SmartWay
Transport Partnership
U.S. Environmental Protection Agency

Truck Carrier Partner 2.0.13 Tool: Technical Documentation 2013 Data Year - United States Version

EPA United States Environmental Protection Agency

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Transportation and Climate Division
Office of Transportation and Air Quality
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SmartWay 2.0.13
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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 2.0.13. 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, and PM (PM_{10} and $PM_{2.5}$), 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 different emission rates and constraints than

[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.

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 and PM 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 and PM 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 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.[4]

2.1 CO_2 Factors

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

[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 (CO2, 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.

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-equivalent gallons (on a Btu basis), or in standard cubic feet (scf). If CNG consumption is expressed in scf, the Tool applies a fuel factor expressed in grams per scf (57.8), based on 983 Btu/scf and 58,819 g CO_2/mmBtu.[7]

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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.

[7] See footnote 4, v.

2.2 NOx and PM Factors

The SmartWay Truck Tool contains NOx, PM_{10} and $PM_{2.5}$ emission factor outputs for on-road operation from EPA's MOVES2010b model for gasoline, diesel, and E10[8] for all heavy truck classes (2b – 8b) under national default temperature and fuel conditions, for model years 1987 through 2014, for the 2014 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.

Short-duration (less than 15 minutes) idle emission factors for NOx and PM were developed separately by model year, truck class, and fuel type (diesel and gasoline). MOVES2010b does not currently provide short duration idle factors in terms of grams per hour, so MOVES2010b 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 obtain g/hr factors.

MOVES2010b 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.[9] 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[10]) emissions are assumed unchanged relative to their conventional vehicle counterparts. Finally, battery-electric trucks are assumed to have no idle emissions.

The resulting idle factors are presented in Appendix B.

Version 2.0.13 of the Truck Tool also calculates the NOx and PM emissions associated with use of transportation refrigeration (reefer) units. EPA's NONROAD2008a emissions model was used to develop emission rates for these units for the 2014 calendar year, following these steps:

- Three A/C refrigeration (reefer) unit standard classification codes (SCCs) were identified within the NONROAD model – 2265003060 (gasoline); 2268003060 (CNG); and 2270003060 (diesel);
- A national average model run was performed for these three fuel types for 2014;

[8] ERG identified an inconsistency associated with future year E10 emissions estimation within MOVES2010b. Therefore in order to estimate E10 emission factors for 2014, ERG used the ratio of emissions between gasoline and E10 from MOVES2010a, and applied this ratio to the gasoline emission factors from MOVES2010b for this assessment.

[9] 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.

[10] 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 exhaust emission rates are assumed to equal conventional vehicle equivalents in the current Truck Tool.

- Tons per year outputs were converted to grams per year for each horsepower (hp) bin grouping, for each fuel type, for NOx, PM_{10} and $PM_{2.5}$;
- Grams/gallon factors were calculated for each hp bin by dividing grams/year by gallons/year, for each fuel type, for NOx, PM_{10} and $PM_{2.5}$;
- Weighting factors were applied to the gram per gallon factors for each hp bin. These weighting factors reflected relative emission impacts across the different hp bins, accounting for differences in equipment population, hours of use, and engine load factors. For a given hp bin, the weighting factor is expressed as:

  weighting factor = pop x avg hp x hrs/year x engine load factor

- Weighted g/gal factors were summed across hp bins for each fuel type and pollutant to obtain the final, national fleet-average fuel factors for reefers.

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

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

Fuel	NOx	PM_{10}	$PM_{2.5}$
Diesel	62.026	4.044	3.922
Gasoline	16.369	1.010	0.929
CNG	17.732	0.790	0.790

The next section describes the process followed to select the on-road emission factors from MOVES2010b for use in the Truck Tool. Emission factors in grams per mile were developed for gasoline, E10, and diesel fuel types for all MOVES source types that correspond to MOBILE6 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

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

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

Where:

E` = uncorrected[11] mass emissions calculated based on operating mode and emissions contribution by speed bin

A_{1-3} = 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.)

