SmartWay®
Transport Partnership
U.S. ENVIRONMENTAL PROTECTION AGENCY

2018 SmartWay Truck Carrier Partner Tool: Technical Documentation

U.S. Version 2.0.17 (Data Year 2017)

EPA United States Environmental Protection Agency

SmartWay Transport Partnership
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Transportation and Climate Division
Office of Transportation and Air Quality
U.S. Environmental Protection Agency

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1.0 Overview

This document provides detailed background information on the data sources, calculation methods, and assumptions used within the SmartWay Truck Tool, version 2.0.17. The SmartWay Truck Tool utilizes the most up-to-date emission factors, in combination with detailed vehicle activity data, to estimate emissions and associated performance metrics. The primary purpose of the Tool is to help fleets calculate actual pollutant emissions for specific truck types and applications and track their emissions performance over time. Shippers can, in turn, use the data that truck carriers report using these Tools to develop more advanced emissions inventories associated with their freight activity and to track their emissions performance over time.

The Tool allows the user to evaluate fleet performance in terms of different mass-based performance metrics for CO_2, NOx, PM (PM_{10} and $PM_{2.5}$), and black carbon (BC) including:[1]

- Grams per mile
- Grams per average payload ton-mile
- Grams per thousand cubic foot-miles
- Grams per thousand utilized cubic foot-miles

The Tool can also generate estimates of emissions associated with the total miles, loaded miles, and revenue miles traveled by a fleet. Fleet performance can then be assessed at the truck-class and/or fuel-type level, or on an aggregated basis across all classes and fuels.

The Tool also collects extensive information on fleet operations and truck body types, allowing detailed segmentation of Partner fleets for more appropriate, equitable comparisons. For example, fleets that cube-out with low payloads (e.g., those hauling potato chips) will be able to compare themselves to similar fleets on a simple grams per mile basis, rather than a mix of fleets that includes fleets that routinely weigh-out. Similarly, fleets that operate in primarily short-haul, urban environments at relatively low average speeds will have fundamentally

[1] At this time the Truck Tool does not calculate performance metrics for specialty fleets that track their activity in terms of hours of use rather than miles traveled or freight hauled (e.g., refuse haulers and utility fleets). Future modifications may be made to the current Tool to accommodate such fleets.

different emission rates and constraints than long-haul fleets operating at highway speeds. By collecting detailed information on fleet operations (short vs. long, TL vs. LTL, urban vs. highway, etc.), as well as truck class (2b through 8b) and body type (dry van, reefer, flatbeds, etc.), individual fleets can compare their performance to other, similar fleets, which can help them to better manage their emissions performance.

2.0 Data Inputs and Sources

The SmartWay Truck Tool user provides most vehicle characteristic, operational, and activity data needed for emissions performance estimation (see Section 3 for more information). The Tool calculates emissions by multiplying fleet activity data with EPA-approved emission rate factors that are stored in look-up tables within the Tool.

The Tool contains different types of emission rate factors for different pollutants. CO_2 factors are expressed in grams of CO_2 *per gallon of fuel*.[2,3] NOx, PM, and BC factors are expressed in grams of pollutant per mile traveled for operating emissions, and in grams per hour for idle emissions. In general, CO_2 factors are independent of the truck types, classes, and operational practices in a fleet. NOx, PM and BC factors, however, vary depending upon a number of parameters, including:

- Truck class
- Engine model year/emission certification standard
- Vehicle speed
- Vehicle driving pattern (referred to as "drive cycle")

In addition, PM and BC emissions will also vary with the application of PM control retrofits, including diesel oxidation catalysts (DOC), closed crankcase ventilation (CCV), and diesel particulate filters ("PM traps" or flow-through filters). In the Tool, PM control retrofits are assumed to have the same impact on operating and idle emission factors, and control effectiveness for PM is assumed to equal the effectiveness for BC.[4]

2.1 CO_2 Factors

EPA populated the SmartWay Truck Tool with CO_2 factors that are based on fuel consumption. These factors and their sources and are summarized below in Table 1.

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[2] At this time other greenhouse gases such as methane (CH_4), nitrous oxide (N_2O) and black carbon are not included in the current Truck Tool.

[3] The Truck Tool also estimates emissions associated with battery-electric trucks. In this case pollutant emissions (CO_2, NOx and PM) are determined based on the kWhrs used for charging.

[4] Future versions of the Tool may account for differences in retrofit effectiveness for running versus idle emissions, and differences between PM and BC control effectiveness.

Table 1. CO_2 Factors by Fuel Type*

	g/gal	Source[5]
Gasoline	8,887	(i)
Diesel	10,180	(ii)
Biodiesel (B100)	9,460	(iii)
Ethanol (E100)	5,764	(iv)
CNG	7,030	(v)
LNG	4,394	(vi)
LPG	5,790	(vii)

*** 100% combustion (oxidation) assumed**

Note that the Tool calculates tailpipe emissions from biofuel blends (gasoline/ethanol, diesel/biodiesel) by applying separate emission factors to the user-specified volume of each blend component. The Tool then adds the emissions from each blend component together to determine total CO_2 emissions. Therefore, emission factors for specific blend ratios are not needed for CO_2.[6]

Within the Tool, users may provide their CNG fuel use estimates in terms of gasoline-gallon equivalent (GGE) (on a Btu basis), diesel-gallon equivalent (DGE), or in standard cubic feet (scf). If CNG consumption is expressed in DGE or scf, the Tool uses the following factors to convert the CNG fuel estimates to GGE.

For CNG:

Diesel-Gallon Equivalent (DGE) to Gasoline-Gallon Equivalent (GGE)

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[5] i) Final Rule on Light-Duty Vehicle Greenhouse Gas Emissions Standards and Corporate Average Fuel Economy Standards (75 FR 25324, May 7, 2010). The gasoline factor used in this rule was sourced from the California Air Resources Board and is based on measurement of carbon from a gasoline test fuel (indolene).
ii) Fuel economy calculations in 40 C.F.R 600.113 available at http://edocket.access.gpo.gov/cfr_2004/julqtr/pdf/40cfr600.113-93.pdf.
iii) Tables IV.A.3-2 and 3-3 in A Comprehensive Analysis of Biodiesel Impacts on Exhaust Emissions, available at http://www.epa.gov/oms/models/analysis/biodsl/p02001.pdf
iv) Final Rule on Mandatory Reporting of Greenhouse Gases (70 FR 56260, October 30, 2009). Full source documentation is available on pp. 31-32 in the Technical Support Document, *Petroleum Products and Natural Gas Liquids: Definitions, Emission Factors, Methods and Assumptions*, available at www.epa.gov/climatechange/emissions/downloads09/documents/SubpartMMProductDefinitions.pdf.
v) Calculations of Lifecycle Greenhouse Gas Emissions for the 2005 Gasoline and Diesel Baselines in the Notice of Availability of Expert Peer Review Record supporting the proposed revisions to the Renewable Fuel Standard Program (74 FR 41359) available in Docket EPA-HQ-OAR-2005-0161-0925.1 (Spreadsheet "Emission Factors").
vi) Assuming 74,720 Btu/gal lower heating value (http://www.afdc.energy.gov/afdc/fuels/properties.html), and 0.059 g/Btu (from CNG calculation, source v).
vii) Table C-1 in the Final Rule on Mandatory Reporting of Greenhouse Gases (70 FR 56260, October 30, 2009). Full source documentation is available in Table A-39 and pg. A-60 of the *Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990 – 2007* available at http://epa.gov/climatechange/emissions/downloads/US_GHG_Inv_Annexes_1990-2007.pdf

[6] The Tool also estimates the barrels of petroleum required to make the reported gallons of diesel and gasoline based on national averages: 19 gallons of gasoline and 10 gallons of diesel assumed per barrel of petroleum – see http://205.254.135.24/tools/faqs/faq.cfm?id=24&t=10 and http://205.254.135.24/tools/faqs/faq.cfm?id=327&t=9.

- 1 DGE = 1.112 GGE[7]
- Note: 1 GGE = 125,000 BTU and 1 DGE = 139,000 BTU, so 1 DGE = 1.112 GGE (139,000/125,000).

Cubic Feet (cuft) to Gasoline-Gallon Equivalent (GGE)

- 123.57 cuft = 1 GGE[8]

For LNG, users may provide their fuel use estimates in terms of physical gallons, gasoline-gallon equivalent (GGE) (on a Btu basis), diesel-gallon equivalent (DGE), or in pounds (lbs). If LNG consumption is expressed in GGE, DGE, or pounds, the Tool uses the following factors to convert the LNG fuel estimates to physical gallons.

For LNG:

Diesel-Gallon Equivalent (DGE) to Physical Gallon

- 1 DGE = 1.7 Gallons LNG[9]

Gasoline-Gallon Equivalent (GGE) to Physical Gallon

- 1 GGE = 1.5 Gallons LNG[10]

Pounds (lbs) to Physical Gallon

- 3.49 lbs LNG = 1 LNG Gallons[11]

2.2 NOx, PM and BC Factors

The SmartWay Truck Tool contains NOx, PM_{10}, $PM_{2.5}$ and BC[12] emission factor outputs for on-road operation from EPA's MOVES2014a model for diesel and E10[13] for all heavy truck classes (2b – 8b) under national default temperature and fuel conditions, for model years 1987 through 2019, for the 2018 calendar year (see Appendix A for a full list of factors). The emission factors are broken out by general drive cycle type (urban or highway), and average speed range, as discussed below.

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[7] Midwest Energy Solutions. Energy Volume & Weight. http://www.midwestenergysolutions.net/cng-resources/energy-volume-weight

[8] Alternative Fuels Data Center. Gasoline and Diesel Gallon Equivalency Methodology. http://www.afdc.energy.gov/fuels/equivalency_methodology.html

[9] Midwest Energy Solutions. Energy Volume & Weight. http://www.midwestenergysolutions.net/cng-resources/energy-volume-weight

[10] Midwest Energy Solutions. Energy Volume & Weight. http://www.midwestenergysolutions.net/cng-resources/energy-volume-weight

[11] Midwest Energy Solutions. Energy Volume & Weight. http://www.midwestenergysolutions.net/cng-resources/energy-volume-weight

[12] Black carbon factors are assumed to equal the elemental carbon gram per mile factors output by the MOVES model.

[13] All gasoline consumption in the United States and Canada is now assumed to consist of E10. Pure gasoline (E0) emission factors are no longer used in the Truck Tool. References to "gasoline" in the Tool and the associated documentation refer to E10.

Short-duration (less than 60 minutes) idle emission factors for NOx, PM and BC were developed separately by model year, truck class, and fuel type (diesel and gasoline). MOVES2014a does not currently provide short duration idle factors in terms of grams per hour, so MOVES2014a was run using the Project Level scale with a single link and with an average speed of zero. Runs were performed for typical winter and summer conditions, taking the average of outputs from those runs to obtain g/hr factors.

MOVES2014a does provide emission factors for long-duration idle for long-haul diesel trucks. These factors are applied separately to the long-duration idle hour estimates provided for Class 8b trucks within the Truck Tool.[14] Short-duration factors are applied across the board for the remaining truck class types.

Note that hybrid electric trucks are assumed to have no short-duration idle emissions (due to assumed engine auto-shut off), although long-duration idle (and regular exhaust[15]) emissions are assumed unchanged relative to their conventional vehicle counterparts. Finally, battery-electric trucks are assumed to have no idle emissions of either kind.

The resulting idle factors are presented in Appendix B.

Version 2.0.17 of the Truck Tool also calculates the NOx, PM and BC emissions associated with transportation refrigeration (reefer) units. The MOVES2014a emissions model was used to develop emission rates for these units for the 2018 calendar year, following these steps:

- A national average model run was performed for the Industrial sector, including gasoline and diesel fueled equipment;
- The A/C refrigeration (reefer) unit standard classification codes (SCCs) were extracted from the output files – 2265003060 (gasoline) and 2270003060 (diesel);
- Grams per day outputs for weekdays and weekends for each of the 12 months were converted to grams per year by aggregating emissions over day types to arrive at an average day value, multiplying by the number of days in each month, and summing over month. This resulted in annual grams of emissions (of NOx, PM_{10}, and $PM_{2.5}$) and grams of fuel consumed (in terms of brake specific fuel consumption or BSFC), for each fuel type;
- BSFC was converted from grams to gallons fuel using the MOVES energy density values of 2,819 g/gal and 3,167 g/gal for gasoline and diesel, respectively.

[14] NOx factors for long-term extended idling are higher than short-duration factors (at least for late model engines), since engine operation temperatures and loads at idle are generally not high enough to activate late-model emission controls such as SCR and EGR.

[15] While there is evidence that NOx emissions may be decreased through the use of hybrid electric technology, EPA has not performed emission testing to assess this effect. Therefore hybrid NOx and PM/BC exhaust emission rates are assumed to equal conventional vehicle equivalents in the current Truck Tool.

- Grams/gallon emission factors were then calculated for each pollutant by dividing the annual grams of emissions of NOx, PM_{10} and $PM_{2.5}$ by the annual gallons of fuel consumed for gasoline and diesel.

Black carbon emissions associated with reefer activity were scaled from $PM_{2.5}$ reefer emissions, applying conversion factors for nonroad equipment from the Commission for Environmental Cooperation (0.349 for diesel engines and 0.122 for gasoline engines).[16]

Table 2 provides the fuel factors used in the latest Truck Tool.

Table 2. Weighted Average Reefer Fuel Factors (g/gallon)

Fuel	NOx	PM_{10}	$PM_{2.5}$	BC
Diesel	54.670	1.952	1.893	0.661
Gasoline	17.817	1.023	0.941	0.115

The next section describes the process followed to select the on-road emission factors from MOVES2014a for use in the Truck Tool. Emission factors in grams per mile were developed for E10 and diesel fuel types for all MOVES source types that correspond to the regulatory heavy duty vehicle classes, 2b-8b inclusive. The MOVES source types modeled are shown in the table below. Of these, school buses, refuse trucks and motor homes represent only a small fraction of total activity.

Table 3. MOVES Source Types Associated with Class 2b – 8b Vehicles

Source Type ID	Source Type Name
31	Passenger Truck
32	Light Commercial Truck
43	School Bus
51	Refuse Truck
52	Single Unit Short-haul Truck
53	Single Unit Long-haul Truck
54	Motor Home
61	Combination Short-haul Truck
62	Combination Long-haul Truck

[16] Commission for Environmental Cooperation (CEC), 2015. North American Black Carbon Emissions Estimation Guidelines: Methods for Estimating Black Carbon Emissions. Prepared for the CEC by Eastern Research Group, Inc. Final Report, May 2015.

Separate factors were developed for “Urban” and “Highway/Rural” roadway types. These factors were apportioned according to MOVES operating mode groups, which correspond to speed ranges of 0-25 mph, 25-50 mph, and 50+ mph.

Emission factors calculated by the model, output by MOVES source type, were then converted to a MOBILE6 vehicle class basis. In this way, the Truck Tool can select appropriate emission factors for use by:

- weight class
- model year
- road type (urban vs. highway/rural)
- speed distribution

The following describes the methodology for the emission factor calculation.

Calculation of MOVES emission factors by operating mode

In calculating emission factors, the primary goal is to disaggregate factors by the percentage of time a given type of vehicle spends operating at certain speeds. The ranges of speeds analyzed include 0-25 mph, 25-50 mph, and greater than 50 mph. These speed ranges correspond to MOVES operating modes #11-16, 21-29, and 30-40 inclusive, where each operating mode is defined by both the speed of the vehicle and its vehicle specific power (VSP). First, for a given source type and model year, the fraction of emissions attributable to each range of speed was determined. Emissions for a vehicle can be expressed in Equation 1:

Equation 1

$$\mathbf{E` = A_1E_1` + A_2E_2` + A_3E_3` + A_IE_I + A_BE_B}$$

Where:

E` = uncorrected[17] mass emissions calculated based on operating mode and emissions contribution by speed bin

$A_{1\text{-}3}$ = the sum of activity fractions (in seconds) over speed range n. (A_I and A_B represent the activity associated with the individual operating modes for idling and braking, respectively.)

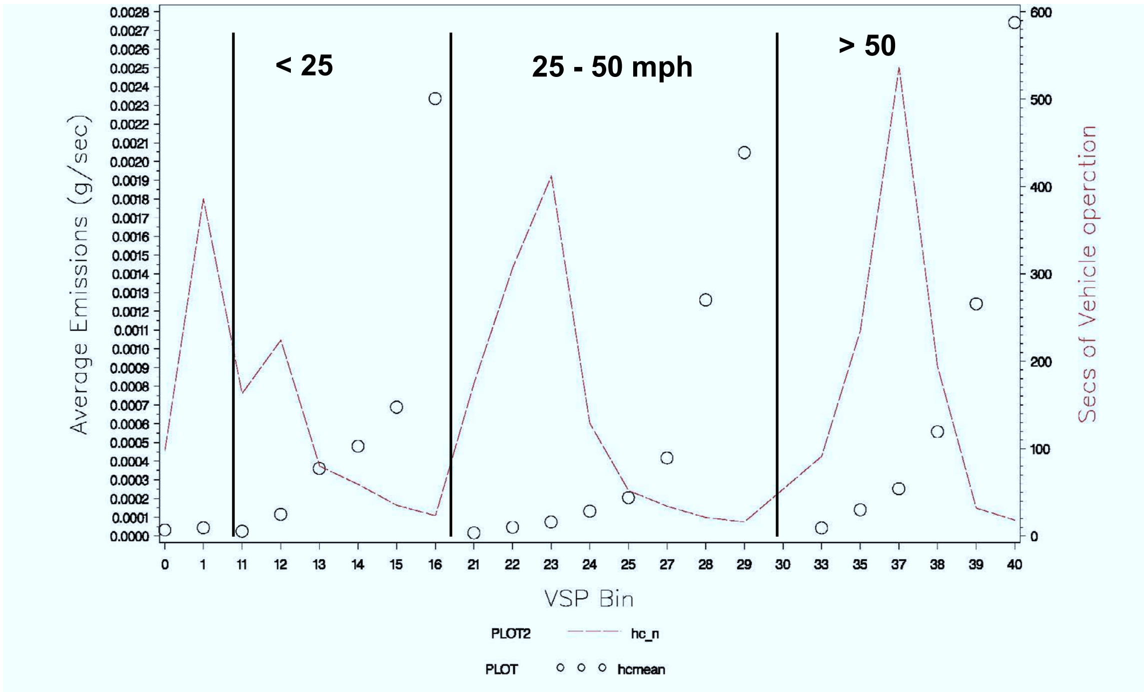
$E_{1\text{-}3}$` = the weighted average emissions over a given speed range n. (E_I and E_B represent the emissions associated with the individual operating modes for idling and braking, respectively.)

The following figure shows a range of emissions and activity fractions for an example source type and model year. The operating mode (or VSP bin) are shown on the x-axis. The dashed red

[17] Subsequent adjustment factors are presented in Equation 3 below.

line presents the fraction of vehicle activity associated with a given operating mode, while the black circles present average HC emissions for each operating mode.

Figure 1. Example Emissions and Activity Fractions by Operating Mode



For our purposes, A_n from Equation 1 is obtained by retaining the “opmodefraction2” table from the “MOVESExecution” database, which is created by the Operating Mode Distribution Generator (OMDG) during a MOVES run. This table contains operating mode fractions by source type, roadway type, average speed bin, and pollutant/process. The fractions from this table are normalized using average speed distributions from the “avgspeeddist” table, and the sum of the normalized operating mode fractions in each speed bin constitutes A_n.

E_n` is derived from data obtained from the default MOVES “emissionratebyage” table. This table contains emission rates by pollutant process, operating mode, and age group for a wide variety of *sourcebinIDs*. For this analysis, a MySQL query was used to select *sourcebinIDs* corresponding to the source type, fuel type, and calendar year of interest, and limited our rate selection to the 4-5 year age group. The emissions obtained here were then converted to a source type basis (from their current *sourcebinID* basis); this was done by retaining the “sourcebindistribution” table from the MOVESExecution database, which is created by the Source Bin Distribution Generator (SBDG) during each MOVES run, and weighting the activity fractions for each source type and model year combination in this table with the data from the “emissionratebyage” table described above. Having finished this mapping, an emission rate is generated, by source type and model year, for each operating mode (corresponding to the circles in the figure above). Since E_n` for each speed range represents the average emissions of the range weighted by the activity in that range, the weighted average emissions can be calculated from the 0-25 mph speed bin, $E_1$`, as follows in Equation 2:

Equation 2

$$E_1` = \frac{R_{11}T_{11} + R_{12}T_{12} + R_{13}T_{13} + R_{14}T_{14} + R_{15}T_{15} + R_{16}T_{16}}{\sum_{11}^{16} R_n}$$

Where:

R_n = The activity fraction for operating mode n, obtained from the "opmodedist2" table
T_n = The emissions for operating mode n.

Other speed bins will use different operating modes in their calculations; the equation above is merely an example illustrating the calculation method for the first speed bin. Having calculated an appropriate E_n` for each speed range for a given source type and model year, Equation 1 can be used, along with the appropriate activity fraction, to arrive at a total uncorrected emissions value. In and of itself, this emission factor has little value in estimating emissions. However, it can be used along with the <u>modeled</u> emission factor for a particular source type and model year to arrive at an overall adjustment factor, as shown in Equation 3:

Equation 3

$$Z = \frac{E}{E`}$$

Where:

E = The <u>modeled</u> emission, obtained from MOVES outputs, for an individual source type and model year
E`= The uncorrected emissions for an individual source type and model year, calculated using operating mode distributions and emission factors from the "emissionratebyage" table

This overall adjustment factor, in turn, can be applied to each individual emissions component, E_n`, as shown in Equation 4:

Equation 4

$$E_n = ZE_n`$$

The adjusted emissions, E_n, are subsequently used to calculate a total, corrected emission factor for a given source type and model year combination, as described by Equation 5:

Equation 5

$$E = A_1E_1 + A_2E_2 + A_3E_3 + A_IE_I + A_BE_B$$

In this way, a representative emission factor is calculated by operating mode/speed group. This will allow the Truck Tool to adjust the default operating mode percentages (A_n) to more accurately represent a user-provided speed profile for the vehicles they are evaluating. Default operating mode percentages may also be used, as calculated above.

Conversion of Emission Factors from Source Type to Weight Class Basis

Ultimately, emission factor lookup tables are required for use in the Truck Tool by weight class, fuel type, and model year. However, modeled output from MOVES is aggregated by source type. Therefore a post-processing Tool was developed to convert vehicle emission factors from source types to weight class based on internal MOVES tables. The conversion methodology used in this Tool is described below.

First, the adjusted emissions and activity output from MOVES are combined, *by pollutantID*, by joining the "movesoutput" and "movesactivityoutput" tables by calendar year, source type, fuel type and model year. The sourcetype and model year for each record are combined in a new field, *sourcetypemodelyearID*.

Next, the emissions and activity output from the first step are combined with the MOVES "sizeweightfraction" table by joining on the *sourcetypemodelyearID*. The "sizeweightfraction" table contains, for a given combination of source type and model year, the fraction of vehicles apportioned across *weightclassID*. Given the *weightclassID*, the portion of emissions and activity attributable to a given range of vehicle weights is determined, and subsequently, those weights (along with fuel type) are mapped back to MOBILE6 vehicle classes, which are based on GVWR. (This is achieved with a separate lookup table, "M6VehType", which is derived from Appendix B, Table 3 of the EPA's MOBILE6.2 User's Guide.) For each calendar year, *sourcetypemodelyearID* and *pollutantID*, the sizeweightfraction is multiplied by the emissions (in grams) and activity (in miles) to obtain *EmissionFrac* and *ActivityFrac*, respectively.

Finally, the *EmissionFrac* and *ActivityFrac* calculated above are summed by *yearID*, *pollutantID*, *fueltypeID*, and MOBILE6 vehicle type (e.g., HDDV8b). This provides total emissions and activity independent of the MOVES source type or vehicle model year. Finally, the aggregated emissions are divided by the activity to arrive at g/mi emission factors presented in Appendix A.

Modeling E10 Emission Rates

In a MOVES run that uses nationwide defaults for fuel supply, the model includes dozens of fuel formulations on a by-fuel region basis in its calculations. In addition to diesel fuels, many counties in the model defaults are characterized by varying market shares of and E10 and E15.[18]

[18] Only 2001+ model year light-duty vehicles may use E15 fuel, and it is only sold at a handful of stations in Midwest states. See http://www.afdc.energy.gov/fuels/ethanol_e15.html.

In order to isolate Gasoline emission factors, the new Fuels Wizard included in MOVES2014a was used to alter the ethanol percentage of fuels nationwide to zero.

Sensitivity Analysis Results

The relative emissions impact of different speed regimes were evaluated for four road types – urban arterial, urban freeway, rural arterial, and rural freeway. To simplify the sensitivity analysis, MOVES outputs were generated for diesel long-haul combination trucks, model year 2012, run for the 2014 calendar year, using national average defaults (e.g., fuel specifications, temperatures, etc.). The results of the analysis are shown for NOx and $PM_{2.5}$ below.

Figure 1

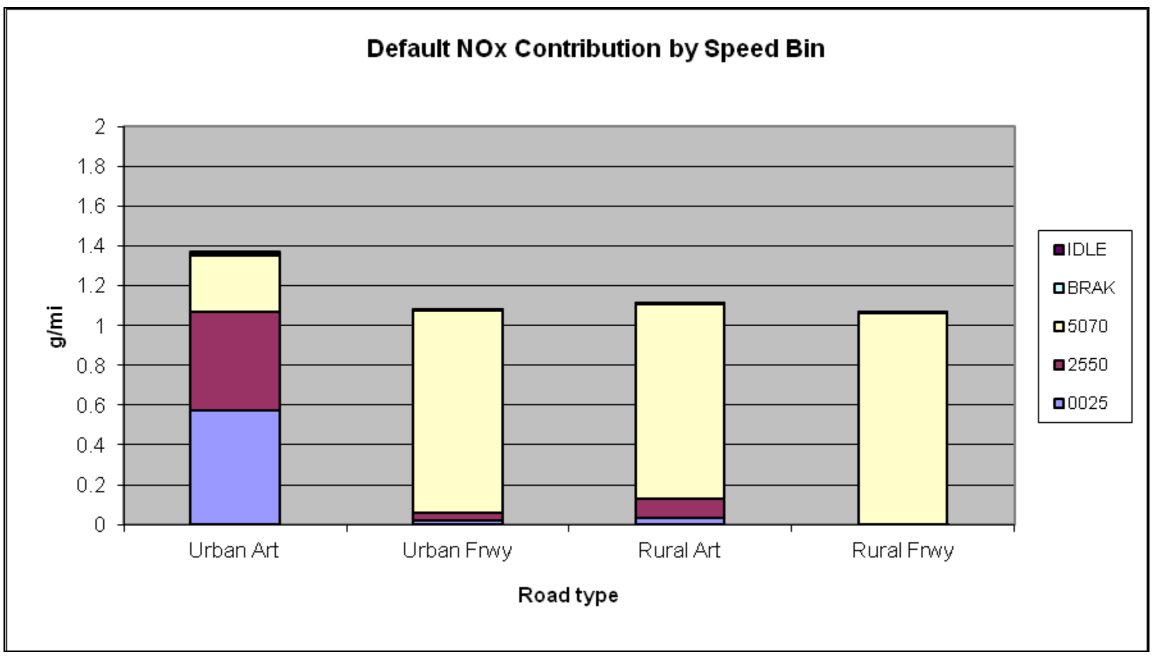
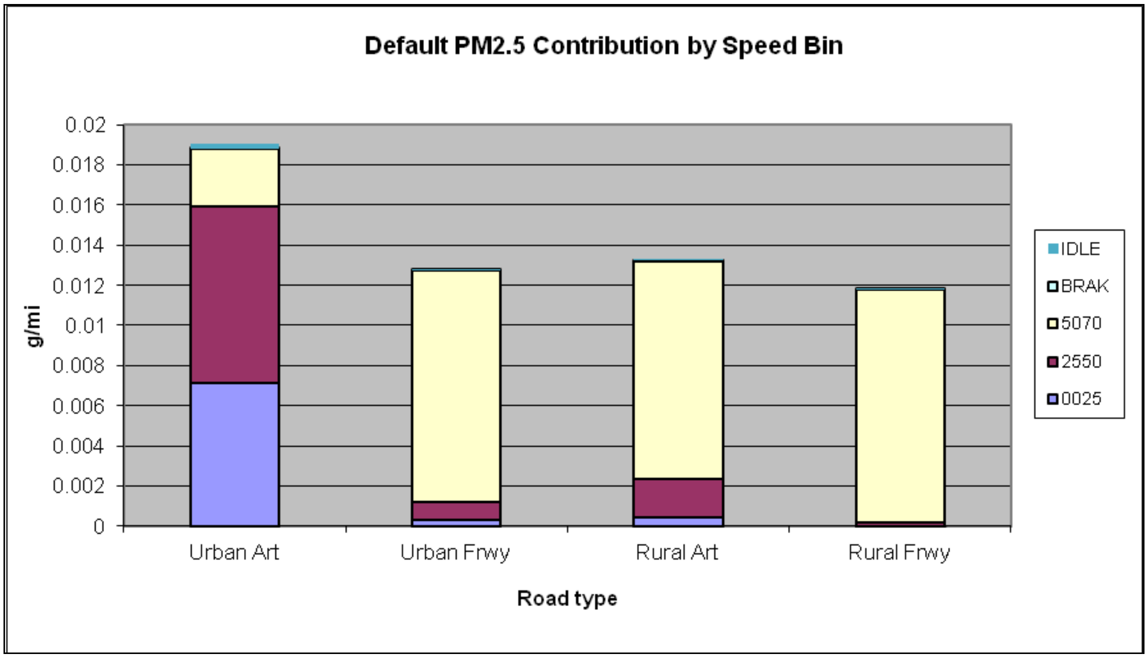


Figure 2



As shown in the above charts, the emissions for urban freeways, rural arterials, and rural freeways are all heavily dominated by high speed (50 – 70 mph) operation.[19] In addition, actual emission levels are relatively insensitive to road type across these three types. However, speed distribution appears to have a significant bearing on emissions for urban arterial operation. Accordingly, the recommendation for Truck Tool application was to develop fully disaggregated emission factor look up tables (retaining all four road types), and then weight urban freeway, rural arterial, and rural freeway road type operations in order to aggregate emission lookup tables within the SmartWay Tool to reflect "urban" (i.e., urban arterial) and "other" road types. In addition, under this approach users can choose default speed distributions for these selections, or specify the percent of operation by major speed range (0 – 25, 25 – 50, 50 – 70). Given the relative insensitivity to speed for the "other" category, specifying speed distributions would only be permitted for urban arterial operation.

Under this approach, the user is given the follow input options:

- Specify % Highway/Rural ("other") operation fraction
- Specify % urban operation distribution by speed bin, or select "default speed distribution"

Data entry is handled through the addition of a popup screen for non-default selections (see the Truck Tool User Guides for details).

[19] This finding is consistent with the 2008 SmartWay Partner data submissions, wherein 87% of Partners selected the 50+ mph category as the most representative of their non-urban operations.

2.3 Alternative Fuels

Heavy truck emission factors are not available from MOVES2014a for certain alternative fuels, including E85, natural gas, and LPG. Accordingly, EPA used adjustment factors from a number of sources described below to estimate NOx and PM/BC factors for these other fuels.

NOx and PM emission factors for biodiesel are based on the findings from an EPA study, A Comprehensive Analysis of Biodiesel Impacts on Exhaust Emissions (EPA420-P-02-001, October 2002). This study developed regression equations to predict the percentage change in NOx and PM emission rates relative to conventional diesel fuel, as a function of biodiesel blend percentage, expressed in the following form:

Equation 6

$$\%\ \text{change in emissions} = \{\exp[a \times (\text{vol\% biodiesel})] - 1\} \times 100\%$$

Where:

a = 0.0009794 for NOx, and
a = -0.006384 for PM and BC[20]

Using Equation 6, adjustment factors were developed for biodiesel blends based on the percentage of the biofuel component,[21] and then these adjustment factors were applied to the appropriate conventional diesel emission factors in Appendix A (see Section 2.2 for the sources of conventional diesel emission factors). Note that the fleet-average blend value is assumed to be the same for all truck classes, since the biofuel consumption data is not collected at the truck class level. (This assumption holds for ethanol consumption data inputs as well.)

MOVES2014a now incorporates specific modeling assumptions for biodiesel, including options for modeling 5 and 20 percent biodiesel (B5 and B20). While the pre-2007 vehicle estimates are consistent with EPA's 2002 study findings, MOVES does not estimate an emissions effect on 2007+ model year diesel trucks because the literature does not show observed consistent or significant biodiesel effects on theses engines.[22,23] Accordingly, the Truck Tool only applies adjustment factors for diesel engine model years prior to 2007.

[20] BC emission rates as a function of biodiesel blend have not been identified at this time and are currently assumed identical to the PM relationship.

[21] Biodiesel blend percentage is calculated by dividing B100-equivalent gallons by total fuel gallons at the fleet level – see the Truck Tool User Guides for details regarding biodiesel use inputs.

[22] McCormick, R. and A. Williams, 2011. *Impact of Biodiesel on Modern Diesel Engine Emissions*. Project ID: FT011. National Renewable Energy Laboratory, Golden, CO. May 9, 2011. http://energy.gov/eere/vehicles/downloads/impact-biodiesel-modern-diesel-engine-emissions.

[23] CARB 2011. *Final Report for the CE-CERT Engine Testing Portion for the CARB Assessment of the Emissions from the Use of Biodiesel as a Motor Vehicle Fuel in California Biodiesel Characterization and NOx Mitigation Study*. Final Report Prepared for CARB. October.

For gasoline-ethanol blends, the SmartWay Truck Tool only accepts fuel consumption estimates for E10 and E85 since, unlike biodiesel where the biofuel fraction can vary significantly, ethanol is generally blended with gasoline at two discrete levels: 10% (E10) and 85% (E85). As discussed in Section 2.2 above, NOx and PM factors for E10 were output directly from MOVES2014a. Given the lack of heavy-duty E85 test data, adjustment factors for E85 were based on emissions estimates for light-duty vehicles cited by the US DOE Alternative Fuels and Advanced Vehicles Data Center.[24] These estimates come from a technical paper published in the Journal of Air & Waste Management.[25] Relative to conventional gas vehicles, the authors of this paper estimate that vehicles running on E85 provide an average NOx reduction of 54% (based on 73 vehicle tests), and an average PM reduction of 34% (based on 3 vehicle tests). These adjustment factors are applied to the appropriate gasoline engine emission factors in Appendix A to develop emission factors for E85.

Emission adjustment factors were used for gaseous fuels (LPG, CNG and LNG), developed by the National Renewable Energy Lab and University of West Virginia based on field studies on natural gas vehicles.[26] For this assessment, it was assumed that CNG and LNG emissions were identical. In addition, it was also assumed LPG vehicle emissions would be equal to natural gas vehicle emissions.[27] To be conservative, the smallest emission reduction estimates were selected from the natural gas vehicle field test data (86% for PM and 17% for NOx) relative to comparable diesel vehicles. These adjustment factors are applied to the diesel emission factors in Appendix A and B to develop emission factors for these fuels.

Note, however, that the emissions associated with alternative fuels may be different for older trucks (with minimal emission controls) and newer trucks (with extensive control systems in place) due to recent vehicle emission standards. Newer studies suggest there are differences by model year in the emission rates of gaseous fuel vehicles. A 2014 study performed by West Virginia University[28] using Class 8 trucks found that a model year 2011 dual-fuel (5% diesel, 95% LNG) high-pressure direct injection (HDPI) truck emitted 63% and 48% less NOx and PM, respectively compared to a MY 2011 diesel truck equipped with an SCR and DPF. Both vehicles operated on the urban dynamometer driving schedule (UDDS). The same WVU study found that a MY 2011 natural gas engine equipped with a three-way catalyst (TWC) emitted 79% and 56% less NOx and PM compared to the MY 2011 diesel truck, also on the UDDS.

Based on this new information, the Tool uses a simple average across the two engines tested in the WVU study, resulting in a 71% reduction for NOx and a 52% reduction for PM, and applies these new reduction values to comparable diesel emission factors for 2010 and later model

[24] See http://www.afdc.energy.gov/afdc/vehicles/emissions_e85.html, last validated December 22, 2011.
[25] http://www.afdc.energy.gov/afdc/pdfs/technical_paper_feb09.pdf,
[26] http://www.conaturalgascoalition.com/clean.html, last validated 3-4-16.
[27] The PM and NOx estimates cited by this source for LPG vehicles were actually slightly lower than for natural gas vehicles - http://www.afdc.energy.gov/afdc/vehicles/emissions_propane.html. However, based on engineering judgment it was assumed that LPG PM and NOx emissions would be similar to comparable CNG vehicles.
[28] Carder, D.K., M. Gautam, A. Thiruvengadam, M. Besch. *In-Use Emissions Testing and Demonstration of Retrofit Technology for Control of On-Road Heavy-Duty Engines.* Prepared for the South Coast Air Quality Management District. July.

year gaseous fuel trucks. For model years prior to 2010, the adjustment factors of 17% for NOx and 86% for PM are retained.

Emission estimates for battery-electric trucks are based on national average electric generation mix profiles from USDOE's GREET model, as described in Appendix C.

Black carbon (BC) emissions associated with gaseous fuels are determined by multiplying the ratio of elemental carbon (EC) and $PM_{2.5}$ emission factors from MOVES2014a for CNG transit buses, for calendar year 2018. The ratio EC to $PM_{2.5}$ varies by model year group (0.0925 for pre-2002 model years, and 0.1112 for 2002+ model years), so these different factors are applied for the different engine age groups as appropriate in order to determine BC levels for these fuel types.

2.4 PM Control Effectiveness

The Truck Tool applies adjustment factors to the PM emission factors in Appendix A and B for any pre-2007 diesel truck for which Partners have installed a specific retrofit control device. The following adjustment factors were obtained from EPA OTAQ (presented as a % reduction in emissions; see Section 3.2 below for details):

- Diesel oxidation catalyst (DOC) – 25%
- Closed crankcase ventilation (CCV) – 5%
- Diesel particulate filter (DPF) – 90%

References from EPA's Clean Diesel Program are generally consistent with the DOC and DPF effectiveness estimates above (20 – 40% for DOCs, and 85% or more for DPFs).[29,30] Note that an independent estimate of CCV effectiveness was not identified, as EPA and CARB only verify CCVs when packaged with DOCs.[31]

The Tool applies the above adjustment factors to pre-2007 PM operating and idle emission estimates. The Tool also allows for situations where CCVs are applied in combination with either DOCs or DPFs. In such a case, the reduction effectiveness is calculated additively. For example, if pre-control operating emissions were 1.0 g/mile for a diesel truck, and a CCV and DOC were applied, the resulting emission rate would be:

Equation 7

1.0 x [1 – (0.25 + 0.05)] = 0.07 g/mile, post-control

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[29] EPA 2010a, National Clean Diesel Campaign Technical Bulletin: Diesel Oxidation Catalyst General Information. See https://www.epa.gov/sites/production/files/2016-03/documents/420f10031.pdf.
[30] EPA 2010b, National Clean Diesel Campaign Technical Bulletin: Diesel Particulate Filter General Information. See https://www.epa.gov/sites/production/files/2016-03/documents/420f10029.pdf.
[31] See https://www.epa.gov/sites/production/files/2015-09/documents/420b13025.pdf.

However, the Truck Tool assumes that DOC and DPF application are mutually exclusive.

At this time the relative effectiveness of the controls addressed above are assumed to be equal for PM and BC.

3.0 Emission and Activity Estimation

The emission rates and adjustment factors discussed above are combined with appropriate activity data (provided by the Partners) to calculate mass emissions at the fleet and/or partner level for CO_2, NOx, PM, and BC as described below.

3.1 CO_2

CO_2 is calculated within the Truck Tool utilizing emission factors expressed in *grams per gallon of fuel*, (with the exception of battery-electric trucks), as discussed in Section 2.1 above. The general equation for calculating CO_2 emissions using reported fuel consumption values is

Equation 8

$$\mathbf{E_{CO2} = ((F - B) \times EF_F) + (B \times EF_B)}$$

Where:

E_{CO2} = grams CO_2 per year
F = Total Fuel (Gallons per year)
B = Biofuel (Gallons per year)
EF_F = Fossil Fuel Emissions Factor (g/gal based on fuel type)
EF_B = Biofuel Emissions Factor (g/gal based on biofuel type)

Emissions for *all* pollutants for battery electric trucks are calculated by multiplying the reported kWhrs used for charging by the associated g/kWhr factor (see Appendix C).

