ITEM #2A

National Capital Region
Transportation Planning Board
COMMUTER CONNECTIONS PROGRAM

Transportation Demand Management (TDM)
Program Elements
DRAFT Revised Evaluation Framework
FY 2018 – FY 2020

Prepared for:

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Executive Summary

Overview of the Evaluation Framework

The Commuter Connections Program of the Metropolitan Washington Council of Governments (COG), in concert with program partners, is responsible for implementing a package of Transportation Demand Management (TDM) program elements in the metropolitan Washington region. The objective of these elements is to improve the travel experience of regional commuters and support regional efforts to meet air quality goals and mitigate growth in vehicle miles traveled. The four TDM program elements covered by this evaluation framework include:

- Maryland and Virginia Telework Assistance – The Maryland portion of this element 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 for 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. This program element includes the efforts of jurisdiction sales representatives to foster new and expanded trip reduction programs. The Employer Outreach for Bicycling component 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 program element.

Commuter Connections also operates the Commuter Operations Center (COC), providing direct commute assistance services, such as carpool and vanpool matching, transit information, and other travel information services through telephone and internet assistance to commuters. The COC supports each of the four program elements described above.

Note that the TDM program elements included in the Commuter Connections evaluation framework do not encompass all the TDM activities currently ongoing in the Washington metropolitan region. Many other organizations, such as states and local jurisdictions, transportation management associations, transit agencies, vanpool vendors, other transportation service providers, employers, commercial and residential building operators, and other public and private organizations also offer services that perform similar functions to the TDM program elements implemented by Commuter Connections. The impacts of these other TDM services are not addressed in this framework, but certainly are expected to provide travel and air quality benefits to the region and personal benefits to the commuters who use them.

This report provides a framework and methodology for evaluating the transportation and air quality impacts of these TDM program elements. This methodology and numerous surveys and other data collection tools described later in this report have been developed to estimate impacts of these elements for the period from July 2017 through June 2020 (FY 2018 – FY 2020). These impacts then will be compared against the goals established for each element by COG's National Capital Region Transportation Planning

Board (TPB), the region's designated Metropolitan Planning Organization (MPO). The TDM evaluation framework and analysis reports are reviewed by the Commuter Connections Subcommittee and the TDM Evaluation Group.

When the TDM program elements were first implemented, Commuter Connections elected to undertake significant evaluation for each element. This evaluation and analysis process has been ongoing since 1997. The objective of the evaluation process is to provide timely and meaningful information on the performance of each element to decision-makers and other groups, including the TPB and other regional policy makers; COG program funders; Commuter Connections staff; TDM program partners, such as local jurisdictions and Transportation Management Associations (TMA); and employers and commuters who comprise Commuter Connections' clients.

Seven previous evaluation frameworks have been prepared, for the following time periods:

- January 1997 through June 1999 (FY 1997 – FY 1999)
- July 1999 through June 2002 (FY 2000 – FY 2002)
- July 2002 through June 2005 (FY 2003 – FY 2005)
- July 2005 through June 2008 (FY 2006 – FY 2008)
- July 2008 through June 2011 (FY 2009 – FY 2011)
- July 2011 through June 2014 (FY 2012 – FY 2014)
- July 2014 through June 2017 (FY 2012 – FY 2014)

Impact Performance Measures and Calculation of Impacts

The evaluation framework presented in this document builds on the framework used in the FY 2015 – FY 2017 analysis. Several changes have been made to the TDM evaluation framework for FY 2018 – FY 2020 to update the methodology to reflect methods applied in the 2017 TDM analysis. These are described later in this document.

The evaluation process outlined in this framework applies several types of performance measures to allow for both on-going estimation of program effectiveness and for annual and triennial evaluations. Measures reflecting commuters' and users' awareness, participation, and satisfaction with the program, and their attitudes related to transportation options are examined to track program recognition and output, and program service quality. Measures documenting shifts to alternative modes following use of TDM program elements are reported to assess the effectiveness of the elements in motivating travel behavior change. Performance data is collected through surveys of users of each program and documented in the survey reports.

Program impact measures are used to quantify five key outcome results:

- Vehicle trips reduced
- Vehicle miles of travel (VMT) reduced
- Emissions reduced: Volatile Organic Compounds (VOC), Oxides of Nitrogen (NOx), Particulate Matter (PM2.5), and Carbon Dioxide (CO2) and other associated greenhouse gases
- Energy reduction (fuel saving)
- Consumer saving (commuting cost saving)

To calculate these impacts, the evaluation process uses several calculation factors derived from surveys of Commuter Connections' program applicants and/or the public-at-large. These factors include:

- Placement rate (percentage of commuters who shift to alternative modes)
- Vehicle trip reduction (VTR) factor (average daily trips reduced for each commuter placed in an alternative mode)
- Average commute trip distance
- Drive alone access percentage (proportion of rideshare and transit users who drive alone to meet their carpool, vanpool, bus, or train)

These performance measures and factors are applied within the basic methodology steps listed below to calculate program impacts for each TDM program element.

1) Estimate commuter population "base" for the TDM program element (e.g., all commuters, GRH applicants, rideshare matching applicants, Employer Outreach employees, etc.)
2) Calculate "placement rate" – Percentage of commuters in the population base who made a travel change as a result of the TDM program element
3) Estimate the number of new alternative mode placements – Multiply placement rate by the population base for the evaluation period
4) Calculate the vehicle trip reduction (VTR) factor for new placements – Average daily vehicle trips reduced per placement
5) Estimate vehicle trips reduced – Multiply number of placements by the VTR factor
6) Estimate vehicle miles traveled (VMT) reduced – Multiply number of vehicle trips reduced by average commute distance
7) Adjust vehicle trips and VMT for access mode – Discount vehicle trips reduced and VMT reduced to account for commuters who drive alone to meet rideshare modes and transit
8) Estimate NOx, VOC, PM2.5, and CO_2 emissions reduced – Multiply adjusted vehicle trips and VMT reduced by emissions factors consistent with the regional planning process
9) Estimate the energy and commuter and societal cost savings – Multiply VMT reduced by fuel efficiency and vehicle operating cost factors and by societal benefit cost factors

The calculations outlined above have been embedded into a spreadsheet used by Commuter Connections and its partners to track estimated results on a quarterly basis. A summary of these results is included in Commuter Connections' Annual Report. The factors used in the spreadsheet are updated as new surveys relevant to each element are completed. At the end of the three-year evaluation period, a TDM Analysis Report is prepared to summarize placements; reductions in vehicle trips, VMT, and emissions; and progress toward goals in each of these performance measures for the three-year period.

Throughout the evaluation period, additional reports are prepared to present results of major data collection efforts, such as the rideshare applicant placement survey, the "State of the Commute" survey of regional commuting trends and attitudes, GRH Applicant survey, and others. These reports are distributed to program partners, policy makers, and others with an interest in regional transportation.

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Table of Contents

Table of Contents (continued)

Section 1 Overview

This report provides a framework and methodology for evaluating transportation and air quality impacts of four Transportation Demand Management (TDM) program elements in the metropolitan Washington region. The objective of these elements is to improve the travel experience of regional commuters, and support regional efforts to meet air quality goals and mitigate growth in vehicle miles traveled. The four TDM program elements covered by this evaluation framework include:

- Maryland and Virginia Telework Assistance – The Maryland portion of this TDM program element 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 for 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. Includes the efforts of jurisdiction sales representatives to foster new and expanded trip reduction programs. The Employer Outreach for Bicycling component 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 TDM program element.

Commuter Connections also operates the Commuter Operations Center (COC), providing direct commute assistance services, such as carpool and vanpool matching, transit information, and other travel information services through telephone and internet assistance to commuters. The COC supports all the elements described above.

Note that the TDM program elements included in the Commuter Connections evaluation framework do not encompass all the TDM activities currently ongoing in the Washington metropolitan region. Many other organizations, such as states and local jurisdictions, transportation management associations, transit agencies, vanpool vendors, other transportation service providers, employers, commercial and residential building operators, and other public and private organizations also offer services that perform similar functions to the TDM program elements implemented by Commuter Connections. The impacts of these other TDM services are not addressed in this framework, but certainly are expected to provide travel and air quality benefits to the region and personal benefits to the commuters who use them.

The evaluation framework serves two purposes. First, it assesses Commuter Connections' progress in meeting the transportation and air quality goals established by COG's National Capital Region Transportation Planning Board (TPB) for the TDM program elements for the period July 2014 through June 2017 (FY15-FY17). Second, it guides COG's assessment of the effectiveness of each element. The TDM evaluation framework and analysis reports are reviewed by the Commuter Connections Subcommittee and the TDM Evaluation Group.

This report represents an update to the most recent of seven previous evaluation framework documents developed to evaluate results and progress toward goals during previous three-year time periods:

- January 1997 through June 1999[1]
- July 1999 through June 2002[2]
- July 2002 through June 2005[3]
- July 2005 through June 2008[4]
- July 2008 through June 2011[5]
- July 2011 through June 2014[6]
- July 2014 through June 2017[7]

The upcoming evaluation seeks to quantify the impacts of the four TDM program elements, results that will be used in regional transportation and air quality planning and congestion management efforts.

This evaluation framework report is organized into eight sections:

- Section 1 presents the framework overview.
- Section 2 defines evaluation objectives and issues guiding the process.
- Section 3 enumerates performance measures to be used to assess program effectiveness and cost effectiveness.
- Section 4 discusses evaluation components specific to each TDM program element: Maryland and Virginia Telework Assistance, Guaranteed Ride Home, Employer Outreach/Employer Outreach for Bicycling, and Mass Marketing. This section also presents evaluation activities relevant for the Commuter Operations Center (COC) and the Software Upgrade component of Integrated Rideshare, which was combined with the COC in a previous evaluation period.
- Section 5 describes the data sources and data collection tools used to collect TDM program element analysis data.
- Section 6 outlines the method to calculate travel, air quality, energy, and consumer cost impacts of the TDM program elements.
- Section 7 describes tools currently used to report Commuter Connections' evaluation results to various stakeholder audiences.

Section 8 outlines the evaluation schedule and responsibilities.

[1] Commuter Connections Transportation Demand Management Evaluation Project: Transportation Control Measures Evaluation Framework, June 30, 1997.
[2] Commuter Connections, Transportation Demand Management Evaluation Project: Transportation Emission Reduction Measures (TERMs) Revised Evaluation Framework 1999-2002, MWCOG, March 20, 2001.
[3] Commuter Connections, Transportation Demand Management Evaluation Project: Transportation Emission Reduction Measures (TERMs) Revised Evaluation Framework 2002-2005, MWCOG, March 16, 2004.
[4] Commuter Connections, Transportation Demand Management Evaluation Project: Transportation Emission Reduction Measures (TERMs) Revised Evaluation Framework 2005-2008, MWCOG, May 15, 2007.
[5] Commuter Connections, Transportation Demand Management Evaluation Project: Transportation Emission Reduction Measures (TERMs) Revised Evaluation Framework 2008-2011, MWCOG, May 18, 2010.
[6] Commuter Connections, Transportation Demand Management Evaluation Project: Transportation Emission Reduction Measures (TERMs) Revised Evaluation Framework 2011-2014, MWCOG, May 21, 2013.
[7] Commuter Connections, Transportation Demand Management Evaluation Project: Transportation Emission Reduction Measures (TERMs) Revised Evaluation Framework 2015-2017, MWCOG, March 15, 2016.

Section 2 Evaluation Objectives and Issues

Objectives of the Evaluation

The objective of the evaluation process is to provide timely and meaningful information on the performance of TDM program elements to document program benefits for regional air quality and congestion management planning, identify program enhancements that will support effective program outreach and service delivery, and guide future decision-making about funding priorities. This information includes travel and air quality impacts, such as reductions in vehicle trips, vehicle miles of travel, and emissions generated by use of Commuter Connections' TDM program elements, as well as data on commuters' travel patterns, opportunities, constraints, and attitudes. Two topics that are of particular new interest for the 2018-2020 evaluation are the contribution of Commuter Connections' TDM program elements to regional transportation-related societal goals and how the availability and use of new technologies can influence commute decisions.

Key audiences for the evaluation results include decision-makers such as the TPB and other regional policy makers; COG program funders; COG/TPB staff; Commuter Connections program partners, such as local jurisdictions and transportation management associations (TMAs); and employers and commuters who comprise Commuter Connections' clients. Specific information relevant to each group includes:

- Regional policy-makers – Impacts and cost-effectiveness of TDM program elements in contributing to regional goals for reducing congestion, enhancing transportation system performance, improving air quality, reducing energy consumption, and improving mobility and accessibility.
- Program funders – Impacts and cost-effectiveness of the TDM program elements implemented via the Commuter Connections program.
- Regional policy-makers and TDM program staff – Regional commute trends and attitudes and the collective impact of Commuter Connections programs on regional traffic and air quality. The 2018 – 2020 evaluation will continue to collect travel pattern data that Commuter Connections can provide for MWCOG and local jurisdiction analyses regarding regional transportation system performance measurement. The evaluation also will continue to compile evaluation data to assist program managers to report TDM program element benefits in ways that are meaningful to policy-makers and funders.
- COG TPB staff and Commuter Connections program partners – Potential program enhancements that will increase service effectiveness and efficiency of service delivery and attract additional commuters to alternative modes.
- Employers and commuters – Collective, regional impacts of individual participation, benefits for employers that support commute programs, and personal benefits received by commuters who use alternative modes. Evaluation information also can be useful to educate employers about feasible and effective trip reduction strategies for their specific worksite conditions.

Evaluation Principles and Issues

Several overarching principles and issues apply to evaluation of the TDM program elements and the Commuter Operations Center. They are presented here to emphasize the underlying foundation of the evaluation process.

Document Progress Toward TDM Goals and Support Program Management

- The evaluation uses common, quantitative performance measures for all TDM program elements to allow for comparisons among program elements and between program elements and other strategies that could be implemented to address congestion and air quality concerns. Consistent methodologies also enhance confidence in the results. These common performance measures are enumerated in Section 3.
- The evaluation framework allows for quarterly projection of benefits as a program management information tool. While assessment of travel and air quality benefits is the key purpose of the evaluation, the process also provides information to support administration of Commuter Connections TDM program elements.
- The evaluation process follows industry-accepted evaluation techniques and is rigorous, ongoing, resource efficient, unobtrusive for Commuter Connections partners, and compatible with regional, state, and national practices.
- The evaluation framework addresses collection of data to assist MWCOG to integrate Commuter Connections' TDM program elements into its response to the FAST Act federal performance-based planning requirements and the regional congestion management process.

Separating Impacts of Program Elements

- The evaluation separates the impacts of individual Commuter Connections TDM program elements and applies discount factors to avoid double counting benefits when a commuter uses more than one of the program element services. For example, carpools might be formed as a joint result of ridematching and GRH. These impacts must either be credited to one of the two program elements or divided between the elements. Program benefits are not necessarily additive.
- Similarly, the evaluation separates the impacts of Commuter Operations Center "basic" services from the impacts of the other TDM program elements. The method for attributing impacts to a specific element or service is discussed in Section 6. This is especially relevant for the Mass Marketing program element, because its impacts can be "direct," meaning the marketing alone motivated an alternative mode shift, or "referred," meaning the marketing influenced commuters to utilize another Commuter Connections program, such as GRH or ridematching. In such cases, the travel and air quality impacts will be assigned to the element or to the Commuter Operations Center, based on their respective influences.
- When possible, the evaluation recognizes and attempts to address the possible impacts of exogenous factors. Travel decisions also are influenced by the extent of congestion, work and home locations, economic factors, fuel prices, and other factors. User surveys must explore the reasons for shifting to alternative modes to define the relative importance of elements in influencing mode choices. Data collected through the State of the Commute survey also support this objective by suggesting exogenous factors that might have influenced travel changes.

Accounting for Prior Mode and Access Mode

- 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 or vanpool to transit). Section 6 describes the development of the

vehicle trip reduction (VTR) factor used to convert the number of alternative modes placements into the number of vehicle trips reduced, taking into account various types of before-after alternative mode combinations.

- For emission reduction evaluation purposes, it is necessary to know the access mode of carpoolers, vanpoolers, and transit riders, that is, how commuters who use these modes travel from home to Park & Ride lots, bus stops, train stations, 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 reduction, because access trips generally account for a very small portion of the total miles between home and work 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 emissions analysis.

Updating Calculation Factors and Assumptions Used in the Evaluation

- The TDM evaluation methodology applies calculation factors developed from surveys and other research conducted during the evaluation period. Revisions will be incorporated in the FY 2018 – FY 2020 evaluation as noted later in this report for each element. Additionally, regional emissions factors will be updated to reflect factors that will apply in 2020.

Apply Life-cycle Assessment to Mode Shifts to Capture the Full Duration of Benefits for TDM Impacts

- In Commuter Connections evaluations prior to 2017, mode shifts motivated by TDM program elements during the evaluation period were not carried over to the next evaluation cycle. But numerous surveys conducted for past TDM program 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 during the current cycle.

  The survey interviewed Commuter Connections online system users and GRH users who last participated in these programs prior to the start of the current evaluation period. Users were asked about their current modes, how long they had used their current modes, and what Commuter Connections services they received. Commuters who were still using alternative modes were asked if and how Commuter Connections services influenced them to continue to use alternative modes. These survey data were used to develop "retained" placement rates and other factors for the GRH TERM and for the Commuter Operations Center and the 2017 TDM analysis calculated "retained" impact credits for each of these program elements. Section 5 provides additional details on the Retention Rate survey.

Specific Evaluation Issues for Individual TDM Program Elements

In general, the analysis approaches documented in the 2017 TDM Analysis Report are used as the basis for the evaluation methods described in this framework. A sample of the calculations are included in Appendices C through H, as excerpted from the 2017 TDM Analysis Report.

- Maryland and Virginia Telework Assistance – The Telework program element 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 assessed, including: trip reduction due to telework, the mode on non-telework days, and mode and travel distance to

telework locations other than home. Telework impacts for the Maryland component of the element are estimated from the State of the Commute survey and from surveys conducted with Maryland employers that received telework information or assistance from Commuter Connections. Impacts for the Virginia portion of the element are estimated from baseline and follow-up surveys of employees at Virginia worksites of employers participating in the Telework!VA (TWVA) program. These survey data are collected by the Virginia Department of Rail and Public Transportation.

- Guaranteed Ride Home (GRH) – The primary goal of GRH is to encourage commuters who drive alone to shift to alternative modes and to encourage commuters who were ridesharing before they registered for GRH to continue or expand their use of these modes. The evaluation for GRH will estimate the influence of GRH availability on both mode shifts and frequency of ridesharing. The 2018–2020 methodology includes the "retained" component, described above, for registrants who ended their participation in GRH prior to the start of the current evaluation period but who are continuing to use alternative modes to commute.

- Employer Outreach – The evaluation of Employer Outreach applies a two-faceted approach employing empirical data on employer programs and modeled impacts. The empirical data come from the regional ACT! database of employer contacts, which includes information on TDM strategies implemented by employers at their worksite. The EPA COMMUTER model (v 2.0) applies these empirical data to project the likely change in employee commuting behavior for given changes in the employer's program.

  The COMMUTER Model uses time and cost coefficients that are compatible with coefficients used by MWCOG in regional transportation modeling. In 2007, COG and the evaluation team adjusted the cost coefficients used in the model, to correct for the COMMUTER Model's tendency to overestimate the likely impacts of financial incentives on shifts to non-SOV modes. These coefficients were used for the 2008 and 2011 evaluations. During 2010-2012, MWCOG developed a new regional travel model. This might be expected to require updated COMMUTER Model cost and time coefficients. MWCOG modeling staff reviewed the COMMUTER Model coefficients used by the consulting staff for the 2011 evaluation and determined that no further adjustment would be needed for 2014 to be consistent with the new regional model. MWCOG continues to use this regional model, thus, the coefficients used in 2011, 2014, and 2017 will be carried over for the 2018-2020 evaluation.

  The 2018-2020 methodology also will distinguish three types of Employer Outreach impacts: maintained, new, and expanded. The Employer Outreach program element has been in effect for many years. Beginning with the 2008 analysis, new Employer Outreach goals were established for the overall program and for new program activity during each new evaluation period. The Employer Outreach evaluation now calculates impacts for "maintained" employer programs and "new/expanded" programs.

  - Maintained impacts will include employers that joined EO before the start of the evaluation period (e.g., July 1, 2017), continued in the program, but made no changes since that date.
  - New impacts will include employers that joined the EO program during the current evaluation period.
  - Expanded impacts will include employers that were involved in EO before July 1, 2017, but that expanded their commute assistance services after that date.

The evaluation also estimates impacts for employers that participated in the program during the most recent past evaluation period (2015-2017), but dropped out of EO before the start of the new period. Impacts that would have been credited for these employers would have to be replaced or "back-filled" by new/expanded impacts.

