA but lived outside it. This

distinction was made because applicants who lived outside the MSA traveled a portion of their VMT outside the MSA. The average VMT for “out of MSA” applicants was discounted to include only the portion of the VMT reduction that occurred within the MSA. Approximately 38% of the total participants lived outside the MSA.

#### Retention Rate Survey

The 2016 Retention Rate Survey interviewed 989 commuters who participated in GRH or another Commuter Connections program before the FY 2015-17 evaluation period (Pre-FY 2015). About 81% of survey respondents had registered for GRH. Data for these respondents was used to derive the GRH retained placement rate.

The objective of the survey was to identify past GRH registrants who made a change to an alternative mode to participate in GRH or while participating in GRH (alternative mode placement) and who had continued using the alternative mode after their GRH participation ended (retained in alternative modes). For this purpose, the survey included questions about, among other elements:

- Current commute pattern: Current modes, frequency of mode use, and commute distance
- Previous commute patterns: Modes used prior to joining GRH and frequency of mode use
- Motivation: Importance of GRH to continue use of alternative modes

Data from the Retention Rate survey were used to derive the retained placement rate, VTR factor, and travel distance multipliers for past GRH participants. The survey did not ask respondents about their home location, so it was not possible to calculate separate Within MSA and Outside MSA factors. Because all commuters traveled part of their commute within the MSA, it was reasonable to use an overall placement rate and an overall VTR factor for all respondents, but it was necessary to adjust the overall travel distance to include only the Within MSA portion of VMT. In past GRH surveys, the Within MSA distance was approximately 75% of the overall distance; this discount factor was applied to the overall distance from the Retention Rate survey to estimate the Within MSA factor.

#### Calculation Factors and Impacts

**Placement Rate and Placements** – The placement rate represents the percentage of GRH participant who made a shift to an alternative mode. For FY 2015-17 program participants, the GRH placement rate was calculated for Within MSA participants and Outside MSA participants. Numerous past GRH surveys have documented that GRH participants use alternative modes considerably longer than the 36-month evaluation period. Thus, for purposes of the analysis, all GRH placements were considered “continued placements.”

The placement rate for Pre-FY 2015 “retained” registrants was calculated from the Retention Rate survey. Because participants must have continued their use of alternative modes to be counted as retained, all of the Pre-FY 2015 placements also would be counted as continued.

To determine the number of commuters placed in alternative modes, the placement rates were multiplied by the numbers of commuters who participated in GRH for the time period and location. A total of 16,742 commuters were current participants in FYs 2015-17. The count of past participants, who were registered in the Pre-FY 2015 time period, was 16,917.

These calculations resulted in a total of **9,945 placements**, divided as shown below, with 7,526 (76%) new placements from FY 2015-17 GRH registrants and 2,419 (24%) retained placements from Pre-FY 2015 GRH registrants.:

	<u>Population base</u>	<u>Placement Rate</u>	<u>Placements</u>
<u>FY 2015-17</u>			
• Within MSA	10,380 x	44.5% =	4,619
• Outside MSA	6,362 x	45.7% =	2,907
<u>Pre-FY 2015</u>			
• Within MSA	10,488 x	14.3% =	1,500
• Outside MSA	6,428 x	14.3% =	919

Total Placements = 7,526 new placements + 2,419 retained placements = **9,945**

**VTR Factors and Vehicle Trips Reduced** – These placement figures were then multiplied by GRH VTR factors derived from the survey data to estimate the number of vehicle trips reduced. The VTR factors for the Within MSA and Outside MSA groups were as follows:

FY 2015-17

- Within MSA 0.79 vehicle trips reduced per placement
- Outside MSA 0.88 vehicle trips reduced per placement

Pre-FY 2015

- Within MSA 0.31 vehicle trips reduced per placement
- Outside MSA 0.31 vehicle trips reduced per placement

As noted earlier, VTR factors represent the average daily number of vehicle trips reduced by a new alternative mode placement. They combine the vehicle trip reduction contributions of various types of mode changes, such as from transit to rideshare, drive alone to transit, and drive alone to carpool, each of which reduces a different number of vehicle trips per day, into one number. For a program that applies to rideshare, transit, and bicycling, VTR factors of less than 1.0 generally indicate a moderate number of the changes were from one alternative mode to another and/or reflect part-time changes to alternative modes.

The calculation of vehicle trips reduced produced a total of **6,957 vehicle trips reduced**; 6,207 vehicle trips reduced by new (FY 2015-17) registrants and 750 from retained (Pre-FY 2015) registrants.

**Commute Distance and VMT Reduced** – Next, VMT reduction from GRH was calculated by multiplying the numbers of vehicle trips reduced by the average trip length for GRH commuters who made a shift to an alternative mode. For the FY 2015-17 registrants, the one-way trip distance for the within MSA respondents was 28.2 miles. The actual one-way distance for the outside MSA respondents was an average of 50.3 miles, but to discount the distance credited to the outside MSA respondents, their one-way travel distance was set equal to that of the distance for the within MSA respondents. For the Pre-FY 2015 retained registrants, the adjusted commute distance was 29.4 miles; this was used for both the Within MSA and Outside MSA groups:

FY 2015-17

- Within MSA/Outside MSA 28.2 miles reduced per trip

Pre-FY 2015

- Within MSA/Outside MSA 29.4 miles reduced per trip

The calculation of VMT reduced produced a total of **197,088 VMT reduced**, with 175,038 VMT reduced by new FY 2015-17 registrants and 22,050 VMT reduced by retained (Pre-FY 2015) registrants.

**Emissions Reduced** – Estimates of reductions in NO<sub>x</sub>, VOC, PM 2.5, PM 2.5 pre-cursor NO<sub>x</sub>, and CO<sub>2</sub> for GRH were calculated using regional emission factors, as described for the Telework TERM. Details of these calculations are shown in Appendix 3.

**GRH Impacts Assigned to Mass Marketing** – Note that the GRH results were adjusted to eliminate double counting between GRH and the Mass Marketing TERM. About 9% of the FY 2015-17 GRH impacts were assigned to the Mass Marketing TERM to recognize that some GRH applicants were influenced to contact Commuter Connections and apply for GRH after they heard a Mass Marketing ad. The impacts shown in Table 7 account for the adjustment and reflect the net GRH impacts.

## GUARANTEED RIDE HOME SUMMARY OF GOALS AND IMPACTS

Table 7 presents the transportation and emission impact results for GRH and compares the results against the goals established for the TERM.

**Table 7**  
**Guaranteed Ride Home Goals and Estimated Impacts**

	<b>TERM Goal</b>	<b>Estimated Impacts</b>
• Number of GRH participants FY 2015-17 *	36,992	16,742
• New applicants during evaluation period	N/A	10,283
• Number of past participants (Pre-FY 2015)	N/A	16,917
• Daily vehicle trips reduced	12,593	6,398
• Daily VMT reduced	355,136	181,355
• Daily tons NOx reduced	0.1766 T	0.0396 T
• Daily tons VOC reduced	0.0970 T	0.0227 T
• Annual tons PM 2.5 reduced	N/A	0.552 T
• Annual tons PM 2.5 pre-cursor NOx reduced	N/A	10.579 T
• Annual tons CO2 reduced	N/A	17,664.2 T

\* Number of participants currently enrolled in GRH

### Impacts vs Goals

<b>Participation Benefit</b> (net over or (under) goal):	Participants: (20,250)
<b>Transportation Benefit</b> (net over or (under) goal):	Vehicle Trips: (6,195) VMT: (173,801 miles)
<b>Emission Benefit</b> (net over or (under) goal):	NOx: (0.1370 tons per day) VOC: (0.0743 tons per day)

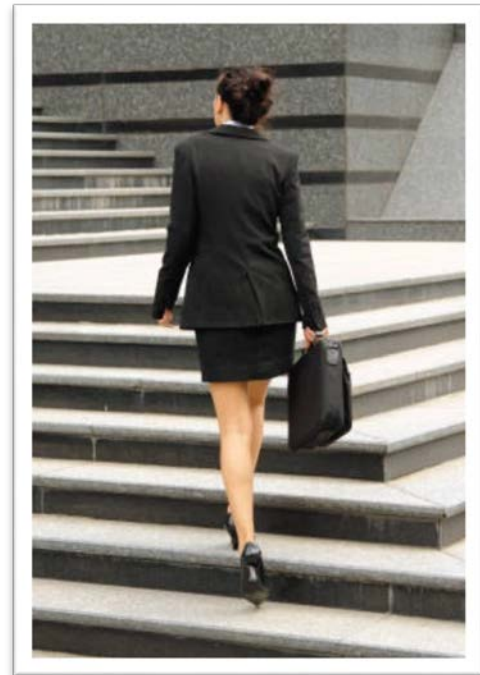
The number of commuters participating in GRH in June 2017 was less than half of the participant goal. The vehicle trip reduction, VMT, and emissions impacts were correspondingly short of the goals for these measures. Participation in GRH dropped substantially since 2005, the year the goals were established. Some of the decline could be due to reduced level of Commuter Connections program advertising and outreach focused exclusively on GRH. The 2016 State of the Commute survey found that only 21% of respondents said they knew a regional GRH program existed, compared to 59% who said they knew about the program in the 2004 SOC survey.

## SECTION 6 EMPLOYER OUTREACH

### BACKGROUND

The Employer Outreach TERM was adopted by the TPB in FY 1995-2000 TIP. This program provides regional outreach to encourage private sector employers to implement TDM strategies that will contribute to reducing vehicle trips to their worksites. The voluntary program was designed to increase outreach efforts in jurisdictions located in the region. A share of the funds received by COG for the Employer Outreach program element is passed-through to the jurisdictions for implementation of the program. Commuter Connections assists the sales force with the following services, designed to enhance regional coordination and consistency:

- Computerized regional employer contact database
- Marketing and information materials
- Employer outreach sales and service force training and support
- Annual evaluation program
- Support to Employer Outreach Committee



### EVALUATION METHODOLOGY AND DATA SOURCES

Employer Outreach is aimed at increasing the number of private employers implementing worksite commuter assistance programs, but Employer Outreach is ultimately designed to encourage employees of client employers to shift from driving alone to alternative modes.

Two primary evaluation questions are thus important. First, how many employers start or expand commuter assistance programs? And second, how many employees use alternative modes in response to new employer-sponsored services at the worksite? These two variables are strongly linked, as other TDM effectiveness research has shown. Higher levels of employer effort can be expected to offer greater incentive to employees to use alternative modes, leading to reductions in vehicle trips, VMT, and emissions.

The populations of interest for this TERM are:

- Employers that participate in Employer Outreach
- Employers that offer bicycle services (Employer Outreach for Bicycling)
- Employees at Employer Outreach worksites
- Employees at worksites that offer bicycle services

#### Employer Participation in Commute Programs

The employer participation component of the analysis was assessed through data collected by Commuter Connections from sales and outreach contacts with employers. Employer Outreach jurisdiction sales representatives documented the levels of programs implemented by their employer clients in the ACT! contact management database maintained by Commuter Connections. The Employer Outreach program specified services employers offered, for example, transit subsidy, information/promotions, Guaranteed Ride Home, etc.

The Employer Outreach program defined four levels of employer effort: Bronze (Level 1), Silver (Level 2), Gold (Level 3), and Platinum (Level 4), distinguished by the expected increasing trip reduction effectiveness of the services offered and the commitment of the employer, as shown below.<sup>1</sup>

- **Level 1 (Bronze1) programs** offer only commute information and/or electric car charging stations.
- **Level 2 (Silver) programs** offer two or more commute support services, such as: Employee Transportation Coordinator (ETC), preferential parking, carpool/vanpool formation meetings, bike racks or lockers, Capital Bikeshare Corporate Partner, transportation fairs, telework program with 1-20% of employees participating, and compressed work schedule with 1-20% of employees participating.
- **Level 3 (Gold) programs** include, in addition to the Level 2 services, at least one of services such as transit subsidy or parking “cash out,” telework program with more than 20% of employees participating, parking fee discount for carpool/vanpools, shuttle to transit stations, comprehensive bicycle/walking program, and company vanpools.
- **Level 4 (Platinum) programs** include two or more of the Level 3 program components, at least two Level 2 strategies, and actively promote the program.

When the Employer Outreach TERM was adopted, the TPB established a goal to be achieved by June 2005 and evaluations conducted for periods through June 2005 measured impacts against this goal. Beginning with the 2005-2008 analysis, new Employer Outreach goals were established for the overall program and for new program activity during the evaluation period. Thus, for the FY 2015-17 evaluation, impacts were calculated for “maintained” employer programs and “new/expanded” programs.

Maintained impacts included employers that joined EO before July 1, 2014 and made no changes since that date. Expanded impacts included employers that were involved in EO before July 1, 2014 but expanded their commute assistance services after that date. New impacts included employers that joined the EO program on or after July 1, 2014. A final category was defined to calculate the impacts of employers that were included in the FY 2012-14 evaluation but dropped out of EO before June 2017. Commuter Connections determined that the impacts that would have been credited for these employers would have to be replaced by new/expanded impacts. Impacts were estimated for the following groups of employers:

- Maintained – June 2014 employer programs continued with no change
- Expanded – June 2014 employer programs expanded since June 2014
- New – Employer programs started since June 2014
- Deleted – June 2014 employer programs deleted between July 2014 and June 2017

The overall benefit of the program is the sum of continued programs plus expanded and new programs. As shown below, in June 2017, the ACT! database included 2,046 employers with programs that met the Level 3 or 4 definitions. These employers accounted for 692,270 employees. Level 1 and 2 employers were not included in the regional impact calculation because their level of impact would be very small due to the absence of financial incentives or other substantial commute support services.

Of the Level 3 and 4 employers, 1,281 joined Employer Outreach prior to July 2014 and made no program changes since that time. The expanded category included 188 employers and 577 were listed as “new” since June 2014. Finally, 285 employers that were counted in the 2014 evaluation were no longer involved in the program. These employers accounted for 115,011 employees. Had the deleted employers continued in the program, the total employee count would have been 807,281, so they represented a drop of about 14% in total employees in the program. But the deleted employee count was less than the 136,028 employees at new EO worksites, so new employers more than replaced the deleted employers. Employers with expanded programs accounted for an additional 110,207 employees, further helping to offset the loss in program credit from deleted employers.

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<sup>1</sup> For more details of employer levels, see Appendix 4.

<u>Employer Status (June 2017)</u>	<u>Number of Employers</u>			<u>Number of Employees</u>
	<u>Total</u>	<u>&lt;100<sup>1)</sup></u>	<u>100+</u>	
- Maintained/unchanged from June 2014	1,281	691	590	446,035
- Expanded after June 2014	188	81	107	110,207
- New programs	577	349	228	136,028
<b>Total</b>	<b>2,046</b>	<b>1,121</b>	<b>925</b>	<b>692,270</b>
Deleted from 2014	285	145	140	115,011

1) Actual number of employers with fewer than 100 employees.

#### Employee Participation in Commute Programs

The second variable in the impact evaluation, employees' response to services offered, was more difficult to obtain. Starting mode split data were available for about 500 employers that had conducted a baseline commuter survey prior to implementing the TDM program. But as is typical for voluntary programs, only a few had conducted a follow-up survey by the time the evaluation data were being collected. Because baseline data were available, but post-program survey data were not, the researchers elected to estimate employee behavior changes using the US EPA's COMMUTER Model v 2.0, which estimates worksite mode shifts from inputs on starting mode split and TDM program components. This was the same methodology as was used in the 2014 evaluation.

**Starting Mode Split** – The COMMUTER model v 2.0 requires several “scenario” inputs, including the type of employer (primarily office or non-office occupations) and the starting mode split. For employers that had conducted a baseline, “pre-program” survey, the actual mode split from the survey was used as the input. But for employers that had not conducted a survey, a starting mode split was assigned that reflected the average mode split that would be likely for employers with similar location and employee work conditions.

These average mode splits were calculated by aggregating employers in the ACT! database that had conducted baseline surveys into six groups, based on two employer/site variables that are known to influence mode choice: 1) type of employer/work performed, either office or non-office, and 2) availability of transit service: low, moderate, or high. Low transit was defined as limited bus service within ½ mile of the worksite. Moderate transit included a higher level of frequency and route availability. To be designated as a “high transit” employer, the site had to be within ½ mile of a Metrorail station and have access to a significant level of bus service.

For each of the six combinations of these two variables, for example, non-office employers with high transit and office employer with moderate transit, an average mode split was calculated from the baseline survey data of employers in that employer group that had conducted commuter surveys.

**Program Definition** – The TERM analysis also classified employers by the specific commuter program services they offered. The COMMUTER model v 2.0 permits direct analysis of strategies that change the travel cost of a mode (e.g., transit subsidies), and strategies that change the duration of a trip (e.g., express transit service).

The model also has the capability to predict impacts of telework and compressed work schedules (CWS), when certain parameters of the work hour arrangements are known. The ACT! database indicated employers that had a telework program. Some records noted the actual number of employees at the worksite who were teleworking. Employers that offered telework, but for which participation numbers were not available were assumed to have telework rates equal to the regional average calculated from the 2016 State of the Commute survey. The ACT! database also noted employers that offered CWS. When participation counts were missing for these employers, a default percentage calculated from the SOC survey was assigned.

Other commute strategies, such as GRH, flextime, information support, and preferential parking, all are treated by the model as elements in a “support package.” They are not modeled separately. Rather the level or extent of the support service package is modeled and the higher the number of these strategies offered, the higher the level of support that is modeled.



The strategy package assigned to an employer was thus comprised of the following potential actions:

- Amount of mode-specific financial incentives (transit, carpool, vanpool, bicycle)
- Amount of parking fee discounts (rideshare parking discount, parking cash out)
- Estimated percentage of telecommuting employees (actual or assumed percentage)
- Estimated percentage of employees working a compressed schedule (actual or assumed percentage)
- Level of alternative mode commuter support (e.g., ridematching, mode information, employee transportation coordinator, Guaranteed Ride Home, preferential parking, flextime, vanpool formation support)
- Availability of bicycle services
- Availability of a shuttle bus to Metrorail or other transit location

The COMMUTER model v 2.0 was run in a batch format that allowed each employer's program components to be modeled separately. The analysis thus calculated for each employer, the final mode split with the program in place. By comparing the starting and ending mode splits, the percentage trip reduction that would be expected following implementation of the program elements was calculated. This trip reduction was then applied to the number of employees at the worksite to estimate the number of vehicle trips reduced for that employer.

Because travel distance was not available for either individual employees or employers in the ACT! database, the number of VMT reduced was estimated by multiplying the vehicle trips reduced for an employer by the average regional one-way trip lengths for each mode, as measured through the 2016 State of the Commute Survey. Emissions reduced were calculated by multiplying trips and VMT reduced by 2017 regional emission factors provided by MWCOG staff. Finally, the individual results for each employer were aggregated to estimate the combined impact of all employers in the TERM. Appendix 3 provides details of the calculations of impacts for Employer Outreach.

## EMPLOYER OUTREACH SUMMARY OF GOALS AND IMPACTS

The impacts calculated as described above, were compared against the TERM goals. The total goals and impacts are shown in Table 8.

**Table 8**  
**Employer Outreach Goals and Estimated Impacts**

	<b>EO Goal</b>	<b>Estimated Impacts</b>
<b>Employer Outreach (all programs)</b>		
• Employers participating - total	1,847	2,046
– Maintained from 2014	1,756	1,281
– Expanded after 2014	No goal	188
– New in 2017	91	577

- Total employers and employees by jurisdiction and count of new/expanded employers

	<b>Total Employers</b>	<b>Employees</b>	<b>New/Expanded Employers</b>
– Alexandria, VA	151	30,110	49
– Arlington County, VA	353	68,240	174
– District of Columbia	702	245,163	247
– Fairfax County, VA	265	196,636	90
– Frederick County, MD	23	21,853	10
– Loudoun County, VA	16	11,190	5
– Montgomery County, MD	463	81,495	163
– Prince George’s County, MD	31	23,231	14
– Prince William County, VA	29	11,400	6
– Tri-County Council, MD	13	2,952	7

- Total employers and employees by size category and count of new/expanded employers

	<b>Total Employers</b>	<b>Employees</b>	<b>New/Expanded Employers</b>
– Sites with 100+ employees	925	650,947	335
– Sites with less than 100 employees	1,121	41,323	430
– “Equivalent 100+” <sup>1)</sup>	413		144

- 1) For purposes of program tracking, employers with fewer than 100 employees are grouped into “equivalent 100+” employers. The 1,121 employers in this category employ 41,323 employees, thus represent 413 “equivalent 100” employers (41,323 / 100).

### **Impacts vs Goals**

#### **Overall Employer Outreach Program**

	<b><u>EO Goal</u></b>	<b><u>Estimated Impacts</u></b>
Total Program		
• Daily vehicle trips reduced	82,524	102,625
• Daily VMT reduced	1,393,783	1,841,429
• Daily tons NOx reduced	0.5606 T	0.4736
• Daily tons VOC reduced	0.3195 T	0.3501
• Annual tons PM 2.5 reduced	N/A	6.275 T
• Annual tons PM 2.5 pre-cursor NOx reduced	N/A	126.775 T
• Annual tons CO2 reduced	N/A	190,093.1 T

<b>Participating Employers</b> (net over or (under) goal):	Employers: 199
<b>Transportation Benefit</b> (net over or (under) goal):	Vehicle Trips: 20,101 VMT: 447,646 miles
<b>Emission Benefit</b> (net over or (under) goal):	NOx: (0.0870) tons per day VOC: 0.0306 tons per day

New / Expanded Employer Programs

	<u>EO Goal</u>	<u>Estimated Impacts</u>
• New/expanded programs	91	765
• Daily vehicle trips reduced	N/A	25,936
• Daily VMT reduced	N/A	482,153
• Daily tons NOx reduced	N/A	0.1232 T
• Daily tons VOC reduced	N/A	0.0897 T
• Annual tons PM 2.5 reduced	N/A	1.650 T
• Annual tons PM 2.5 pre-cursor NOx reduced	N/A	32.975 T
• Annual tons CO2 reduced	N/A	49,801.5 T

<b>Participating Employers</b> (net over or (under) goal):	Employers: 674
<b>Transportation Benefit</b> (net over or (under) goal):	Vehicle Trips: No goal for comparison VMT: No goal for comparison
<b>Emission Benefit</b> (net over or (under) goal):	NOx: No goal for comparison VOC: No goal for comparison

As shown, even with the loss of 285 employers that dropped out since 2014, both the overall number of employers participating in the program and the number of new / expanded employers were well above the goals. The overall TERM results for also substantially exceeded the goals for reductions in vehicle trips (25% over the goal) and VMT (32% over the goal).