In most instances reefer fuel is aggregated with vehicle fuel inputs in the Truck Tool, with the reefer fuel type assumed to be the same as the vehicle fuel type. However, reefer units associated with LPG and electric trucks are assumed to use diesel fuel (by far the most common type of reefer engine). Accordingly, any reefer fuel use reported for LPG and electric trucks is included in the total CO_2 calculation using the diesel fuel factors in Equation 8.

Fuel Allocator

The Truck Carrier Tool asks users to enter Gallons of Diesel Used by truck class in order to estimate CO_2 emissions. This information may be entered directly if available. However, if the user does not have this information but does know total fuel use and MPG by truck class, the Truck Tool's Fuel Allocator can be used to apportion fuel use across truck classes.

In the **Fuel Allocator**, the user enters total fuel consumption and truck class MPG estimates. The allocator then calculates the fuel used for each class based on the total fuel and class MPG. If the total fuel calculated matches the total fuel entered to within 2%, the allocator indicates a "Match". However, instead of writing the exact calculated value seen in the Fuel Allocator to the Activity screen, the Tool adjusts the class fuel amounts (and therefore MPG) so the sum matches the Total Fuel entered exactly, and then writes these values on the Activity screen. That means, the MPG entered into the Fuel Allocator, and the calculated fuel used seen on the Fuel Allocator, are not necessarily equal to the MPG and the fuel used that is written to the Activity Screen.

If the user re-opens the Fuel Allocator at this point, the Allocator brings in the MPGs listed on the Activity Screen, NOT the MPGs the user input into the calculator the first time (although it doesn't overwrite the saved MPGs entered on the worksheet, if the user presses Cancel). For remaining calculations in the Tool, the values shown on the Activity Screen are used. The Allocator values the user entered are saved for the XML file, but aren't used for further calculations. Separately in the XML, the MPG and fuel totals that were put onto the Activity Screen are also written.

3.2 NOx, PM and BC

Unlike CO_2 emissions which only vary with fuel type, NOx, PM and BC emission rates also vary substantially depending upon engine model year and/or emission certification level, vehicle class, drive cycle, speed, and operation mode (running or idle). For this reason, EPA developed lookup tables in the Truck Tool with emission factors that correspond to user-supplied inputs regarding their fleet activity. The NOx, PM and BC emission rates expressed in *grams per mile* were combined with the appropriate mileage metric (i.e., total miles) in order to estimate mass emissions. The general equation for calculating NOx emissions is as follows:

Equation 9

$$\mathbf{E_{NOx} = \sum [(M_C \times ((GPM_H \times HDC) + (GPM_{U1} \times UDC_1) + (GPM_{U2} \times UDC_2) + (GPM_{U3} \times UDC_3) + (GPM_{U4} \times UDC_4))) \times T_{CY} / T_{CT}) + (GPH_I \times H_I \times T_{CY}) + (GPH_I \times H_I \times T_{CY})]}$$

Where:

E_{NOx} = grams NOx per year for a given truck class
$\sum$ = summation across model years
M_C = Miles driven for Truck Class C per year
GPM_H = Grams/mi (by truck class & engine yr) for Highway/Rural Driving
HDC = Highway drive cycle % (% of miles under highway/rural driving)
$GPM_{U1/2/3/4}$ = Grams/mi (by truck class & engine yr) for Urban Driving by mode (1 = 0 – 25 mph; 2 = 25 – 50 mph; 3 = 50+ mph; 4 = deceleration)
$UDC_{1/2/3/4}$ = Urban drive cycle % (% of miles under urban driving conditions, by mode (1, 2, 3, 4))
T_{CY} = Number of trucks for a given Class/Year combination
T_{CT} = Number of trucks total for a given Class
GPH_{SDI} = Grams per hour (by truck class & engine year) for short-duration Idling[32]
H_{SDI} = Hours of short duration Idling per year (average per truck per year by class)

[32] The idle calculation for Class 8a and lighter trucks does not distinguish between short and long duration idling, and all idle hours are multiplied by the short duration idle factor for these trucks. Hybrid electric trucks are assumed to have no short-duration idling emissions, while battery-electric trucks have no idling emissions of any kind.

GPH_{LDI} = Grams per hour (by truck class & engine year) for long-duration Idling
H_{LDI} = Hours of long duration Idling per year (average per truck per year by class)

PM emissions for non-diesel vehicles are calculated using an equation identical to that for NOx, utilizing PM emission factors. PM emission for diesel vehicles may be adjusted for PM control effectiveness, as shown below. (BC emissions are calculated in identical fashion.)

Equation 10

$$\mathbf{E_{PM} = \sum [(((M_C \times ((GPM_H \times HDC) + (GPM_{U1} \times UDC_1) + (GPM_{U2}\ x\ UDC_2) + (GPM_{U3}\ x\ UDC_3) + (GPM_{U4}\ x\ UDC_4))) \times T_{CY} / T_{CT}) + (GPH_{SDI} \times H_{SDI} \times T_{CY}) + (GPH_{LDI} \times H_{LDI} \times T_{CY})) \times (1 - ((0.25 \times T_{DOC} / T_{CT}) + (0.05 \times T_{CCV} / T_{CT}) + (0.9 \times T_{DPF} / T_{CT})))]}$$

Where:

E_{PM} = grams PM per year for a given truck class
T_{DOC} = Number of trucks using Diesel Oxidation Catalysts by class
T_{CCV} = Number of trucks using Closed Crankcase Ventilation by class
T_{DPF} = Number of trucks using Diesel Particulate Filters by class
0.25 = Effectiveness of DOCs (25%) at reducing particulate matter
0.05 = Effectiveness of CCVs (5%) at reducing particulate matter
0.9 = Effectiveness of DPFs (90%) at reducing particulate matter

Note the above calculation methodology assumes that the same highway/urban drive cycle fractions apply across all model years of a given truck class. Similarly, the method assumes that estimated idle hours apply equally to all model years of a given truck class.

The above methodology also utilizes estimates for the fraction of miles traveled associated with different road types and speed categories, as shown in the equations above. The Truck Tool user must provide an estimate of the percent of total miles associated with highway/rural driving for each truck class. The user may also provide percentages for the miles spent driving in urban conditions (e.g., unrestricted access, surface roads in well-traveled urban areas), for different speed categories (0 – 25 / 25 – 50 / 50+ mph). This information may be obtained from analysis of truck ECM or possibly GPS data. If urban speed distribution data is not available, the user may select to use default distributions, obtained from the MOVES model. The default speed distributions for urban operation (as defined in Section 2.2 above) varies with vehicle class and model year. However, the variation over model years is very slight (typically with a range of 1 to 2 percent for the largest speed category), the percentages were averaged over all model years for a given speed category/vehicle type combination for use within the Truck Tool.

Table 4 presents the resulting default urban speed distributions by speed category for each truck class, for both diesel and gasoline vehicles. Note that the Truck Tool utilizes the diesel default speed distributions for LPG, LNG, and CNG.

Vehicle Class	Speed Group	Percent by Class*
Diesels		
HDDV2b	0 - 25	35%
	25 - 50	38%
	50+	13%
	Deceleration	15%
HDDV3	0 - 25	41%
	25 - 50	36%
	50+	12%
	Deceleration	11%
HDDV4	0 - 25	42%
	25 - 50	35%
	50+	12%
	Deceleration	11%
HDDV5	0 - 25	42%
	25 - 50	35%
	50+	12%
	Deceleration	11%
HDDV6	0 - 25	42%
	25 - 50	35%
	50+	12%
	Deceleration	10%
HDDV7	0 - 25	42%
	25 - 50	35%
	50+	12%
	Deceleration	10%
HDDV8a	0 - 25	44%
	25 - 50	35%
	50+	12%
	Deceleration	9%
HDDV8b	0 - 25	45%
	25 - 50	34%
	50+	12%
	Deceleration	8%

* May not sum to 100 due to rounding error

Vehicle Class	Speed Group	Percent by Class*
Gasoline		
HDGV2b	0 - 25	43%
	25 - 50	31%
	50+	10%
	Deceleration	15%
HDGV3	0 - 25	45%
	25 - 50	34%
	50+	11%
	Deceleration	11%
HDGV4	0 - 25	45%
	25 - 50	34%
	50+	11%
	Deceleration	10%
HDGV5	0 - 25	46%
	25 - 50	33%
	50+	10%
	Deceleration	11%
HDGV6	0 - 25	46%
	25 - 50	33%
	50+	10%
	Deceleration	11%
HDGV7	0 - 25	45%
	25 - 50	32%
	50+	10%
	Deceleration	14%
HDGV8a	0 - 25	45%
	25 - 50	34%
	50+	11%
	Deceleration	10%
HDGV8b	0 - 25	43%
	25 - 50	31%
	50+	10%
	Deceleration	15%

Table 4. Default Speed Category Distributions by Vehicle Class for Urban Operation (MOVES2010a basis)[33]

As seen in the above table, the MOVES model assumes that some fraction of vehicle operation is associated with "deceleration" events, evaluated independently from other operation due to their unique emission rate patterns.[34] However, it is assumed that most Truck Tool users will

[33] These values represent the urban component of driving only. If the user specifies a non-zero percentage for Highway/Rural driving, the values in the above table are automatically renormalized, so as to make the sum across urban and highway operation modes equal to 100%.

[34] MOVES also assigns some fraction of emissions to idle operation. However, operating fractions and emission factors associated with idle in MOVES outputs are expressed in grams per mile rather than grams per hour. Thus, in order to utilize the grams per hour emission factors developed especially for use in the Truck Tool, MOVES outputs associated with idle operation were removed and the operating mode fractions for the four remaining categories were renormalized to equal 100%.

not know their fleet's deceleration fraction. As such, the Truck Tool will adjust any values input by the user to include a deceleration fraction based on MOVES model percentages. If the user selects the default urban speed distributions, the Truck Tool will adjust the urban values from Table 4 to account for the percentage of miles specified for Highway/Rural operation as well. The following provides an illustrative example for calculating PM emissions for diesels given a specific set of road type/speed category distributions. NOx and BC emission calculations follow the same procedure.

User specifies 1 Class 8b diesel, model year 2011, traveling 100,000 mi/yr.
User specifies the following Road type/speed category distributions:

40% highway/rural
30% 0-25 mph
20% 25-50 mph
10% 50+ mph

For highway/rural operation, the lookup value from MOVES is 0.0187 g/mi for PM2.5
For urban operation, the lookup values are as follows (2016 calendar year basis):

0-25: 0.0272 g/mi
25-50: 0.0463 g/mi
50+: 0.0233 g/mi
deceleration: 0.0015 g/mi

Now the urban speed distribution percentage inputs must to account for deceleration, as follows:

0-25: 30% x sum of default percentages for the three speed bins (but excluding default deceleration fraction) = 30% x (45% + 34% + 12%) = 27.3%

25-50: 20% x sum of default percentages (45% + 34% + 12%) = 18.2%

50+: 10% x sum of default percentages (45% + 34% + 12%) = 9.1%

deceleration: the remaining percentage, which equals 100% - 40% (highway) - 27.3% - 18.2% - 9.1% = 5.4%

Now apply these percentage weights to the total mileage, and then multiply by the corresponding emission factors to obtain mass, as follows:

Highway/rural component: 0.40 x 100,000 x 0.0187 = 748 grams
0-25 urban component: 0.273 x 100,000 x 0.0272 = 743 grams
25 - 50 urban component: 0.182 x 100,000 x 0.0463 = 843 grams
50+ urban component: 0.091 x 100,000 x 0.0233 = 212 grams
Deceleration urban component: 0.54 x 100,000 x 0.0015 = 81 grams

Therefore total = 2,627 grams of PM2.5 (This value will then be summed with any other model year/vehicle class combinations and converted to short tons.)

As discussed in Section 2.3, the Truck Tool assumes that B100-equivalent biodiesel volumes are distributed proportionately across all diesel vehicle classes. For example, if a fleet uses 100 B-100 equivalent gallons of biodiesel, and 1,000 gallons of fuel total, the Tool assumes that B10 (100 / 1,000 = 10%) is the blend used by each truck class. Accordingly, emission rate adjustment factors are calculated for B10 using Equation 6, and applied to the diesel emission factors for each vehicle class.

Finally, note that the PM factors output by the MOVES model for use in the Truck Tool are expressed in terms of $PM_{2.5}$. The MOVES2014a model assumes a fixed ratio of PM_{10} / $PM_{2.5}$ for a given fuel type, as summarized below:

- Gasoline – 1.1304
- Diesel – 1.087
- CNG – 1.1304

These factors are applied directly to the $PM_{2.5}$ emission factors to obtain mass emission and performance metrics for PM_{10} within the Truck Tool. In addition, it was assumed that LNG and LPG have PM ratios equivalent to the CNG value. The ratio for biodiesel was assumed to equal that for diesel.

3.3 Activity Calculations

The Truck Tool requires users to provide specific activity information on fuel consumption, miles traveled, payload, cargo volume, average used cargo volume %, road type/speed, and idle hours at the vehicle class level for the emissions performance assessment (see Section 4.0 below). While the user may provide direct data inputs for any or all of these activity parameters, the Truck Tool also allows the user to select default values for payload and volume determination, in the absence of fleet-specific information. (Direct inputs for payload are highly preferred over the use of calculator defaults.) The data sources and assumptions used to develop these default values are discussed below.

<u>Default Payload Distributions</u>

Average payloads can vary widely among fleets, even within a given vehicle class, depending upon commodity type and body/trailer type. (While the Truck Tool does collect commodity information, this information is not used in determining payloads.) With the exception of LTL and Package carriers, exact data entries were used from the 2011 Truck Tool submissions to obtain payload distributions for the 2017 Tool.[35] This data was categorized by fuel type, truck class, body-type, and SmartWay ranking category. Body-type refers to the categories presented in the Truck Tool payload calculator (e.g., Step Van, Beverage, Combination Flatbed, etc.). Ranking category is based on the Fleet Description inputs (e.g., Truckload Dry Van, Dray, Mixed, etc.). 1,850 unique records were identified using this categorization of the 2011 Partner data.

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[35] An evaluation of carrier payload data in 2016 found the vast majority of fleets selected from the tool's default ranges rather than providing exact values. Accordingly the available 2016 data was not robust enough to use as the basis for an update to the existing ranges provided in the tool.

This data was then reviewed and four outliers were identified and removed from the data set.[36] Next, the data was grouped by truck class and body type and examined for notable differences in payload values across ranking categories. However, with the exception of certain Class 8 trucks, no truck class/body-type/ranking category combination had greater than 20 observations. Therefore, it was concluded that there was not an adequately large data set available for establishing ranking-category specific payload distributions for Truck Classes 2b-7. In these cases, payload data were aggregated across all ranking categories for each truck class/body-type combination.

The larger population of Class 8 trucks in the 2011 data set allowed for a differentiation of payload distributions across ranking categories. Considering both available sample size and average payloads, the following unique truck class/body-type/SmartWay ranking category groupings were established.

- Class 8a Dry Van Single body-types: differentiate LTL (9.9 tons average) and non-LTL (12.4 tons average) categories. No differentiation across categories for other body-types.
- Class 8b Dry Van Single body-types: differentiate Heavy-bulk (24.1 tons), LTL/Moving/Package (15.0 tons), Tanker (24 tons), and all other categories (18.5 tons).
- Class 8b Specialty body-types: differentiate Auto Carriers (16.2 tons), Heavy/Mixed (30.3 tons), Flatbed (21.6 tons), and all other categories (25.6 tons).
- Class 8b Dry Van Double body-types: differentiate TL/Reefer/Mixed (27.7 tons) and all other categories (19.4 tons)
- Class 8b Other body-types: differentiate Heavy/Flatbed/Mixed (27.4 tons) and all other categories (21.5 tons).

Based on this data, Table 5 presents the payload averages, standard deviations, minimum and maximum values by truck class/body-type/and-or ranking category.[37] Note that the average values and standard deviations presented below are not weighted by fleet size.

Table 5. Average Payload and Standard Deviation (short tons) by Vehicle Class/Body-Type/Ranking Category (2011 SmartWay Partner Data – Exact Payload Entries)

Body-Type (Bin Category)	Avg Payload (tons)	Std Dev
Class 2b		
Flatbed	1.19	0.69
Step Van	1.14	0.48
Walk-In Van	1.05	0.48
Conventional Van	0.77	0.41
Other	0.58	0.49

[36] Three Class 2b entries were removed due to suspiciously high payloads (16, 13, and 5 tons). One Class 8b truck was also removed (1 ton) due to an incongruous text explanation ("none used").
[37] Given the lack of data on non-diesel heavy-duty vehicles, payload ranges are assumed to apply to all fuel types.

Body-Type (Bin Category)	Avg Payload (tons)	Std Dev
Class 3		
Step Van	1.65	0.53
Walk-In Van	1.64	0.57
Conventional Van	1.50	0.83
Other	1.08	0.90
Class 4		
Flatbed	2.68	1.53
Step Van	2.24	1.19
Walk-In Van	1.70	0.80
Conventional Van	2.27	0.90
Other	1.16	0.76
Class 5		
Walk-In Van	1.99	1.08
Conventional Van	3.39	0.99
Other	2.91	1.19
Class 6		
Flatbed	4.67	1.71
Reefer	4.84	1.80
Walk-In Van	4.01	1.68
Single-Axle Van	3.78	1.19
Other	4.17	1.48
Class 7		
Beverage	6.10	2.22
Flatbed	7.05	0.85
Reefer	6.03	1.27
Tanker	7.45	0.92
Single-Axle Van	5.53	1.83
Other - straight truck	8.30	4.63
Combination Flatbed	5.22	0.41
Combination Reefer	3.58	1.01
Dry Van - Single	5.44	2.57
Other - combo	5.90	1.15
Class 8a		
Flatbed	10.04	5.88
Tanker	12.12	5.43
Single-Axle Van	8.09	3.80
Other - straight truck	9.76	4.08
Beverage	12.30	4.40
Combination Flatbed	12.51	1.41
Dry Van - Single (other than LTL)	12.42	4.66
Other - combo	12.68	4.56
Class 8b		
Dry Van - Single (Heavy-Bulk)	24.1	2.98
Dry Van - Single (other bins)	18.46	3.97
Dry Van - Double (Tanker)	24.06	2.96

Body-Type (Bin Category)	Avg Payload (tons)	Std Dev
Dry Van - Double (Mixed-TL-Reefer)	27.74	13.33
Dry Van - Double (Other bins)	19.39	3.82
Dry Van – Triple	27.10	3.20
Combination Reefer	20.10	2.82
Combination Flatbed	22.50	4.23
Combination Tanker	24.90	2.89
Chassis	21.80	5.28
Specialty (Other bins)	25.62	2.72
Other (Other bins)	21.50	8.41
Specialty (Auto bin)*	18.22	5.29
Specialty (Heavy-bulk bin)*	29.23	7.15
Specialty (Moving bin)*	14.57	2.70
Specialty (Flatbed bin)	21.56	2.58
Other (Heavy-Flatbed-Mixed bins)	27.41	6.36

* calculated using 2014 calendar year data, for new body type additions to the payload calculator.

The values above serve as the basis for the default payload ranges provided in the Truck Tool payload calculator. For most vehicle class/body-type/ranking category combinations,[38] seven default ranges are offered for Partner selection:

- Range 1: from 0 tons to (Average payload – 2 x standard deviation);
- Range 2: from (Average payload – 2 x standard deviation) to (Average payload – 1 x standard deviation);
- Ranges 3-5: evenly split in three sections, from (Average payload – 1 x standard deviation) to (Average payload + 1 x standard deviation);
- Range 6: from (Average payload + 1 x standard deviation) to (Average payload + 2 x standard deviation); and,
- Range 7: from (Average payload + 2 x standard deviation) to (Average payload + 3 x standard deviation).

Once a particular range is selected, the payload calculator determines the midpoint of the range in order to estimate class level average payloads. The midpoint payload values for each body type are weighted by one of the four allocation methods specified by the user in the payload calculator: # miles, # trips, % operation, and # vehicles by body type. The weighted sum is then used as the class level average payload, which in turn is used directly in determining grams per ton-mile performance metrics for the fleet.

Payload data based on bills of lading and entered directly into the payload calculator are validated using the same data described above (see Section 3.4).

[38] In a few instances, the calculated lower bound value for Range 2 was less than zero. In these cases the lower bound value for Range 2 was set to zero and the Payload Calculator indicates Range 1 as "N/A".

LTL and Package Fleet Payloads

For most payload validations in the Tool, ranges are calculated by class and by body type as described above. LTL and package delivery payload validation ranges were updated using data from the 2015 tools, and are calculated on a simple truck class basis, as there was not enough LTL and Package Delivery Partner information to break payload out by body type. Therefore, each body type in a class is validated using the same range, as shown in Table 6 below.

Table 6. Payload Validation Ranges (Short Tons) for LTL and Package Delivery Fleets

Truck Class	Avg Payload	# Obs	Standard Dev	R1 Min	R2 Min	R3 Min	R4 Min	R5 Min	R6 Min	R7 Min
2B	0.96	12	0.195	>0	0.565	0.761	0.891	1.021	1.151	1.249
3	1.57	19	0.303	>0	0.967	1.270	1.472	1.674	1.876	2.027
4	1.92	11	0.679	>0	0.562	1.241	1.693	2.146	2.598	2.937
5	2.79	10	0.790	>0	1.212	2.002	2.529	3.055	3.582	3.977
6	3.72	70	0.678	>0	2.362	3.040	3.492	3.945	4.397	4.736
7	5.44	64	0.981	>0	3.481	4.462	5.116	5.770	6.424	6.914
8A	9.78	63	2.170	>0	5.437	7.607	9.054	10.501	11.948	13.033
8B	15.79	110	3.532	>0	8.729	12.261	14.615	16.970	19.324	21.090

The lower payload ranges (for “R1” and “R2”) were set so as to identify less than 20% of the observed LTL/package fleets during validation. The middle R3-R5 ranges extend from one standard deviation less than the average payload to one standard deviation greater than the average. The upper payload values for “R6” range from the payload average plus one standard deviation to the average plus 1.5 standard deviations. The range for “R7” extends above the “R6” maximum value. The maximum R7 range values are taken directly from the original R7 maximum values described above by class and by body type.[39]

Starting with the 2015 Truck Tool fleets with a SmartWay Category designation of LTL must also provide estimates for the average weight per shipment and the average number of shipments per truck. These values will be used to help refine the payload validation ranges for Shippers using LTL carriers. As a validation check, the Truck Tool compares the average payload per truck derived from these inputs (i.e., average weight per shipment x average shipments per truck) with the average payload calculated from the Activity screen. If the difference is greater than +/- 20% a validation warning is provided.

[39] For two body types under Class 7 trucks (Combination Flatbed and Combination Reefer), the original Range 7 max value is less than the new Range 6 max value. (R7 max is 6.45 and 6.61 respectively, while the new R6 max value for all class 7 body types is 6.914). Therefore, for just these two body types within Class 7, instead of using the original Range 7 max, we use the Range 7 max that would be calculated from the new table values. This is calculated as Avg + 2.5 x standard deviation, based on the table above (7.896 in this case). [Note it is Avg + 2.5 x standard deviation instead of Avg + 3 x standard deviation because of the 1.5 sigma rule for Range 6. Therefore the Range 7 max value is simply 1 standard deviation larger than the Range 6 max.]

Default Cargo Volumes[40]

The Truck Tool also provides a volume calculator to estimate the cubic feet associated with the common straight truck body types (classes 2b through 7) identified using the 2011 Partner dataset, as well as typical trailer, container, carrier, and tanker sizes, for combination trucks (classes 8a and b).[41] Cargo volumes in cubic feet are relatively easy to estimate for many combination trucks. Per unit interior volume defaults are assumed for standard dry vans - no high cubes, reefers, etc.), and containers. Trailer calculations assume an 8' x 9' cross-section, and the exterior length less 1/2 foot. 20 and 40 foot container dimensions are referenced in many places, such as http://www.mussonfreight.com/containers/containers.html.[42] Table 7 summarizes the default volumes assumed for a number of standard trailers, containers, tankers, and bulk carriers.

Table 7. Default Average Cubic Feet (Class 8a – 8b trucks)

Type	Size	Cubic Feet
Trailers	28ft	1,980
	40ft	2,844
	42ft	2,988
	45ft	3,204
	48ft	3,420
	53ft	3,780
	57ft	4,068
	28x28	3,960
	48x28	4,824
	40x40	5,688
	48x48	6,840
	28x28x28	5,940
Containers	20ft	1,159
	40ft	2,347
	45 ft[43]	3,031
	48 ft	3,454
	53ft	3,148
Tankers	Small (3,000 gal)	401
	Medium (5,250 gal)	702
	Large (7,500 gal)	1,003
Bulk Carriers	Small (22'x8'10.25')	1,804
	Medium (32'x8'x11')	2,816
	Large (42'x8.5'x11.5')	4,106

[40] The Truck Tool allows users to enter cargo volume in either cubic feet or TEUs, with one TEU assumed equal to 1,360 cubic feet – see http://www.dimensionsinfo.com/20ft-container-size/.
[41] Default cargo volumes for Class 7 combination vehicles were not available, and were set equal to the average volume for Class 8 combination trucks in the 2010 SmartWay database.
[42] 53 foot containers are assumed to have interior dimensions of 52' 5" x 7' 8" x 7' 10"
[43] 45 and 48 foot container references from http://www.shippingcontainers24.com/dimensions/45-foot/, and http://www.containertech.com/container-sales/48ft-high-cube-container-domestic/

Cargo volume capacity data is often not readily available for straight trucks, however. Such trucks are highly variable in their configuration and when volume estimates are found, the data often do not permit cross-referencing with vehicle class. Most highway infrastructure and operating agencies, including enforcement, are concerned about weight (e.g., pavement and structure damage), but not cubic capacity. The operating agencies are also concerned about maximum dimensions, of length, height and width (for, respectively, turning radii, vertical clearance, and lane width) but the shape of the box and its relation to the truck superstructure, not these maximums, dictates cubic capacity. Little public research on the cubic capacity of the box has been done, and thus little information is published.

A relatively small number of volume estimates were compiled from the 2011 Partner data (218 unique observations for truck class/body-type combinations). Of these observations 13 were identified as outliers and removed from the data set (11 observations of less than 100 cu ft; one Class 3 truck at 1,360 cu ft; and one Class 2b truck at 3,600 cu ft). Given the overall "thinness" of the dataset, those truck class/body-type combinations with three or more observations were used to estimate average cargo volumes. The following truck class/body-type combinations had fewer than three observations in the Partner dataset.

- Class 2b Flatbed
- Class 3 Other
- Class 4 Flatbed, Step Van, Other
- Class 6 Flatbed, Walk-In Van
- Class 7 Flatbed, Tanker
- Class 8a Beverage

For these remaining truck class/body-type combinations available information was compiled as it relates to cargo *volume* capacity for the common straight truck body types.

Without a comprehensive data source, such as the Partner data, other strategies needed to be employed to develop examples, or ranges, of volume capacity for the remaining body type/truck class combinations of interest. A literature review and vendor interviews were performed to determine appropriate values for cargo volume capacity. The first step in the literature review involved preparing a list of vendors responsible for designing, manufacturing, or operating all the different truck types identified.

Cubic capacity is also dependent upon a variety of factors and is not uniform for even the same make and model, as many truck manufactures will design to specifications based on a client's unique needs for their cargo. For example, a client may request a manufacturer to design a truck interior to best accommodate the delivery of a certain size of parcel, and install shelving or otherwise compartmentalize to that end. Consideration was given to these factors during the review.

The literature review encompassed Internet searches of vendors of the truck types described above. Sources explored included truck manufacturers, dealers, and fleet lessors of vehicles such as Budget/U-haul/Enterprise/Ryder/E-Dart). Additionally, validation searches were performed on websites outlining current truck sales to help identify the appropriate size/class of the vehicles and applicable specifications. The following information was collected from these searches for over 40 different vehicles currently available on the market:

- Length, width, height of the cargo hold
- Reported cargo space (cubic feet)
- Gross Vehicle Weight
- Payload
- Manufacturer
- Make/Model
- Reference website

Outreach to key stakeholders in the commercial vehicle industry was also performed to further validate the information collected from the literature and resource review. Contact was made with representatives from Volvo Trucks North America; the American Transportation Research Institute (ATRI); the Commercial Vehicle Safety Alliance (CVSA); the Truck Manufacturers Association (TMA); Federal Highway Administration (FHWA) Truck Size and Weight; and a wide variety of trucking manufactures and other vendors.

The results of this review are combined with the averages from the Partner data and are provided in Table 8 below for straight trucks, classes 2b through 7. In those instances where multiple vehicle models were identified for a given body type/vehicle class combination, simple averages were calculated across models.

Table 8. Estimated Cargo Volumes (cubic feet) for Straight Truck Body Types, by Vehicle Class

Body- type	Average Cargo Volume (Cubic Feet)
Class 2b	
Flatbed*	336
Step Van	479
Walk-In Van	580
Conventional Van	357
Other	303
Class 3	
Step Van	468
Walk-In Van	706
Conventional Van	538
Other*	599
Class 4	
Flatbed*	448
Step Van*	700
Walk-In Van	667

Body- type	Average Cargo Volume (Cubic Feet)
Conventional Van	699
Other*	830
Class 5	
Walk-In Van	655
Conventional Van	1,010
Other	691
Class 6	
Flatbed*	672
Reefer	1,146
Walk-In Van*	1,496
Single-Axle Van	1,583
Other	1,257
Class 7	
Beverage	1,576
Flatbed*	728
Reefer	1,413
Tanker*	267
Single-Axle Van	1,476
Other	1,486

*From literature/web review

Once a default cargo volume is selected, the volume calculator weights the volume estimates for each body type by one of the four allocation methods: # miles, # trips, % operation, and # vehicles by body type. The weighted sum is then used as the class level average cargo volume, which in turn is used directly in determining grams per volume-mile performance metrics for the fleet.

A list of websites utilized in the literature review is provided below.

Truck manufacturers:
www.gmc.com
www.chevrolet.com
www.ford.com
www.freightlinersprinterusa.com
www.silvercrowncoach.com

Fleet operators:
www.uhaul.com
www.pensketruckrental.com
www.budgettruck.com
www.hendersonrentals.co.nz
www.hackneybeverage.com
www.hackneyusa.com

www.fedex.com
www.grummanolson.com

Other sources:
www.usedtruckdepot.com
www.usedtrucks.ryder.com
www.truckingauctions.com
www.truckpaper.com
www.motortrend.com
files.harc.edu/Projects/Transportation/FedExReportTask3.pdf

The detailed findings of the literature/web review are presented in Appendix D.

3.4 Data Validation

The SmartWay Truck Tool has a number of standard logical, range and value checks that must be passed before Partners can submit their data to EPA. Many of these checks simply confirm the presence of required data (e.g., total miles for each truck class selected), or the accuracy of logical relationships (e.g., revenue miles <= total miles). The list of these basic checks is provided below. Partners will not be able to finalize their fleet files until all associated errors have been resolved. Also note that there is an implicit validation check on all numeric fields because the system will not accept any non-numeric characters (including minus signs) within these fields.

Table 9. Basic Range and Logical Checks – Conditions Resulting in Error or Warning Messages

Contact Information	User must enter at least two distinct contacts
Fleet Description	User must include a Partner Name.
Fleet Description	If entered, SCACs must be between 2 and 4 characters in length, and at least one character must be a letter. Multiple SCACs must be separated by commas.
Fleet Description	If entered, MCNs must be between 6 and 7 digits.
Fleet Description	If entered, DOT numbers must be 7 digits or less.
Fleet Description	User must select a Fleet Type.
Fleet Description	User must indicate operational control over at least 95% of the fleet. (If Partner does not have at least 95% operational control, Truck Tool may not be used for the fleet.)
Fleet Description	The Operation Category totals must add up to 100%.
Fleet Description	The Body Type totals must add up to 100%.
Fleet Description	If a value for the Special Hauler body type is entered, a description must be provided.
Fleet Description	Warnings are issued for any of the following Operation Type/Body Type combinations. NOTE: This validation will only be invoked if there is a single selection made for either Operation or Body Type - otherwise combinations can't be determined with certainty. LTL/Chassis; LTL/Moving; LTL/Heavy; LTL/Specialized; Dray/Flatbed; Dray/Moving; Dray/Utility; Package/Flatbed; Package/Chassis; Package/Heavy; Package/Auto; Package/Moving; Package/Utility; Package/Specialized.

General Information	User must designate the operations split between U.S. and Canadian operations.
General Information	User must designate the Short-haul vs. Long-haul split.
General Information	User must select at least one fuel type.
General Information	User indicate if they broker-out some portion of the company's total freight volume, and if so, what percent.
General Information	User indicate if they broker-out some portion of the company's total freight volume, and if so, what percent.
General Information	For percent of total freight volume brokered-out, the percent must be less than or equal to 5 percent. (warning)
Activity Information	All fields are required, so no field can be left blank. (If appropriate, a zero can be placed in certain fields.)
Activity Information	For all numeric fields except Empty Miles, Biofuel gallons, and Idle Hours, the value must be greater than zero. (An explanation must be provided for zero Empty Miles and idle hours).
Activity Information	For mileage and gallons fields, enter exact rather than rounded values. (warning)
Activity Information	For Revenue Miles, the amount cannot exceed the number of Total Miles Driven.
Activity Information	Revenue Miles that are significantly outside the expected range for percent of total miles for the given truck class (based on a lookup table) must be explained.
Activity Information	For Empty Miles, the amount must be less than the number of Total Miles.
Activity Information	Empty Miles that are significantly outside the expected range for the given truck class (based on a lookup table) must be explained.
Activity Information	Distance per truck that is significantly outside the expected range for the given truck class (based on a lookup table) must be explained.
Activity Information	On the Biofuel Blend Worksheet, the total gallons of biofuel cannot exceed the amount entered for Total Fuel on the Activity Information screen.
Activity Information	For Average used cargo volume percent, the value cannot exceed 100%.
Activity Information	For Average Used Cargo Volume Percent, the value must be less than 100% if user indicated that the fleet is 100% Less-Than-Truckload (LTL). (By definition, LTL fleets cannot have 100% average used cargo volume.)
Activity Information	Average Used Cargo Volume Percent that is significantly outside the expected range for the given truck class (based on a lookup table) must be explained.
Activity Information	The implicit commodity density derived from the payload, volume, and average used cargo volume inputs must be between 0.001 and 0.65 tons/cubic foot.[44]
Activity Information	For Idle Hours, the value cannot exceed 8,760.
Activity Information	For Idle Hours, values significantly outside the expected range for daily short duration idle hours, daily long duration idle hours, and average number of days on the road must be explained.
Activity Information	MPG must be greater than zero.
Activity Information	MPG that is significantly outside the expected range for the given truck class (based on a lookup table) must be explained.
Activity Information	Reefer fuel inputs for each fuel type must be less than the total vehicle fuel volume

[44] The upper bound density range was based on gold (~0.6 tons/cubic foot) and the lower bound range on potato chips (~0.003 tons/cubic foot) – see http://www.aqua-calc.com/page/density-table/substance/Snacks-coma-and-blank-potato-blank-chips-coma-and-blank-white-coma-and-blank-restructured-coma-and-blank-baked.

	input.
Activity Information	Reefer fuel as a percent of total fuel that is significantly outside the expected range for a given fleet (based on lookup table) must be explained.
Model Year & Class	Total truck count for each fleet cannot be zero.
Model Year & Class	Total truck counts for each selected truck class (those with a check mark) cannot be zero.
PM Reduction	The number of trucks using any particular PM reduction strategy cannot be greater than the number of trucks for the given class and model year.
PM Reduction	The sum of the trucks using either DOC or Particulate Matter Traps cannot be greater than the number of trucks for the given class and model year.
PM Reduction	If user indicates that the company uses PM reduction equipment, there must be at least one truck included on the PM Reduction sub-tab.
Payload & Volume Calculators	User must provide a preferred allocation method for the information entered on the calculators.
Payload & Volume Calculators	The sum of the total miles or total trucks entered in the calculator must equal the number entered on the Activity Information screen.
Payload & Volume Calculators	The calculated average cannot be equal to zero.
Payload & Volume Calculators	For percentages, the total must equal 100%.
Payload & Volume Calculators	For each body type for which some information has been entered, all of the visible field must be completed (including the explanation field if shown).
Payload & Volume Calculators	Zero is not a valid value for any payload or volume.
Payload & Volume Calculators	Values that are significantly outside the expected range for the given body type and class must be explained.
Payload & Volume Calculators	The body types indicated in the Volume Calculator must agree with those used in the Payload Calculator.
Payload & Volume Calculators	Ensure consistency between body-type selections in the Fleet Description section with those from the Payload and Volume Calculators. For example, if 100% is specified for Dry Van under Fleet Description, only Dry Vans (single, double, triple) may be selected within the calculators. See Table 9.
Payload & Volume Calculators	If "# of Vehicles in this class" is selected for both the Payload and Volume calculators for a given truck class, the number of trucks entered into each calculator must agree.
Payload & Volume Calculators	If "# of Vehicles in this class" is selected for either the Payload or Volume calculator, the number of body-types selected cannot exceed the number of vehicles specified.
Payload & Volume Calculators	If "# of miles in this class" is selected for both the Payload and Volume calculators for a given truck class, the number of miles entered into each calculator must agree.
Payload & Volume Calculators	If "# of Trips done by this class" is selected for both the Payload and Volume calculators for a given truck class, the number of trips entered into each calculator must agree.
Payload & Volume Calculators	Ensure consistency between the body-type selections in the Class 8a/b payload calculator and the corresponding Volume calculator – i.e., issue warnings for any type of dry van, reefer or beverage selected in the payload calculator but no Trailers specified in volume calculator.
Data Sources	Data sources for Total Miles Driven, Gallons of Fuel Used, Average Payload, and Other Data must be specified.

Validations have been added to the Truck Tool to ensure the selections in the 8a/8b volume calculator are consistent with the selections in the payload calculator for those classes:

RED errors (must address):

- If the user has values for 8a body type “Beverage” or “Dry Van – Single” in the Payload calculator, they must have a value in the “Trailer” section of the volume calculator.
- If the user has values for 8b body type “Dry Van – Single” or “Dry Van – Double” or “Dry Van – Triple” in the Payload calculator, they must have a value in the “Trailer” section of the volume calculator.

YELLOW warnings (comments/changes not mandatory):

- If the user has values for 8a body type “Flatbed” or “Combination Flatbed” in the Payload calculator, they must have a “Flatbed” checkbox checked in the “Trailer” section of the volume calculator.
- If the user has values for 8a body type “Single-Axle Van” or “Dry Van - Single” in the Payload calculator, they must have a “Box” checkbox checked in the “Trailer” section of the volume calculator.
- If the user has values for 8a body type “Beverage” in the Payload calculator, they must have a “Box” or “Reefer” checkbox checked in the “Trailer” section of the volume calculator.
- If the user has values for 8a body type “Tanker” in the Payload calculator, they must have a value in the “Tanker” section of the volume calculator.
- If the user has values for 8a body type “Other (straight truck)” or “Other (combo)” in the Payload calculator, they must have a value in the “Bulk”, “Auto Carrier”, or “Other” section of the volume calculator.

- If the user has values for 8b body type “Dry Van – Single” or “Dry Van – Double” or “Dry Van – Triple” in the Payload calculator, they must have a “Box” checkbox checked in the “Trailer” section of the volume calculator.
- If the user has values for 8b body type “Combination Reefer” in the Payload calculator, they must have a “Reefer” checkbox checked in the “Trailer” section of the volume calculator.
- If the user has values for 8b body type “Combination Flatbed” in the Payload calculator, they must have a “Flatbed” checkbox checked in the “Trailer” section of the volume calculator.
- If the user has values for 8b body type “Combination Tanker” in the Payload calculator, they must have a value in the “Tanker” section of the volume calculator.
- If the user has values for 8b body type “Chassis” in the Payload calculator, they must have a value in the “Chassis” section of the volume calculator.
- If the user has values for 8b body type “Specialty” or “Other” in the Payload calculator, they must have a value in the “Bulk”, “Auto Carrier”, or “Other” section of the calculator

As noted in Table 9, a warning is issued if an inconsistency is identified between body-types specified within the Fleet Description Section and those within the Payload/Volume Calculators. Warning conditions (associated with 100% body-type entries under Fleet Description) are presented in Table 10 below. Warnings are also issued if a body type is specified in the Fleet Description section that does not appear in the payload and volume calculators.