Finally, employer bicycle programs, which were evaluated separately from other Employer Outreach services prior to 2008, under the Employer Outreach for Bicycling component, are now addressed within the broad Employer Outreach program element. But the contribution of these bicycle programs will continue to be calculated and reported separately.

- Mass Marketing – The critical issue for this program element is attributing changes in attitudes and behavior to the mass marketing campaign versus another TDM program element. The following types of impacts are evaluated for Mass Marketing:

  1) *"Direct marketing" impacts* generated by commuters who cite regional commute advertising messages as the reason for their commuting change
  2) *"Referred marketing" impacts* that are generated when advertising encourages commuters to submit rideshare and GRH applications
  3) *Event impacts* generated from mode shifts related to special event programs, such as the Bike to Work Day and Car Free Day events
  4) *Incentive impacts* generated by shifts to alternative modes by commuters who receive 'Pool Rewards carpool start-up and vanpool start-up/continuation incentives, Flextime Rewards incentive for shifting travel out of the peak period, and IncenTrip rewards for alternative mode trips logged using the mobile application
  5) *Dynamic ridematch impacts* generated by shifts to carpool by commuters who use the CarpoolNow dynamic ridematch mobile application

  Most of these components were addressed in the 2015-2017 TDM evaluation, but three are new for the 2018-2020 evaluation. Two new Commuter Connections incentive programs, Flextime Rewards and IncenTrip, will be analyzed for the "incentive impacts" component. The "dynamic ridematch impact" component for CarpoolNow also will be a new service analyzed under the Mass Marketing TDM program element in the 2018 – 2020 evaluation. Proposed methodologies to analyze these new programs, using a variety of data sources, are further explained in Section 4.

- Commuter Operations Center and Integrated Rideshare–Software Upgrades – Impacts for Commuter Operations Center (COC) will be evaluated as in the 2017 TDM analysis. Integrated Rideshare-Software Upgrades will continue to be evaluated as part of the COC under the Integrated Rideshare program element. However, their impacts will be calculated and reported as a sub-set of the Commuter Operations Center.

  The 2018-2020 methodology for the Commuter Operations Center also will continue two new components that were added to the methodology in the 2017 TDM analysis. First, it includes the "retained" component, described above, for online system applicants who received services before the start of the current evaluation period but who are continuing to use alternative modes to commute. Second, the COC methodology will incorporate impacts from Commuter Connections-assisted telework that occurs outside of the telework components of the Maryland and Virginia Telework Assistance program element.

Section 4 elaborates on the evaluation activities and issues for individual TDM program elements.

Section 3 Performance Measures

Performance Measures by Category

Previous Commuter Connections TDM program evaluation frameworks established performance measures for each TDM program element. Performance measures assess the extent to which the program is meeting the program objectives, in particular the travel and emission targets set by the TPB for each TDM program element, but also customer-focused performance related to service use and user satisfaction. Generally, the evaluation framework applies performance measures in the following broad categories:

- Awareness and attitudes
- Program participation and satisfaction
- Mode utilization
- Program impacts

Awareness and Attitudes

Awareness measures assess the degree to which commuters know about the Commuter Connections program and its services. Awareness has assumed a larger role in recent evaluation periods because it is a primary objective of the Mass Marketing program element. A related type of measure is commuters' attitudes, their personal feelings about their commute experience, commute travel mode options available in the region, and their willingness to consider and try new modes of travel.

- Awareness – Program awareness will be assessed by the proportion of residents and commuters who recognize the Commuter Connections "branding" and who are aware of transportation infrastructure, alternative modes, and commuter assistance services available to them. Awareness will be assessed by questions in the State of the Commute (SOC) survey and/or other surveys of the public at large.
- Attitudes – One goal of the Mass Marketing program element is to address commuters' frustration with increasing congestion. The evaluation will document travel attitudes over time, including commute ease and commute satisfaction, the extent of recent shifts to alternative modes, and the reasons and influences for those shifts. This information is currently captured in the SOC survey and will continue to be tracked as more general population surveys are conducted.

Program Participation and Satisfaction

Participation refers to indicators related to use of TDM program element services by targeted populations, for example, the number of matchlist requests, the number of GRH applicants, the number of bicyclists who register for Bike-to-Work Day, or the number of employers that participate in Employer Outreach. Participation data measure program outputs and are needed to calculate program impacts.

Satisfaction measures commuters' satisfaction with various features of TDM services and the efficiency of service delivery, for example, the speed with which requests are fulfilled and users' impression of the usefulness of the services. These measures are important to track funding, estimate staffing, and identify program improvements.

- Program Participation – Program participation will be assessed by the number of clients or customers who request individual Commuter Connections TDM program services and the number who are assisted. Participation could include the numbers of new employer who participate in Employer Outreach services, new and re-registering GRH applicants, online information system users,

telework employer sites, etc. A primary participation measure is generally the *number of applicants or users*, but other measures, specific to individual TDM program elements, also are described in Section 4. These measures are typically tracked through internal databases by Commuter Connections staff who administer each TDM program element.

- Program and Service Satisfaction – A primarily qualitative set of performance measures is suggested to assess client satisfaction and determine how well services are meeting customers' needs and expectations. Satisfaction of various customer groups is examined through questions in user surveys (e.g., GRH survey, applicant placement survey, employer satisfaction survey).

Mode Utilization

Utilization refers to new and expanded use of alternative modes motivated by use of TDM program element services, for example, the percentage of GRH registrants who shift from driving alone to an alternative mode to be eligible for GRH. Data on mode shifts is assessed through user surveys that document current mode use and modes used before receiving TDM services.

- Alternative Mode Placements – The measure of "placements" is defined as the number of commuters who shift to (i.e., are "placed" in) alternative mode arrangements following use of the Commuter Connections services. These commuters could be new carpoolers, vanpoolers, transit riders, bicyclists/walkers, or teleworkers, as well as commuters who increase use of these modes.

Program Impacts

Program impacts estimate the travel, air quality, energy, and commuter cost saving benefits of the TDM program elements. The impact measures and targets set for 2018-2020 were established by Commuter Connections following the 2017 TDM analysis. They reflect both past trends and proposed future resources and efforts by Commuter Connections and program partner staffs. This section describes several performance measures to be assessed for each element and for the program as a whole. Other performance measures specific to each element are listed in Section 4. Impact measure goals also are defined for each element in Section 4.

- Vehicle Trips Reduced – The number of vehicle trips reduced is a travel impact measure. It estimates the number of daily vehicle trips that alternative mode placements remove from the road during peak commuting periods. This is a primary indicator of congestion relief through its role in reduced delay, increased travel speed, reduced travel time, and improved roadway service levels. In essence, trip reduction equates to a roadway capacity increase, by freeing up roadway space for additional vehicles. It also is a primary input (trip end emissions) to the air quality analysis.

  Vehicle trip reduction is estimated using a *vehicle trip reduction (VTR) factor*, defined as the average number of vehicle trips reduced per day for each alternative mode placement. The VTR factor accounts for shifts from drive alone to alternative modes, shifts among alternative modes (e.g., from carpool to vanpool and from transit to carpool), increases in the days per week that a commuter uses an alternative mode, and changes in carpool and vanpool occupancy. Shifts from alternative modes to drive alone are not included, because these changes are not motivated by commuters' contact with Commuter Connections. Appendix A describes how the VTR factor is calculated.

- Vehicle Miles of Travel (VMT) Reduced – VMT reduced, a second travel impact measure, estimates the total daily miles of vehicle travel removed by mode shifts. VMT reduction is important to the air quality and energy evaluation, but also is relevant to any assessments of the roadway system performance impacts.

- Emissions Reduced – Emissions reduced measures the decrease in mobile source emissions resulting from reductions in vehicle trips or VMT. From the start of the TDM evaluations, the primary pollutants of concern were Nitrogen Oxides (NOx) and Volatile Organic Compounds (VOC), both of which are ozone precursors. The 2008 TDM Analysis added calculation of impacts for two components of particulate matter (PM), direct PM2.5 emission, and NOx precursors, and for Carbon Dioxide (CO2), the primary greenhouse gas. These impact performance measures also will be estimated in the 2018–2020 evaluation.
- Energy Saving – Energy saving, resulting when commuters reduce VMT, is defined as the reduction in the number of gallons of gasoline consumed.
- Consumer Cost Saving – Another measure of program impact is the aggregate cost savings realized by commuters who reduce daily vehicle trips and VMT.

Societal Benefit Cost Savings

A mew analysis component that was not in the 2015-2017 evaluation framework, but that was added to the 2017 TDM analysis was calculation of the societal benefit cost savings generated by Commuter Connections TDM program vehicle trip and VMT impacts. The benefits include cost savings for reductions in air pollution, greenhouse gases, and noise pollution, reduced hours of travel delay, gallons of fuel saved, and reduced vehicle crashes.

The 2017 analysis, which is summarized in Appendix I, applies benefit "unit conversion" and unit cost multipliers to translate VMT reduction impacts into units of benefits and daily cost savings for each benefit and for all societal benefits combined. 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). This societal benefits cost savings calculation also will be prepared for the 2020 TDM Analysis.

Future Review and Updates to Performance Measures

The impact measures described above were developed primarily to report the performance of TDM program elements as compared with regional goals set for them by COG's National Capital Region Transportation Planning Board (TPB) for air quality conformity determination. In 2015, air quality data compiled by COG indicated that the region was meeting federal standards for ground-level ozone and PM2.5 fine particulate matter. With this achievement, the TPB eliminated the conformity-related emission targets set for the Commuter Connections TDM program elements.

This administrative change did not eliminate, however, COG's commitment to TDM strategies. The November 2016 conformity analysis referenced the continued role of the Commuter Connections TDM strategies to the region; the Chair of COG's Air Quality Committee wrote, "We urge TPB's continued investment in … travel demand management strategies to continue to mitigate future growth in vehicle emissions."[8]

In the Visualize 2045 long-range transportation plan approved in October 2018, the TPB reiterated the important regional role of the Commuter Connections program and of the transportation options that Commuter Connections promotes and encourages. The report stated that "Commuter Connections is the major demand management component of the TPB's congestion management process and it helps

[8] Metropolitan Washington Council of Governments. Air Quality Conformity Analysis of the 2016 CLRP Amendments and FY2017-2022 TIP, November 2016. http://www1.mwcog.org/clrp/resources/2016/ConformityReportFull.pdf

support regional air quality goals" and noted that one goal in the 2014 Regional Transportation Priorities Plan (RTPP) was to "provide a comprehensive range of transportation options," which would be expected to help "protect and enhance the environment, promote energy conservation, and improve quality of life."[9] Further, the Visualize 2045 plan, which includes aspirational initiatives that go beyond fiscal constraints, defined a "call to action" for policies, programs, and projects that "better manage peak period travel demand, reduce single occupant travel, make transit more viable and affordable, and enhance existing infrastructure.[10]

The regional planning documents cited above suggest that while the regulatory focus on Commuter Connections TDM program impacts has changed, the specific performance measures defined for the TDM program elements remain valid now, as when they were initially defined and this evaluation framework does not recommend any official changes.

But the TDM program elements do offer other benefit to the Washington region, in the societal objectives noted above. Documenting and communicating the type and magnitude of these benefits will demonstrate the broad value of Commuter Connections programs to the community and reinforce the value of investments made in the programs. Documenting these contributions also will support the regional response to the new, federally-mandated, Performance-based planning and programming (PBPP) process required of states and MPOs.[11] Under this requirement, MWCOG must track a variety of performance indicators related to transportation system performance. Two indicators of particular relevance for Commuter Connections include annual per capital hours of peak hour excessive roadway delay and percent of non-single occupant vehicle travel. Commuter Connections already has begun to address these indicators through various data collection and analysis activities in the TDM evaluation and the 2018-2020 evaluation will continue to identify ways that Commuter Connections can provide useful data to support MWCOG's regional response.

The SOC and user surveys conducted throughout the evaluation period offer immediate opportunities for Commuter Connections to collect data related to system performance and other regional, societal benefits of TDM programs as well as data on other emerging transportation issues. For example, the 2013 and 2016 SOC and GRH surveys included questions about the primary roadways that commuters used for their trip to work and the time they typically arrive at work. The 2016 SOC survey also included questions to explore how residents' perceptions of transportation satisfaction are related to the availability and quality of transportation services. The 2019 SOC survey is expected to retain many of these questions and add new inquiries on the role of technology in influencing commute mode choice, commuters' use of transportation network companies and shared-mode transportation services, current and past use of transit service for commuting, and other issues related to transportation system performance.

[9] National Capital Region Transportation Planning Board. Visualize 2045: A Long-Range Transportation Plan for the National Capital Region, October 17, 2018, page 89-90.
[10] Ibid, page 34.
[11] Federal Register, Vol. 81, No. 103, Friday, May 27, 2016, page 34051, Section B.1.

Section 4 Evaluation Components for Individual TDM Program Elements

Sections 2 and 3 stated the objectives and issues guiding the evaluation process and defined several common performance measures that will be used for all TDM program elements. This section details the specific evaluation approach for each of the TDM program elements.

The TDM program elements included are:

- Maryland and Virginia Telework Assistance
- Guaranteed Ride Home
- Employer Outreach/Employer Outreach for Bicycling
- Mass Marketing
- Commuter Operations Center/Integrated Rideshare

For each element, the following information is provided:

- TDM program element description
- Goals defined for the element for 2020
- Nature of the evaluation
- Performance measures recommended for the element
- Data needed to estimate impacts and recommended data sources

Section 5 of this report provides a more detailed description of the surveys and other data sources referenced in this section. Section 8 presents a schedule for the collection of data and defines the party responsible for collecting the data. Included in the appendices are examples of how travel and emission impacts are calculated for each TDM program element. These are excerpted from the 2017 TDM Analysis Report to provide real examples of how the calculations were performed in the most recent evaluation period. These calculation methods form the basis for the refinements included in this evaluation framework.

The specific data required for each program element to calculate alternative mode placements, vehicle trips reduced, and VMT reduced are described in the individual program element evaluation component sections that follow. Additionally, some common data are needed to calculate emissions, commuter cost, and energy impacts of each element, including:

- Access mode and distance to meeting locations for alternative mode users (for air quality analysis)
- Regional emissions factors (to determine emission reductions)
- Regional fuel economy data in average miles per gallon consumed (to calculate energy saving)
- Vehicle operating costs (to estimate commuter cost savings)

4-A Maryland and Virginia Telework Assistance

Program Description

The Maryland and Virginia Telework Assistance program element is comprised of resources to help employers, commuters, and program partners initiate and expand telework programs. This program element has two components, one focused on telework among Maryland employers and commuters and a second for the Telework!VA program in Virginia.

- In the Maryland component, Commuter Connections, working with numerous partners in Maryland, assists employers to establish worksite telework programs and arrangements and provides telework information to individual commuters. This component estimates the impact of telework among commuters who work or live in Maryland that is attributable to Commuter Connections' telework assistance.
- The Virginia component of the element encompasses impacts of the Telework!VA (TWVA) program offered to employer worksites in Virginia. The program, jointly funded and administered by the Virginia Departments of Rail and Public Transportation (DRPT) and Transportation (VDOT), provides financial incentives and program development assistance to participating Virginia employers to establish and expand worksite telework programs.
- The evaluation will count Commuter Connections-assisted telework not described above through the Commuter Operations Center TDM program element.[12]

Evaluation Methodology Changes Since FY 2015 – FY 2017

- No changes since 2015-2017

Stated Goals

The purpose of the Telework program element is to increase the number of full-time or part-time home-based and telework center-based teleworkers.

Commuter Connections defined five goals for the Maryland portion of this element for 2017:

- Maintain 31,854 teleworkers
- Reduce 11,830 daily vehicle trips
- Reduce 241,209 daily miles of travel
- Reduce 0.1222 daily tons of NOx
- Reduce 0.0723 daily tons of VOC

[12] The Telework program element includes all Maryland residents, regardless of their work location, residents of the District of Columbia and Virginia who work in Maryland, and District of Columbia and Virginia residents who work at a TWVA-participating worksite. Commuter Connections also provides 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.

The goals for the TWVA portion of this element were established by the Virginia Department of Transportation and the Virginia Department of Rail and Public Transportation:

- Increase telework by 800 teleworkers at TWVA worksites
- Reduce 155 daily vehicle trips
- Reduce 2,538 daily miles of travel
- Reduce 0.0028 daily tons of NOx
- Reduce 0.0014 daily tons of VOC

Nature of Evaluation

The three populations of interest for this element include:

1 (Maryland) – Teleworkers who live and/or work in Maryland who are influenced by Telework services/assistance they receive from Commuter Connections/MWCOG to begin teleworking
2 (Maryland) – Telework employees at Maryland worksites that are assisted by Commuter Connections
3 (Virginia) – Telework employees at Virginia worksites that participate in the Telework!VA program

1 (Maryland) – For the first population, the evaluation determines the number of teleworkers who live or work in Maryland who were influenced or assisted by the Telework program element services to begin teleworking and the travel impacts of their teleworking. Data for this component come from the State of the Commute survey:

- Number of Maryland teleworkers and their frequency of teleworking
- Telework locations – the mix between home-based and non-home-based telework
- Teleworkers' commute modes and commute distance on non-telework days
- Teleworkers' travel patterns to telework locations outside the home
- Sources of information teleworkers had used to learn about telework

Placement rates and average trips reduced per placement are derived for home-based teleworkers and for those working at non-home locations.

2 (Maryland) – For the second population, the evaluation estimates the portion of teleworking influenced by the Telework program element through telework assistance to Maryland employers. This analysis uses data from a survey of telework-assisted Maryland employers to determine:

- Percentage of Maryland employers with telework programs before and after receiving telework assistance
- Percentage of teleworkers at assisted Maryland worksites before and after the employer received assistance

Thus, to estimate the share of Maryland-based telework attributable to the Telework program element, the evaluation will define the telework universe among Maryland commuters, and examine employers' and commuters' sources of information for telework and the value of that information or assistance in their starting or expanding telework programs.

3 (Virginia) – The evaluation for the third population is similar to that for the second population; the evaluation estimates the portion of teleworking influenced by direct TWVA assistance to participating Virginia employers. This analysis compares data from baseline and follow-up surveys of teleworkers at TWVA-assisted worksites to determine the percentage of teleworkers at assisted sites before and after

telework assistance is provided. The comparison of the before and after survey data will define the increase in telework resulting from TWVA assistance.

Performance Measures

Performance measures recommended to evaluate the Maryland and Virginia Telework Assistance program element include:

Maryland Component – Participation, Satisfaction, and Utilization Measures:

- Number of Maryland employers that receive telework assistance from Commuter Connections
- Number of Maryland employers that implement/expand telework programs after receiving assistance
- Number of Maryland commuters who receive telework information from Commuter Connections
- Number of Maryland commuters who begin teleworking after receiving assistance
- Number of new Maryland teleworkers – home-based and non-home based
- Maryland telework placement rate

Virginia Component – Participation, Satisfaction, and Utilization Measures:

- Number of Virginia employers that receive telework assistance through TWVA
- Number of commuters at TWVA worksites who begin teleworking after TWVA assistance is provided
- Number of new home-based TWVA teleworkers
- TWVA placement rate

Program Impact Measures (Maryland and Virginia):

- Daily vehicle trips reduced
- Daily VMT reduced (in miles)
- Daily emissions reduced (in tons of pollutants)

Data Needs and Sources

The following data are needed to assess impacts of this program element. Each data source is described in Section 5.

Data Need (Maryland Component)	*Data Source*
• Home-based teleworkers	State of the Commute (SOC) survey
• Non-home-based teleworkers	SOC survey
• Telework frequency (average days/week)	SOC survey
• Percent drive-alone on non-telework days	SOC survey
• Travel distance on non-telework days	SOC survey
• Travel distance to telework centers	SOC survey
• Commuters' source of telework information	SOC survey
• Telework at assisted employers' worksites	MD-TW assistance survey

Data Need (Virginia Component/TWVA)	*Data Source*
• Home-based teleworkers (before/since assistance)	TWVA baseline/follow-up surveys
• Telework frequency (average days/week)	TWVA baseline/follow-up surveys
• Percent drive-alone on non-telework days	TWVA baseline/follow-up surveys
• Travel distance on non-telework days	TWVA baseline/follow-up surveys

Proposed timing of data collection:

- SOC survey – January-April 2019
- Commuter Connections Telework assistance survey – Early 2020
- TWVA baseline surveys – ongoing through February 2020
- TWVA follow-up surveys – ongoing through February 2020

To avoid double counting benefits, the employers included in the Maryland and Virginia Telework Assistance program element will be cross-referenced against employers that participate in the Employer Outreach program element. The telework impacts for any employers that participate in both programs will be subtracted from their impacts in the Employer Outreach program element, but non-telework impacts for these employers will continue to be included in Employer Outreach.