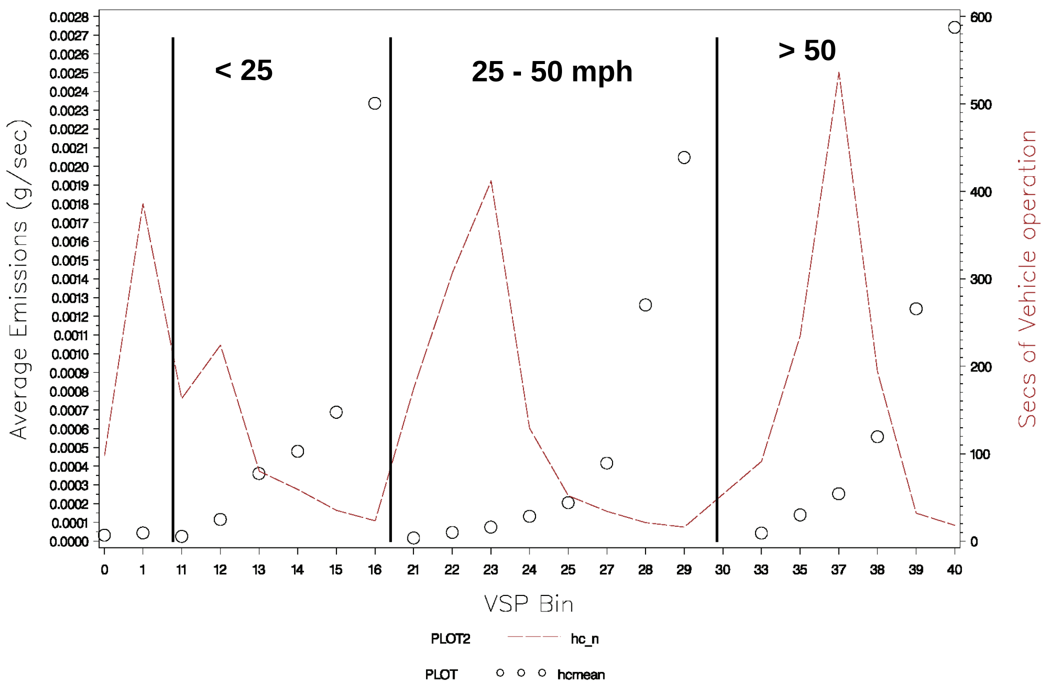
E_{1-3}` = the weighted average emissions over a given speed range n. (E_I and E_B represent the emissions associated with the individual operating modes for idling and braking, respectively.)

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 line presents the fraction of vehicle activity associated with a given

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

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 "opmodedistribution" table from the Operating Mode Distribution Generator (OMDG), which is created during a MOVES run. This table contains operating mode fractions by source type, roadway type, and pollutant/process. The sum of the 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 Source Bin Distribution Generator (SBDG), which is created 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 OMDG 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

$$\mathbf{E_n = ZE_n`}$$

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

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

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.