Table 10. Consistent Body-Types Resulting in No Warning Messages

Acceptable selections -								
Body Type (100%)	**2b**	**3**	**4**	**5**	**6**	**7**	**8a**	**8b**
Dry Van	all except flatbed	all	all except flatbed	all	walk-in, single axle van	beverage, single axle van, dry van single	single axle van, beverage, dry van single	dry van (single, double, triple)
Refrigerated	other	other	other	other	reefer, other	reefer, beverage, combination reefer, other	beverage, other	combination reefer, dry van double, dry van triple
Flatbed	flatbed	other	flatbed	other	flatbed	flatbed, combination flatbed	flatbed, combination flatbed	combination flatbed
Tanker	other	other	other	other	other	tanker	Tanker	combination tanker
Chassis	N/A	N/A	N/A	N/A	N/A	other	Other	chassis
Heavy-Bulk	N/A	N/A	N/A	N/A	N/A	other	Other	heavy-bulk
Auto Carrier	N/A	N/A	N/A	N/A	N/A	other	Other	auto carrier
Moving	all except flatbed	all	all except flatbed	all	all except reefer, flatbed	single axle van, dry van-single, other	single axle van, dry van-single, other	moving, dry van single, dry van double, dry van triple, other
Specialty Hauler	other	other	other	other	other	other	Other	Specialty, other
Utility	all	all	all	all	all except reefer	single axle van, combination flatbed, other	single axle van, combination flatbed, other	dry van single, combination flatbed, other

Additional, rigorous validation checks of key data inputs are also needed to ensure the overall quality of the performance metrics calculated by the Truck Tool. Validation checks serve three purposes to this end. First, unusually high or low values can be identified and flagged for the user's attention before finalizing inputs. For example, a user may misplace a decimal, inadvertently add an extra zero, or utilize the wrong units (e.g. reporting pounds instead of tons for payload) upon data entry. By comparing these data entries to reliable industry averages and distributions, these values can be flagged allowing users to quickly correct such errors.

Second, under certain circumstances Partners may operate their fleets under atypical conditions, resulting in extreme (outlier) data values. For example, permitted heavy-haul operations may routinely exceed industry-average payload values by 10 or more tons. By flagging such data entries Partners have the opportunity to provide additional information regarding their unique operating conditions through use of the Truck Tool comment fields.

Finally, independent criteria can be established to ensure that data inputs are never allowed to exceed certain physically-constrained absolute limits. For example, a truck cannot exceed roughly 500,000 miles per year, even with dual drivers and minimal maintenance time, simply due to the available hours per year and highway speed limits. Data values above these absolute maximum levels are not allowed by the Truck Tool, and users are required to modify the associated inputs before proceeding.

The following presents the updates to the Truck Tool validation ranges for all parameters but payload and volume, which are discussed above. Validation ranges are of three types:

1. "Yellow" values indicating that the input or derived performance value is notably lower/higher than the expected value. Partners may enter an explanation backing up such entries, but this is not mandatory.
2. "Red" values indicating that the input or derived performance value differs greatly from the expected value. In this case the partner must enter text explaining why this value is accurate. Once entered, the value will change from "Red" to "Yellow" on the data entry screen.
3. "Absolute errors" exceed values deemed physically possible and must be changed in order to be accepted by the tool.

Reefer Fuel Validation

507 diesel fleets designated as "Reefer" for the 2013 calendar year were evaluated to determine the distribution of the fraction of reefer fuel consumption to total fuel consumption. Ten of these observations were dropped from the analysis data set, having either 0 gallons of reefer fuel entered, or reefer fuel consumption was greater than total consumption.[45] As shown in Figure 3 below, the distribution for the remaining reefer fleets was highly skewed toward low fractions (reefer consumption / total consumption). For this reason, EPA simply

[45] Additional validation rules have been implemented, so such data entries are no longer possible.

used 5% increments for the Range 1 and 2 validation values, but used the average plus 1 to 2 standard deviations for Range 4, and > 2 standard deviations for Range 5. The resulting values are shown in Table 11 below.

Figure 3

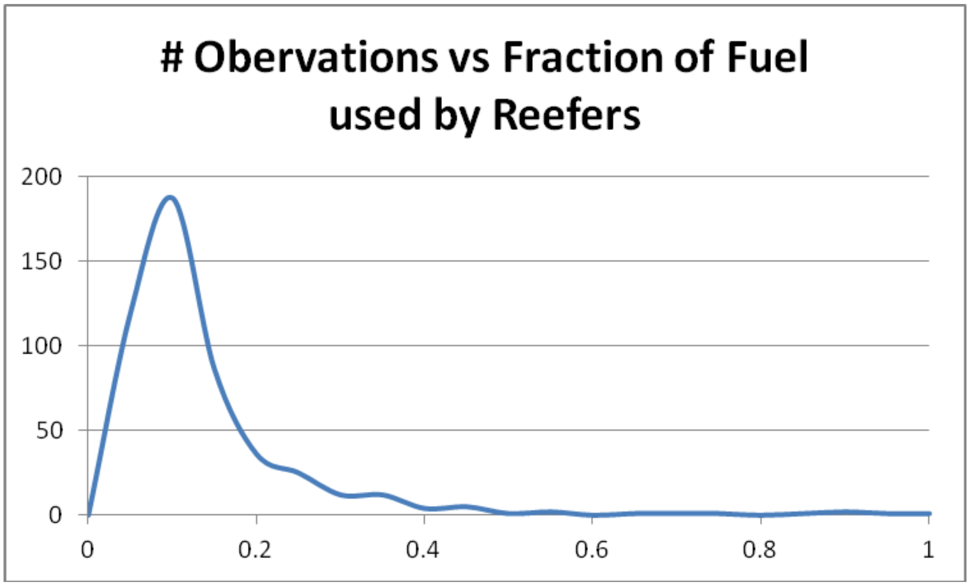


Table 11. Reefer Fuel Consumption Validation Ranges

	Min	Max	% of Obs	Comments
Range 1^	>0	0.18%	4.8%	Set to include ~5% of obs
Range 2	0.18%	1.45%	5.2%	Set to include ~5% of obs
Range 3	1.45%	24.25%	81.1%	Max value set at average + 1 sigma
Range 4	24.25%	36.90%	4.8%	between 1 and 2 sigma from average
Range 5*	36.90%	<100%	4.0%	2+ sigma from avg
^ Note - reefer fuel consumption cannot = 0 - absolute error				
* Note - reefer fuel consumption cannot = 100% - absolute error				
Basis - all diesel reefer fleets, 2013 reporting year				

The percentages shown above are multiplied by the total fuel value entered on the Activity screen to determine the Reefer fuel validation ranges for a given fleet. If the percentage designated as "Reefer" in the Body Types section of the Truck Tool is less than 100%, then the fuel validation ranges are scaled downward by the reported percentage.

OTC Fleet Validation

If the user indicates their fleet operates within the Ozone Transport Commission (OTC) region on the General Information screen, they may provide estimates for the portion of fuel consumed or miles travelled in OTC states. If so, the Truck Tool will perform a validation check to ensure that the gallons or miles entered here do not exceed the total gallons or miles provided on the Activity screen.

Data Processing

Except as noted above, the validation range recommendations are based upon a distributional analysis performed on the 2015 Truck Partner input and performance data. Fleet level data was input into SAS and grouped by truck class and bin category. If a particular combination had less than 20 fleets, it was aggregated to the next "higher" level until at least 20 fleets were included. This process resulted in 29 groupings, as shown in Table 12. Note these groupings are mutually exclusive – e.g. "Class 6_Mixed" (Group 6) includes all Class 6 vehicles with the exception of TL/Dry Van, LTL/Dry Van, and Package (Groups 8, 10, and 11).

Table 12. Truck Fleet Groupings Used for Distributional Analysis

Group #	Name	# Fleets
1	2B_Expedited	35
2	2B_Mixed	96
3	2B_Package	34
4	2B_TL/Dry Van	42
5	3_Mixed	85
6	4_Mixed	71
7	5_Mixed	59
8	6_LTL/Dry Van	55
9	6_Mixed	124
10	6_Package	25
11	6_TL/Dry Van	51
12	7_LTL/Dry Van	61
13	7_Mixed	144
14	7_TL/Dry Van	44
15	8A_LTL/Dry Van	54
16	8A_Mixed	106
17	8A_Refrigerated	21
18	8A_TL/Dry Van	61
19	8B_AutoCarrier	36
20	8B_Dray	109
21	8B_Expedited	26
22	8B_Flatbed	159
23	8B_Heavy/Bulk	22
24	8B_LTL/Dry Van	106

Group #	Name	# Fleets
25	8B_Mixed	470
26	8B_Refrigerated	574
27	8B_Specialized	60
28	8B_TL/Dry Van	912
29	8B_Tanker	84

A distributional assessment was then performed for each of the above groupings for the following parameters.

- Miles per vehicle
- Miles per gallon
- Revenue Miles (as a percent of total miles)
- Empty Miles (as a percent of total miles)
- Percent Average Used Cargo Volume

The following parameters were not updated based on 2015 data due to one of two reasons: (1) the data set for 2015 was too thin, or (2) the majority of the data relied on default values.

- Percent Biofuel
- Percent Miles Traveled, Urban
- Percent Miles Traveled, Highway
- Average Idle Hours per Year

ERG then identified suspected outliers and erroneous data entry values for each parameter/group combination, based on the criteria presented in Table 13.

Table 13. Outlier Definition

Metric	Unreasonably Low	Unreasonably High
Miles per Vehicle	Mean – 3*Std dev	Mean + 3*std dev
MPG	0	Mean + 3*std dev
Percent Revenue Miles	<40	100
Percent Empty Miles	0	>60
Percent Biofuel	0	>20
Percent Average Used Cargo Volume	0	100
Percent Urban Operation	0	100
Percent Highway Operation	0	100
Average Idle Hours	0	Mean + 3*std dev

Using these criteria ERG identified 132 values, which were subsequently dropped from the data set in order to develop "yellow" and "red" validation ranges for generalized distributions. The dropped values are shown below in Table 14.

Table 14. Values Flagged as Outliers

Parameter	Class/Category	Value	Mean
gallons per year	2B_Expedited	412,514	53,503
gallons per year	2B_Mixed	1,118,423	97,172
gallons per year	2B_Mixed	2,575,025	97,172
gallons per year	2B_Mixed	1,155,575	97,172
gallons per year	2B_Package	16,598,790	1,573,156
gallons per year	2B_Package	18,812,438	1,573,156
gallons per year	2B_TL/Dry Van	9,561,432	297,320
gallons per year	3_Mixed	7,488,083	566,721
gallons per year	3_Mixed	6,000,532	566,721
gallons per year	3_Mixed	10,025,500	566,721
gallons per year	3_Mixed	6,895,410	566,721
gallons per year	4_Mixed	32,131,244	1,287,415
gallons per year	4_Mixed	23,340,749	1,287,415
gallons per year	5_Mixed	5,886,948	526,173
gallons per year	5_Mixed	8,195,008	526,173
gallons per year	5_Mixed	5,391,967	526,173
gallons per year	6_LTL/Dry Van	3,981,088	229,194
gallons per year	6_LTL/Dry Van	2,229,735	229,194
gallons per year	6_Mixed	971,878	64,977
gallons per year	6_Mixed	434,514	64,977
gallons per year	6_Mixed	655,144	64,977
gallons per year	6_Package	42,086,822	5,063,945
gallons per year	6_TL/Dry Van	4,063,283	202,354
gallons per year	7_LTL/Dry Van	2,027,074	251,393
gallons per year	7_LTL/Dry Van	2,991,399	251,393
gallons per year	7_LTL/Dry Van	2,241,644	251,393
gallons per year	7_Mixed	6,172,258	273,971
gallons per year	7_Mixed	3,374,633	273,971
gallons per year	7_Mixed	5,989,442	273,971
gallons per year	7_Mixed	3,559,828	273,971
gallons per year	7_TL/Dry Van	4,950,320	262,592
gallons per year	8A_LTL/Dry Van	36,116,464	3,648,512
gallons per year	8A_LTL/Dry Van	53,625,048	3,648,512
gallons per year	8A_Mixed	57,351,694	986,765
gallons per year	8A_Refrigerated	5,643,067	443,374
gallons per year	8A_TL/Dry Van	70,846,629	2,760,796
gallons per year	8B_AutoCarrier	25,533,283	3,748,093

Parameter	Class/Category	Value	Mean
gallons per year	8B_Dray	14,150,069	1,604,817
gallons per year	8B_Dray	34,766,125	1,604,817
gallons per year	8B_Dray	13,354,331	1,604,817
gallons per year	8B_Expedited	1,424,076	218,990
gallons per year	8B_Flatbed	36,752,966	2,361,101
gallons per year	8B_Flatbed	34,640,701	2,361,101
gallons per year	8B_Flatbed	17,704,415	2,361,101
gallons per year	8B_Flatbed	17,023,256	2,361,101
gallons per year	8B_Heavy/Bulk	9,404,277	1,037,619
gallons per year	8B_LTL/Dry Van	92,200,872	7,616,076
gallons per year	8B_LTL/Dry Van	124,000,000	7,616,076
gallons per year	8B_LTL/Dry Van	89,849,912	7,616,076
gallons per year	8B_Mixed	66,558,332	2,535,432
gallons per year	8B_Mixed	37,456,768	2,535,432
gallons per year	8B_Mixed	59,418,064	2,535,432
gallons per year	8B_Mixed	48,225,936	2,535,432
gallons per year	8B_Mixed	180,000,000	2,535,432
gallons per year	8B_Mixed	119,000,000	2,535,432
gallons per year	8B_Refrigerated	33,225,674	1,941,435
gallons per year	8B_Refrigerated	42,919,799	1,941,435
gallons per year	8B_Refrigerated	28,773,217	1,941,435
gallons per year	8B_Refrigerated	37,152,519	1,941,435
gallons per year	8B_Refrigerated	20,502,480	1,941,435
gallons per year	8B_Refrigerated	53,869,408	1,941,435
gallons per year	8B_Refrigerated	18,295,369	1,941,435
gallons per year	8B_Refrigerated	18,899,380	1,941,435
gallons per year	8B_Refrigerated	31,452,760	1,941,435
gallons per year	8B_Refrigerated	67,708,438	1,941,435
gallons per year	8B_Specialized	109,000,000	3,815,822
gallons per year	8B_TL/Dry Van	39,566,042	3,015,269
gallons per year	8B_TL/Dry Van	86,776,622	3,015,269
gallons per year	8B_TL/Dry Van	41,147,713	3,015,269
gallons per year	8B_TL/Dry Van	40,502,655	3,015,269
gallons per year	8B_TL/Dry Van	102,000,000	3,015,269
gallons per year	8B_TL/Dry Van	47,825,507	3,015,269
gallons per year	8B_TL/Dry Van	131,000,000	3,015,269
gallons per year	8B_TL/Dry Van	55,482,608	3,015,269
gallons per year	8B_TL/Dry Van	72,226,731	3,015,269
gallons per year	8B_TL/Dry Van	182,000,000	3,015,269

Parameter	Class/Category	Value	Mean
gallons per year	8B_TL/Dry Van	61,329,730	3,015,269
gallons per year	8B_TL/Dry Van	99,023,569	3,015,269
gallons per year	8B_Tanker	63,833,642	2,691,859
annual miles/vehicle	2B_Mixed	116,299	28,854
annual miles/vehicle	3_Mixed	85,788	22,873
annual miles/vehicle	3_Mixed	81,697	22,873
annual miles/vehicle	4_Mixed	87,149	23,285
annual miles/vehicle	5_Mixed	93,600	18,865
annual miles/vehicle	5_Mixed	77,510	18,865
annual miles/vehicle	6_Mixed	343,740	34,199
annual miles/vehicle	6_Package	103,854	24,362
annual miles/vehicle	6_TL/Dry Van	116,000	36,656
annual miles/vehicle	7_Mixed	135,356	35,442
annual miles/vehicle	7_Mixed	117,865	35,442
annual miles/vehicle	7_TL/Dry Van	166,021	37,351
annual miles/vehicle	8B_Flatbed	5,000	78,258
annual miles/vehicle	8B_Flatbed	7,500	78,258
annual miles/vehicle	8B_LTL/Dry Van	271,366	69,987
annual miles/vehicle	8B_Mixed	203,275	74,314
annual miles/vehicle	8B_Mixed	175,555	74,314
annual miles/vehicle	8B_Refrigerated	215,350	101,711
annual miles/vehicle	8B_Refrigerated	211,217	101,711
annual miles/vehicle	8B_Refrigerated	248,360	101,711
annual miles/vehicle	8B_Refrigerated	221,995	101,711
annual miles/vehicle	8B_Refrigerated	225,974	101,711
annual miles/vehicle	8B_Refrigerated	262,511	101,711
annual miles/vehicle	8B_Refrigerated	208,809	101,711
annual miles/vehicle	8B_Specialized	189,507	73,838
annual miles/vehicle	8B_TL/Dry Van	195,768	90,012
annual miles/vehicle	8B_TL/Dry Van	193,195	90,012
annual miles/vehicle	8B_TL/Dry Van	189,257	90,012
annual miles/vehicle	8B_TL/Dry Van	250,391	90,012
annual miles/vehicle	8B_TL/Dry Van	194,704	90,012
annual miles/vehicle	8B_TL/Dry Van	191,012	90,012
annual miles/vehicle	8B_TL/Dry Van	215,143	90,012
annual miles/vehicle	8B_Tanker	148,721	79,629
MPG	3_Mixed	23.29	9.98
MPG	4_Mixed	18.55	9.11
MPG	5_Mixed	18.30	7.95

Parameter	Class/Category	Value	Mean
MPG	8A_LTL/Dry Van	9.50	6.37
MPG	8A_Refrigerated	10.86	6.60
MPG	8A_TL/Dry Van	9.50	6.48
MPG	8B_Dray	8.44	5.85
MPG	8B_Refrigerated	8.23	5.97
MPG	8B_Refrigerated	8.39	5.97
MPG	8B_Refrigerated	8.05	5.97
MPG	8B_TL/Dry Van	8.47	6.20
MPG	8B_TL/Dry Van	10.54	6.20
MPG	8B_TL/Dry Van	8.49	6.20
MPG	8B_TL/Dry Van	8.71	6.20
MPG	8B_TL/Dry Van	8.81	6.20
MPG	8B_Tanker	10.97	6.01
% Empty Miles	3_Mixed	90.19	13.39
% Empty Miles	8B_Specialized	99.38	30.34
% Empty Miles	2B_Mixed	0.02	82.54
% Empty Miles	8B_TL/Dry Van	35.17	87.37

Once values were defined as outliers and excluded from the data set, the mean and standard deviation of the distribution for each truck fleet grouping were then re-calculated for each metric. Each fleet was treated equally in the distributional assessment, independent of the number of vehicles in the fleet. Histograms presenting the distributions for each truck fleet grouping/metric combination are available electronically from SmartWay.

For groupings with large numbers of fleets (e.g., Class 8b diesel TL/Dry Van, Refrigerated, and Mixed), the data for miles per vehicle and MPG appear normally distributed. Examples for Class 8b TL/Dry Van Diesel fleets are shown in Figures 4 and 5.

Figure 4. Annual Miles per Vehicle Distribution, Class 8b TL/Dry Van Diesel Fleets

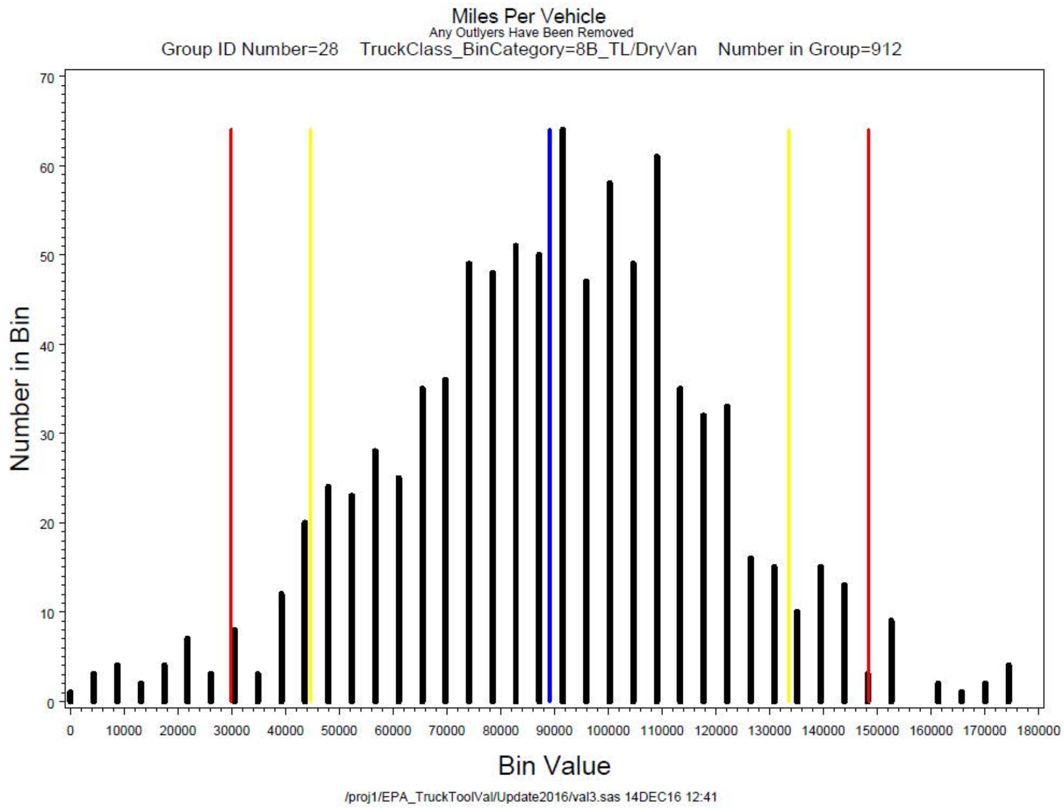
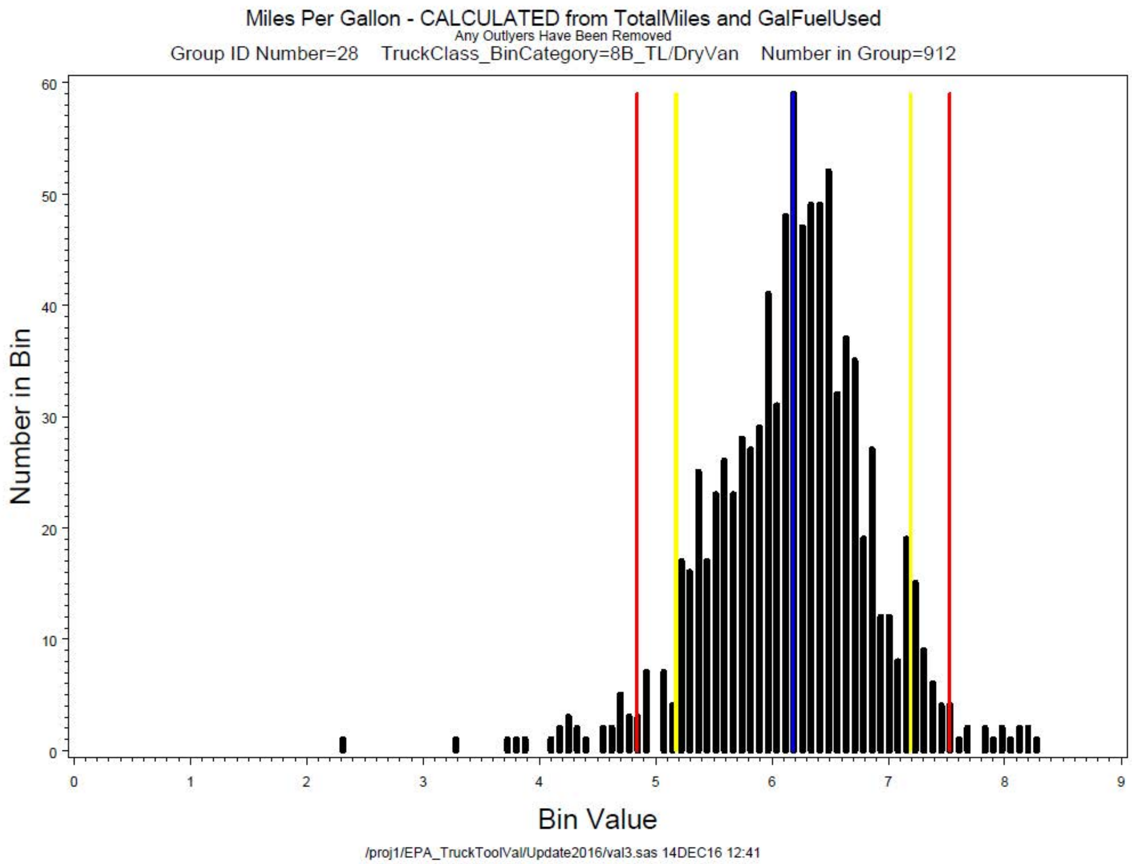


Figure 5. Miles per Gallon Distribution, Class 8b TL/Dry Van Diesel Fleets



Other fleet group/metric combinations displayed sharp drop offs at certain discrete levels. For example, % Revenue Miles were seldom less than 50% of total miles, and conversely, % Empty Miles were seldom greater than 50% of total miles. % Biofuel also displayed a discrete maximum value with no fleets using blends higher than 20% biodiesel.[46]

Based on this preliminary assessment, red and yellow flag areas were defined for each fleet group/metric combination as shown in Table 15.

[46] As such, a yellow warning is issued for any biodiesel blend > 20%, with no red warning.

Table 15. "Red" and "Yellow" Flag Criteria

Class_Category	Count	Variable	Low Red	Low Yellow	High Yellow	High Red
2B_Expedited	35	Miles Per Vehicle	5.0%	15.0%	85.0%	95.0%
2B_Mixed	96	Miles Per Vehicle	5.0%	15.0%	85.0%	95.0%
2B_Package	34	Miles Per Vehicle	5.0%	15.0%	85.0%	95.0%
2B_TL/DryVan	42	Miles Per Vehicle	5.0%	15.0%	85.0%	95.0%
3_Mixed	85	Miles Per Vehicle	NONE	5,000	Mean+1.5StD	Mean+2StD
4_Mixed	71	Miles Per Vehicle	5.0%	15.0%	85.0%	95.0%
5_Mixed	59	Miles Per Vehicle	5.0%	15.0%	85.0%	95.0%
6_LTL/DryVan	55	Miles Per Vehicle	5.0%	15.0%	85.0%	95.0%
6_Mixed	124	Miles Per Vehicle	5.0%	15.0%	85.0%	95.0%
6_Package	25	Miles Per Vehicle	5.0%	15.0%	85.0%	95.0%
6_TL/DryVan	51	Miles Per Vehicle	5.0%	15.0%	85.0%	95.0%
7_LTL/DryVan	61	Miles Per Vehicle	5.0%	15.0%	85.0%	95.0%
7_Mixed	144	Miles Per Vehicle	NONE	5,000	Mean+1.5StD	Mean+2StD
7_TL/DryVan	44	Miles Per Vehicle	5.0%	15.0%	85.0%	95.0%
8A_LTL/DryVan	54	Miles Per Vehicle	5.0%	15.0%	85.0%	95.0%
8A_Mixed	106	Miles Per Vehicle	5.0%	15.0%	85.0%	95.0%
8A_Refrigerated	21	Miles Per Vehicle	5.0%	15.0%	85.0%	95.0%
8A_TL/DryVan	61	Miles Per Vehicle	5.0%	15.0%	85.0%	95.0%
8B_AutoCarrier	36	Miles Per Vehicle	Mean – 2StD	Mean-1.5StD	Mean+1.5StD	Mean+2StD
8B_Dray	109	Miles Per Vehicle	Mean – 2StD	Mean-1.5StD	Mean+1.5StD	Mean+2StD
8B_Expedited	26	Miles Per Vehicle	5.0%	15.0%	85.0%	95.0%
8B_Flatbed	159	Miles Per Vehicle	Mean – 2StD	Mean-1.5StD	Mean+1.5StD	Mean+2StD
8B_Heavy/Bulk	22	Miles Per Vehicle	5.0%	15.0%	85.0%	95.0%
8B_LTL/DryVan	106	Miles Per Vehicle	Mean – 2StD	Mean-1.5StD	Mean+1.5StD	Mean+2StD
8B_Mixed	470	Miles Per Vehicle	Mean – 2StD	Mean-1.5StD	Mean+1.5StD	Mean+2StD
8B_Refrigerated	574	Miles Per Vehicle	Mean – 2StD	Mean-1.5StD	Mean+1.5StD	Mean+2StD
8B_Specialized	60	Miles Per Vehicle	5.0%	15.0%	85.0%	95.0%
8B_TL/DryVan	912	Miles Per Vehicle	Mean – 2StD	Mean-1.5StD	Mean+1.5StD	Mean+2StD
8B_Tanker	84	Miles Per Vehicle	Mean – 2StD	Mean-1.5StD	Mean+1.5StD	Mean+2StD
2B_Expedited	35	Miles Per Gallon	5.0%	15.0%	85.0%	95.0%
2B_Mixed	96	Miles Per Gallon	5.0%	15.0%	85.0%	95.0%
2B_Package	34	Miles Per Gallon	5.0%	15.0%	85.0%	95.0%
2B_TL/DryVan	42	Miles Per Gallon	5.0%	15.0%	85.0%	95.0%
3_Mixed	85	Miles Per Gallon	Mean – 2StD	Mean-1.5StD	Mean+1.5StD	Mean+2StD
4_Mixed	71	Miles Per Gallon	5.0%	15.0%	85.0%	95.0%
5_Mixed	59	Miles Per Gallon	Mean – 2StD	Mean-1.5StD	Mean+1.5StD	Mean+2StD
6_LTL/DryVan	55	Miles Per Gallon	5.0%	15.0%	85.0%	95.0%
6_Mixed	124	Miles Per Gallon	Mean – 2StD	Mean-1.5StD	Mean+1.5StD	Mean+2StD
6_Package	25	Miles Per Gallon	5.0%	15.0%	85.0%	95.0%
6_TL/DryVan	51	Miles Per Gallon	Mean – 2StD	Mean-1.5StD	Mean+1.5StD	Mean+2StD

Class_Category	Count	Variable	Low Red	Low Yellow	High Yellow	High Red
7_LTL/DryVan	61	Miles Per Gallon	Mean – 2StD	Mean-1.5StD	Mean+1.5StD	Mean+2StD
7_Mixed	144	Miles Per Gallon	Mean – 2StD	Mean-1.5StD	Mean+1.5StD	Mean+2StD
7_TL/DryVan	44	Miles Per Gallon	5.0%	15.0%	85.0%	95.0%
8A_LTL/DryVan	54	Miles Per Gallon	Mean – 2StD	Mean-1.5StD	Mean+1.5StD	Mean+2StD
8A_Mixed	106	Miles Per Gallon	Mean – 2StD	Mean-1.5StD	Mean+1.5StD	Mean+2StD
8A_Refrigerated	21	Miles Per Gallon	5.0%	15.0%	85.0%	95.0%
8A_TL/DryVan	61	Miles Per Gallon	Mean – 2StD	Mean-1.5StD	Mean+1.5StD	Mean+2StD
8B_AutoCarrier	36	Miles Per Gallon	5.0%	15.0%	85.0%	95.0%
8B_Dray	109	Miles Per Gallon	Mean – 2StD	Mean-1.5StD	Mean+1.5StD	Mean+2StD
8B_Expedited	26	Miles Per Gallon	5.0%	15.0%	85.0%	95.0%
8B_Flatbed	159	Miles Per Gallon	Mean – 2StD	Mean-1.5StD	Mean+1.5StD	Mean+2StD
8B_Heavy/Bulk	22	Miles Per Gallon	5.0%	15.0%	85.0%	95.0%
8B_LTL/DryVan	106	Miles Per Gallon	Mean – 2StD	Mean-1.5StD	Mean+1.5StD	Mean+2StD
8B_Mixed	470	Miles Per Gallon	Mean – 2StD	Mean-1.5StD	Mean+1.5StD	Mean+2StD
8B_Refrigerated	574	Miles Per Gallon	Mean – 2StD	Mean-1.5StD	Mean+1.5StD	Mean+2StD
8B_Specialized	60	Miles Per Gallon	5.0%	15.0%	85.0%	95.0%
8B_TL/DryVan	912	Miles Per Gallon	Mean – 2StD	Mean-1.5StD	Mean+1.5StD	Mean+2StD
8B_Tanker	84	Miles Per Gallon	Mean – 2StD	Mean-1.5StD	Mean+1.5StD	Mean+2StD
2B_Expedited	35	Percent Revenue Miles	5.0%	15.0%	NONE	NONE
2B_Mixed	96	Percent Revenue Miles	5.0%	15.0%	NONE	NONE
2B_Package	34	Percent Revenue Miles	5.0%	15.0%	NONE	NONE
2B_TL/DryVan	42	Percent Revenue Miles	5.0%	15.0%	NONE	NONE
3_Mixed	85	Percent Revenue Miles	5.0%	15.0%	NONE	NONE
4_Mixed	71	Percent Revenue Miles	5.0%	15.0%	NONE	NONE
5_Mixed	59	Percent Revenue Miles	5.0%	15.0%	NONE	NONE
6_LTL/DryVan	55	Percent Revenue Miles	5.0%	15.0%	NONE	NONE
6_Mixed	124	Percent Revenue Miles	5.0%	15.0%	NONE	NONE
6_Package	25	Percent Revenue Miles	5.0%	15.0%	NONE	NONE
6_TL/DryVan	51	Percent Revenue Miles	5.0%	15.0%	NONE	NONE
7_LTL/DryVan	61	Percent Revenue Miles	5.0%	15.0%	NONE	NONE
7_Mixed	144	Percent Revenue Miles	5.0%	15.0%	NONE	NONE
7_TL/DryVan	44	Percent Revenue Miles	5.0%	15.0%	NONE	NONE
8A_LTL/DryVan	54	Percent Revenue Miles	5.0%	15.0%	NONE	NONE
8A_Mixed	106	Percent Revenue Miles	5.0%	15.0%	NONE	NONE
8A_Refrigerated	21	Percent Revenue Miles	5.0%	15.0%	NONE	NONE
8A_TL/DryVan	61	Percent Revenue Miles	5.0%	15.0%	NONE	NONE
8B_AutoCarrier	36	Percent Revenue Miles	Mean – 2StD	Mean-1.5StD	NONE	NONE
8B_Dray	109	Percent Revenue Miles	5.0%	15.0%	NONE	NONE
8B_Expedited	26	Percent Revenue Miles	5.0%	15.0%	NONE	NONE
8B_Flatbed	159	Percent Revenue Miles	Mean – 2StD	Mean-1.5StD	NONE	NONE
8B_Heavy/Bulk	22	Percent Revenue Miles	5.0%	15.0%	NONE	NONE
8B_LTL/DryVan	106	Percent Revenue Miles	Mean – 2StD	Mean-1.5StD	NONE	NONE

Class_Category	Count	Variable	Low Red	Low Yellow	High Yellow	High Red
8B_Mixed	470	Percent Revenue Miles	Mean – 2StD	Mean-1.5StD	NONE	NONE
8B_Refrigerated	574	Percent Revenue Miles	Mean – 2StD	Mean-1.5StD	NONE	NONE
8B_Specialized	60	Percent Revenue Miles	5.0%	15.0%	NONE	NONE
8B_TL/DryVan	912	Percent Revenue Miles	Mean – 2StD	Mean-1.5StD	NONE	NONE
8B_Tanker	84	Percent Revenue Miles	Mean – 2StD	Mean-1.5StD	Mean+1.5StD	Mean+2StD
2B_Expedited	35	Percent Empty Miles	NONE	NONE	85.0%	95.0%
2B_Mixed	96	Percent Empty Miles	NONE	NONE	Mean+1.5StD	Mean+2StD
2B_Package	34	Percent Empty Miles	NONE	NONE	Mean+1.5StD	Mean+2StD
2B_TL/DryVan	42	Percent Empty Miles	5.0%	15.0%	Mean+1.5StD	Mean+2StD
3_Mixed	85	Percent Empty Miles	NONE	NONE	85.0%	95.0%
4_Mixed	71	Percent Empty Miles	NONE	NONE	85.0%	95.0%
5_Mixed	59	Percent Empty Miles	NONE	NONE	85.0%	95.0%
6_LTL/DryVan	55	Percent Empty Miles	NONE	NONE	Mean+1.5StD	Mean+2StD
6_Mixed	124	Percent Empty Miles	NONE	NONE	Mean+1.5StD	Mean+2StD
6_Package	25	Percent Empty Miles	NONE	NONE	85.0%	95.0%
6_TL/DryVan	51	Percent Empty Miles	NONE	NONE	85.0%	95.0%
7_LTL/DryVan	61	Percent Empty Miles	NONE	NONE	85.0%	95.0%
7_Mixed	144	Percent Empty Miles	NONE	NONE	85.0%	95.0%
7_TL/DryVan	44	Percent Empty Miles	NONE	NONE	Mean+1.5StD	Mean+2StD
8A_LTL/DryVan	54	Percent Empty Miles	NONE	NONE	Mean+1.5StD	Mean+2StD
8A_Mixed	106	Percent Empty Miles	NONE	NONE	85.0%	95.0%
8A_Refrigerated	21	Percent Empty Miles	NONE	NONE	Mean+1.5StD	Mean+2StD
8A_TL/DryVan	61	Percent Empty Miles	Mean – 2StD	Mean-1.5StD	Mean+1.5StD	Mean+2StD
8B_AutoCarrier	36	Percent Empty Miles	5.0%	15.0%	85.0%	95.0%
8B_Dray	109	Percent Empty Miles	5.0%	15.0%	85.0%	95.0%
8B_Expedited	26	Percent Empty Miles	5.0%	15.0%	85.0%	95.0%
8B_Flatbed	159	Percent Empty Miles	5.0%	15.0%	85.0%	95.0%
8B_Heavy/Bulk	22	Percent Empty Miles	NONE	NONE	Mean+1.5StD	Mean+2StD
8B_LTL/DryVan	106	Percent Empty Miles	NONE	NONE	Mean+1.5StD	Mean+2StD
8B_Mixed	470	Percent Empty Miles	NONE	NONE	Mean+1.5StD	Mean+2StD
8B_Refrigerated	574	Percent Empty Miles	NONE	NONE	Mean+1.5StD	Mean+2StD
8B_Specialized	60	Percent Empty Miles	5.0%	15.0%	85.0%	95.0%
8B_TL/DryVan	912	Percent Empty Miles	NONE	NONE	Mean+1.5StD	Mean+2StD
8B_Tanker	84	Percent Empty Miles	5.0%	15.0%	NONE	50.0%
2B_Expedited	35	Percent Biofuel	5.0%	15.0%	85.0%	95.0%
2B_Mixed	96	Percent Biofuel	5.0%	15.0%	85.0%	95.0%
2B_Package	34	Percent Biofuel	5.0%	15.0%	85.0%	95.0%
2B_TL/DryVan	42	Percent Biofuel	5.0%	15.0%	85.0%	95.0%
3_Mixed	85	Percent Biofuel	5.0%	15.0%	85.0%	95.0%
4_Mixed	71	Percent Biofuel	5.0%	15.0%	85.0%	95.0%
5_Mixed	59	Percent Biofuel	5.0%	15.0%	85.0%	95.0%
6_LTL/DryVan	55	Percent Biofuel	5.0%	15.0%	85.0%	95.0%

Class_Category	Count	Variable	Low Red	Low Yellow	High Yellow	High Red
6_Mixed	124	Percent Biofuel	5.0%	15.0%	85.0%	95.0%
6_Package	25	Percent Biofuel	5.0%	15.0%	85.0%	95.0%
6_TL/DryVan	51	Percent Biofuel	5.0%	15.0%	85.0%	95.0%
7_LTL/DryVan	61	Percent Biofuel	5.0%	15.0%	85.0%	95.0%
7_Mixed	144	Percent Biofuel	5.0%	15.0%	85.0%	95.0%
7_TL/DryVan	44	Percent Biofuel	5.0%	15.0%	85.0%	95.0%
8A_LTL/DryVan	54	Percent Biofuel	5.0%	15.0%	85.0%	95.0%
8A_Mixed	106	Percent Biofuel	5.0%	15.0%	85.0%	95.0%
8A_Refrigerated	21	Percent Biofuel	5.0%	15.0%	85.0%	95.0%
8A_TL/DryVan	61	Percent Biofuel	5.0%	15.0%	85.0%	95.0%
8B_AutoCarrier	36	Percent Biofuel	5.0%	15.0%	85.0%	95.0%
8B_Dray	109	Percent Biofuel	5.0%	15.0%	85.0%	95.0%
8B_Expedited	26	Percent Biofuel	5.0%	15.0%	85.0%	95.0%
8B_Flatbed	159	Percent Biofuel	5.0%	15.0%	85.0%	95.0%
8B_Heavy/Bulk	22	Percent Biofuel	5.0%	15.0%	85.0%	95.0%
8B_LTL/DryVan	106	Percent Biofuel	5.0%	15.0%	85.0%	95.0%
8B_Mixed	470	Percent Biofuel	5.0%	15.0%	85.0%	95.0%
8B_Refrigerated	574	Percent Biofuel	5.0%	15.0%	85.0%	95.0%
8B_Specialized	60	Percent Biofuel	5.0%	15.0%	85.0%	95.0%
8B_TL/DryVan	912	Percent Biofuel	5.0%	15.0%	85.0%	95.0%
8B_Tanker	84	Percent Biofuel	5.0%	15.0%	85.0%	95.0%
2B_Expedited	35	Capacity Utilization	5.0%	15.0%	85.0%	95.0%
2B_Mixed	96	Capacity Utilization	Mean – 2StD	Mean-1.5StD	NONE	NONE
2B_Package	34	Capacity Utilization	5.0%	15.0%	85.0%	95.0%
2B_TL/DryVan	42	Capacity Utilization	Mean – 2StD	Mean-1.5StD	NONE	NONE
3_Mixed	85	Capacity Utilization	Mean – 2StD	Mean-1.5StD	NONE	NONE
4_Mixed	71	Capacity Utilization	Mean – 2StD	Mean-1.5StD	NONE	NONE
5_Mixed	59	Capacity Utilization	Mean – 2StD	Mean-1.5StD	NONE	NONE
6_LTL/DryVan	55	Capacity Utilization	Mean – 2StD	Mean-1.5StD	NONE	NONE
6_Mixed	124	Capacity Utilization	Mean – 2StD	Mean-1.5StD	NONE	NONE
6_Package	25	Capacity Utilization	Mean – 2StD	Mean-1.5StD	NONE	NONE
6_TL/DryVan	51	Capacity Utilization	50.0%	NONE	NONE	NONE
7_LTL/DryVan	61	Capacity Utilization	Mean – 2StD	Mean-1.5StD	NONE	NONE
7_Mixed	144	Capacity Utilization	Mean – 2StD	Mean-1.5StD	NONE	NONE
7_TL/DryVan	44	Capacity Utilization	Mean – 2StD	Mean-1.5StD	NONE	NONE
8A_LTL/DryVan	54	Capacity Utilization	Mean – 2StD	Mean-1.5StD	NONE	NONE
8A_Mixed	106	Capacity Utilization	Mean – 2StD	Mean-1.5StD	NONE	NONE
8A_Refrigerated	21	Capacity Utilization	Mean – 2StD	Mean-1.5StD	NONE	NONE
8A_TL/DryVan	61	Capacity Utilization	Mean – 2StD	Mean-1.5StD	NONE	NONE
8B_AutoCarrier	36	Capacity Utilization	5.0%	15.0%	NONE	NONE
8B_Dray	109	Capacity Utilization	5.0%	15.0%	NONE	NONE
8B_Expedited	26	Capacity Utilization	5.0%	15.0%	NONE	NONE

Class_Category	Count	Variable	Low Red	Low Yellow	High Yellow	High Red
8B_Flatbed	159	Capacity Utilization	Mean – 2StD	Mean-1.5StD	NONE	NONE
8B_Heavy/Bulk	22	Capacity Utilization	5.0%	15.0%	NONE	NONE
8B_LTL/DryVan	106	Capacity Utilization	Mean – 2StD	Mean-1.5StD	NONE	NONE
8B_Mixed	470	Capacity Utilization	Mean – 2StD	Mean-1.5StD	NONE	NONE
8B_Refrigerated	574	Capacity Utilization	Mean – 2StD	Mean-1.5StD	NONE	NONE
8B_Specialized	60	Capacity Utilization	Mean – 2StD	Mean-1.5StD	NONE	NONE
8B_TL/DryVan	912	Capacity Utilization	Mean – 2StD	Mean-1.5StD	NONE	NONE
8B_Tanker	84	Capacity Utilization	Mean – 2StD	Mean-1.5StD	NONE	NONE

For distributions that appeared to have a relatively normal distribution on the low and/or high end, yellow flag criteria were set at ± 1.5 times the standard deviation (StD), and the red flag criteria at ± 2.0 times the standard deviation of the distribution for each truck fleet grouping. In most cases these criteria result in roughly 10-20% of the values for these metrics being flagged as either red or yellow for partner attention. For several variables with a clearly skewed distribution yellow cutoffs were set to include approximately 15% of observations, and red cutoffs were selected to include approximately 5% of observations. Selecting cutoffs at these levels of stringency is intended to identify likely input errors without unduly burdening the large majority of Truck Tool users with unnecessary data checks and text explanations.