4-B Guaranteed Ride Home

Program Description

The Guaranteed Ride Home (GRH) Program eliminates a real or perceived barrier to use of alternative modes – the fear of being stranded without a personal vehicle. GRH provides free return transportation by taxi or rental car in the event of an unexpected personal emergency or unscheduled overtime to commuters who carpool, vanpool, use transit, or bike or walk to work at least two times per week on average. Commuters pre-register for GRH and may use the service up to four times per year. The program also allows "one-time exception" rides provided to non-registered commuters who used an alternative mode on the day a GRH trip was needed. Commuters who wish to use GRH again in the future must then register.

Evaluation Methodology Changes Since FY 2015 – FY 2017

- No changes since 2015-2017

Stated Goals

Commuter Connections defined the following regional goals for GRH for 2017:

- Maintain 36,992 GRH applicants
- Reduce 12,593 daily vehicle trips
- Reduce 355,136 daily vehicle miles of travel
- Reduce 0.1766 daily tons of NOx
- Reduce 0.0970 daily tons of VOC

Nature of Evaluation

GRH is intended to encourage drive-alone commuters to shift to alternative modes. Additionally, GRH is expected to help maintain existing alternative mode arrangements and increase frequency of alternative mode use. The evaluation estimates the number of new alternative mode users whose shifts were influenced by GRH and the number of commuters who used alternative modes before registering who were influenced to increase use of the modes.

The GRH program element evaluation for 2018-2020 will estimate impacts for three commuter groups:

- Commuters who were registered for/participating in GRH at any time during the three-year evaluation period, even if they were no longer registered at the end of the period
- Commuters who did not register for GRH but took a "one-time exception" trip during the three-year evaluation period
- Commuters who participated in GRH prior to the evaluation period, but who are continuing to use alternative modes

Performance Measures

The following performance measures are used for GRH:

Participation, Satisfaction, and Utilization Measures:

- Number of GRH applicants
- Number of one-time exception users
- GRH placement rate
- Percentage of GRH participants who take a GRH trip
- Satisfaction of GRH users with the service

Program Impact Measures:

- Daily vehicle trips reduced
- Daily VMT reduced (in miles)
- Daily emissions reduced (in tons of pollutants)

Data Needs and Sources

The following data are needed to estimate GRH impacts. Each data source is described in Section 5.

Data Need	*Data Source*
• GRH applicants	GRH database/archived GRH database
• One-time GRH exception users	GRH database/archived GRH database
• GRH placement rate	GRH Applicant survey
• GRH VTR factor	GRH Applicant survey
• Average travel distance (trip length)	GRH Applicant survey
• GRH retained placement rate	CC Retention Rate survey
• GRH retained VTR Factor and average travel distance	CC Retention Rate survey

Proposed timing of data collection:

- Commuter Connections GRH database – ongoing
- Commuter Connections Retention Rate survey – Results from the 2016 survey will be used for the 2018-2020 TDM analysis; the next Retention Rate survey will be conducted in 2021
- GRH Applicant survey – April-May 2019
- GRH Trip Customer Satisfaction Survey – ongoing

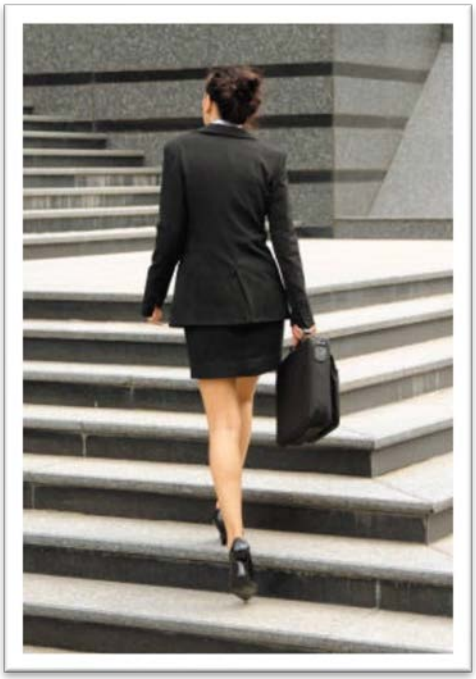
Two subgroups are identified for GRH. The first sub-group includes participants who both live and work within the Washington Metropolitan Statistical Area (MSA). The second group includes participants who work within the MSA but live outside it. Placement rates, VTR factors (average trips reduced per placement), and travel distances are estimated for each of the two sub-groups ("in MSA" and "out of MSA"). This distinction is made because credit for the "out of MSA" participants is discounted to eliminate the VMT reduction that occurs outside the MSA.

The GRH analysis also includes steps to avoid credit double-counting from overlap with two other TDM program elements. Overlap occurs between GRH and the Commuter Operations Center because some GRH applicants also obtain ridematch lists, transit information, or other commute assistance information. The COC impacts are discounted to account for this overlap. GRH results also will be adjusted to assign a portion of the GRH impacts to the Mass Marketing program element to recognize that some GRH applicants will be influenced to apply for GRH by hearing a Mass Marketing advertisement.

4-C Employer Outreach

Program Description

The Employer Outreach program element is designed to encourage employers to implement new commute assistance programs and to expand the services they offer in existing programs. In this element, jurisdiction-based sales representatives contact employers, educate them about the benefits commuter assistance programs offer to employers, employees, and the region, and assist them to develop, implement, and monitor worksite commuter assistance programs. Commuter Connections assists the sales force with the following services, designed to enhance regional coordination and consistency:



- Internet-based regional employer contact database
- Marketing and information materials
- Employer outreach sales and service force training
- Annual evaluation program
- Support to Employer Outreach Committee
- Employer satisfaction survey

Evaluation Methodology Changes Since FY 2015 – FY 2017

- No changes since 2015-2017

Stated Goals

Commuter Connections has defined the following regional goals for Employer Outreach for 2017:

Participation Goals

- Overall – 1,847 total participating employers
- Employers with bike services – 590 participating employers
- Employers without bike services – 1,257 participating employers

Impact Goals

Employer Outreach Overall (Non-bicycle plus Bicycle services)

- Reduce 82,120 daily vehicle trips
- Reduce 1,393,783 daily vehicle miles of travel
- Reduce 0.5606 daily tons of NOx
- Reduce 0.3195 daily tons of VOC

Employer Outreach Non-bicycle services

- Reduce 81,716 daily vehicle trips
- Reduce 1,391,362 daily vehicle miles of travel
- Reduce 0.5590 daily tons of NOx
- Reduce 0.3180 daily tons of VOC

Employer Outreach for Bicycling

- Reduce 404 daily vehicle trips
- Reduce 2,421 daily vehicle miles of travel
- Reduce 0.0016 daily tons of NOx
- Reduce 0.0015 daily tons of VOC

Nature of Evaluation

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? The populations of interest for this element are:

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

Differentiation Between New and Maintained Impacts – When the Employer Outreach program element was adopted, the TPB established a goal that was to be achieved by June 2005 and evaluations conducted for periods through June 2005 estimated impacts against this goal. Beginning with the 2008 Analysis, the Employer Outreach goals were re-set to include a goal for the overall program and a goal for new program activity since 2005. For this reason, the 2008, 2011, 2014, and 2017 TDM analyses defined two categories of Employer Outreach impacts: "maintained" impacts and "new/expanded" impacts.

In 2018, the Employer Outreach goals were again re-set, to reflect the 2017 impacts as a new starting point, again with goals for maintained and new/expanded impacts. For the 2020 analysis, maintained impacts will include those from employers that joined EO before July 1, 2017, the start of the 2018-2020 evaluation period and made no changes since that date. These impacts are considered part of the 2018-2020 baseline for EO. New impacts will include those from employers that joined the EO program after June 30, 2017. Expanded impacts will include those for employers that were involved in EO before the start of the evaluation period but expanded their commute services since June 30, 2017. Additionally, impacts from program reductions will be "back-filled" from new or expanded programs.

Apply Batch Methodology for COMMUTER Model (v2.0) Runs – The TDM analysis runs the COMMUTER Model (v2.0) in a batch format that allows each employer's program to be modeled separately and that calculates trip reduction for each employer individually. This method will enable Commuter Connections to define individual employers' contributions to the impacts, should Commuter Connections or local jurisdictions choose to do so.

Employer Outreach for Bicycling – In the 2002 and 2005 TDM evaluations, bicycle programs offered by employers were evaluated separately from other Employer Outreach services under the Employer Outreach for Bicycling (EOB) program element. EOB was later incorporated into the overall EO element and will be addressed similarly in the 2020 evaluation. However, the contribution of these bicycle programs to the overall EO impact will continue to be calculated and reported separately. The Employer Outreach

for Bicycling component also will include employers' support for bikesharing programs, particularly for employers that offer Bikeshare Corporate accounts to employees.

Performance Measures:

The following performance measures are recommended for Employer Outreach:

Participation, Satisfaction, and Utilization Measures:

- Number of employer clients (employers with commuter assistance programs and employers with bicycle programs) – total and new/expanded
- Number of employees at client worksites (worksites with commuter assistance programs and bicycle programs) – total and new/expanded
- Level/extent of employers' commuter assistance programs
- Alternative mode use at worksites with commuter assistance programs (placements)
- Employer satisfaction with outreach assistance and services

Program Impact Measures:

- Daily vehicle trips reduced
- Daily VMT reduced (in miles)
- Daily emissions reduced (in tons of pollutants)

Data Needs and Sources

The following data items will be used to calculate EO program impacts. Each data source is described in Section 5.

Data Need	*Data Source*
• Employers participating in Employer Outreach	ACT! database
• Participating employers that offer bicycling services to employees	ACT! database
• Employer characteristics	ACT! database
• Commuter assistance services at worksite	ACT! database
• Starting Average Vehicle Ridership (AVR)	Employee baseline surveys
• Ending AVR (estimated)	EPA COMMUTER Model 2.0
• Average travel distance	SOC survey

Proposed timing of data collection

- ACT! database – ongoing
- Employee baseline surveys – ongoing; data to be compiled in Fall 2019
- SOC survey – January-April 2019

The Employer Outreach program element is the only element for which placement rates and VTR factors are not directly used to determine the number of new participants, vehicle trips reduced, or VMT reduced. This is because sufficient employee survey data are not available to assess employees' post-program travel behavior. These missing evaluation elements are modeled using the EPA COMMUTER Model (v2.0).

To estimate impacts, employers' starting mode shares and commuter assistance program strategies are input into the COMMUTER Model (v2.0) and the model estimates "after" mode split and average

vehicle ridership, that is, with the program in place. The TDM analysis used this model in past evaluations. The COMMUTER Model uses time and cost coefficients that are compatible with coefficients used by MWCOG in regional transportation modeling. In 2007, COG and the evaluation team adjusted the cost coefficients used in the model, to correct for the COMMUTER Model's tendency to overestimate the likely impacts of financial incentives on shifts to non-SOV modes. These coefficients were used for the 2008 and 2011 evaluations.

During 2010-2012, MWCOG developed a new regional travel model. This might be expected to require updated COMMUTER Model cost and time coefficients. MWCOG modeling staff reviewed the COMMUTER Model coefficients used by the consulting staff for the 2011 evaluation and determined that no further adjustment would be needed for 2014 to be consistent with the new regional model. MWCOG continues to use this regional model, thus, the coefficients used in 2011, 2014, and 2017 will be carried over for the 2018-2020 evaluation.

4-D Mass Marketing

Program Description

In 2003, Commuter Connections embarked on an ambitious effort to educate the region's commuters about alternatives to stress-filled solo commuting and to raise awareness of commute assistance services available through Commuter Connections and its partners. Radio, television, social media, direct mail, transit advertising, and other media are used to create a new level of public awareness and to provide a call to action to entice commuters to switch to alternative modes.

Other marketing-related programs and events have been added to this program element since it was first implemented. Support for Bike to Work Day was added in the 2005-2008 evaluation, the 'Pool Rewards carpool incentive program was added in the 2008-2011 evaluation, and the vanpool component of 'Pool Rewards was added in the 2015-2017 evaluation.

The objectives of the Mass Marketing program element are to:

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

Evaluation Methodology Changes Since FY 2015 – FY 2017

- Add Flextime Rewards incentive component to the evaluation
- Add IncenTrip rewards mobile application component to the evaluation
- Add CarpoolNow dynamic ridematch mobile application component to the evaluation

Stated Goals

Commuter Connections has defined the following regional goals for Mass Marketing for 2017:

- Encourage 23,168 commuters to switch modes
- Reduce 10,809 daily vehicle trips
- Reduce 181,932 daily vehicle miles of travel
- Reduce 0.0850 daily tons of NOx
- Reduce 0.0250 daily tons of VOC

Nature of Evaluation

The Mass Marketing program element has numerous populations of interest:

1) All commuters in the Commuter Connections air quality non-attainment service area
2) Commuter Connections rideshare and GRH applicants who were influenced by the marketing campaign to request Commuter Connections services
3) Commuters who participate in regional special events (e.g., Bike-to-Work Day, Car Free Day)

4) Commuters who participate in Commuter Connections incentive programs ('Pool Rewards carpool/vanpool incentive program, Flextime Rewards incentive program, and/or IncenTrip rewards mobile application)
5) Commuters who register with the CarpoolNow dynamic ridematch mobile application

The Mass Marketing element presents two challenges not encountered in most of the other program elements. First, it is more difficult to assess the influence of a strategy, such as a marketing campaign, that is applied to the general commuting public, than it is to identify and track known participants in a registration-based program such as GRH. Second, when commuters who changed travel behavior can be identified, it is still necessary to identify what motivated their change. So, the critical issue for this element is attributing changes in attitudes and behavior – to the mass marketing campaign, another program element, or to some other outside influence.

Type of Changes Addressed – The Mass Marketing evaluation method examines impacts from several components, which are estimated separately.

1 – *"Directly influenced"* changes – These are mode shifts that are made when Mass Marketing ads directly 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 the ad and asks a co-worker to carpool. Direct influences can only be assessed through a regional survey of commuters that asks about recent mode changes and the reasons for the changes.

This influence of Mass Marketing on the general commuting population will be assessed through questions in the State of Commute survey that estimate the incidence of mode shifting in the region and the motivation for the shift. If a mode shift is attributed to a Mass Marketing campaign message, the associated vehicle trip, VMT, and emissions reductions can be credited to the campaign. Note that this calculation needs to correct for double counting with commuters who also cite influence of other program elements on their travel change.

2 – "R*eferred"* changes – These are mode shifts that occur when a commuter is influenced by an ad to contact Commuter Connections, such as when a commuter hears a radio ad for GRH and registers for the program. Under the evaluation method, any mode change the commuter makes in response to GRH would be defined through the GRH assessment, but a portion of the influence for that change would be credited to Mass Marketing, which provided the information about GRH.

Referred influences are best assessed by tracking changes in the volume of GRH and Commuter Operations Center information and services requests. 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 program element impacts then can be assigned to Mass Marketing.

3 – "S*pecial event*" changes – These are changes such as would occur following a Bike to Work Day or Car Free Day event. Special events are typically short-term. For example, both Bike to Work Day and Car Free Day are one-day events. But the influence of these events can be ongoing; their purpose is to introduce commuters to a new travel option, with the goal that some will continue using the new mode after the event or benefit period ends. Impacts for events will be calculated using data from post-event participant surveys that define changes in commuters' travel during the event, but also ongoing use of the mode in the months after the event.

4 – "I*ncentive*" programs changes – These are generated from commuters' participation in programs such as the 'Pool Rewards, Flextime Rewards, and/or IncenTrip incentive programs. Incentive programs offer a financial motivation to switch to an alternative mode. Some incentives provide the benefit for a short-term, start-up period; 'Pool Rewards offers incentives to new carpoolers for a 3-month enrollment period. Others, such as 'Pool Rewards for vanpools, provide an on-going monthly incentive. Flextime Rewards offers an incentive to commuters who travel to/from work outside the peak commuting period on days when traffic is disrupted by an accident or other roadway incident. As with special event programs, incentive program can encourage both short-term and long-term impacts, if commuters continue using the new mode after the benefit period ends.

Impacts for the carpool component of the 'Pool Rewards incentive will be calculated using data from a post-enrollment participant survey that defines changes in commuters' travel during the program and ongoing use of the mode in the months after the incentive period. Impacts for the vanpool component of 'Pool Rewards will be estimated using pre-vanpool mode information provided in program applications and trip information provided through vanpool logs.

Impacts for the Flextime Rewards incentives will be calculated primarily from trip tracking data compiled through the program; digital records from the program will record the day and time of trips and the type of trip adjustment made (e.g., shift time, eliminate trip, etc). Impacts for IncenTrip will be estimated primarily using trip log data entered by participating commuters, which identifies trip origin, destination, mode use, and travel distance, but some indication of trip purpose also might be needed to capture the share of trips that are commute-related.

5 – "*Dynamic ridematch*" changes – This component includes impacts from the CarpoolNow mobile application. In this application, registered users can request a ride (participate as a passenger) or a rider (participate as a driver) for a one-time carpool arrangement. Because each ride/rider request is for a single trip, the impact of a commuter's participation could be limited. However, as with events and incentives, the influence of the service could be ongoing either by repeated use of the service or by encouraging commuters to seek more permanent carpool arrangements with commuters they meet through the service.

Ideally, the impacts for this service would be calculated using data from a survey of registered users that inquires about frequency of use of the service, successful one-time carpool trips formation, ongoing carpool formation, purpose of trips made, and other trip characteristics. This survey is not currently programmed in the 2018-2020 evaluation period, however, thus, the evaluation of this program in the 2020 analysis might need to apply assumptions derived from real-time ridematching applications operated in other regions.

Performance Measures

The following performance measures are proposed for the Mass Marketing program element:

Direct/Referred Impacts – Participation, Satisfaction, and Utilization Measures:

- Percentage of regional commuters who are aware of ad campaign and messages
- Percentage of commuters with positive attitudes toward alt modes (e.g., willingness to try)
- Percentage of regional commuters aware of Commuter Connections programs/services
- Number of contacts to Commuter Connections (e.g., call volumes, web hits, registrants)
- Direct change placement rates (temporary and continued change)

Special Events – Participation, Satisfaction, and Utilization Measures:

- Number of riders participating in Bike to Work
- Participants' frequency of bike commuting before and after the Bike to Work Day event
- Number of commuters participating in Car Free Day
- Participants' frequency of alternative mode use before and after Car Free Day
- Commuters' satisfaction with events – Bike to Work Day, Car Free Day

Incentive Programs – Participation, Satisfaction, and Utilization Measures:

- Number of commuters participating in 'Pool Rewards
- Participants' frequency of alternative mode use before, during, and after 'Pool Rewards
- Number of commuters participating in Flextime Rewards
- Participants' frequency of peak period travel before and during Flextime Rewards and share of trips with time shifts, mode shifts, and trip elimination (telework)
- Number of commuters participating in IncenTrip
- Participants' frequency of alternative mode use before and during IncenTrip enrollment
- Share of IncenTrip trips made for commute vs non-commute
- Commuters' satisfaction with incentive programs – 'Pool Rewards, Flextime Rewards, IncenTrip

Dynamic Ridematch Programs – Participation, Satisfaction, and Utilization Measures:

- Number of commuters participating in CarpoolNow
- Participants' frequency of carpool use before and during CarpoolNow enrollment
- Share of new carpool trips made for commute vs non-commute
- Commuters' satisfaction with incentive programs – 'Pool Rewards, Flextime Rewards, IncenTrip

Program Impact Measures (all components):

- Daily vehicle trips reduced
- Daily VMT reduced (in miles)
- Daily emissions reduced (in tons of pollutants)

Data Needs and Sources

Data Needs	*Data Source*
Advertising Campaign	
• Regional commuters aware of ads / messages	SOC survey
• Percentage of commuters who make alternative mode changes after ads	SOC survey
• Influence of ads on mode change	SOC survey
• Contacts to CC info sources	SOC survey and COC tracking
• MM placement rates (temporary and continued)	SOC survey and COC tracking
• MM VTR factors	SOC survey, GRH survey, CC Applicant Placement survey
Bike to Work Day (BTWD)	
• Number of BTWD participants	BTWD survey
• Bike use before, during, and after event	BTWD survey
• Average travel distance	BTWD survey

Car Free Day (CFD)

- Number of CFD participants — CFD database
- Alternative mode use before, during event — CFD database
- Average travel distance — CFD database or SOC survey

'Pool Rewards ('PR)

- Number of carpool/vanpool 'PR participants — 'PR database
- Carpool use before, during, and after enrollment — 'PR database and 'PR survey
- Vanpool use before and during enrollment — 'PR log database
- Average travel distance, carpool/vanpool — 'PR database

Flextime Rewards (FR)

- Number of FR participants — FR database
- Peak period trips adjusted — FR database
- Time/mode changes on FR days — FR database or FR survey
- Average travel distance — FR database

IncenTrip (IT)

- Number of IT participants — IT database
- IT travel characteristics (mode, distance) — IT trip log database
- Average travel distance — IT trip log database
- IT share of commute trips — IT trip log database

CarpoolNow (CPN)

- Number of CPN participants — CPN database
- Carpool use before and during enrollment — CPN database or CPN survey
- Average travel distance — CPN database
- CPN share of commute trips — CPN survey

Proposed timing of data collection

- SOC survey – January-April 2019
- CC Online Placement survey (November 2017) – completed, next survey November 2020
- GRH Applicant survey – April-May 2019
- Commuter Operations Center (COC) tracking – Ongoing
- Bike-to-Work Day (BTWD) event survey – Fall 2019
- 'Pool Rewards program mode use – Ongoing
- Car Free Day event survey – TBD 2019 or 2020
- Flextime Rewards survey – TBD 2019 or 2020
- CarpoolNow survey – TBD 2019 or 2020

Not all increases in program inquiries resulting from indirect impacts will be assigned to the Mass Marketing program element. The share of GRH and COC indirect impacts to be assigned to MM will be determined by estimating the increase in applications that occur during period when MM ads are run. These credits will be subtracted from GRH or COC to avoid double counting.