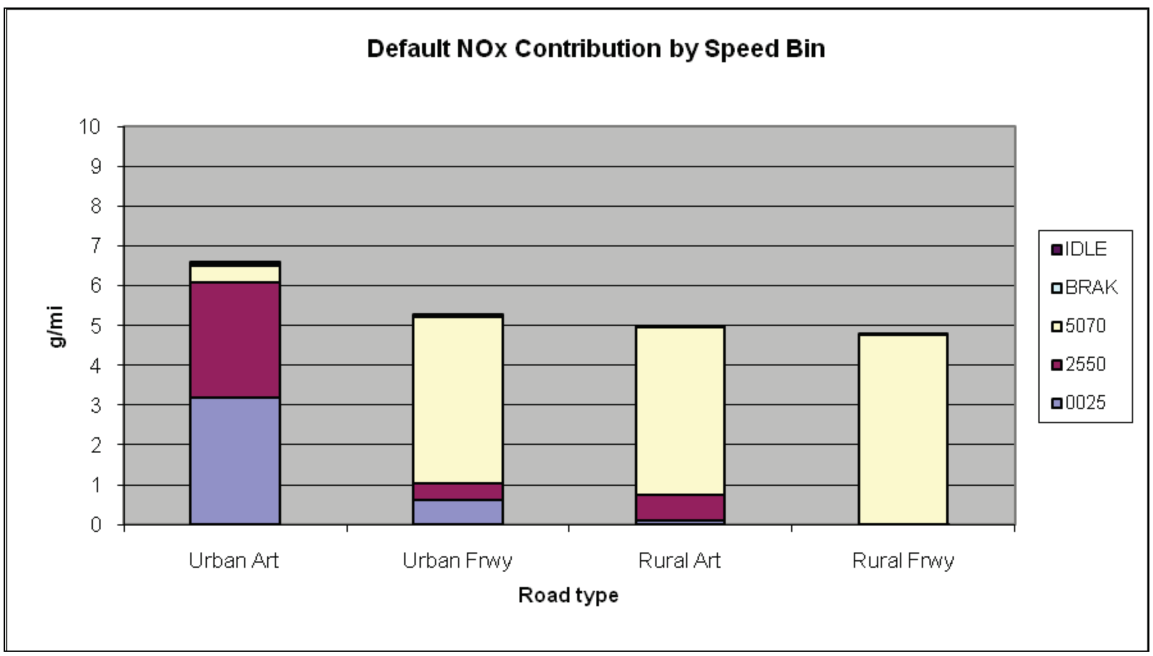
Modeling E10 Emission Rates

In a MOVES run that uses nationwide defaults for fuel supply, the model includes many thousands of fuel formulations on a by-county basis in its calculations. In addition to diesel fuels, many counties in the model defaults are characterized by varying market shares of gasoline and E10. This intertwining of fuel mixtures by market share can make isolation of nationwide E10-based and gasoline-based emission factors from the model somewhat difficult.

In order to isolate E10 emission factors, an external database Tool was used to alter the MOVES "*fuelsupply*" table for two scenarios: one in which market shares for E10 and gasoline fuels were set to 1 and 0, respectively, and the inverse case, in which market shares for E10 and gasoline fuels were set to 0 and 1. Importing the updated "*fuelsupply*" tables using external MySQL scripts, separate E10 and gasoline MOVES runs were then performed using the newly updated information.

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 2008, run for the 2011 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.



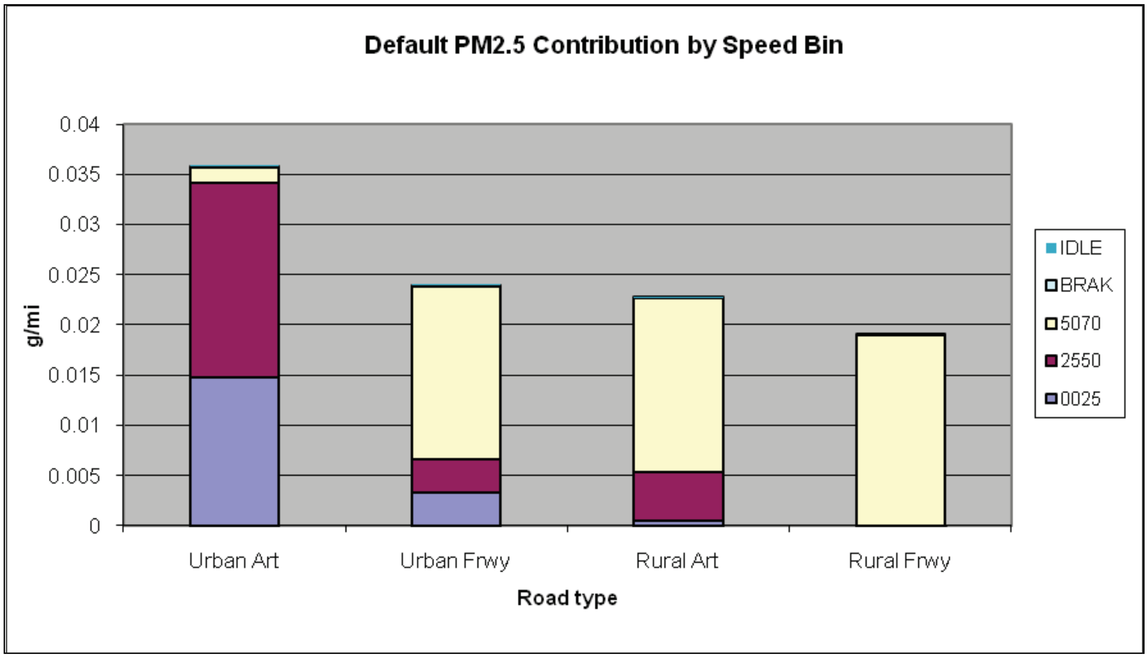


Figure 2. Default NOx and $PM_{2.5}$ Emission Contribution by Speed Bin

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.[12] 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 data entry (see the Truck Tool User Guides for details).