Finally, certain distributions showed common values up to and including the absolute min/max values. For example, a substantial number of truck carriers reported revenue miles equal to 100% of total miles. In these instances no yellow/red flags are assigned for that variable.

Tables 16-21 present the actual yellow and red flag values for each fleet group/metric combination, given the decision criteria presented in Table 15. Tables 22-26 present the number of observations that would be flagged with yellow and red warnings for these combinations. The complete set of histograms associated with the distributional analysis of the 2016 data is available upon request from SmartWay.

Table 16. Yellow/Red Criteria by Fleet Group/Metric Combination
Annual Miles per Vehicle

Class-Category	Absolute Min	Low Red	Low Yellow	High Yellow	High Red	Absolute Max
2B-Expedited	>0	9,698	16,183	63,029	90,800	500,000
2B-Mixed	>0	2,046	7,741	53,432	71,391	500,000
2B-PD	>0	5,247	11,565	47,936	65,500	500,000
2B-TL/Dry van	>0	6,799	18,007	52,984	58,368	500,000
3-Mixed	>0	0	5,000	45,712	53,814	500,000
4-Mixed	>0	1,402	6,556	40,071	51,362	500,000
5-Mixed	>0	306	3,470	40,000	49,485	500,000
6-LTL/Dry van	>0	9,631	11,696	49,080	60,950	500,000
6-Mixed	>0	2,036	10,931	51,916	67,014	500,000
6-Moving	>0	3,000	8,000	68,107	79,506	500,000
6-PD	>0	5,921	9,073	65,000	72,065	500,000
6-TL/Dry van	>0	8,632	14,133	56,713	68,836	500,000
7-LTL/Dry van	>0	12,488	15,654	54,122	72,666	500,000
7-Mixed	>0	0	5,000	67,560	78,694	500,000
7-TL/Dry van	>0	2,326	10,312	57,249	79,650	500,000
8A-LTL/.Dry van	>0	10,558	15,625	68,215	88,352	500,000
8A-Mixed	>0	6,271	13,039	85,890	102,000	500,000
8A-Reefer	>0	15,505	26,162	70,000	79,308	500,000
8A-TL/Dry van	>0	10,069	13,877	97,567	128,406	500,000
8B-Auto	>0	43,112	51,769	103,710	112,367	500,000
8B-Dray	>0	6,985	18,413	86,984	98,413	500,000
8B-Expedited	>0	23,226	27,112	92,857	140,232	500,000
8B-Flatbed	>0	36,935	47,495	110,856	121,416	500,000
8B-Heavy	>0	44,171	48,663	101,118	108,168	500,000
8B-LTL/Dry van	>0	13,983	27,504	108,634	122,156	500,000
8B-Mixed	>0	12,029	27,477	120,168	135,616	500,000
8B-Reefer	>0	36,939	52,743	147,566	163,370	500,000
8B-Special	>0	20,765	39,854	105,338	117,433	500,000
8B-TL/Dry van	>0	29,853	44,672	133,586	148,405	500,000
8B-Tanker	>0	36,503	47,076	110,517	121,090	500,000

Table 17. Yellow/Red Criteria by Fleet Group/Metric Combination Miles per Gallon[47]

Class-Category	Absolute Min	Low Red	Low Yellow	High Yellow	High Red	Absolute Max
2B-Expedited	>0	10.2	11.1	17.9	22.9	37.5
2B-Mixed	>0	6.9	8.2	17.6	19.9	34.4
2B-PD	>0	5.7	6.9	15.6	18.6	31.1
2B-TL/Dry van	>0	5.4	6.8	15.4	17.3	29.2
3-Mixed	>0	4.4	5.8	13.9	15.2	28.5
4-Mixed	>0	3.6	6.7	11.7	12.2	24.4
5-Mixed	>0	2.4	3.7	11.8	13.2	21.4
6-LTL/Dry van	>0	5.7	6.5	9.4	10.2	16.8
6-Mixed	>0	5.0	5.7	10.1	10.9	18.1
6-Moving	>0	5.8	6.2	8.5	8.9	18
6-PD	>0	3.0	5.4	9.8	10.6	17.1
6-TL/Dry van	>0	4.9	5.6	10.1	10.8	15
7-LTL/Dry van	>0	5.4	6.0	9.6	10.2	15.8
7-Mixed	>0	4.4	5.2	9.9	10.7	16.9
7-TL/Dry van	>0	6.0	6.5	9.0	9.4	14.6
8A-LTL/.Dry van	>0	5.0	5.3	7.3	7.6	12.2
8A-Mixed	>0	4.3	4.9	8.2	8.8	13.4
8A-Reefer	>0	5.3	5.8	6.8	7.6	12.5
8A-TL/Dry van	>0	4.6	5.0	7.8	8.3	13
8B-Auto	>0	4.0	4.5	5.4	5.9	9.3
8B-Dray	>0	4.6	4.9	6.8	7.1	10.5
8B-Expedited	>0	4.9	5.4	6.6	6.6	10.2
8B-Flatbed	>0	4.5	4.9	6.7	7.1	10.8
8B-Heavy	>0	4.2	4.7	5.8	6.1	9.9
8B-LTL/Dry van	>0	5.0	5.3	7.2	7.6	11.8
8B-Mixed	>0	4.5	4.9	7.0	7.3	11.8
8B-Reefer	>0	4.7	5.0	6.9	7.3	11.9
8B-Special	>0	2.8	4.2	6.1	6.5	10.1
8B-TL/Dry van	>0	4.8	5.2	7.2	7.5	12.4
8B-Tanker	>0	4.4	4.8	7.1	7.5	10.8

[47] Equivalent MPG cutoffs can be found by dividing these values by 1.26 for gasoline and CNG vehicles; dividing by 1.35 for LPG vehicles; and dividing by 1.52 for LNG vehicles – see "Non-Diesel MPG" section below for details.

Table 18. Yellow/Red Criteria by Fleet Group/Metric Combination
% Revenue Miles

Class-Category	Absolute Min	Low Red	Low Yellow	High Yellow	High Red	Absolute Max
2B-Expedited	N/A	52	59	N/A	N/A	N/A
2B-Mixed	N/A	53	61	N/A	N/A	N/A
2B-PD	N/A	66	72	N/A	N/A	N/A
2B-TL/Dry van	N/A	69	74	N/A	N/A	N/A
3-Mixed	N/A	65	71	N/A	N/A	N/A
4-Mixed	N/A	65	71	N/A	N/A	N/A
5-Mixed	N/A	59	67	N/A	N/A	N/A
6-LTL/Dry van	N/A	61	68	N/A	N/A	N/A
6-Mixed	N/A	55	63	N/A	N/A	N/A
6-Moving	N/A	55	65	N/A	N/A	N/A
6-PD	N/A	75	80	N/A	N/A	N/A
6-TL/Dry van	N/A	56	64	N/A	N/A	N/A
7-LTL/Dry van	N/A	64	71	N/A	N/A	N/A
7-Mixed	N/A	57	64	N/A	N/A	N/A
7-TL/Dry van	N/A	64	70	N/A	N/A	N/A
8A-LTL/.Dry van	N/A	67	73	N/A	N/A	N/A
8A-Mixed	N/A	52	59	N/A	N/A	N/A
8A-Reefer	N/A	59	65	N/A	N/A	N/A
8A-TL/Dry van	N/A	69	74	N/A	N/A	N/A
8B-Auto	N/A	43	50	N/A	N/A	N/A
8B-Dray	N/A	46	54	N/A	N/A	N/A
8B-Expedited	N/A	57	63	N/A	N/A	N/A
8B-Flatbed	N/A	62	67	N/A	N/A	N/A
8B-Heavy	N/A	34	43	N/A	N/A	N/A
8B-LTL/Dry van	N/A	68	73	N/A	N/A	N/A
8B-Mixed	N/A	62	68	N/A	N/A	N/A
8B-Reefer	N/A	72	76	N/A	N/A	N/A
8B-Special	N/A	40	49	N/A	N/A	N/A
8B-TL/Dry van	N/A	68	73	N/A	N/A	N/A
8B-Tanker	N/A	48	50	N/A	N/A	N/A

Table 19. Yellow/Red Criteria by Fleet Group/Metric Combination
% Empty Miles

Class-Category	Absolute Min	Low Red	Low Yellow	High Yellow	High Red	Absolute Max
2B-Expedited	N/A	1	5	38	44	N/A
2B-Mixed	N/A	1	5	41	48	N/A
2B-PD	N/A	1	5	31	37	N/A
2B-TL/Dry van	N/A	1	5	28	33	N/A
3-Mixed	N/A	1	5	28	34	N/A
4-Mixed	N/A	1	5	30	35	N/A
5-Mixed	N/A	1	5	33	40	N/A
6-LTL/Dry van	N/A	1	5	36	44	N/A
6-Mixed	N/A	1	5	38	45	N/A
6-Moving	N/A	1	5	40	50	N/A
6-PD	N/A	1	5	15	31	N/A
6-TL/Dry van	N/A	1	5	35	47	N/A
7-LTL/Dry van	N/A	1	5	32	35	N/A
7-Mixed	N/A	1	5	33	44	N/A
7-TL/Dry van	N/A	1	5	33	39	N/A
8A-LTL/.Dry van	N/A	1	5	30	36	N/A
8A-Mixed	N/A	1	5	36	47	N/A
8A-Reefer	N/A	1	5	35	41	N/A
8A-TL/Dry van	N/A	1	5	31	36	N/A
8B-Auto	N/A	5	15	40	49	N/A
8B-Dray	N/A	5	7	40	50	N/A
8B-Expedited	N/A	5	6	33	37	N/A
8B-Flatbed	N/A	5	7	27	37	N/A
8B-Heavy	N/A	1	5	56	64	N/A
8B-LTL/Dry van	N/A	1	5	29	34	N/A
8B-Mixed	N/A	1	5	34	40	N/A
8B-Reefer	N/A	1	5	25	29	N/A
8B-Special	N/A	1	5	49	50	N/A
8B-TL/Dry van	N/A	1	5	28	32	N/A
8B-Tanker	N/A	20	36	50	50	N/A

Table 20. Yellow/Red Criteria by Fleet Group/Metric Combination
Average Used Cargo Volume %

Class-Category	Absolute Min	Low Red	Low Yellow	High Yellow	High Red	Absolute Max
2B-Expedited	N/A	25	50	90	100	N/A
2B-Mixed	N/A	26.1	36.4	100	100	N/A
2B-PD	N/A	40	70	87	100	N/A
2B-TL/Dry van	N/A	47.5	54.7	100	100	N/A
3-Mixed	N/A	38.8	47.8	100	100	N/A
4-Mixed	N/A	41.8	50	100	100	N/A
5-Mixed	N/A	47.8	54.5	100	100	N/A
6-LTL/Dry van	N/A	40.7	49.1	90	95	N/A
6-Mixed	N/A	43.8	52.2	100	100	N/A
6-Moving	N/A	36	42	80	90	N/A
6-PD	N/A	44.8	53.1	100	100	N/A
6-TL/Dry van	N/A	50	50	100	100	N/A
7-LTL/Dry van	N/A	44.4	52.2	90	95	N/A
7-Mixed	N/A	46	54.2	100	100	N/A
7-TL/Dry van	N/A	56.3	62.3	100	100	N/A
8A-LTL/.Dry van	N/A	48.4	55.6	90	95	N/A
8A-Mixed	N/A	56.2	62.4	100	100	N/A
8A-Reefer	N/A	37	46.1	100	100	N/A
8A-TL/Dry van	N/A	56.7	63.5	100	100	N/A
8B-Auto	N/A	76	80	100	100	N/A
8B-Dray	N/A	66	76	100	100	N/A
8B-Expedited	N/A	62	67	100	100	N/A
8B-Flatbed	N/A	67.9	73	100	100	N/A
8B-Heavy	N/A	70	80	100	100	N/A
8B-LTL/Dry van	N/A	53.2	59.8	90	95	N/A
8B-Mixed	N/A	65.5	70.6	100	100	N/A
8B-Reefer	N/A	68.2	73.1	100	100	N/A
8B-Special	N/A	63.4	69.7	100	100	N/A
8B-TL/Dry van	N/A	66	71.3	100	100	N/A
8B-Tanker	N/A	74.7	78.9	100	100	N/A

Table 21. Yellow/Red Criteria by Fleet Group/Metric Combination
Idle Hours and Days of Use per Year

Class-Category	Low Red	Low Yellow	High Yellow	High Red
	Average Service Days/Year			
Non-Class 8b (less Package/Specialty)	96	171	320	--
Non-Class 8b (Package/Specialty)	142	200	315	--
Class 8b (less LTL/Package)	157	213	325	--
Class 8b (LTL/Package)	135	193	309	--
	Average Hours Long Duration Idle/Day			
Non-Class 8b (less Package/Specialty)	--	1.00	1.73	2.81
Non-Class 8b (Package/Specialty)	--	1.00	24.00	--
Class 8b (less LTL/Package)	--	1.00	4.11	6.10
Class 8b (LTL/Package)	--	1.00	2.53	4.18
	Average Hours Short Duration Idle/Day			
Non-Class 8b (less Package/Specialty)	--	0	1.87	2.81
Non-Class 8b (Package/Specialty)	--	0	1.42	1.99
Class 8b (less LTL/Package)	--	0	2.36	3.60
Class 8b (LTL/Package)	--	0	2.63	4.15

Table 22. Number of Values Flagged by Fleet Group/Metric Combination
Annual Miles per Vehicle

Class/Category	N	Minimum Value	Low Red Flags	Low Yellow Flags	Mean Value	High Yellow Flags	High Red Flags	Maximum Value
2B_Expedited	35	6,001	1	3	40,870	3	1	95,938
2B_Mixed	96	720	4	9	27,933	9	4	76,590
2B_Package	34	4,144	1	3	30,012	3	1	70,685
2B_TL/Dry Van	42	505	2	3	31,821	3	2	59,203
3_Mixed	85	581	0	6	21,406	6	4	76,320
4_Mixed	71	117	3	6	22,373	6	3	53,172
5_Mixed	59	83	2	5	16,525	5	2	54,486
6_LTL/Dry Van	55	1,429	2	5	29,919	5	2	70,391
6_Mixed	124	53	6	11	31,682	11	6	79,858
6_Package	25	814	1	1	21,050	1	1	90,196
6_TL/Dry Van	51	3,179	2	4	35,069	4	2	93,498
7_LTL/Dry Van	61	5,701	3	5	34,379	5	3	87,534
7_Mixed	144	100	0	10	34,158	7	6	106,615
7_TL/Dry Van	44	1,693	2	3	34,359	3	2	109,287
8A_LTL/Dry Van	54	3,458	2	5	45,351	5	2	108,183
8A_Mixed	106	155	5	9	47,086	9	5	124,901
8A_Refrigerated	21	1,738	1	1	45,741	1	1	79,469
8A_TL/Dry Van	61	7,460	3	5	59,438	5	3	155,136

Class/Category	N	Minimum Value	Low Red Flags	Low Yellow Flags	Mean Value	High Yellow Flags	High Red Flags	Maximum Value
8B_AutoCarrier	36	47,525	0	2	77,740	1	1	120,671
8B_Dray	109	3,165	1	9	52,699	4	4	102,164
8B_Expedited	26	22,697	1	1	63,362	1	1	150,415
8B_Flatbed	159	15,680	3	5	79,175	8	2	130,597
8B_Heavy/Bulk	22	40,305	1	1	73,132	1	1	116,004
8B_LTL/Dry Van	106	14,096	0	5	68,069	3	3	146,016
8B_Mixed	470	3,658	7	20	73,822	22	11	151,353
8B_Refrigerated	574	9,171	20	20	100,155	22	10	203,947
8B_Specialized	60	4,568	2	5	71,877	5	2	178,303
8B_TL/Dry Van	912	2,072	27	33	89,129	39	19	176,478
8B_Tanker	84	28,055	4	3	78,796	0	3	136,449

Table 23. Number of Values Flagged by Fleet Group/Metric Combination
Miles per Gallon

Class/Category	N	Minimum Value	Low Red Flags	Low Yellow Flags	Mean Value	High Yellow Flags	High Red Flags	Maximum Value
2B_Expedited	35	10.00	1	3	14.47	3	1	25.00
2B_Mixed	96	2.00	4	9	12.93	9	4	22.91
2B_Package	34	3.51	1	3	11.68	3	1	20.74
2B_TL/Dry Van	42	2.50	2	3	10.68	3	2	19.50
3_Mixed	85	1.07	2	3	9.82	6	1	18.99
4_Mixed	71	1.34	3	6	8.98	6	3	16.27
5_Mixed	59	0.96	3	1	7.77	2	1	14.25
6_LTL/Dry Van	55	0.68	2	5	8.01	5	2	11.17
6_Mixed	124	4.02	1	6	7.93	2	2	12.06
6_Package	25	0.91	1	1	7.39	1	1	11.37
6_TL/Dry Van	51	0.76	1	0	7.86	0	0	10.00
7_LTL/Dry Van	61	5.48	0	2	7.82	2	2	10.50
7_Mixed	144	3.69	4	4	7.55	3	4	11.25
7_TL/Dry Van	44	4.60	2	3	7.76	3	2	9.76
8A_LTL/Dry Van	54	4.25	1	0	6.31	1	1	8.13
8A_Mixed	106	3.38	3	3	6.57	5	3	8.97
8A_Refrigerated	21	5.19	1	2	6.38	2	1	8.34
8A_TL/Dry Van	61	1.84	1	1	6.43	0	1	8.69
8B_AutoCarrier	36	4.29	1	3	4.96	3	1	6.22
8B_Dray	109	3.35	5	2	5.83	3	0	7.00
8B_Expedited	26	4.79	1	1	6.04	1	1	6.80
8B_Flatbed	159	3.10	5	4	5.80	6	2	7.20
8B_Heavy/Bulk	22	4.11	1	1	5.32	1	1	6.63
8B_LTL/Dry Van	106	4.08	5	3	6.27	1	1	7.87

Class/Category	N	Minimum Value	Low Red Flags	Low Yellow Flags	Mean Value	High Yellow Flags	High Red Flags	Maximum Value
8B_Mixed	470	3.18	17	11	5.94	17	6	7.88
8B_Refrigerated	574	1.11	12	15	5.96	19	15	7.96
8B_Specialized	60	0.50	3	6	5.07	6	3	6.72
8B_TL/Dry Van	912	2.30	26	21	6.18	36	16	8.26
8B_Tanker	84	2.66	2	4	5.95	4	0	7.21

Table 24. Number of Values Flagged by Fleet Group/Metric Combination
% Revenue Miles

Class/Category	N	Minimum Value	Low Red Flags	Low Yellow Flags	Mean Value	High Yellow Flags	High Red Flags	Maximum Value
2B_Expedited	35	54.2	0	3	80.9	0	0	100
2B_Mixed	96	50.0	3	9	83.4	0	0	100
2B_Package	34	60.1	3	1	88.6	0	0	100
2B_TL/Dry Van	42	63.3	1	2	89.7	0	0	100
3_Mixed	85	57.0	3	7	89.7	0	0	100
4_Mixed	71	65.0	3	9	90.4	0	0	100
5_Mixed	59	50.0	2	5	88.5	0	0	100
6_LTL/Dry Van	55	50.0	3	4	88.4	0	0	100
6_Mixed	124	47.0	8	2	84.4	0	0	100
6_Package	25	64.0	2	0	94.2	0	0	100
6_TL/Dry Van	51	45.2	3	1	87.3	0	0	100
7_LTL/Dry Van	61	65.0	0	10	89.2	0	0	100
7_Mixed	144	50.0	6	2	84.4	0	0	100
7_TL/Dry Van	44	41.1	2	2	89.5	0	0	100
8A_LTL/Dry Van	54	55.0	5	2	90.5	0	0	100
8A_Mixed	106	46.1	5	4	82.3	0	0	100
8A_Refrigerated	21	60.0	0	2	85.0	0	0	100
8A_TL/Dry Van	61	49.1	3	3	91.3	0	0	100
8B_AutoCarrier	36	50.0	0	0	71.8	0	0	100
8B_Dray	109	49.5	0	7	79.2	0	0	100
8B_Expedited	26	56.2	1	2	82.8	0	0	100
8B_Flatbed	159	50.0	6	5	82.8	0	0	100
8B_Heavy/Bulk	22	46.0	0	0	70.9	0	0	100
8B_LTL/Dry Van	106	55.0	4	5	89.0	0	0	100
8B_Mixed	470	50.0	18	30	85.4	0	0	100
8B_Refrigerated	574	50.0	25	25	88.4	0	0	100
8B_Specialized	60	49.4	0	0	74.6	0	0	100
8B_TL/Dry Van	912	50.0	49	34	87.4	0	0	100
8B_Tanker	84	44.9	4	2	61.9	1	1	100

Table 25. Number of Values Flagged by Fleet Group/Metric Combination
% Empty Miles

Class/Category	N	Minimum Value	Low Red Flags	Low Yellow Flags	Mean Value	High Yellow Flags	High Red Flags	Maximum Value
2B_Expedited	35	2.96	0	0	20.65	3	1	45.75
2B_Mixed	96	0.00	0	0	18.10	8	3	50.00
2B_Package	34	0.00	0	0	12.26	1	4	39.91
2B_TL/Dry Van	42	0.00	0	3	14.00	0	2	39.60
3_Mixed	85	0.00	0	0	12.47	7	4	42.23
4_Mixed	71	0.00	0	0	12.55	6	3	40.00
5_Mixed	59	0.00	0	0	16.01	5	2	50.00
6_LTL/Dry Van	55	0.00	0	0	14.99	3	2	50.00
6_Mixed	124	0.00	0	0	16.57	2	9	52.99
6_Package	25	0.00	0	0	6.27	1	1	35.98
6_TL/Dry Van	51	0.00	0	0	17.42	4	2	54.76
7_LTL/Dry Van	61	0.00	0	0	13.09	5	3	40.00
7_Mixed	144	0.00	0	0	17.54	13	7	50.00
7_TL/Dry Van	44	0.00	0	0	15.42	4	1	45.00
8A_LTL/Dry Van	54	0.00	0	0	11.35	5	2	45.00
8A_Mixed	106	0.00	0	0	19.51	9	5	53.91
8A_Refrigerated	21	0.00	0	0	14.93	2	0	40.00
8A_TL/Dry Van	61	0.00	0	0	13.44	3	2	50.94
8B_AutoCarrier	36	0.00	0	3	29.68	3	1	50.00
8B_Dray	109	0.00	3	10	25.36	10	5	50.45
8B_Expedited	26	5.00	1	1	18.12	1	1	43.83
8B_Flatbed	159	0.00	3	15	18.12	15	7	50.00
8B_Heavy/Bulk	22	0.00	0	0	31.51	0	0	50.81
8B_LTL/Dry Van	106	0.00	0	0	12.65	4	6	50.00
8B_Mixed	470	0.00	0	0	16.49	28	22	50.00
8B_Refrigerated	574	0.00	0	0	12.91	20	25	50.00
8B_Specialized	60	0.00	0	4	29.17	4	2	50.61
8B_TL/Dry Van	912	0.00	0	0	13.71	39	51	50.00
8B_Tanker	84	3.00	4	7	43.51	0	9	55.12

Table 26. Number of Values Flagged by Fleet Group/Metric Combination
Average Used Cargo Volume %

Class/Category	N	Minimum Value	Low Red Flags	Low Yellow Flags	Mean Value	High Yellow Flags	High Red Flags	Maximum Value
2B_Expedited	35	24.00	1	3	67.80	3	0	100.00
2B_Mixed	96	1.00	3	6	67.39	0	0	100.00
2B_Package	34	38.00	1	3	74.50	2	0	100.00
2B_TL/Dry Van	42	20.00	1	1	76.24	0	0	100.00
3_Mixed	85	10.00	4	2	74.89	0	0	100.00
4_Mixed	71	20.00	5	4	74.58	0	0	100.00
5_Mixed	59	32.00	2	3	74.64	0	0	100.00
6_LTL/Dry Van	55	5.00	3	0	74.38	0	0	95.00
6_Mixed	124	25.00	7	4	77.10	0	0	100.00
6_Package	25	31.00	2	0	77.84	0	0	100.00
6_TL/Dry Van	51	50.00	0	0	76.59	0	0	100.00
7_LTL/Dry Van	61	24.00	4	2	75.69	0	0	98.00
7_Mixed	144	10.00	7	3	78.78	0	0	100.00
7_TL/Dry Van	44	50.00	1	3	80.18	0	0	100.00
8A_LTL/Dry Van	54	26.00	3	1	77.28	0	0	96.00
8A_Mixed	106	49.00	2	9	81.18	0	0	100.00
8A_Refrigerated	21	22.00	2	0	73.43	0	0	100.00
8A_TL/Dry Van	61	25.00	1	3	84.07	0	0	100.00
8B_AutoCarrier	36	75.00	1	0	92.47	0	0	100.00
8B_Dray	109	65.00	5	0	89.03	0	0	100.00
8B_Expedited	26	49.00	1	1	82.50	0	0	100.00
8B_Flatbed	159	30.00	2	8	88.50	0	0	100.00
8B_Heavy/Bulk	22	70.00	0	1	90.14	0	0	100.00
8B_LTL/Dry Van	106	5.00	4	0	79.54	0	0	95.00
8B_Mixed	470	40.00	20	25	85.95	0	0	100.00
8B_Refrigerated	574	40.00	23	17	87.69	0	0	100.00
8B_Specialized	60	43.00	2	2	88.65	0	0	100.00
8B_TL/Dry Van	912	38.00	36	51	87.06	0	0	100.00
8B_Tanker	84	52.00	2	2	91.55	0	0	100.00

Absolute errors were also developed for each fleet category/metric combination. Cutoffs for absolute errors are intended to prevent users from inadvertently entering data with incorrect units and typos. For this reason we have defined absolute errors to ensure an adequate "safety" interval between the highest values observed in the cleaned (no outlier) dataset. The recommended values for absolute errors and their associated justifications are discussed below for each metric.

Annual Miles per Vehicle

The maximum number of miles a vehicle can accumulate in a year are constrained by truck highway speed limits (typically 65 mph or less) and the number of hours in a year.[48] Excluding engine down-time associated with maintenance and repairs, the absolute maximum annual mileage possible for a truck is estimated to be ~500,000 miles per year. This estimate is more than twice the highest observed value of 228,151 miles per year (for Class 8b TL/Dry Van diesels). Therefore 500,000 miles per year value is set as the absolute maximum for all vehicle classes. Values greater than 0 and less than 500,000 are permissible.

Miles per Gallon

The maximum and minimum miles per gallon from the diesel dataset (prior to cleaning) are presented in Table 27.

Table 27. Maximum and Minimum Observed Miles per Gallon

Class/Category	N	Minimum Value	Maximum Value
2B_Expedited	35	10.0	25.0
2B_Mixed	96	2.0	22.9
2B_Package	34	3.5	20.7
2B_TL/Dry Van	42	2.5	19.5
3_Mixed	85	1.1	19.0
4_Mixed	71	1.3	16.3
5_Mixed	59	1.0	14.2
6_LTL/Dry Van	55	0.7	11.2
6_Mixed	124	4.0	12.1
6_Package	25	0.9	11.4
6_TL/Dry Van	51	0.8	10.0
7_LTL/Dry Van	61	5.5	10.5
7_Mixed	144	3.7	11.3
7_TL/Dry Van	44	4.6	9.8
8A_LTL/Dry Van	54	4.3	8.1
8A_Mixed	106	3.4	9.0
8A_Refrigerated	21	5.2	8.3
8A_TL/Dry Van	61	1.8	8.7
8B_AutoCarrier	36	4.3	6.2
8B_Dray	109	3.4	7.0
8B_Expedited	26	4.8	6.8
8B_Flatbed	159	3.1	7.2
8B_Heavy/Bulk	22	4.1	6.6
8B_LTL/Dry Van	106	4.1	7.9
8B_Mixed	470	3.2	7.9
8B_Refrigerated	574	1.1	8.0

[48] While DOT regulations limit drivers' daily hours, some companies utilize driver teams to maximize on-road time.

Class/Category	N	Minimum Value	Maximum Value
8B_Specialized	60	0.5	6.7
8B_TL/Dry Van	912	2.3	8.3
8B_Tanker	84	2.7	7.2

[Note: Unlike the other parameters discussed above, miles per gallon values are derived from other inputs (total miles and gallons). Therefore, any changes to address absolute limits on MPG (as well as red and yellow warnings) must be handled through updates to one or both of these primary inputs.]

As seen from the above table, fuel efficiency estimates can be very low (<1.0) and for this reason no absolute lower bound is used for miles per gallon. To establish absolute upper bounds for miles per gallon estimates the results from the PERE modeling analysis previously developed for the 2010 Truck Model were used. Background on the PERE modeling exercise is provided in Appendix E.

Absolute maximum miles per gallon estimates were developed for conventional diesel trucks using the PERE model, and are shown in Table 28 by truck class.

Table 28. Maximum Diesel Miles per Gallon Estimates (PERE Model Basis)

Class	Maximum MPG
2b	25.0
3	23.3
4	20.2
5	18.7
6	18.0
7	14.5
8a	11.2
8b	11.2

Note that the maximum MPG estimates obtained from the PERE model are substantially higher than almost all of the maximum value observed for diesel trucks in the 2016 Truck Tool data.

Non-Diesel MPG

The 2016 data submissions from SmartWay Truck partners did not include enough information on non-diesel trucks in order to develop a robust distribution of mpg values specific to non-diesels for validation purposes. Accordingly, engineering judgment was used to adjust the diesel mpg values for other fuel types, accounting for general, relative vehicle and/or fuel efficiency differences. First, a ratio was developed for adjusting diesel mpg values to comparable gasoline mpg values, based upon simulated modeling performed by Argonne

National Laboratory.[49] The Argonne data for gas and diesel trucks was based on PSAT simulations of a typical pickup in the Class 2b or Class 3 range. The fuel consumption was reported for the same truck equipped with both gasoline and diesel engines over the various EPA emissions and fuel economy driving cycles. Using this data, a combined fuel economy was calculated using the method from EPA's pre-2008 combined 2-cycle fuel economy using the FTP and Highway cycles as given in 40 CFR Part 600. This method uses a weighted harmonic average of the two values, with the FTP weighted at 55% and the Highway weighted at 45%.

The difference in the calculated combined fuel economies for the gas- and diesel-powered model results showed that the diesel had a 25.9% greater fuel economy than gasoline. These results are a direct volumetric comparison rather than in terms of gasoline-equivalent gallons. As such, the diesel mpg values shown in Table 28 above can be divided by 1.259 to obtain comparable mpg ranges for gasoline vehicles. Since CNG vehicle fuel consumption is reported in terms of gasoline-equivalent gallons, the mpg validation ranges for CNG vehicles can be set equal to those for comparable gasoline vehicles.

Validation ranges for LPG and LNG vehicles can be developed from the gasoline ranges, dividing the gasoline values by the appropriate gasoline gallon-equivalent factor for these fuels (1.35 for LPG and 1.52 for LNG),[50] thereby adjusting mpg values for volumetric energy density. Table 29 presents the corresponding upper bound MPG values for non-diesel vehicles by truck class.

Table 29. Maximum Miles per Gallon Estimates – Non-Diesel Vehicles

Class	Gasoline/CNG	LPG	LNG
2b	19.9	18.5	16.4
3	18.5	17.3	15.3
4	16.0	15.0	13.3
5	14.9	13.9	12.3
6	14.3	13.3	11.8
7	11.5	10.7	9.5
8a	8.9	8.3	7.4
8b	8.9	8.3	7.4

Hybrid MPG

EPA's Physical Emission Rate Estimator (PERE) model was used in order to establish estimates of the fuel economy benefit of hybridization of medium- and heavy-duty trucks. The details of the modeling are presented in Appendix E.

[49] Delorme, A. et. al., *Impact of Advanced Technologies on Medium-Duty Trucks Fuel Efficiency*, Argonne National Laboratory, 2010-01-1929.

[50] https://www.afdc.energy.gov/afdc/prep/popups/gges.html

However, the in-use fuel economy of hybrid vehicles is highly dependent upon drive cycle. Specifically the expected hybrid truck fuel economy will vary depending upon the relative fraction of highway versus urban driving. Therefore the MPG ranges used for validation of hybrid fuel economy are calculated using the following steps.

Step 1 – Weight the following GALLON PER MILE (Not MPG) values based on the Highway/Urban split.

Gal/Mi - Urban

Group #	Name	Low Red	Low Yellow	Mean	High Yellow	High Red
1	2B_Mixed	0.2641	0.1813	0.0942	0.0636	0.0576
2	3_Mixed	0.2340	0.1857	0.1147	0.0830	0.0760
3	4_Mixed	0.2090	0.1763	0.1213	0.0925	0.0861
4	5_Mixed	0.2599	0.2127	0.1392	0.1026	0.0943
5	6_LTL/Dry Van_Diesel	0.1951	0.1765	0.1390	0.1147	0.1080
6	6_Mixed	0.2200	0.1972	0.1467	0.1179	0.1111
7	6_Moving	0.1906	0.1783	0.1514	0.1301	0.1242
8	6_Package_Diesel	0.1788	0.1628	0.1254	0.1029	0.0965
9	6_TL/Dry Van_Diesel	0.2350	0.2056	0.1495	0.1175	0.1097
10	7_LTL/Dry Van_Diesel	0.1968	0.1806	0.1450	0.1211	0.1148
11	7_Mixed	0.2506	0.2169	0.1545	0.1200	0.1117
12	7_TL/Dry Van_Diesel	0.2131	0.1915	0.1467	0.1202	0.1130
13	8A_LTL/Dry Van_Diesel	0.2184	0.2104	0.1837	0.1653	0.1607
14	8A_Mixed	0.2747	0.2519	0.1950	0.1591	0.1492
15	8A_Refrigerated_Diesel	0.2502	0.2402	0.2036	0.1793	0.1716
16	8A_TL/Dry Van_Diesel	0.2477	0.2337	0.1966	0.1697	0.1630
17	8B_AutoCarrier_Diesel	0.2980	0.2781	0.2407	0.2158	0.2052
18	8B_Dray_Diesel	0.2434	0.2338	0.2056	0.1835	0.1780
19	8B_Flatbed_Diesel	0.2912	0.2727	0.2248	0.1942	0.1857
20	8B_Heavy/Bulk_Diesel	0.3768	0.3371	0.2562	0.2033	0.1912
21	8B_LTL/Dry Van_Diesel	0.2383	0.2250	0.2025	0.1814	0.1761
22	8B_Mixed	0.2597	0.2493	0.2149	0.1889	0.1807
23	8B_Refrigerated_Diesel	0.2656	0.2500	0.2236	0.1992	0.1931
24	8B_Specialized_Diesel	0.3389	0.2995	0.2342	0.1894	0.1789
25	8B_TL/Dry Van_Diesel	0.2534	0.2436	0.2147	0.1891	0.1836
26	8B_Tanker_Diesel	0.2596	0.2492	0.2149	0.1888	0.1806

Gal/Mi – Highway

Group #	Name	Low Red	Low Yellow	Mean	High Yellow	High Red
1	2B_Mixed	0.1759	0.1208	0.0627	0.0424	0.0383
2	3_Mixed	0.1594	0.1265	0.0781	0.0565	0.0518
3	4_Mixed	0.1482	0.1250	0.0860	0.0656	0.0611
4	5_Mixed	0.1805	0.1477	0.0967	0.0713	0.0655
5	6_LTL/Dry Van_Diesel	0.1470	0.1330	0.1047	0.0864	0.0813
6	6_Mixed	0.1657	0.1486	0.1105	0.0889	0.0837
7	6_Moving	0.1436	0.1343	0.1141	0.0980	0.0936
8	6_Package_Diesel	0.1347	0.1226	0.0944	0.0775	0.0727
9	6_TL/Dry Van_Diesel	0.1770	0.1549	0.1127	0.0885	0.0826
10	7_LTL/Dry Van_Diesel	0.1513	0.1389	0.1115	0.0931	0.0883
11	7_Mixed	0.1928	0.1668	0.1188	0.0923	0.0859
12	7_TL/Dry Van_Diesel	0.1640	0.1473	0.1128	0.0924	0.0869
13	8A_LTL/Dry Van_Diesel	0.1558	0.1501	0.1310	0.1179	0.1147
14	8A_Mixed	0.1960	0.1796	0.1391	0.1135	0.1065
15	8A_Refrigerated_Diesel	0.1785	0.1714	0.1452	0.1279	0.1224
16	8A_TL/Dry Van_Diesel	0.1767	0.1667	0.1402	0.1210	0.1163
17	8B_AutoCarrier_Diesel	0.2126	0.1984	0.1717	0.1539	0.1464
18	8B_Dray_Diesel	0.1736	0.1668	0.1467	0.1309	0.1270
19	8B_Flatbed_Diesel	0.2078	0.1945	0.1604	0.1385	0.1325
20	8B_Heavy/Bulk_Diesel	0.2688	0.2405	0.1828	0.1450	0.1364
21	8B_LTL/Dry Van_Diesel	0.1700	0.1605	0.1445	0.1294	0.1256
22	8B_Mixed	0.1853	0.1779	0.1533	0.1347	0.1289
23	8B_Refrigerated_Diesel	0.1894	0.1783	0.1595	0.1421	0.1378
24	8B_Specialized_Diesel	0.2418	0.2137	0.1670	0.1351	0.1276
25	8B_TL/Dry Van_Diesel	0.1807	0.1738	0.1532	0.1349	0.1310
26	8B_Tanker_Diesel	0.1852	0.1778	0.1533	0.1347	0.1288

Example – Truck Class 2b has 40% urban, 60% highway. The Low Red Gallon/Mile value is therefore 0.2641 x 0.40 + 0.1759 x 0.60 = 0.2112

Step 2: Convert the weighted gallon per mile values back to MPG
Example: 0.2112 gal/mi = 4.74 MPG

Step 3: Use these final, weighted, converted MPG values for validation.