4-E Commuter Operations Center

Program Description

Since the 1970's, COG has offered basic commute information and assistance, such as regional ridematching database, 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 RideFinders program. Because these services were available when the other TDM program elements were developed, the Center was defined as an ongoing program. It is also part of the region's congestion management process.

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 ridematching 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.

Included within the Commuter Operations Center program is the Integrated Rideshare-Software Upgrades Project. When it began, Integrated Rideshare provided improvements to the quality and delivery of alternative mode information. In particular, Commuter Connections 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.[13]

Evaluation Methodology Changes Since FY 2015 – FY 2017

- No changes since 2015-2017

[13] Integrated Rideshare originally had two components; Ridematching Software Upgrades, and Inf-Express Kiosks. The InfoExpress Kiosk project was discontinued during the 2005-2008 evaluation period.

Stated Goals

Commuter Connections has defined the following goals for the Commuter Operations Center for 2017:

Commuter Operations Center (basic services)

- Register/assist 91,609 commuters
- Reduce 24,425 daily vehicle trips
- Reduce 512,637 daily vehicle miles of travel
- Reduce 0.2410 daily tons of NOx
- Reduce 0.1150 daily tons of VOC

Integrated Rideshare-Software Upgrade Project (additional to Basic COC)

- Assist 4,681 commuters
- Reduce 2,379 daily vehicle trips
- Reduce 66,442 daily vehicle miles of travel
- Reduce 0.0280 daily tons of NOx
- Reduce 0.0110 daily tons of VOC

Nature of Evaluation

Since the basic Commuter Connections ridematching and information services are covered in the conformity baseline, this evaluation component seeks to credit the program with any increases in effectiveness due to program enhancements not covered by other program elements. Thus, the basic approach is to determine the total transportation and air quality impacts for all Commuter Connections services and subtract out impacts assigned to GRH, Mass Marketing, and any other element that overlaps with the COC. The balance of impacts equals the impacts of the COC.

The Integrated Rideshare Software Upgrade component is directed to a subset of Commuter Connections clients; applicants who remember receiving transit and/or Park and Ride, telecenter/co-working locations, and bicycling information with other ridematching information provided through the Commuter Operations Center. This program is aimed at improving the quality and availability of commute information and encouraging commuters to try transit, bicycling, and telework for occasional and full-time use, even if they did not have these options in mind when they contacted Commuter Connections. Integration of transit and Park & Ride, telecenter/co-working locations, and bicycling information into the computer system will be evaluated through the applicant placement rate survey, described in Section 5. From this survey, a separate placement rate can be derived for those who shifted to an alternative mode after receiving transit or Park & Ride, telework, and bicycling information.

Performance Measures

The following performance measures are proposed for the Commuter Operations Center:

COC (Basic) – Participation, Satisfaction, and Utilization Measures:

- Number of commuters who use the online information system
- Distribution of services accessed (e.g., ridematch, transit, bicycle, telework)
- Online system placement rate
- Applicant satisfaction with online service

Integrated Rideshare-Software Upgrades Project – Participation, Satisfaction, and Utilization Measures:

- Number of applicants who remember receiving or accessing transit, P&R, telework, or bicycle information through the online system
- Number of applicants who use transit, P&R, telework, or bicycle information that was received but not specifically requested
- Software upgrade placement rate (percentage of applicants who use the software upgrade information to shift to an alternative mode)

Program Impact Measures (basic COC and Software Upgrades):

- Daily vehicle trips reduced
- Daily VMT reduced (in miles)
- Daily emissions reduced (in tons of pollutants)

Data Needs and Sources:

The following data items will be used to calculate program impacts for the Commuter Operations Center, including the improved transit information from the software upgrades. Each data source is described in Section 5.

Data Needs	*Data Source*
Commuter Operations Center (Basic)	
• Commuter Connections (CC) online system users	CC online system database
• COC placement rate	CC Online Placement survey
• COC VTR Factor and average travel distance	CC Online Placement survey
• COC retained placement rate	CC Retention Rate survey
• COC retained VTR Factor and average travel distance	CC Retention Rate survey
• Vehicle trips/VMT assigned to other program elements	Results of other element evaluations
Integrated Rideshare–Software Upgrades (IR-SU)	
• Database applicants	CC Online system database
• Applicants who remember receiving transit, P&R, bicycle information	CC Online Placement survey
• IR-SU placement rate	CC Online Placement survey
• IR-SU VTR Factor	CC Online Placement survey
• Average travel distance	CC Online Placement survey

Proposed timing of data collection

- Commuter Connections database – ongoing
- CC Online Placement survey (November 2017) – completed, next survey November 2020
- CC Retention Rate survey – March 2021
- SOC survey – January-April 2019

Double counting is avoided by subtracting the credit assigned to the Integrated Rideshare-Software Upgrades from the impacts calculated for the Commuter Operations Center (Basic).

Section 5 Descriptions of Data Sources

Much of the data needed to perform the evaluation outlined in this framework is available from two basic sources. Data on program participation will be obtained from ongoing monitoring activities of Commuter Connections and its partners in the form of application records, GRH registration forms, etc. The basic source of travel impact and attitudinal information is periodic surveys of applicants, service users, or the public-at-large. All but one of the surveys proposed for FY15-FY17 have been used in past years. Previously-administered surveys will be reviewed and modified as needed for the 2017 evaluation. The new Retention Rate survey will be developed and administered for the first time in the spring of 2016. The data sources and surveys can be divided into two groups as follows:

Ongoing Monitoring

- Commuter Connections GRH registrant database and archived GRH database(GRH)
- ACT! Employer Contact database (Employer Outreach and Telework)
- Commuter Operations Center activity tracking (Mass Marketing)
- Bike to Work Day participant records (Mass Marketing)
- Car Free Day participant records (Mass Marketing)
- 'Pool Rewards registrant database (Mass Marketing)
- Flextime Reward registrant database (Mass Marketing)
- IncenTrip registrant database (Mass Marketing)
- CarpoolNow registrant database (Mass Marketing)
- Commuter Connections online information user database (COC, IR SU)

Resident and User Surveys

- Maryland Telework assisted employer follow-up survey
- State of the Commute survey
- GRH registrant survey
- Employee commute surveys (voluntarily administered by employers)
- Commuter Connections online assistance placement rate survey (completed in November 2014)
- Bike-to-Work Day participant survey
- Retention rate survey
- Telework!VA baseline / follow-up surveys (conducted by VDRPT/VDOT)
- 'Pool Rewards registrant survey
- CarpoolNow registrant survey (proposed)

Each data source, survey, and analysis tool is described below, noting the TDM program element or elements for which it collects evaluation data. Table 1 serves as a quick reference for the proposed uses of each data source. In general, the data are used for either or both of two purposes. The first, TDM program element tracking, monitors use of and user satisfaction with the elements. The second purpose, impact analysis, refers to the calculation of transportation, air quality, energy, and cost impacts of the element. This evaluation framework document deals primarily with the second of the purposes.

Table 1
Data Collection Activities
Applicable TDM Program Elements and Uses of the Data

Evaluation Activity/Tool	Applicable Element	Use of Data
Ongoing Monitoring		
• GRH registrant / archived database	Guaranteed Ride Home	TDM element tracking, impact analysis
• ACT! Employer Outreach & Telework Contact Database	Employer Outreach & Telework	TDM element tracking, impact analysis
• COC website and call volume tracking	Mass Marketing (Secondary – COC, GRH)	TDM element tracking, impact analysis
• Documentation of media/marketing activities	Mass Marketing	Impact analysis
• Bike to Work Day participant records	Mass Marketing (BTW component)	TDM element tracking, impact analysis
• Car free Day participant records	Mass Marketing (CFD component)	TDM element tracking, impact analysis
• 'Pool Rewards participant records	Mass Marketing ('PR component)	TDM element tracking, impact analysis
• Flextime Rewards participant records	Mass Marketing (FR component)	TDM element tracking, impact analysis
• IncenTrip participants records	Mass Marketing (IT component)	TDM element tracking, impact analysis
• CarpoolNow participant records	Mass Marketing (CPN component)	TDM element tracking, impact analysis
• CC online information system user database	COC, Integrated Rideshare-Software Upgrades (Secondary – Mass Marketing)	TDM element tracking, impact analysis
Resident and User Surveys		
• Maryland Telework assisted employer follow-up survey	Telework	TDM element tracking, impact analysis
• State of the Commute survey	Telework, Mass Marketing	Commute trends, impact analysis
• GRH registrant survey	Guaranteed Ride Home	Impact analysis
• Employee commute surveys (employer- administered)	Employer Outreach	TDM element tracking, impact analysis
• CC online system user placement rate survey	COC, Integrated Rideshare-Software Upgrades (Secondary – Mass Marketing)	TDM element tracking, impact analysis
• Bike-to-Work participant survey	Mass Marketing (BTW component)	TDM element tracking, impact analysis
• Retention Rate survey	Guaranteed Ride Home and COC	TDM element tracking, impact analysis
• Telework!VA baseline / follow-up surveys (conducted by VDRPT/VDOT)	Telework	TDM element tracking, impact analysis
• CarpoolNow user survey (NEW)	Mass Marketing (CPN component)	Impact analysis

Ongoing Monitoring

Program activity and utilization tracking is an ongoing function already performed by Commuter Connections staff and regional partners. Included here are records of services provided (e.g., number of employers contacted and GRH rides provided) and information on requests received (e.g., number of ride-match applications, tracked by individual program element.

The information gathered in the ongoing tracking process is summarized in a quarterly Commuter Connections "report card" that shows participation and utilization data and applies factors generated from the most recent placement rate survey to estimate travel, air quality, energy and consumer savings benefits for the quarter. This tool is used primarily by COG/TPB staff and staff of regional Commuter Connections partner programs as a quarterly check of progress in various activity and program areas. Annual Commuter Connections evaluation results also are reported to other policy-makers and to program funding agencies. Additional details on how Commuter Connections evaluation results will be reported are presented in Section 7.

- GRH Registrant / Archived Database – Ongoing tracking of registered and one-time exception GRH users. Database includes contact information, mode at time of registration, and GRH uses. *(Used for GRH program element.)*
- ACT! Employer Client Database – Tracks the number of employers participating in Employer Outreach Program and the commuter assistance services they offer in worksite programs, including Telework. Sales representatives who assist employers to begin and maintain commuter assistance programs update the database when new employers join the program and when employers already participating in EO change their commuter assistance services. The database includes information on employer characteristics (e.g., number of employees, location, transit accessibility) and on the strategies (e.g., transit subsidies, GRH, preferential parking, teleworking) that the employer offers. *(Used for Employer Outreach and Telework program elements)*
- Documentation of Commuter Connections Media / Marketing Activities – Ongoing tracking of the dates and types of media activities (media buys, direct mail, Internet outreach, etc) and the number and time distribution of telephone and Internet information requests made to Commuter Connections. Maintained/compiled by Commuter Connections staff, staff of GRH online system vendor, and COG marketing consultant. *(Used for Mass Marketing program element; secondary use for GRH program element and Commuter Operations Center, including Integrated Rideshare-Software Upgrades Project)*
- Bike-to-Work Day Records – Provides contact information on commuters who register to participate in Bike-to-Work Day. *(Used for Mass Marketing program element)*
- Car Free Day Records – Provides information on commuters who register to participate in Car Free Day. Data include contact information, mode used prior to CFD, and mode registrant pledges to use on CFD. *(Used for Mass Marketing program element)*
- 'Pool Rewards Registrant Records – Provides information on commuters who register to participate in 'Pool Rewards carpool and vanpool incentive program. Data include contact information, mode used for commuting prior to registration, and carpool and vanpool days recorded during the enrollment period. *(Used for Mass Marketing program element)*
- Flextime Rewards Registrant Records – Provides information on commuters who register to participate in Flextime Rewards incentive program. Data include contact information, typical commuting

time (departure/arrival), mode used for commuting prior to registration, and trips shifted/eliminated by day/time. *(Used for Mass Marketing program element)*

- IncenTrip Registrant Records – Provides information on commuters who register for IncenTrip rewards program. Data include contact information, trips made by day/time, mode used for each trip, and travel distance. *(Used for Mass Marketing program element)*
- CarpoolNow Registrant Records – Provides information on commuters who register to participate in CarpoolNow dynamic ridematch program. Data include contact information, trips requested/offered and trips accepted by day/time, and travel distance. *(Used for Mass Marketing program element)*
- Commuter Connections Online Information System Database – Ongoing tracking of commuters who establish accounts for the online information system and counts of non-registered users. Includes contact information for account holders *(Used for Commuter Operations Center, including Integrated Rideshare-Software Upgrades Project; secondary use for GRH and Mass Marketing program elements)*

Resident and User Surveys

Several surveys are conducted by Commuter Connections to follow-up with program applicants and assess user satisfaction. These surveys also provide data used to estimate program impacts. Some of the surveys, such as the online system user placement survey and GRH Survey, also provide information used by Commuter Connections staff to fine tune program operations and policies.

- Maryland Employer Telework Assistance Follow-up Survey – Sent to employers in Maryland that received telework assistance from Commuter Connections to determine if and how they used the information they received. Specifically, the survey asks if the employer has started or expanded a telework program since receiving the information and if the information was helpful. This information is used to estimate the number of teleworkers who were indirectly influenced by Commuter Connections Telework Assistance. *(Used for Telework program element)*
- TWVA surveys – Administered to employees who work at worksites participating in the Telework!VA (TWVA) program. A baseline survey, administered before telework assistance is provided, is used to define the percentage of employees who telework prior to the program implementation and their telework characteristics. A follow-up survey conducted six to eight months later will determine the percentage of new teleworkers. *(Used for Telework program element)*
- State of the Commute Survey – The SOC survey, a random sample survey of employed adults in the Washington metro region, serves several purposes. First, it establishes trends in commuting behavior, such as commute mode and distance, and awareness and attitudes about commuting, and awareness and use of transportation services, such as HOV lanes and public transportation, available to commuters in the region. To this end, it will be compared to data from past State of the Commute surveys (2001, 2004, 2007, 2010, 2013, and 2016).

  SOC survey data also are used to estimate the impacts of TDM program elements that have a possible influence on the population-at-large. Specifically, the survey generates information for the Mass Marketing and Telework program elements, both of which have broad application and for which it is not possible to identify all users from any Commuter Connections database. The survey also is used to assess awareness of the regional GRH program.

Next, by querying respondents about their attitudes about alternative modes and reasons for choosing or not choosing alternative modes, the survey also suggests how commuter service programs and marketing efforts influence commuting behavior in the region. In this way, it helps to establish the influence of the Mass Marketing advertising messages on mode switching and use of Commuter Connections services, provides opinion research data that could contribute to assessment of broad social and personal benefits of commute programs, and offers an opportunity to test concepts for new services.

The SOC survey is a triennial survey and will be conducted in early 2019. The survey will be conducted primarily via Internet, with a random sample of households in each of the 11 MWCOG jurisdictions receiving a postcard invitation specifying the survey website link. As in 2016, the survey also will include samples for both landline phones and cell phones, with approximately 40% of total interviews being conducted with cell phone users. This combined Internet/phone method will allow valid comparisons to past surveys, with more representative data and a considerable cost savings over the cost of telephone survey alone. *(Used for Telework and Mass Marketing program elements)*

- GRH Applicant Survey – Commuters who registered with the GRH program or used a one-time exception trip will be surveyed to establish how the availability and use of GRH influenced their decision to use an alternative mode and to maintain that mode. Satisfaction with GRH services also will be polled. Some data collected in the survey, such as current and previous mode, travel distance, and access mode, will be used to develop the GRH placement rate and VTR factor.

  As was done in both 2010, 2013, and 2016, the 2016 GRH survey will be conducted by a combination of Internet and telephone methods. COG's online TDM system database vendor has programmed the GRH questionnaires for online application. This tool will be used to survey applicants who provided an email address and have a current GRH account. To ensure that all GRH registrants are included in the survey, past registrants who provided an email address will be surveyed by web-based survey administered through a consultant server. Telephone interviews will be conducted with GRH respondents who did not provide an email address. The data from these methods will be combined for analysis of the GRH survey and used to estimate impacts for the GRH program element.

- Employee Commute Surveys – Some employers conduct baseline surveys of employees' commute patterns, before they develop commuter assistance programs. The results of these surveys also are available through an employee survey database. *(Used for Employer Outreach program element)*

- Commuter Connections Online Information System User Placement Rate Survey – Since May 1997, Commuter Connections has conducted commuter applicant placement surveys to assess the effectiveness of the Commuter Operations Center. Data from the applicant placement surveys are used to calculate placement rates and VTR factors for the Commuter Operations Center and for the Mass Marketing program element (referred impacts). The surveys also assess users' perceptions of and satisfaction with the services provided.

  One placement survey, which was conducted in November 2017, will be used in the 2018-2020 evaluation period. Results of the survey conducted during this evaluation period were presented in a survey report finalized in May 2018.[14] Reported results are primarily for internal use by program and technical staff, but results also can be summarized for policy makers, such as the TPB, the TPB's

[14] Fiscal Year 2018 Applicant Database Annual Placement Survey Report, Applications Received During July-September 2017 (November 2017 Survey), May 15, 2018.

Technical Committee, and other regional policy makers. *(Used for the Commuter Operations Center (Basic), and Software Upgrades; secondary use for Mass Marketing and GRH program elements)*

- Bike-to-Work Day Participant Survey – A survey among registered participants in the Bike-to-Work Day event is undertaken to assess travel behavior before and after the Bike-to-Work Day, as well as commute distance and travel on non-bike days. The survey also collects data on participant satisfaction with the event, data that is shared with other organizations that sponsor and promote the event. *(Used for Mass Marketing program element)*

- Retention Rate Survey – In Commuter Connections evaluations prior to 2017, mode shifts motivated by TDM program elements during the evaluation period were not carried over to the next evaluation cycle. But numerous surveys conducted for past TDM program 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 during the current cycle.

  The survey interviewed Commuter Connections online system users and GRH users who last participated in these programs prior to the start of the current evaluation period. Users were asked about their current modes, how long they had used their current modes, and what Commuter Connections services they received. Commuters who were still using alternative modes were asked if and how Commuter Connections services influenced them to continue to use alternative modes. These survey data were used to develop "retained" placement rates and other factors for the GRH TERM and for the Commuter Operations Center. These factors were used in the 2017 TDM analysis to calculate "retained" impact credits for each of these program elements. This survey will be repeated in FY 2021. Because this will be after the 2020 TDM analysis is performed, the calculation factors from the 2016 Retention Rate Survey will be used for the 2020 analysis. *(Used for Commuter Operations Center (Basic) and for GRH program element)*

  'Pool Rewards Participant Survey – Registered participants in the 'Pool Rewards carpool incentive program are surveyed after they complete their 3-month enrollment period. Carpoolers participating in 'Pool Rewards log their carpool trips during the enrollment period, thus the focus on the survey is to determine the share of participants who continue to carpool after the incentive ends. The survey also collects data on participant satisfaction with the program. *(Used for Mass Marketing program element)*

- CarpoolNow Participant Survey (Proposed) – A new survey proposed for the 2018-2020 evaluation would interview commuters who register for the CarpoolNow dynamic ridematch service. This survey could be administered to all registered commuters at one time or as a rolling survey, after commuters have been registered for a defined period of time. The CarpoolNow system records the date, time, and locations of ride/rider requests and acceptances, so some trip pattern data are available on an ongoing basis. The function of the CPN survey would be to determine if matches actually resulted in carpool trips, the share of trips that were for commuting, and if CPN users subsequently formed ongoing carpool arrangements. The survey also would collect data on participant satisfaction with the service. *(Used for Mass Marketing program element)*

Analysis Tools

The EPA COMMUTER model (v 2.0), which will be used for the 2020 analysis of the Employer Outreach program element, predicts likely change in employee commuting behavior for given changes in an employer's commute assistance program. The COMMUTER Model uses time and cost coefficients that are compatible with coefficients used by MWCOG in regional transportation modeling. In 2007, COG and the evaluation team adjusted the cost coefficients used in the model, to correct for the COMMUTER Model's tendency to overestimate the likely impacts of financial incentives on shifts to non-SOV modes. Descriptions of the adjustment and the original and adjusted coefficients are presented in Appendix B. These coefficients were used for the 2008 and 2011 evaluations.