[12] 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

NOx and PM emission factors are not available from MOVES2010b for certain alternative fuels, including biodiesel, E85, natural gas, and LPG. Accordingly, EPA used adjustment factors from a number of sources described below to estimate NOx and PM factors for these other fuels.

NOx and PM emission factors for biodiesel were 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

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

Where:

a = 0.0009794 for NOx, and
a = -0.006384 for PM

Using Equation 6, adjustment factors were developed for biodiesel blends based on the percentage of the biofuel component,[13] 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.)

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 MOVES2010a. 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.[14] These estimates come from a technical paper published in the Journal of Air & Waste Management.[15] 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.

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[13] 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.
[14] See http://www.afdc.energy.gov/afdc/vehicles/emissions_e85.html, last validated December 22, 2011.
[15] http://www.afdc.energy.gov/afdc/pdfs/technical_paper_feb09.pdf

If the consumption level of E10 is unknown, the Truck Tool user may also specify national average default blend levels for ethanol. National totals for gasoline use for 2012 were obtained from the Energy Information Administration's (EIA) Annual Energy Outlook Reference Case for 2013, Table 37 (Transportation Sector Energy Use by Fuel Type within a Mode). Summing the energy use values for light-duty gasoline vehicles, commercial light trucks, and freight trucks from the table yields an estimate of 16,040 TBtu (15,315 + 336 + 389) for 2012. National fuel ethanol consumption estimates for 2012 were also obtained from the EIA, totaling 1,064 TBtu (see Table 10.3, consumption minus denaturant in http://www.eia.gov/totalenergy/data/monthly/pdf/sec10_7.pdf). Assuming 114,100 Btu/gallon of gasoline, and 76,100 Btu/gallon of E100,[16] ethanol is estimated to constitute 9.05% of gasoline fuel consumption in the U.S., on a volumetric basis**.**[17]

Emission adjustment factors were used for gaseous fuels (LPG, CNG and LNG) that were cited by the Alternative Fuels and Advanced Vehicles Data Center, Table 2: NREL/UWV Field Tests of Natural Gas Vehicle Emissions.[18]. These factors were developed by the National Renewable Energy Lab and University of West Virginia based on field studies on natural gas vehicles. 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.[19] To be conservative, the smallest emission reduction estimates were selected from Table 2 (**86% for PM and 17% for NOx**) relative to comparable diesel vehicles. These adjustment factors are then applied to the diesel emission factors in Appendix A for to develop emission factors for these fuels.

The same adjustment factors are applied for all model years in the Truck Tool because model year-specific emissions data do not appear to be available at this time. Note, however, that the emissions from the combustion of alternative fuels may be different for older trucks (with minimal emission controls) and newer trucks (with extensive control systems in place) due to vehicle emission standards.

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.

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

[16] https://www.afdc.energy.gov/afdc/prep/popups/gges.html, last verified 12-22-11.

[17] 16,040 TBtu gasoline x 10^{12} Btu/TBtu / 114,100 Btu/gal = 1.41 x 10^{11} gallons of gasoline;
1,064 TBtu E100 x 10^{12} Btu/TBtu / 76,100 Btu/gal = 0.140 x 10^{11} gallons of E100;
0.140 / (1.41 + 0.140) = 9.05%.
Note this methodology disregards the relatively small volumes of ethanol consumed as E85.

[18] http://www.afdc.energy.gov/afdc/vehicles/emissions_natural_gas.html, last validated 12-22-11.

[19] 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.

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%

The Tool applies these 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

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

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 division level for CO_2, NOx and PM, 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

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

Where:

E_{CO2} = grams CO_2 per year
F = Fossil 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.