Electric Truck Efficiency

Mi/kWhr estimates for battery electric trucks were developed based on available data sources and engineering judgment. The average value for Class 2b trucks was assumed to equal the mi/kWhr value estimates for large SUVs in EPA's MARKAL model (3.01). The values for Class 4 and 6 electric trucks (1.43 and 1.00 respectively) were taken from Calstart's E-Truck Task Force Business Case Calculator. Values for Class 3 and 5 trucks were based on simple averages of the Class 2b, 4, and 6 values. Given the lack of available data for the heavier truck classes, values for Class 7 (0.75), Class 8a (0.5) and Class 8b (0.4) were based on engineering judgment.

Once average mi/kWhr estimates were derived, "red" and "yellow" ranges were established based on simple multiplicative factors applied to the averages – Low red from 0 to 0.5 x average; low yellow from 0.5 x average to 0.75 x average; high yellow from 1.25 x average to 1.5 x average; and high red from 1.5 x average to 10 x average (absolute max).

Percent Revenue Miles

Revenue miles were frequently equal to total miles in the dataset. Accordingly, no absolute upper (or lower) bound was set for this field, beyond requiring all values to be ≥ 0 and ≤ 100.

Percent Empty Miles

Empty miles were occasionally equal to 0 in the dataset. Accordingly, no absolute lower (or upper) bound was set for this field, beyond requiring all values to be ≥ 0 and ≤ 100.

Percent Biodiesel

While the maximum observed blend level for biodiesel was 20 percent, B100 use is possible. Therefore no absolute upper (or lower) bound was set for this field, beyond requiring all values to be ≥ 0 and ≤ 100.

Average Payload

The maximum and minimum payloads from the 2011 dataset (prior to cleaning) are presented in Table 30.[51]

Table 30. Maximum and Minimum Observed Payloads (Short Tons)

Group #	Name	Min	Mean	Max
1	2B_Mixed	0.1	1.0	1.9[52]
2	3_Mixed	0.1	1.7	3.0
3	4_Mixed	0.5	2.4	4.0
4	5_Mixed	1.3	3.1	5.3
5	6_LTL/Dry Van_Diesel	0.9	4.6	6.3

[51] As noted above, the 2016 dataset did not have an adequate number of exact payload estimates to allow for a robust distributional analysis. Accordingly the 2011 payload analysis results are retained in the current Truck Tool.

[52] Three extreme outliers for Class 2b trucks were dropped for the purposes of establishing maximum upper bounds: 16.0, 13.0 and 5.0 tons.

Group #	Name	Min	Mean	Max
6	6_Mixed	0.9	4.5	6.5
7	6_Moving	2.5	3.6	4.9
8	6_Package_Diesel	2.0	4.2	6.0
9	6_TL/Dry Van_Diesel	0.9	4.1	6.9
10	7_LTL/Dry Van_Diesel	1.8	6.0	8.7
11	7_Mixed	1.1	6.0	20.0
12	7_TL/Dry Van_Diesel	4.5	6.4	12.7
13	8A_LTL/Dry Van_Diesel	6.0	10.6	15.0
14	8A_Mixed	1.9	11.3	24.0
15	8A_Refrigerated_Diesel	6.3	13.3	21.0
16	8A_TL/Dry Van_Diesel	3.8	11.4	20.0
17	8B_AutoCarrier_Diesel	9.3	19.6	24.5
18	8B_Dray_Diesel	15.0	20.5	24.5
19	8B_Flatbed_Diesel	14.8	23.2	33.3
20	8B_Heavy/Bulk_Diesel	20.0	27.6	40.0
21	8B_LTL/Dry Van_Diesel	7.8	18.2	27.9
22	8B_Mixed	7.5	20.3	33.1
23	8B_Refrigerated_Diesel	13.2	20.9	27.5
24	8B_Specialized_Diesel	7.3	24.4	37.0
25	8B_TL/Dry Van_Diesel	6.5	18.9	50.0
26	8B_Tanker_Diesel	17.5	24.6	34.6

Based on a review of previous out of range values, unit conversion problems are the most common source of data entry errors for payload. One type of error results from data being entered in pounds instead of short tons, resulting in overestimates by a factor of 2,000. Such errors should be easy to prevent using a reasonable upper bound ton level. Another possible source of error could be reporting metric or long tons instead of short tons, although detecting these errors will be extremely difficult, due to the small difference in units (roughly 10 percent difference). Finally, note that standard payload limitations can be waived by obtaining permits for heavy loads, or by avoiding over-the-road operation.[53] Accordingly, the absolute upper bound payload levels were set equal to 3 times the maximum observed values shown in Table 30.

However, no absolute lower-bound payload value was set, to allow for light package and specialty deliveries. Therefore, the only low end constraint is the requirement that payloads be > 0.

[53] One SmartWay Truck Partner indicated unusually high payloads for their Class 2b truck fleet, but noted they only use their trucks in terminal operations.

Average Volume
The maximum and minimum observed volumes from the 2011 dataset (prior to cleaning) are presented in Table 31.[54]

Table 31. Maximum and Minimum Observed Volumes (cubic feet)

Group #	Name	Min	Mean	Max
1	2B_Mixed	1	343	1,000
2	3_Mixed	1	498	940
3	4_Mixed	54	659	1,185
4	5_Mixed	141	1,215	1,894
5	6_LTL/Dry Van_Diesel	693	1,375	1,115
6	6_Mixed	336	1,324	878
7	6_Moving	141	1,382	1,894
8	6_Package_Diesel	300	1,398	1,800
9	6_TL/Dry Van_Diesel	693	1,255	1,521[55]
10	7_LTL/Dry Van_Diesel	693	1,687	3,765
11	7_Mixed	267	1,601	3,521
12	7_TL/Dry Van_Diesel	728	1,581	3,521
13	8A_LTL/Dry Van_Diesel	1,000	3,272	3,852
14	8A_Mixed	1	2,862	6,302
15	8A_Refrigerated_Diesel	1	2,759	3,780
16	8A_TL/Dry Van_Diesel	1,454	3,410	3,848
17	8B_AutoCarrier_Diesel	2,844	4,424	8,350
18	8B_Dray_Diesel	1,516	2,387	3,892
19	8B_Flatbed_Diesel	2,341	3,485	5,000
20	8B_Heavy/Bulk_Diesel	1,000	3,114	4,824
21	8B_LTL/Dry Van_Diesel	2,205	3,615	4,925
22	8B_Mixed	1,991	3,565	4,896
23	8B_Refrigerated_Diesel	3,171	3,721	4,068
24	8B_Specialized_Diesel	450	2,604	5,843
25	8B_TL/Dry Van_Diesel	1,159	3,740	6,316
26	8B_Tanker_Diesel	702	1,210	4,004

Maximum volumes are extremely difficult to define given the presence of non-uniform body styles, oversized loads, etc. Accordingly a simple upper bound was set at 3 times the maximum observed values shown above.

[54] As with the 2016 payload dataset, the 2016 volume data set did not allow for a distributional analysis.
[55] One Class 6 LTL fleet with an extreme outlier volume of 12,000 cubic feet was dropped for the purposes of this analysis.

However, no absolute lower-bound volume value was set, to allow for small package and specialty deliveries. Therefore, the only low end constraint is the requirement that volumes be > 0.

Average Used Cargo Volume %

Average used cargo volume % was frequently equal to 100 in the dataset. Accordingly, no upper bound was set for this field. In addition, no absolute lower-bound was set for utilization either, to allow for small package and LTL/specialty deliveries. The only requirement is that all values be ≥ 0 and ≤ 100.

The Truck Tool provides an option for Dray carriers allowing them to select an industry average used cargo volume % factor, since these carriers may not know how their containers are loaded. To calculate the industry average value the following calculation steps were performed:

1) All truck carriers with a Dray Operation tag were identified from the 2012 Truck Tool submittals - 109 dray carriers with 20,774 trucks. 75.9% of these trucks had a Chassis Body Type tag, 23.2% had a Dry Van tag, and 0.9% had a Mixed tag. No other body type tags were reported for dray carriers. Essentially all of these trucks were Class 8b diesels.

2) All *non*-dray carriers with Chassis, Dry Van, and Mixed Body Type tags were selected, and the average used cargo volume % was calculated for Body Type tag, weighted by the number of trucks. (This approach assumes that none of the average used cargo volume % values reported for Dray carriers were reliable, regardless of their Data Source selection.) There were 229,349 trucks in this data set. The weighted average used cargo volume % values for non-dray carriers were as follows.

Chassis	90.5%
Dry Van	84.8%
Mixed	85.4%

3) The weighted average used cargo volume % values from Step 2 were combined with the body type percentage distribution from Step 1 to obtain a single, industry average for used cargo volume % value for use by Dray carriers of 89.13%. This estimate applies for all truck classes and fuel types, as the data set is very thin for anything other than class 8b diesels. Note that this value will only be used if a Dray Carrier selects the "Industry Average" button on the Activity screen. Also note that the default option is only available to carriers that specified a non-zero Dray operations percentage in the Fleet Description section - otherwise the Industry Average button will not appear.

Percent Urban/Highway Miles

There is no clear distributional pattern associated with these data fields, with values frequently ranging from 0 to 100. Therefore, no lower or upper bound values are set.

Idle Hours per Day and Days of Use per Year

Absolute limits are placed on the number of hours per day (short plus long duration idle hours less than or equal to 24) and days of use per year (less than or equal to 365). In addition, since extended idling is defined as sustained idling events an hour or more in duration, warnings are issued for extended idle hour per day entries less than an hour.

4.0 Performance Metrics

The Truck Tool allows the user to calculate their emissions performance using a number of different metrics, at different levels of aggregation. Available performance metrics include:

- Grams per mile
- Grams per Payload Ton-Mile
- Grams per Thousand Cubic Foot-Miles
- Grams per Thousand Utilized Cubic Foot-Miles

The Internal Metrics report within the Truck Tool presents the results of 36 calculations (4 x 4 x 3 = 48), which represent the following four calculations for each of the three pollutants (CO_2, NOx, PM_{10} and $PM_{2.5}$) and for each of three different mileage types (total, loaded, and revenue). Note that all capitalized fields represent fields in the user interface:

1. **g/mile: ∑ E / M**
   where E = Emissions, M = Miles Driven
2. **g/avg payload ton-mile: ∑ E / (M × AP)**
   where E = Emissions, M = Miles Driven, AP = Average Payload
3. **g/avg cubic foot volume: ∑ E / (M × ACV)**
   where E = Emissions, M = Miles Driven, ACV = Average Cargo Volume
4. **g/avg utilized cubic foot: ∑ E / (M × ACV) / CU**
   where E = Emissions, M = Miles Driven, ACV = Average Cargo Volume, CU = % Cube Utilization

For all four calculations:

Emissions = grams of pollutant (as specified above)

Miles Driven = Total Miles, Revenue Miles, or Loaded Miles (Total Miles minus Empty Miles)

As shown in the equations above, summations are performed for the different metrics. Each of the metrics is automatically aggregated across model years (for NOx and PM) for all reporting purposes. Additional aggregation may be reported across truck classes, fuel types, fleets, and at the company level, as specified by the user.

Appendix A - MOVES2014a NOx, PM & BC Emission Factors (g/mi) 2018 Calendar Year

		Diesel														
		Highway			Urban											
					Decel			0-25			25-50			>50		
Model Yr	**Vehicle Class**	**NOx**	**BC**	**PM**	**NOx**	**BC**	**PM**	**NOx**	**BC**	**PM**	**NOx**	**BC**	**PM**	**NOx**	**BC**	**PM**
1987	HDV2B	15.855	0.36575	0.590	1.784	0.01035	0.022	27.099	0.38909	0.828	33.371	0.53895	1.143	16.817	0.44740	0.951
1987	HDV3	19.052	0.42585	0.657	2.034	0.01174	0.025	30.380	0.44783	0.912	39.375	0.67486	1.351	20.854	0.52367	1.068
1987	HDV4	18.578	0.42785	0.686	2.061	0.01276	0.028	29.990	0.44651	0.975	38.083	0.60591	1.321	19.480	0.56154	1.227
1987	HDV5	21.457	0.46271	0.686	2.016	0.01173	0.024	31.169	0.47504	0.935	41.324	0.73761	1.410	23.707	0.56553	1.118
1987	HDV6	21.823	0.46625	0.683	2.006	0.01143	0.023	31.387	0.47917	0.919	41.995	0.76779	1.428	24.527	0.56077	1.079
1987	HDV7	25.585	0.52128	0.719	1.963	0.01099	0.022	32.875	0.52603	0.935	45.851	0.90226	1.542	29.970	0.61852	1.105
1987	HDV8a	31.680	0.60939	0.773	1.867	0.00978	0.017	35.802	0.61609	0.949	53.781	1.18665	1.774	41.005	0.72307	1.117
1987	HDV8b	35.824	0.66967	0.810	1.770	0.00870	0.013	38.245	0.68827	0.962	60.046	1.41525	1.959	49.965	0.81079	1.135
1988	HDV2B	15.855	0.36575	0.5898	1.784	0.01035	0.0220	27.099	0.38909	0.8277	33.371	0.53895	1.1434	16.817	0.44740	0.9513
1988	HDV3	19.052	0.42585	0.6568	2.034	0.01174	0.0247	30.380	0.44783	0.9117	39.375	0.67486	1.3506	20.854	0.52367	1.0683
1988	HDV4	18.578	0.42785	0.6863	2.061	0.01276	0.0279	29.990	0.44651	0.9746	38.083	0.60591	1.3211	19.480	0.56154	1.2273
1988	HDV5	21.457	0.46271	0.6865	2.016	0.01173	0.0244	31.169	0.47504	0.9346	41.324	0.73761	1.4100	23.707	0.56553	1.1183
1988	HDV6	21.823	0.46625	0.6826	2.006	0.01143	0.0234	31.387	0.47917	0.9194	41.995	0.76779	1.4277	24.527	0.56077	1.0795
1988	HDV7	25.585	0.52128	0.7190	1.963	0.01099	0.0217	32.875	0.52603	0.9350	45.851	0.90226	1.5416	29.970	0.61852	1.1051
1988	HDV8a	31.680	0.60939	0.7725	1.867	0.00978	0.0170	35.802	0.61609	0.9488	53.781	1.18665	1.7740	41.005	0.72307	1.1167
1988	HDV8b	35.824	0.66967	0.8102	1.770	0.00870	0.0129	38.245	0.68827	0.9624	60.046	1.41525	1.9594	49.965	0.81079	1.1351
1989	HDV2B	22.089	0.46862	0.6792	1.926	0.01100	0.0224	30.928	0.47828	0.9052	41.269	0.76558	1.4012	24.826	0.55886	1.0622
1989	HDV3	16.911	0.39616	0.6393	2.039	0.01195	0.0256	29.494	0.42490	0.9081	37.264	0.60466	1.2876	18.175	0.50055	1.0706
1989	HDV4	18.364	0.42470	0.6827	2.060	0.01272	0.0278	29.937	0.44464	0.9705	37.967	0.60409	1.3169	19.308	0.55719	1.2179
1989	HDV5	19.663	0.43784	0.6711	2.033	0.01191	0.0252	30.497	0.45589	0.9295	39.756	0.68334	1.3634	21.469	0.54338	1.1111
1989	HDV6	22.205	0.47405	0.6909	2.006	0.01149	0.0236	31.433	0.48481	0.9284	42.390	0.77879	1.4400	25.038	0.57257	1.0996
1989	HDV7	21.575	0.46558	0.6862	2.017	0.01162	0.0240	31.135	0.47668	0.9281	41.751	0.75598	1.4218	24.102	0.56505	1.1021
1989	HDV8a	29.473	0.58010	0.7570	1.919	0.01038	0.0191	34.492	0.58356	0.9496	51.003	1.08163	1.6939	36.846	0.68876	1.1234
1989	HDV8b	35.720	0.66945	0.8115	1.776	0.00878	0.0132	38.159	0.68815	0.9668	59.885	1.40814	1.9565	49.714	0.81121	1.1414
1990	HDV2B	11.905	0.35369	0.5680	1.278	0.00986	0.0204	19.693	0.37608	0.7924	24.276	0.51065	1.0673	12.780	0.43435	0.9093
1990	HDV3	13.514	0.40932	0.6497	1.590	0.01225	0.0257	22.836	0.44076	0.9239	29.033	0.63477	1.3181	14.621	0.51988	1.0862

		Diesel														
		Highway			Urban											
					Decel			0-25			25-50			>50		
Model Yr	Vehicle Class	NOx	BC	PM	NOx	BC	PM	NOx	BC	PM	NOx	BC	PM	NOx	BC	PM
1990	HDV4	13.343	0.40474	0.6534	1.588	0.01222	0.0262	22.986	0.43722	0.9370	29.138	0.61124	1.3095	14.336	0.51824	1.1116
1990	HDV5	14.179	0.42114	0.6661	1.582	0.01221	0.0261	23.233	0.44811	0.9452	29.790	0.63819	1.3347	15.277	0.53537	1.1309
1990	HDV6	17.409	0.48032	0.6973	1.545	0.01147	0.0234	24.458	0.49590	0.9418	33.043	0.79237	1.4573	19.737	0.58008	1.1045
1990	HDV7	17.788	0.48760	0.7027	1.542	0.01145	0.0233	24.579	0.50139	0.9453	33.402	0.80711	1.4709	20.236	0.58848	1.1126
1990	HDV8a	24.593	0.61633	0.7827	1.445	0.00991	0.0172	27.665	0.62717	0.9705	41.796	1.19204	1.7911	31.922	0.73652	1.1418
1990	HDV8b	28.186	0.68457	0.8264	1.356	0.00866	0.0125	29.848	0.71118	0.9894	47.267	1.44775	2.0021	39.825	0.83838	1.1671
1991	HDV2B	10.676	0.25977	0.3876	1.314	0.01801	0.0314	17.528	0.32324	0.6563	21.606	0.37016	0.7167	11.510	0.32040	0.6094
1991	HDV3	12.309	0.29086	0.4447	1.457	0.01172	0.0243	21.057	0.39597	0.8161	27.229	0.43219	0.8798	13.221	0.33011	0.6746
1991	HDV4	17.898	0.46784	0.6145	1.393	0.01081	0.0207	23.204	0.49085	0.8456	32.645	0.77793	1.2378	20.821	0.52710	0.8589
1991	HDV5	12.660	0.28972	0.4283	1.472	0.01657	0.0312	20.124	0.37142	0.7745	25.718	0.40402	0.8064	13.430	0.33811	0.6734
1991	HDV6	15.516	0.39215	0.5415	1.427	0.01129	0.0225	22.167	0.44586	0.8320	30.188	0.61764	1.0710	17.310	0.43539	0.7731
1991	HDV7	18.674	0.48757	0.6319	1.393	0.01082	0.0206	23.378	0.49954	0.8504	33.503	0.81433	1.2732	21.886	0.54844	0.8796
1991	HDV8a	24.265	0.66836	0.8052	1.308	0.00944	0.0148	26.063	0.62680	0.8888	41.319	1.30747	1.7854	32.481	0.82625	1.1386
1991	HDV8b	26.579	0.75190	0.8869	1.239	0.00848	0.0114	27.625	0.68934	0.9068	44.833	1.57292	2.0554	37.723	0.97487	1.2759
1992	HDV2B	9.992	0.23992	0.3558	1.224	0.01719	0.0294	15.928	0.28788	0.5769	19.405	0.33240	0.6359	10.790	0.29686	0.5566
1992	HDV3	12.057	0.28551	0.4373	1.406	0.01149	0.0235	20.580	0.38615	0.7913	26.392	0.41874	0.8532	12.921	0.32258	0.6583
1992	HDV4	12.153	0.28900	0.4446	1.457	0.01171	0.0241	21.062	0.39611	0.8139	27.105	0.42889	0.8802	13.044	0.32922	0.6761
1992	HDV5	13.073	0.29213	0.4408	1.460	0.01204	0.0254	21.234	0.39208	0.8237	27.598	0.40678	0.8416	13.866	0.32307	0.6731
1992	HDV6	16.198	0.41126	0.5605	1.418	0.01116	0.0218	22.467	0.45983	0.8360	30.925	0.65611	1.1155	18.307	0.45974	0.7986
1992	HDV7	18.352	0.47191	0.6164	1.399	0.01096	0.0211	23.231	0.49071	0.8497	33.008	0.76856	1.2265	21.229	0.52573	0.8610
1992	HDV8a	24.569	0.67936	0.8161	1.297	0.00932	0.0144	26.315	0.63430	0.8926	41.606	1.33317	1.8114	33.045	0.84224	1.1544
1992	HDV8b	26.677	0.74807	0.8823	1.235	0.00850	0.0114	27.696	0.69195	0.9114	44.990	1.56041	2.0443	37.961	0.97207	1.2752
1993	HDV2B	11.194	0.27169	0.4111	1.404	0.01628	0.0296	18.928	0.35060	0.7167	23.497	0.39220	0.7777	11.947	0.32648	0.6399
1993	HDV3	11.956	0.28508	0.4369	1.439	0.01255	0.0252	20.568	0.38436	0.7923	26.251	0.41866	0.8522	12.784	0.32652	0.6649
1993	HDV4	13.459	0.33052	0.4840	1.443	0.01154	0.0236	21.486	0.41428	0.8196	28.172	0.50067	0.9511	14.618	0.37002	0.7134
1993	HDV5	12.460	0.29065	0.4436	1.457	0.01183	0.0247	21.082	0.39288	0.8166	27.228	0.42142	0.8642	13.314	0.32698	0.6743

		Diesel														
		Highway			Urban											
					Decel			0-25			25-50			>50		
Model Yr	**Vehicle Class**	**NOx**	**BC**	**PM**	**NOx**	**BC**	**PM**	**NOx**	**BC**	**PM**	**NOx**	**BC**	**PM**	**NOx**	**BC**	**PM**
1993	HDV6	15.618	0.39334	0.5426	1.426	0.01133	0.0227	22.197	0.44435	0.8315	30.154	0.61208	1.0631	17.352	0.43418	0.7739
1993	HDV7	16.709	0.43125	0.5793	1.416	0.01112	0.0218	22.576	0.46445	0.8366	31.382	0.69425	1.1497	18.954	0.47911	0.8152
1993	HDV8a	24.435	0.67957	0.8168	1.302	0.00934	0.0146	26.204	0.63075	0.8891	41.441	1.33552	1.8124	32.774	0.84051	1.1514
1993	HDV8b	26.699	0.75300	0.8875	1.237	0.00848	0.0114	27.702	0.69253	0.9098	45.021	1.57625	2.0592	38.001	0.97867	1.2802
1994	HDV2B	10.993	0.31462	0.4875	1.179	0.01563	0.0328	17.939	0.48776	1.0401	22.347	0.46373	0.9812	11.731	0.32339	0.6856
1994	HDV3	11.824	0.35178	0.5406	1.384	0.01895	0.0396	19.772	0.54880	1.1653	25.091	0.55118	1.1544	12.645	0.37604	0.7915
1994	HDV4	12.169	0.36190	0.5637	1.457	0.01959	0.0423	21.071	0.57096	1.2314	27.130	0.57154	1.2318	13.066	0.38974	0.8405
1994	HDV5	12.985	0.38471	0.5889	1.459	0.02004	0.0435	21.215	0.59023	1.2763	27.680	0.59218	1.2578	13.874	0.41887	0.9001
1994	HDV6	15.268	0.44397	0.6318	1.436	0.01912	0.0401	21.997	0.60608	1.2228	29.911	0.75400	1.4086	16.856	0.46351	0.9049
1994	HDV7	18.397	0.52626	0.6938	1.400	0.01786	0.0354	23.237	0.63343	1.1573	33.290	1.00340	1.6397	21.484	0.53852	0.9319
1994	HDV8a	24.971	0.69993	0.8285	1.295	0.01447	0.0224	26.480	0.71451	1.0187	42.390	1.66393	2.2556	33.989	0.75159	1.0403
1994	HDV8b	26.612	0.74354	0.8623	1.241	0.01311	0.0179	27.639	0.73419	0.9717	44.870	1.87157	2.4412	37.778	0.81543	1.0701
1995	HDV2B	10.286	0.32176	0.4835	1.322	0.02028	0.0387	16.527	0.52533	1.0667	20.098	0.50682	1.0057	11.071	0.36205	0.7199
1995	HDV3	12.313	0.36648	0.5675	1.449	0.01977	0.0424	20.899	0.58054	1.2470	27.005	0.58168	1.2373	13.250	0.39758	0.8497
1995	HDV4	12.973	0.38408	0.5811	1.444	0.01968	0.0418	21.138	0.58685	1.2365	27.487	0.62304	1.2750	14.037	0.41185	0.8570
1995	HDV5	14.377	0.42081	0.6166	1.443	0.01961	0.0418	21.735	0.60671	1.2607	28.963	0.68713	1.3486	15.636	0.44785	0.9103
1995	HDV6	15.766	0.45649	0.6406	1.427	0.01884	0.0391	22.258	0.61412	1.2130	30.517	0.80328	1.4554	17.673	0.47496	0.9021
1995	HDV7	17.814	0.51052	0.6825	1.406	0.01816	0.0364	23.016	0.63299	1.1793	32.688	0.95854	1.6002	20.633	0.52564	0.9290
1995	HDV8a	24.821	0.69629	0.8251	1.301	0.01463	0.0231	26.379	0.70833	1.0186	42.136	1.65661	2.2444	33.624	0.74466	1.0343
1995	HDV8b	26.566	0.74246	0.8605	1.245	0.01315	0.0181	27.596	0.72728	0.9640	44.785	1.87735	2.4413	37.643	0.81092	1.0627
1996	HDV2B	10.415	0.33238	0.4992	1.324	0.02067	0.0397	17.147	0.53333	1.0856	20.633	0.52847	1.0541	11.118	0.37119	0.7412
1996	HDV3	12.380	0.36821	0.5670	1.459	0.01956	0.0418	21.087	0.57047	1.2199	27.094	0.58873	1.2446	13.347	0.39421	0.8385
1996	HDV4	14.205	0.41524	0.6052	1.443	0.01899	0.0400	21.862	0.58830	1.2003	28.826	0.70087	1.3540	15.620	0.43292	0.8628
1996	HDV5	15.592	0.45319	0.6410	1.437	0.01935	0.0406	22.113	0.61191	1.2352	29.728	0.75766	1.4099	17.101	0.47388	0.9270
1996	HDV6	16.917	0.48788	0.6629	1.423	0.01835	0.0374	22.743	0.61309	1.1721	31.478	0.89315	1.5330	19.224	0.49749	0.9054
1996	HDV7	19.457	0.55349	0.7143	1.393	0.01739	0.0336	23.762	0.64221	1.1327	34.417	1.09374	1.7234	23.238	0.56609	0.9438

		Diesel														
		Highway			Urban											
					Decel			0-25			25-50			>50		
Model Yr	**Vehicle Class**	**NOx**	**BC**	**PM**	**NOx**	**BC**	**PM**	**NOx**	**BC**	**PM**	**NOx**	**BC**	**PM**	**NOx**	**BC**	**PM**
1996	HDV8a	25.176	0.70605	0.8321	1.299	0.01431	0.0220	26.692	0.70980	1.0026	42.513	1.70270	2.2849	34.460	0.75571	1.0355
1996	HDV8b	26.767	0.74849	0.8659	1.246	0.01304	0.0177	27.831	0.73360	0.9646	44.943	1.90063	2.4654	38.192	0.82109	1.0709
1997	HDV2B	8.854	0.29424	0.4366	1.192	0.01945	0.0359	14.087	0.48961	0.9713	16.423	0.46225	0.8934	9.420	0.33750	0.6532
1997	HDV3	13.052	0.38733	0.5804	1.425	0.01965	0.0412	20.887	0.58712	1.2275	26.935	0.63300	1.2698	14.124	0.41475	0.8514
1997	HDV4	12.219	0.36383	0.5692	1.463	0.01988	0.0430	21.178	0.58782	1.2720	27.089	0.57276	1.2395	13.155	0.39791	0.8611
1997	HDV5	13.501	0.39863	0.6039	1.460	0.02023	0.0439	21.489	0.60732	1.3064	27.921	0.61487	1.2834	14.448	0.43566	0.9282
1997	HDV6	14.261	0.41690	0.6103	1.446	0.01937	0.0411	21.831	0.60259	1.2433	28.897	0.70145	1.3586	15.663	0.44094	0.8868
1997	HDV7	15.941	0.46120	0.6440	1.434	0.01887	0.0391	22.367	0.61412	1.2140	30.574	0.82301	1.4706	17.910	0.47802	0.9041
1997	HDV8a	24.023	0.67495	0.8064	1.322	0.01506	0.0250	26.051	0.68612	1.0220	40.615	1.58209	2.1644	31.865	0.70834	1.0052
1997	HDV8b	26.395	0.73765	0.8549	1.257	0.01325	0.0187	27.587	0.71417	0.9523	44.274	1.87192	2.4272	37.248	0.79889	1.0475
1998	HDV2B	6.958	0.14529	0.2139	1.020	0.01822	0.0311	9.827	0.14832	0.2766	11.393	0.19621	0.3566	7.981	0.21879	0.3884
1998	HDV3	11.350	0.19586	0.3208	1.685	0.01984	0.0405	18.148	0.22810	0.4687	22.883	0.32468	0.6666	13.762	0.27929	0.5729
1998	HDV4	11.495	0.19761	0.3244	1.721	0.01994	0.0411	18.437	0.23096	0.4755	23.393	0.33062	0.6806	14.006	0.28197	0.5807
1998	HDV5	11.813	0.19715	0.3231	1.722	0.02054	0.0426	18.496	0.22380	0.4635	23.489	0.31621	0.6546	14.277	0.28732	0.5961
1998	HDV6	11.745	0.20092	0.3269	1.721	0.02005	0.0413	18.475	0.23115	0.4740	23.582	0.33495	0.6827	14.299	0.28602	0.5864
1998	HDV7	13.462	0.23291	0.3543	1.701	0.01967	0.0400	18.996	0.25376	0.4895	24.891	0.39838	0.7473	16.461	0.31246	0.6078
1998	HDV8a	22.325	0.41825	0.5150	1.549	0.01467	0.0241	22.513	0.44414	0.6415	34.802	0.94211	1.3320	32.121	0.50524	0.7344
1998	HDV8b	24.731	0.46975	0.5605	1.458	0.01246	0.0175	23.996	0.51392	0.6966	38.205	1.13841	1.5378	37.908	0.57921	0.7861
1999	HDV2B	5.061	0.15658	0.2276	0.914	0.02227	0.0373	7.534	0.15972	0.2949	8.419	0.21011	0.3772	6.473	0.25380	0.4444
1999	HDV3	7.030	0.19024	0.3145	0.930	0.02099	0.0431	11.411	0.21771	0.4514	12.478	0.30063	0.6217	8.924	0.28407	0.5869
1999	HDV4	7.125	0.19172	0.3185	0.929	0.02082	0.0434	11.613	0.22062	0.4594	12.744	0.30637	0.6376	9.074	0.28551	0.5951
1999	HDV5	7.235	0.19439	0.3208	0.930	0.02078	0.0433	11.651	0.22222	0.4607	12.866	0.31266	0.6446	9.207	0.28757	0.5965
1999	HDV6	7.485	0.20026	0.3254	0.924	0.02093	0.0436	11.665	0.22358	0.4591	12.957	0.31841	0.6468	9.451	0.29421	0.6061
1999	HDV7	8.420	0.22295	0.3450	0.929	0.02043	0.0420	12.156	0.24121	0.4741	13.960	0.37202	0.7072	10.582	0.31086	0.6147
1999	HDV8a	16.576	0.42604	0.5219	0.945	0.01469	0.0241	18.116	0.45239	0.6467	24.607	0.96987	1.3580	23.539	0.51705	0.7460
1999	HDV8b	18.580	0.47806	0.5686	0.931	0.01229	0.0171	20.249	0.52396	0.7058	27.888	1.16825	1.5690	27.851	0.58869	0.7943

		Diesel														
		Highway			Urban											
					Decel			0-25			25-50			>50		
Model Yr	Vehicle Class	NOx	BC	PM	NOx	BC	PM	NOx	BC	PM	NOx	BC	PM	NOx	BC	PM
2000	HDV2B	5.437	0.15713	0.2397	0.857	0.02010	0.0352	8.194	0.16538	0.3187	8.914	0.21503	0.4050	6.775	0.24231	0.4457
2000	HDV3	7.077	0.19085	0.3158	0.926	0.02077	0.0428	11.494	0.21907	0.4545	12.597	0.30355	0.6290	8.990	0.28373	0.5873
2000	HDV4	7.258	0.19482	0.3211	0.930	0.02075	0.0431	11.675	0.22295	0.4616	12.915	0.31434	0.6476	9.236	0.28775	0.5956
2000	HDV5	7.403	0.19822	0.3239	0.932	0.02070	0.0429	11.723	0.22498	0.4632	13.075	0.32235	0.6565	9.411	0.29047	0.5973
2000	HDV6	7.413	0.19839	0.3238	0.926	0.02091	0.0435	11.644	0.22274	0.4590	12.939	0.31620	0.6460	9.379	0.29250	0.6035
2000	HDV7	9.296	0.24526	0.3647	0.929	0.01995	0.0405	12.739	0.26090	0.4911	14.813	0.42126	0.7617	11.624	0.32721	0.6236
2000	HDV8a	15.760	0.40542	0.5040	0.935	0.01544	0.0265	17.437	0.42637	0.6255	23.169	0.88957	1.2705	21.857	0.49020	0.7280
2000	HDV8b	18.559	0.47797	0.5686	0.932	0.01235	0.0173	20.223	0.52325	0.7054	27.820	1.16598	1.5663	27.771	0.58780	0.7941
2001	HDV2B	4.180	0.14666	0.1957	0.913	0.02347	0.0373	6.081	0.14254	0.2433	7.173	0.19086	0.3181	5.589	0.25235	0.4127
2001	HDV3	7.077	0.19209	0.3149	0.934	0.02110	0.0428	11.388	0.21872	0.4505	12.489	0.30482	0.6239	8.962	0.28534	0.5840
2001	HDV4	7.149	0.19230	0.3191	0.931	0.02074	0.0432	11.655	0.22162	0.4609	12.801	0.30874	0.6418	9.105	0.28528	0.5936
2001	HDV5	7.250	0.19476	0.3211	0.932	0.02070	0.0430	11.689	0.22310	0.4621	12.912	0.31456	0.6482	9.225	0.28716	0.5949
2001	HDV6	8.352	0.22203	0.3445	0.924	0.02057	0.0425	12.131	0.23977	0.4723	13.724	0.36213	0.6943	10.406	0.30976	0.6165
2001	HDV7	8.223	0.21827	0.3410	0.927	0.02050	0.0423	12.089	0.23805	0.4716	13.722	0.35959	0.6938	10.319	0.30679	0.6121
2001	HDV8a	17.101	0.43969	0.5343	0.937	0.01409	0.0224	18.674	0.47016	0.6613	25.345	1.01596	1.4063	24.572	0.53436	0.7576
2001	HDV8b	18.520	0.47570	0.5661	0.928	0.01233	0.0172	20.181	0.52128	0.7029	27.807	1.16056	1.5606	27.764	0.58684	0.7926
2002	HDV2B	4.114	0.14507	0.1930	0.906	0.02344	0.0373	5.939	0.13978	0.2380	7.047	0.18687	0.3099	5.531	0.25351	0.4145
2002	HDV3	6.717	0.18397	0.3039	0.903	0.02191	0.0443	10.672	0.20559	0.4259	11.638	0.27498	0.5656	8.499	0.28647	0.5876
2002	HDV4	6.916	0.18674	0.3132	0.905	0.02173	0.0456	11.137	0.21181	0.4444	12.229	0.28522	0.5984	8.832	0.29042	0.6094
2002	HDV5	6.916	0.18674	0.3132	0.905	0.02173	0.0456	11.137	0.21181	0.4444	12.229	0.28522	0.5984	8.832	0.29042	0.6094
2002	HDV6	7.140	0.19176	0.3169	0.901	0.02189	0.0460	11.113	0.21128	0.4411	12.296	0.28832	0.5984	9.039	0.29653	0.6200
2002	HDV7	8.913	0.23595	0.3558	0.903	0.02094	0.0432	12.183	0.24761	0.4725	14.013	0.38465	0.7055	11.083	0.32732	0.6360
2002	HDV8a	16.022	0.41186	0.5091	0.928	0.01554	0.0265	17.489	0.43186	0.6269	23.514	0.91045	1.2866	22.413	0.50222	0.7400
2002	HDV8b	18.425	0.47224	0.5625	0.922	0.01251	0.0175	20.040	0.51668	0.6977	27.649	1.14781	1.5449	27.628	0.58506	0.7918
2003	HDV2B	3.214	0.12515	0.1695	0.415	0.01962	0.0315	4.139	0.12141	0.2099	5.716	0.16112	0.2710	4.570	0.21474	0.3551
2003	HDV3	5.251	0.16719	0.2759	1.281	0.01935	0.0392	9.249	0.18791	0.3890	9.428	0.25365	0.5219	7.178	0.25642	0.5264