During 2010-2012, MWCOG developed a new regional travel model. This might be expected to require updated COMMUTER Model cost and time coefficients. MWCOG modeling staff reviewed the COMMUTER Model coefficients used by the consulting staff for the 2011 evaluation and determined that no further adjustment would be needed for 2014 to be consistent with the new regional model. MWCOG continues to use this regional model, thus, the coefficients used in 2011, 2014, and 2017 will be carried over for the 2018-2020 evaluation.

Section 6 Basic Method for Calculating Program Impacts

This section presents the methodology for calculating and quantifying the travel, emissions, energy and commuter cost impacts of the TDM program elements. Following are the basic calculation steps that apply a series of multiplier factors to the participation count for the program element. This method is consistent across program elements, with two exceptions. Employer Outreach uses a modeled method applied to known commute services offered at worksites. And Mass Marketing uses information from the State of the Commute and COC activity tracking to assess mode change due to Mass Marketing advertising campaign activities. Specific examples of the evaluation calculations and unique methodological elements for each TDM program element are presented in Appendices C through H:

- Appendix C – Maryland and Virginia Telework Assistance
- Appendix D – Guaranteed Ride Home
- Appendix E – Employer Outreach
- Appendix F – Mass Marketing
- Appendix G – Commuter Operations Center
- Appendix H – Integrated Rideshare – Software Upgrades Project

Documenting Program Participation and Utilization

The evaluation of program impacts requires first an accurate documentation of the participation of employers and commuters in each TDM program element. The calculation methodology begins with consistent and continuous tracking of the number of participants or users of each element:

- Employers participating in Telework activities – Track participation in Commuter Connections' Maryland telework programs through telework contact records maintained by Commuter Connections and in the regional ACT! Employer Outreach database. Telework placement rates (proportion of employees at the worksites who become teleworkers) and a corresponding VTR factor will be developed from data collected in the Maryland employer telework follow-up survey. Participation for the Telework!VA program will be tracked by VDOT/DRPT.

- GRH registrants and one-time exception users – Track separately from Commuter Connections online system applicants. A GRH placement rate and VTR factor will be developed from the GRH survey for registrants who participated in GRH during the evaluation period. Also retain information on commuters who participated in GRH and who registration expired prior to the start of the evaluation period; placement rates and VTR factors will be defined for these commuters though the Retention Rate survey.

- Employers participating in Employer Outreach – Track details about the employer size, location, transit access, and commute assistance services offered at the worksite.

- Commuters participating in Bike-to-Work Day, Car Free Day, and other one-time special events/programs – Track to determine the total number of commuters who register to participate and number of actual participants, if different from the registration count.

- Commuters participating in 'Pool Rewards carpools and vanpools – Track counts of participants, starting mode, pool occupants, and total carpool and vanpool days during the incentive period.

- Commuters participating in Flextime Rewards – Track counts of participants, number and locations of trips shifted/eliminated on roadway incident days.
- Commuters participating in IncenTrip – Track counts of participants, trips taken by location, mode and by day/time of day.
- Commuters participating in CarpoolNow – Track counts of participants, rides/riders requested and accepted by location and day/time of day.
- Commuters who request or access Commuter Connections assistance through online information system – Track number of participants, dates of assistance/requests, and type of information requested (e.g. ridematching, transit information, telework assistance, bicycle information, etc.). Using the results of the online system user placement survey and other surveys conducted under this project, separate placement rates will be developed for the Commuter Operations Center and for the Software Upgrade component previously included in the Integrated Rideshare program element but now part of the COC section in this report. Also retain information on commuters who received services from the online system prior to the evaluation period; placement rates and VTR factors will be defined for these commuters though the Retention Rate survey.

The purpose of this tracking process is to determine the "population base" to be used to quantify impacts and then to credit those impacts to the program element from which they were derived. Other program information, in addition to participation and utilization, also could be tracked and documented for use in program refinement.

Information on participation and utilization will be included in quarterly and annual program summaries. The intent is for Commuter Connections and its partners to input participation results, credited to each program element, into a form that allows for the calculation of impacts. This is accomplished with a simple spreadsheet that includes the factors discussed below.

Calculating Program Impacts

The following subsection provides an example of how program impacts will be calculated for the four TDM program elements and for the Operations Center. As each of these services has become fully operational, tailored surveys have been developed to produce unique placement rates and VTR factors for each element.

Nine basic steps are used to calculate program impacts. These steps are described below. A hypothetical numerical example of the steps is presented in Figure 1 for one TDM program element.

TDM Program Element Evaluation
Basic Program Impact Calculation Methodology Steps

1. Estimate commuter "population base" for the element	= e.g., all commuters, GRH applicants, CC online system users, EO employees
2. Calculate placement rate (from user survey data)	= Proportion of commuters who made a travel change as a result of the element
3. Estimate number of "placements"	= Population base x placement rate
4. Estimate VTR factor (from user survey data)	= Average daily vehicle trips reduced per placement
5. Estimate vehicle trips (VT) reduced	
- GRH, COC, Telework, MM	= placements x VTR factor
- Employer Outreach	= Modeled method
6. Estimate VMT reduced	= Vehicle trips reduced x avg. trip length
7. Adjust VT and VMT for SOV access	
- Adjusted vehicle trips reduced	= Total vehicle trips – SOV access trips
- Adjusted VMT reduced	= Total VMT – SOV access VMT
8. Estimate emissions reduced	= Vehicle trips x "trip end" emission factors = VMT x "running" emission factor
9. Estimate energy and commuter savings	= VMT reduced x average fuel consumption = VMT reduced x average vehicle operating cost

Step 1 – Determine Commuter Population Base

The first step establishes the population base, or population of interest, relevant to the specific program element. This is the population that potentially could have been influenced by the element. Depending on the element being evaluated, this could be all commuters, GRH applicants, teleworkers, or some other population. The population bases for GRH and the Commuter Operation Center will include both current registrants/users and past participants who continue to use alternative modes, as defined by the Retention Rate survey. In the example shown in Figure 1, the population base is 8,000 commuters.

Step 2 – Calculate Placement Rate

The next step in determining program impacts is to calculate the placement rate for the population base exposed to the program element. The placement rate is equal to the percentage of commuters in the population base who shift to an alternative mode (carpool, vanpool, public transportation, walk/bike, telework) after receiving assistance under the element. Placement rates are calculated from user survey data

Figure 1
Example of Basic Program Impact Calculation Methodology Steps for a TDM Program Element
(Note: hypothetical example; do not use factors in the example for actual evaluation purposes)

1.	Estimate program element "population base"	= 8,000 commuters
2.	Calculate placement rate	= 20%
3.	Estimate number of "placements"	= 8,000 x 0.2 =1,600 commuters placed
4.	Estimate VTR factor	= 0.7 daily vehicle trips reduced per placement
5.	Estimate vehicle trips (VT) reduced	= 1,600 x 0.7 trips reduced per placement = 1,120 daily vehicle trips reduced
6.	Estimate VMT reduced	= 1,120 vehicle trips reduced x 25 miles/trip = 28,000 daily VMT reduced
7.	Adjust VT and VMT for SOV access	(assume 60% of placements have SOV access and drive 5 miles to meeting point)
	- Adjusted vehicle trips reduced	= 1,120 trips – 0.6 x 1,120 = 1,120 - 672 = 448 vehicle trips (without SOV access)
	- Adjusted VMT reduced	= 28,000 VMT – (0.6 x 1,120 x 5 miles) = 28,000 – 3,360 = 24,640 VMT
8.	Estimate emissions reduced (VOC)	= 448 trips x 2.857 g/trip = 1,280 g = 24,640 VMT x 0.092 g/VMT = 2,267 gm = (1,280 gm + 2,267 g) / 907,185 gm/ton = 0.0039 daily tons VOC reduced
	Similar calculations used to estimate reductions of NOx, PM2.5 NOx precursors, PM2.5, and CO2	
9.	Estimate energy and commuter savings	
	Energy saving (gallons of fuel)	= 24,640 daily VMT / 19.9 mpg = 1,238 gallons per day x 250 work days/yr = 309,500 gallons saved per year
	Commuter cost saving ($)	= 24,640 VMT x $0.170/mile = $4,189 per day x 250 work days/year = $1,047,250 saved per year / 1,600 placements = $655 saved per placement per year

Two placement rates are calculated for each program element, to account for the length of time the commuter uses the alternative mode after shifting: continued rate (did not shift back to original mode), and temporary rate (tried new alternative mode but shifted back to original mode within the evaluation period). For simplicity, Figure 1 shows only one placement rate, 20%. This means that 20% of the commuters in the population base made a change to an alternative mode as a result of the element. The placement rates for one element will not necessarily be the same as the placement rates for any other element.

Step 3 – Estimate Number of New Placements

Step 3 estimates the number of new commuter placements in alternative modes. This is the actual number of commuters who are estimated to have made the shift to alternative modes as a result of the element. It is calculated by multiplying the placement rate (calculated in Step 2 from a survey of a sample of commuters in the population base) by the total population base. In the example in Figure 1, the calculation of placements is as shown below:

Placements = 8,000 commuters (population base) x 0.2
= 1,600 placements

Step 4 – Estimate VTR Factor

From the same survey data used to calculate placement rate, the Vehicle Trip Reduction (VTR) factor is next calculated. This is equal to the average daily vehicle trips reduced per placement. As described in Section 3, not all commuter placements will reduce the same number of trips. Three types of commute shifts are captured in the VTR factor:

1) Drive alone applicants shifting to alternative modes
2) Alternative mode users shifting to different alternative modes (e.g., carpool to bus or bus to vanpool)
3) Alternative mode users increasing the number of days they use alternative modes

The number of trips reduced also depends on the frequency with which they use the alternative mode, compared to the number of days they used it before. The VTR factor combines the varied trip reduction results of all commuter placements to develop an average reduction per placement. An explanation of how the VTR Factor is calculated is provided in Appendix A and a numeric example is shown in Appendix B. As for placement rate, VTR factors might be different for different program elementss. As shown in Figure 1, the VTR factor for the element in the hypothetical example is 0.70. This means that each of the placements for this element reduces, on average, 0.7 vehicle trips per day.

Step 5 – Estimate Daily Vehicle Trips Reduced

The number of daily vehicle trips reduced for the program element is then estimated by multiplying the number of commuter placements from Step 3 by the VTR factor, the average number of daily trips reduced per placement, calculated in Step 4. The calculation of vehicle trips reduced for the example shown in Figure 1 would be as follows:

Vehicle trips reduced = 1,600 placements x 0.7 trips reduced per placement
= 1,120 daily vehicle trips reduced

Step 6 – Estimate Daily VMT Reduced

The total daily VMT reduced is calculated by multiplying the number of daily vehicle trips reduced (Step 5) by the average commute distance for the population of interest. The average distance for the population is calculated from the same survey data used to calculate the placement rate and VTR factor. The example in Figure 1 assumes that the average distance is 25 miles per one-way trip. Using this distance, the total VMT reduced for 1,120 vehicle trips is:

VMT reduced = 1,120 vehicle trips reduced x 25 miles per trips
= 28,000 daily VMT reduced

Step 7 – Adjust Vehicle Trips and VMT for SOV Access

Because a basic purpose for implementing the program elements is to meet regional air quality emission reduction targets, single occupant vehicle (SOV) access to alternative modes must be considered. Emission reduction, as explained in Step 8, is calculated by multiplying vehicle trips reduced and VMT reduced by emission factors. But because commuters who drive-alone to meet a carpool, vanpool, bus, or train create a "cold start," their trips must be subtracted from the vehicle trip reduction to assess the air quality impact of elements. Additionally, the distance they travel to the meeting point must be subtracted from the VMT reduced to obtain an accurate VMT reduction count. It is these "adjusted" vehicle trips reduced and VMT reduced, rather than the initial totals, that are used to calculate emissions reduced.

In the Figure 1 example, it is assumed that 60% of the commuter placements drive alone to the rideshare or transit meeting point and that the average distance to this point is 5 miles. Using these figures, the "adjusted" vehicle trips reduced and VMT reduced are shown below:

Adjusted vehicle trips reduced = 1,120 trips – (1,120 x 0.6 with SOV access)
= 1,120 trips – 672 trips
= 448 vehicle trips reduced (for emissions calculation)

Adjusted VMT reduced = 28,000 VMT – (1,120 trips x 0.6 SOV access x 5 miles)
= 28,000 – 3,360
= 24,640 VMT reduced (for emissions calculation)

Step 8 – Estimate Daily Emissions Reduced

Daily emissions reduced are estimated by applying two regional emission factors, a "trip end emissions" factor and a "running emissions" factor, respectively, to the number of vehicle trips or "trip ends" reduced and to the VMT reduced to determine the pollutants (in this case NOx and VOC) reduced as result of the program. The trip end emissions factor accounts for the emissions created from a "cold start," when a vehicle is first started, and a "hot soak," that occur when the vehicle is later turned off. The running emission factor accounts for the emissions generated per mile of travel by a warmed-up engine.

The emission factors[15] used in the 2017 TDM analysis were:

Emission Factors	NOx	VOC	PM2.5 NOx	PM2.5	CO2
• Trip end *(gm / one-way vehicle trip)*	1.2435	2.5814	0.0312	1.3603	227.06
• Running *(gm / mile)*	0.1897	0.0688	0.0115	0.2019	380.68

[15] The emission factors presented here are derived from the EA's MOVES emission model. If the model parameters or inputs change, the emission factors also could change.

To estimate total daily emissions, the trip end emission factor is multiplied by the adjusted daily vehicle trips reduced (Step 7) and the running factor is multiplied by the adjusted daily VMT reduced (Step 7). These two products are then added to determine total daily NOx and VOC reductions in grams. This total is then divided by 907,185 grams per ton to convert the emissions reduced to tons per day. Using these emissions factors, the total NOx reduced for our example in Figure 1 is:

VOC = 448 trips x 1.2435 g/trip = 557 gr
= 24,640 VMT x 0.1897 gr/VMT = 4,674 gr
= (557 gm + 4,674 gr) / 907,185 gr/ton

= 0.0058 daily tons NOx reduced

The emission reductions for the other four pollutants (VOC, PM2.5 NOX precursors; PM2.5, and CO2) are calculated similarly, using emission factors noted above for each pollutant. However, emissions for PM2.5, PM2.5 NOx precursors, and CO2 are reported as annual reductions, rather than daily reductions. This additional calculation is made by multiplying daily impacts by 250 working days per year.

Step 9 – Estimate Energy and Commuter Cost Savings

While travel and emission impacts are the primary focus of the TDM impact analysis, energy and consumer benefits also are real and tangible benefits from commuter assistance programs. For this analysis, energy and commuter cost savings factors are applied to the VMT reduced. In 2017, these factors were as follows:

- Energy savings are based on an average fuel consumption factor of 18.0 miles per gallon for the Washington metropolitan area fleet of light duty vehicles (data derived from TRIMMS™ model)
- Consumer savings are based on an average marginal operating cost per mile (oil, gasoline, maintenance) for a mix of vehicle types and average distance driven per year. The American Automobile Association estimated a composite national average cost to be 20.5 cents per mile in 2017. When the 2020 TDM analysis is conducted, the cost per mile will be updated to reflect expenses at that time.

For this analysis, energy and commuter cost savings are calculated by multiplying the energy and consumer cost factors to the total (not adjusted) VMT reduced. As shown in Figure 1, the daily and annual energy and cost savings for the example element are as follows:

Energy saving (gallons of fuel)	= 24,640 daily VMT / 18.0 mpg
Daily saving	= 1,369 gallons per day
Annual saving (250 work days)	= 342,250 gallons saved per year
Commuter cost saving ($)	= 24,640 VMT x $0.205/mile
Daily saving	= $5,051 per day
Annual saving (250 work days)	= $1,262,750 saved per year
Annual saving per commuter (based on 1,600 placements)	= $789 saved per placement per year

Sample Calculations of Impacts for each TDM Program Element

The impact calculation methodology described above described the basic steps applied to all TDM program elements and provided one hypothetical numerical example. However, each element has unique placement rates and VTR factors and some of the steps differ slightly. Specific examples are presented for each element in Appendices C through H.

It should be noted that the numbers shown in the example are from the 2017 TDM Analysis Report, which forms the basis of this evaluation framework. The actual FY 2018 – FY 2020 values for placement rates, VTR factors, trip distances, SOV access percentages, and other calculation variables will be computed after the appropriate surveys have been completed and are likely to be somewhat different that the values shown in the appendices examples. The appendices are provided for illustrative purposes only.

Section 7 Reporting and Communication of Evaluation Results

The objective of the TDM evaluation process is to provide data on the performance of TDM program elements to assist regional and local decision-makers, funders, Commuter Connections program staff, and program partners to make sound program funding and operations decisions. To this end, the TDM evaluation produces a technical assessment of performance to apply to regional transportation and air quality planning and performance review efforts. Because the TDM program elements are offered, at least in part, to provide these benefits to the region, past TDM evaluations have focused primarily on analyzing travel and emissions impacts from use of Commuter Connections program.

However, the many surveys and analyses performed for the evaluation also collect a wealth of data on travel patterns and trends, traveler attitudes, and customer satisfaction that could be used to "tell the Commuter Connections story" to other audiences and to contribute to a broad range of regional transportation planning activities. By expanding the range of data transmitted and focusing the presentation of data on the needs and interests of other audiences, Commuter Connections could expand the value of its data collection and analysis investment and provide value to various new audiences.

Commuter Connections currently uses four reporting mechanisms to disseminate evaluation results:

- Survey reports and presentations
- Quarterly "Report Card"
- Program Annual Report
- TDM Analysis Report

Commuter Connections and/or a contractor produces a technical report for each data collection activity, such as the GRH survey report and the State of the Commute survey report. These reports present technical details of the survey methodology and results. The responsible party also prepares presentation materials to summarize highlights of the research for technical audiences, such as the TDM Evaluation Group, Commuter Connections Subcommittee, the Transportation Planning Board, and the TPB Technical Committee. And MWCOG media/publications staff use survey data in press releases and infographics for other publications.

COG/TPB's Commuter Connections staff prepares quarterly report card summaries for use by internal staff and local jurisdiction program partners to assess on-going progress. Staff compiles an annual report distributed to COG/TPB staff, local jurisdiction program partners, and regional policy-makers for administrative purposes. Finally, Commuter Connections produces a triennial TDM Analysis Report that documents the impacts of the TDM program elements for the three-year TDM evaluation period. Formal review of each of these documents is an integral part of the work program development for both COG/TPB staff and Commuter Connections program partners.

In ongoing discussions with local partners, Commuter Connections staff determined that brief "top findings" summaries of survey and evaluation data could be useful tools to disseminate evaluation results to audiences that would be unlikely to read technical reports. In the 2015-2017 evaluation period, the consulting team worked with COG staff to provide and format data that Commuter Connections used to prepare such survey and evaluation summaries in a variety of formats, such as printed survey topic "briefs" and online distribution methods (e.g., social media, targeted emails, blogs, net-conferences, etc.). During the 2018-2020 evaluation period, the contractor will continue to provide data and results in similar formats.

Section 8 Evaluation Responsibilities and Schedule

The key to any successful evaluation effort is for evaluation information to be generated and reported in a timely manner to decision makers. Commuter Connections prepares quarterly summaries for use by internal staff and local jurisdiction program partners to assess on-going progress. Annual and triennial evaluation results are reported to COG/TPB staff, local jurisdiction program partners, and regional policy-makers for policy purposes. Formal review of the results is an integral part of the work program development for both COG/TPB staff and Commuter Connections program partners.

Evaluation Frequencies and Schedule

Evaluation activities fall into three categories, with various recommended frequencies as described in Table 2. The first column shows evaluation activities in three categories: surveys, on-going tracking, and reporting. The second column indicates the frequency for administering surveys and on-going tracking. The specific schedule for all data collection activities has been established by Commuter Connections and is included as Appendix J. The final column of Table 2 indicates the party responsible for collecting or maintaining the data.