3.2 NOx and PM

Unlike CO_2 emissions which only vary with fuel type, NOx and PM 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 and PM 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

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

Where:

E_{NOx} = grams NOx per year for a given truck class
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_I = Grams per hour (by truck class & engine year) for Idling[20]
H_I = Hours of 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.

Equation 10

$$\mathbf{E_{PM} = (((M_C \times ((GPM_H \times HDC) + (GPM_{U1} \times UDC_1) + (GPM_{U2} \times UDC_2) + (GPM_{U3} \times UDC_3) + (GPM_{U4} \times UDC_4))) \times T_{CY} / T_{CT}) + (GPH_I \times H_I \times T_{CY})) \times (1 - ((0.25 \times T_{DOC} / T_{CT}) + (0.05 \times T_{CCV} / T_{CT}) + (0.9 \times T_{DPF} / T_{CT})))}$$

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

[20] As discussed in Section 2 above, separate emission factors are applied for Class 8b diesel trucks to differentiate short- and long-duration idling. In addition, hybrid electric trucks are assumed to have no short-duration idling emissions, while battery-electric trucks have no idling emissions of any kind.

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%
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%

Vehicle Class	Speed Group	Percent by Class
	50+	10%

Vehicle Class	Speed Group	Percent by Class
	Deceleration	15%

Table 4. Default Speed Category Distributions by Vehicle Class for Urban Operation (MOVES2010a basis)[21]

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.[22] However, it is assumed that most Truck Tool users will 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 emission calculations follow the same procedure.

[21] 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%.

[22] 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%.

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 0.0195 g/mi for PM2.5
For urban operation, the lookup values are as follows:

0-25: 0.031 g/mi
25-50: 0.052 g/mi
50+: 0.012 g/mi
deceleration: 0.002 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%) = 27.5%

25-50: 20% x sum of default percentages (45% + 34% + 12%) = 18.3%

50+: 10% x sum of default percentages (45% + 34% + 12%) = 9.2%

deceleration: the remaining percentage, which equals 100% - 40% (highway) - 27.5% - 18.3% - 9.2% = 5.1%

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 0.0195 = 780 grams
0-25 urban component: 0.275 x 100,000 x 0.031 = 826 grams
25 - 50 urban component: 0.183 x 100,000 x 0.052 = 952 grams
50+ urban component: 0.092 x 100,000 x 0.012 = 110 grams
Deceleration urban component: 0.51 x 100,000 x 0.002 = 10 grams

Therefore total = 2,678 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.

Emission calculations for ethanol blends follow a different methodology, however, applying discrete emission factors for gasoline and E10 from MOVES (and adjusted gasoline emission factors for E85) with the specific fuel volume estimates provided by the user. The following provides an example illustrating how the miles of travel are apportioned across different blend volumes, in order to estimate mass emissions.

> User specifies 1,000 gallons of fuel total, and 10,000 miles of travel total
>
> User inputs:
> 100 gallons of E10
> 100 gallons of E85
>
> Therefore there are 800 gallons of pure gasoline (1,000 – 100 - 100)
>
> Apportion the 10,000 miles of travel across the different blend levels using gasoline-gallon equivalent (gge) factors (from https://www.afdc.energy.gov/afdc/prep/popups/gges.html) as follows:
>
> 100 gallons of E10 is equivalent to 100/1.05 = 95 gallons of gasoline*
> 100 gallons of E85 is equivalent to 100/1.39 = 72 gallons of gasoline
>
> Therefore there are 800 + 95 + 72 = 967 gasoline equivalent gallons of fuel, total.
>
> Applying the energy-equivalent fuel volume ratios to the 10,000 miles of total travel:
>
> gasoline (E0) miles = 10,000 x 800/967 = 8,273 miles
> E10 miles = 10,000 x 95/967 = 982 miles
> E85 miles = 10,000 x 72/967 = 745 miles
>
> Finally, multiplying these mileage values by the appropriate E0 and E10 gram/mile emission factors from MOVES results in the desired mass emission estimates. Similarly, multiplying the E85 miles by the E85 emission factors (adjusted from E0 factors as discussed in Section 2.3, provides mass emissions associated with E85).
>
> * E10 gge factor developed from linear interpolation of E100 and gasoline Btu/gallon values

In addition, if national default ethanol blend levels are specified for gasoline fuel use, the Truck Tool assumes that *all* ethanol consumed is in an E10 blend. For example, assuming 1,000 gallons of gasoline are specified by the user, there would be 905 gallons of E10 (1,000 x .905 – see Section 2.3), and 95 (1,000 - 905) gallons of gasoline. Mass emissions would then be calculated for the gasoline and E10 components of the fuel as in the above example, apportioning total miles across gasoline and E10 in order to apply the appropriate g/mi factors.