		Diesel														
		Highway			Urban											
					Decel			0-25			25-50			>50		
Model Yr	Vehicle Class	NOx	BC	PM	NOx	BC	PM	NOx	BC	PM	NOx	BC	PM	NOx	BC	PM
2003	HDV4	5.407	0.16990	0.2840	1.415	0.01937	0.0405	9.715	0.19360	0.4051	9.875	0.26330	0.5509	7.463	0.26088	0.5459
2003	HDV5	5.407	0.16990	0.2840	1.415	0.01937	0.0405	9.715	0.19360	0.4051	9.875	0.26330	0.5509	7.463	0.26088	0.5459
2003	HDV6	5.529	0.17479	0.2878	1.411	0.01949	0.0408	9.759	0.19389	0.4030	9.973	0.26784	0.5528	7.593	0.26648	0.5547
2003	HDV7	6.114	0.21844	0.3262	1.394	0.01858	0.0381	10.114	0.22971	0.4337	10.566	0.36322	0.6583	8.212	0.29761	0.5720
2003	HDV8a	8.317	0.37828	0.4657	1.313	0.01374	0.0231	11.787	0.39827	0.5742	13.782	0.84541	1.1889	11.513	0.45975	0.6716
2003	HDV8b	9.031	0.42978	0.5113	1.244	0.01120	0.0156	12.579	0.47075	0.6344	15.023	1.04822	1.4085	12.903	0.53136	0.7175
2004	HDV2B	3.033	0.12634	0.1721	0.413	0.01972	0.0318	4.115	0.12306	0.2144	5.386	0.16250	0.2749	4.262	0.21657	0.3604
2004	HDV3	5.260	0.16614	0.2753	1.288	0.01955	0.0399	9.280	0.18624	0.3870	9.428	0.24938	0.5152	7.200	0.25779	0.5317
2004	HDV4	5.419	0.16853	0.2826	1.411	0.01958	0.0411	9.711	0.19121	0.4012	9.873	0.25765	0.5406	7.495	0.26185	0.5494
2004	HDV5	5.419	0.16853	0.2826	1.411	0.01958	0.0411	9.711	0.19121	0.4012	9.873	0.25765	0.5406	7.495	0.26185	0.5494
2004	HDV6	5.529	0.17315	0.2862	1.408	0.01965	0.0412	9.753	0.19198	0.4000	9.963	0.26282	0.5441	7.610	0.26675	0.5566
2004	HDV7	6.047	0.21102	0.3194	1.393	0.01886	0.0389	10.065	0.22285	0.4264	10.485	0.34488	0.6351	8.154	0.29362	0.5714
2004	HDV8a	8.226	0.36647	0.4548	1.313	0.01420	0.0244	11.690	0.38355	0.5604	13.596	0.80328	1.1413	11.350	0.44772	0.6642
2004	HDV8b	9.017	0.42327	0.5049	1.242	0.01141	0.0161	12.551	0.46253	0.6263	14.976	1.02433	1.3820	12.876	0.52509	0.7127
2005	HDV2B	2.833	0.13089	0.1701	0.371	0.02147	0.0338	3.672	0.12521	0.2090	5.277	0.16895	0.2757	4.143	0.23040	0.3706
2005	HDV3	5.153	0.16757	0.2742	1.233	0.01953	0.0389	9.056	0.18796	0.3864	9.217	0.25471	0.5194	7.004	0.25610	0.5197
2005	HDV4	5.397	0.17088	0.2850	1.418	0.01919	0.0401	9.717	0.19533	0.4080	9.874	0.26749	0.5587	7.437	0.25993	0.5430
2005	HDV5	5.397	0.17088	0.2850	1.418	0.01919	0.0401	9.717	0.19533	0.4080	9.874	0.26749	0.5587	7.437	0.25993	0.5430
2005	HDV6	5.511	0.17631	0.2894	1.415	0.01923	0.0402	9.763	0.19712	0.4078	9.976	0.27526	0.5651	7.562	0.26532	0.5498
2005	HDV7	6.138	0.22147	0.3290	1.395	0.01832	0.0374	10.141	0.23393	0.4387	10.609	0.37376	0.6732	8.232	0.29853	0.5694
2005	HDV8a	8.341	0.37754	0.4648	1.310	0.01365	0.0228	11.811	0.39826	0.5739	13.820	0.84494	1.1893	11.557	0.45974	0.6704
2005	HDV8b	9.030	0.42675	0.5083	1.242	0.01126	0.0157	12.573	0.46719	0.6308	15.013	1.03782	1.3973	12.902	0.52862	0.7151
2006	HDV2B	2.940	0.13960	0.1800	0.388	0.02323	0.0364	3.816	0.13335	0.2212	5.544	0.18081	0.2934	4.338	0.24787	0.3969
2006	HDV3	5.168	0.16793	0.2747	1.235	0.01992	0.0395	9.073	0.18806	0.3865	9.257	0.25449	0.5186	7.042	0.25886	0.5246
2006	HDV4	5.402	0.17037	0.2845	1.416	0.01928	0.0403	9.716	0.19443	0.4065	9.874	0.26531	0.5547	7.450	0.26042	0.5445
2006	HDV5	5.402	0.17037	0.2845	1.416	0.01928	0.0403	9.716	0.19443	0.4065	9.874	0.26531	0.5547	7.450	0.26042	0.5445

		Diesel														
		Highway			Urban											
					Decel			0-25			25-50			>50		
Model Yr	Vehicle Class	NOx	BC	PM	NOx	BC	PM	NOx	BC	PM	NOx	BC	PM	NOx	BC	PM
2006	HDV6	5.505	0.17559	0.2888	1.414	0.01930	0.0403	9.759	0.19651	0.4069	9.969	0.27346	0.5620	7.562	0.26532	0.5503
2006	HDV7	6.092	0.21806	0.3260	1.396	0.01845	0.0377	10.112	0.23096	0.4359	10.559	0.36568	0.6633	8.186	0.29641	0.5688
2006	HDV8a	8.286	0.37476	0.4625	1.313	0.01381	0.0233	11.760	0.39433	0.5708	13.724	0.83368	1.1767	11.455	0.45572	0.6683
2006	HDV8b	9.019	0.42740	0.5090	1.244	0.01126	0.0157	12.564	0.46777	0.6316	14.995	1.03942	1.3991	12.877	0.52866	0.7153
2007	HDV2B	1.623	0.00102	0.0105	0.624	0.00049	0.0051	2.508	0.00127	0.0135	2.967	0.00162	0.0171	2.189	0.00165	0.0174
2007	HDV3	2.968	0.00095	0.0106	0.589	0.00023	0.0025	5.220	0.00155	0.0172	5.307	0.00182	0.0202	4.099	0.00146	0.0162
2007	HDV4	3.071	0.00095	0.0106	0.585	0.00019	0.0021	5.473	0.00157	0.0176	5.592	0.00183	0.0205	4.313	0.00144	0.0161
2007	HDV5	3.071	0.00095	0.0106	0.585	0.00019	0.0021	5.473	0.00157	0.0176	5.592	0.00183	0.0205	4.313	0.00144	0.0161
2007	HDV6	3.148	0.00097	0.0108	0.586	0.00019	0.0021	5.504	0.00158	0.0177	5.668	0.00186	0.0208	4.379	0.00145	0.0163
2007	HDV7	3.772	0.00113	0.0127	0.543	0.00018	0.0020	6.095	0.00175	0.0195	6.452	0.00225	0.0251	5.012	0.00157	0.0175
2007	HDV8a	5.666	0.00164	0.0184	0.342	0.00016	0.0018	8.387	0.00240	0.0269	9.867	0.00389	0.0435	7.735	0.00205	0.0230
2007	HDV8b	6.201	0.00179	0.0200	0.253	0.00014	0.0016	9.290	0.00266	0.0297	11.017	0.00447	0.0499	8.692	0.00223	0.0250
2008	HDV2B	1.483	0.00102	0.0106	0.659	0.00052	0.0055	2.263	0.00126	0.0133	2.853	0.00160	0.0169	2.068	0.00169	0.0178
2008	HDV3	2.725	0.00092	0.0102	0.647	0.00025	0.0028	4.743	0.00145	0.0161	4.815	0.00162	0.0180	3.738	0.00149	0.0165
2008	HDV4	2.875	0.00090	0.0101	0.646	0.00019	0.0021	5.091	0.00147	0.0165	5.192	0.00163	0.0182	4.031	0.00145	0.0162
2008	HDV5	2.875	0.00090	0.0101	0.646	0.00019	0.0021	5.091	0.00147	0.0165	5.192	0.00163	0.0182	4.031	0.00145	0.0162
2008	HDV6	2.920	0.00091	0.0102	0.646	0.00019	0.0021	5.113	0.00148	0.0165	5.236	0.00164	0.0184	4.070	0.00146	0.0163
2008	HDV7	3.233	0.00100	0.0111	0.624	0.00019	0.0021	5.405	0.00156	0.0174	5.615	0.00183	0.0204	4.374	0.00151	0.0169
2008	HDV8a	5.066	0.00148	0.0166	0.444	0.00017	0.0019	7.455	0.00214	0.0239	8.568	0.00325	0.0363	6.725	0.00190	0.0212
2008	HDV8b	6.068	0.00175	0.0196	0.281	0.00015	0.0016	9.044	0.00259	0.0289	10.686	0.00429	0.0480	8.449	0.00219	0.0244
2009	HDV2B	1.376	0.00094	0.0095	0.512	0.00040	0.0041	2.082	0.00110	0.0115	2.467	0.00150	0.0156	1.838	0.00149	0.0155
2009	HDV3	2.965	0.00096	0.0106	0.557	0.00022	0.0024	5.202	0.00154	0.0172	5.253	0.00184	0.0204	4.063	0.00145	0.0160
2009	HDV4	3.123	0.00096	0.0107	0.569	0.00019	0.0021	5.573	0.00160	0.0179	5.698	0.00189	0.0211	4.388	0.00144	0.0161
2009	HDV5	3.123	0.00096	0.0107	0.569	0.00019	0.0021	5.573	0.00160	0.0179	5.698	0.00189	0.0211	4.388	0.00144	0.0161
2009	HDV6	3.201	0.00098	0.0109	0.574	0.00019	0.0021	5.584	0.00160	0.0179	5.756	0.00191	0.0213	4.443	0.00146	0.0163
2009	HDV7	3.854	0.00116	0.0129	0.528	0.00018	0.0020	6.212	0.00178	0.0199	6.588	0.00232	0.0259	5.110	0.00158	0.0176

		Diesel														
		Highway			Urban											
					Decel			0-25			25-50			>50		
Model Yr	Vehicle Class	NOx	BC	PM	NOx	BC	PM	NOx	BC	PM	NOx	BC	PM	NOx	BC	PM
2009	HDV8a	5.746	0.00167	0.0187	0.327	0.00016	0.0018	8.529	0.00244	0.0273	10.048	0.00399	0.0446	7.858	0.00208	0.0232
2009	HDV8b	6.246	0.00181	0.0202	0.244	0.00014	0.0016	9.378	0.00269	0.0300	11.121	0.00453	0.0506	8.753	0.00225	0.0251
2010	HDV2B	0.536	0.00084	0.0083	0.214	0.00033	0.0034	0.736	0.00093	0.0096	0.974	0.00134	0.0137	0.740	0.00132	0.0134
2010	HDV3	0.881	0.00087	0.0096	0.238	0.00020	0.0022	1.553	0.00138	0.0154	1.577	0.00164	0.0181	1.185	0.00132	0.0146
2010	HDV4	0.924	0.00087	0.0098	0.245	0.00017	0.0019	1.673	0.00145	0.0162	1.699	0.00170	0.0190	1.266	0.00132	0.0148
2010	HDV5	0.924	0.00087	0.0098	0.245	0.00017	0.0019	1.673	0.00145	0.0162	1.699	0.00170	0.0190	1.266	0.00132	0.0148
2010	HDV6	0.949	0.00089	0.0099	0.245	0.00017	0.0019	1.683	0.00145	0.0162	1.721	0.00171	0.0191	1.295	0.00134	0.0150
2010	HDV7	1.069	0.00104	0.0117	0.242	0.00017	0.0019	1.759	0.00161	0.0180	1.843	0.00206	0.0230	1.423	0.00144	0.0161
2010	HDV8a	1.474	0.00155	0.0173	0.230	0.00015	0.0017	2.083	0.00226	0.0253	2.443	0.00366	0.0409	2.041	0.00193	0.0216
2010	HDV8b	1.593	0.00170	0.0190	0.219	0.00014	0.0015	2.220	0.00252	0.0282	2.650	0.00425	0.0475	2.274	0.00212	0.0237
2011	HDV2B	0.587	0.00084	0.0087	0.269	0.00041	0.0043	0.867	0.00103	0.0109	1.151	0.00134	0.0142	0.843	0.00138	0.0147
2011	HDV3	0.884	0.00085	0.0094	0.247	0.00022	0.0024	1.556	0.00135	0.0150	1.595	0.00156	0.0173	1.204	0.00133	0.0147
2011	HDV4	0.922	0.00085	0.0095	0.242	0.00017	0.0019	1.658	0.00140	0.0156	1.685	0.00160	0.0179	1.271	0.00132	0.0147
2011	HDV5	0.922	0.00085	0.0095	0.242	0.00017	0.0019	1.658	0.00140	0.0156	1.685	0.00160	0.0179	1.271	0.00132	0.0147
2011	HDV6	0.941	0.00086	0.0096	0.241	0.00017	0.0019	1.667	0.00140	0.0157	1.703	0.00162	0.0181	1.292	0.00133	0.0149
2011	HDV7	1.038	0.00099	0.0110	0.239	0.00017	0.0019	1.729	0.00153	0.0171	1.801	0.00190	0.0212	1.394	0.00141	0.0158
2011	HDV8a	1.442	0.00149	0.0167	0.229	0.00015	0.0017	2.046	0.00217	0.0242	2.380	0.00344	0.0385	1.982	0.00187	0.0209
2011	HDV8b	1.588	0.00168	0.0188	0.219	0.00014	0.0015	2.212	0.00249	0.0279	2.638	0.00417	0.0467	2.264	0.00210	0.0234
2012	HDV2B	0.600	0.00084	0.0088	0.269	0.00041	0.0043	0.894	0.00104	0.0111	1.166	0.00135	0.0143	0.856	0.00138	0.0147
2012	HDV3	0.890	0.00085	0.0094	0.246	0.00021	0.0023	1.574	0.00136	0.0151	1.609	0.00157	0.0174	1.215	0.00133	0.0147
2012	HDV4	0.921	0.00085	0.0095	0.242	0.00017	0.0019	1.657	0.00140	0.0156	1.683	0.00160	0.0179	1.269	0.00132	0.0147
2012	HDV5	0.921	0.00085	0.0095	0.242	0.00017	0.0019	1.657	0.00140	0.0156	1.683	0.00160	0.0179	1.269	0.00132	0.0147
2012	HDV6	0.940	0.00086	0.0097	0.242	0.00017	0.0019	1.667	0.00141	0.0157	1.702	0.00163	0.0182	1.289	0.00133	0.0149
2012	HDV7	1.001	0.00094	0.0105	0.240	0.00017	0.0019	1.706	0.00148	0.0166	1.762	0.00180	0.0201	1.353	0.00138	0.0154
2012	HDV8a	1.385	0.00141	0.0158	0.232	0.00015	0.0017	1.989	0.00204	0.0229	2.292	0.00317	0.0355	1.887	0.00179	0.0200
2012	HDV8b	1.570	0.00164	0.0184	0.220	0.00014	0.0015	2.191	0.00243	0.0272	2.601	0.00402	0.0450	2.226	0.00205	0.0229

		Diesel														
		Highway			Urban											
					Decel			0-25			25-50			>50		
Model Yr	Vehicle Class	NOx	BC	PM	NOx	BC	PM	NOx	BC	PM	NOx	BC	PM	NOx	BC	PM
2013	HDV2B	0.576	0.00080	0.0084	0.263	0.00039	0.0042	0.867	0.00100	0.0108	1.137	0.00130	0.0139	0.834	0.00134	0.0143
2013	HDV3	0.814	0.00077	0.0085	0.226	0.00019	0.0021	1.440	0.00123	0.0137	1.476	0.00142	0.0158	1.115	0.00121	0.0134
2013	HDV4	0.837	0.00076	0.0085	0.220	0.00016	0.0017	1.506	0.00126	0.0141	1.530	0.00144	0.0160	1.155	0.00119	0.0133
2013	HDV5	0.837	0.00076	0.0085	0.220	0.00016	0.0017	1.506	0.00126	0.0141	1.530	0.00144	0.0160	1.155	0.00119	0.0133
2013	HDV6	0.852	0.00078	0.0087	0.219	0.00015	0.0017	1.513	0.00127	0.0141	1.544	0.00146	0.0163	1.171	0.00120	0.0134
2013	HDV7	0.902	0.00084	0.0094	0.218	0.00015	0.0017	1.543	0.00133	0.0148	1.593	0.00160	0.0179	1.222	0.00124	0.0138
2013	HDV8a	1.226	0.00124	0.0139	0.209	0.00014	0.0015	1.769	0.00180	0.0201	2.035	0.00277	0.0310	1.672	0.00158	0.0176
2013	HDV8b	1.391	0.00144	0.0161	0.195	0.00012	0.0014	1.942	0.00214	0.0239	2.304	0.00353	0.0395	1.971	0.00180	0.0201
2014	HDV2B	0.579	0.00080	0.0084	0.263	0.00039	0.0042	0.874	0.00101	0.0108	1.140	0.00131	0.0139	0.836	0.00134	0.0143
2014	HDV3	0.812	0.00077	0.0085	0.225	0.00019	0.0021	1.440	0.00123	0.0137	1.475	0.00142	0.0158	1.114	0.00121	0.0134
2014	HDV4	0.833	0.00076	0.0085	0.219	0.00015	0.0017	1.502	0.00126	0.0140	1.525	0.00143	0.0160	1.151	0.00119	0.0133
2014	HDV5	0.833	0.00076	0.0085	0.219	0.00015	0.0017	1.502	0.00126	0.0140	1.525	0.00143	0.0160	1.151	0.00119	0.0133
2014	HDV6	0.847	0.00077	0.0087	0.219	0.00015	0.0017	1.507	0.00126	0.0141	1.538	0.00146	0.0163	1.166	0.00120	0.0134
2014	HDV7	0.890	0.00083	0.0093	0.217	0.00015	0.0017	1.534	0.00132	0.0148	1.582	0.00159	0.0178	1.214	0.00123	0.0138
2014	HDV8a	1.180	0.00120	0.0135	0.205	0.00014	0.0015	1.732	0.00177	0.0197	1.992	0.00272	0.0305	1.636	0.00155	0.0173
2014	HDV8b	1.316	0.00139	0.0155	0.189	0.00012	0.0013	1.878	0.00208	0.0233	2.227	0.00344	0.0384	1.905	0.00175	0.0196
2015	HDV2B	0.377	0.00049	0.0052	0.170	0.00024	0.0025	0.573	0.00062	0.0066	0.741	0.00080	0.0085	0.544	0.00082	0.0087
2015	HDV3	0.540	0.00049	0.0054	0.149	0.00012	0.0013	0.959	0.00079	0.0088	0.982	0.00091	0.0101	0.741	0.00077	0.0085
2015	HDV4	0.554	0.00049	0.0055	0.146	0.00010	0.0011	1.000	0.00081	0.0090	1.016	0.00092	0.0103	0.766	0.00076	0.0085
2015	HDV5	0.554	0.00049	0.0055	0.146	0.00010	0.0011	1.000	0.00081	0.0090	1.016	0.00092	0.0103	0.766	0.00076	0.0085
2015	HDV6	0.565	0.00050	0.0056	0.146	0.00010	0.0011	1.005	0.00081	0.0091	1.026	0.00094	0.0105	0.778	0.00077	0.0086
2015	HDV7	0.601	0.00054	0.0061	0.145	0.00010	0.0011	1.030	0.00086	0.0096	1.064	0.00104	0.0116	0.817	0.00080	0.0089
2015	HDV8a	0.838	0.00083	0.0093	0.142	0.00009	0.0010	1.218	0.00121	0.0135	1.405	0.00188	0.0210	1.156	0.00106	0.0118
2015	HDV8b	0.948	0.00097	0.0108	0.135	0.00008	0.0009	1.351	0.00145	0.0163	1.603	0.00241	0.0269	1.372	0.00122	0.0137
2016	HDV2B	0.376	0.00049	0.0052	0.170	0.00024	0.0025	0.571	0.00062	0.0066	0.739	0.00080	0.0085	0.543	0.00082	0.0087
2016	HDV3	0.539	0.00049	0.0054	0.149	0.00012	0.0013	0.958	0.00079	0.0088	0.981	0.00091	0.0101	0.741	0.00077	0.0085

		Diesel														
		Highway			Urban											
					Decel			0-25			25-50			>50		
Model Yr	Vehicle Class	NOx	BC	PM	NOx	BC	PM	NOx	BC	PM	NOx	BC	PM	NOx	BC	PM
2016	HDV4	0.554	0.00049	0.0055	0.146	0.00010	0.0011	1.000	0.00081	0.0090	1.016	0.00092	0.0103	0.766	0.00076	0.0085
2016	HDV5	0.554	0.00049	0.0055	0.146	0.00010	0.0011	1.000	0.00081	0.0090	1.016	0.00092	0.0103	0.766	0.00076	0.0085
2016	HDV6	0.565	0.00050	0.0056	0.146	0.00010	0.0011	1.005	0.00081	0.0091	1.026	0.00094	0.0105	0.778	0.00077	0.0086
2016	HDV7	0.601	0.00054	0.0061	0.145	0.00010	0.0011	1.030	0.00086	0.0096	1.064	0.00104	0.0116	0.817	0.00080	0.0089
2016	HDV8a	0.838	0.00083	0.0093	0.142	0.00009	0.0010	1.217	0.00121	0.0135	1.404	0.00188	0.0210	1.156	0.00106	0.0118
2016	HDV8b	0.948	0.00097	0.0108	0.135	0.00008	0.0009	1.351	0.00145	0.0163	1.603	0.00241	0.0269	1.372	0.00122	0.0137
2017	HDV2B	0.370	0.00049	0.0052	0.170	0.00024	0.0025	0.569	0.00062	0.0066	0.732	0.00080	0.0085	0.532	0.00082	0.0087
2017	HDV3	0.539	0.00049	0.0054	0.149	0.00012	0.0013	0.958	0.00079	0.0088	0.979	0.00091	0.0101	0.739	0.00077	0.0085
2017	HDV4	0.554	0.00049	0.0055	0.146	0.00010	0.0011	1.000	0.00081	0.0090	1.016	0.00092	0.0103	0.766	0.00076	0.0085
2017	HDV5	0.554	0.00049	0.0055	0.146	0.00010	0.0011	1.000	0.00081	0.0090	1.016	0.00092	0.0103	0.766	0.00076	0.0085
2017	HDV6	0.565	0.00050	0.0056	0.146	0.00010	0.0011	1.005	0.00081	0.0091	1.026	0.00094	0.0105	0.778	0.00077	0.0086
2017	HDV7	0.601	0.00054	0.0061	0.145	0.00010	0.0011	1.030	0.00086	0.0096	1.064	0.00104	0.0116	0.817	0.00080	0.0089
2017	HDV8a	0.838	0.00083	0.0093	0.142	0.00009	0.0010	1.218	0.00121	0.0135	1.405	0.00188	0.0210	1.156	0.00106	0.0118
2017	HDV8b	0.948	0.00097	0.0108	0.135	0.00008	0.0009	1.351	0.00146	0.0163	1.603	0.00241	0.0269	1.372	0.00123	0.0137
2018	HDV2B	0.282	0.00048	0.0051	0.122	0.00024	0.0025	0.435	0.00061	0.0066	0.539	0.00078	0.0083	0.396	0.00080	0.0086
2018	HDV3	0.485	0.00049	0.0054	0.131	0.00012	0.0013	0.865	0.00079	0.0088	0.877	0.00090	0.0101	0.661	0.00077	0.0085
2018	HDV4	0.504	0.00049	0.0055	0.133	0.00010	0.0011	0.912	0.00081	0.0090	0.925	0.00092	0.0103	0.695	0.00076	0.0085
2018	HDV5	0.504	0.00049	0.0055	0.133	0.00010	0.0011	0.912	0.00081	0.0090	0.925	0.00092	0.0103	0.695	0.00076	0.0085
2018	HDV6	0.516	0.00050	0.0056	0.133	0.00010	0.0011	0.918	0.00081	0.0091	0.938	0.00094	0.0105	0.708	0.00077	0.0086
2018	HDV7	0.558	0.00054	0.0061	0.133	0.00010	0.0011	0.950	0.00086	0.0096	0.982	0.00104	0.0116	0.753	0.00080	0.0089
2018	HDV8a	0.825	0.00083	0.0093	0.137	0.00009	0.0010	1.185	0.00121	0.0136	1.373	0.00189	0.0211	1.133	0.00106	0.0119
2018	HDV8b	0.947	0.00097	0.0108	0.134	0.00008	0.0009	1.346	0.00146	0.0163	1.598	0.00241	0.0270	1.369	0.00123	0.0137
2019	HDV2B	0.282	0.00048	0.005	0.122	0.00024	0.003	0.435	0.00061	0.007	0.539	0.00078	0.008	0.396	0.00080	0.009
2019	HDV3	0.485	0.00049	0.005	0.131	0.00012	0.001	0.865	0.00079	0.009	0.877	0.00090	0.010	0.661	0.00077	0.009
2019	HDV4	0.504	0.00049	0.005	0.133	0.00010	0.001	0.912	0.00081	0.009	0.925	0.00092	0.010	0.695	0.00076	0.009
2019	HDV5	0.504	0.00049	0.005	0.133	0.00010	0.001	0.912	0.00081	0.009	0.925	0.00092	0.010	0.695	0.00076	0.009

		Diesel														
		Highway			Urban											
					Decel			0-25			25-50			>50		
Model Yr	**Vehicle Class**	**NOx**	**BC**	**PM**	**NOx**	**BC**	**PM**	**NOx**	**BC**	**PM**	**NOx**	**BC**	**PM**	**NOx**	**BC**	**PM**
2019	HDV6	0.516	0.00050	0.006	0.133	0.00010	0.001	0.918	0.00081	0.009	0.938	0.00094	0.010	0.708	0.00077	0.009
2019	HDV7	0.558	0.00054	0.006	0.133	0.00010	0.001	0.950	0.00086	0.010	0.982	0.00104	0.012	0.753	0.00080	0.009
2019	HDV8a	0.825	0.00083	0.009	0.137	0.00009	0.001	1.185	0.00121	0.014	1.373	0.00189	0.021	1.133	0.00106	0.012
2019	HDV8b	0.947	0.00097	0.011	0.134	0.00008	0.001	1.346	0.00146	0.016	1.598	0.00241	0.027	1.369	0.00123	0.014

		E10														
		Highway			Urban											
					Braking			0-25			25-50			>50		
Model Yr	Vehicle Class	NOx	BC	PM	NOx	BC	PM	NOx	BC	PM	NOx	BC	PM	NOx	BC	PM
1987	HDV2B	5.401	0.01008	0.0688	0.218	0.00060	0.004	4.303	0.00819	0.056	7.949	0.00950	0.065	8.205	0.01249	0.085
1987	HDV3	8.967	0.02199	0.1501	0.261	0.00068	0.005	8.588	0.01696	0.116	12.624	0.01314	0.090	13.044	0.01994	0.136
1987	HDV4	9.088	0.02279	0.1555	0.261	0.00068	0.005	8.546	0.01677	0.114	12.669	0.01313	0.090	13.134	0.02049	0.140
1987	HDV5	8.743	0.02047	0.1397	0.259	0.00066	0.005	8.846	0.01798	0.123	12.601	0.01416	0.097	12.853	0.01890	0.129
1987	HDV6	8.728	0.02038	0.1391	0.259	0.00066	0.005	8.835	0.01794	0.122	12.587	0.01406	0.096	12.839	0.01879	0.128
1987	HDV7	8.628	0.01978	0.1350	0.260	0.00066	0.005	8.760	0.01769	0.121	12.496	0.01341	0.092	12.743	0.01808	0.123
1987	HDV8a	9.702	0.02631	0.1795	0.253	0.00065	0.004	9.574	0.02042	0.139	13.595	0.02098	0.143	13.860	0.02613	0.178
1987	HDV8b	14.014	0.05219	0.3561	0.196	0.00056	0.004	14.317	0.03624	0.247	19.502	0.06348	0.433	20.051	0.07253	0.495
1988	HDV2B	5.401	0.01008	0.0688	0.218	0.00060	0.0041	4.303	0.00819	0.0559	7.949	0.00950	0.0648	8.205	0.01249	0.0853
1988	HDV3	8.967	0.02199	0.1501	0.261	0.00068	0.0046	8.588	0.01696	0.1157	12.624	0.01314	0.0897	13.044	0.01994	0.1361
1988	HDV4	9.088	0.02279	0.1555	0.261	0.00068	0.0046	8.546	0.01677	0.1145	12.669	0.01313	0.0896	13.134	0.02049	0.1398
1988	HDV5	8.743	0.02047	0.1397	0.259	0.00066	0.0045	8.846	0.01798	0.1227	12.601	0.01416	0.0966	12.853	0.01890	0.1289
1988	HDV6	8.728	0.02038	0.1391	0.259	0.00066	0.0045	8.835	0.01794	0.1224	12.587	0.01406	0.0960	12.839	0.01879	0.1282
1988	HDV7	8.628	0.01978	0.1350	0.260	0.00066	0.0045	8.760	0.01769	0.1207	12.496	0.01341	0.0915	12.743	0.01808	0.1234
1988	HDV8a	9.702	0.02631	0.1795	0.253	0.00065	0.0045	9.574	0.02042	0.1393	13.595	0.02098	0.1432	13.860	0.02613	0.1783
1988	HDV8b	14.014	0.05219	0.3561	0.196	0.00056	0.0038	14.317	0.03624	0.2473	19.502	0.06348	0.4332	20.051	0.07253	0.4950
1989	HDV2B	5.445	0.01013	0.0691	0.219	0.00060	0.0041	4.340	0.00819	0.0559	7.969	0.00945	0.0645	8.269	0.01241	0.0847
1989	HDV3	8.879	0.02146	0.1465	0.261	0.00068	0.0046	8.528	0.01673	0.1142	12.514	0.01281	0.0874	12.979	0.01940	0.1324
1989	HDV4	9.061	0.02262	0.1544	0.261	0.00068	0.0046	8.529	0.01671	0.1141	12.641	0.01302	0.0889	13.114	0.02034	0.1388
1989	HDV5	8.491	0.01898	0.1295	0.261	0.00066	0.0045	8.553	0.01689	0.1152	12.197	0.01253	0.0855	12.633	0.01700	0.1160
1989	HDV6	8.491	0.01898	0.1295	0.261	0.00066	0.0045	8.553	0.01689	0.1152	12.197	0.01253	0.0855	12.633	0.01700	0.1160
1989	HDV7	8.491	0.01898	0.1295	0.261	0.00066	0.0045	8.553	0.01689	0.1152	12.197	0.01253	0.0855	12.633	0.01700	0.1160
1989	HDV8a	13.923	0.05303	0.3619	0.234	0.00065	0.0045	14.238	0.03639	0.2483	21.214	0.06727	0.4591	21.053	0.07199	0.4913
1989	HDV8b	13.923	0.05303	0.3619	0.234	0.00065	0.0045	14.238	0.03639	0.2483	21.214	0.06727	0.4591	21.053	0.07199	0.4913
1990	HDV2B	5.017	0.01838	0.1254	0.142	0.00021	0.0014	5.258	0.00246	0.0168	8.243	0.00699	0.0477	6.874	0.01227	0.0837

		E10														
		Highway			Urban											
					Braking			0-25			25-50			>50		
Model Yr	Vehicle Class	NOx	BC	PM	NOx	BC	PM	NOx	BC	PM	NOx	BC	PM	NOx	BC	PM
1990	HDV3	5.700	0.02548	0.1739	0.138	0.00023	0.0016	6.519	0.00290	0.0198	9.150	0.00547	0.0373	7.348	0.01144	0.0781
1990	HDV4	5.947	0.02718	0.1855	0.138	0.00023	0.0016	6.549	0.00295	0.0201	9.333	0.00674	0.0460	7.548	0.01262	0.0861
1990	HDV5	5.447	0.02403	0.1640	0.137	0.00023	0.0016	6.563	0.00289	0.0197	9.006	0.00513	0.0350	7.128	0.01052	0.0718
1990	HDV6	5.447	0.02403	0.1640	0.137	0.00023	0.0016	6.563	0.00289	0.0197	9.006	0.00513	0.0350	7.128	0.01052	0.0718
1990	HDV7	5.447	0.02403	0.1640	0.137	0.00023	0.0016	6.563	0.00289	0.0197	9.006	0.00513	0.0350	7.128	0.01052	0.0718
1990	HDV8a	9.395	0.05803	0.3960	0.126	0.00020	0.0013	10.858	0.00672	0.0459	16.342	0.07799	0.5322	13.147	0.05823	0.3974
1990	HDV8b	9.395	0.05803	0.3960	0.126	0.00020	0.0013	10.858	0.00672	0.0459	16.342	0.07799	0.5322	13.147	0.05823	0.3974
1991	HDV2B	4.800	0.00813	0.0555	0.142	0.00057	0.0039	4.620	0.01071	0.0731	7.973	0.00462	0.0315	6.792	0.00436	0.0297
1991	HDV3	5.727	0.01474	0.1006	0.138	0.00062	0.0043	6.521	0.01639	0.1119	9.170	0.00547	0.0373	7.369	0.00448	0.0306
1991	HDV4	5.930	0.01539	0.1050	0.137	0.00063	0.0043	6.607	0.01665	0.1136	9.385	0.00653	0.0446	7.557	0.00497	0.0339
1991	HDV5	5.568	0.01431	0.0976	0.137	0.00062	0.0042	6.523	0.01644	0.1122	9.065	0.00513	0.0350	7.234	0.00424	0.0289
1991	HDV6	5.451	0.01403	0.0958	0.137	0.00062	0.0042	6.570	0.01663	0.1135	9.019	0.00519	0.0354	7.131	0.00413	0.0282
1991	HDV7	5.451	0.01403	0.0958	0.137	0.00062	0.0042	6.570	0.01663	0.1135	9.019	0.00519	0.0354	7.131	0.00413	0.0282
1991	HDV8a	6.028	0.01594	0.1088	0.136	0.00062	0.0043	6.943	0.01776	0.1212	9.803	0.00927	0.0633	7.767	0.00592	0.0404
1991	HDV8b	6.028	0.01594	0.1088	0.136	0.00062	0.0043	6.943	0.01776	0.1212	9.803	0.00927	0.0633	7.767	0.00592	0.0404
1992	HDV2B	4.956	0.00936	0.0639	0.139	0.00057	0.0039	5.018	0.01184	0.0808	8.180	0.00466	0.0318	6.882	0.00426	0.0291
1992	HDV3	5.809	0.01497	0.1022	0.138	0.00063	0.0043	6.527	0.01640	0.1119	9.228	0.00568	0.0387	7.436	0.00462	0.0315
1992	HDV4	6.053	0.01574	0.1074	0.137	0.00063	0.0043	6.623	0.01667	0.1138	9.474	0.00688	0.0469	7.654	0.00518	0.0353
1992	HDV5	5.605	0.01439	0.0982	0.138	0.00062	0.0043	6.510	0.01638	0.1118	9.080	0.00512	0.0349	7.265	0.00427	0.0292
1992	HDV6	5.452	0.01403	0.0958	0.137	0.00062	0.0042	6.572	0.01664	0.1135	9.023	0.00519	0.0354	7.132	0.00413	0.0282
1992	HDV7	5.452	0.01403	0.0958	0.137	0.00062	0.0042	6.572	0.01664	0.1135	9.023	0.00519	0.0354	7.132	0.00413	0.0282
1992	HDV8a	6.217	0.01656	0.1130	0.136	0.00063	0.0043	7.078	0.01817	0.1240	10.077	0.01069	0.0729	7.988	0.00654	0.0446
1992	HDV8b	6.217	0.01656	0.1130	0.136	0.00063	0.0043	7.078	0.01817	0.1240	10.077	0.01069	0.0729	7.988	0.00654	0.0446
1993	HDV2B	5.004	0.01006	0.0687	0.137	0.00057	0.0039	5.191	0.01235	0.0843	8.200	0.00459	0.0314	6.906	0.00412	0.0281
1993	HDV3	5.618	0.01448	0.0988	0.138	0.00062	0.0043	6.445	0.01619	0.1105	9.003	0.00509	0.0347	7.278	0.00426	0.0291
1993	HDV4	5.746	0.01480	0.1010	0.138	0.00062	0.0043	6.463	0.01621	0.1106	9.112	0.00532	0.0363	7.379	0.00445	0.0303

		E10														
		Highway			Urban											
					Braking			0-25			25-50			>50		
Model Yr	Vehicle Class	NOx	BC	PM	NOx	BC	PM	NOx	BC	PM	NOx	BC	PM	NOx	BC	PM
1993	HDV5	5.616	0.01446	0.0987	0.138	0.00062	0.0043	6.437	0.01617	0.1103	8.996	0.00502	0.0342	7.274	0.00424	0.0289
1993	HDV6	5.380	0.01394	0.0951	0.138	0.00062	0.0042	6.445	0.01630	0.1112	8.797	0.00500	0.0341	7.071	0.00398	0.0271
1993	HDV7	5.380	0.01394	0.0951	0.138	0.00062	0.0042	6.445	0.01630	0.1112	8.797	0.00500	0.0341	7.071	0.00398	0.0271
1993	HDV8a	5.505	0.01435	0.0979	0.138	0.00062	0.0042	6.523	0.01653	0.1128	8.963	0.00584	0.0399	7.203	0.00435	0.0297
1993	HDV8b	5.505	0.01435	0.0979	0.138	0.00062	0.0042	6.523	0.01653	0.1128	8.963	0.00584	0.0399	7.203	0.00435	0.0297
1994	HDV2B	4.735	0.01045	0.0713	0.112	0.00031	0.0021	4.639	0.00233	0.0159	7.661	0.00728	0.0496	6.759	0.01825	0.1246
1994	HDV3	5.598	0.01687	0.1151	0.135	0.00038	0.0026	6.438	0.00326	0.0223	9.019	0.01232	0.0841	7.227	0.02725	0.1860
1994	HDV4	5.914	0.01869	0.1276	0.135	0.00038	0.0026	6.522	0.00332	0.0226	9.304	0.01312	0.0896	7.504	0.02918	0.1991
1994	HDV5	5.649	0.01721	0.1174	0.136	0.00038	0.0026	6.355	0.00315	0.0215	8.972	0.01210	0.0826	7.246	0.02746	0.1874
1994	HDV6	5.359	0.01545	0.1054	0.135	0.00038	0.0026	6.457	0.00332	0.0227	8.860	0.01195	0.0816	7.012	0.02567	0.1752
1994	HDV7	5.359	0.01545	0.1054	0.135	0.00038	0.0026	6.457	0.00332	0.0227	8.860	0.01195	0.0816	7.012	0.02567	0.1752
1994	HDV8a	9.242	0.03741	0.2553	0.124	0.00034	0.0023	10.681	0.00737	0.0503	16.077	0.03383	0.2309	12.933	0.06555	0.4473
1994	HDV8b	9.242	0.03741	0.2553	0.124	0.00034	0.0023	10.681	0.00737	0.0503	16.077	0.03383	0.2309	12.933	0.06555	0.4473
1995	HDV2B	4.713	0.01024	0.0699	0.116	0.00034	0.0023	4.630	0.00323	0.0220	7.620	0.00443	0.0303	6.714	0.00541	0.0369
1995	HDV3	5.476	0.01627	0.1111	0.135	0.00039	0.0027	6.409	0.00453	0.0309	8.904	0.00414	0.0282	7.117	0.00526	0.0359
1995	HDV4	5.654	0.01682	0.1148	0.135	0.00039	0.0027	6.409	0.00451	0.0308	9.026	0.00455	0.0310	7.266	0.00560	0.0382
1995	HDV5	5.549	0.01646	0.1123	0.135	0.00039	0.0027	6.380	0.00449	0.0307	8.930	0.00405	0.0276	7.174	0.00533	0.0364
1995	HDV6	5.352	0.01594	0.1088	0.135	0.00039	0.0027	6.445	0.00458	0.0313	8.840	0.00413	0.0282	7.007	0.00507	0.0346
1995	HDV7	5.352	0.01594	0.1088	0.135	0.00039	0.0027	6.445	0.00458	0.0313	8.840	0.00413	0.0282	7.007	0.00507	0.0346
1995	HDV8a	9.242	0.03095	0.2112	0.124	0.00036	0.0025	10.681	0.00818	0.0558	16.077	0.04855	0.3313	12.933	0.02566	0.1751
1995	HDV8b	9.242	0.03095	0.2112	0.124	0.00036	0.0025	10.681	0.00818	0.0558	16.077	0.04855	0.3313	12.933	0.02566	0.1751
1996	HDV2B	3.508	0.00882	0.0602	0.099	0.00044	0.0030	3.417	0.00255	0.0174	5.168	0.00673	0.0459	4.977	0.00291	0.0199
1996	HDV3	5.557	0.01614	0.1101	0.135	0.00047	0.0032	6.405	0.00367	0.0251	8.962	0.00611	0.0417	7.184	0.00276	0.0188
1996	HDV4	5.705	0.01650	0.1126	0.135	0.00047	0.0032	6.403	0.00368	0.0251	9.054	0.00656	0.0447	7.303	0.00289	0.0197
1996	HDV5	5.637	0.01633	0.1115	0.136	0.00047	0.0032	6.361	0.00366	0.0250	8.971	0.00590	0.0402	7.238	0.00278	0.0190
1996	HDV6	5.364	0.01566	0.1068	0.135	0.00046	0.0032	6.465	0.00368	0.0251	8.876	0.00605	0.0413	7.016	0.00262	0.0179