Note that Employer Outreach could overlap with the Telework TERM, if Employer Outreach clients also had received Telework Assistance services; the telework portion of these employers' programs would appropriately be counted in the Telework TERM's "assisted employer" category. To assess the level of overlap, the list of the employers that received Telework Assistance was compared against the ACT! client database. Only two employers that offered telework also had received telework assistance from Commuter Connections. To avoid double counting credits, the impacts from the telework components of these employers' program were excluded from the Employer Outreach TERM total, but impacts of other, non-telework, strategies offered by these employers were included in the Employer Outreach impact calculation. The results presented in Table 8 show the adjusted impacts.

### **Employer Outreach for Bicycling**

A similar exercise was performed to estimate the contribution of bike strategies to Employer Outreach program impacts. The Employer Outreach for Bicycling TERM was adopted by the TPB in the Fiscal Year 1997-2002 TIP. This project provides regional outreach to encourage private sector and non-profit employers to implement worksites strategies that encourage employees to use bicycling for commuting.

A total of 597 employers offered bicycle strategies in their worksite programs in 2017. The impacts for these employers were modeled “with bicycling” and “without bicycling.” The difference in vehicle trips reduced between these two cases was determined to be the bike strategies’ share of the impacts. It was assigned to the Employer Outreach for Bicycling TERM component of Employer Outreach.

The VMT reduced for bicycling was estimated by multiplying the vehicle trips reduced by an average one-way trip length for bicycle commuters, of 4.4 miles, calculated from the 2016 State of the Commute (SOC) Survey.

The Employer Outreach for Bicycling TERM met its goal for the number of employers offering bike strategies, but fell slightly short of the vehicle trip, VMT, and emissions goals established for the program (Table 9).

**Table 9**  
**Employer Outreach – Bike Services Goals and Estimated Impacts**

	<b><u>EO Goal</u></b>	<b><u>Estimated Impacts</u></b>
• Employers with bike strategies	590	597
• Daily vehicle trips reduced	404	373
• Daily VMT reduced	2,421	1,640
• Daily tons NOx reduced	0.0016 T	0.0008 T
• Daily tons VOC reduced	0.0015 T	0.0012 T
• Annual tons PM 2.5 reduced	N/A	0.000 T
• Annual tons PM 2.5 pre-cursor NOx reduced	N/A	0.250 T
• Annual tons CO2 reduced	NA	195.3 T
<b>Participating Employers</b> (net over or (under) goal):		Bike Employers: 7
<b>Transportation Benefit</b> (net over or (under) goal):		Vehicle Trips: (31) VMT: (781) miles
<b>Emission Benefit</b> (net over or (under) goal):		NOx: (0.0008) tons per day VOC: (0.0003) tons per day

## SECTION 7 MASS MARKETING

### BACKGROUND

In July 2003, Commuter Connections embarked on an ambitious effort to educate the region about alternatives to stress-filled solo commuting and to raise awareness of commute assistance services available through Commuter Connections and its partners. This effort, captured in the Mass Marketing TERM, employs radio, television, direct mail, social media, and other mass media to create a new umbrella level of public awareness and to provide a call to action to entice commuters to switch to alternative modes.

The objectives of the Mass Marketing TERM are to:

- Raise regional awareness about the Commuter Connections brand
- Address commuters' frustration with congestion
- Induce commuters to try and adopt alternative commute modes



The 2017 Mass Marketing TERM analysis also includes impacts for the annual Bike-to-Work Day and Car Free Day events and the regional 'Pool Rewards carpool and vanpool incentive. Commuter Connections' role in these events is regional and primarily promotional in nature, so their impacts are most appropriately included in the Mass Marketing TERM calculation.

### Evaluation Methodology and Data Sources – Umbrella Marketing Campaign

The Mass Marketing TERM has six populations of interest:

- 1) All commuters in the Commuter Connections service area
- 2) Commuter Connections rideshare applicants who were influenced by the marketing campaign to request Commuter Connections services
- 3) GRH applicants who were influenced by the marketing campaign to request Commuter Connections services
- 1) Commuters who participated in the 'Pool Rewards carpool/vanpool incentive program
- 4) Commuters who participate in the Bike-to-Work Day event
- 5) Commuters who participate in the Car-Free Day event

This TERM presents two challenges not encountered in most of the other TERMS. First, it is more difficult to assess influence on the general commuting public than it is to identify and track program participants. Second, when commuters who changed travel behavior can be identified, it is still necessary to identify what motivated their change – the media campaign or another influence.

The Mass Marketing evaluation method examines impacts from two types of commute mode changes, which are measured separately. The first, *“directly”* influenced mode changes, occur when ads motivate commuters to change mode with no intermediate contact with Commuter Connections. An example of this type of change would be a carpool formed when a commuter hears an ad and asks a co-worker to carpool. Direct influences can only be assessed through a regional survey of commuters that asks about mode changes and the reasons for the changes. If a shift occurred and the shift can be attributed to a message that is part of the Mass Marketing campaign, the associated trip, VMT, and emissions reductions can be credited to the campaign.

The second, “*referred*” mode changes, result when commuters who are influenced to contact Commuter Connections by the ads make mode changes after receiving Commuter Connections assistance. This type of change would include, for example, a commuter who hears the ad, requests a ridematch from Commuter Connections, then forms a new carpool as a result. Referred influences are best measured by tracking changes in the volume of inquiries and applications received for two Commuter Connections’ traditional programs: the Commuter Operations Center and GRH. A comparison of the volumes of requests received during periods of media activity to periods without media activity can provide an estimate of the change in requests as a result of the ads. A pro-rated share of the impacts of these other TERM impacts then can be assigned to Mass Marketing.

#### Evaluation of Direct Influence

Directly influenced change is measured for this evaluation through the 2016 regional State of the Commute survey, which included questions related to the following:

- Ad awareness – Were commuters aware of commute advertising and the specific messages conveyed and could the source of the ad be reasonably assigned to Commuter Connections?
- Changes made after hearing the ads – How many commuters who recalled Commuter Connections’ ad messages shifted to alternative modes after hearing the ads and how were they traveling before the change?
- Reasons for change – Did the ads influence the commuters to make the change?
- Other commute services used – Did the commuters use any commute services provided by Commuter Connections?

Results for these questions were used to estimate the number of regional commuters who were influenced by ads to change mode without contact with Commuter Connections. The survey results were as follows:

Percentage of commuters who:

- Recalled Commuter Connections ad message 21%

Commuters who recalled specific commute messages were asked about actions and influences related to the ads. Among respondents who recalled Commuter Connections messages, the surveyed indicated:

- Shifted to an alternative mode after hearing CC ads 3.3%
- Said the ad influenced their decision to shift 60%
- Did not use any other Commuter Connections or employer service 100%
- **Resulting influence percentage from CC ads 0.42%**

Thus, 0.42% of regional commuters were directly influenced to make a change. This percentage was multiplied by the number of regional commuters (2,940,524) to estimate 12,227 alternative mode placements.

Further analysis of survey respondents who made a change showed that 46% continued using the new mode and 54% were temporary or occasional users. Continued users reduced on average 0.8 vehicle trips per day with their changes and temporary users reduced an average of 1.0 vehicle trips per day. These factors, and the 15.4 mile per trip distance calculated from the State of the Commute data were applied to the total number of new alternative mode placements to obtain the numbers of vehicle trips and VMT reduced by direct influence.

#### Evaluation of Referred Influence

Indirect influences were estimated through comparison of the volume of requests made to the Commuter Connections’ website and the numbers of ridematch and GRH applications received:

- In months between July 2014 and June 2017 when MM ads were aired
- In months between July 2011 and June 2017 when MM ads were NOT aired

As a first step, this analysis calculated the average numbers of applications received during “with MM” and “without MM” periods and compared the numbers. An increase in requests observed during the “with MM” periods could be assumed to result from the ads and other marketing efforts performed during the same time periods. Thus, the analysis also calculated volumes of website, phone, and social media information requests (CC inquiries) that were received under “with ad” and “without ad” scenarios.

The analysis suggested that the ads prompted an additional 16% of ridematch applications, but that GRH applications declined during the ad months:

	<u>Increase in Applications</u>		
	<u>CC Inquiries</u>	<u>RS Apps</u>	<u>GRH Apps</u>
• With ads compared to no ads	19%	16%	-9%

But the use of the Commuter Connections inquiries received via the Internet and 800 telephone number increased by 19% during MM advertising periods. Note that commuters can access numerous commute information services directly from the Internet, without registering or providing contact information. Because these respondents cannot be included in the applicant follow-up surveys that Commuter Connections conducts to estimate impacts from use of the services, any travel changes that they made after using the website are not included in the Commuter Operations Center calculation, so a MM “referred influence” calculation based solely on the number of rideshare applications or GRH applications likely undercounts the impacts of this MM component.

For these reasons, it was decided to base the MM referred influence percentage on the increase in the volume of website uses, rather than on application counts. When taken as a percentage of total website users, these increases translate to about 16% of total uses (19/119).

## Evaluation Methodology and Data Sources – ‘Pool Rewards Program

Impacts for the fourth component of this TERM, ‘Pool Rewards carpool and vanpool incentives, were calculated in a manner similar to that used for the GRH TERM. The numbers of carpool and vanpool participants were multiplied by placement rate, VTR factor, and travel distance calculation multipliers specific to the carpool and vanpool programs to estimate the travel impacts. Data to derive the carpool multipliers were collected through three tools: mode tracking required of all participating commuters and two post-program surveys. Data for the vanpool multipliers were estimated from data collected by MWCOG staff on each vanpool for submittal to the National Transit Database (NTD).

### ‘Pool Rewards Carpool Program

Since the program was open only to commuters who were driving alone prior to the program, all ‘Pool Rewards carpool participants were placed in a new mode. A survey conducted by Commuter Connections in 2011, following the end of the first participants’ enrollment period found that 93% had continued to carpool immediately after the program ended. A more recent follow-up survey, conducted in spring 2017 with ‘Pool Rewards participants registered during the 2015-17 evaluation period, explored retention in alternative modes of this recent participant group. The survey found that 80% of participants were still using an alternative mode and 20% had returned to driving alone to work. These results were used to derive the long-term carpool retention placement factors: 80% continued placement and 20% temporary placement.

The temporary VTR factor for carpool was derived from mode use logs submitted by participants at the end of their enrollment period. Participants were required to document how many days they carpooled during their enrollment period. The travel during their enrollment period was compared to their pre-program travel (all drive alone) to determine the average daily drive alone trips they reduced (VTR factor), equal to 0.94 daily trips reduced. The 2017 ‘Pool Rewards carpool participant survey was used to estimate the VTR factor and travel distance for long-term, continued placements. That survey estimated a carpool VTR factor of 0.92 and a one-way travel distance of 28.2 miles.

Between July 2014 and June 2017, 131 commuters had completed the 'Pool Rewards carpool program. When this participation number was multiplied by the placement rates, the calculation resulted in 105 continued carpool placements and 26 temporary placements. Applying the VTR factors and one-way travel distance resulted in 109 daily vehicle trips reduced and 3,074 daily VMT reduced from 'Pool Rewards carpool component.

#### 'Pool Rewards Vanpool Program

The vanpool program also was open only to commuters who had been driving alone prior to the program. Thus, all 'Pool Rewards vanpool participants were classified as new placements. Multiplier factors for this program were derived from NTD data collected by MWCOG staff on the number of vanpools in the program, the number of riders in each van, and the miles traveled by each van with the full complement of riders (revenue miles).

Twenty-three vans, with 213 total passengers participated in the program between FY 2015 and FY 2017. These vanpools were first defined as either continued, meaning they were still in operation during FY 2017, or temporary, meaning they had operated in FY 2015 or FY 2016, but had ceased operation prior to FY 2017. This step indicated that seven vans, carrying 77 total riders, or 36% of the total 213 riders, had continued operation. The remaining 16 vans, with 136 riders (64%) were defined as temporary.

The continued and temporary VTR factors for vanpool were derived using the average number of riders in continued vanpools (10.2 riders) and temporary vanpools (8.3 riders) and assuming that vanpool riders rode in the van nine of ten work days (per two weeks) and drove to work all work days prior to joining the vanpool. These calculations resulted in VTR factors of 1.62 daily vehicle trips reduced for continued placements and 1.58 daily vehicle trips reduced for temporary placements. The revenue miles data per vanpool were used to derive one-way travel distances for continued placements (39.3 miles) and temporary placements (33.1 miles).

When these factors were applied to the 213 total vanpool riders, the calculation resulted in 77 continued vanpool placements and 136 temporary placements. Applying the VTR factors and one-way travel distance resulted in 233 daily vehicle trips reduced and 8,552 daily VMT reduced from 'Pool Rewards vanpool component.

## **Evaluation Methodology and Data Sources – Bike to Work Day Event**

Impacts for the fifth component of this TERM, Bike-to-Work Day (BTWD) Event, were calculated using data obtained from a survey of BTWD participants conducted following the 2016 BTW Day event. The survey included questions regarding participants' use of bicycling for commuting before and after the event, and their ongoing level of bicycle commuting.

The impact methodology estimated the trip reduction impacts of new ridership by calculating the number of commuters who started riding to work after the event or increased the days per week they rode to work and the average number of "new" bike days per week. Two time periods were examined: 1) spring through early fall following the event and 2) early winter following the event. From these data the number of new "seasonal" use and "continued winter" use days were calculated for a year. This number was then translated to a daily figure.

The number of vehicle trips reduced by new bicycling was estimated by multiplying the percentage of participants who drove alone or carpooled on non-bike days (46%) by the number of daily bicycle trips. VMT reductions were estimated by multiplying the vehicle trip reduction by the average one-way commute distance of these participants (10.2 miles). Emissions reduced were calculated as for other TERMS.

## **Evaluation Methodology and Data Sources – Car Free Day Event**

The final Mass Marketing component was Car Free Day, an annual event to encourage commuters to leave their cars at home for one day. CFD events were held in the Washington region in November of 2014, 2015, and 2016. Commuters who participated in the events made online pledges, indicating the types of transportation they intended to use for that day and the type of transportation they typically would have used for those trips.



Data were available from participant pledges to estimate the impacts on the day of the event. The distribution of pledged modes included 40% transit, 45% bike or walk, 7% carpool/vanpool, and 8% telework. Additionally, 31% of participants said they regularly drove alone and the pledge data indicated that the average trip reduced 10.5 miles. These data were used to determine the vehicle trip and VMT reductions for the event days.

Comprehensive survey data regarding long-term continuation of CFD pledges were not available at the time of this evaluation, but the event had many similarities in participants' non-event commute travel to that of BTW Day participants, thus, data from that event were used as proxies for the CFD analysis. As noted, 31% of CF Day participants regularly drove alone to work and 85% of pledges were made for transit, bike, or walk activity.

The BTW Day survey found that about 28% of participants started biking to work or increased their bike commute days after the event and 21% continued biking into the winter months. For the CF Day analysis, a conservative estimate of 10% was assumed as the share of new participants who continued to use the new alternative modes following the event.

The number of vehicle trips and VMT reduced by use of new alternative modes was estimated by multiplying the number of participants by the 10% continuation rate, by a VTR factors that assumed the participant used the new alternative mode two days per week, and by the 10.4 mile average VMT reduction. Emissions reduced were calculated as for other TERMS.

## MASS MARKETING SUMMARY OF GOALS AND IMPACTS

Table 10 presents the results for the Mass Marketing TERM, compared to the goals. Individual goals were not established for any of the individual elements that comprised the Mass Marketing TERM (direct influence, indirect ridematch and GRH influences, 'Pool Rewards, BTW Day, Car Free Day, and indirect GRH influence).

**Table 10**  
**Mass Marketing Goals and Estimated Impacts**

	<b>MM Goal</b>	<b>Estimated Impacts</b>
<b>Total Mass Marketing</b>		
• Commuter placements	23,168	23,016
• Daily vehicle trips reduced	10,809	10,133
• Daily VMT reduced	181,932	163,250
• Daily tons NOx reduced	0.0850 T	0.0424 T
• Daily tons VOC reduced	0.0250 T	0.0185 T
• Annual tons PM 2.5 reduced	N/A	0.556 T
• Annual tons PM 2.5 pre-cursor NOx reduced	N/A	11.368 T
• Annual tons CO2 reduced	N/A	65,644.8 T

### Impacts vs Goals

<b>Participation Benefit</b> (net over or (under) goal):	Commuters: (152)
<b>Transportation Benefit</b> (net over or (under) goal):	Vehicle Trips: (676) VMT: (18,682)
<b>Emission Benefit</b> (net over or (under) goal):	NOx: (0.0426) tons per day VOC: (0.0065) tons per day

The Mass Marketing TERM nearly met its goals for commuter placements, falling only 1% short. MM generated vehicle trip reduction within 6% below its goal and VMT reduction 10% under the goal. Details of the calculation for Mass Marketing are presented in Appendix 5.

Goals were not established for any of the individual elements that comprised the Mass Marketing TERM (direct influence, indirect ridematch and GRH influences, 'Pool Rewards, BTW Day, Car Free Day, and indirect GRH influence). But the analysis determined that direct ad influences accounted for 67% of Mass Marketing vehicle trips reduced, 'Pool Rewards and the Bike-to-Work and Car Free Day events accounted for about 25% of the total, and the ridematch and GRH referrals contributed the remaining 8%.

## SECTION 8 COMMUTER OPERATIONS CENTER

### BACKGROUND

Since the 1970's, COG has offered basic commute information and assistance, such as regional ride-matching, to commuters living and/or working in the Washington metropolitan region. Prior to 1997, when Commuter Connections was established, these services were provided by COG's Ride-Finders program. Because these services were available when the emissions baseline was developed for regional conformity, the Center was not established as a TERM, but was included in the region's TIP as an ongoing program and is part of the region's congestion management process. But only benefits above the 1997 baseline are included as a TERM.



The function of the Commuter Operations Center is to increase commuters' awareness of alternative modes, through regional and local marketing and outreach programs and to encourage and assist commuters to form ridesharing arrangements. Encouraging commuters who drive alone to shift to alternative modes is a priority for the COC, but the COC also assists commuters who now use alternative modes to continue to do so, by offering ride-matching and transit assistance when carpools break up or commuters' travel patterns change and disrupt existing alternative mode arrangements.

Commuter Connections program services include: carpool and vanpool matchlists, transit route and schedule information, information on Park & Ride lot locations and HOV lanes, telework information, commute program assistance for employers, GRH, and bicycling and walking information. Commuters obtain services and information primarily through the Commuter Connections website, but also can call a toll-free telephone number or contact a local partner assistance program for personal assistance from a commuter services representative.

### EVALUATION METHODOLOGY AND DATA SOURCES

In past years, the Commuter Operations Center has enhanced the services it offers to commuters and expanded its marketing of alternative modes to raise public awareness of and interest in alternatives. These efforts were designed to increase the number of commuters placed in alternative modes and generate trip, VMT, and emission reduction benefits for the region. Further, the activities of the COC support the implementation of the TERMS administered by Commuter Connections. Thus, although it is not an adopted TERM, the COC is included in this evaluation.

#### Base COC Impacts

The base impacts of the Commuter Operations Center were measured through two surveys, the 2014 Commuter Applicant Placement Survey, conducted in November 2014, and the 2016 Retention Rate survey, conducted in the spring of 2016. The 2014 Placement survey assessed commute travel for commuters who received commute assistance services from Commuter Connections during the 2017 evaluation period. The Retention Rate survey examined commute travel for commuters who received services prior to the 2017 evaluation period.

### Placement Survey

The November 2014 Placement Survey polled 716 commuters who received commute assistance services from Commuter Connections between July 1, 2014 and September 30, 2014. The survey asked detailed questions to define travel behavior changes commuters made after they received the commute services. Information collected, included, among other elements:

- Commute patterns: Current mode and previous mode (if commuter made a mode shift), frequency of mode use, travel distance, access mode to rideshare/transit pick-up point, and pool occupancy
- Permanence of mode changes: Whether change was continued (still in effect) or temporary (commuter had reverted to the original mode)
- Motivation: Role of Commuter Connections' assistance in decisions to start or increase alternative mode use

Data from the Placement survey were used to derive the placement rates, VTR factors, and travel distance impact calculation multipliers for the commuters who received Commuter Connections services during the FY 2015-17 evaluation period (July 2014 through June 2017). These multipliers were estimated for two applicant sub-populations. The first included respondents who both lived and worked in the Washington, DC Metropolitan Statistical Area (MSA); that is within the 11-jurisdiction area covered by the TERM evaluation. The second included respondents who worked in the MSA but lived outside it. This distinction was made because applicants who lived outside the MSA traveled a portion of their VMT outside the MSA. These "out of MSA" applicants were discounted to include only the portion of the VMT reduction that occurred within the MSA. Approximately 42% of the total participants lived outside the MSA.

### Retention Rate Survey

The 2016 Retention Rate Survey interviewed 989 commuters who had participated in Commuter Connections services prior to the start of the FY 2015-17 evaluation period (Pre-FY 2015). About 81% of the survey respondents had been registered for GRH and 19% had used only a non-GRH service. Impacts for respondents who participated in GRH are counted in the TERM analysis under the GRH TERM. Respondents who used only non-GRH services are counted in the TERM analysis under the Commuter Operations Center.

The objective of the Retention survey was to identify past COC applicants who made a change to an alternative mode after receiving commute assistance (alternative mode placement) and who were still using the alternative mode at the time of the survey (retained in alternative modes). For this purpose, the survey included questions about, among other elements:

- Current commute pattern: Current modes, frequency of mode use, and commute distance
- Previous commute patterns: Modes used prior to receiving Commuter Connections services and frequency of mode use
- Motivation: Importance of Commuter Connections services to continue use of alternative modes

Data from the Retention Rate survey were used to derive the placement rate, VTR factor, and travel distance calculation multipliers for past "retained" COC applicants. The survey did not ask respondents about their home location, so it was not possible to calculate separate Within MSA and Outside MSA factors. Because all commuters traveled part of their commute within the MSA, it was reasonable to use an overall placement rate and an overall VTR factor for all respondents, but it was necessary to adjust the overall travel distance to include only the Within MSA portion of VMT. In past placement surveys, the Within MSA distance was approximately 75% of the overall distance; this discount factor was applied to the overall distance from the Retention Rate survey to estimate the Within MSA factor.