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 MOVES model assumes a fixed ratio of PM_{10} / $PM_{2.5}$ for a given fuel type, as summarized below:

- Gasoline – 1.086
- Diesel – 1.031
- CNG – 1.000

These factors were 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 had PM ratios equivalent to the CNG value (1.00). Ethanol was assumed to have a ratio equal to that for gasoline, while 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, capacity volume, capacity volume utilization, 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.

Default Payload Distributions

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.) Exact data entries were used from the 2011 Truck Tool submissions to obtain payload distributions for the 2013 Tool. This data was categorized by fuel type, truck class, body-type, and operation bin category. Body-type refers to the categories presented in the Truck Tool payload calculator (e.g., Step Van, Beverage, Combination Flatbed, etc.). Operation bin category is based on the Fleet Characterization inputs (e.g., Truckload Dry Van, Dray, Mixed, etc.). 1,850 unique records were identified using this categorization of the 2011 Partner data.

This data was then reviewed and four outliers were identified and removed from the data set.[23] Next, the data was grouped by truck class and body type and examined for notable differences in payload values across bin categories. However, with the exception of certain Class 8 trucks, no truck class/body-type/bin category combination had greater than 20 observations. Therefore it was concluded that there was not an adequately large data set available for establishing bin-category specific payload distributions for Truck Classes 2b-7. In these cases payload data were aggregated across all bin 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 operation bin categories. Considering both available sample size and average payloads, the following unique truck class/body-type/bin category groupings were established.

[23] 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”).

- Class 8a Dry Van Single body-types: differentiate LTL (9.9 tons average) and non-LTL (12.4 tons average) bin categories. No differentiation across bin 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 bin 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 bin categories (25.6 tons).
- Class 8b Dry Van Double body-types: differentiate TL/Reefer/Mixed (27.7 tons) and all other bin categories (19.4 tons)
- Class 8b Other body-types: differentiate Heavy/Flatbed/Mixed (27.4 tons) and all other bin 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 bin category.[24] Note that the average values and standard deviations presented below are not weighted by fleet size.

[24] Given the lack of data on non-diesel heavy-duty vehicles, payload ranges are assumed to apply to all fuel types.

Table 5. Average Payload and Standard Deviation (short tons) by Vehicle Class/Body-Type/Bin 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
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

Body-Type (Bin Category)	Avg Payload (tons)	Std Dev
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 (LTL)	9.90	2.64
Dry Van - Single (other than LTL)	12.42	4.66
Other - combo	12.68	4.56
Class 8b		
Dry Van - Single (LTL-Moving-Package)	15.03	4.07
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
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)	16.18	5.22
Specialty (Heavy-Mixed bins)	30.25	13.78
Specialty (Flatbed bin)	21.56	2.58
Other (Heavy-Flatbed-Mixed bins)	27.41	6.36

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/bin category combinations,[25] five default ranges are offered for Partner selection:

[25] 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”.

- 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);
- Range 3: from (Average payload – 1 x standard deviation) to (Average payload + 1 x standard deviation);
- Range 4: from (Average payload + 1 x standard deviation) to (Average payload + 2 x standard deviation); and,
- Range 5: from (Average payload + 2 x standard deviation) to (Average payload + 3 x standard deviation).

Once a particular range is selected, the payload calculator estimates the midpoint of the range in order to estimate class level average payloads. The estimated 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).

Default Capacity Volumes[26]

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).[27] Capacity 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.[28] Table 6 summarizes the default volumes assumed for a number of standard trailers, containers, tankers, and bulk carriers.