		E10														
		Highway			Urban											
					Braking			0-25			25-50			>50		
Model Yr	Vehicle Class	NOx	BC	PM	NOx	BC	PM	NOx	BC	PM	NOx	BC	PM	NOx	BC	PM
1996	HDV7	5.364	0.01566	0.1068	0.135	0.00046	0.0032	6.465	0.00368	0.0251	8.876	0.00605	0.0413	7.016	0.00262	0.0179
1996	HDV8a	9.242	0.02548	0.1739	0.124	0.00042	0.0029	10.681	0.00610	0.0416	16.077	0.06137	0.4188	12.933	0.01220	0.0833
1996	HDV8b	9.242	0.02548	0.1739	0.124	0.00042	0.0029	10.681	0.00610	0.0416	16.077	0.06137	0.4188	12.933	0.01220	0.0833
1997	HDV2B	3.240	0.00701	0.0478	0.106	0.00020	0.0014	3.012	0.00180	0.0123	4.793	0.00547	0.0373	4.462	0.00730	0.0498
1997	HDV3	5.471	0.01222	0.0834	0.135	0.00023	0.0015	6.438	0.00248	0.0169	8.933	0.00507	0.0346	7.115	0.00844	0.0576
1997	HDV4	5.680	0.01290	0.0880	0.135	0.00023	0.0016	6.385	0.00246	0.0168	9.022	0.00506	0.0345	7.278	0.00893	0.0609
1997	HDV5	5.568	0.01252	0.0854	0.135	0.00023	0.0015	6.386	0.00245	0.0168	8.951	0.00485	0.0331	7.188	0.00864	0.0590
1997	HDV6	5.365	0.01188	0.0811	0.135	0.00022	0.0015	6.467	0.00248	0.0169	8.880	0.00507	0.0346	7.017	0.00815	0.0556
1997	HDV7	5.365	0.01188	0.0811	0.135	0.00022	0.0015	6.467	0.00248	0.0169	8.880	0.00507	0.0346	7.017	0.00815	0.0556
1997	HDV8a	9.242	0.02655	0.1812	0.124	0.00019	0.0013	10.681	0.00520	0.0355	16.077	0.04479	0.3057	12.933	0.02848	0.1944
1997	HDV8b	9.242	0.02655	0.1812	0.124	0.00019	0.0013	10.681	0.00520	0.0355	16.077	0.04479	0.3057	12.933	0.02848	0.1944
1998	HDV2B	2.407	0.00571	0.0390	0.115	0.00025	0.0017	1.729	0.00193	0.0132	3.645	0.00498	0.0340	3.950	0.00527	0.0360
1998	HDV3	4.196	0.01533	0.1046	0.258	0.00030	0.0021	4.039	0.00387	0.0264	6.218	0.00892	0.0608	6.526	0.01172	0.0800
1998	HDV4	4.501	0.01708	0.1165	0.253	0.00030	0.0020	4.214	0.00426	0.0291	6.779	0.01282	0.0875	6.819	0.01316	0.0898
1998	HDV5	3.840	0.01341	0.0915	0.263	0.00031	0.0021	3.779	0.00336	0.0229	5.506	0.00384	0.0262	6.195	0.01009	0.0689
1998	HDV6	3.812	0.01315	0.0898	0.263	0.00031	0.0021	3.822	0.00340	0.0232	5.505	0.00393	0.0268	6.161	0.00994	0.0678
1998	HDV7	3.812	0.01315	0.0898	0.263	0.00031	0.0021	3.822	0.00340	0.0232	5.505	0.00393	0.0268	6.161	0.00994	0.0678
1998	HDV8a	5.344	0.02158	0.1473	0.226	0.00026	0.0018	5.646	0.00702	0.0479	9.737	0.03400	0.2320	8.192	0.01994	0.1361
1998	HDV8b	5.344	0.02158	0.1473	0.226	0.00026	0.0018	5.646	0.00702	0.0479	9.737	0.03400	0.2320	8.192	0.01994	0.1361
1999	HDV2B	2.466	0.00593	0.0405	0.128	0.00006	0.0004	1.880	0.00082	0.0056	3.620	0.00336	0.0229	3.958	0.00213	0.0145
1999	HDV3	3.846	0.01334	0.0910	0.263	0.00007	0.0005	3.814	0.00139	0.0095	5.547	0.00184	0.0126	6.202	0.00264	0.0180
1999	HDV4	3.934	0.01376	0.0939	0.262	0.00007	0.0005	3.849	0.00143	0.0097	5.694	0.00286	0.0195	6.283	0.00291	0.0198
1999	HDV5	3.828	0.01339	0.0914	0.264	0.00007	0.0005	3.766	0.00137	0.0094	5.481	0.00129	0.0088	6.190	0.00262	0.0179
1999	HDV6	3.829	0.01339	0.0914	0.264	0.00007	0.0005	3.765	0.00137	0.0094	5.481	0.00129	0.0088	6.190	0.00262	0.0179
1999	HDV7	3.802	0.01313	0.0896	0.263	0.00007	0.0005	3.793	0.00137	0.0094	5.469	0.00131	0.0089	6.161	0.00250	0.0171
1999	HDV8a	3.983	0.01385	0.0945	0.261	0.00007	0.0005	3.921	0.00146	0.0100	5.832	0.00393	0.0268	6.332	0.00305	0.0208

		E10														
		Highway			Urban											
					Braking			0-25			25-50			>50		
Model Yr	**Vehicle Class**	**NOx**	**BC**	**PM**	**NOx**	**BC**	**PM**	**NOx**	**BC**	**PM**	**NOx**	**BC**	**PM**	**NOx**	**BC**	**PM**
1999	HDV8b	3.983	0.01385	0.0945	0.261	0.00007	0.0005	3.921	0.00146	0.0100	5.832	0.00393	0.0268	6.332	0.00305	0.0208
2000	HDV2B	2.407	0.00502	0.0342	0.129	0.00006	0.0004	1.802	0.00062	0.0043	3.574	0.00313	0.0214	3.897	0.00278	0.0190
2000	HDV3	3.801	0.01083	0.0739	0.264	0.00007	0.0005	3.773	0.00082	0.0056	5.453	0.00128	0.0088	6.167	0.00305	0.0208
2000	HDV4	3.816	0.01092	0.0745	0.264	0.00007	0.0005	3.762	0.00082	0.0056	5.463	0.00128	0.0087	6.182	0.00308	0.0210
2000	HDV5	3.822	0.01096	0.0748	0.264	0.00007	0.0005	3.756	0.00082	0.0056	5.465	0.00127	0.0086	6.188	0.00309	0.0211
2000	HDV6	3.822	0.01096	0.0748	0.264	0.00007	0.0005	3.756	0.00082	0.0056	5.465	0.00127	0.0086	6.188	0.00310	0.0211
2000	HDV7	3.796	0.01080	0.0737	0.264	0.00007	0.0005	3.777	0.00082	0.0056	5.449	0.00128	0.0088	6.162	0.00304	0.0207
2000	HDV8a	3.798	0.01081	0.0738	0.264	0.00007	0.0005	3.778	0.00082	0.0056	5.452	0.00130	0.0089	6.163	0.00305	0.0208
2000	HDV8b	3.798	0.01081	0.0738	0.264	0.00007	0.0005	3.778	0.00082	0.0056	5.452	0.00130	0.0089	6.163	0.00305	0.0208
2001	HDV2B	1.016	0.00382	0.0260	0.055	0.00003	0.0002	0.663	0.00062	0.0042	1.479	0.00328	0.0223	1.619	0.00255	0.0174
2001	HDV3	1.759	0.01343	0.0916	0.121	0.00004	0.0003	1.754	0.00058	0.0039	2.535	0.00147	0.0100	2.843	0.00900	0.0614
2001	HDV4	1.769	0.01354	0.0924	0.121	0.00004	0.0003	1.742	0.00057	0.0039	2.538	0.00147	0.0100	2.854	0.00900	0.0614
2001	HDV5	1.771	0.01358	0.0926	0.121	0.00004	0.0003	1.736	0.00057	0.0039	2.535	0.00141	0.0096	2.856	0.00899	0.0614
2001	HDV6	1.771	0.01358	0.0927	0.121	0.00004	0.0003	1.736	0.00057	0.0039	2.535	0.00141	0.0096	2.856	0.00899	0.0614
2001	HDV7	1.755	0.01338	0.0913	0.121	0.00004	0.0003	1.758	0.00058	0.0039	2.533	0.00147	0.0100	2.838	0.00900	0.0614
2001	HDV8a	1.758	0.01340	0.0914	0.121	0.00004	0.0003	1.761	0.00058	0.0040	2.540	0.00156	0.0107	2.841	0.00900	0.0614
2001	HDV8b	1.758	0.01340	0.0914	0.121	0.00004	0.0003	1.761	0.00058	0.0040	2.540	0.00156	0.0107	2.841	0.00900	0.0614
2002	HDV2B	0.989	0.00245	0.0167	0.050	0.00013	0.0009	0.647	0.00129	0.0088	1.427	0.00271	0.0185	1.564	0.00219	0.0150
2002	HDV3	1.760	0.00626	0.0427	0.121	0.00014	0.0010	1.759	0.00212	0.0145	2.540	0.00222	0.0151	2.841	0.00336	0.0229
2002	HDV4	1.768	0.00633	0.0432	0.121	0.00014	0.0010	1.748	0.00211	0.0144	2.540	0.00221	0.0151	2.851	0.00339	0.0231
2002	HDV5	1.770	0.00635	0.0433	0.121	0.00014	0.0010	1.742	0.00210	0.0143	2.538	0.00219	0.0149	2.853	0.00339	0.0232
2002	HDV6	1.770	0.00636	0.0434	0.121	0.00014	0.0010	1.742	0.00210	0.0143	2.538	0.00219	0.0149	2.854	0.00340	0.0232
2002	HDV7	1.756	0.00624	0.0425	0.121	0.00014	0.0010	1.763	0.00212	0.0145	2.539	0.00222	0.0151	2.838	0.00334	0.0228
2002	HDV8a	1.759	0.00625	0.0426	0.121	0.00014	0.0010	1.764	0.00213	0.0145	2.543	0.00225	0.0153	2.840	0.00335	0.0229
2002	HDV8b	1.759	0.00625	0.0426	0.121	0.00014	0.0010	1.764	0.00213	0.0145	2.543	0.00225	0.0153	2.840	0.00335	0.0229
2003	HDV2B	1.038	0.00299	0.0204	0.053	0.00006	0.0004	0.685	0.00081	0.0055	1.512	0.00298	0.0203	1.649	0.00211	0.0144

		E10														
		Highway			Urban											
					Braking			0-25			25-50			>50		
Model Yr	Vehicle Class	NOx	BC	PM	NOx	BC	PM	NOx	BC	PM	NOx	BC	PM	NOx	BC	PM
2003	HDV3	1.759	0.00887	0.0605	0.121	0.00008	0.0005	1.759	0.00140	0.0096	2.540	0.00129	0.0088	2.841	0.00403	0.0275
2003	HDV4	1.767	0.00897	0.0612	0.121	0.00008	0.0005	1.749	0.00139	0.0095	2.541	0.00129	0.0088	2.850	0.00407	0.0278
2003	HDV5	1.769	0.00900	0.0614	0.121	0.00008	0.0005	1.744	0.00138	0.0094	2.538	0.00125	0.0085	2.852	0.00409	0.0279
2003	HDV6	1.769	0.00901	0.0614	0.121	0.00008	0.0005	1.743	0.00138	0.0094	2.538	0.00125	0.0085	2.852	0.00409	0.0279
2003	HDV7	1.756	0.00883	0.0602	0.121	0.00008	0.0005	1.763	0.00140	0.0096	2.539	0.00129	0.0088	2.838	0.00401	0.0274
2003	HDV8a	1.759	0.00885	0.0603	0.121	0.00008	0.0005	1.764	0.00141	0.0096	2.543	0.00134	0.0091	2.840	0.00402	0.0274
2003	HDV8b	1.759	0.00885	0.0603	0.121	0.00008	0.0005	1.764	0.00141	0.0096	2.543	0.00134	0.0091	2.840	0.00402	0.0274
2004	HDV2B	0.657	0.00138	0.0094	0.037	0.00009	0.0006	0.477	0.00069	0.0047	0.890	0.00153	0.0104	0.987	0.00155	0.0106
2004	HDV3	1.759	0.00354	0.0241	0.121	0.00011	0.0007	1.760	0.00141	0.0096	2.540	0.00125	0.0085	2.840	0.00329	0.0224
2004	HDV4	1.765	0.00358	0.0244	0.121	0.00011	0.0007	1.752	0.00141	0.0096	2.541	0.00125	0.0085	2.848	0.00333	0.0227
2004	HDV5	1.767	0.00360	0.0245	0.121	0.00011	0.0007	1.747	0.00141	0.0096	2.538	0.00124	0.0084	2.850	0.00334	0.0228
2004	HDV6	1.767	0.00360	0.0246	0.121	0.00011	0.0007	1.746	0.00141	0.0096	2.538	0.00124	0.0084	2.850	0.00334	0.0228
2004	HDV7	1.756	0.00352	0.0240	0.121	0.00011	0.0007	1.763	0.00141	0.0096	2.539	0.00125	0.0085	2.838	0.00328	0.0224
2004	HDV8a	1.759	0.00353	0.0241	0.121	0.00011	0.0007	1.764	0.00142	0.0097	2.543	0.00127	0.0086	2.840	0.00328	0.0224
2004	HDV8b	1.759	0.00353	0.0241	0.121	0.00011	0.0007	1.764	0.00142	0.0097	2.543	0.00127	0.0086	2.840	0.00328	0.0224
2005	HDV2B	0.454	0.00115	0.0078	0.028	0.00009	0.0006	0.300	0.00062	0.0042	0.631	0.00154	0.0105	0.702	0.00142	0.0097
2005	HDV3	1.759	0.00354	0.0241	0.121	0.00011	0.0007	1.760	0.00141	0.0096	2.540	0.00125	0.0085	2.841	0.00329	0.0225
2005	HDV4	1.766	0.00359	0.0245	0.121	0.00011	0.0007	1.751	0.00141	0.0096	2.541	0.00125	0.0085	2.849	0.00333	0.0227
2005	HDV5	1.767	0.00360	0.0246	0.121	0.00011	0.0007	1.746	0.00141	0.0096	2.538	0.00123	0.0084	2.851	0.00334	0.0228
2005	HDV6	1.768	0.00361	0.0246	0.121	0.00011	0.0007	1.745	0.00141	0.0096	2.538	0.00123	0.0084	2.851	0.00334	0.0228
2005	HDV7	1.756	0.00352	0.0240	0.121	0.00011	0.0007	1.763	0.00141	0.0096	2.539	0.00125	0.0085	2.838	0.00328	0.0224
2005	HDV8a	1.759	0.00353	0.0241	0.121	0.00011	0.0007	1.765	0.00142	0.0097	2.543	0.00127	0.0086	2.840	0.00328	0.0224
2005	HDV8b	1.759	0.00353	0.0241	0.121	0.00011	0.0007	1.765	0.00142	0.0097	2.543	0.00127	0.0086	2.840	0.00328	0.0224
2006	HDV2B	0.448	0.00122	0.0083	0.029	0.00009	0.0006	0.305	0.00064	0.0044	0.591	0.00155	0.0106	0.673	0.00146	0.0100
2006	HDV3	1.758	0.00353	0.0241	0.121	0.00011	0.0007	1.761	0.00141	0.0096	2.540	0.00125	0.0085	2.840	0.00329	0.0224
2006	HDV4	1.763	0.00357	0.0243	0.121	0.00011	0.0007	1.755	0.00141	0.0096	2.541	0.00125	0.0085	2.846	0.00332	0.0226

		E10														
		Highway			Urban											
					Braking			0-25			25-50			>50		
Model Yr	Vehicle Class	NOx	BC	PM	NOx	BC	PM	NOx	BC	PM	NOx	BC	PM	NOx	BC	PM
2006	HDV5	1.764	0.00358	0.0244	0.121	0.00011	0.0007	1.750	0.00141	0.0096	2.538	0.00124	0.0084	2.847	0.00333	0.0227
2006	HDV6	1.764	0.00358	0.0244	0.121	0.00011	0.0007	1.750	0.00141	0.0096	2.538	0.00124	0.0084	2.847	0.00333	0.0227
2006	HDV7	1.756	0.00352	0.0240	0.121	0.00011	0.0007	1.763	0.00141	0.0096	2.539	0.00125	0.0085	2.838	0.00328	0.0224
2006	HDV8a	1.758	0.00353	0.0241	0.121	0.00011	0.0007	1.764	0.00142	0.0097	2.543	0.00127	0.0086	2.839	0.00328	0.0224
2006	HDV8b	1.758	0.00353	0.0241	0.121	0.00011	0.0007	1.764	0.00142	0.0097	2.543	0.00127	0.0086	2.839	0.00328	0.0224
2007	HDV2B	0.377	0.00116	0.0079	0.022	0.00009	0.0006	0.244	0.00062	0.0042	0.481	0.00153	0.0104	0.559	0.00142	0.0097
2007	HDV3	1.758	0.00354	0.0241	0.121	0.00011	0.0007	1.760	0.00141	0.0096	2.540	0.00125	0.0085	2.840	0.00329	0.0224
2007	HDV4	1.764	0.00358	0.0244	0.121	0.00011	0.0007	1.753	0.00141	0.0096	2.541	0.00125	0.0085	2.847	0.00332	0.0227
2007	HDV5	1.766	0.00359	0.0245	0.121	0.00011	0.0007	1.748	0.00141	0.0096	2.538	0.00124	0.0084	2.849	0.00333	0.0227
2007	HDV6	1.766	0.00359	0.0245	0.121	0.00011	0.0007	1.748	0.00141	0.0096	2.538	0.00124	0.0084	2.849	0.00333	0.0227
2007	HDV7	1.756	0.00352	0.0240	0.121	0.00011	0.0007	1.763	0.00141	0.0096	2.539	0.00125	0.0085	2.838	0.00328	0.0224
2007	HDV8a	1.758	0.00353	0.0241	0.121	0.00011	0.0007	1.764	0.00142	0.0097	2.542	0.00126	0.0086	2.839	0.00328	0.0224
2007	HDV8b	1.758	0.00353	0.0241	0.121	0.00011	0.0007	1.764	0.00142	0.0097	2.542	0.00126	0.0086	2.839	0.00328	0.0224
2008	HDV2B	0.250	0.00119	0.0081	0.013	0.00009	0.0006	0.134	0.00063	0.0043	0.334	0.00154	0.0105	0.396	0.00144	0.0098
2008	HDV3	0.527	0.00353	0.0241	0.036	0.00011	0.0007	0.528	0.00141	0.0096	0.762	0.00125	0.0085	0.852	0.00329	0.0224
2008	HDV4	0.529	0.00356	0.0243	0.036	0.00011	0.0007	0.527	0.00141	0.0096	0.762	0.00125	0.0085	0.853	0.00331	0.0226
2008	HDV5	0.529	0.00357	0.0243	0.036	0.00011	0.0007	0.526	0.00141	0.0096	0.762	0.00124	0.0085	0.854	0.00332	0.0226
2008	HDV6	0.529	0.00357	0.0244	0.036	0.00011	0.0007	0.526	0.00141	0.0096	0.762	0.00124	0.0085	0.854	0.00332	0.0226
2008	HDV7	0.527	0.00352	0.0240	0.036	0.00011	0.0007	0.529	0.00141	0.0096	0.762	0.00125	0.0085	0.851	0.00328	0.0224
2008	HDV8a	0.527	0.00353	0.0241	0.036	0.00011	0.0007	0.529	0.00142	0.0097	0.763	0.00126	0.0086	0.852	0.00328	0.0224
2008	HDV8b	0.527	0.00353	0.0241	0.036	0.00011	0.0007	0.529	0.00142	0.0097	0.763	0.00126	0.0086	0.852	0.00328	0.0224
2009	HDV2B	0.185	0.00096	0.0066	0.005	0.00007	0.0005	0.090	0.00051	0.0035	0.220	0.00125	0.0085	0.279	0.00117	0.0080
2009	HDV3	0.527	0.00291	0.0198	0.036	0.00009	0.0006	0.528	0.00116	0.0079	0.762	0.00103	0.0070	0.852	0.00271	0.0185
2009	HDV4	0.529	0.00294	0.0200	0.036	0.00009	0.0006	0.526	0.00116	0.0079	0.762	0.00103	0.0070	0.854	0.00273	0.0186
2009	HDV5	0.529	0.00295	0.0201	0.036	0.00009	0.0006	0.525	0.00116	0.0079	0.762	0.00102	0.0070	0.854	0.00274	0.0187
2009	HDV6	0.529	0.00295	0.0201	0.036	0.00009	0.0006	0.525	0.00116	0.0079	0.762	0.00102	0.0070	0.854	0.00274	0.0187

		E10														
		Highway			Urban											
					Braking			0-25			25-50			>50		
Model Yr	**Vehicle Class**	**NOx**	**BC**	**PM**	**NOx**	**BC**	**PM**	**NOx**	**BC**	**PM**	**NOx**	**BC**	**PM**	**NOx**	**BC**	**PM**
2009	HDV7	0.527	0.00290	0.0198	0.036	0.00009	0.0006	0.529	0.00116	0.0079	0.762	0.00103	0.0070	0.851	0.00270	0.0184
2009	HDV8a	0.527	0.00290	0.0198	0.036	0.00009	0.0006	0.529	0.00116	0.0079	0.762	0.00104	0.0071	0.852	0.00270	0.0184
2009	HDV8b	0.527	0.00290	0.0198	0.036	0.00009	0.0006	0.529	0.00116	0.0079	0.762	0.00104	0.0071	0.852	0.00270	0.0184
2010	HDV2B	0.173	0.00094	0.0064	0.004	0.00007	0.0005	0.079	0.00050	0.0034	0.202	0.00125	0.0085	0.260	0.00115	0.0079
2010	HDV3	0.527	0.00291	0.0198	0.036	0.00009	0.0006	0.528	0.00116	0.0079	0.762	0.00103	0.0070	0.852	0.00271	0.0185
2010	HDV4	0.529	0.00294	0.0200	0.036	0.00009	0.0006	0.526	0.00116	0.0079	0.762	0.00103	0.0070	0.854	0.00273	0.0186
2010	HDV5	0.529	0.00295	0.0201	0.036	0.00009	0.0006	0.525	0.00116	0.0079	0.762	0.00102	0.0070	0.854	0.00274	0.0187
2010	HDV6	0.529	0.00295	0.0201	0.036	0.00009	0.0006	0.525	0.00116	0.0079	0.762	0.00102	0.0070	0.854	0.00274	0.0187
2010	HDV7	0.527	0.00290	0.0198	0.036	0.00009	0.0006	0.529	0.00116	0.0079	0.762	0.00103	0.0070	0.851	0.00270	0.0184
2010	HDV8a	0.527	0.00290	0.0198	0.036	0.00009	0.0006	0.529	0.00116	0.0079	0.762	0.00104	0.0071	0.852	0.00270	0.0184
2010	HDV8b	0.166	0.00290	0.0198	0.036	0.00009	0.0006	0.529	0.00116	0.0079	0.762	0.00104	0.0071	0.852	0.00270	0.0184
2011	HDV2B	0.527	0.00092	0.0062	0.004	0.00007	0.0005	0.089	0.00048	0.0032	0.191	0.00113	0.0077	0.243	0.00108	0.0074
2011	HDV3	0.528	0.00260	0.0177	0.036	0.00008	0.0005	0.528	0.00104	0.0071	0.762	0.00092	0.0063	0.852	0.00242	0.0165
2011	HDV4	0.529	0.00262	0.0179	0.036	0.00008	0.0005	0.527	0.00104	0.0071	0.762	0.00092	0.0063	0.853	0.00244	0.0166
2011	HDV5	0.529	0.00263	0.0179	0.036	0.00008	0.0005	0.526	0.00104	0.0071	0.762	0.00091	0.0062	0.853	0.00244	0.0167
2011	HDV6	0.527	0.00263	0.0179	0.036	0.00008	0.0005	0.526	0.00104	0.0071	0.762	0.00091	0.0062	0.854	0.00244	0.0167
2011	HDV7	0.527	0.00259	0.0177	0.036	0.00008	0.0005	0.529	0.00104	0.0071	0.762	0.00092	0.0063	0.851	0.00241	0.0165
2011	HDV8a	0.527	0.00260	0.0177	0.036	0.00008	0.0005	0.529	0.00104	0.0071	0.763	0.00093	0.0063	0.852	0.00242	0.0165
2011	HDV8b	0.527	0.00260	0.0177	0.036	0.00008	0.0005	0.529	0.00104	0.0071	0.763	0.00093	0.0063	0.852	0.00242	0.0165
2012	HDV2B	0.176	0.00096	0.0066	0.005	0.00007	0.0005	0.100	0.00049	0.0033	0.201	0.00113	0.0077	0.255	0.00111	0.0076
2012	HDV3	0.527	0.00260	0.0177	0.036	0.00008	0.0005	0.529	0.00104	0.0071	0.762	0.00092	0.0063	0.852	0.00242	0.0165
2012	HDV4	0.528	0.00261	0.0178	0.036	0.00008	0.0005	0.528	0.00104	0.0071	0.762	0.00092	0.0063	0.853	0.00243	0.0166
2012	HDV5	0.528	0.00262	0.0179	0.036	0.00008	0.0005	0.527	0.00104	0.0071	0.762	0.00092	0.0062	0.853	0.00243	0.0166
2012	HDV6	0.528	0.00262	0.0179	0.036	0.00008	0.0005	0.527	0.00104	0.0071	0.762	0.00092	0.0062	0.853	0.00243	0.0166
2012	HDV7	0.527	0.00259	0.0177	0.036	0.00008	0.0005	0.529	0.00104	0.0071	0.762	0.00092	0.0063	0.851	0.00241	0.0165
2012	HDV8a	0.527	0.00260	0.0177	0.036	0.00008	0.0005	0.529	0.00104	0.0071	0.763	0.00093	0.0063	0.852	0.00242	0.0165

		E10														
		Highway			Urban											
					Braking			0-25			25-50			>50		
Model Yr	Vehicle Class	NOx	BC	PM	NOx	BC	PM	NOx	BC	PM	NOx	BC	PM	NOx	BC	PM
2012	HDV8b	0.527	0.00260	0.0177	0.036	0.00008	0.0005	0.529	0.00104	0.0071	0.763	0.00093	0.0063	0.852	0.00242	0.0165
2013	HDV2B	0.139	0.00086	0.0058	0.004	0.00006	0.0004	0.079	0.00044	0.0030	0.159	0.00101	0.0069	0.201	0.00099	0.0067
2013	HDV3	0.420	0.00233	0.0159	0.029	0.00007	0.0005	0.425	0.00093	0.0064	0.613	0.00082	0.0056	0.685	0.00216	0.0148
2013	HDV4	0.420	0.00234	0.0159	0.029	0.00007	0.0005	0.425	0.00093	0.0064	0.613	0.00083	0.0056	0.686	0.00217	0.0148
2013	HDV5	0.421	0.00234	0.0160	0.029	0.00007	0.0005	0.424	0.00093	0.0064	0.613	0.00082	0.0056	0.686	0.00218	0.0149
2013	HDV6	0.421	0.00234	0.0160	0.029	0.00007	0.0005	0.424	0.00093	0.0064	0.613	0.00082	0.0056	0.686	0.00218	0.0149
2013	HDV7	0.419	0.00232	0.0158	0.029	0.00007	0.0005	0.425	0.00093	0.0064	0.613	0.00082	0.0056	0.685	0.00216	0.0147
2013	HDV8a	0.420	0.00232	0.0159	0.029	0.00007	0.0005	0.426	0.00093	0.0064	0.614	0.00083	0.0057	0.685	0.00216	0.0148
2013	HDV8b	0.420	0.00232	0.0159	0.029	0.00007	0.0005	0.426	0.00093	0.0064	0.614	0.00083	0.0057	0.685	0.00216	0.0148
2014	HDV2B	0.141	0.00087	0.0059	0.004	0.00006	0.0004	0.081	0.00044	0.0030	0.161	0.00100	0.0068	0.204	0.00099	0.0068
2014	HDV3	0.419	0.00232	0.0158	0.029	0.00007	0.0005	0.424	0.00093	0.0063	0.612	0.00082	0.0056	0.684	0.00216	0.0147
2014	HDV4	0.419	0.00233	0.0159	0.029	0.00007	0.0005	0.424	0.00093	0.0063	0.612	0.00082	0.0056	0.684	0.00216	0.0148
2014	HDV5	0.420	0.00233	0.0159	0.029	0.00007	0.0005	0.423	0.00093	0.0063	0.611	0.00082	0.0056	0.684	0.00217	0.0148
2014	HDV6	0.420	0.00233	0.0159	0.029	0.00007	0.0005	0.423	0.00093	0.0063	0.611	0.00082	0.0056	0.684	0.00217	0.0148
2014	HDV7	0.418	0.00231	0.0158	0.029	0.00007	0.0005	0.425	0.00093	0.0063	0.612	0.00082	0.0056	0.683	0.00215	0.0147
2014	HDV8a	0.419	0.00232	0.0158	0.029	0.00007	0.0005	0.425	0.00093	0.0063	0.612	0.00083	0.0056	0.684	0.00216	0.0147
2014	HDV8b	0.419	0.00232	0.0158	0.029	0.00007	0.0005	0.425	0.00093	0.0063	0.612	0.00083	0.0056	0.684	0.00216	0.0147
2015	HDV2B	0.110	0.00056	0.0038	0.003	0.00004	0.0003	0.072	0.00028	0.0019	0.120	0.00064	0.0044	0.152	0.00064	0.0043
2015	HDV3	0.419	0.00148	0.0101	0.029	0.00005	0.0003	0.424	0.00059	0.0040	0.612	0.00052	0.0036	0.684	0.00138	0.0094
2015	HDV4	0.419	0.00148	0.0101	0.029	0.00005	0.0003	0.424	0.00059	0.0040	0.612	0.00053	0.0036	0.684	0.00138	0.0094
2015	HDV5	0.419	0.00149	0.0101	0.029	0.00005	0.0003	0.423	0.00059	0.0040	0.611	0.00052	0.0036	0.684	0.00138	0.0094
2015	HDV6	0.420	0.00149	0.0101	0.029	0.00005	0.0003	0.423	0.00059	0.0040	0.611	0.00052	0.0036	0.684	0.00138	0.0094
2015	HDV7	0.418	0.00148	0.0101	0.029	0.00005	0.0003	0.425	0.00059	0.0040	0.612	0.00052	0.0036	0.683	0.00137	0.0094
2015	HDV8a	0.419	0.00148	0.0101	0.029	0.00005	0.0003	0.425	0.00059	0.0040	0.612	0.00053	0.0036	0.684	0.00138	0.0094
2015	HDV8b	0.419	0.00148	0.0101	0.029	0.00005	0.0003	0.425	0.00059	0.0040	0.612	0.00053	0.0036	0.684	0.00138	0.0094
2016	HDV2B	0.109	0.00055	0.0038	0.003	0.00004	0.0003	0.071	0.00028	0.0019	0.119	0.00064	0.0044	0.150	0.00063	0.0043

		E10														
		Highway			Urban											
					Braking			0-25			25-50			>50		
Model Yr	Vehicle Class	NOx	BC	PM	NOx	BC	PM	NOx	BC	PM	NOx	BC	PM	NOx	BC	PM
2016	HDV3	0.419	0.00148	0.0101	0.029	0.00005	0.0003	0.424	0.00059	0.0040	0.612	0.00052	0.0036	0.684	0.00138	0.0094
2016	HDV4	0.419	0.00148	0.0101	0.029	0.00005	0.0003	0.424	0.00059	0.0040	0.612	0.00053	0.0036	0.684	0.00138	0.0094
2016	HDV5	0.419	0.00149	0.0101	0.029	0.00005	0.0003	0.423	0.00059	0.0040	0.611	0.00052	0.0036	0.684	0.00138	0.0094
2016	HDV6	0.420	0.00149	0.0101	0.029	0.00005	0.0003	0.423	0.00059	0.0040	0.611	0.00052	0.0036	0.684	0.00138	0.0094
2016	HDV7	0.418	0.00148	0.0101	0.029	0.00005	0.0003	0.425	0.00059	0.0040	0.612	0.00052	0.0036	0.683	0.00137	0.0094
2016	HDV8a	0.419	0.00148	0.0101	0.029	0.00005	0.0003	0.425	0.00059	0.0040	0.612	0.00053	0.0036	0.684	0.00138	0.0094
2016	HDV8b	0.419	0.00148	0.0101	0.029	0.00005	0.0003	0.425	0.00059	0.0040	0.612	0.00053	0.0036	0.684	0.00138	0.0094
2017	HDV2B	0.130	0.00055	0.0038	0.004	0.00004	0.0003	0.078	0.00028	0.0019	0.147	0.00064	0.0044	0.186	0.00063	0.0043
2017	HDV3	0.419	0.00148	0.0101	0.029	0.00005	0.0003	0.424	0.00059	0.0040	0.612	0.00052	0.0036	0.684	0.00138	0.0094
2017	HDV4	0.419	0.00148	0.0101	0.029	0.00005	0.0003	0.424	0.00059	0.0040	0.612	0.00053	0.0036	0.684	0.00138	0.0094
2017	HDV5	0.419	0.00149	0.0101	0.029	0.00005	0.0003	0.423	0.00059	0.0040	0.611	0.00052	0.0036	0.684	0.00138	0.0094
2017	HDV6	0.420	0.00149	0.0101	0.029	0.00005	0.0003	0.423	0.00059	0.0040	0.611	0.00052	0.0036	0.684	0.00138	0.0094
2017	HDV7	0.418	0.00148	0.0101	0.029	0.00005	0.0003	0.425	0.00059	0.0040	0.612	0.00052	0.0036	0.683	0.00137	0.0094
2017	HDV8a	0.419	0.00148	0.0101	0.029	0.00005	0.0003	0.425	0.00059	0.0040	0.612	0.00053	0.0036	0.684	0.00138	0.0094
2017	HDV8b	0.419	0.00148	0.0101	0.029	0.00005	0.0003	0.425	0.00059	0.0040	0.612	0.00053	0.0036	0.684	0.00138	0.0094
2018	HDV2B	0.097	0.00053	0.0036	0.003	0.00004	0.0002	0.058	0.00026	0.0018	0.104	0.00060	0.0041	0.134	0.00060	0.0041
2018	HDV3	0.350	0.00148	0.0101	0.024	0.00005	0.0003	0.352	0.00059	0.0040	0.508	0.00052	0.0036	0.568	0.00138	0.0094
2018	HDV4	0.351	0.00148	0.0101	0.024	0.00005	0.0003	0.353	0.00059	0.0040	0.510	0.00053	0.0036	0.571	0.00138	0.0094
2018	HDV5	0.352	0.00149	0.0101	0.024	0.00005	0.0003	0.353	0.00059	0.0040	0.511	0.00052	0.0036	0.572	0.00138	0.0094
2018	HDV6	0.352	0.00149	0.0101	0.024	0.00005	0.0003	0.354	0.00059	0.0040	0.511	0.00052	0.0036	0.572	0.00138	0.0094
2018	HDV7	0.349	0.00148	0.0101	0.024	0.00005	0.0003	0.352	0.00059	0.0040	0.507	0.00052	0.0036	0.567	0.00137	0.0094
2018	HDV8a	0.349	0.00148	0.0101	0.024	0.00005	0.0003	0.352	0.00059	0.0040	0.508	0.00053	0.0036	0.567	0.00138	0.0094
2018	HDV8b	0.349	0.00148	0.0101	0.024	0.00005	0.0003	0.352	0.00059	0.0040	0.508	0.00053	0.0036	0.567	0.00138	0.0094
2019	HDV2B	0.097	0.00053	0.0101	0.003	0.00004	0.000	0.058	0.00026	0.002	0.104	0.00060	0.004	0.134	0.00060	0.004
2019	HDV3	0.350	0.00148	0.0101	0.024	0.00005	0.000	0.352	0.00059	0.004	0.508	0.00052	0.004	0.568	0.00138	0.009
2019	HDV4	0.351	0.00148	0.0101	0.024	0.00005	0.000	0.353	0.00059	0.004	0.510	0.00053	0.004	0.571	0.00138	0.009

		E10														
		Highway			Urban											
					Braking			0-25			25-50			>50		
Model Yr	**Vehicle Class**	**NOx**	**BC**	**PM**	**NOx**	**BC**	**PM**	**NOx**	**BC**	**PM**	**NOx**	**BC**	**PM**	**NOx**	**BC**	**PM**
2019	HDV5	0.352	0.00149	0.0101	0.024	0.00005	0.000	0.353	0.00059	0.004	0.511	0.00052	0.004	0.572	0.00138	0.009
2019	HDV6	0.352	0.00149	0.0101	0.024	0.00005	0.000	0.354	0.00059	0.004	0.511	0.00052	0.004	0.572	0.00138	0.009
2019	HDV7	0.349	0.00148	0.0101	0.024	0.00005	0.000	0.352	0.00059	0.004	0.507	0.00052	0.004	0.567	0.00137	0.009
2019	HDV8a	0.349	0.00148	0.0101	0.024	0.00005	0.000	0.352	0.00059	0.004	0.508	0.00053	0.004	0.567	0.00138	0.009
2019	HDV8b	0.349	0.00148	0.0101	0.024	0.00005	0.000	0.352	0.00059	0.004	0.508	0.00053	0.004	0.567	0.00138	0.009

Note –MOVES does not provide consistent outputs for Class 8b gasoline vehicles; therefore gasoline 8bs are set equal to 8as.