### Calculation Factors and Impacts

**Placement Rate and Placements** – The first calculation factor used in the TERM analysis is placement rate, equal to the percentage of COC applicants who made a mode shift to an alternative mode. For the FY 2015-17 program participants, the placement rate was calculated for Within MSA participants and Outside MSA participants. For each geographic sub-population, two rates were calculated, based on the amount of time the respondent had used the new alternative mode. A “continued” rate was estimated for respondents who continued using the new alternative mode until the placement survey was conducted. A “temporary” rate was estimated for respondents who made a switch, but returned to their original mode before the survey.

The placement rate for Pre FY 15 “retained” applicants was calculated from the Retention Rate survey. Because participants must have continued their use of alternative modes to be counted as retained, all of the Pre-FY 2015 placements were counted as continued.

To determine the number of commuters placed in alternative modes, the placement rates were multiplied by the numbers of COC applicants for the time period and geographic location. A total of 77,662 commuters received services during the FY 2015-17 time period. About 46% of the requests were from new applicants or re-applicants. The COC also provided follow-up assistance, with additional match names for existing carpools and vanpools that needed a new or additional rider to maintain or expand existing ridesharing arrangements. The count of Pre FY 2015 applicants, was 3,651. <sup>2</sup>

These calculations resulted in a total of **31,663 placements**, divided as shown below, with 30,953 (98%) new placements from FY 2015-17 applicants and 710 (2%) retained placements from Pre-FY2015 applicants:

	<u>Population base</u>	<u>Placement Rate</u>	<u>Placements</u>
<u>FY 2015-17</u>			
• Within MSA - continued	45,044 x	32.3% =	14,549
• Within MSA - temporary	45,044 x	4.7% =	2,117
• Outside MSA - continued	32,618 x	38.2% =	12,460
• Outside MSA - temporary	32,618 x	5.6% =	1,827
<u>Pre-FY 2015</u>			
• Within MSA - continued	2,117 x	19.5% =	415
• Outside MSA - continued	1,533 x	19.5% =	301

Total Placements = 30,953 new placements + 716 retained placements = **31,669**

**VTR Factors and Vehicle Trips Reduced** – These placement figures were then multiplied by VTR factors derived from the Placement survey (FY 2015-17) and Retention Rate survey (Pre-FY 2015) to estimate the number of vehicle trips reduced. The VTR factor for each sub-population is as follows:

<u>FY 2015-17</u>	
• Within MSA - continued	0.40 vehicle trips reduced per placement
• Within MSA - temporary	0.18 vehicle trips reduced per placement
• Outside MSA - continued	0.46 vehicle trips reduced per placement
• Outside MSA - temporary	0.38 vehicle trips reduced per placement
<u>Pre-FY 2015</u>	
• Within MSA - continued	0.73 vehicle trips reduced per placement
• Outside MSA - continued	0.73 vehicle trips reduced per placement

<sup>2</sup> The 3,651 commuter applicants assigned to the COC for the Pre FY 2015 time period includes commuters who received ONLY non-GRH services. An additional number of commuters received both non-GRH and GRH services before July 2014. These commuters are counted under the GRH TERM.

The vehicle trip reductions for temporary placements also were discounted to reflect their short duration of 6.7 weeks (13% of a year). The calculation of vehicle trips reduced produced a total of **12,214 vehicle trips reduced**; 11,691 vehicle trips reduced by new (FY 2015-17) applicants and 523 from retained (Pre-FY 2015) applicants.

**Commute Distance and VMT Reduced** – Next, VMT reduction from COC applicants was calculated by multiplying the numbers of vehicle trips reduced by the average trip length for commuters who made a shift to an alternative mode. For The FY 2015-17 registrants, the one-way trip distance for the within MSA respondents was 28.9 miles for applicants with continued mode changes and 26.0 miles for applicants with temporary changes. The actual one-way distance for the outside MSA respondents was more than 50 miles, but to discount the distance credited to the outside MSA respondents, their one-way travel distance was set equal to that of the distance for the within MSA respondents. For the Pre-FY 2015 retained registrants, the commute distance was 19.9 miles; this was used for both the Within MSA and Outside MSA groups:

FY 2015-17

- Within MSA/Outside MSA - continued 28.9 miles reduced per trip
- Within MSA/Outside MSA - temporary 26.0 miles reduced per trip

Pre-FY 2015

- Within MSA/Outside MSA - continued 19.9 miles reduced per trip

The calculation of VMT reduced produced a total of **347,875 VMT reduced**, with 337,467 VMT reduced by new FY 2015-17 applicant and 10,408 VMT reduced by retained (Pre-FY 2015) applicants.

**Emissions Reduced** – Estimates of reductions in NO<sub>x</sub>, VOC, PM 2.5, PM 2.5 pre-cursor NO<sub>x</sub>, and CO<sub>2</sub> for the COC were calculated using regional emission factors, as described for the Telework TERM. Details of these calculations are presented in Appendix 6. The overall COC results were adjusted to account for overlap with the Software Upgrades (described below), GRH, and Mass Marketing. To avoid double counting of impacts, the COC’s contributions to these TERMS were subtracted from the COC “basic impacts.”

Telework Assistance Outside of Maryland

As noted in Section 4 (Telework Assistance), commuters who received telework assistance from Commuter Connections but who lived and/or worked outside Maryland are not counted in the Telework TERM. Instead, their impacts are counted in the COC. The calculation for these impacts follows the method described in Section 4.

Using results from the State of Commute survey, the number of non-Maryland telecommuters who had direct contact with the Telework TERM during the evaluation period were estimated and divided into “home-based” and “non-home-based” groups. These numbers of telecommuters were then multiplied by average VTR factors and one-way travel distances, as identified by the appropriate survey data, to obtain the number of vehicle trips and VMT reduced by their telecommuting.

- VTR factor for non-Maryland-based home-based telecommuters was 0.36 daily trips reduced per telecommuter and the average one-way travel distance was 15.5 miles.
- The VTR factor for non-home-based telecommuters was 0.07 and the net VMT reduced per telework day was 10.4 miles.

These calculations resulted in an estimated **36,109 telecommuters, 12,789 daily vehicle trips reduced, and 197,975 daily VMT reduced** by Commuter Connections-assisted telecommuting. These impacts were added to the COC base impacts.

Software Upgrade

Included within the Commuter Operations Center program is the Integrated Rideshare TERM-Software Upgrades Project. When it began, the Integrated Rideshare TERM provided improvements to the quality and delivery of al-

ternative mode information. In particular, the TERM added transit, park and ride, telecenter, and bicycling information to carpool/vanpool ridematch lists to inform commuters of the range of travel options that were available. Since 2008, when Commuter Connections introduced its updated web-based TDM system, these additional services have been available on a self-service basis through the online information system. But these services represent upgrades to the original ridematching services, so their impacts are captured under the Commuter Operations Center, but are reported separately.<sup>3</sup>

By providing transit and telework information to all commuters who received ridematches, the service is expected to encourage commuters to try transit and park & ride lots, even if they did not have these options in mind when they requested assistance. The Software Upgrade portion of the TERM was implemented in October 1998. In the 2008 evaluation, this component was merged into the COC impacts. This arrangement was used also for the 2011 and 2014 evaluations, but Software Upgrade impacts are calculated separately.

Impacts of the Software Upgrades was assessed using data from the November 2014 Applicant Placement Survey. This survey assessed changes commuters made after receiving a ridematch or other commute service from Commuter Connections. Respondents were asked if they remembered receiving information about transit options, park & ride (P&R) locations, bicycle routes, and/or telework when they received assistance from Commuter Connections. Respondents who recalled any or all of these services were asked follow-up questions to determine if they used the information to make any travel changes. Mode changes that were influenced by use of any of these information services were captured in this COC component.

**Placement Rate and Placements** – The surveys showed that 5.8% of applicants who lived within the MSA and 4.8% of applicants who lived outside the MSA used the transit, P&R, bicycle, and/or telework information to shift to an alternative mode. Most said they continued using the alternative mode. To estimate commuter placements, placement rates were multiplied by the commuters who applied to Commuter Connections or received follow-up assistance from Commuter Connections during the evaluation period. These calculations resulted in a total of **4,178 placements**, divided as shown below:

	<u>Population base</u>	<u>Placement Rate</u>	<u>Placements</u>
• Within MSA - continued	45,044 x	4.1% =	1,847
• Within MSA - temporary	45,044 x	1.7% =	766
• Outside MSA - continued	32,618 x	4.4% =	1,435
• Outside MSA - temporary	32,618 x	0.4% =	130

**VTR Factors and Vehicle Trips Reduced** – These placement figures were then multiplied by VTR factors derived from the Placement survey to estimate the number of vehicle trips reduced. The VTR factor for each sub-population is as follows:

• Within MSA - continued	0.60 vehicle trips reduced per placement
• Within MSA - temporary	0.19 vehicle trips reduced per placement
• Outside MSA - continued	0.45 vehicle trips reduced per placement
• Outside MSA - temporary	0.38 vehicle trips reduced per placement

The vehicle trip reductions for temporary placements also were discounted to reflect their short duration of 6.7 weeks (13% of a year). The calculation of vehicle trips reduced produced a total of **1,779 vehicle trips reduced** by applicants who were assisted or influenced by the Software Upgrades.

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<sup>3</sup> The Integrated Rideshare TERM originally had two components; Ridematching Software Upgrades, and Info-Express Kiosks. The InfoExpress Kiosk project was discontinued during the 2005-2008 evaluation period.

**Commute Distance and VMT Reduced** – VMT reduction was calculated by multiplying the numbers of vehicle trips reduced by the average trip length for commuters who made a shift to an alternative mode:

- Within MSA/Outside MSA - continued 28.9 miles reduced per trip
- Within MSA/Outside MSA - temporary 26.0 miles reduced per trip

As noted in the descriptions for both the GRH TERM and the COC, these distances were used for both Within MSA and Outside MSA respondents. The calculation of VMT reduced produced a total of **51,340 VMT reduced**.

**Emissions Reduced** – Emission reduction was calculated using trip-based and VMT-based regional emission factors. Calculation details for the software upgrade are shown in Appendix 7. To avoid double counting of impacts, the Software Upgrades impacts were subtracted from the COC “basic impacts.”

## COMMUTER OPERATIONS CENTER SUMMARY OF GOALS AND IMPACTS

Shown below are the evaluation results for the COC and the goals established for the Center (Table 11).

**Table 11**  
**Commuter Operations Center Regional Goals and Estimated Impacts**

	<b>COC Goal</b>	<b>Estimated Impacts</b>
<u>Commuter Operations Center</u> (basic services)		
• Total commuters (new, re-apply, follow-up)	91,609	77,662
• New applicants during evaluation period	N/A	14,787
• Number of past applicants (Pre FY 2015)	N/A	3,651
• Daily vehicle trips reduced	24,425	19,949
• Daily VMT reduced	512,637	401,327
• Daily tons NOx reduced	0.2410 T	0.1050 T
• Daily tons VOC reduced	0.1150 T	0.0789 T
• Annual tons PM 2.5 reduced	N/A	1.377 T
• Annual tons PM 2.5 pre-cursor NOx reduced	N/A	28.137 T
• Annual tons CO2 reduced	N/A	41,766.3 T
<u>Software Upgrades</u> (additional to Basic COC)		
• Daily vehicle trips reduced	2,379	1,779
• Daily VMT reduced	66,442	51,340
• Daily tons NOx reduced	0.0280 T	0.0111 T
• Daily tons VOC reduced	0.0110 T	0.0064 T
• Annual tons PM 2.5 reduced	N/A	0.150 T
• Annual tons PM 2.5 pre-cursor NOx reduced	N/A	2.975 T
• Annual tons CO2 reduced	N/A	4,981.1 T



Impacts vs Goals**Basic COC**

<b>Transportation Benefit</b> (net over or (under) goal):	Vehicle Trips: (4,468) VMT: (111,070) miles
<b>Emission Benefit</b> (net over or (under) goal):	NOx: (0.1360) tons per day VOC: (0.0360) tons per day

**Software Upgrades**

<b>Transportation Benefit</b> (net over or (under) goal):	Vehicle Trips: (600) VMT: (15,102) miles
<b>Emission Benefit</b> (net over or (under) goal):	NOx: (0.0169) tons per day VOC: (0.0046) tons per day

The Basic COC services missed the vehicle trip and VMT reduction goals by 18% and 22% respectively. The telework impacts accounted for 64% of the total COC vehicle trips reduced and 49% of the COC's VMT reduction. The COC Base goals were increased following the FY 2012-14 evaluation to represent the addition of non-Maryland telework credit to the Commuter Operations Center. The non-Maryland telework portion of the TERM contributed approximately the same vehicle trip and VMT reductions in the 2017 evaluation as in 2014, so the COC goal deficit was largely due to the decline in commuter applications from 2014. Additionally, a larger share of the COC base was credited to the Guaranteed Ride Home TERM in 2017 (29%) than had been credited in 2014 (23%), to account for overlap between the COC and GRH. The FY 2015-17 COC data indicated that a larger share of COC applicants had also participated in GRH in 2017 than in 2014. The Software Upgrades component also missed the goals for vehicle trips and VMT reduced, by 25% and 23%, respectively.

In recent years, several external factors have occurred that could have influenced commuters' interest in alternative mode use. One such factor is gasoline prices, which fell significantly in 2010 and which have remained relatively stable, eliminating one of the prime motivations to seek a rideshare arrangement. A second factor could be reductions in employer-provided transit/vanpool financial incentives that are available to employees. In the 2010 State of the Commute survey, 45% of employees said their employers offered a transit/vanpool subsidy. In 2016, only 37% said such a service was available. This likely reduced the attractiveness of transit and vanpooling for some employees. A third consideration is the expanded availability of private ridematch options, such as Craigslist, ZimRide, UberPool, and other informal applications, which could be attracting some commuters who seek commute information.

Finally, it is likely that the COC calculation underrepresents the true impact of both the Software Upgrades and basic COC program. The COC impacts are calculated only on commuters who can be contacted through a follow-up survey to identify travel changes they made after receiving Commuter Connections services. But the online information system permits commuters to access several services, such as bicycle and transit information, without making a formal application to Commuter Connections. Thus, some COC service recipients likely were excluded from the analysis. The extent of the impact undercounting cannot be estimated, but in the 2016 SOC survey, nearly 200,000 commuters said they had contacted Commuter Connections or visited the Commuter Connections website in the past year. These commuters represented more than 6% of all commuters region-wide.

The results shown in Table 12 were adjusted to eliminate overlap between the COC and individual TERMS. A portion of COC impacts were assigned to Software Upgrades and to GRH. Finally, the impacts for about 3% of new COC applicants were assigned to the Mass Marketing TERM, to reflect the impact of this TERM in influencing commuters to contact CC for travel-assistance services.

**Table 12**  
**Adjustment of Vehicle Trips and VMT for Overlap between the COC and TERMS**  
**(excluding telework credit for non-Maryland telecommuters)**

<u>Evaluation Measure</u>	<u>Basic COC</u>	<u>Mass Marketing</u>	<u>Software Upgrades</u>	<u>GRH</u>	<u>Net Basic COC</u>
VT reduced	12,210	351	1,779	2,912	7,168
VMT reduced	347,777	10,124	51,340	87,721	203,592

## Notes:

- Mass Marketing – new applicants influenced by ads to contact CC, see Section 6
- Software upgrades – see description in this section
- GRH – 59% of new/reapply applicants who shifted to alternative modes registered for GRH = 29% of Base COC credit was assigned to GRH (63% x 46% new/reapply share of total applicants)

Table 13 shows the addition of the net Base COC and telework credit for non-Maryland telecommuters who were assisted by Commuter Connections.

**Table 13**  
**Total Commuter Operations Center Credit**  
**(Adjusted Base COC + Non-Maryland Telework)**

<u>Evaluation Measure</u>	<u>Net Basic COC</u>	<u>Non-MD Telework</u>	<u>NET COC TOTAL</u>
VT reduced	7,168	12,789	19,957
VMT reduced	203,592	197,975	401,567

## SECTION 9 SUMMARY OF TERM IMPACTS

The preceding sections of this report documented estimated impacts for four individual TERMS and for the Commuter Operations Center. As noted earlier in the report, the four TERMS combined exceeded the collective goals for vehicle trips reduced by 14% and exceeded the VMT goal by about 18%.

The TERMS did not reach the emission goals; the impact for NO<sub>x</sub> was about 31% under the goal and VOC impact was 10% under the goal, but these deficits were due largely to reductions in the emission factors. The TERM goals were set in 2006, using 2006 emission factors. Goals for some TERMS were re-set since the issuance of the FY2012 – 2014 Commuter Connections TERM Analysis Report in 2014. Emission factors used in the 2017 evaluation were considerably lower than the factors from 2014 and lower still than the factors used in 2011, reflecting a cleaner vehicle fleet.

When the COC results are added to the TERM impacts, the combined impacts exceeded vehicle trip and VMT reduction goals by 8% and 9%, respectively. The combined TERM–COC program impact fell 37% short of the NO<sub>x</sub> goal and was 14% below the VOC goal. Again, the change in the emission factors affected the emission results.



Where shortfalls occurred against the vehicle trip and VMT reduction goals, they appeared related to lower than expected participation rates, rather than overly-optimistic travel change factors. COG revised the TERM goals following the 2005 analysis to reflect actual behavior changes that commuters make when using TERM services. COG again revised goals for some TERMS following the 2014 analysis, to account for additions or deletions to activities or services covered by those TERMS. Individual sections of this report have discussed factors that affected the achievement of goals. Highlights of those discussions are presented below for the four TERMS and the COC.

### MARYLAND AND VIRGINIA TELEWORK ASSISTANCE

The incidence of telework continues to grow in the Washington region. In 1996, about 150,000 regional workers were telecommuting. The 2016 State of Commute Survey estimated the number of telecommuters had grown nearly six-fold, to more than 887,200, or about 32% of regional commuters. Telework growth is likely the result of several factors, including the use of telework by employers to recruit and retain employees. Increasing traffic congestion in the Washington region also might have prompted some commuters to work at home to avoid traffic. Emergency preparedness, with a focus on continuity of operation, also has been a catalyst in the growth of telework. Finally, the desire of employees for a better balance of work and family, a trend occurring nationally, and greater affordability of sophisticated technology, also might have contributed to the growth in telecommuting.

The Telework TERM includes three components, two for Maryland and one for Virginia:

- Maryland – Regional telecommuters who live and/or work in Maryland who were influenced by Telework services/assistance to begin telecommuting
- Maryland – Telecommuting employees at Maryland worksites that were assisted by Commuter Connections
- Virginia – Telecommuting employees at Virginia worksites that received on-site Telework! VA assistance

**Maryland Telework TERM** – Overall, about 5% of regional telework can be attributed to the efforts of the Telework TERM, either directly through information distributed to commuters, through regional advertising to the public-at-large, or through assistance to employers that want to start a telework program. In the 2016 State of the

Commuter Survey, Maryland telecommuters accounted for approximately 45% of regional telecommuters and 11% of these telecommuters mentioned Commuter Connections or MWCOG as a source of telework information.

The number of Maryland telecommuters estimated for the TERM was 39% over the number of telecommuters expected from this TERM activities. The Maryland portion of the TERM also exceeded the reduction goals for vehicle trips (25%) and VMT (50%). The Telework goals were revised following the 2014 analysis and now more closely represent the actual telework patterns existing in the region; primarily the average frequency of 1.4 days per week and the 61% drive alone mode share of telecommuters on non-telework days. These two factors have a substantial impact on the total trip reduction generated by teleworking.

One possible area in which the Telework TERM's contribution to the regional telework impacts could have been undercounted is in the area of regional employer outreach. More than seven in ten (73%) telecommuters said they learned of teleworking from their employer. While employers could have learned of telework from many sources, the Commuter Connections Employer Outreach TERM also promotes telework to employers. So this response likely indicates additional telecommuters who learned about teleworking indirectly from Commuter Connections. Because this cannot be clearly documented, no additional credit is attributed to the Telework TERM. But these impacts are included in the Employer Outreach calculation for employers that offer telework.

Note also that the Telework TERM includes only outreach and assistance efforts to commuters who live or work in Maryland and to a small number of employers that receive telework assistance from Commuter Connections or from Telework! VA. Commuter Connections also provides telework information and assistance to commuters in other parts of the Washington metropolitan region. The impacts of these efforts are now counted under the Commuter Operations Center.

**Telework! VA** – Fifteen employers, representing 4,938 employees, were participating in the Telework! VA program in June 2017. Using data from baseline and post-assistance surveys, the analysis estimated that 31% of employees either started teleworking (5%) during the assistance period or increased their telework frequency (26%). These new/increased teleworkers equated to 1,531 placements. The new/increased teleworking count was nearly twice the 800-teleworker goal set for the program. Telework! VA also substantially exceeded the vehicle trip and VMT goals for the program. As a result of these significant impacts compared with the goals, the Telework! VA program also met its emission reduction goals.

## **GUARANTEED RIDE HOME**

The GRH TERM met only 51% of the goals for vehicle trips reduced and VMT reduced. The shortfalls primarily resulted because the number of new GRH registrants has dropped substantially since 2008. COG adjusted the goals for this TERM after the 2005 evaluation to reflect the actual travel patterns of typical GRH applicants and the fact that a sizeable share of GRH registrants were ridesharing or using transit prior to registering. These changes resulted in the vehicle trip and VMT calculations more accurately measuring the trip reduction per new GRH registrant, but the lower participation levels resulted in correspondingly lower results for vehicle trip and VMT reduction goals.

The number of commuters participating in GRH in June 2017 was about 55% below the participant goal. The vehicle trip reduction, VMT, and emissions impacts were also less than half of the goals for these measures. About 9% of GRH impacts were assigned to the Mass Marketing TERM to recognize that some GRH applicants were influenced to apply for GRH after they heard a Mass Marketing advertisement. But the deficits are due primarily to the substantial drop in GRH participation since 2005, the year the goals were established. Some of the decline could be due to reduced Commuter Connections GRH advertising. The 2016 State of the Commute survey found that only 21% of respondents said they knew a regional GRH program existed, compared to 59% who said they knew about the program in the 2004 SOC survey.