Table 2 also shows recommended results reporting activities. It is assumed that reports will be prepared following each survey (placement survey, GRH survey, SOC survey, Retention Rate survey, etc.) to document the results of the survey and calculate updated placement rates and VTR factors (if applicable) for the populations surveyed. As Table 2 indicates, in addition to these reports, internal activity and evaluation reports also are produced to report the progress of the Commuter Connections program as a whole and for individual TDM program elements. A full TDM Analysis Report will be developed every three years to document the TDM program element impacts during the previous three-year period. Finally, as described in Section 7, Commuter Connections is considering additional methods to present and disseminate results of its TDM evaluations. The specific schedules for these activities will be documented as the activities are defined.

Evaluation Responsibilities

The primary responsibility for performing quarterly and annual evaluations will reside with COG/TPB. COG/TPB will assume responsibility for managing regular and special Commuter Connections survey efforts conducted by outside contractors and will conduct some surveys, such as the GRH satisfaction survey, using in-house staff. COG/TPB staff also will assemble ongoing monitoring data, oversee all activities, and seek input to ensure consistency with accepted TDM analysis methods.

Commuter Connections local jurisdiction program partners will play a role in tracking some ongoing activities, especially in Employer Outreach, and will review and provide input on TDM evaluation activities.

Contractors may be used for some data collection and evaluation activities as directed by Commuter Connections staff. GRH service providers will provide data on usage as required in their contracts. Finally, employers will work with the Commuter Connections network members to provide information on program service utilization.

Table 2
Data Collection and Reporting Activities
Frequency and Responsibility

Evaluation Activity/Tool	Frequency	Responsibility
Ongoing Monitoring		
• Telework assistance database	Ongoing	CC
• GRH registrant / archived database	Ongoing	CC
• ACT! employer contact database	Monthly	CC, Sales representatives
• COC website and call volume tracking	Ongoing	CC
• Documentation of media / marketing activities	Ongoing	CC, Contractor
• Bike-to-Work Day participant records	Annual	CC
• Car Free day participant records	Ongoing	CC
• 'Pool Rewards participant records	Annual	CC
• Flextime Rewards participant records	Ongoing	CC
• IncenTrip participant records	Ongoing	CC
• CarpoolNow participant records	Ongoing	CC
• Commuter Connections Applicant Database	Ongoing	CC, Contractor
Resident / User Surveys		
• Telework-assisted employer follow-up survey	Triennial	CC, Contractor
• State of the Commute survey	Triennial	Contractor
• GRH registrant survey	Triennial	CC, Contractor
• Employee commute surveys	Ongoing	CC, Sales representatives, Contractor
• CC online system user placement rate survey	Triennial	CC, Contractor
• Bike-to-Work participant survey	Triennial	CC, WABA
• Retention Rate survey	Five-year	CC, Contractor
• 'Pool Rewards participant survey	Triennial	CC, Contractor
• CarpoolNow participant survey	Triennial	CC, Contractor
Evaluation Results Reporting		
• Commuter Connections "Report Card"	Quarterly	CC
• CC Program Annual Report	Annual	CC
• TDM Evaluation Report	Triennial	CC, Contractor
• Commuter Connections survey reports	As produced	CC, Contractor

CC – COG TPB – Commuter Connections

WABA – Washington Area Bicyclist Association

List of Appendices

Appendix A
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 carpools, he would make ½ vehicle trip to work and ½ 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 A, 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
	M	T	W	T	F	M	T	W	T	F	M	T	W	T	F	Change
Placement 1	D	D	D	D	D	C	C	C	C	C						
DA to 2p CP	2	2	2	2	2	1	1	1	1	1	-1	-1	-1	-1	-1	-5 trips
Placement 2	D	D	D	D	D	T	T	T	T	T						
DA to TR	2	2	2	2	2	0	0	0	0	0	-2	-2	-2	-2	-2	-10 trips
Placement 3	D	D	D	D	D	D	D	C	C	C						
DA to TC/DA (part-time)	2	2	2	2	2	2	2	2	0	0	0	0	0	-2	-2	-4 trips
Placement 4	D	D	D	D	D	D	D	C	C	C						
DA to CP/DA (part-time)	2	2	2	2	2	2	2	2	1	1	0	0	0	-1	-1	-2 trips
Placement 5	C	C	C	C	C	T	T	T	T	T						
2p CP to TR	1	1	1	1	1	0	0	0	0	0	-1	-1	-1	-1	-1	-5 trips
Placement 6	T	T	T	T	T	C	C	C	C	C						
TR to 2p CP	0	0	0	0	0	1	1	1	1	1	+1	+1	+1	+1	+1	+5 trips
Placement 7	D	D	D	D	C	D	D	C	C	C						
DA/CP to CP (part-time)	2	2	2	2	1	2	2	1	1	1	0	0	-1	-1	0	-2 trips
Total weekly trips	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 B
2008 Adjustment to COMMUTER Model Coefficients

Impacts for the Employer Outreach program element are calculated using the EPA COMMUTER model (v 2.0). Prior to the 2008 analysis, the default cost and time coefficients for the Washington DC region were used in model runs. Analysis performed by the LDA Consulting team for COG in 2007 suggested the COMMUTER model overestimated the likely impacts of employers' strategies, in particular those related to financial incentives. Thus the team examined possible adjustment to the COMMUTER model to give more conservative results for the 2008 TDM analysis.

The results of the analysis suggested the most acceptable option was to reduce the cost coefficient to a level that could be expected to produce a vehicle trip reduction (VTR) change that approximated employee survey results of employers for which before commuter programs were implemented and after implementation. Because "with program" employee survey data were not available for the MWCOG region, the team used data from the Seattle, WA metropolitan region and determined the Seattle cost coefficient that would have predicted the result found in the Seattle survey data. The team then applied a proportional reduction to the current MWCOG cost coefficient.

The team performed a coefficient sensitivity analysis to estimate the VTR result at various cost coefficient levels. Two sensitivity cases were run, to test two different employer situations. The first included employers that had maintained or expanded the services in their commute programs, regardless of their program level (Level 1-4). The second case included employers that would have been classified as Level 3 or Level 4 in the TDM analysis, regardless of the changes they had made in their program. This case was run because it was consistent with the TDM analysis methodology.

Table 1 below shows the results for the Level 3-4 employer case, which was deemed more appropriate for this analysis.

Table 1 - COMMUTER model Vehicle Trip Rate (VTR) change prediction by travel cost coefficient - Level 3 and 4 Employers (Sample size 609)

Travel Cost Coefficient	Survey VTR Change	COMMUTER VTR Change
-0.0009	-2.32	-1.89
-0.0013	-2.32	-2.19
-0.0015	-2.32	**-2.35**
-0.0019	-2.32	-2.66
-0.0024*	**-2.32**	-3.06
-0.0029	-2.32	-3.46
-0.0031	-2.32	-3.62
-0.0034	-2.32	-3.86
-0.0039	-2.32	-4.26
-0.0043**	-2.32	-4.58
-0.0047	-2.32	-4.9
-0.0049	-2.32	-5.06

Coefficient -0.0024 vs -.0015,
Difference of 0.0009
VTR change difference 0.74

VTR difference 0.74
Coefficient difference of 0.009
-0.0043 vs -0.0034

*Coefficient for Seattle **Coefficient for MWCOG region

As shown, the VTR reduction estimated from the Seattle survey for these employers was -2.32. The COMMUTER model, using the Seattle cost coefficient of -0.0024 would have predicted a VTR result of -3.06, or a difference of about 0.74. To obtain a result of -2.32, the cost coefficient would have to have been -0.0015, or a reduction of 0.0009.

Appendix B, continued

When the sensitivity results were plotted with coefficient on one axis and the VTR change on the other, it was clear that the change in VTR was directly proportional to the change in coefficient. Thus, it was reasonable to apply the same 0.74 difference from the Seattle VTR results to the MWCOG predicted result to estimate the coefficient that would produce a proportionately accurate result in the MWCOG region.

The cost coefficient used with the COMMUTER model in the 2002-2005 TDM analysis was -0.0043. Referring again to Table, 1, a coefficient of -0.0043 would predict a VTR change of -4.58. Applying the 0.74 difference in the VTR change result from the Seattle case to the MWCOG coefficient would result in a new VTR change of -3.84. This number does not match the -2.32 VTR change result for the Seattle data, not is it reasonable to expect that it would, since the Seattle area survey results reflect Seattle area conditions. It is not unreasonable to assume that the MWCOG area could have a higher VTR change when similar commuter program conditions are in place.

To obtain this -3.84 VTR value, the coefficient for MWCOG would have to be -0.0034. The VTR result of -3.84 would represent about a 16% reduction in impact compared to that produced using the -0.0043 cost coefficient.

With these changes, the old (2005) and new (2008) coefficients used in the COMMUTER Model were as follows. No changes were made to the time coefficients. The 2008 coefficients also were used in the 2011 analysis.

	2008 Coefficients	2005 Coefficients
IVTT- In-vehicle travel time - all modes (minutes)	-0.0300	-0.0300
OVTT - Transit walk time (minutes)	-0.0750	-0.0750
OVTT - Transit wait time (minutes)	-0.0750	-0.0750
Cost - Auto parking (cents)	-0.0034	-0.0043
Cost - Transit fare (cents)	-0.0034	-0.0043

During 2010-2012, MWCOG developed a new regional travel model. This might be expected to require updated COMMUTER Model cost and time coefficients. MWCOG modeling staff reviewed the COMMUTER Model coefficients used by the consulting staff for the 2011 evaluation and determined that no further adjustment would be needed for 2014 to be consistent with the new regional model. MWCOG continues to use this regional model, thus, the coefficients used in 2011 and 2014 will be carried over for the 2018-2020 evaluation.

Appendix C
Sample Calculations of Telework Impacts

(Note: Impacts shown below include only Maryland telework; Impacts for the new Virginia (TWVA) component were not part of the Telework program element in 2014. The calculation of the Virginia component in 2017 will be similar to the calculation for Employees at Maryland TW assisted worksites)

Populations of Interest

All regional telecommuters	676,053	(from SOC survey)
Teleworkers with MD home or work	287,630	43% (from SOC survey)
Teleworkers not in MD	388,423	57% (from SOC survey)
Employees at TW assisted worksites	26,620	(from TW assistance survey)

Commuter Connections TW Placement Rates

Directly assisted TW

• Within Maryland	9.1%	(% of TC assisted by CC, from SOC survey)
• Not in Maryland	9.1%	(% of TC assisted by CC, from SOC survey)

TW at assisted worksites (MD only

• Within Maryland	0.6%	(% 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 element)

• Directly assisted telecommuters	26,174	(regional TC x directly assisted placement rate)
• Telecommuters at TW assisted sites	160	(employees at assisted sites x assisted site placement rate)
Total assisted telecommuters - MD	**26,334**	

Not Maryland (to be credited to COC)

• Directly assisted telecommuters	35,346	(regional TC x directly assisted placement rate)
• Telecommuters at TW assisted sites	0	(employees at assisted sites x assisted site placement rate)
Total assisted telecommuters – Not MD	**35,346**	

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

• % Home-based telecommuters	99%	(from SOC survey)
• % Non-home (NH)-based telecommuters	1%	(from SOC survey)

Maryland (credited to Telework element)

• Home-based telecommuters	26,071	(total assisted TW x % Home-based TW)
• NH-based telecommuters	263	(total assisted TW x % NH-based TW)

Not Maryland (credited to COC)

• Home-based telecommuters	34,993	(total assisted TW x % Home-based TW)
• NH-based telecommuters	353	(total assisted TW x % NH-based TW)

Appendix C, continued

Daily Vehicle Trips Reduced

VTR Factors

• Home-based factor - MD	0.37	(from SOC survey)
• Home-based factor – Not MD	0.35	(from SOC survey)
• NH-based factor – MD and Not-MD	0.02	(from SOC survey)

Maryland (credited to Telework element)

• Home-based VT reduced	9,646	(HB TW x HB VTR factor)
• NH-based VT reduced	5	(NH-based TW x NH VTR factor)
Daily Vehicle Trips Reduced - MD	**9,651**	

Not Maryland (credited to COC)

• Home-based VT reduced	12,248	(HB TW x HB VTR factor)
• NH-based VT reduced	7	(NH-based TW x NH VTR factor)
Daily Vehicle Trips Reduced – Not MD	**12,255**	

Daily VMT Reduced

Ave one-way trip distance (mi) to main workplace

• Home-based – MD	21.3	(SOC survey)
• Home-based – Not MD	15.3	(SOC survey)

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

• Non-home based – to main workplace	20.3	(SOC survey)
• Non-home based – to TW location	10.2	(SOC survey)
• Non-home based – net VMT reduced	10.1	(SOC survey)

VMT reductions on TW days

Maryland (credited to Telework element)

• Home-based VMT reduced	205,460	(HB VT reduced x average OW miles to main workplace)
• NH-based VMT reduced	51	(NHB VT reduced x net OW miles reduced per trip)
Daily VMT Reduced - MD	**205,511**	

Not Maryland (credited to COC)

• Home-based VMT reduced	187,394	(HB VT reduced x average OW miles to main workplace)
• NH-based VMT reduced	71	(NHB VT reduced x net OW miles reduced per trip)
Daily VMT Reduced – Not MD	**187,465**	

Appendix C, continued

Maryland (credited to Telework element)

Daily Emissions Reduced – NOx and VOC

NOx	Trips	15 Emission Factor	VMT	15 Emission Factor	Tot gm	Tot ton
• From Starts	9,651	1.5408			14,870	0.0164
• From Running			205,511	0.3737	76,799	0.0847
Total NOx reduced (tons)					**Daily**	**0.1011**

VOC	Trips	15 Emission Factor	VMT	15 Emission Factor	Tot gm	Tot ton
• From Starts	9,651	2.8573			27,576	0.0304
• From Running			205,511	0.0915	18,804	0.0207
Total VOC reduced (tons)					**Daily**	**0.0511**

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

PM 2.5	Trips	15 Emission Factor	VMT	15 Emission Factor	Tot gm	Tot ton
• From Starts	9,651	0.0367			354	0.0004
• From Running			205,511	0.0170	3,494	0.0039
Total PM 2.5 reduced (tons)					**Daily**	**0.0043**
					Annual	**1.075**

PM 2.5 Precursor NOx	Trips	15 Emission Factor	VMT	15 Emission Factor	Tot gm	Tot ton
• From Starts	9,651	1.7510			16,899	0.0186
• From Running			205,511	0.3663	75,278	0.0830
Total PM 2.5 Precursor NOx reduced (tons)					**Daily**	**0.1016**
					Annual	**25.400**

CO2	Trips	15 Emission Factor	VMT	15 Emission Factor	Tot gm	Tot ton
• From Starts	9,651	239.26			2,309,098	2.55
• From Running			205,511	404.17	83,061,179	91.56
Total CO2 reduced (tons)					**Daily**	**94.11**
					Annual	**23,527.5**

Appendix C, continued

Not Maryland (credited to COC)

Daily Emissions Reduced – NOx and VOC

NOx	Trips	15 Emission Factor	VMT	15 Emission Factor	Tot gm	Tot ton
• From Starts	12,255	1.5408			18,883	0.0208
• From Running			187,465	0.3737	70,056	0.0772
Total NOx reduced (tons)					**Daily**	**0.0980**

VOC	Trips	15 Emission Factor	VMT	15 Emission Factor	Tot gm	Tot ton
• From Starts	12,255	2.8573			35,016	0.0386
• From Running			187,465	0.0915	17,153	0.0189
Total VOC reduced (tons)					**Daily**	**0.0575**

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

PM 2.5	Trips	15 Emission Factor	VMT	15 Emission Factor	Tot gm	Tot ton
• From Starts	12,255	0.0367			450	0.0005
• From Running			187,465	0.0170	3,187	0.0035
Total PM 2.5 reduced (tons)					**Daily**	**0.0040**
					Annual	**1.000**

PM 2.5 Precursor NOx	Trips	15 Emission Factor	VMT	15 Emission Factor	Tot gm	Tot ton
• From Starts	12,255	1.7510			21,459	0.0237
• From Running			187,465	0.3663	68,668	0.0757
Total PM 2.5 Precursor NOx reduced (tons)					**Daily**	**0.0994**
					Annual	**24.850**

CO2	Trips	15 Emission Factor	VMT	15 Emission Factor	Tot gm	Tot ton
• From Starts	12,255	239.26			2,932,131	3.23
• From Running			187,465	404.17	75,767,608	83.52
Total CO2 reduced (tons)					**Daily**	**86.75**

Appendix D
Sample Calculations of Guaranteed Ride Home Impacts

Populations of Interest		
• New GRH registrants (FY12-FY14)	13,255	(GRH database)
• Re-registrants from FY2012	7,610	
• One-time exceptions	291	(GRH database)
Total GRH base	**21,156**	
Within MSA	63%	13,328
Outside MSA	37%	7,828
GRH Placement Rates (continued rate only)		
• Within MSA placement rate	61.3%	(GRH survey)
• Outside MSA placement rate	61.1%	(GRH survey)
Placements (continued only)		
• Within MSA	**8,170**	(Within MSA base x within MSA placement rate)
• Outside MSA	**4,783**	(Outside MSA base x outside MSA placement rate)
Total Placements	**12,953**	
Daily Vehicle Trips Reduced		
VTR Factors (continued only)		
• Within MSA	0.68	(GRH survey)
• Outside MSA	0.61	(GRH survey)
VT Reduced (continued only)		
• Within MSA	**5,556**	**(**Within MSA placements x within MSA VTR factor)
• Outside MSA	**2,918**	(Outside MSA placements x outside MSA VTR factor**)**
Total Daily Vehicle Trips Reduced	**8,474**	
Daily VMT Reduced		
• Ave one-way trip distance (mi)		
• Within MSA	27.6	(from GRH survey)
• Outside MSA	27.6	(discounted from actual 50.1 miles from GRH survey)
VMT reduced		
• Within MSA	153,346	(Within MSA VT reduced x trip distance)
• Outside MSA	80,537	(Outside MSA VT reduced x trip distance)
Total Daily VMT Reduced	**233,883**	

Appendix D, continued

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

Inside MSA

- SOV access percentage 70% (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 8,474
- Within MSA access VT (deduct) - 3,889 (VT reduction within MSA x SOV access %)
- Outside MSA access VT 0 No deduction (access trips are outside MSA)

Total VT for AQ analysis 4,585

Adjusted VMT Reduction – net of VMT access

- Total VMT reduced 233,883
- Within MSA access VMT (deduct) - 20,612 (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 213,271

Daily Emissions Reduced – NOx and VOC

NOx	Trips	15 Emission Factor	VMT	15 Emission Factor	Tot gm	Tot ton
• From Starts	4,585	1.5408			7,065	0.0078
• From Running			213,271	0.3737	79,699	0.0879
Total NOx reduced (tons)					**Daily**	**0.0957**

VOC	Trips	15 Emission Factor	VMT	15 Emission Factor	Tot gm	Tot ton
• From Starts	4,585	2.8573			13,101	0.0144
• From Running			213,271	0.0915	19,514	0.0215
Total VOC reduced (tons)					**Daily**	**0.0359**

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

PM 2.5	Trips	15 Emission Factor	VMT	15 Emission Factor	Tot gm	Tot ton
• From Starts	4,585	0.0367			168	0.0002
• From Running			213,271	0.0170	3,626	0.0040
Total PM 2.5 reduced (tons)					**Daily**	**0.0042**
					Annual	**1.0455**

PM 2.5 Precursor NOx	Trips	15 Emission Factor	VMT	15 Emission Factor	Tot gm	Tot ton
• From Starts	4,585	1.7510			8,028	0.0088
• From Running			213,271	0.3663	78,121	0.0862
Total PM 2.5 Precursor NOx reduced (tons)					**Daily**	**0.0950**
					Annual	**23.7409**

Appendix D, continued

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

CO2	Trips	15 Emission Factor	VMT	15 Emission Factor	Tot gm	Tot ton
• From Starts	4,585	239.26			1,097,007	1.2092
• From Running			213,271	404.17	86,197,740	95.0167
Total CO2 reduced (tons)					**Daily**	**96.2259**
					Annual	**24,056.5**

Correction for Overlap with MM Program Element

Total GRH apps FY 12, 13, 14	21,156	
New GRH apps FY 12, 13, 14	13,255	63%
Estimated MM share of new GRH	15%	
Estimated MM share of GRH impact	9%	

Net GRH = GRH Base – Mass Marketing credit

	Net GRH	GRH Base	Mass Mkt
Placements	11,787	12,953	1,166
VMT reduced	7,711	8,474	763
VMT reduced (mi)	212,834	233,883	21,049
Daily Emissions Reduced			
NOx (T)	0.0871	0.0957	0.0086
VOC (T)	0.0327	0.0359	0.0032
Annual Emissions Reduced			
PM 2.5 (T)	0.9514	1.0455	0.0941
PM 2.5 Precursor NOx (T)	21.6042	23.741	2.1367
CO2 (T)	21,891.4	24,056.5	2,165.1