Appendix B – NOx, PM & BC Idle Factors – g/hr
(MOVES2014a, 2018 Calendar Year, ULSD)

Short Duration Idle Emission Factors (< 60 minutes per idle event) (g/hr)

Pollutant	Fuel	Model Year	Class 2b	Class 3	Classes 4-5	Classes 6-7	Classes 8a/b
NOx	E10	1987	22.937	14.176	14.176	14.176	14.176
NOx	E10	1988	22.937	14.176	14.176	14.176	14.176
NOx	E10	1989	24.019	14.176	14.176	14.176	14.176
NOx	E10	1990	12.240	7.044	7.044	7.044	7.044
NOx	E10	1991	12.288	7.044	7.044	7.044	7.044
NOx	E10	1992	12.560	7.044	7.044	7.044	7.044
NOx	E10	1993	12.737	7.044	7.044	7.044	7.044
NOx	E10	1994	12.589	6.924	6.924	6.924	6.924
NOx	E10	1995	12.816	6.924	6.924	6.924	6.924
NOx	E10	1996	12.974	6.924	6.924	6.924	6.924
NOx	E10	1997	13.131	6.924	6.924	6.924	6.924
NOx	E10	1998	27.498	14.348	14.348	14.348	14.348
NOx	E10	1999	27.498	14.348	14.348	14.348	14.348
NOx	E10	2000	27.498	14.348	14.348	14.348	14.348
NOx	E10	2001	25.203	10.112	10.112	10.112	10.112
NOx	E10	2002	25.203	10.112	10.112	10.112	10.112
NOx	E10	2003	25.203	10.112	10.112	10.112	10.112
NOx	E10	2004	25.203	10.112	10.112	10.112	10.112
NOx	E10	2005	25.203	10.112	10.112	10.112	10.112
NOx	E10	2006	25.498	10.112	10.112	10.112	10.112
NOx	E10	2007	25.498	10.112	10.112	10.112	10.112
NOx	E10	2008	12.935	3.034	3.034	3.034	3.034
NOx	E10	2009	0.322	3.034	3.034	3.034	3.034
NOx	E10	2010	0.322	3.034	3.034	3.034	3.034
NOx	E10	2011	0.259	3.034	3.034	3.034	3.034
NOx	E10	2012	0.259	3.034	3.034	3.034	3.034
NOx	E10	2013	0.203	1.640	1.640	1.640	1.640
NOx	E10	2014	0.203	1.640	1.640	1.640	1.640
NOx	E10	2015	0.118	1.640	1.640	1.640	1.640
NOx	E10	2016	0.118	1.640	1.640	1.640	1.640
NOx	E10	2017	0.176	1.640	1.640	1.640	1.640
NOx	E10	2018	0.103	0.961	1.640	1.640	1.640
NOx	E10	2019	0.103	0.961	1.640	1.640	1.640
NOx	Diesel	1987	200.878	191.986	191.986	191.986	191.986
NOx	Diesel	1988	200.878	191.986	191.986	191.986	191.986
NOx	Diesel	1989	210.952	191.986	191.986	191.985	191.986
NOx	Diesel	1990	242.153	148.269	148.269	148.269	148.269
NOx	Diesel	1991	219.589	139.403	139.403	139.403	139.403
NOx	Diesel	1992	224.736	139.403	139.404	139.403	139.403
NOx	Diesel	1993	228.082	139.403	139.403	139.403	139.403

Pollutant	Fuel	Model Year	Class 2b	Class 3	Classes 4-5	Classes 6-7	Classes 8a/b
NOx	Diesel	1994	229.498	139.403	139.404	139.404	139.403
NOx	Diesel	1995	233.873	139.404	139.403	139.404	139.403
NOx	Diesel	1996	236.911	139.403	139.403	139.403	139.404
NOx	Diesel	1997	239.948	139.403	139.404	139.403	139.403
NOx	Diesel	1998	194.099	117.055	117.055	117.055	117.055
NOx	Diesel	1999	194.099	96.293	96.293	96.293	154.416
NOx	Diesel	2000	194.099	96.293	96.293	96.293	154.416
NOx	Diesel	2001	195.128	96.293	96.293	96.293	154.416
NOx	Diesel	2002	195.128	96.293	96.293	96.293	154.416
NOx	Diesel	2003	44.355	45.696	45.696	45.696	56.802
NOx	Diesel	2004	44.355	45.696	45.696	45.696	56.802
NOx	Diesel	2005	44.355	45.696	45.696	45.696	56.802
NOx	Diesel	2006	44.823	45.696	45.696	45.696	56.802
NOx	Diesel	2007	41.620	22.780	22.780	22.780	53.190
NOx	Diesel	2008	41.620	22.780	22.780	22.780	53.190
NOx	Diesel	2009	41.620	22.780	22.780	22.780	53.190
NOx	Diesel	2010	17.673	7.212	8.088	8.088	10.054
NOx	Diesel	2011	17.765	7.212	8.088	8.088	10.054
NOx	Diesel	2012	17.765	7.212	8.088	8.088	10.054
NOx	Diesel	2013	17.765	7.212	7.212	6.768	8.964
NOx	Diesel	2014	17.765	7.212	7.212	6.768	8.964
NOx	Diesel	2015	11.566	4.564	4.564	4.777	6.489
NOx	Diesel	2016	11.566	4.564	4.564	4.777	6.489
NOx	Diesel	2017	11.566	4.564	4.564	4.777	6.489
NOx	Diesel	2018	8.084	3.190	4.564	4.777	6.489
NOx	Diesel	2019	8.084	3.190	4.564	4.777	6.489
Total PM_{10}	E10	1987	1.113	1.113	1.113	1.113	1.113
Total PM_{10}	E10	1988	1.113	1.113	1.113	1.113	1.113
Total PM_{10}	E10	1989	1.113	1.113	1.113	1.113	1.113
Total PM_{10}	E10	1990	0.351	0.351	0.351	0.351	0.351
Total PM_{10}	E10	1991	0.391	0.391	0.391	0.391	0.391
Total PM_{10}	E10	1992	0.391	0.391	0.391	0.391	0.391
Total PM_{10}	E10	1993	0.391	0.391	0.391	0.391	0.391
Total PM_{10}	E10	1994	0.128	0.128	0.128	0.128	0.128
Total PM_{10}	E10	1995	0.152	0.152	0.152	0.152	0.152
Total PM_{10}	E10	1996	0.354	0.354	0.354	0.354	0.354
Total PM_{10}	E10	1997	0.372	0.372	0.372	0.372	0.372
Total PM_{10}	E10	1998	0.222	0.222	0.222	0.222	0.222
Total PM_{10}	E10	1999	0.082	0.082	0.082	0.082	0.082
Total PM_{10}	E10	2000	0.036	0.036	0.036	0.036	0.036
Total PM_{10}	E10	2001	0.033	0.033	0.033	0.033	0.033
Total PM_{10}	E10	2002	0.139	0.139	0.139	0.139	0.139

Pollutant	Fuel	Model Year	Class 2b	Class 3	Classes 4-5	Classes 6-7	Classes 8a/b
Total PM_{10}	E10	2003	0.082	0.082	0.082	0.082	0.082
Total PM_{10}	E10	2004	0.056	0.056	0.056	0.056	0.056
Total PM_{10}	E10	2005	0.056	0.056	0.056	0.056	0.056
Total PM_{10}	E10	2006	0.056	0.056	0.056	0.056	0.056
Total PM_{10}	E10	2007	0.056	0.056	0.056	0.056	0.056
Total PM_{10}	E10	2008	0.056	0.056	0.056	0.056	0.056
Total PM_{10}	E10	2009	0.046	0.046	0.046	0.046	0.046
Total PM_{10}	E10	2010	0.046	0.046	0.046	0.046	0.046
Total PM_{10}	E10	2011	0.042	0.042	0.042	0.042	0.042
Total PM_{10}	E10	2012	0.042	0.042	0.042	0.042	0.042
Total PM_{10}	E10	2013	0.037	0.037	0.037	0.037	0.037
Total PM_{10}	E10	2014	0.037	0.037	0.037	0.037	0.037
Total PM_{10}	E10	2015	0.024	0.024	0.024	0.024	0.024
Total PM_{10}	E10	2016	0.024	0.024	0.024	0.024	0.024
Total PM_{10}	E10	2017	0.024	0.024	0.024	0.024	0.024
Total PM_{10}	E10	2018	0.024	0.024	0.024	0.024	0.024
Total PM_{10}	E10	2019	0.024	0.024	0.024	0.024	0.024
Total PM_{10}	Diesel	1987	4.400	4.400	4.400	4.400	4.375
Total PM_{10}	Diesel	1988	4.400	4.400	4.400	4.400	4.375
Total PM_{10}	Diesel	1989	4.400	4.400	4.400	4.400	4.375
Total PM_{10}	Diesel	1990	4.400	4.400	4.400	4.400	4.375
Total PM_{10}	Diesel	1991	3.877	4.400	4.400	4.400	4.375
Total PM_{10}	Diesel	1992	3.877	4.400	4.400	4.400	4.375
Total PM_{10}	Diesel	1993	3.877	4.400	4.400	4.400	4.375
Total PM_{10}	Diesel	1994	8.139	7.607	7.607	7.607	6.689
Total PM_{10}	Diesel	1995	8.139	7.607	7.607	7.607	6.689
Total PM_{10}	Diesel	1996	8.139	7.607	7.607	7.607	6.689
Total PM_{10}	Diesel	1997	8.139	7.607	7.607	7.607	6.689
Total PM_{10}	Diesel	1998	7.655	7.222	7.222	7.222	6.397
Total PM_{10}	Diesel	1999	7.655	7.222	7.222	7.222	6.397
Total PM_{10}	Diesel	2000	7.655	7.222	7.222	7.222	6.397
Total PM_{10}	Diesel	2001	7.655	7.222	7.222	7.222	6.397
Total PM_{10}	Diesel	2002	7.655	7.222	7.222	7.222	6.397
Total PM_{10}	Diesel	2003	6.511	6.511	6.511	6.511	5.781
Total PM_{10}	Diesel	2004	6.511	6.511	6.511	6.511	5.781
Total PM_{10}	Diesel	2005	6.511	6.511	6.511	6.511	5.781
Total PM_{10}	Diesel	2006	6.511	6.511	6.511	6.511	5.781
Total PM_{10}	Diesel	2007	0.523	0.217	0.217	0.217	0.217
Total PM_{10}	Diesel	2008	0.523	0.217	0.217	0.217	0.217
Total PM_{10}	Diesel	2009	0.523	0.217	0.217	0.217	0.217
Total PM_{10}	Diesel	2010	0.437	0.181	0.205	0.205	0.205
Total PM_{10}	Diesel	2011	0.437	0.181	0.205	0.205	0.205

Pollutant	Fuel	Model Year	Class 2b	Class 3	Classes 4-5	Classes 6-7	Classes 8a/b
Total PM_{10}	Diesel	2012	0.437	0.181	0.205	0.205	0.205
Total PM_{10}	Diesel	2013	0.437	0.181	0.181	0.169	0.181
Total PM_{10}	Diesel	2014	0.437	0.181	0.181	0.169	0.181
Total PM_{10}	Diesel	2015	0.262	0.109	0.109	0.114	0.127
Total PM_{10}	Diesel	2016	0.262	0.109	0.109	0.114	0.127
Total PM_{10}	Diesel	2017	0.262	0.109	0.109	0.114	0.127
Total PM_{10}	Diesel	2018	0.262	0.109	0.109	0.114	0.127
Total PM_{10}	Diesel	2019	0.262	0.109	0.109	0.114	0.127
Total $PM_{2.5}$	E10	1987	0.985	0.985	0.985	0.985	0.985
Total $PM_{2.5}$	E10	1988	0.985	0.985	0.985	0.985	0.985
Total $PM_{2.5}$	E10	1989	0.985	0.985	0.985	0.985	0.985
Total $PM_{2.5}$	E10	1990	0.310	0.310	0.310	0.310	0.310
Total $PM_{2.5}$	E10	1991	0.345	0.345	0.345	0.345	0.345
Total $PM_{2.5}$	E10	1992	0.345	0.345	0.345	0.345	0.345
Total $PM_{2.5}$	E10	1993	0.345	0.345	0.345	0.345	0.345
Total $PM_{2.5}$	E10	1994	0.113	0.113	0.113	0.113	0.113
Total $PM_{2.5}$	E10	1995	0.135	0.135	0.135	0.135	0.135
Total $PM_{2.5}$	E10	1996	0.313	0.313	0.313	0.313	0.313
Total $PM_{2.5}$	E10	1997	0.329	0.329	0.329	0.329	0.329
Total $PM_{2.5}$	E10	1998	0.197	0.197	0.197	0.197	0.197
Total $PM_{2.5}$	E10	1999	0.072	0.072	0.072	0.072	0.072
Total $PM_{2.5}$	E10	2000	0.032	0.032	0.032	0.032	0.032
Total $PM_{2.5}$	E10	2001	0.029	0.029	0.029	0.029	0.029
Total $PM_{2.5}$	E10	2002	0.123	0.123	0.123	0.123	0.123
Total $PM_{2.5}$	E10	2003	0.072	0.072	0.072	0.072	0.072
Total $PM_{2.5}$	E10	2004	0.050	0.050	0.050	0.050	0.050
Total $PM_{2.5}$	E10	2005	0.050	0.050	0.050	0.050	0.050
Total $PM_{2.5}$	E10	2006	0.050	0.050	0.050	0.050	0.050
Total $PM_{2.5}$	E10	2007	0.050	0.050	0.050	0.050	0.050
Total $PM_{2.5}$	E10	2008	0.050	0.050	0.050	0.050	0.050
Total $PM_{2.5}$	E10	2009	0.041	0.041	0.041	0.041	0.041
Total $PM_{2.5}$	E10	2010	0.041	0.041	0.041	0.041	0.041
Total $PM_{2.5}$	E10	2011	0.037	0.037	0.037	0.037	0.037
Total $PM_{2.5}$	E10	2012	0.037	0.037	0.037	0.037	0.037
Total $PM_{2.5}$	E10	2013	0.033	0.033	0.033	0.033	0.033
Total $PM_{2.5}$	E10	2014	0.033	0.033	0.033	0.033	0.033
Total $PM_{2.5}$	E10	2015	0.021	0.021	0.021	0.021	0.021
Total $PM_{2.5}$	E10	2016	0.021	0.021	0.021	0.021	0.021
Total $PM_{2.5}$	E10	2017	0.021	0.021	0.021	0.021	0.021
Total $PM_{2.5}$	E10	2018	0.021	0.021	0.021	0.021	0.021
Total $PM_{2.5}$	E10	2019	0.021	0.021	0.021	0.021	0.021
Total $PM_{2.5}$	Diesel	1987	3.892	3.892	3.892	3.892	3.870

Pollutant	Fuel	Model Year	Class 2b	Class 3	Classes 4-5	Classes 6-7	Classes 8a/b
Total $PM_{2.5}$	Diesel	1988	3.892	3.892	3.892	3.892	3.870
Total $PM_{2.5}$	Diesel	1989	3.892	3.892	3.892	3.892	3.870
Total $PM_{2.5}$	Diesel	1990	3.892	3.892	3.892	3.892	3.870
Total $PM_{2.5}$	Diesel	1991	3.430	3.892	3.892	3.892	3.870
Total $PM_{2.5}$	Diesel	1992	3.430	3.892	3.892	3.892	3.870
Total $PM_{2.5}$	Diesel	1993	3.430	3.892	3.892	3.892	3.870
Total $PM_{2.5}$	Diesel	1994	7.200	6.729	6.729	6.729	5.917
Total $PM_{2.5}$	Diesel	1995	7.200	6.729	6.729	6.729	5.917
Total $PM_{2.5}$	Diesel	1996	7.200	6.729	6.729	6.729	5.917
Total $PM_{2.5}$	Diesel	1997	7.200	6.729	6.729	6.729	5.917
Total $PM_{2.5}$	Diesel	1998	6.772	6.389	6.389	6.389	5.659
Total $PM_{2.5}$	Diesel	1999	6.772	6.389	6.389	6.389	5.659
Total $PM_{2.5}$	Diesel	2000	6.772	6.389	6.389	6.389	5.659
Total $PM_{2.5}$	Diesel	2001	6.772	6.389	6.389	6.389	5.659
Total $PM_{2.5}$	Diesel	2002	6.772	6.389	6.389	6.389	5.659
Total $PM_{2.5}$	Diesel	2003	5.760	5.760	5.760	5.760	5.114
Total $PM_{2.5}$	Diesel	2004	5.760	5.760	5.760	5.760	5.114
Total $PM_{2.5}$	Diesel	2005	5.760	5.760	5.760	5.760	5.114
Total $PM_{2.5}$	Diesel	2006	5.760	5.760	5.760	5.760	5.114
Total $PM_{2.5}$	Diesel	2007	0.463	0.192	0.192	0.192	0.192
Total $PM_{2.5}$	Diesel	2008	0.463	0.192	0.192	0.192	0.192
Total $PM_{2.5}$	Diesel	2009	0.463	0.192	0.192	0.192	0.192
Total $PM_{2.5}$	Diesel	2010	0.387	0.160	0.181	0.181	0.181
Total $PM_{2.5}$	Diesel	2011	0.387	0.160	0.181	0.181	0.181
Total $PM_{2.5}$	Diesel	2012	0.387	0.160	0.181	0.181	0.181
Total $PM_{2.5}$	Diesel	2013	0.387	0.160	0.160	0.150	0.160
Total $PM_{2.5}$	Diesel	2014	0.387	0.160	0.160	0.150	0.160
Total $PM_{2.5}$	Diesel	2015	0.232	0.096	0.096	0.101	0.112
Total $PM_{2.5}$	Diesel	2016	0.232	0.096	0.096	0.101	0.112
Total $PM_{2.5}$	Diesel	2017	0.232	0.096	0.096	0.101	0.112
Total $PM_{2.5}$	Diesel	2018	0.232	0.096	0.096	0.101	0.112
Total $PM_{2.5}$	Diesel	2019	0.232	0.096	0.096	0.101	0.112
Black Carbon	E10	1987	0.144	0.144	0.144	0.144	0.144
Black Carbon	E10	1988	0.144	0.144	0.144	0.144	0.144
Black Carbon	E10	1989	0.144	0.144	0.144	0.144	0.144
Black Carbon	E10	1990	0.045	0.045	0.045	0.045	0.045
Black Carbon	E10	1991	0.051	0.051	0.051	0.051	0.051
Black Carbon	E10	1992	0.051	0.051	0.051	0.051	0.051
Black Carbon	E10	1993	0.051	0.051	0.051	0.051	0.051
Black Carbon	E10	1994	0.017	0.017	0.017	0.017	0.017
Black Carbon	E10	1995	0.020	0.020	0.020	0.020	0.020
Black Carbon	E10	1996	0.046	0.046	0.046	0.046	0.046

Pollutant	Fuel	Model Year	Class 2b	Class 3	Classes 4-5	Classes 6-7	Classes 8a/b
Black Carbon	E10	1997	0.048	0.048	0.048	0.048	0.048
Black Carbon	E10	1998	0.029	0.029	0.029	0.029	0.029
Black Carbon	E10	1999	0.011	0.011	0.011	0.011	0.011
Black Carbon	E10	2000	0.005	0.005	0.005	0.005	0.005
Black Carbon	E10	2001	0.004	0.004	0.004	0.004	0.004
Black Carbon	E10	2002	0.018	0.018	0.018	0.018	0.018
Black Carbon	E10	2003	0.011	0.011	0.011	0.011	0.011
Black Carbon	E10	2004	0.007	0.007	0.007	0.007	0.007
Black Carbon	E10	2005	0.007	0.007	0.007	0.007	0.007
Black Carbon	E10	2006	0.007	0.007	0.007	0.007	0.007
Black Carbon	E10	2007	0.007	0.007	0.007	0.007	0.007
Black Carbon	E10	2008	0.007	0.007	0.007	0.007	0.007
Black Carbon	E10	2009	0.006	0.006	0.006	0.006	0.006
Black Carbon	E10	2010	0.006	0.006	0.006	0.006	0.006
Black Carbon	E10	2011	0.005	0.005	0.005	0.005	0.005
Black Carbon	E10	2012	0.005	0.005	0.005	0.005	0.005
Black Carbon	E10	2013	0.005	0.005	0.005	0.005	0.005
Black Carbon	E10	2014	0.005	0.005	0.005	0.005	0.005
Black Carbon	E10	2015	0.003	0.003	0.003	0.003	0.003
Black Carbon	E10	2016	0.003	0.003	0.003	0.003	0.003
Black Carbon	E10	2017	0.003	0.003	0.003	0.003	0.003
Black Carbon	E10	2018	0.003	0.003	0.003	0.003	0.003
Black Carbon	E10	2019	0.003	0.003	0.003	0.003	0.003
Black Carbon	Diesel	1987	1.740	1.740	1.740	1.740	1.062
Black Carbon	Diesel	1988	1.740	1.740	1.740	1.740	1.062
Black Carbon	Diesel	1989	1.740	1.740	1.740	1.740	1.062
Black Carbon	Diesel	1990	1.740	1.740	1.740	1.740	1.062
Black Carbon	Diesel	1991	1.533	1.740	1.740	1.740	1.062
Black Carbon	Diesel	1992	1.533	1.740	1.740	1.740	1.062
Black Carbon	Diesel	1993	1.533	1.740	1.740	1.740	1.062
Black Carbon	Diesel	1994	3.218	3.008	3.008	3.008	1.624
Black Carbon	Diesel	1995	3.218	3.008	3.008	3.008	1.624
Black Carbon	Diesel	1996	3.218	3.008	3.008	3.008	1.624
Black Carbon	Diesel	1997	3.218	3.008	3.008	3.008	1.624
Black Carbon	Diesel	1998	3.027	2.856	2.856	2.856	1.553
Black Carbon	Diesel	1999	3.027	2.856	2.856	2.856	1.553
Black Carbon	Diesel	2000	3.027	2.856	2.856	2.856	1.553
Black Carbon	Diesel	2001	3.027	2.856	2.856	2.856	1.553
Black Carbon	Diesel	2002	3.027	2.856	2.856	2.856	1.553
Black Carbon	Diesel	2003	2.575	2.575	2.575	2.575	1.404
Black Carbon	Diesel	2004	2.575	2.575	2.575	2.575	1.404
Black Carbon	Diesel	2005	2.575	2.575	2.575	2.575	1.404

Pollutant	Fuel	Model Year	Class 2b	Class 3	Classes 4-5	Classes 6-7	Classes 8a/b
Black Carbon	Diesel	2006	2.575	2.575	2.575	2.575	1.404
Black Carbon	Diesel	2007	0.045	0.019	0.019	0.019	0.019
Black Carbon	Diesel	2008	0.045	0.019	0.019	0.019	0.019
Black Carbon	Diesel	2009	0.045	0.019	0.019	0.019	0.019
Black Carbon	Diesel	2010	0.038	0.016	0.018	0.018	0.018
Black Carbon	Diesel	2011	0.038	0.016	0.018	0.018	0.018
Black Carbon	Diesel	2012	0.038	0.016	0.018	0.018	0.018
Black Carbon	Diesel	2013	0.038	0.016	0.016	0.015	0.016
Black Carbon	Diesel	2014	0.038	0.016	0.016	0.015	0.016
Black Carbon	Diesel	2015	0.023	0.009	0.009	0.010	0.011
Black Carbon	Diesel	2016	0.023	0.009	0.009	0.010	0.011
Black Carbon	Diesel	2017	0.023	0.009	0.009	0.010	0.011
Black Carbon	Diesel	2018	0.023	0.009	0.009	0.010	0.011
Black Carbon	Diesel	2019	0.023	0.009	0.009	0.010	0.011

Extended Idle Emission Factors – Class 8b Diesels Only (g/hr)

Model Year	NOx	PM_{10}	$PM_{2.5}$	BC
1987	119.599	5.014	4.613	1.061
1988	119.599	5.014	4.613	1.061
1989	117.933	5.011	4.610	1.080
1990	113.640	5.002	4.602	1.128
1991	240.243	5.012	4.611	1.073
1992	240.636	5.013	4.612	1.071
1993	233.769	5.006	4.605	1.109
1994	239.542	7.697	7.081	1.659
1995	239.104	7.700	7.084	1.664
1996	237.157	7.712	7.095	1.686
1997	239.505	7.697	7.081	1.660
1998	237.408	7.371	6.781	1.609
1999	241.362	7.349	6.761	1.567
2000	241.987	7.345	6.757	1.560
2001	239.293	7.360	6.771	1.589
2002	237.722	7.369	6.780	1.605
2003	239.341	6.651	6.119	1.435
2004	237.076	6.662	6.129	1.457
2005	238.327	6.656	6.123	1.445
2006	239.046	6.652	6.120	1.438
2007	210.121	0.418	0.385	0.034
2008	208.658	0.418	0.384	0.034
2009	211.704	0.419	0.385	0.034
2010	211.266	0.417	0.383	0.034
2011	210.133	0.416	0.383	0.034
2012	210.133	0.416	0.383	0.034
2013	210.133	0.413	0.380	0.034
2014	210.133	0.413	0.380	0.034
2015	210.132	0.413	0.380	0.034
2016	210.132	0.413	0.380	0.034
2017	210.132	0.413	0.380	0.034
2018	210.133	0.413	0.380	0.034
2019	210.133	0.413	0.380	0.034

Appendix C – Derivation of National Average g/kW-hr Emission Factors

From Argonne GREET Model Version 2016.

http://greet.es.anl.gov/

1. **Electric Generation Mix (From Annual Energy Outlook 2016)**

	U.S. Mix
Residual oil	0.7%
Natural gas	32.9%
Coal	33.5%
Nuclear power	19.7%
Biomass	1.0%
Others	12.2%

Others = Hydro, Wind, Geothermal, Solar PV etc.

2. **Electric Transmission and Distribution Loss = 8.0%**

3. **Power Plant Emissions: in Grams per kWh of Electricity Available at Power Plant Gate**

	GREET-Calculated Emission Factors				
	By Fuel-Type Plants (Stationary and Transportation)				
	Oil-Fired	NG-Fired	Coal-Fired	Biomass-Fired	TOTAL based on US Mix
NOx	4.3	0.41	0.49	1.06	0.366
PM10	0.18	0.01379	0.16	2.08	0.083
PM2.5	0.13	0.01344	0.062	0.61	0.034
CO2	950	440	960	1,530	559
CO2 in burnt biomass from atmosphere				-750	

Assumes no emissions from nuclear power plants or "Others"

4. **Power Plant Emissions: Grams per kWh of Electricity Available at User Sites (wall outlets)**

Total power plant gate emissions/(1-electric transmission and distribution loss)

	Total delivered based on US electric generation mix
NO_x	0.40
PM_{10}	0.091
$PM_{2.5}$	0.037
CO_2	607

Appendix D - Cargo Volume Literature Review Summary

Class	Application	Body Type	VIUS Category	Manuf	Model	Cargo Space (cubic feet)	Unit	Max Payload	GVW	Notes or Comments	URL
2b	Full Size Pick-up	Pick-up		Chevy	Silverado 2500HD		Cu. Ft	3,644	9,200		http://www.chevrolet.com/vehicles/2010/silverado2500hd/features.do
2b	Full Size Pick-up	Pick-up		Ford	F250		Cu. Ft	2,900	9,400		http://www.fordf150.net/specs/05sd_specs.pdf
2b	Step Van	Budget Cargo Van	step/walk-in	Ford		309	Cu. Ft	3,116	8,600		http://www.budgettruck.com/Moving-Trucks.aspx
2b	Step Van	Step Van	step/walk-in	Freightliner-Sprinter	2500 Standard Roof	318	Cu. Ft	3,469	8,550		http://www.freightlinersprinterusa.com/vehicles/cargo-van/models/specifications.php
2b	Utility Van	Utility/ cargo van	van (basic enclosed)	Ford	E350	237	Cu. Ft	4,239	9,500		http://www.motortrend.com/cars/2008/ford/e_350/specifications/index.html
2b	Utility Van	Uhaul 10' Truck	van (basic enclosed)	GMC		402	Cu. Ft	2,810	8,600		http://www.uhaul.com/Reservations/EquipmentDetail.aspx?model=EL
2b	Utility Van	Budget 10' Moving Truck	van (basic enclosed)			380	Cu. Ft	3,100	8,600		http://www.budgettruck.com/Moving-Trucks.aspx
2b	Stake Truck	Stake/ platform	flatbed/stake/ platform	Supreme		336	Cu. Ft				
3	Pickup	Pick-up		GMC	Sierra 3500		Cu. Ft	4,566	10,700		http://www.gmc.com/sierra/3500/specsStandard.jsp
3	Step Van	Step Van	step/walk-in	Freightliner-Sprinter	3500 Standard Roof	547	Cu. Ft	4,845	11,030		http://www.freightlinersprinterusa.com/vehicles/cargo-van/models/3500-high-roof-170-wb-6-specs.php
3	Conventional Van	Penske 12' Cargo Van	van (basic enclosed)			450	Cu. Ft	2,600			http://www.pensketruckrental.com/commercial-truck-rentals/moving-vans/12-ft.html
3	City Delivery	Budget 16' Moving Truck				800	Cu. Ft	3,400	11,500		http://www.budgettruck.com/Moving-Trucks.aspx

Class	Application	Body Type	VIUS Category	Manuf	Model	Cargo Space (cubic feet)	Unit	Max Payload	GVW	Notes or Comments	URL
4	Conventional Van	Uhaul 14' Truck		Ford		733	Cu. Ft	6,190	14,050		http://www.uhaul.com/Reservations/EquipmentDetail.aspx?model=EL
4	Conventional Van	Uhaul 17' Truck		Ford		865	Cu. Ft	5,930	14,050		http://www.uhaul.com/Reservations/EquipmentDetail.aspx?model=EL
4	Conventional Van	Penske 16' Economy Van				826	Cu. Ft	4,300	15,000		http://www.pensketruckrental.com/commercial-truck-rentals/moving-cargo-vans/16-ft.html
4	City Delivery	Penske 16' Cargo Van				1,536	Cu. Ft	5,100			http://www.pensketruckrental.com/commercial-truck-rentals/moving-cargo-vans/16-ft.html
4	Large Walk-In	Walk-in			W700 Step Van	700	Cu. Ft	5,720	16,000		http://files.harc.edu/Projects/Transportation/FedExReportTask3.pdf
4	Large Walk-In	Walk-in		Eaton Hybrid	W700 Step Van	700	Cu. Ft	5,390	16,000		http://files.harc.edu/Projects/Transportation/FedExReportTask3.pdf
4	UPS	Walk-in		Grumman							http://www.grummanolson.com/index2.htm
4	Stake Truck	Stake/platform	flatbed/stake/platform	GMC	W4500	448	Cu. Ft		14,500		http://www.usedtrucksdepot.com/browse_listdetails.php?manf=GMC&scate=Stake+Truck&catname=Medium+Duty+Trucks&main_id=208
5	Bucket Truck	Bucket truck					Cu. Ft				
5	City Delivery	Uhaul 24' Truck	van (basic enclosed)			1,418	Cu. Ft	6,500	18,000		http://www.uhaul.com/Reservations/EquipmentDetail.aspx?model=EL
5	City Delivery	Uhaul 26' Truck	van (basic enclosed)			1,611	Cu. Ft	7,400	18,000		http://www.uhaul.com/Reservations/EquipmentDetail.aspx?model=EL
5	Large Walk-In	Large Walk-in	step/walk-in			670	Cu. Ft		16,000		http://news.van.fedex.com/node/7379
6	Beverage	Beverage		Hackney	6-Bay 52" Performer	588/case capacity = 531 @	Cu. Ft/cases cans	11,601	21,150		http://www.hackneybeverage.com/bodycad5.htm

Class	Application	Body Type	VIUS Category	Manuf	Model	Cargo Space (cubic feet)	Unit	Max Payload	GVW	Notes or Comments	URL
						120z cans					
6	Single Axle Van	Budget 24' Truck	van (basic enclosed)			1,380	Cu. Ft	12,000	25,500		http://www.budgettruck.com/Moving-Trucks.aspx
6	Stake Truck	24' Stake Truck	flatbed/stake/platform	International/ Supreme	24'	672	Cu. Ft		25,900		http://www.usedtrucks.ryder.com/Vehicle/VehicleSearch.aspx?VehicleTypeId=1&VehicleGroupId=5
6	Refrigerated /Reefer	24' Kold King Refrigerated	reefer	Supreme	24'	1,521	Cu. Ft				http://www.silvercrowncoach.com/supreme.php?page=product&body=refrigerated&product=21&section=specs
6	Landscape Van	Vanscaper Landscape Van	step/walk-in	Supreme	22'	1,496	Cu. Ft			Note: typical step/walk-ins do not reach this size. This is a speciality vehicle	http://www.silvercrowncoach.com/supreme.php?page=product&body=landscaping&product=30
7	Refuse	Refuse Truck					Cu. Ft				
7	Furniture	Furniture Truck				2,013	Cu. Ft				http://www.hendersonrentals.co.nz/?t=38
7	Beverage	Beverage (delivery body)		Hackney	Hackney 10-Bay-48" Aluminum	1251/ case capacity = 1,100 12 oz cans	Cu. Ft/case cans	23,700	37,733		http://hackneyusa.com/
7	Stake Truck	flatbed/stake/platform	flatbed/stake/platform	Supreme	SH20096	728			33,000		http://www.usedtrucks.ryder.com/Vehicle/VehicleSearch.aspx?VehicleTypeId=1&VehicleGroupId=5
7	Refrigerated /Reefer	28' Kold King Refrigera	reefer	Supreme	28'	1,774	Cu. Ft				http://www.silvercrowncoach.com/supreme.php?page=product&body=refrigerated&product=21&section=specs

Class	Application	Body Type	VIUS Category	Manuf	Model	Cargo Space (cubic feet)	Unit	Max Payload	GVW	Notes or Comments	URL
		ted									
7	Tanker Truck	tank (fluid)	tank (fluid)	Ford	F750 XL	267	Cu. Ft	2,000-4000 GAL	26,000		http://www.truckingauctions.com/browse_listdetails.php?scate=Water%20Tank%20Truck&manf=GMC&catname=Heavy%20Duty%20Trucks
7	Single Axle Van	Freightliner Truck	van (basic enclosed)	Freightliner Business Class (24')	Business Class M2 112	1,552			33,000	Note: front axle lbs 12,000/rear axle 21,000 lbs (each add'l axle approx 12,000 lbs)	http://www.truckpaper.com/listingsdetail/detail.aspx?OHID=2379362

Appendix E - PERE Efficiency Modeling Methodology

The PERE model is not specifically designed for modeling heavy duty hybrid trucks, but as it is a physical model that is primarily dependent upon input values, its use was considered appropriate for the estimation of the fuel economy effects of truck hybridization. The model calculates second-by-second fuel consumption for user-defined drive cycles based on a physical model. The model takes a number of user-specified parameters, along with some of its own defaults, to perform these calculations for a variety of vehicle and powertrain types. The assumptions and data sources for the model inputs that were used are presented below. The defaults for some parameters, such as hybrid regeneration efficiency and hybrid battery efficiency, were assumed to remain unchanged when scaling from light-duty to heavy-duty vehicles.

Many vehicle parameters, such as road load and transmission data, were used from work already done with the PERE model for the SmartWay program. Many of the parameters for that previous work were taken from findings of internet searches for specifications of various trucks in new "as-delivered" condition, prior to the addition of various vocational or cargo equipment installations that would increase drag and vehicle weight. To establish the test weights for each truck class in this modeling effort, the original estimate of minimum weight was averaged with the maximum possible weight for each truck class. This was done with the intent of modeling an average or medium payload for each truck class. An important source of information was an EPA draft document discussing the use of the PERE model by Nam and Gianelli[56]. This document contained equations that could be used for estimates of some of the input parameters, along with information describing the use of the model.

The two foremost inputs to the model include the vehicle weight and engine size. Vehicle empty weights and engine sizes were taken from manufacturer supplied truck specifications where possible. For example, Ford published a .pdf file titled *F-250/F-350/F-450/F-550 Specifications*[57] that contains base curb weights and engine sizes for some of their offerings in the light and medium duty market. Another useful source of manufacturer data was in the *Kenworth T170/T270/T370 Body Builders* Manual[58]. The T170-T370 range consists of medium duty trucks that can be delivered with a cab-only chassis. The manual describes all of the dimensions relevant to the builder of a body or cargo area on the rear of the chassis. As such, it includes curb weights, length and width dimensions, and gross vehicle weight ratings that were instrumental in creating many of the inputs for the Class 5, 6, and 7 fuel economy models. Where specifications of multiple trucks in a class were found, values were taken that would result in maximum fuel economy unless they seemed noticeably atypical of in-use vehicles. Variations in weight and engine size over the ranges found in literature

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56 Nam, Edward and Gianelli, Robert, Fuel Consumption Modeling of Conventional and Advanced Technology Vehicles in the Physical Emission Rate Estimator (PERE). US EPA Publication EPA420-P-05-001, February 2005.

57 FordF150.net. F-250/F-350/F-450/F-550 Specifications. Retrieved from http://www.fordf150.net/specs/05sd_specs.pdf

58 Kenworth. Kenworth T170/T270/T370 Body Builders Manual. Retrieved from http://www.kenworth.com/brochures/2009_Hybrid_Body_Builders_Manual.pdf

did not have as large an effect on fuel economy as some of the other inputs to the PERE model. For hybrid modeling, the engine size reduction due to hybridization ranged from 1 liter for the Class 2b and 3 trucks, up to 4 liters for the Class 8 trucks. This range was chosen based on the nature of hybrid trucks currently available on the market. Class 2 hybrid trucks on the market typically have very little engine downsizing from hybridization, however larger trucks were found to have more engine downsizing.

The number of transmission gears in each truck class was also based on specifications found on manufacturers' web sites, but there is a wide range of the number of gears in the different available transmissions. While it is very likely that the most efficient setup for Class 2b through 4 would be a 6 speed manual transmission, there are a variety of options for Classes 5 through 8. It is also typical for a modern Class 8 truck to have 10 gears, so the model input for Class 6 was taken to be 8 as a representation of typical trucks in that class, and all trucks were modeled with manual transmissions. The PERE model also requires shift speeds as an input to the model, and examples of these were not found in literature or internet searches. ERG has previously logged on-road data from Class 8 trucks with 10-speed manual transmissions, and this data was analyzed briefly to create an estimate of typical upshift speeds for this type of truck. Using this speed/gear curve, two other curves were created by scaling for the 6 and 8 speed trucks modeled in the study. Unfortunately, the shift speed chart has a very strong effect on the model's predicted fuel economy, but using carefully scaled shift point curves hopefully mitigated this source of error. The hybrid trucks were modeled with exactly the same transmissions as the conventional trucks. The model did not readily include a provision for changing the transmission characteristics when changing from conventional to hybrid powertrains. All transmission parameters were kept the same when making this change with the intent of ensuring the resulting fuel economy effects were only due to hybridization, not due to transmission effects.

There were three other values regarding the driveline that were input for this study. The engine efficiency was taken to be 40% over the cycle. The maximum engine speeds and highway cruise speeds were adjusted together as well, to account for the larger displacement heavy duty engines turning more slowly than typical Class 2b truck engines. The effects of the engine speed parameters on fuel economy were fairly small.

The road load estimation required assumptions and calculations as road load curves are not generally a part of manufacturers' literature. The method of road load calculation used for this PERE modeling was based on the coefficient of rolling resistance (C_R), the aerodynamic drag coefficient (C_d), and the vehicle frontal area (A_F) in a physical equation of the truck's road load, given in Equation 1 from Nam and Gianelli (2005). Coefficients of drag were based on values in literature, such as manufacturers' specifications for Class 2b and in a report publication by Argonne National Laboratory[59]. Values for C_d ranged from .45 for the

59 Delorme, A., Karbowski, D., and Sharer, P. Evaluation of Fuel Consumption Potential of Medium and Heavy Duty Vehicles through Modeling and Simulation. Argonne National Laboratory, DEPS-BEES-001, October 2009.

Class 2b and the smaller medium duty trucks, to .5 for the class 8 long-haul trucks. The heavier medium duty trucks were assumed to have a C_d of .55 as they were assumed to be vocational trucks with less streamlined aerodynamics. Frontal area was taken from manufacturer specifications where available. As given in Nam and Gianelli, the product of truck height and width was multiplied by a factor of 0.93 to get an estimate of effective A_F. Engineering judgment was applied to the dimensions found in literature to ensure a representative increase in frontal area from the smaller to larger trucks. The rolling resistance values were estimated using the trends observed by both Nam and Gianelli (2005) along with Delorme Karbowski, and Sharer (2009), ranging from 0.01 for the light and medium duty trucks, down to 0.008 for the class 8 trucks.

The final input to the PERE model was the driving cycle. In order to get a representative range of fuel economy benefit, two drive cycles were modeled. The first was the Heavy-Duty Urban Dynamometer Driving Schedule (HDUDDS), and the second was the EPA Highway Fuel Economy Test (HwFET). The HDUDDS can be thought of as a city-type cycle with frequent stops and starts. The HwFET simulates rural driving with varying speeds but no stops. Even though the HwFET is designed only for light duty vehicles, it was still used as it was the best representation available for in-use highway driving.

The key values used as the inputs for the PERE model fuel economy calculations are given by truck class in Table E-1.

Table E-1. PERE Model Inputs for Fuel Economy Estimation

Class	Modeled Test Weight, lbs	Conventional Engine Disp., L	Hybrid Engine Disp., L	Number of Gears	Effective Gear Ratio, RPM/mph
2b	7,875	6.0	5	6	35
3	10,000	6.0	5	6	35
4	12,250	6.4	5.4	6	33
5	14,500	6.7	5.7	6	33
6	19,500	6.7	5.7	8	33
7	24,000	8.3	6.3	10	31
8	52,500	13	9	10	30

For modeling hybrid vehicles in the PERE model, the user must adjust the hybrid threshold for each different vehicle and drive cycle combination. This variable represents the amount of power demand during acceleration that is required to cause the engine to start up to assist the electric motor. The user must adjust this value such that the amount of energy taken from the battery is approximately equal to the amount of energy charged back into the battery during regenerative braking. If this is not done, the fuel economy will be misrepresented due to the battery ending up with a different state of charge at the end of the cycle compared to the beginning of the cycle.

For the HwFET cycle in the lower truck classes, there were not enough deceleration events charge the battery back to its initial charge level, even with the hybrid threshold variable at its minimum value. This meant that the battery was ending at a lower level of charge at the end of the cycle than the beginning, which has the effect of overestimating the trucks actual fuel economy. For this reason, ERG added an extra calculation to the model in order to account for the net change in battery power. This calculation used the various efficiencies of the hybrid system to estimate the fuel required to make up the change in battery charge over the cycle, and add that number to the modeled fuel consumption. This calculation was needed for the trucks in Classes 2b through 5.