The current GRH participation does not entirely reflect the impact of the GRH program, however. In 2016, COG conducted a "Retention Rate" survey, which asked commuters who participated in GRH and/or other Commuter

Connections services prior to the FY 2015-17 evaluation period about their current commute travel. The survey estimated that about 14% of past GRH registrants had made shifts to new alternative modes and were continuing to use these new modes during the FY 2015-17 evaluation period, even though they were no longer in GRH. Thus, the GRH program impacts extend beyond the 3-year evaluation period. These “retained” alternative mode placements added about 11% to the vehicle trip and VMT reductions for the GRH.

## **EMPLOYER OUTREACH**

Employer Outreach greatly exceeded the participation goals set for the program, for both overall participation and participation of employers with new or expanded programs. A total of 2,046 employers were participating in Employer Outreach in June 2017 and more than one-third of these employers had either new programs or expanded programs since June 2014. Employer Outreach, the overall program exceeded its vehicle trip and VMT goals by 24% and 32%, respectively. Employer Outreach also met the goal for VOC emissions reduced. It did not meet the NOx emission goal, but this was due to the change in emission factors described earlier in the report.

Separate impacts also were calculated for the Employer Outreach for Bicycling component of this TERM. This project provides regional outreach to encourage employers to implement worksites strategies that encourage employees to use bicycling for commuting. A total of 597 employers offered bicycle strategies in their worksite programs, just above the 590-employer goal for this project. But Employer Outreach for Bicycling slightly missed the vehicle trip and VMT reduction goals established for the program, but the absolute deficits were small.

## **MASS MARKETING**

This TERM estimates impacts for six primary groups of commuters:

- 2) All commuters in the Commuter Connections service area
- 3) Commuter Connections rideshare applicants who were influenced by the marketing campaign to request Commuter Connections services
- 4) GRH applicants who were influenced by the marketing campaign to request Commuter Connections services
- 5) Commuters who participated in the ‘Pool Rewards carpool/vanpool incentive program
- 6) Commuters who participate in the Bike-to-Work Day event
- 7) Commuters who participate in Car Free Day

The Mass Marketing TERM nearly met its goals for commuter placements, falling only 1% short. MM generated vehicle trip reduction within 6% of its goal and VMT reduction 10% under the goal. Goals were not established for any of the individual elements that comprised the Mass Marketing TERM (direct influence, indirect ridematch and GRH influences, ‘Pool Rewards, BTW Day, Car Free Day, and indirect GRH influence). But the analysis determined that direct ad influences accounted for 67% of Mass Marketing vehicle trips reduced, ‘Pool Rewards and the Bike-to-Work and Car Free Day events accounted for about 25% of the total, and the ridematch and GRH referrals contributed the remaining 8%.

## **COMMUTER OPERATIONS CENTER**

The Commuter Operations Center is not an adopted TERM, but was included in this evaluation because it supports the success of several TERMS, including GRH, Integrated Rideshare, and Employer Outreach. The COC received nearly 78,000 applications between July 2014 and June 2017. About 46% of the requests were from new applicants or re-applicants and 54% represented additional follow-up assistance to existing applicants who needed a new or additional rider to maintain or expand existing ridesharing arrangements. Impacts for telework assistance provided by Commuter Connections to commuters who live and work outside Maryland also are included in the COC impacts.

The Basic COC services missed the vehicle trip and VMT reduction goals by 18% and 22% respectively. The telework impacts accounted for 64% of the total COC vehicle trips reduced and 49% of the COC’s VMT reduction. The COC

Base goals were increased following the FY 2012-14 evaluation to represent the addition of non-Maryland telework credit to the Commuter Operations Center. The non-Maryland telework portion of the TERM contributed approximately the same vehicle trip and VMT reductions in the 2017 evaluation as in 2014, so the COC goal deficit was largely due to the decline in commuter applications from 2014. Additionally, a larger share of the COC base was credited to the Guaranteed Ride Home TERM in 2017 (29%) than had been credited in 2014 (23%), to account for overlap between the COC and GRH. The FY 2015-17 COC data indicated that a larger share of COC applicants had also participated in GRH in 2017 than in 2014. The Software Upgrades component also missed the goals for vehicle trips and VMT reduced, by 25% and 23%, respectively.

In recent years, several external factors have occurred that could have influenced commuters' interest in alternative mode use. One such factor is gasoline prices, which fell significantly in 2010 and which have remained relatively stable, eliminating one of the prime motivations to seek a rideshare arrangement. A second factor could be reductions in employer-provided transit/vanpool financial incentives that are available to employees. In the 2010 State of the Commute survey, 45% of employees said their employers offered a transit/vanpool subsidy. In 2016, only 37% said such a service was available. This likely reduced the attractiveness of transit and vanpooling for some employees. A third consideration is the expanded availability of private ridematch options, such as Craigslist, ZimRide, UberPool, and other informal applications, which could be attracting some commuters who seek commute information.

Finally, it is likely that the COC calculation underrepresents the true impact of both the Software Upgrades and basic COC program. The COC impacts are calculated only on commuters who can be contacted through a follow-up survey to identify travel changes they made after receiving Commuter Connections services. But the online information system permits commuters to access several services, such as bicycle and transit information, without making a formal application to Commuter Connections. Thus, some COC service recipients likely were excluded from the analysis. The extent of the impact undercounting cannot be estimated, but in the 2016 SOC survey, nearly 200,000 commuters said they had contacted Commuter Connections or visited the Commuter Connections website in the past year. These commuters represented more than 6% of all commuters region-wide.

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- Appendix 1 – Basic Calculation of Vehicle Trip Reduction (VTR) Factor
- Appendix 2 – Calculation of Telework Assistance Impacts
- Appendix 3 – Calculation of Guaranteed Ride Home Impacts
- Appendix 4 – Calculation of Employer Outreach Impacts
- Appendix 5 – Calculation of Mass Marketing Impacts
- Appendix 6 – Calculation of Commuter Operations Center Impacts
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- Appendix 8 – Reduction in Delay Due to Program-induced VMT Reduction
- Appendix 9 – Calculation of Societal Benefits Generated by TERM Impacts

## APPENDIX 1 – BASIC CALCULATION OF VTR FACTOR

The vehicle trip reduction (VTR) factor represents the average number of vehicle trips that a commuter “placed” in an alternative mode would reduce per day. The VTR factor combines the trip reduction results of three possible types of travel changes that new commuter placements might make:

1. Drive alone commuters shifting to an alternative mode
2. Commuters who currently use an alternative mode shifting to another alternative mode (e.g., from carpool to bus, train to bus, vanpool to carpool, etc)
3. Commuters who currently use an alternative mode increasing their weekly frequency of alternative mode use (e.g., from carpool one time per week to carpool three times per week).

Shown below is a brief example of how the VTR factor would be calculated for seven commuters who made the following travel changes:

- Placement 1 – shifts from driving alone, 5 days per week, to a two-person carpool, 5 days per week
- Placement 2 – shifts from driving alone, 5 days per week, to transit, 5 days per week
- Placement 3 – shifts from driving alone, 5 days per week, to teleworking, 2 days per week and driving alone 3 days per week
- Placement 4 – shifts from driving alone, 5 days per week, to two-person carpool, 2 days per week and driving alone 3 days per week
- Placement 5 – shifts from a two-person carpool, 5 days per week, to transit, 5 days per week
- Placement 6 – shifts from transit, 5 days per week, to a two-person carpool, 5 days per week
- Placement 7 – increases the frequency of carpool from 1 day per week to 3 days per week, driving alone the other 2 days

The VTR factor is calculated by determining the number of vehicle trips all placements would reduce together and dividing that total by the number of placements. We assume that a commuter makes two trips a day, one from home to work and a second from work to home. Thus a commuter who drives alone would make 2 vehicle trips each day. If the commuter carools, he would make  $\frac{1}{2}$  vehicle trip to work and  $\frac{1}{2}$  trip back home, for a total of 1 vehicle trip per day. A commuter who uses bus, train, bike, or walk is assumed to make 0 vehicle trips. A commuter who teleworks also makes 0 vehicle trips for telework days.

Shown on the next page are the travel modes and the numbers of vehicle trips each of the seven commuters described above would make for each day of the week before the shift to an alternative mode and after the shift. The third column shows the net vehicle trips (number of trips after the shift minus number of trips before the shift). The final column shows the total weekly trips reduced. Note that commuter #6 actually increases his weekly commute trips, because he shifts from a higher occupancy alternative mode (transit) to a lower occupancy mode (carpool).



Appendix 1, continued

**Sample VTR Calculation  
Travel Modes Before and After Shifts to Alternative Modes  
By Commuter and by Day of the Week**

	Vehicle Trips Before Shift					Vehicle Trips After Shift					Vehicle Trips Net Trips					Weekly Change
	<u>M</u>	<u>T</u>	<u>W</u>	<u>T</u>	<u>F</u>	<u>M</u>	<u>T</u>	<u>W</u>	<u>T</u>	<u>F</u>	<u>M</u>	<u>T</u>	<u>W</u>	<u>T</u>	<u>F</u>	
<b>Placement 1</b> DA to 2p CP	D	D	D	D	D	C	C	C	C	C	-1	-1	-1	-1	-1	-5 trips
<b>Placement 2</b> DA to TR	D	D	D	D	D	T	T	T	T	T	-2	-2	-2	-2	-2	-10 trips
<b>Placement 3</b> DA to TC/DA (part-time)	D	D	D	D	D	D	D	C	C	C	0	0	0	-2	-2	-4 trips
<b>Placement 4</b> DA to CP/DA (part-time)	D	D	D	D	D	D	D	C	C	C	0	0	0	-1	-1	-2 trips
<b>Placement 5</b> 2p CP to TR	C	C	C	C	C	T	T	T	T	T	-1	-1	-1	-1	-1	-5 trips
<b>Placement 6</b> TR to 2p CP	T	T	T	T	T	C	C	C	C	C	+1	+1	+1	+1	+1	+5 trips
<b>Placement 7</b> DA/CP to CP (part-time)	D	D	D	D	C	D	D	C	C	C	0	0	-1	-1	0	-2 trips
<b>Total weekly trips</b>	11	11	11	11	10	8	8	7	4	4	-3	-3	-4	-7	-6	-23 trips

Total placements = 7 placements (travel for each shown above)  
 Total trips reduced per week = 23 trips per week (all placements together)  
 Total trips per day (all placements together) = 23 trips per week / 5 days per week  
 =4.6 trips per day

Average trips reduced per placement = 4.6 trips per day / 7 placements  
 = 0.66 trips per placement

The seven commuter placements would reduce a total of 4.6 trips during a single day, thus the average number of trips reduced per day by each of the seven placements would be 0.66. This is the VTR factor.

## APPENDIX 2 – CALCULATION OF TELEWORK ASSISTANCE IMPACTS

3 impact components

- CC Assisted Telework – Maryland
- CC Assisted Telework – Non-Maryland
- Telework! VA

### CC Assisted Telework – Maryland and Non-Maryland

#### Populations of Interest

All regional telecommuters	887,202	(from SOC survey)
Teleworkers with MD home or work	399,241	45% (from SOC survey)
Teleworkers not in MD	487,961	55% (from SOC survey)
Employees at TW assisted worksites	4,219	(from TW assistance survey)

#### Commuter Connections TW Placement Rates

##### Directly assisted TW

- Within Maryland 11.1% (% of TC assisted by CC, from SOC survey)
- Not in Maryland 7.4% (% of TC assisted by CC, from SOC survey)

##### TW at assisted worksites (MD only)

- Within Maryland 0.8% (% of new TC at sites, from TW assistance survey)
- Not in Maryland 0.0% Program not in effect outside of Maryland

#### TW Placements (Mixed home and Non-home based)

##### Maryland (credited to Telework TERM)

- Directly assisted telecommuters 44,316 (regional TC x directly assisted placement rate)
- Telecommuters at TW assisted sites 34 (employees at assisted sites x assisted site placement rate)

<b>Total assisted telecommuters - MD</b>	<b>44,350</b>
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##### Not Maryland (to be credited to COC)

- Directly assisted telecommuters 36,109 (regional TC x directly assisted placement rate)
- Telecommuters at TW assisted sites 0 (employees at assisted sites x assisted site placement rate)

<b>Total assisted telecommuters – Not MD</b>	<b>36,109</b>
----------------------------------------------	---------------

#### Placements by Location (home-based and non-home-based)

- % Home-based telecommuters 98% (from SOC survey)
- % Non-home (NH)-based telecommuters 2% (from SOC survey)

##### Maryland (credited to Telework TERM)

- Home-based telecommuters 43,463 (total assisted TW x % Home-based TW)
- NH-based telecommuters 887 (total assisted TW x % NH-based TW)

##### Not Maryland (credited to COC)

- Home-based telecommuters 35,387 (total assisted TW x % Home-based TW)
- NH-based telecommuters 722 (total assisted TW x % NH-based TW)

Appendix 2, continued

**Daily Vehicle Trips Reduced****VTR Factors**

- Home-based factor – MD 0.34 (from SOC survey)
- Home-based factor – Not MD 0.36 (from SOC survey)
- NH-based factor – MD and Not-MD 0.07 (from SOC survey)

**Maryland (credited to Telework TERM)**

- Home-based VT reduced 14,777 (HB TW x HB VTR factor)
- NH-based VT reduced 62 (NH-based TW x NH VTR factor)

<b>Daily Vehicle Trips Reduced - MD</b>	<b>14,839</b>
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**Not Maryland (credited to COC)**

- Home-based VT reduced 12,739 (HB TW x HB VTR factor)
- NH-based VT reduced 50 (NH-based TW x NH VTR factor)

<b>Daily Vehicle Trips Reduced – Not MD</b>	<b>12,789</b>
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**Daily VMT Reduced****Ave one-way trip distance (mi) to main workplace**

- Home-based – MD 24.4 (SOC survey)
- Home-based – Not MD 15.5 (SOC survey)

**Ave one-way trip distance (mi) for non-home-based TW (MD and Not-MD)**

- Non-home based – to main workplace 15.1 (SOC survey)
- Non-home based – to TW location 4.7 (SOC survey)
- Non-home based – net VMT reduced 10.4 (SOC survey)

**VMT reductions on TW days****Maryland (credited to Telework TERM)**

- Home-based VMT reduced 360,559 (HB VT reduced x average OW miles to main workplace)
- NH-based VMT reduced 645 (NHB VT reduced x net OW miles reduced per trip)

<b>Daily VMT Reduced - MD</b>	<b>361,204</b>
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**Not Maryland (credited to COC)**

- Home-based VMT reduced 197,455 (HB VT reduced x average OW miles to main workplace)
- NH-based VMT reduced 520 (NHB VT reduced x net OW miles reduced per trip)

<b>Daily VMT Reduced – Not MD</b>	<b>197,975</b>
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Appendix 2, continued

Maryland (credited to Telework TERM)**Daily Emissions Reduced – NOx and VOC**

<b>NOx</b>	<b>Trips</b>	<b>17 Emission Factor</b>	<b>VMT</b>	<b>17 Emission Factor</b>	<b>Tot gm</b>	<b>Tot ton</b>
• From Starts	14,839	1.2435			18,452	0.0203
• From Running			361,204	0.1897	68,520	<u>0.0755</u>
<b>Total NOx reduced (tons)</b>					<b>Daily</b>	<b>0.0958</b>

<b>VOC</b>	<b>Trips</b>	<b>17 Emission Factor</b>	<b>VMT</b>	<b>17 Emission Factor</b>	<b>Tot gm</b>	<b>Tot ton</b>
• From Starts	14,839	2.5814			38,305	0.0422
• From Running			361,204	0.0688	24,851	<u>0.0274</u>
<b>Total VOC reduced (tons)</b>					<b>Daily</b>	<b>0.0696</b>

**Annual Emissions Reduced – PM 2.5, Precursor NOx, and CO2**

<b>PM 2.5</b>	<b>Trips</b>	<b>17 Emission Factor</b>	<b>VMT</b>	<b>17 Emission Factor</b>	<b>Tot gm</b>	<b>Tot ton</b>
• From Starts	14,839	0.0312			463	0.0005
• From Running			361,204	0.0115	4,154	<u>0.0046</u>
<b>Total PM 2.5 reduced (tons)</b>					<b>Daily</b>	<b>0.0051</b>
					<b>Annual</b>	<b>1.275</b>

<b>PM 2.5 Precursor NOx</b>	<b>Trips</b>	<b>17 Emission Factor</b>	<b>VMT</b>	<b>17 Emission Factor</b>	<b>Tot gm</b>	<b>Tot ton</b>
• From Starts	14,839	1.3603			20,185	0.0223
• From Running			361,204	0.2019	72,927	<u>0.0804</u>
<b>Total PM 2.5 Precursor NOx reduced (tons)</b>					<b>Daily</b>	<b>0.1027</b>
					<b>Annual</b>	<b>25.675</b>

<b>CO2</b>	<b>Trips</b>	<b>17 Emission Factor</b>	<b>VMT</b>	<b>17 Emission Factor</b>	<b>Tot gm</b>	<b>Tot ton</b>
• From Starts	14,839	227.06			3,369,343	3.71
• From Running			361,204	380.68	137,503,139	<u>151.57</u>
<b>Total CO2 reduced (tons)</b>					<b>Daily</b>	<b>155.28</b>
					<b>Annual</b>	<b>38,820.0</b>

Appendix 2, continued

Non-Maryland (credited to COC)**Daily Emissions Reduced – NOx and VOC**

<b>NOx</b>	<b>Trips</b>	<b>17 Emission Factor</b>	<b>VMT</b>	<b>17 Emission Factor</b>	<b>Tot gm</b>	<b>Tot ton</b>
• From Starts	12,789	1.2435			15,903	0.0175
• From Running			197,975	0.1897	37,556	<u>0.0414</u>
<b>Total NOx reduced (tons)</b>					<b>Daily</b>	<b>0.0589</b>

<b>VOC</b>	<b>Trips</b>	<b>17 Emission Factor</b>	<b>VMT</b>	<b>17 Emission Factor</b>	<b>Tot gm</b>	<b>Tot ton</b>
• From Starts	12,789	2.5814			33,014	0.0364
• From Running			197,975	0.0688	13,621	<u>0.0150</u>
<b>Total VOC reduced (tons)</b>					<b>Daily</b>	<b>0.0514</b>

**Annual Emissions Reduced – PM 2.5, Precursor NOx, and CO2**

<b>PM 2.5</b>	<b>Trips</b>	<b>17 Emission Factor</b>	<b>VMT</b>	<b>17 Emission Factor</b>	<b>Tot gm</b>	<b>Tot ton</b>
• From Starts	12,789	0.0312			399	0.0004
• From Running			197,975	0.0115	2,277	<u>0.0025</u>
<b>Total PM 2.5 reduced (tons)</b>					<b>Daily</b>	<b>0.0029</b>
					<b>Annual</b>	<b>0.725</b>

<b>PM 2.5 Precursor NOx</b>	<b>Trips</b>	<b>17 Emission Factor</b>	<b>VMT</b>	<b>17 Emission Factor</b>	<b>Tot gm</b>	<b>Tot ton</b>
• From Starts	12,789	1.3603			17,397	0.0192
• From Running			197,975	0.2019	39,971	<u>0.0441</u>
<b>Total PM 2.5 Precursor NOx reduced (tons)</b>					<b>Daily</b>	<b>0.0633</b>
					<b>Annual</b>	<b>15.825</b>

<b>CO2</b>	<b>Trips</b>	<b>17 Emission Factor</b>	<b>VMT</b>	<b>17 Emission Factor</b>	<b>Tot gm</b>	<b>Tot ton</b>
• From Starts	12,789	227.06			2,903,870	3.20
• From Running			197,975	380.68	75,365,123	<u>83.08</u>
<b>Total CO2 reduced (tons)</b>					<b>Daily</b>	<b>86.28</b>
					<b>Annual</b>	<b>21,570.0</b>

Appendix 2, continued

**Telework! VA****Populations of Interest**

Employees at TW! VA worksites 4,938 (from TW! VA data)

**TW! VA Placements**

- Placement rate-assisted worksites 31.0% (from TW baseline/post-assistance surveys)

<b>Total Placements</b>	<b>1,531</b>
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**Daily Vehicle Trips Reduced**

- Continued VTR factor 0.32 (from TW baseline/post-assistance surveys)

<b>Total Daily Vehicle Trips Reduced</b>	<b>490</b>
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**Daily VMT Reduced**

- Ave one-way trip dist (mi) 19.1 (from TW post-assistance survey)

<b>Total Daily VMT Reduced</b>	<b>9,359</b>
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**Daily Emissions Reduced – NOx and VOC**

<b>NOx</b>	<b>Trips</b>	<b>17 Emission Factor</b>	<b>VMT</b>	<b>17 Emission Factor</b>	<b>Tot gm</b>	<b>Tot ton</b>
• From Starts	490	1.2435			609	0.0007
• From Running			9,359	0.1897	1,775	<u>0.0020</u>
<b>Total NOx reduced (tons)</b>					<b>Daily</b>	<b>0.0027</b>

<b>VOC</b>	<b>Trips</b>	<b>17 Emission Factor</b>	<b>VMT</b>	<b>17 Emission Factor</b>	<b>Tot gm</b>	<b>Tot ton</b>
• From Starts	490	2.5814			1,265	0.0014
• From Running			9,359	0.0688	644	<u>0.0007</u>
<b>Total VOC reduced (tons)</b>					<b>Daily</b>	<b>0.0021</b>

**Annual Emissions Reduced – PM 2.5, Precursor NOx, and CO2**

<b>PM 2.5</b>	<b>Trips</b>	<b>17 Emission Factor</b>	<b>VMT</b>	<b>17 Emission Factor</b>	<b>Tot gm</b>	<b>Tot ton</b>
• From Starts	490	0.0312			15	0.0000
• From Running			9,359	0.0115	108	<u>0.0001</u>
<b>Total PM 2.5 reduced (tons)</b>					<b>Daily</b>	<b>0.0001</b>
					<b>Annual</b>	<b>0.025</b>