Appendix E
Sample Calculation of Employer Outreach

Populations of Interest

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

	Employers	Employees
• 2011 unchanged programs	626	228,720
• Expanded programs in 2014	329	179,374
• New programs in 2014	801	241,354
• Deleted programs since 2011	150	42,426

Average Vehicle Occupancy (AVO)

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

	Starting AVO	Ending AVO
• 2011 unchanged programs	1.26	1.36
• Expanded programs – continued base	1.23	1.31
• Expanded programs – new impacts	1.31	1.33
• New programs	1.29	1.42
• Deleted programs	1.29	1.21

Daily person trips

Total employees x 2 one-way trips per day
Starting (pre-program) and ending (with-program)

	Starting	Ending
• 2011 unchanged programs	457,440	457,440
• Expanded programs	358,748	358,748
• New programs	482,708	482,708
• Deleted programs	84,852	84,852

Daily vehicle trips

Total employees / starting AVO)
Starting (pre-program) and ending (with-program)

	Starting	Ending	Difference
• 2011 unchanged programs	363,048	336,353	26,694
• Expanded programs – maintained base	291,665	273,853	17,812
• Expanded programs – new impact	273,853	269,735	4,118
• New programs	374,192	339,935	34,257
• Deleted programs	65,777	70,126	(4,349)

Total Daily Vehicle Trips Reduced	
• 2011 maintained impacts	44,507
• New/expanded impacts	38,375
Net 2014 reduction	**82,882**

Appendix E, continued

Daily VMT reduced

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

- 2011 unchanged programs 426,893
- Expanded programs – maintained base 258,725
- Expanded programs – new impact 25,143
- New programs 542,935
- Deleted programs (73,348)

Total Daily VMT Reduced

- 2011 continued impacts 685,618
- New/expanded impacts 568,078

Net 2011 reduction 1,253,696

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

- SOV access percentage 29% (from 2013 SOC survey)
- SOV access distance (mi) 2.9 (from 2013 SOC survey)

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

(VT reduced x non-SOV access %)

- 2011 maintained impacts 31,600
- New/expanded impacts 27,246

VMT Reduction without SOV access

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

- 2011 maintained impacts 648,188
- New/expanded impacts 535,804

Emissions Reduced – Maintained from 2011

Daily Emissions Reduced – NOx and VOC

NOx	Trips	15 Emission Factor	VMT	15 Emission Factor	Tot gm	Tot ton
• From Starts	31,600	1.5408			48,689	0.0537
• From Running			648,188	0.3737	242,228	0.2670
Total NOx reduced (tons)					**Daily**	**0.3207**

VOC	Trips	15 Emission Factor	VMT	15 Emission Factor	Tot gm	Tot ton
• From Starts	31,600	2.8573			90,291	0.0995
• From Running			648,188	0.0915	59,309	0.0654
Total VOC reduced (tons)					**Daily**	**0.1649**

Appendix E, continued

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

PM 2.5	Trips	15 Emission Factor	VMT	15 Emission Factor	Tot gm	Tot ton
• From Starts	31,600	0.0367			1,160	0.0013
• From Running			648,188	0.0170	11,019	0.0121
Total PM 2.5 reduced (tons)					**Daily**	**0.0134**
					Annual	**3.356**

PM 2.5 Precursor NOx	Trips	15 Emission Factor	VMT	15 Emission Factor	Tot gm	Tot ton
• From Starts	31,600	1.7510			55,332	0.0610
• From Running			648,188	0.3663	237,431	0.2617
Total PM 2.5 Precursor NOx reduced (tons)					**Daily**	**0.3227**
					Annual	**80.679**

CO2	Trips	15 Emission Factor	VMT	15 Emission Factor	Tot gm	Tot ton
• From Starts	31,600	239.26			7,560,616	8.3342
• From Running			648,188	404.17	261,978,144	288.7814
Total CO2 reduced (tons)					**Daily**	**297.116**
					Annual	**74,278.9**

Emissions Reduced - New / Expanded

Daily Emissions Reduced – NOx and VOC

NOx	Trips	15 Emission Factor	VMT	15 Emission Factor	Tot gm	Tot ton
• From Starts	27,246	1.5408			41,981	0.0463
• From Running			535,804	0.3737	200,230	0.2207
Total NOx reduced (tons)					**Daily**	**0.2670**

VOC	Trips	15 Emission Factor	VMT	15 Emission Factor	Tot gm	Tot ton
• From Starts	27,246	2.8573			77,850	0.0858
• From Running			535,804	0.0915	49,026	0.0540
Total VOC reduced (tons)					**Daily**	**0.1398**

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

PM 2.5	Trips	15 Emission Factor	VMT	15 Emission Factor	Tot gm	Tot ton
• From Starts	27,246	0.0367			1,000	0.0011
• From Running			535,804	0.0170	9,109	0.0100
Total PM 2.5 reduced (tons)					**Daily**	**0.0111**
					Annual	**2.786**

Appendix E, continued

Emissions Reduced - New / Expanded (cont)

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

PM 2.5 Precursor NOx	Trips	15 Emission Factor	VMT	15 Emission Factor	Tot gm	Tot ton
• From Starts	27,246	1.7510			47,708	0.0526
• From Running			535,804	0.3663	196,265	0.2163
Total PM 2.5 Precursor NOx reduced (tons)					**Daily**	**0.2689**
					Annual	**67.234**

CO2	Trips	15 Emission Factor	VMT	15 Emission Factor	Tot gm	Tot ton
• From Starts	27,246	239.26			6,518,878	7,1858
• From Running			535,804	404.17	216,555,903	238,7120
Total CO2 reduced (tons)					**Daily**	**245.8978**
					Annual	**61,474.5**

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

	Total EO	EO w/o bike	EO-bike
Vehicle Trips Reduced	78,533	78,210	323
VMT Reduced (miles)	1,327,044	1,325,107	1,937
Daily Emissions Reduced			
NOx (tons)	0.5340	0.5327	0.0013
VOC (tons)	0.3047	0.3035	0.0012
Annual Emissions Reduced			
PM 2.5 (T)	6.1419	6.1295	0.0124
PM 2.5 Precursor NOx (T)	147.9125	147.5612	0.3513
CO2 (T)	135,753.3	135,516.3	237.0

COMMUTER CONNECTIONS
EMPLOYER SERVICES PARTICIPATION LEVELS
(EFFECTIVE July 1, 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 Stations(s) at worksite

Appendix E, continued

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

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 F
Sample 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 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 – GRH credit

PART 1 – Direct Ad Influence

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

Total commuters in region	2,481,673	(SOC)
• % recall any commute message	41%	(SOC)
• % recall CC/COG commute message	21%	(SOC)
• % chg to alt mode after CC/COG ads	2.8%	(SOC)
• % changers influenced by ad	84%	(SOC)
Placements – no contact with CC	**12,257**	(Commuters x CC recall X change % x influence %)
Placement Rates		
• Continued placement rate	40%	(SOC)
• Temporary placement rate	60%	(SOC)
Placements		
• Continued placements	4,903	(Placements x continued placement rate)
• Temporary placements	7,354	(Placements x temporary placement rate)
Daily Vehicle Trips Reduced		
• Continued VTR factor	0.70	(SOC)
• Temporary VTR factor	0.62	(SOC)
• Continued VT reduced	3,432	(Continued placements x continued VTR factor)
• Temporary VT reduced	3,511	(Temporary placements x temporary VTR factor x 77% credit for temporary use)
Total Daily Vehicle Trips Reduced	**6,943**	
Daily VMT Reduced		
• Ave one-way trip dist (mi)	15.8	(SOC)
Total Daily VMT Reduced	**109,699**	

Appendix F, 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	2,083	(VT x SOV access %)
• VT with no SOV access	4,860	(Total VT – SOV access VT)

Adjusted VMT Reduction

• SOV access VMT	5,624	(VT x SOV % x trip distance)
• VMT with no SOV access	104,075	(Total VMT – SOV access VMT)

Total VT for AQ analysis	**4,860**
Total VMT for AQ analysis	**104,075**

PART 2 – Pool Rewards Participants

Program participants (through June 2014) 359

Placement Rates – by retention after program ended

• Continued placement rate (June 2014)	65%	(2014 'Pool Rewards follow-up survey)
• Temporary placement rate	35%	(2014 'Pool Rewards follow-up survey)

Placements

• Continued placements	233	(Placements x continued placement rate)
• Temporary placements	126	(Placements x temporary placement rate)
Total placements	**359**	

Daily Vehicle Trips Reduced

• Continued VTR factor	0.72	(2014 'Pool Rewards follow-up survey)
• Temporary VTR factor	0.64	('Pool Rewards logging data for program period)
• Temporary discount	50%	(assumes 13 weeks of program + 13 weeks after program)
• Continued VT reduced	168	(Continued placements x continued VTR factor)
• Temporary VT reduced	41	(Temporary placements x temporary VTR factor x 25% credit for temporary use)
Total Daily Vehicle Trips Reduced	**209**	

Daily VMT Reduced

• Ave one-way trip dist (mi)	31.2	(2014 'Pool Rewards follow-up survey)
Total Daily VMT Reduced	**6,521**	

Appendix F, 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	50%	
• SOV access distance (mi)	5.5	

Adjusted VT Reduction

• SOV access VT	105	(VT x SOV access %)
• VT with no SOV access	104	(Total VT – SOV access VT)

Adjusted VMT Reduction

• SOV access VMT	578	(VT x SOV % x trip distance)
• VMT with no SOV access	5,943	(Total VMT – SOV access VMT)

Total VT for AQ analysis	**104**
Total VMT for AQ analysis	**5,943**

PART 3 – Car Free Day Event

Pledges (estimate 75% participation of pledges)

Fall 2011 – 12,000	9,000
Fall 2012 – 6,572	4,929
Fall 2013 – 4,188	3,141
Total Placements	**17,070**

Event Impacts

Daily Vehicle Trips Reduced

• % driving alone on non-Car Free days	46%	(Pledge data)
• Event VTR factor	0.85	(Pledge data)
• Event VT reduced	14,510	(Pledges x event VTR factor)
• Equivalent daily VT	19	(Event VT reduced / 750 days over 3 years)

Daily VMT Reduced

• Ave one-way trip distance (mi)	19.4	(Pledge data)
• Event VMT reduced	281,494	(Event VT reduced x distance)
• Equivalent daily VMT	375	(Event VMT reduced / 750 days over 3 years)

Ongoing Impacts

Daily Vehicle Trips Reduced

• Estimate continued use after CFD	5%	
Ongoing placements	**854**	(Total participants x continued rate)
• Ongoing VTR factor (after CFD)	0.34	
• Ongoing daily VT reduced	290	(Ongoing participants x ongoing VTR factor)
Total Daily VT Reduced	**309**	(Event equivalent daily VT + ongoing daily VT)

Appendix F, continued

PART 3 (Car Free Day) (continued)

Ongoing Impacts (cont)

Daily VMT Reduced

• Trip distance	19.4	
• Ongoing daily VT	5,626	(Ongoing daily VT x trip distance)
Total Daily VMT Reduced	**6,001**	(Event equivalent daily VMT + ongoing daily VMT)

Summary of Travel Impacts for Parts 1, 2, 3

	Total 1, 2, 3	Direct Ads	'Pool Rewards	Car Free Day
Placements	13,470	12,257	359	854
Vehicle Trips Reduced	7,461	6,943	209	309
VMT Reduced (miles)	122,221	109,699	6,521	6,001
Air Quality Adjusted VT / VMT				
Vehicle Trips Reduced	5,273	4,860	104	309
VMT Reduced (miles)	116,019	104,075	5,943	6,001

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

NOx	Trips	15 Emission Factor	VMT	15 Emission Factor	Tot gm	Tot ton
• From Starts	5,273	1.5408			8,125	0.0090
• From Running			116,019	0.3737	43,356	0.0478
Total NOx reduced (tons)					**Daily**	**0.0568**

VOC	Trips	15 Emission Factor	VMT	15 Emission Factor	Tot gm	Tot ton
• From Starts	5,273	2.8573			15,067	0.0166
• From Running			116,019	0.0915	10,616	0.0117
Total VOC reduced (tons)					**Daily**	**0.0283**

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

PM 2.5	Trips	15 Emission Factor	VMT	15 Emission Factor	Tot gm	Tot ton
• From Starts	5,273	0.0367			194	0.0002
• From Running			116,019	0.0170	1,972	0.0022
Total PM 2.5 reduced (tons)					**Daily**	**0.0024**
					Annual	**0.597**

Appendix F, continued

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

PM 2.5 Precursor NOx	Trips	15 Emission Factor	VMT	15 Emission Factor	Tot gm	Tot ton
• From Starts	5,273	1.7510			9,233	0.0102
• From Running			116,019	0.3663	42,498	0.0468
Total PM 2.5 Precursor NOx reduced (tons)					**Daily**	**0.0570**
					Annual	**14.256**

CO2	Trips	15 Emission Factor	VMT	15 Emission Factor	Tot gm	Tot ton
• From Starts	5,273	239.26			1,261,618	1.3907
• From Running			116,019	404.17	46,891,399	51.6889
Total CO2 reduced (tons)					**Daily**	**53.0896**
					Annual	**13,269.9**

PART 4 - Bike to Work Day Credit

Participants' riding percentage and frequency

Number of riders	19,707	(BTWD registration data, 2012, 2013, 2014, adjusted for use by some 2012 participants in 2013 and 2014)
% biking to work before event	82.6%	(BTWD survey)
% new riders	10.7%	(BTWD survey)
Number of new riders	2,109	
% who increase riding days	21.8%	
Number of increased riders	4,296	
Total placements	**6,405**	(Total new + increased riders)

Change in Bike Days

Summer Biking		
% new riders in summer	10.2%	(BTWD survey)
Weekly new bike days summer	1.4	(BTWD survey)
Weekly new bike days summer	2,814	
% increased riders in summer	20.3%	(BTWD survey)
Weekly inc bike days summer	1.6	(BTWD survey)
Weekly inc bike days summer	6,401	
Winter Biking		
% new riders biking winter	8.5%	(BTWD survey)
Weekly new bike days winter	1.4	(BTWD survey)
Weekly new bike days winter	2,345	
% increased riders biking winter	13.9%	(BTWD survey)
Weekly increased bike days winter	1.8	(BTWD survey)
Weekly increased bike days winter	4,931	

Appendix F, continued

PART 4 (Bike to Work Day) (continued)

Additional Bike Days (New and Increased Riding)

• NEW bike days summer	9,215	(riders x % new after event x ave new days bike after)
• NEW bike days fall-winter	7,276	(riders x % new after event x % still riding late fall x ave new days bike in late fall)
• Total additional bike days summer	258,020	(weekly summer days x 28 weeks – Apr-Oct)
• Total additional bike days winter	160,072	(weekly winter days x 22 weeks – Nov-Mar)
• Total additional bike days - year	418,092	(summer bike days + winter bike days)
• Additional bike trips - year	836,184	(annual bike days x 2 trips per day)

Additional Bike Trips and Vehicle Trip and VMT Reductions

• Ave new daily bike trips	3,345	(Annual new bike trips / 250)
• % Drive alone/CP/VP on non-bike days	47%	(BTWD survey)
BTWD Daily Vehicle Trips Reduced	**1,572**	(daily new bike trips x DA/CP/VP percentage)

Daily VMT Reduced

• Ave trip distance (mi)	10.4	(BTWD survey)
BTWD Daily VMT Reduced	**16,349**	(vehicle trips reduced x average trip distance)

<u>Daily Emissions Reduced</u> – NOx and VOC – Bike to Work Day

		15 Emission		15 Emission		
NOx	**Trips**	**Factor**	**VMT**	**Factor**	**Tot gm**	**Tot ton**
• From Starts	1,572	1.5408			2,422	0.0027
• From Running			16,349	0.3737	6,110	<u>0.0067</u>
Total NOx reduced (tons)					**Daily**	**0.0094**

		15 Emission		15 Emission		
VOC	**Trips**	**Factor**	**VMT**	**Factor**	**Tot gm**	**Tot ton**
• From Starts	1,572	2.8573			4,492	0.0050
• From Running			16,349	0.0915	1,496	<u>0.0016</u>
Total VOC reduced (tons)					**Daily**	**0.0066**

<u>Annual Emissions Reduced</u> – PM 2.5, Precursor NOx, and CO2

		15 Emission		15 Emission		
PM 2.5	**Trips**	**Factor**	**VMT**	**Factor**	**Tot gm**	**Tot ton**
• From Starts	1,572	0.0367			58	0.0001
• From Running			16,349	0.0170	278	<u>0.0003</u>
Total PM 2.5 reduced (tons)					**Daily**	**0.0004**
					Annual	**0.093**

		15 Emission		15 Emission		
PM 2.5 Precursor NOx	**Trips**	**Factor**	**VMT**	**Factor**	**Tot gm**	**Tot ton**
• From Starts	1,572	1.7510			2,753	0.0030
• From Running			16,349	0.3663	5,989	<u>0.0066</u>
Total PM 2.5 Precursor NOx reduced (tons)					**Daily**	**0.0096**
					Annual	**2.409**

Appendix F, continued

PART 4 (Bike to Work Day) (continued)

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

CO2	Trips	15 Emission Factor	VMT	15 Emission Factor	Tot gm	Tot ton
• From Starts	1,572	239.26			376,117	0.4146
• From Running			16,349	404.17	6,607,775	7.2838
Total CO2 reduced (tons)					**Daily**	**7.6984**
					Annual	**1,924.6**

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 2012	6,241	(CC database)
• FY 2013	5,736	(CC database)
• FY 2014	4,721	(CC database)
Total new applicants	**16,698**	
Total CC applicants	87,247	(includes new, re-apply, and follow-up)
New apps 12-14 as % of total	19.1%	(new apps FYs 12-14 / total CC apps)
% influenced by ads to contact CC	15%	(COC – monthly applicant analysis)
% all apps influenced by ads	2.9%	

CC Impacts – FY 12-14

Travel Impacts	MM Share	COC base
• CC placements	1,024	35,310
• CC Vehicle trips reduced	498	17,172
• CC VMT reduced	13,650	470,691

Emissions Impacts	MM Share	COC base	
• NOx reduced (daily tons)	0.0060	0.2052	Daily
• VOC reduced (tons)	0.0024	0.0811	Daily
• PM2.5 reduced (tons)	0.0647	2.2304	Annual
• PM2.5-NOx reduced (tons)	1.4801	51.0371	Annual
• CO2 reduced (tons)	1,480.8	51,060.9	Annual

Appendix F, continued

PART 6 – GRH Credit – From GRH Analysis

Total GRH apps FY 12, 13, 14	21,156	
New GRH apps FY 12, 13, 14	13,255	63% of total applications
Estimated MM share of new GRH	15%	
Estimated MM share of GRH impact	9.0%	

GRH Impacts – FY 12-14

Travel Impacts	**MM Share**	**GRH base**
• GRH placements	1,166	12,953
• GRH Vehicle trips reduced	763	8,474
• GRH VMT reduced	21,049	233,883

Emissions Impacts	**MM Share**	**Total**	
• NOx reduced (daily tons)	0.0086	0.0957	Daily
• VOC reduced (tons)	0.0032	0.0359	Daily
• PM2.5 reduced (tons)	0.0941	1.0455	Annual
• PM2.5-NOx reduced (tons)	2.1367	23.7409	Annual
• CO2 reduced (tons)	2,165.1	24,056.5	Annual

Mass Marketing – Summary

Total – PART 1, PART 2, PART 3, PART 4, PART 5, PART 6

	Total MM	**Direct Ad Infl**	**'Pool Rewards**	**Car Free Day**	**BTW**	**COC Credit**	**GRH Credit**
Placements	22,065	12,257	359	854	6,405	1,024	1,166
VT reduced	10,294	6,943	209	309	1,572	498	763
VMT reduced	173,269	109,699	6,521	6,001	16,349	13,650	21,049
		67%	2%	3%	15%	5%	7%
Daily Emissions Reduced							
NOx (T)	0.0808						
VOC (T)	0.0239						
Annual Emissions Reduced							
PM 2.5 (T)	0.8481						
PM 2.5 Precursor (T)	20.281						
CO2 (T)	18,840.4						

Appendix G
Sample Calculation of Commuter Operations Center Impacts

PART 1 – Commute Information Requests

Populations of Interest – Commuter Connections Rideshare Applicants

New, Reapply, Transit/other, follow-up requests

• FY 2012	31,209	(CC database)
• FY 2013	30,656	(CC database)
• FY 2014	25,382	(CC database)
Total assisted commuters	**87,247**	