Appendix 2, continued

**Annual Emissions Reduced – PM 2.5, Precursor NOx, and CO2 (continued)**

		17 Emission		17 Emission		
PM 2.5 Precursor NOx	Trips	Factor	VMT	Factor	Tot gm	Tot ton
• From Starts	490	1.3603			667	0.0007
• From Running			9,359	0.2019	1,890	<u>0.0021</u>
<b>Total PM 2.5 Precursor NOx reduced (tons)</b>					<b>Daily</b>	<b>0.0028</b>
					<b>Annual</b>	<b>0.700</b>
CO2	Trips	17 Emission	VMT	17 Emission	Tot gm	Tot ton
		Factor		Factor		
• From Starts	490	227.06			111,259	0.12
• From Running			9,359	380.68	3,562,784	<u>3.93</u>
<b>Total CO2 reduced (tons)</b>					<b>Daily</b>	<b>4.05</b>
					<b>Annual</b>	<b>1,012.5</b>

## APPENDIX 3 – CALCULATION OF GUARANTEED RIDE HOME IMPACTS

### Populations of Interest

#### FY 2015-17 Registrant Base (New credit)

• New GRH registrants (FY 2015-17)	10,283	(GRH database)
• Re-registrants from FY 2015	6,401	(Commuter Connections archive database)
• One-time exceptions (FY 2015-17)	<u>58</u>	(GRH database)
<b>New FY 2015-17 GRH base</b>	<b>16,742</b>	

#### Pre-FY 2015 Registrant Base (Retained credit)

• GRH registrants Pre-FY 2015	24,348	(COC GRH/Online databases)
• Valid contact percentage	69%	(Retention rate survey)
<b>Retained Pre-FY 2015 GRH base</b>	<b>16,917</b>	

### Distribution of In/Out MSA

#### FY 2015-17 Registrant Base (New)

Within MSA	62%	10,380
Outside MSA	38%	6,362

#### Pre-FY 2015 Registrant Base (Retained)

Within MSA	62%	10,488
Outside MSA	38%	6,428

### GRH Placement Rates and Placements (continued only) (MSA base x MSA placement rate)

#### FY 2015-17 Registrants (New)

• Within MSA rate	44.5%	4,619
• Outside MSA rate	45.7%	2,907

#### Pre-FY 2015 Registrants (Retained)

• Within MSA rate	14.3%	1,500
• Outside MSA rate	14.3%	919

<b>Total Placements</b>	<b>9,945</b>
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### VTR Factors and Daily Vehicle Trips Reduced (continued only) (MSA placement x MSA VTR factor)

#### FY 2015-17 Registrants (New)

• Within MSA VTR factor	0.79	3,649
• Outside MSA VTR factor	0.88	2,558

#### Pre-FY 2015 Registrants (Retained)

• Within MSA VTR factor	0.31	465
• Outside MSA VTR factor	0.31	285

<b>Total Daily Vehicle Trips Reduced</b>	<b>6,957</b>
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### Commute Distance and Daily VMT Reduced (MSA VT reduced x MSA distance)

#### FY 2015-17 Registrants (New)

• Within MSA distance	28.2	102,902
• Outside MSA distance	28.2	72,136 (discount actual 50.3 miles from GRH survey)

#### Pre-FY 2015 Registrants (Retained)

• Within MSA distance	29.4	13,671
• Outside MSA distance	29.4	8,379

<b>Total Daily VMT Reduced</b>	<b>197,088</b>
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## Appendix 3, continued

**Trip and VMT Adjustment for SOV Access to HOV Modes (reduce VT and VMT for AQ analysis)**

## Inside MSA

- SOV access percentage 75% (GRH survey)
- SOV access distance (mi) 5.3 (GRH survey)

## Outside MSA

- Adjustments are not applicable, because all access VT and VMT occur outside MSA

**Adjusted VT Reduction – net of VMT access**

- Total VT reduced 6,957
- Within MSA access VT (deduct) - 3,086 (Total VT reduction within MSA x SOV access %)
- Outside MSA access VT 0 No deduction (access trips are outside MSA)

**Total VT for AQ analysis 3,871****Adjusted VMT Reduction – net of VMT access**

- Total VMT reduced 197,088
- Within MSA access VMT (deduct) - 16,356 (SOV Access VT within MSA x SOV access distance)
- Outside MSA access VMT 0 No deduction (access VMT are outside MSA)

**Total VMT for AQ analysis 180,732****Daily Emissions Reduced – NOx and VOC**

NOx	Trips	17 Emission Factor	VMT	17 Emission Factor	Tot gm	Tot ton
• From Starts	3,871	1.2435			4,814	0.0053
• From Running			180,732	0.1897	34,285	<u>0.0378</u>
<b>Total NOx reduced (tons)</b>					<b>Daily</b>	<b>0.0431</b>

VOC	Trips	17 Emission Factor	VMT	17 Emission Factor	Tot gm	Tot ton
• From Starts	3,871	2.5814			9,993	0.0110
• From Running			180,732	0.0688	12,434	<u>0.0137</u>
<b>Total VOC reduced (tons)</b>					<b>Daily</b>	<b>0.0247</b>

**Annual Emissions Reduced – PM 2.5, Precursor NOx, and CO2**

PM 2.5	Trips	17 Emission Factor	VMT	17 Emission Factor	Tot gm	Tot ton
• From Starts	3,871	0.0312			121	0.0001
• From Running			180,732	0.0115	2,078	<u>0.0023</u>
<b>Total PM 2.5 reduced (tons)</b>					<b>Daily</b>	<b>0.0024</b>
					<b>Annual</b>	<b>0.606</b>

PM 2.5 Precursor NOx	Trips	17 Emission Factor	VMT	17 Emission Factor	Tot gm	Tot ton
• From Starts	3,871	1.3603			5,266	0.0058
• From Running			180,732	0.2019	36,490	<u>0.0402</u>
<b>Total PM 2.5 Precursor NOx reduced (tons)</b>					<b>Daily</b>	<b>0.0460</b>
					<b>Annual</b>	<b>11.51</b>

Appendix 3, continued

**Annual Emissions Reduced – PM 2.5, Precursor NOx, and CO2 (continued)**

CO2	17 Emission		17 Emission		Tot gm	Tot ton
	Trips	Factor	VMT	Factor		
• From Starts	3,871	227.06			878,949	0.97
• From Running			180,732	380.68	68,801,058	<u>75.84</u>
<b>Total CO2 reduced (tons)</b>					<b>Daily</b>	<b>76.81</b>
					<b>Annual</b>	<b>19,202.5</b>

**Correction for Overlap with MM TERM**

Total GRH apps FYs 15, 16, 17	16,742		
New GRH apps FY 15, 16, 17	10,283	61%	
Estimated MM share of new GRH	16%		
FY 2015-17 VMT as % of total VMT	89%		(Exclude Retained credit from discount)
Estimated MM share of GRH impact	9%		

**Net GRH = GRH Base – Mass Marketing credit**

	GRH Base	Mass Mkt	Net GRH
Placements	9,945	677	9,268
VMT reduced	6,957	559	6,398
VMT reduced (mi)	197,088	15,753	181,335
Daily Emissions Reduced			
NOx (T)	0.0431	0.0035	0.0396
VOC (T)	0.0247	0.0020	0.0227
Annual Emissions Reduced			
PM 2.5 (T)	0.600	0.048	0.552
PM 2.5 Precursor NOx (T)	11.500	0.921	10.579
CO2 (T)	19,202.3	1,538.1	17,664.2

## APPENDIX 4 – CALCULATION OF EMPLOYER OUTREACH IMPACTS

### Populations of Interest

Level 3 or 4 sites (data from ACT! database)

	<u>Employers</u>	<u>Employees</u>
• 2014 unchanged programs	1,281	446,035
• Expanded programs in 2017	188	110,207
• New programs in 2017	577	136,028
• Deleted programs since 2014	285	115,011

### Average Vehicle Occupancy (AVO)

Starting AVO from employee survey data, Final AVO from COMMUTER model

	<u>Starting AVO</u>	<u>Ending AVO</u>
• 2014 unchanged programs	1.25	1.36
• Expanded programs – continued base	1.28	1.44
• Expanded programs – new impacts	1.44	1.49
• New programs	1.29	1.44
• Deleted programs	1.32	1.23

### Daily person trips

Total employees x 2 one-way trips per day

Starting (pre-program) and ending (with-program)

	<u>Starting</u>	<u>Ending</u>
• 2014 unchanged programs	892,070	892,070
• Expanded programs	220,414	220,414
• New programs	272,056	272,056
• Deleted programs	230,022	230,022

### Daily vehicle trips

Total employees / starting AVO)

Starting (pre-program) and ending (with-program)

	<u>Starting</u>	<u>Ending</u>	<u>Difference</u>
• 2014 unchanged programs	713,086	655,452	57,634
• Expanded programs – maintained base	172,333	153,278	19,055
• Expanded programs – new impact	153,278	148,427	4,851
• New programs	210,407	189,322	21,085
• Deleted programs	172,689	187,620	(14,931)

### Total Daily Vehicle Trips Reduced

• 2014 maintained impacts	76,689
• New/expanded impacts	25,936
<b>Net 2017 reduction</b>	<b>102,625</b>

## Appendix 4, continued

**Daily VMT reduced**

Results produced by COMMUTER model, assuming travel distance by mode from SOC survey

• 2014 unchanged programs	1,020,435
• Expanded programs – maintained base	38,841
• Expanded programs – new impact	93,493
• New programs	388,660
• Deleted programs	(276,102)

Total Daily VMT Reduced

• 2014 continued impacts	1,359,276
• New/expanded impacts	482,153
<b>Net 2011 reduction</b>	<b>1,841,429</b>

**Trip and VMT Adjustment for SOV Access to HOV Modes (reduce VT and VMT for AQ analysis)**

• Non-SOV access percentage	74%	(from 2016 SOC survey)
• SOV access percentage	26%	(from 2016 SOC survey)
• SOV access distance (mi)	2.8	(from 2016 SOC survey)

**VT Reduction without SOV access – used as base for AQ analysis**

(Total VT reduced x non-SOV access %)

• 2014 maintained impacts	56,750
• New/expanded impacts	19,193

**VMT Reduction without SOV access**

(Total VMT reduced – (Total daily VT reduced x SOV % x SOV access trip distance))

• 2014 maintained impacts	1,303,447
• New/expanded impacts	463,273

Emissions Reduced – Maintained from 2014Daily Emissions Reduced – NOx and VOC

NOx	Trips	17 Emission Factor	VMT	17 Emission Factor	Tot gm	Tot ton
• From Starts	56,750	1.2435			70,569	0.0778
• From Running			1,303,447	0.1897	247,264	0.2726
<b>Total NOx reduced (tons)</b>					<b>Daily</b>	<b>0.3504</b>

VOC	Trips	17 Emission Factor	VMT	17 Emission Factor	Tot gm	Tot ton
• From Starts	56,750	2.5814			146,494	0.1615
• From Running			1,303,447	0.0688	89,677	0.0989
<b>Total VOC reduced (tons)</b>					<b>Daily</b>	<b>0.2604</b>

Appendix 4, continued

**Annual Emissions Reduced – PM 2.5, Precursor NOx, and CO2**

		17 Emission		17 Emission		
PM 2.5	Trips	Factor	VMT	Factor	Tot gm	Tot ton
• From Starts	56,750	0.0312			1,771	0.0020
• From Running			1,303,447	0.0115	14,990	<u>0.0165</u>
<b>Total PM 2.5 reduced (tons)</b>					<b>Daily</b>	<b>0.0185</b>
					<b>Annual</b>	<b>4.619</b>
PM 2.5 Precursor NOx	Trips	Factor	VMT	Factor	Tot gm	Tot ton
• From Starts	56,750	1.3603			77,197	0.0851
• From Running			1,303,447	0.2019	263,166	<u>0.2901</u>
<b>Total PM 2.5 Precursor NOx reduced (tons)</b>					<b>Daily</b>	<b>0.3752</b>
					<b>Annual</b>	<b>93.797</b>
CO2	Trips	Factor	VMT	Factor	Tot gm	Tot ton
• From Starts	56,750	227.06			12,885,655	14.20
• From Running			1,303,447	380.68	496,196,204	<u>546.96</u>
<b>Total CO2 reduced (tons)</b>					<b>Daily</b>	<b>561.17</b>
					<b>Annual</b>	<b>140,291.6</b>

**Emissions Reduced - New / Expanded****Daily Emissions Reduced – NOx and VOC**

		17 Emission		17 Emission		
NOx	Trips	Factor	VMT	Factor	Tot gm	Tot ton
• From Starts	19,193	1.2435			23,866	0.0263
• From Running			463,273	0.1897	87,883	<u>0.0969</u>
<b>Total NOx reduced (tons)</b>					<b>Daily</b>	<b>0.1232</b>
VOC	Trips	Factor	VMT	Factor	Tot gm	Tot ton
• From Starts	19,193	2.5814			49,545	0.0546
• From Running			463,273	0.0688	31,873	<u>0.0351</u>
<b>Total VOC reduced (tons)</b>					<b>Daily</b>	<b>0.0897</b>

**Annual Emissions Reduced – PM 2.5, Precursor NOx, and CO2**

		17 Emission		17 Emission		
PM 2.5	Trips	Factor	VMT	Factor	Tot gm	Tot ton
• From Starts	19,193	0.0312			599	0.0007
• From Running			463,273	0.0115	5,328	<u>0.0059</u>
<b>Total PM 2.5 reduced (tons)</b>					<b>Daily</b>	<b>0.0066</b>
					<b>Annual</b>	<b>1.650</b>

Appendix 4, continued

Emissions Reduced - New / Expanded (cont)**Annual Emissions Reduced – PM 2.5, Precursor NOx, and CO2**

<b>PM 2.5 Precursor NOx</b>	<b>Trips</b>	<b>17 Emission Factor</b>	<b>VMT</b>	<b>17 Emission Factor</b>	<b>Tot gm</b>	<b>Tot ton</b>
• From Starts	19,193	1.3603			26,108	0.0288
• From Running			463,273	0.2019	93,535	<u>0.1031</u>
<b>Total PM 2.5 Precursor NOx reduced (tons)</b>					<b>Daily</b>	<b>0.1319</b>
					<b>Annual</b>	<b>32.975</b>

<b>CO2</b>	<b>Trips</b>	<b>17 Emission Factor</b>	<b>VMT</b>	<b>17 Emission Factor</b>	<b>Tot gm</b>	<b>Tot ton</b>
• From Starts	19,193	227.06			4,357,963	4.80
• From Running			463,273	380.68	176,358,766	<u>194.40</u>
<b>Total CO2 reduced (tons)</b>					<b>Daily</b>	<b>199.20</b>
					<b>Annual</b>	<b>49,801.5</b>

**Distribution of Employer Outreach Impacts to EO Base and EO for Bicycling**

	<b>Total EO</b>	<b>EO w/o bike</b>	<b>EO-bike</b>
Vehicle Trips Reduced	102,625	102,252	373
VMT Reduced (miles)	1,841,429	1,839,789	1,640
Daily Emissions Reduced			
NOx (tons)	0.4736	0.4728	0.0008
VOC (tons)	0.3501	0.3489	0.0012
Annual Emissions Reduced			
PM 2.5 (T)	6.275	6.275	0.000
PM 2.5 Precursor NOx (T)	126.775	126.525	0.250
CO2 (T)	190,093.1	189,897.8	195.3

Appendix 4, continued

**COMMUTER CONNECTIONS  
EMPLOYER SERVICES PARTICIPATION LEVELS  
(EFFECTIVE Retroactively to July 1, 2015)  
October 20, 2015**

**SUPPORT STRATEGIES**

**Likely range of trip reduction                    0%**

- Expresses Interest and/or distributes/displays information on Ozone Actions Days

**LEVEL 1 (BRONZE)**

**Likely range of trip reduction                    0% to 1%**

- Expresses interest in telework, transit benefits, Smart Benefits, or other TDM strategy
- Conducts Commuter Survey
- Distributes alternative commute info to employees
- Posts alternative commute information on employee bulletin board(s), intranet sites, newsletter or e-mail
- Installs Electric Car Charging Station(s) at worksite

**LEVEL 2 (SILVER) – Implements two or more of the following strategies**

**Likely range of trip reduction                    0% to 3% without Telework/Compressed Work Schedules  
0% to 9% with Telework/Compressed Work Schedules**

- Installs a permanent display case or brochure holders and stock with alternative commute information
- Installs electronic screens or desktop feed of real-time travel information for transit and/or other alternative mode availability.
- Participates in the Capital Bikeshare Program as a Corporate Partner
- Provides preferential parking for carpools and vanpools
- Implements a telework program with 1-20% of employees participating
- Facilitates car/vanpool formation meetings
- Hosts/sponsors an alternative commute day or transportation fair
- Implements flex-time or staggered work schedule
- Implements compressed work week for 1-20% of employees
- Installs bicycle racks or lockers
- Installs shower facilities for bicyclists and walkers
- Establishes an ETC who regularly provides alternative commute information to employees
- Becomes a Commuter Connections member and provides on-site ridematching
- Supplements GRH program with payment for additional trips or own program

Appendix 4, continued

### LEVEL 3 (GOLD)

**Implements at least one of the following (in addition to the two or more Level 2 strategies):**

**Likely range of trip reduction**                      **2% to 5% without financial incentive/disincentive,  
Telework/Compressed Work Schedules**  
**5% to 20% with financial incentive/disincentive,  
Telework/Compressed Work Schedules**

- Implements a telework program with more than 20% of employees participating
- Implements compressed work week for 21%+ of employees
- Implements a transit/vanpool benefit, Smart Benefits, Federal Bicycle Benefit, or parking "cash out" program
- Implements a carpool/bicycle/walk benefit
- Provides free or significantly reduced fee parking for carpools and vanpools (valid only for companies where employees pay for parking)
- Implements a parking fee (valid only for companies that previously did not charge for parking)
- Provides employee shuttle service to transit stations
- Provides company vanpools for employees' commute to work
- Implements a comprehensive Bicycle/Walking program (includes installation of showers bicycle racks/lockers, and financial incentives for bicycling and/or walking, or a Capital Bikeshare Station)

### LEVEL 4 (PLATINUM)

**Likely range of trip reduction**                      **2% to 8% without financial incentive,  
Telework/Compressed Work Schedules**  
**5% to 30% with financial incentive,  
Telework/Compressed Work Schedules**

- Implements two or more of the Level 3 TDM programs (in addition to the 2 or more Level 2 strategies) and actively promotes these programs and alternative commuting



## APPENDIX 5 – CALCULATION OF MASS MARKETING IMPACTS

### 6 impact components

- Part 1 – Commuters influenced by ads to change mode – no contact CC (direct influence)
- Part 2 – ‘Pool Rewards carpool/vanpool incentive participants
- Part 3 – Car-Free Day event
- Part 4 – Bike to Work Day event
- Part 5 – Commuters influenced by ads to contact CC (referred influence)
- Part 6 – Commuters influenced by ads to join GRH (referred influence)

### **PART 1 – Direct Ad Influence**

Populations of Interest – commuters influenced by ads to change mode – no contact CC

Total commuters in region	2,940,524	(SOC)
• % recall any commute message	54%	(SOC)
• % recall CC/COG commute message	21%	(SOC)
• % chg to alt mode after CC/COG ads	3.3%	(SOC)
• % changers influenced by ad	60%	(SOC)

**Placements – no contact with CC**                      **12,227** (Commuters x CC recall X change % x influence %)

#### **Placement Rates**

- Continued placement rate                      46% (SOC)
- Temporary placement rate                      54% (SOC)

#### **Placements**

- Continued placements                      5,624 (Placements x continued placement rate)
- Temporary placements                      6,603 (Placements x temporary placement rate)

#### **Daily Vehicle Trips Reduced**

- Continued VTR factor                      0.80 (SOC)
- Temporary VTR factor                      1.00 (SOC)
- Continued VT reduced                      4,499 (Continued placements x continued VTR factor)
- Temporary VT reduced                      2,245 (Temporary placements x temporary VTR factor x 34% credit for temporary use)

<b>Total Daily Vehicle Trips Reduced</b>	<b>6,744</b>
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#### **Daily VMT Reduced**

- Ave one-way trip distance (mi)                      15.4 (SOC)

<b>Total Daily VMT Reduced</b>	<b>103,858</b>
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Appendix 5, continued

PART 1 (Direct Ad Influence) (cont.)

**Trip and VMT Adjustment for SOV Access to HOV Modes (reduce VT and VMT for AQ analysis)**

- SOV access percentage 30% (from SOC – transit riders)
- SOV access distance (mi) 2.7 (from SOC – transit riders)

**Adjusted VT Reduction**

- SOV access VT 2,023 (Total VT x SOV access %)
- VT with no SOV access 4,721 (Total VT – SOV access VT)

**Adjusted VMT Reduction**

- SOV access VMT 5,462 (Total VT x SOV % x trip distance)
- VMT with no SOV access 98,396 (Total VMT – SOV access VMT)

**Total VT for AQ analysis 4,721****Total VMT for AQ analysis 98,396****PART 2 – ‘Pool Rewards Carpool/Vanpool Participants**

Carpool program participants (FY 2015-17) 131

Vanpool program participants (FY 2015-17) 213

**Placement Rates – by retention after program ended**Carpool Component

- Continued placement rate 80% (‘Pool Rewards follow-up survey)
- Temporary placement rate 20% (‘Pool Rewards follow-up survey)

Vanpool Component

- Continued placement rate 36% (‘Pool Rewards NTD vanpool data)
- Temporary placement rate 64% (‘Pool Rewards NTD vanpool data)

**Placements**Carpool Component

- Continued placements 105 (Placements x continued placement rate)
- Temporary placements 26 (Placements x temporary placement rate)

**Carpool placements 131**Vanpool Component

- Continued placements 77 (Placements x continued placement rate)
- Temporary placements 136 (Placements x temporary placement rate)

**Vanpool placements 213****Total ‘Pool Rewards placements 344**

## Appendix 5, continued

## PART 2 ('Pool Rewards) (cont.)

**Daily Vehicle Trips Reduced**Carpool Component

- Continued VTR factor 0.92 ('Pool Rewards follow-up survey)
- Temporary VTR factor 0.94 ('Pool Rewards logging data for program period)
- Temporary discount 50% (assumes 13 weeks of program + 13 weeks after program)
  
- Continued VT reduced 97 (Continued placements x continued VTR factor)
- Temporary VT reduced 12 (Temporary placements x temporary VTR factor x 50% credit for temporary use)

**Carpool VT Reduced 109**Vanpool Component

- Continued VTR factor 1.62 ('Pool Rewards NTD vanpool data)
- Temporary VTR factor 1.58 ('Pool Rewards NTD vanpool data)
- Temporary discount 50% (Ave temporary vanpool duration = 1.5 yr of 3 yr total)
  
- Continued VT reduced 125 (Continued placements x continued VTR factor)
- Temporary VT reduced 108 (Temporary placements x temporary VTR factor x 50% credit for temporary use)

**Vanpool VT Reduced 233****Total Daily Vehicle Trips Reduced 342****Daily VMT Reduced**Carpool Component

- Ave continued one-way trip dist (mi) 28.2 ('Pool Rewards follow-up survey)
- Ave temporary one-way trip dist (mi) 28.2 ('Pool Rewards follow-up survey)
  
- Continued VMT reduced 2,736 (Continued placements x continued VTR factor)
- Temporary VMT reduced 338 (Temporary placements x temporary VTR factor x 50% credit)

**Carpool VMT Reduced 3,074**Vanpool Component

- Ave continued one-way trip dist (mi) 39.3 ('Pool Rewards NTD vanpool data)
- Ave temporary one-way trip dist (mi) 33.7 ('Pool Rewards NTD vanpool data)
  
- Continued VMT reduced 4,912 (Continued placements x continued VTR factor)
- Temporary VMT reduced 3,640 (Temporary placements x temporary VTR factor x 50% credit)

**Vanpool VMT Reduced 8,552****Total Daily VMT Reduced 11,626**

## Appendix 5, continued

## PART 2 ('Pool Rewards) (cont.)

**Trip and VMT Adjustment for SOV Access to HOV Modes (reduce VT and VMT for AQ analysis)**

- SOV access percentage (carpool) 72% (SOC survey)
- SOV access percentage (vanpool) 90% (Estimate)
- SOV access distance (mi) (car/vanpool) 5.5

**Adjusted VT Reduction**Carpool Component

- SOV access VT 78 (Total VT x SOV access %)
- **VT with no SOV access 31** (Total VT – SOV access VT)

Vanpool Component

- SOV access VT 210 (Total VT x SOV access %)
- **VT with no SOV access 23** (Total VT – SOV access VT)

**Adjusted VMT Reduction**Carpool Component

- SOV access VMT 429 (Total VT x SOV % x trip distance)
- **VMT with no SOV access 2,645** (Total VMT – SOV access VMT)

Vanpool Component

- SOV access VMT 1,155 (Total VT x SOV % x trip distance)
- **VMT with no SOV access 7,397** (Total VMT – SOV access VMT)

**Total VT for AQ analysis 54**  
**Total VMT for AQ analysis 10,042**

**PART 3 – Car Free Day Event**

Pledges (estimate 90% participation of pledges)

Fall 2014 – 4,656 4,190  
 Fall 2015 – 3,442 3,098  
 Fall 2016 – 4,497 4,047

<b>Total Placements</b>	<b>11,335</b>
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Event Impacts**Daily Vehicle Trips Reduced**

- % driving alone on non-Car Free days 31% (Pledge data – average of 2014-2016)
- Event VTR factor 0.62 (Pledge data – average of 2014-2016)
- Event VT reduced 7,028 (Pledges x event VTR factor)
- **Equivalent daily VT 9** (Event VT reduced / 750 days over 3 years)

**Daily VMT Reduced**

- Ave one-way trip distance (mi) 10.5 (Pledge data)
- Event VMT reduced 73,794 (Event VT reduced x trip distance)
- **Equivalent daily VMT 98** (Event VMT reduced / 750 days over 3 years)

Appendix 5, continued

PART 3 (Car-Free Day) (cont.)

Ongoing Impacts**Daily Vehicle Trips Reduced**

• Estimate continued use after CFD	10%	(Assumed, based on Bike-to-Work survey)
<b>Ongoing placements</b>	<b>1,134</b>	(Total participants x continued rate)
• Ongoing VTR factor (after CFD)	0.25	(Assumes 2 days/week continued alternative mode use)
• <b>Ongoing daily VT reduced</b>	<b>284</b>	(Ongoing participants x ongoing VTR factor)
<b>Total Daily VT Reduced</b>	<b>293</b>	(Event equivalent daily VT + ongoing daily VT)

**Daily VMT Reduced**

• Trip distance	10.5	(Pledge data – average of 2014-2016)
• <b>Ongoing daily VT</b>	<b>2,982</b>	(Ongoing daily VT x trip distance)
<b>Total Daily VMT Reduced</b>	<b>3,080</b>	(Event equivalent daily VMT + ongoing daily VMT)

**Summary of Travel Impacts for Parts 1, 2, 3**

	<b>Total 1, 2, 3</b>	<b>Direct Ads</b>	<b>'Pool Rewards</b>	<b>Car Free Day</b>
Placements	13,705	12,227	344	1,134
Vehicle Trips Reduced	7,379	6,744	342	293
VMT Reduced (miles)	118,564	103,858	11,626	3,080
Air Quality Adjusted VT / VMT				
• Vehicle Trips Reduced	5,068	4,721	54	293
• VMT Reduced (miles)	111,518	98,396	10,042	3,080

**Daily Emissions Reduced – NOx and VOC – Parts 1, 2, 3**

NOx	Trips	17 Emission		17 Emission		Tot gm	Tot ton
		Factor	VMT	Factor			
• From Starts	5,068	1.2435				6,302	0.0069
• From Running			111,518	0.1897		21,155	<u>0.0233</u>
<b>Total NOx reduced (tons)</b>						<b>Daily</b>	<b>0.0302</b>
VOC	Trips	17 Emission		17 Emission		Tot gm	Tot ton
		Factor	VMT	Factor			
• From Starts	5,068	2.5814				13,083	0.0144
• From Running			111,518	0.0688		7,672	<u>0.0085</u>
<b>Total VOC reduced (tons)</b>						<b>Daily</b>	<b>0.0229</b>

Appendix 5, continued

**Annual Emissions Reduced – PM 2.5, Precursor NOx, and CO2 (continued) – Parts 1, 2, 3**

	Trips	17 Emission Factor	VMT	17 Emission Factor	Tot gm	Tot ton
<b>PM 2.5</b>						
• From Starts	5,068	0.0312			158	0.0002
• From Running			111,518	0.0115	1,282	<u>0.0014</u>
<b>Total PM 2.5 reduced (tons)</b>					<b>Daily</b>	<b>0.0016</b>
					<b>Annual</b>	<b>0.400</b>
<b>PM 2.5 Precursor NOx</b>						
• From Starts	5,068	1.3603			6,894	0.0076
• From Running			111,518	0.2019	22,515	<u>0.0248</u>
<b>Total PM 2.5 Precursor NOx reduced (tons)</b>					<b>Daily</b>	<b>0.0324</b>
					<b>Annual</b>	<b>8.100</b>
<b>CO2</b>						
• From Starts	5,068	227.06			1,150,740	1.27
• From Running			111,518	380.68	42,452,672	<u>46.80</u>
<b>Total CO2 reduced (tons)</b>					<b>Daily</b>	<b>48.07</b>
					<b>Annual</b>	<b>12,016.1</b>

**PART 4 - Bike to Work Day Credit****Participants' riding percentage and frequency**

Number of riders	24,539	(BTWD registration data, 2015-2017; 2016 and 2017 adjusted for participation also in 2015)
% biking to work before event	86.3%	(BTWD survey)
% new riders	8.5%	(BTWD survey)
Number of new riders	2,086	
% who increase riding days	22.9%	(BTWD survey)
Number of increased riders	5,619	
<b>Total placements</b>	<b>7,705</b>	(Total new + increased riders)

**Change in Bike Days**Summer Biking

% new riders in summer	7.6%	(BTWD survey)
Weekly new bike days summer	1.4	(BTWD survey)
Weekly new bike days summer	2,611	(total riders x % new ride summer x ave days biking summer)
% increased riders in summer	19.9%	(BTWD survey)
Weekly increased bike days summer	1.7	(BTWD survey)
Weekly increased bike days summer	8,302	(total riders x % inc ride summer x ave days biking summer)

## Appendix 5, continued

## PART 4 (Bike to Work Day) (continued)

Winter Biking

% new riders biking winter	6.5%	(BTWD survey)
Weekly new bike days winter	1.3	(BTWD survey)
Weekly new bike days winter	2,074	(total riders x % new ride winter x ave days biking winter)
% increased riders biking winter	14.6%	(BTWD survey)
Weekly increased bike days winter	1.9	(BTWD survey)
Weekly increased bike days winter	6,807	(total riders x % incr ride winter x ave days biking winter)

**Additional Bike Days (New and Increased Riding)**

• NEW/INC bike days summer	10,913	(weekly new and increased bike days summer)
• NEW/INC bike days fall-winter	8,881	(weekly new and increased bike days winter)
• Total additional bike days summer	305,564	(new/inc weekly summer days x 28 weeks – Apr-Oct)
• Total additional bike days winter	195,382	(new/inc weekly winter days x 22 weeks – Nov-Mar)
• Total additional bike days - year	500,946	(summer bike days + winter bike days)
• Additional bike trips - year	1,001,892	(annual bike days x 2 trips per day)

**Additional Bike Trips and Vehicle Trip and VMT Reductions**

• Ave new daily bike trips	4,008	(Annual new bike trips / 250)
• % Drive alone/CP/VP on non-bike days	46%	(BTWD survey)

<b>BTWD Daily Vehicle Trips Reduced</b>	<b>1,844</b>	(daily new bike trips x DA/CP/VP percentage)
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**Daily VMT Reduced**

• Ave trip distance (mi)	10.2	(BTWD survey)
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<b>BTWD Daily VMT Reduced</b>	<b>18,809</b>	(vehicle trips reduced x average trip distance)
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**Daily Emissions Reduced – NOx and VOC – Bike to Work Day**

NOx	Trips	17 Emission Factor	VMT	17 Emission Factor	Tot gm	Tot ton
• From Starts	1,844	1.2435			2,293	0.0025
• From Running			18,809	0.1897	3,568	<u>0.0039</u>
<b>Total NOx reduced (tons)</b>					<b>Daily</b>	<b>0.0064</b>

VOC	Trips	17 Emission Factor	VMT	17 Emission Factor	Tot gm	Tot ton
• From Starts	1,844	2.5814			4,760	0.0052
• From Running			18,809	0.0688	1,294	<u>0.0014</u>
<b>Total VOC reduced (tons)</b>					<b>Daily</b>	<b>0.0066</b>

**Annual Emissions Reduced – PM 2.5, Precursor NOx, and CO2 – Bike to Work Day**

PM 2.5	Trips	17 Emission Factor	VMT	17 Emission Factor	Tot gm	Tot ton
• From Starts	1,844	0.0312			58	0.0001
• From Running			18,809	0.0115	216	<u>0.0002</u>
<b>Total PM 2.5 reduced (tons)</b>					<b>Daily</b>	<b>0.0003</b>
					<b>Annual</b>	<b>0.076</b>

Appendix 5, continued

PART 4 (Bike to Work Day) (continued)

**Annual Emissions Reduced – PM 2.5, Precursor NOx, and CO2 (continued) – Bike to Work Day**

PM 2.5 Precursor NOx	Trips	17 Emission		17 Emission		Tot gm	Tot ton
		Factor	VMT	Factor	VMT		
• From Starts	1,844	1.3603				2,508	0.0028
• From Running			18,809	0.2019		3,798	0.0042
<b>Total PM 2.5 Precursor NOx reduced (tons)</b>						<b>Daily</b>	<b>0.0070</b>
						<b>Annual</b>	<b>1.738</b>
CO2	Trips	17 Emission		17 Emission		Tot gm	Tot ton
		Factor	VMT	Factor	VMT		
• From Starts	1,844	227.06				418,699	0.461
• From Running			18,809	380.68		7,160,210	7.893
<b>Total CO2 reduced (tons)</b>						<b>Daily</b>	<b>8.354</b>
						<b>Annual</b>	<b>2,088.6</b>

**PART 5 – Referred Influence (Commuter Operations Center)**

Populations of Interest – commuters influenced by ads to contact CC

**New CC apps (does not include re-apply or follow-up)**

- FY 2015 4,754 (CC database)
- FY 2016 4,987 (CC database)
- FY 2017 5,046 (CC database)

**Total new applicants 14,787**

Total CC applicants 77,662 (includes new, re-apply, and follow-up)

New apps FY 2015-17 as % of total 19% (new apps FY 2015-17 / total CC apps)

% influenced by ads to contact CC 16% (COC applicant analysis)

% ALL apps influenced by ads 3.0% (% new apps x % influenced by ads)

**CC Impacts – FY 2015-17 (3% of total COC base for each impact below)**

<u>Travel Impacts</u>	MM Share	COC base (excluding retained credit)	
• CC placements	929	30,953	
• CC Vehicle trips reduced	351	11,691	
• CC VMT reduced	10,124	337,467	
<u>Emissions Impacts</u>	MM Share	COC base (excluding retained credit)	
• NOx reduced (daily tons)	0.0023	0.0761	Daily
• VOC reduced (tons)	0.0014	0.0452	Daily
• PM2.5 reduced (tons)	0.0320	1.0671	Annual
• PM2.5-NOx reduced (tons)	0.6090	20.2989	Annual
• CO2 reduced (tons)	1,002.0	33,398.5	Annual



Appendix 5, continued

**PART 6 – GRH Credit – From GRH Analysis**

Total GRH apps FY 2015-17	16,742	
New GRH apps FY 2015-17	10,283	61% of total applications
Estimated MM share of new GRH	16%	
Estimated MM share of GRH impact	9%	(61% of total applications x 16% MM credit)

**GRH Impacts – FY 2015-17** (9% of total COC base for each impact below)

<u>Travel Impacts</u>	<b>MM Share</b>	<b>GRH base (excluding retained credit)</b>
• GRH placements	677	7,526
• GRH Vehicle trips reduced	559	6,207
• GRH VMT reduced	15,753	175,038

<u>Emissions Impacts</u>	<b>MM Share</b>	<b>GRH base (excluding retained credit)</b>
• NOx reduced (daily tons)	0.0035	0.0384 Daily
• VOC reduced (tons)	0.0020	0.0220 Daily
• PM2.5 reduced (tons)	0.0485	0.5393 Annual
• PM2.5-NOx reduced (tons)	0.9217	10.2412 Annual
• CO2 reduced (tons)	1,538.1	17,090.0 Annual

**Mass Marketing – Summary****Total – Sum of impacts from PART 1, PART 2, PART 3, PART 4, PART 5, PART 6**

	<b>Total MM</b>	<b>Direct Ad Infl</b>	<b>'Pool Rewards</b>	<b>Car Free Day</b>	<b>BTW</b>	<b>COC Credit</b>	<b>GRH Credit</b>
Placements	23,016	12,227	344	1,134	7,705	929	677
VT reduced	10,133	6,744	342	293	1,844	351	559
Percentage total MM VT		67%	3%	3%	18%	3%	6%
VMT reduced	163,250	103,858	11,626	3,080	18,809	10,124	15,753
Daily Emissions Reduced							
NOx (T)	0.0424						
VOC (T)	0.0185						
Annual Emissions Reduced							
PM 2.5 (T)	0.556						
PM 2.5 Precursor (T)	11.369						
CO2 (T)	16,644.8						

## APPENDIX 6 – CALCULATION OF COMMUTER OPERATIONS CENTER IMPACTS

### PART 1 – Commute Information Requests

#### Populations of Interest – Commuter Connections Rideshare Applicants

##### FY 2015-17 Applicant Base (New credit) New, Reapply, Transit/other, follow-up requests

• FY 2015	27,149	(CC database)
• FY 2016	24,997	(CC database)
• FY 2017	<u>25,516</u>	(CC database)

**New FY 2015-17 assisted commuters 77,662**

##### Pre-FY 2015 Applicant Base (Retained credit)

• Applicants Pre-FY 2015	5,827	(CC database)
• Valid contact percentage	63%	(Retention rate survey)

**Retained Pre-FY 2015 applicant base 3,671**

#### Distribution of In/Out MSA

##### FY 2015-17 Applicant Base (New)

Within MSA	58%	45,044	(Commuter Connections placement survey)
Outside MSA	42%	32,618	(Commuter Connections placement survey)

##### Pre-FY 2015 Applicant Base (Retained)

Within MSA	58%	2,129
Outside MSA	42%	1,542

#### **COC Placement Rates and Placements**

(MSA base x MSA placement rate)

##### FY 2015-17 Applicants (New)

	Factor	Placements
• Within MSA – continued rate	32.3%	14,549 (Commuter Connections placement survey)
• Within MSA – temporary rate	4.7%	2,117 (Commuter Connections placement survey)
• Outside MSA – continued rate	38.2%	12,460 (Commuter Connections placement survey)
• Outside MSA – temporary rate	5.6%	1,827 (Commuter Connections placement survey)

##### Pre-FY 2015 Registrants (Retained)

• Within MSA – continued rate	19.5%	415 (Retention rate survey)
• Outside MSA – continued rate	19.5%	301 (Retention rate survey)

<b>Total Placements</b>	<b>31,669</b>
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#### **VTR Factors and Daily Vehicle Trips Reduced (continued only)**

(MSA cont placement x MSA cont VTR factor); (MSA temp placement x MSA temp VTR factor x temp discount)

##### FY 2015-17 Applicants (New)

	Factor	VT Reduced
• Temporary discount	12.9%	
• Within MSA – continued VTR factor	0.40	5,820
• Within MSA – temporary VTR factor	0.18	49
• Outside MSA – continued VTR factor	0.46	5,732
• Outside MSA – temporary VTR factor	0.38	90

##### Pre-FY 2015 Applicants (Retained)

• Within MSA – continued VTR factor	0.73	303
• Outside MSA – continued VTR factor	0.73	220

<b>Total Daily Vehicle Trips Reduced</b>	<b>12,214</b>
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## Appendix 6, continued

## PART 1 – Commute Information Requests (continued)

**Commute Distance and Daily VMT Reduced**

(MSA Vehicle trips reduced x MSA distance)

**FY 2015-17 Applicants (New)**

• Within MSA - continued distance	28.9	168,198	
• Within MSA – temporary distance	26.0	1,274	
• Outside MSA – continued distance	28.9	165,655	(Actual outside distance 51.1 miles)
• Outside MSA – temporary distance	26.0	2,340	(Actual outside distance 73.6 miles)

**Pre-FY 2015 Applicants (Retained)**

• Within MSA – continued distance	19.9	6,030
• Outside MSA – continued distance	19.9	4,378

<b>Total Daily VMT Reduced</b>	<b>347,875</b>
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**Trip and VMT Adjustment for SOV Access to HOV Modes (reduce VT and VMT for AQ analysis)**

<u>Inside MSA</u>	<u>Cont</u>	<u>Temp</u>	
• SOV access percentage	72%	45%	(Placement survey)
• SOV access distance (mi)	5.5	4.2	(Placement survey)

Outside MSA

- N/A - all access VT and VMT occur outside MSA

**Adjusted VT Reduction – net of drive alone access (Within MSA VTs x SOV access %)****FY 2015-17 Applicants (New)**

• Total VT reduced	12,214	
• Within MSA access VT (deduct)	- 4,430	(sum within MSA SOV access VTs, continued, temporary)
• Outside MSA access VT	<u>0</u>	No deduction (access trips are outside MSA)

**Total VT (net of SOV access) 7,784****Adjusted VMT Reduction – net of VMT access (Within SOV access VT x SOV access distances)**

• Total VMT reduced	347,875	
• Within MSA access VMT (deduct)	- 24,336	(sum within MSA SOV access VMT, continued, temporary)
• Outside MSA access VMT	<u>0</u>	No deduction (access VMT are outside MSA)

**Total VMT (net of SOV access) 323,539****Total VT for AQ analysis 7,784****Total VMT for AQ analysis 323,539****Daily Emissions Reduced – NOx and VOC (PART 1 – Commute Information Requests)**

NOx	Trips	17 Emission		17 Emission		Tot gm	Tot ton
		Factor	VMT	Factor			
• From Starts	7,784	1.2435				9,679	0.0107
• From Running			323,539	0.1897		61,375	0.0677
<b>Total NOx reduced (tons)</b>						<b>Daily</b>	<b>0.0784</b>

## Appendix 6, continued

Daily Emissions Reduced – NOx and VOC (PART 1 – Commute Information Requests -continued)

VOC	Trips	17 Emission Factor	VMT	17 Emission Factor	Tot gm	Tot ton
• From Starts	7,784	2.5814			20,094	0.0221
• From Running			323,539	0.0688	22,259	<u>0.0245</u>
<b>Total VOC reduced (tons)</b>					<b>Daily</b>	<b>0.0466</b>

Annual Emissions Reduced – PM 2.5, Precursor NOx, and CO2 (PART 1 – Commute Information Requests)

PM 2.5	Trips	17 Emission Factor	VMT	17 Emission Factor	Tot gm	Tot ton
• From Starts	7,784	0.0312			243	0.0003
• From Running			323,539	0.0115	3,721	<u>0.0041</u>
<b>Total PM 2.5 reduced (tons)</b>					<b>Daily</b>	<b>0.0044</b>
					<b>Annual</b>	<b>1.100</b>

PM 2.5 Precursor NOx	Trips	17 Emission Factor	VMT	17 Emission Factor	Tot gm	Tot ton
• From Starts	7,784	1.3603			10,589	0.0117
• From Running			323,539	0.2019	65,323	<u>0.0720</u>
<b>Total PM 2.5 Precursor NOx reduced (tons)</b>					<b>Daily</b>	<b>0.0837</b>
					<b>Annual</b>	<b>20.925</b>

CO2	Trips	17 Emission Factor	VMT	17 Emission Factor	Tot gm	Tot ton
• From Starts	7,784	227.06			1,767,435	1.95
• From Running			323,539	380.68	123,164,827	<u>135.76</u>
<b>Total CO2 reduced (tons)</b>					<b>Daily</b>	<b>137.71</b>
					<b>Annual</b>	<b>34,428.6</b>

**Correction for Overlap between COC Base and Integrated Rideshare and GRH TERMS**

**Net COC Base = COC Base – Mass Marketing credit – Software Upgrades credit – GRH credit**

	COC Base	MM	Soft Upg	GRH	Net COC Base
Placements	31,669	929	4,178	7,703	18,859
Vehicle Trips Reduced	12,214	351	1,779	2,924	7,160
VMT Reduced (miles)	347,875	10,124	51,340	83,059	203,352
Daily Emissions Reduced					
NOx Reduced (tons)	0.0784	0.0023	0.0111	0.0189	0.0461
VOC Reduced (tons)	0.0466	0.0014	0.0064	0.0113	0.0275
Annual Emissions Reduced					
PM 2.5 (T)	1.1000	0.0320	0.1568	0.2642	0.6470
PM 2.5 Precursor (T)	20.9250	0.6090	2.9737	5.0293	12.3130
CO2 (T)	34,428.6	1,002.0	4,981.0	8,249.2	20,196.4