Within MSA (56%)	48,858
Outside MSA (44%)	38,389

COC Placement Rates	**In MSA**	**Out MSA**	
• Continued rate	32.8%	38.6%	
• Temporary rate	6.0%	4.0%	
• Total	38.8%	42.6%	
Placements			
• Continued	16,025	14,818	(Apps x cont. rate)
• Temporary	2,931	1,536	(Apps x temporary rate)
Total placements 35,310			

Daily Vehicle Trips Reduced

VTR Factors			
• Continued	0.51	0.58	
• Temporary	0.53	0.53	
• Temporary discount	17.1%	17.1%	
• Continued trips reduced	8,173	8,594	(Placements x cont. VTR factor)
• Temporary trips reduced	266	139	(Placements x temp VTR factor)
Total VT reduced 17,172			

Daily VMT Reduced

Ave one-way trip distance (mi)			
• Continued	27.5	27.5	(Actual Outside dist. 50.6 miles)
• Temporary	23.7	23.7	(Actual Outside dist. 43.2 miles)
• Continued VMT reduced	224,758	236,335	(Vehicle trips x ave distance)
• Temporary VMT reduced	6,304	3,294	
Total VMT Reduced 470,691			

Appendix G, 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	71%	0%	(CC placement survey)
• SOV access dist (mi) – Continued	3.2	0.0	(CC placement survey)
• Non-SOV access % - Temporary	41%	0%	(CC placement survey)
• SOV access dist (mi) – Temporary	3.2	0.0	(CC placement survey)

Outside MSA – not applicable – all access outside MSA

VT Reduction

• Continued SOV access VT	5,803	0	(Cont VT x SOV access)
• Temporary SOV access VT	109	0	(Temp VT x SOV access)
• Continued VT (without SOV access)	2,370	8,594	(Total Cont VT – SOV access VT)
• Temporary VT (without SOV access)	157	139	(Total Temp VT- SOV access VT)

Total VT (net of SOV access) 11,260

VMT Reduction

• Continued SOV access VMT	18,570	0	(Cont VT x SOV % x access dist)
• Temporary SOV access VMT	349	0	(Cont VT x SOV % x access dist)
• Continued VMT (without SOV access)	206,188	236,335	(Total Temp VMT- SOV access VMT)
• Temporary VMT (without SOV access)	5,955	3,294	(Total Temp VMT- SOV access VMT)

Total VMT (net of SOV access) 451,772

Total VT for AQ analysis 11,260
Total VMT for AQ analysis 451,772

<u>Daily Emissions Reduced</u> – NOx and VOC

NOx	**Trips**	**15 Emission Factor**	**VMT**	**15 Emission Factor**	**Tot gm**	**Tot ton**
• From Starts	11,260	1.5408			17,349	0.0191
• From Running			451,772	0.3737	168,827	<u>0.1861</u>
Total NOx reduced (tons)					**Daily**	**0.2052**

VOC	**Trips**	**15 Emission Factor**	**VMT**	**15 Emission Factor**	**Tot gm**	**Tot ton**
• From Starts	11,260	2.8573			32,173	0.0355
• From Running			451,772	0.0915	41,337	<u>0.0456</u>
Total VOC reduced (tons)					**Daily**	**0.0811**

Appendix G, continued

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

PM 2.5	Trips	15 Emission Factor	VMT	15 Emission Factor	Tot gm	Tot ton
• From Starts	11,260	0.0367			413	0.0005
• From Running			451,772	0.0170	7,680	0.0085
Total PM 2.5 reduced (tons)					**Daily**	**0.0090**
					Annual	**2.230**

PM 2.5 Precursor NOx	Trips	15 Emission Factor	VMT	15 Emission Factor	Tot gm	Tot ton
• From Starts	11,260	1.7510			19,716	0.0217
• From Running			451,772	0.3663	165,484	0.1824
Total PM 2.5 Precursor NOx reduced (tons)					**Daily**	**0.2041**
					Annual	**51.037**

CO2	Trips	15 Emission Factor	VMT	15 Emission Factor	Tot gm	Tot ton
• From Starts	11,260	239.26			2,694,068	2.9697
• From Running			451,772	404.17	182,592,689	201.2739
Total CO2 reduced (tons)					**Daily**	**204.2436**
					Annual	**51,060.9**

Correction for Overlap between COC Base and Integrated Rideshare and GRH Measures
Net COC Base = COC Base – Mass Marketing credit – Software Upgrades credit – GRH credit

	Net COC Base	COC base	MM	Soft Upgrade	GRH
Placements	22,796	35,310	1,024	4,681	6,809
Vehicle Trips Reduced	11,007	17,172	498	2,379	3,288
VMT Reduced (miles)	300,761	470,691	13,650	66,442	89,838
Daily Emissions Reduced					
NOx Reduced (tons)	0.1316	0.2052	0.0060	0.0283	0.0393
VOC Reduced (tons)	0.0520	0.0811	0.0024	0.0112	0.0155
Annual Emissions Reduced					
PM 2.5 (T)	1.4307	2.2304	0.0647	0.3077	0.4273
PM 2.5 Precursor (T)	32.7379	51.0371	1.4801	7.0402	9.7789
CO2 (T)	32,753.5	51,060.9	1,480.8	7,043.1	9,783.5

Notes:
MM influenced commuters – from MM analysis
GRH – 59% of new apps/reapps who made an alt mode change registered for GRH = 23% of COC credit to GRH (59% x 39 new/reapply share of total apps)

Appendix G, 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 program element

Calculation details shown on Telework Assistance Worksheets

Number of teleworkers (non-MD)	388,423	
Share of TW credited to COC	9.1%	Learned of telework from Commuter Connections
Total TW placements credited to COC	35,346	
Vehicle trips reduced	12,255	
VMT reduced	187,465	
Daily NOx reduced (tons)	0.0980	
Daily VOC reduced (tons)	0.0575	
Annual PM2.5 reduced (tons)	1.0000	
Annual PM2.5-NOx reduced (tons)	24.850	
Annual CO2 reduced (tons)	21,687.5	

Total Commuter Operations Center – Including Base COC and Telework Credit
Net COC = Net COC Base + Non-MD TW

	Net COC	Net COC base	Non-MD TW
Placements	58,142	22,796	35,346
Vehicle Trips Reduced	23,262	11,007	12,255
VMT Reduced (miles)	488,226	300,761	187,465
Daily Emissions Reduced			
NOx Reduced (tons)	0.2293	0.1316	0.0980
VOC Reduced (tons)	0.1095	0.0520	0.0575
Annual Emissions Reduced			
PM 2.5 (T)	2.4307	1.4307	1.0000
PM 2.5 Precursor (T)	57.5879	32.7379	24.850
CO2 (T)	54,441.0	32,753.5	21,687.5

Appendix H
Sample Calculation of Integrated Rideshare - Software Upgrade Project Impacts

Populations of Interest – Commuter Connections Rideshare Applicants

New, Reapply, Transit/other, follow-up requests

• FY 2012	31,209	(CC database)
• FY 2013	30,656	(CC database)
• FY 2014	25,382	(CC database)
Total assisted commuters	**87,247**	

Within MSA (56%)	48,858
Outside MSA (44%)	38,389

COC Placement Rates	**In MSA**	**Out MSA**	
• Continued rate	4.7%	5.2%	
• Temporary rate	0.7%	0.5%	
• Total	5.4%	5.7%	
Placements			
• Continued	2,296	1,996	(Applications x continued rate)
• Temporary	342	192	(Applications x temporary rate)
Total placements 4,826			

Daily Vehicle Trips Reduced

VTR Factors			
• Continued	0.50	0.63	
• Temporary	0.54	0.50	
• Temporary discount	17.1%	17.1%	
• Continued trips reduced	1,148	1,257	(Placements x cont. VTR factor)
• Temporary trips reduced	32	16	(Placements x temp VTR factor)
Total VT reduced 2,453			

Daily VMT Reduced

Ave one-way trip distance (mi)			
• Continued	28.0	28.0	(Actual Outside dist. 48.6 miles)
• Temporary	24.1	24.1	(Actual Outside dist. 53.8 miles)
• Continued VMT reduced	32,144	35,196	(Vehicle trips x ave distance)
• Temporary VMT reduced	771	386	
Total VMT Reduced 68,497			

Appendix H, 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	73%	0%	(CC placement survey)
• SOV access dist (mi) – Continued	5.0	0.0	(CC placement survey)
• Non-SOV access % - Temporary	41%	0%	(CC placement survey)
• SOV access dist (mi) – Temporary	5.0	0.0	(CC placement survey)

Outside MSA – not applicable – all access outside MSA

VT Reduction

• Continued SOV access VT	838	0	(Cont VT x SOV access)
• Temporary SOV access VT	13	0	(Temp VT x SOV access)
• Continued VT (without SOV access)	310	1,257	(Total Cont VT – SOV access VT)
• Temporary VT (without SOV access)	19	16	(Total Temp VT- SOV access VT)

Total VT (net of SOV access) 1,602

VMT Reduction

• Continued SOV access VMT	4,190	0	(Cont VT x SOV % x access dist)
• Temporary SOV access VMT	65	0	(Cont VT x SOV % x access dist)
• Continued VMT (without SOV access)	27,954	35,196	(Total Temp VMT- SOV access VMT)
• Temporary VMT (without SOV access)	706	386	(Total Temp VMT- SOV access VMT)

Total VMT (net of SOV access) 64,242

Total VT for AQ analysis 1,602
Total VMT for AQ analysis 64,242

Daily Emissions Reduced – NOx and VOC

NOx	**Trips**	**15 Emission Factor**	**VMT**	**15 Emission Factor**	**Tot gm**	**Tot ton**
• From Starts	1,602	1.5408			2,468	0.0027
• From Running			64,242	0.3737	24,007	0.0265
Total NOx reduced (tons)					**Daily**	**0.0292**

VOC	**Trips**	**15 Emission Factor**	**VMT**	**15 Emission Factor**	**Tot gm**	**Tot ton**
• From Starts	1,602	2.8573			4,577	0.0050
• From Running			64,242	0.0915	5,878	0.0065
Total VOC reduced (tons)					**Daily**	**0.0115**

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

PM 2.5	**Trips**	**15 Emission Factor**	**VMT**	**15 Emission Factor**	**Tot gm**	**Tot ton**
• From Starts	1,602	0.0367			59	0.0001
• From Running			64,242	0.0170	1,092	0.0012
Total PM 2.5 reduced (tons)					**Daily**	**0.0013**
					Annual	**0.317**

Appendix H, continued

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

PM 2.5 Precursor NOx	Trips	15 Emission Factor	VMT	15 Emission Factor	Tot gm	Tot ton
• From Starts	1,602	1.7510			2,805	0.0031
• From Running			64,242	0.3663	23,532	0.0259
Total PM 2.5 Precursor NOx reduced (tons)					**Daily**	**0.0290**
					Annual	**7.258**

CO2	Trips	15 Emission Factor	VMT	15 Emission Factor	Tot gm	Tot ton
• From Starts	1,602	239.26			383,295	0.4225
• From Running			64,242	404.17	25,964,689	28.6212
Total CO2 reduced (tons)					**Daily**	**29.0437**
					Annual	**7,260.9**

Correction for Overlap with MM Program Element

Total CC applications FY 12, 13, 14	87,247	
New CC applications FY 12, 13, 14	16,698	19%
Estimated MM share of new CC	15%	
Estimated MM share of IR impact	3.0%	

Net Software Upgrade = Software Upgrade Base – Mass Marketing credit

	Net SU	SU Base	MM Share
Placements	4,681	4,826	145
VT reduced	2,379	2,453	74
VMT reduced	66,442	68,497	2,055
Daily Emissions Reduced			
NOx reduced (T)	0.0283	0.0292	0.0009
VOC reduced (T)	0.0112	0.0115	0.0003
Annual Emissions Reduced			
PM 2.5 (T)	0.3077	0.3172	0.0095
PM 2.5 Precursor (T)	7.0402	7.2579	0.2177
CO2 (T)	7,043.1	7,260.9	217.8

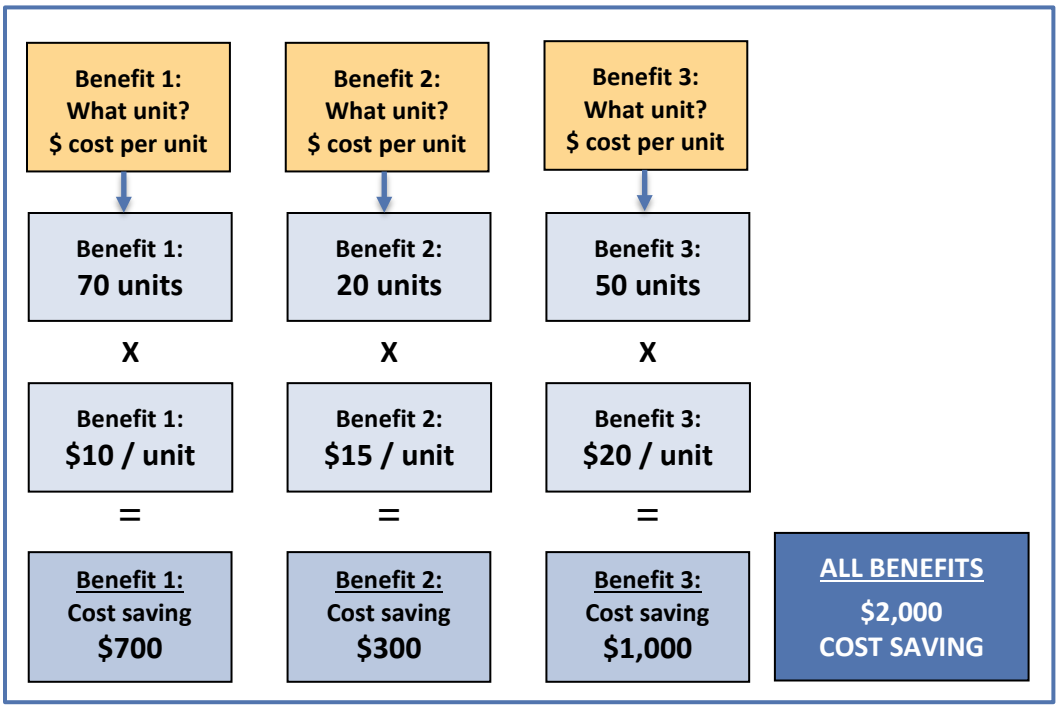
Appendix I
Sample Calculation of Societal Benefits Generated by TDM Program Impacts

The 2015-2017 TDM evaluation included a new analysis component, to estimate regional cost savings generated for selected societal benefits of the TDM program element 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)

The figure 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.

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 TDM program 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 TDM program element eliminated. 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 TDM program analysis, then the cost savings for individual benefits are summed to calculate the total cost saving for all benefits together.

In all cases, the TDM program element 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 program element.

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, TDM program elements 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 TDM analysis calculates the societal cost of four primary air quality pollutants: nitrogen oxides (NOx), volatile organic compounds (VOC), particulate matter 2.5 microns (PM2.5), and PM2.5 NOx precursors. These four pollutants are strongly associated with the health and environmental damage and with motor vehicle operation.

The TDM analysis also calculates the societal cost for Greenhouse gas emissions, defined as tons of carbon dioxide (CO2). 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 NOx 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:

Cost saving for NOx reduction = ((VMT reduced x gm/mi NOx emission factor)
+ (VTrips reduced x gm/trip reduced)) / gm per ton conversion factor
x $ 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 TDM 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.[16]

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 TDM 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 TDM program element 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 TDM Program Element and Commuter Operations Center Impacts

Societal Benefit	Benefit Unit	Benefit Base Units [1)]	Cost per Unit of Benefit [2)]	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
Total air pollution				**$3,240**
Greenhouse gas	**Tons CO2 removed**	**1,244 T**	**$36**	**$44,781**

1) Daily tons of emissions reduced calculated in TDM analysis using MWCOG emission factors.
2) Cost per tons of emissions reduced obtained from TRIMMS™.

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.

[16] TRIMMS™ User Manual, Version 3.0, Center for Urban Transportation Research, USF.

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.

Cost saving for noise reduction = Total VMT reduced
x Noise reduction per VMT reduced
x $ cost per adjusted VMT

Calculating Benefit Units and Cost per Unit of Benefit – The TDM 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 TDM program = 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.

The approach used to estimate vehicle hours of delay reduction first estimates the percentage share of each TDM program element's 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.

Cost saving for reduced congestion = Congested VMT reduced
x Marginal delay hours per VMT
x $ cost per hour of delay

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."[17] 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 the TDM analysis 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 TDM 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 TDM program elements. 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 TDM 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.[18]

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 TDM program elements 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 program elements 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**.

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

[17] 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

[18] 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

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:

Cost saving for reduced fuel consumption = Total VMT reduced
/ Fuel consumption factor (miles per gallon)
x $ cost per gallon of fuel

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 as 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 TDM analysis 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.[19] The result of these calculations is as follows:

Total daily VMT reduced by TDM program elements = 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 TDM 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 TDM analysis, this crash risk factor is multiplied by the total VMT reduced by the TDM program elementS 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:

Cost saving for improved road safety = Total VMT reduced
x Expected crashes per 1,000,000 VMT
x $ cost per accident

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

[19] 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

the occurrence probability of accidents with varying levels of severity (KABCO Injury Classification Scale)[20] 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 1)
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
Weighted cost per 1 M VMT 2)			**$15,952**

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 TDM program elements = 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 TDM program elements and the Commuter Operations Center combined.

[20] 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/hsip/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	3,009244 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 [1)]	Accidents avoided/1 M VMT	3.043 acc.	$15,952	$48,543
All benefits				**$1,198,085**

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

As shown, the combined TDM program 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.

Appendix J
Commuter Connections TDM Evaluation Schedule – FY 2018 – FY 2020

TDM Program Element	Data Collection Activity	Deadline(s)	FY Completion
Telework	2019 State of the Commute Survey	January 2019 July 2019 (report)	FY19-FY20
	Employer Telework Assistance (MD)	April 2020	FY20
Employer Outreach	Database Information Analysis From ACT!	December 2019	FY20
	Customer Satisfaction Survey	June 2019	FY19
GRH	GRH Applicant Survey Washington region	January 2019 July 2019 (report)	FY19-FY20
	GRH Applicant Survey Baltimore	January 2019 July 2019 (report)	FY19-FY20
	Retention Rate Survey	Oct-Nov 2020 Dec 2020 (analysis)	FY21
Commuter Operations Center	Placement Rate survey ***(survey completed)***	November 2017	FY18
	Vanpool Driver	March-April 2020	FY21
	Retention Rate Survey	Oct-Nov 2020	FY21
Mass Marketing	2019 State of the Commute Survey	January 2019	FY19-20
	2019 Bike to Work Day Participant Survey	Nov/Dec 2019	FY20
	'Pool Rewards CP survey	June 2020	FY20
ALL	2018-2020 Framework Methodology	December 2018	FY19
	2019 State of the Commute Survey	January 2019	FY19-FY20
	2018-2020 TERM Analysis Report	January 2020	FY20-FY21

Appendix K
Glossary of Acronyms

CC	-	Commuter Connections
CCWP	-	Commuter Connections Work Program
CO2	-	Carbon dioxide (primary greenhouse gas)
COC	-	Commuter Operations Center
COG	-	Council of Governments
DDOT	-	District of Columbia Department of Transportation
FAST Act	-	Fixing America's Surface Transportation Act
FHWA	-	Federal Highway Administration
GRH	-	Guaranteed Ride Home
HOV(s)	-	High Occupancy Vehicle(s)
MAP-21	-	Moving Ahead for Progress in the 21st Century Act
MTA	-	Maryland Transit Administration
MDOT	-	Maryland Department of Transportation
MWAQC	-	Metropolitan Washington Air Quality Committee
MWCOG	-	Metropolitan Washington Council of Governments
NO_X	-	Nitrogen Oxides
P & R	-	Park and Ride
PM	-	Particulate Matter
PM2.5	-	Particulate Matter, 2.5 microns
SOC	-	State of the Commute
SOV	-	Single Occupant Vehicle
TDM	-	Transportation Demand Management
TERM	-	Transportation Emission Reduction Measure
TIP	-	Transportation Improvement Program
TMA	-	Transportation Management Association
TMO	-	Transportation Management Organization
TPB	-	Transportation Planning Board
VDOT	-	Virginia Department of Transportation
VDRPT	-	Virginia Department of Rail & Public Transportation
VMT	-	Vehicle Miles Traveled
VOC	-	Volatile Organic Compounds
VRE	-	Virginia Railway Express
VT	-	Vehicle Trips
VTR	-	Vehicle Trip Reduction
WMATA	-	Washington Metropolitan Area Transit Authority