Notes: MM influenced commuters – from MM analysis

GRH – 63% of new apps/reapps who made an alt mode change registered for GRH = 29% of COC credit to GRH

(63% x 45.9% new/reapply share of total apps)

Appendix 6, continued

**PART 2 – Telework Credit (Non-Maryland origin / destination)**

- Credit for telework assistance provided directly to commuters who do not live or work in Maryland; credit for Maryland residents/workers is assigned to the Telework Assistance TERM

**NOTE: Calculation details for the Non-Maryland Telework credits below are shown in Appendix 2 (Telework TERM)**

Number of regional teleworkers	887,202	
% of non-MD teleworkers	55%	
Number of teleworkers (non-MD)	487,961	
Share of TW credited to COC	7.4%	Learned of telework from Commuter Connections
Total TW placements credited to COC	36,109	
Vehicle trips reduced	12,789	
VMT reduced	197,975	
Daily NOx reduced (tons)	0.0589	
Daily VOC reduced (tons)	0.0514	
Annual PM2.5 reduced (tons)	0.7250	
Annual PM2.5-NOx reduced (tons)	15.8250	
Annual CO2 reduced (tons)	21,570.0	

**Total Commuter Operations Center – Including Base COC and Telework Credit**

**Net COC = Net COC Base + Non-MD TW**

	<b>Net COC Base</b>	<b>Non-MD TW</b>	<b>Net COC</b>
Placements	18,859	36,109	54,968
Vehicle Trips Reduced	7,160	12,789	19,949
VMT Reduced (miles)	203,352	197,975	401,327
Daily Emissions Reduced			
NOx Reduced (tons)	0.0461	0.0589	0.1050
VOC Reduced (tons)	0.0275	0.0514	0.0789
Annual Emissions Reduced			
PM 2.5 (T)	0.6518	0.7250	1.377
PM 2.5 Precursor (T)	12.3121	15.8250	28.137
CO2 (T)	20,196.3	21,570.0	41,766.3

## APPENDIX 7 – CALCULATION OF SOFTWARE UPGRADE IMPACTS

### Populations of Interest – Commuter Connections Rideshare Applicants

#### FY 2015-17 Applicant Base (New credit) New, Reapply, Transit/other, follow-up requests

- FY 2015 27,149 (CC database)
- FY 2016 24,997 (CC database)
- FY 2017 25,516 (CC database)

**New FY 2015-17 assisted commuters 77,662**

Within MSA (58%) 45,044

Outside MSA (42%) 32,618

#### COC Placement Rates

- |                  | In MSA | Out MSA |                       |
|------------------|--------|---------|-----------------------|
| • Continued rate | 4.1%   | 4.4%    | (CC placement survey) |
| • Temporary rate | 1.7%   | 0.4%    | (CC placement survey) |

#### Placements

- |             |       |       |                                 |
|-------------|-------|-------|---------------------------------|
| • Continued | 1,847 | 1,435 | (Applications x continued rate) |
| • Temporary | 766   | 130   | (Applications x temporary rate) |

**Total placements 4,178**

#### Daily Vehicle Trips Reduced

##### VTR Factors

- |                      |       |       |                       |
|----------------------|-------|-------|-----------------------|
| • Continued          | 0.60  | 0.45  | (CC placement survey) |
| • Temporary          | 0.19  | 0.38  | (CC placement survey) |
| • Temporary discount | 12.9% | 12.9% | (CC placement survey) |

- |                           |       |     |                                                |
|---------------------------|-------|-----|------------------------------------------------|
| • Continued trips reduced | 1,108 | 646 | (Placements x cont. VTR factor)                |
| • Temporary trips reduced | 19    | 6   | (Placements x temp VTR factor x temp discount) |

**Total VT reduced 1,779**

#### Daily VMT Reduced

##### Ave one-way trip distance (mi)

- |             |      |      |                                   |
|-------------|------|------|-----------------------------------|
| • Continued | 28.9 | 28.9 | (Actual Outside dist. 51.1 miles) |
| • Temporary | 26.0 | 26.0 | (Actual Outside dist. 61.7 miles) |

- |                         |        |        |                                |
|-------------------------|--------|--------|--------------------------------|
| • Continued VMT reduced | 32,021 | 18,669 | (Vehicle trips x ave distance) |
| • Temporary VMT reduced | 494    | 156    |                                |

**Total VMT Reduced 51,340**

## Appendix 7, continued

**Trip and VMT Adjustment for SOV Access to HOV Modes (reduce VT and VMT for AQ analysis)**

	In MSA	Out MSA	
• SOV access % -Continued	72%	0%	(CC placement survey)
• SOV access dist (mi) – Continued	5.5	0.0	(CC placement survey)
• Non-SOV access % - Temporary	45%	0%	(CC placement survey)
• SOV access dist (mi) – Temporary	5.5	0.0	(CC placement survey)
Outside MSA – not applicable – all access outside MSA			

**VT Reduction**

• Continued SOV access VT	798	0	(Total cont VT x SOV access)
• Temporary SOV access VT	9	0	(Total temp VT x SOV access)
• Continued VT (without SOV access)	310	646	(Total cont VT – SOV access VT)
• Temporary VT (without SOV access)	10	6	(Total temp VT- SOV access VT)

**Total VT (net of SOV access) 972**

**VMT Reduction**

• Continued SOV access VMT	4,389	0	(Total cont VT x SOV % x access dist)
• Temporary SOV access VMT	50	0	(Total temp VT x SOV % x access dist)
• Continued VMT (without SOV access)	27,632	18,669	(Total cont VMT- SOV access VMT)
• Temporary VMT (without SOV access)	444	156	(Total temp VMT- SOV access VMT)

**Total VMT (net of SOV access) 46,901**

**Total VT for AQ analysis 972**

**Total VMT for AQ analysis 46,901**

**Daily Emissions Reduced – NOx and VOC**

NOx	Trips	17 Emission Factor	VMT	17 Emission Factor	Tot gm	Tot ton
• From Starts	972	1.2435			1,209	0.0013
• From Running			46,901	0.1897	8,897	<u>0.0098</u>
<b>Total NOx reduced (tons)</b>					<b>Daily</b>	<b>0.0111</b>

VOC	Trips	17 Emission Factor	VMT	17 Emission Factor	Tot gm	Tot ton
• From Starts	972	2.5814			2,509	0.0028
• From Running			46,901	0.0688	3,227	<u>0.0036</u>
<b>Total VOC reduced (tons)</b>					<b>Daily</b>	<b>0.0064</b>

**Annual Emissions Reduced – PM 2.5, Precursor NOx, and CO2**

PM 2.5	Trips	17 Emission Factor	VMT	17 Emission Factor	Tot gm	Tot ton
• From Starts	972	0.0312			30	0.0000
• From Running			46,901	0.0115	539	<u>0.0006</u>
<b>Total PM 2.5 reduced (tons)</b>					<b>Daily</b>	<b>0.0006</b>
					<b>Annual</b>	<b>0.150</b>

Appendix 7, continued

Annual Emissions Reduced – PM 2.5, Precursor NOx, and CO2 (continued)

		<b>17 Emission Factor</b>	<b>VMT</b>	<b>17 Emission Factor</b>	<b>Tot gm</b>	<b>Tot ton</b>
<b>PM 2.5 Precursor NOx</b>	<b>Trips</b>					
• From Starts	972	1.3603			1,322	0.0015
• From Running			46,901	0.2019	9,469	<u>0.0104</u>
<b>Total PM 2.5 Precursor NOx reduced (tons)</b>					<b>Daily</b>	<b>0.0119</b>
					<b>Annual</b>	<b>2.975</b>
		<b>17 Emission Factor</b>	<b>VMT</b>	<b>17 Emission Factor</b>	<b>Tot gm</b>	<b>Tot ton</b>
<b>CO2</b>	<b>Trips</b>					
• From Starts	972	227.06			220,702	0.2433
• From Running			46,901	380.68	17,854,273	<u>19.6810</u>
<b>Total CO2 reduced (tons)</b>					<b>Daily</b>	<b>19.9243</b>
					<b>Annual</b>	<b>4,981.1</b>



## APPENDIX 8 – REDUCTION IN DELAY DUE TO TERM VMT REDUCTION

The TERM Revised Evaluation Framework for FY 2015-17 highlighted the opportunity to develop new performance indicators to document societal benefits, such as mobility, health, safety, livability, and quality of life, that are generated by the Commuter Connections TDM program. As performance-based planning becomes a reality through federal and regional policy changes, a benefit of particular interest to stakeholders in the Washington metropolitan region is the impact of TERMS on the performance of the highway system. For this reason, the revised evaluation framework noted “reduction in travel delay” as an emerging metric that seeks to develop a direct relationship between VMT reduction and improved system performance.

As used in this analysis, “travel delay” refers specifically to vehicle hours of delay. Person hours of delay are typically calculated from vehicle hours of delay by applying an assumed or known vehicle occupancy factor. For example, if two people are riding in a vehicle in congestion, both experience the delay, so the person hours of delay would be twice the vehicle hours of delay. However, because this TERM analysis calculates delay reduction from elimination of single-occupant vehicles, each vehicle in the analysis includes only one person, so the hours of delay calculated in this section represents both vehicle hours of delay and person hours of delay.

Ideally, reduction in vehicle hours of delay reduction from use of TERMS would be calculated by measuring the travel speed on regional roads now, with TERMS in place, estimating the lower speed that would be experienced if vehicle trips and VMT eliminated by the TERMS were still on the road system, and comparing the current (with TERMS) to the assumed (without TERMS) conditions to estimate an aggregate delay reduction. Practically, however, this method has multiple issues, such as the need to estimate differential speeds by network links and assign TERM-reduced trips to individual network links to estimate where, and perhaps when, reduced delay occurs.

These issues make the ideal calculation beyond the current scope of the TERM analysis, but the TERM evaluation team defined a substitute method that estimates the average hours of delay for a known number of VMT and applying it to the TERM VMT reduction that would have occurred on congested roads. This calculation requires two steps. The first examines overall delay reduction and calculates a VMT to delay factor to convert VMT into hours of delay across the regional system. The second step is to estimate the share of TERM VMT reduced that would be traveling on congested roadways if the TERM services did not exist. This reduced VMT count is used because a mile traveled on a road with no congestion does not create or add to travel delay, so miles on uncongested roadways would be excluded from the benefit calculation.

### Step 1 – Estimate overall regional delay reduction

This first step establishes a relationship between TERM impacts and system performance; specifically, between VMT reduced by the TERM (TERM impact) to delay reduction (easing congestion over levels that likely would have occurred in the absence of TERMS). This relationship will be the form of a conversion factor.

In assessing the economic impacts of system performance, researchers have established the concept of “*marginal added delay*.” Marginal added delay results from the presence of one extra vehicle on the road and is measured in added hours of delay per thousands of passenger-car equivalent (pce) VMT. To establish this national conversion factor the evaluation team consulted the Trip Reduction Impacts of Mobility Management Strategies (TRIMMS) model developed by the Center for Urban Transportation Research.

TRIMMS estimates societal cost saving benefits of TDM actions for a range of societal benefits, one of which is congestion mitigation or cost of reduced hours of delay on regional roads. The TRIMMS calculation employs a default value of **61.26 hours of delay per 1,000 pce VMT**, as reported by Sinha and Labi<sup>4</sup>, who referred the Highway Economic System Requirements technical documentation.<sup>5</sup> TRIMMS uses this national default conversion factor in its evaluation of societal costs and benefits.

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<sup>4</sup> Kumares Sinha and Samuel Labi, *Transportation Decision-making: Principles of Program Evaluation and Programming*; John Wiley & Sons, 2007, p. 390.

<sup>5</sup> FHWA, Highway Economic Requirements System-State Version: Technical Report, August 2005.

### Estimate TERM VMT Subject to Congested Conditions

The second step is to estimate the TERM VMT reduced that would be traveling in congested conditions if the TERM services did not exist. A commuter traveling on a road segment with no congestion does not create or add to travel delay, so miles on uncongested roadways should be excluded from the calculation of marginal delay. This step requires information on the roads used by commuters who participate in TERM services.

Three surveys conducted by COG for the FY 2015-17 TERM analysis included questions to examine existing or likely road use by commuters who participated in TERM services. The 2014 Applicant Placement Survey assessed roadways used by commuters who participated in Commuter Connections online commute information and ridematching services. The 2016 GRH Survey examined roadway use for GRH participants. The 2016 State of Commute Survey identified roadway use for ridesharers and transit riders, on days they traveled in a personal vehicle. Note that commuters who reported full-time use of public transit were asked what roads they would expect to use if they were to drive to work. In an effort to pinpoint specific road segments used, the SOC survey also asked commuters where they entered and exited individual roadways.

For all three surveys, the samples of commuters using individual road segments were too small to calculate delay reductions by route. But it was possible from each of the surveys to estimate the percentage of commuters who commuted along Interstate highways and major state routes, roadways that would most likely experience congestion. In short, the survey data could be used to estimate the share of TERM VMT reduction that would have traveled on roads that experience peak period congestion. This adjusted VMT count could then be multiplied by the TRIMMS 61.26 hours of delay per 1000 VMT figure to estimate the hours of delay that were eliminated by the TERM-generated VMT reductions.

Table A-1 shows the estimated congested VMT to which the hours of delay per VMT factor would be applied. Because each TERM involves a specific commuter profile, the calculation was performed first for each TERM separately. Then the estimated congested VMT counts by TERM were added for a total congested VMT.

**Table A-1 – Calculation of Estimated Congested VMT by Individual TERM**

<b>TERM</b>	<b>% Commuters Using Major Roads</b>	<b>Base VMT Reduction</b>	<b>% Miles on Major Roads</b>	<b>Estimated Major Roadway VMT</b>
Maryland Telework	72%	361,204	13%	46,957
Virginia Telework	72%	9,359	13%	1,217
Guaranteed Ride Home	83%	181,335	15%	27,200
Employer Outreach	70%	1,841,429	13%	239,386
Mass Marketing	71%	163,250	13%	21,223
Commuter Operations Center	79%	452,667	14%	63,373
<b>All TERMS plus COC</b>				<b>399,355</b>

The basic calculation involves the following steps:

- 1 – Define TERM base VMT reduction
- 2 – Estimate percentage of commuters' VMT in congestion on major roads
  - Estimate percentage of TERM commuters using major roadways (from survey data)
  - Assume commuters using major roadways travel 85% of their commute miles on major roads
  - Estimate 21% share of major roadway miles experience peak period congestion<sup>6</sup>
- 3 – Multiply TERM base VMT reduction x % congested major roads VMT

To illustrate, the calculation for the Maryland Telework Assistance is provided below:

Base VMT reduction for the TERM = **361,204 VMT**

Commute major road VMT % = % commuters using major road x % of travel miles on major roads

- 72% of teleworkers use major roads (from 2016 SOC survey)
- Assume commuters using major roadways travel 85% of their commute miles on major roads
- Estimate 21% share of major roadway miles experience peak period congestion

- Estimated major road VMT % for Telework TERM = 72% x 85% x 21% = **13% major road VMT**

Major road VMT = Base VMT reduction x major road % = 361,204 x 13% = **46,957 major road VMT**

When the calculation provided above is performed for all TERMS, the total congested VMT across all TERMS equals 399,355, or about 13% of the total VMT reduced by the TERM and the Commuter Operations Center combined.

And when the major road VMT total is multiplied by the 62.16 hours of delay per 1000 VMT reduced, the estimated hours of delay reduced by the TERMS equals 24,464 daily hours of delay reduced:

Estimated delay reduction = (399,355 / 1,000) x 61.26 hours per mile = **24,464 daily hours delay reduced**

The calculation shown above uses survey or other measured data on road use to the extent the data are available, but some assumptions are required in the calculation. As noted at the beginning of this appendix, the samples of commuters using individual roads were too small for direct road-by-road analysis of delay impacts. But COG is continuing to collect data on road use by commuters who participate in Commuter Connections TERM services. Over time, the samples for roadways might become large enough for more detailed analyses. This gathering of key geographic information from the same travelers for which VMT impacts are calculated will help estimate where (on which key highways and even road segments) delay reduction occurs.

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<sup>6</sup> MWCOG periodically produces a National Capital Region Congestion Report, which provides statistics on various aspects of roadway network performance. The 2016 report for 2015 reported that 26% of Interstate roadway miles in the region and 15% of the non-Interstate National Highway System roads were congested during the morning peak period. The evaluation team averaged these two to estimate 21% congested miles for the roadways in the analysis.

## APPENDIX 9 – CALCULATION OF SOCIETAL BENEFITS GENERATED BY TERM IMPACTS

The TERM analysis is undertaken primarily to report TERM performance as compared with regional goals set for air quality conformity determination and conformity and congestion management impacts remain the central focus of the FY 2015-17 Commuter Connections TERM evaluation. But the TERMS likely do offer other benefit to residents and commuters of the Washington region, in societal objectives such as Greenhouse gas reductions, greater mobility, improved road safety, and enhanced livability/quality of life. One benefit area that is particularly increasing in importance is transportation system performance, as new performance measurement requirements are established by the Federal Highway Administration to comply with FAST Act transportation funding reauthorization.

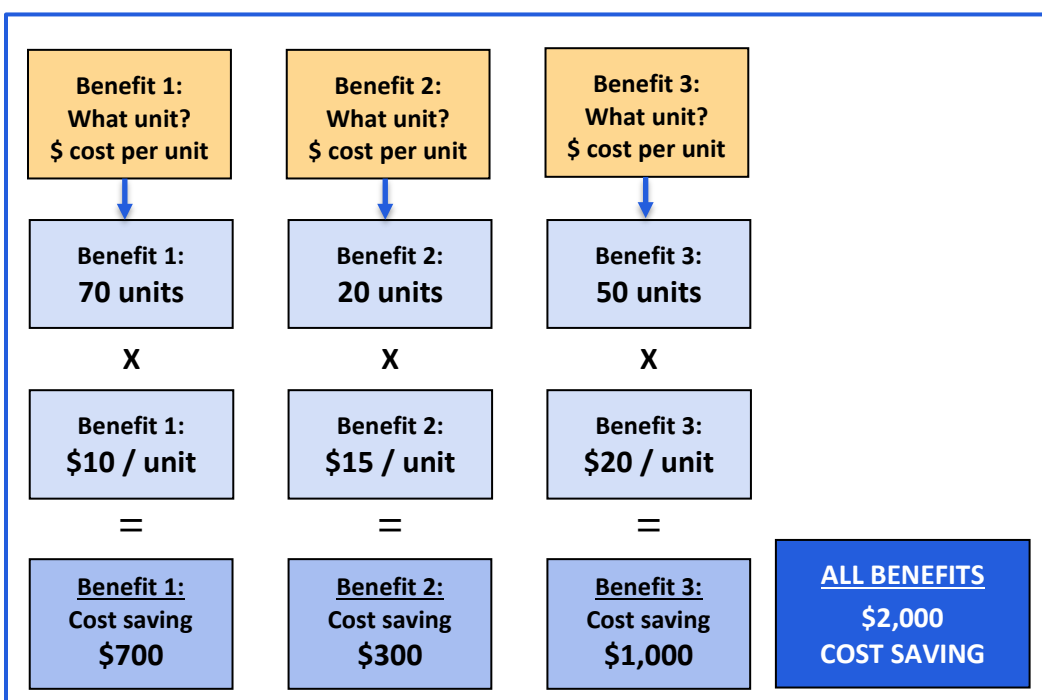
These benefits are joining congestion and air quality as forces shaping the region’s transportation policies, making them also issues relevant to Commuter Connections partners and funders. Documenting the types and magnitude of these benefits demonstrates the broad value of Commuter Connections programs to the community and the value of investments made in the programs.

The FY 2015-17 TERM evaluation included a new analysis component, to estimate regional cost savings generated for selected societal benefits of the TERM travel and emissions impacts. These benefits include the following:

- Air pollution/emissions reductions in NOx, VOC, PM 2.5 pollutants
- Greenhouse gas emissions (CO2) reduction
- Reduction in congestion (reduced hours of travel delay)
- Reduction in fuel consumption (gasoline cost saving)
- Improved road safety (accidents reduced per 1 million VMT)
- Noise pollution reduction (reduced motor vehicle noise)

Figure 2 below shows the basic method for calculating societal cost savings. The approach requires defining the unit of benefit associated with each type of benefit and cost per unit of benefit. The calculation then multiplies the benefit units by a unit cost factor and sums the individual benefit cost savings for a total across all benefits.

**Figure 2 – Example Calculation of Societal Benefits Cost Savings for Three Benefits**



**Define Units of Benefits and Cost Saving per Benefit Unit** – First, the analysis must define a unit measure that represents performance for each benefit. For example, the benefit unit for traffic congestion reduction is the vehicle hours of peak period travel delay reduced and the unit of benefit for reduction in fuel consumption is gallons of gasoline saved (not used). The analysis also must define for each benefit the financial value, or societal cost saving, that a unit of benefit provides. For travel delay reduction, the unit cost is typically a value of time equal to an hourly wage rate. For fuel consumption saving, the unit cost would be the average cost of a gallon of gasoline.

**Calculate Total Benefit Units** – After the benefit units have been defined, the analysis calculates the number of units of benefits generated. The method to calculate units of benefit is specific to the benefit, so the methods can vary by benefit, but in this TERM analysis, all are derived from some measure of travel behavior impact, such as reductions in vehicle trips and/or vehicle miles traveled (VMT).

Continuing the example of travel delay reduction, the analysis calculates the number of hours of travel delay that the TERM eliminated. As described in Appendix 8, this count was made by estimating the VMT removed from congested roadway segments, then dividing that VMT count by a conversion factor of hours of delay reduced per 1000 VMT. Other benefits have similar but unique formulas to convert travel changes into benefit units. These conversion methods are described later in this appendix.

**Calculate Cost Saving for Each Benefit and Total Cost Saving** – The societal cost saving for each benefit is then calculated by multiplying the number of benefit units by the cost saving per unit factor. The cost saving for delay reduction would be calculated by multiplying the hours of travel delay reduced by the average wage rate for workers in the region. Similar calculations are made for the other benefits in the TERM analysis, then the cost savings for individual benefits are summed to calculate the total cost saving for all benefits together.

In all cases, the TERM VMT reduction was the starting point, with conversions made to translate VMT reduction into units of benefit. For most benefits, the method used to derive the units of benefit and the unit cost factors were obtained from the Trip Reduction Impacts of Mobility Management Strategies (TRIMMS™) model developed by the Center for Urban Transportation Research (CUTR). TRIMMS™ estimates societal cost saving benefits of TDM actions for the societal benefits shown above. Following are details of the calculation methodology and calculation results for each TERM.

#### Air Pollution/Emissions Reductions and Greenhouse Gas Reductions

Air pollution has various adverse societal consequences, in particular for human health and for physical impacts on the environment. Health research has documented links between increased levels of pollution and higher levels of respiratory and cardiopulmonary illness, with the greatest risk and incidence occurring among children, the elderly, and people with related diseases. Air pollution also can have negative environmental impacts, through reduced visibility, and damage to agricultural and forest land. Motor vehicles contribute to air pollution through pollutants emitted while vehicles are starting and operating. Thus, TERMS that reduce vehicle emissions contribute to less polluted air and offer benefits from reduction in the healthcare costs associated with pollution-related illness and costs incurred to repair environmental damages.

The TERM analysis calculates the societal cost of four primary air quality pollutants: nitrogen oxides (NO<sub>x</sub>), volatile organic compounds (VOC), particulate matter 2.5 microns (PM<sub>2.5</sub>), and PM<sub>2.5</sub> NO<sub>x</sub> precursors. These four pollutants are strongly associated with the health and environmental damage and with motor vehicle operation.

The TERM analysis also calculates the societal cost for Greenhouse gas emissions, defined as tons of carbon dioxide (CO<sub>2</sub>). Its environmental role is similar to that for other air pollutants, in that motor vehicle emissions are a primary contributor to the problem, but unlike VOC and NO<sub>x</sub> emissions, which dissipate relatively quickly, greenhouse gas emissions accumulate over time in the atmosphere, effecting a cumulative increase in the average global temperature. A warming planet presents potentially very serious and very long-term environmental consequences, including more extreme drought but also more extreme storms, rising sea level that threatens coastal lands, and the loss of arctic sea ice and the ecosystems that rely on it, among other concerns.

The societal cost for emission reduction can be calculated by estimating the tons of pollutant emitted and multiplying by the societal cost of one ton of pollutant. For example, the equation for NOx cost saving would be:

$$\text{Cost saving for NOx reduction} = ((\text{VMT reduced} \times \text{gm/mi NOx emission factor}) + (\text{VTrips reduced} \times \text{gm/trip reduced})) / \text{gm per ton conversion factor} \times \$ \text{ cost per tons NOx reduced}$$

**Calculating Benefit Units and Cost per Unit of Benefit** – The emission factors are related to the types and ages of vehicles being operated and the speed and other conditions of travel and will vary by metropolitan region. They are most accurately derived through runs of emission models, such as the Environmental Protection Agency’s MOVES (Motor Vehicle Emission Simulator) model used by MWCOG, which takes into account the types and ages of vehicles, the speed and operating conditions experienced by travelers, and atmospheric conditions, each of which can affect emission rates.

The dollar costs per ton of pollutant applied in the TERM analysis are taken from CUTR’s TRIMMS™ model. As described in the TRIMMS™ User Manual (Version 3.0), TRIMMS™ uses costs associated with damage to health, visibility, and physical impact on the environment. TRIMMS™ “adopted the costs estimates of Delucchi, who estimated costs for several impact categories for urban areas of the U.S. in 1991. Delucchi recently updated the original values to account for changes in information about pollution and its effects. He customizes these estimates by using regional exposure scalars to get from the average exposure basis in U.S. urban areas to the average exposure in each of the metropolitan statistical areas. According to Delucchi, population density is the best simple measure of exposure to air pollution. The original 1991 \$/Kg are converted to current dollar values using the consumer price index (CPI). These estimates are scaled to each individual region using the ratio of median household income of each area to the U.S. median household income.<sup>7</sup>

**Cost Saving Calculation** – TRIMMS™ methodology estimates benefits for various air pollution emissions. The model calculates emissions by multiplying exhaust tailpipe emission rates generated from the EPA Agency Motor Vehicle Emission Simulator (MOVES2010a) in grams per mile to the VMT reduced. But, because the TERM analysis estimates emissions using locally-specific emission factors derived by MWCOG or the regional conformity determination, the evaluation team calculated emission reductions outside of the TRIMMS™ model, but then applied the default daily costs per day by pollutant to the TERM emissions estimates to calculate air pollution societal benefit costs. The relevant emissions calculations are presented in Table A-2.

**Table A-2 - Daily Air Pollution and Climate Change Societal Benefit Cost Savings Generated by FY 2015-17 TERM and Commuter Operations Center Impacts**

Societal Benefit	Benefit Unit	Benefit Base Units <sup>1)</sup>	Cost per Unit of Benefit <sup>2)</sup>	Total Daily Cost Saving
Air pollution				
- NOx	Tons NOx removed	0.770 T	\$1,612	\$1,241
- VOC	Tons VOC removed	0.548 T	\$133	\$73
- PM 2.5	Tons PM 2.5 removed	0.040 T	\$15,107	\$604
- PM 2.5 NOx	Tons PM 2.5 NOx removed	0.820 T	\$1,612	\$1,322
<b>Total air pollution</b>				<b>\$3,240</b>
<b>Greenhouse gas</b>	<b>Tons CO2 removed</b>	<b>1,244 T</b>	<b>\$36</b>	<b>\$44,781</b>

1) Daily tons of emissions reduced calculated in TERM analysis using MWCOG emission factors.

2) Cost per tons of emissions reduced obtained from TRIMMS™.

<sup>7</sup> TRIMMS™ User Manual, Version 3.0, Center for Urban Transportation Research, USF.

As shown, the daily benefit cost saving for all air pollutant components combined is \$3,240 per day, with a per pollutant range from a low of \$73 per day (VOC) to a high of \$1,241 (PM 2.5 precursors NOx). The daily cost saving for Greenhouse gas reductions, defined by a benefit unit of tons of CO2 reduced, equals \$44,781 saved per day.

### **Noise Pollution Reduction**

The societal benefit for noise pollution reduction is related to the reduced noise associated with the vehicle travel that has been eliminated from the roadway. Noise costs refer to negative externalities associated with motor vehicle noise emissions such as noise from engine acceleration and vibration, tire contact on road surfaces, and horn usage. Traffic noise is an annoyance, but has real health effects from impaired hearing, increased stress, and sleep disruption, and can contribute to reduction in property values in areas with high or sustained noise levels. An analysis of cost saving from noise pollution reduction estimates how much noise will be reduced and multiplies that reduction by a unit cost factor that represents the cost of abatement for that noise level.

$$\begin{aligned} \text{Cost saving for noise reduction} &= \text{Total VMT reduced} \\ &\quad \times \text{Noise reduction per VMT reduced} \\ &\quad \times \$ \text{ cost per adjusted VMT} \end{aligned}$$

**Calculating Benefit Units and Cost per Unit of Benefit** – The TERM analysis applies the approach and benefit unit and unit cost factors from the TRIMMS™ model. TRIMMS™ applies a unit benefit factor of 1.0 to convert total VMT reduced to a noise reduction component. It then multiplies the adjusted VMT by a noise costs of \$0.0223 per mile (derived from a literature review) to estimate the societal cost savings. The composite cost, which includes both health and property value impacts are scaled to account for cost of living differentials between national averages and the Washington metropolitan region.

This calculation estimates a total cost saving for noise pollution reduction of \$67,106 per day, as shown below:

Total daily VMT reduced by TERM programs = 3,009,244

Noise pollution daily cost saving = 3,009,244 x \$0.0223 per VMT = **\$67,106 per day**

### **Congestion (Delay) Reduction**

A third societal benefit is cost savings from reductions in traffic congestion. Traffic congestion slows the flow of traffic, resulting in slower travel speeds and longer trip times. Longer trips create societal dis-benefit primarily through lower business productivity, reduced access to the workforce, and loss of personal time for travelers who travel in congested conditions. The impact of traffic congestion typically is defined by the additional travel time or travel delay experienced by vehicle operators. When TERMS remove vehicles and VMT from congested segments of road, travel speeds on those road segments increase, resulting in shorter trip times and less delay. Because the TERM analysis assesses benefits related to commuting travel, the benefit unit assigned to traffic congestion in the analysis is reduced vehicle hours of peak period travel delay.

Appendix 8 described the method used in the TERM analysis to estimate vehicle hours of delay reduction. This approach estimates the percentage share of the TERMS' total VMT reduced that would have traveled on congested roadways and applies a per VMT delay factor to the reduced VMT to estimate the reduced hours of delay. For example, if 30% of the VMT reduced would have traveled on congested roadways during the peak period, how many additional hours of travel delay would be expected? The hours of delay reduced are then multiplied by a cost per hour of delay to estimate the total cost saving from reduced congestion.

$$\begin{aligned} \text{Cost saving for reduced congestion} &= \text{Congested VMT reduced} \\ &\quad \times \text{Marginal delay hours per VMT} \\ &\quad \times \$ \text{ cost per hour of delay} \end{aligned}$$

**Calculating Benefit Units and Cost per Unit of Benefit** – As shown in Appendix 8, the calculation of “congested VMT” discounted the total VMT reduced to include only miles traveled on Interstate highways and major roadways

in the Washington metropolitan region. The method additionally discounted to include only VMT that would have traveled in congested conditions to align with the marginal delay factor used by TRIMMS™ to convert VMT reduced into hours of delay reduction across the regional system. This factor is a national default value of **61.26 hours of marginal delay per 1,000 passenger car equivalent VMT**.

The unit cost of an hour of delay, often referred to as the value of travel time savings (VTTS), reflects the opportunity cost of time spent traveling that could be used for other activities. The demand for travel is derived from the benefit of accessing a destination, rather than the travel itself. Thus, time spent traveling has a negative value and a reduction in travel time represents a positive benefit. In its simplest form, the value of travel time saving includes costs to businesses in lost productivity and costs to travelers in lost personal time.

Transportation economic analyses typically value an hour of time saved as a labor wage rate. The VTTS will depend on the traveler, the circumstances of the trips, and the travel alternatives. The U.S. Department of Transportation (USDOT) published Departmental guidance regarding value of time for transportation economic analyses to “assist analysts in developing consistent evaluations of actions that save cost or time in travel.”<sup>8</sup> For commuting, when travelers have a defined and non-discretionary trip purpose (getting to/from work), and for TDM strategies, which most often are available to a wide range of commuters, a cost saving analysis can reasonably approximate VTTS over the entire working population, using an average hourly wage rate over all commuters. The USDOT guidance recommends using a VTTS of 100% of the median hourly wage rate, including benefit costs, for “on-the-clock” local business/commercial travel and 50% of the median hourly wage rate, excluding benefits, for personal travel.

However, a consideration that is of great relevance to analysis of the TERMS is that the value travelers place on a congested minute appears to be different than the value for non-congested time, as much as 1.5 to 2.5 times the value of time spent in uncongested travel, depending on the extent of congestion. A substantial body of transit and mode choice research has documented differential values of in-vehicle travel time, out-of-vehicle wait time, and transfer times for transit. Travelers experience wait time and transfer time as longer than the actual time and experience travel time as shorter than actual time. For example, the USDOT guidance recommends that personal time spent walking or waiting, as is common for the rideshare, transit, bicycle, and walking trips generated by TDM strategies, also be valued at 100% of wage rate.

The average wage rate for the TERM analysis would be a composite rate comprised primarily of the local personal travel value, which would suggest a value closer to 50% than 100% of the local wage rate. However, as noted above, USDOT applies a 100% value to access/wait time for travel in non-drive alone modes, which are the focus of the TERMS. Finally, the role of congestion in commuting can be significant, suggesting the wage rate applied should be account be closer to 100% than 50%. For simplicity, the TERM analysis uses a single VTTS of 100% of median hourly wage rate, excluding worker benefits. This number was chosen as an approximation because it is readily available from the U.S. Bureau of Labor Statistics.<sup>9</sup>

**Cost Saving Calculation** – The adjusted “major roadway” VMT calculation described in Appendix 8 estimated that 399,355, or about 13.3% of the total VMT reduced by the TERMS/COC would have traveled on major roadways in congested conditions. When this “congested VMT” total is multiplied by the 61.26 hours of delay per 1000 VMT reduced, the estimated hours of delay reduced by the TERMS equals 24,464 daily hours of delay reduced:

Estimated delay reduction = (399,355 mi / 1,000) x 61.26 hours per mile = **24,464 daily hours delay reduced**.

These hours of delay were multiplied by the \$25.13 median hourly wage rate for all employees working in the Washington metropolitan region, as reported by the Bureau of Labor Statistics. When this cost is multiplied by the 24,464 hours of delay reduced, the total congestion (delay) reduction benefit equals **\$614,793 per day**.

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<sup>8</sup> The U.S. Department of Transportation (USDOT), September 28, 2011, Memorandum Subject: Revised Departmental Guidance on Valuation of Travel Time in Economic Analysis. [https://www.transportation.gov/sites/dot.dev/files/docs/vot\\_guidance\\_092811c.pdf](https://www.transportation.gov/sites/dot.dev/files/docs/vot_guidance_092811c.pdf)

<sup>9</sup> U.S. Department of Labor, Bureau of Labor Statistics (BLS) wage data May 2016 – median hourly wage rate for all occupations combined; [https://www.bls.gov/oes/current/oes\\_nat.htm](https://www.bls.gov/oes/current/oes_nat.htm)



### **Excess Fuel Consumption Reduction**

A reduction in vehicle use results in a direct reduction in the amount of fuel consumed for travel. The TEMR analysis defines the societal benefit of reducing fuel use as the cost saved when gallons of fuel are not purchased. Reduced vehicle use also results in other vehicle operating savings, such as reduced vehicle maintenance and depreciation, but these costs are excluded from the analysis. The cost saving for reduction in fuel use is calculated by converting the VMT reduction into gallons of fuel saved and multiplying by an average fuel cost per gallon:

$$\begin{aligned} \text{Cost saving for reduced fuel consumption} &= \text{Total VMT reduced} \\ &\quad / \text{Fuel consumption factor (miles per gallon)} \\ &\quad \times \$ \text{ cost per gallon of fuel} \end{aligned}$$

**Calculating Benefit Units and Cost per Unit of Benefit** – Fuel consumption has a direct relationship with the number of vehicle miles traveled and is commonly defined by dividing the total VMT by the miles per gallon (mpg) fuel consumption rate. Fuel consumption per mile varies by vehicle type and by travel speed and operating conditions. For example, a large sport utility vehicle (SUV) uses more gasoline per mile or per hour than does a small compact car. And vehicles use different amounts of fuel when traveling at slow speeds than high speeds, with higher speeds generally more efficient use of fuel. TRIMMS™ methodology uses a default value of 18.0 miles per gallon fuel efficiency. This national factor represents the average fuel economy of a typical commuting vehicle in the passenger vehicle fleet, including both large and small vehicles, cars, SUVs, and vans and trucks used as commuting vehicles.

TRIMMS™ methodology uses a default average \$4.00 cost per gallon of fuel. For the TERM estimate a lower per gallon cost was applied. The U.S. Energy Information Administration published average gasoline prices for various parts of the country. In June 2017, the average cost reported for the Mid-Atlantic region was \$2.51 per gallon.<sup>10</sup> The result of these calculations is as follows:

Total daily VMT reduced by TERM programs = 3,009,244

Estimated gallons of fuel saved = 3,009,244 miles / 18.0 miles per gallon = 167,180 gallons

Excess fuel consumption daily cost saving = 167,180 gallons x \$2.51 per gallon = **\$419,622 per day**

The calculation estimates a fuel saving of 167,180 gallons per day and a cost saving from reduction in fuel use of \$419,622 per day.

### **Improved Road Safety (Accident Reduction)**

A reduction in motor vehicle travel generates a benefit of improved road safety by reducing the likelihood of a motor vehicle accident occurring. Quite simply, as vehicles are removed from a roadway, the remaining vehicles have a reduced risk of accidents. The cost saving from reduced vehicle accidents is equal to the reduced risk of a crash multiplied by the economic cost of the average accident.

The TERM analysis applies the road safety/accident reduction approach from the Health and Safety element of the TRIMMS™ methodology. TRIMMS™ applies expected crash rates for accidents of various severities to estimate an overall crash probability per 1 million VMT. In the TERM analysis, this crash risk factor is multiplied by the total VMT reduced by the TERMS to estimate the number of likely crashes that would have been avoided by the reduction in vehicle travel. The number of anticipated crashes is then multiplied by the average cost per accident to estimate the total cost saving:

$$\begin{aligned} \text{Cost saving for improved road safety} &= \text{Total VMT reduced} \\ &\quad \times \text{Expected crashes per 1,000,000 VMT} \\ &\quad \times \$ \text{ cost per accident} \end{aligned}$$

<sup>10</sup> Weekly Retail Gasoline and Diesel Prices, June 2017. U.S. Energy Information Administration. [https://www.eia.gov/dnav/pet/pet\\_pri\\_gnd\\_dcus\\_r1y\\_m.htm](https://www.eia.gov/dnav/pet/pet_pri_gnd_dcus_r1y_m.htm)

**Calculating Benefit Units and Cost per Unit of Benefit** – The value of reduced accidents is calculated by multiplying the estimated number of crashes by crash type by the cost per occurrence of each crash type. TRIMMS™ estimates a composite cost per unit benefit (crash avoided) that includes vehicle crash-related monetary costs for property and personal injury damages caused by collisions, and nonmonetary costs, for pain and loss of productivity. The TRIMMS™ methodology starts with the VMT reduction and applies a multi-level calculation that takes into account the occurrence probability of accidents with varying levels of severity (KABCO Injury Classification Scale)<sup>11</sup> and the average cost per type of accident. Crashes with minor property damage have a higher likelihood of occurring but a lower cost per occurrence. Conversely, crashes with serious or fatal injuries are less likely to occur but have a high societal cost when they do happen. Table A-3 shows crash types, occurrence probabilities and anticipated costs.

**Table A-3 – Crash Costs by Injury Severity**

KABCO Injury Classification Scale	Probability per 1 M VMT	Cost per Occurrence	Expected Cost per 1 M VMT <sup>1)</sup>
No injury (O)	1.00000	\$3,650	\$3,650
Possible injury (C)	0.00055	\$55,768	\$31
Non-incapacitating evident injury (B)	0.00011	\$2,828	\$3
Incapacitating injury (A)	0.00194	\$783,341	\$1,520
Fatal injury (K)	0.00776	\$1,408,533	\$10,930
Overall probability and cost	1.01136		\$16,134
<b>Weighted cost per 1 M VMT <sup>2)</sup></b>			<b>\$15,952</b>

1) Expected cost per 1 million VMT = Probability of occurrence in 1 million VMT x average cost per occurrence.

2) Weighted cost per 1 million VMT = Overall cost ÷ Overall probability.

The calculation in Table A-3 produces an average composite risk of 1.01136 vehicle crashes per 1 million VMT and an average weighted cost per crash of \$15,952. Note that this crash cost accounts for both the high probability (1.0000 per 1M VMT) but low cost (\$3,650) of a no injury crash and the low probability (0.0076 per 1M VMT) but high cost (\$1.4 M) of a fatal injury cost.

The calculation estimates that 3.043 crashes will occur over the 3.009 million VMT reduction. At a per occurrence cost of \$15,952, the total cost saving from crash reduction is \$48,543 per day.

Total daily VMT reduced by TERM programs = 3,009,244

Expected crash occurrence = (3,009,244 miles / 1,000) x 1.01136 crash per 1000 VMT = 3.043 crashes

Health and Safety daily cost saving = 3.043 crashes x \$15.952 per crash = **\$48,543 per day**

### **Total Societal Benefit Cost Saving**

Table A-4 presents the cost saving associated with each type of benefit and the overall societal cost saving calculated for the TERMS and the Commuter Operations Center combined.

<sup>11</sup> Federal Highway Administration. (2017, June 30). *KABCO Injury Classification Scale and Definitions*. Retrieved from FHWA Highway Safety Improvement Program - Safety Performance Management : [https://safety.fhwa.dot.gov/hisp/spm/conversion\\_tbl/pdfs/kabco\\_ctable\\_by\\_state.pdf](https://safety.fhwa.dot.gov/hisp/spm/conversion_tbl/pdfs/kabco_ctable_by_state.pdf)

**Table A-4 – Daily Air Pollution and Climate Change Societal Benefit Cost Savings Generated by**

Societal Benefit	Benefit Unit	Benefit Base Units	Cost per Unit of Benefit	Total Daily Cost Saving
Air pollution				
- NOx	Tons NOx removed	0.770 T	\$1,612	\$1,241
- VOC	Tons VOC removed	0.548 T	\$133	\$73
- PM 2.5	Tons PM 2.5 removed	0.040 T	\$15,107	\$604
- PM 2.5 NOx	Tons PM 2.5 NOx removed	0.820 T	\$1,612	\$1,322
Greenhouse Gas Emissions	Tons CO2 removed	1,244 T	\$36	\$44,781
Noise pollution	Total VMT reduced	3,009,244 VMT	\$0.0223	\$67,106
Congestion	Hours of delay reduced	24,464 hours	\$25.13	\$614,793
Excess fuel used	Gallons of fuel saved	167,180 gal	\$2.51	\$419,622
Health/safety <sup>1)</sup>	Accidents avoided/1 M VMT	3.043 acc.	\$15,952	\$48,543
<b>All benefits</b>				<b>\$1,198,085</b>

1) Health and safety benefit base units and cost per unit are weighted averages of accident occurrences by severity.

As shown, the combined TERM/Commuter Operations Center impacts generate about \$1.2 million of daily cost saving across the societal benefits included in the calculation. The largest share of the cost saving is in reduction of congestion; reduced hours of travel delay are valued at over \$614,793 per day, or about 51% of the total daily benefits. Reduction in fuel used accounts for about 35% of the total daily benefit (\$419,622). Noise pollution reduction generates about 6% and air pollution/climate change benefits and health/safety accident reduction benefits each are responsible for about 4% of the total cost saving.