[26] The Truck Tool allows users to enter capacity 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/.

[27] Default capacity 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.

[28] 53 foot containers are assumed to have interior dimensions of 52' 5" x 7' 8" x 7' 10"

Table 6. 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[29]	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

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

[29] 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/

capacity 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 7 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 7. Estimated Capacity Volumes (cubic feet) for Straight Truck Body Types, by Vehicle Class

Body- type	Average Capacity 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
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

Body- type	Average Capacity Volume (Cubic Feet)
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 capacity 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 capacity 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.

Table 8. Basic Range and Logical Checks – Conditions Resulting in Error or Warning Messages

Contact Information	User must enter at least two distinct contacts
Fleet Characterization	User must include a Partner Name.
Fleet Characterization	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 Characterization	If entered, MCNs must be between 6 and 7 digits.
Fleet Characterization	If entered, DOT numbers must be 7 digits or less.
Fleet Characterization	User must select a Fleet Type.
Fleet Characterization	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 Characterization	User must include a Fleet Contact name for each fleet.
Fleet Characterization	The Operation Category totals must add up to 100%.
Fleet Characterization	The Body Type totals must add up to 100%.
Fleet Characterization	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 Short-haul vs. Long-haul split.
General Information	User must select at least one fuel type.
General Information	User must designate the percentage of truckloads that utilize 100% of available cargo capacity.
General Information	User must indicate the commodities that are carried by each fleet.
General	If participating in the Port Dray Program, user must indicate the number of trucks

Information	equipped with APUs and SmartWay tires. (If none of the trucks in the fleet are equipped with these, a zero must be entered into the field.)
General Information	If participating in the Port Dray Program, the number of trucks equipped with APUs or SmartWay tires cannot exceed the number of trucks in the fleet.
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).
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	For Revenue Miles, if the Data Source Detail "Equal to total miles" is selected, the amount must equal the Total Miles Driven.
Activity Information	For Revenue Miles, if the Data Source Detail "Total miles less empty miles" is selected, the amount must equal the Total Miles Driven minus Empty Miles Driven.
Activity Information	For Empty Miles, the amount must be less than the number of Total Miles.
Activity Information	For Empty Miles, if the Data Source Detail "Total miles less revenue miles " is selected, the amount must equal the Total Miles Driven minus Revenue Miles Driven.
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 each row of data, user must specify a Data Source.
Activity Information	For Capacity Utilization, the value cannot exceed 100%.
Activity Information	For Capacity Utilization, 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% capacity utilization.)
Activity Information	The implicit commodity density derived from the payload, volume, and capacity utilization inputs must be between 0.001 and 0.65 tons/cubic foot.[30]
Activity Information	For Idle Hours, the value cannot exceed 8,760.
Activity Information	For Idle Hours, values significantly outside the expected range must be explained.
Activity Information	If company no idle policy is specified under Idle Data Source, then a warning is displayed if idle hours/yr are > 100.
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	Reefer fuel inputs for each fuel type must be less than the total vehicle fuel volume

[30] 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.

Information	input.
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 participating in the Port Dray Program, the sum of the trucks using either DOC/CCV, Flow Through Filters, 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 Data Source and 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 Characterization section with those from the Payload and Volume Calculators. For example, if 100% is specified for Dry Van under Fleet Characterization, 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 payload calc but no Trailers specified in volume calculator; If flatbed, auto or specialty is selected in payload, "Other Trailers" should be selected in volume calculator

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.

As noted in Table 8 above, a warning is issued if an inconsistency is identified between body-types specified within the Fleet Characterization Section and those within the Payload/Volume Calculators. Warning conditions (associated with 100% body-type entries under Fleet Characterization) are presented in Table 9 below.

Table 9. 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	single axle van, dry van single	single axle van, dry van single	dry van (single, double, triple)
Refrigerated	other	other	other	other	reefer, other	reefer, beverage, combination reefer, other	beverage, other	combination reefer, other
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
Hvy-Bulk	N/A	N/A	N/A	N/A	N/A	other	other	other
Auto Carrier	N/A	N/A	N/A	N/A	N/A	other	other	other
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	dry van single, specialty, other
Spec Hauler	other	other	other	other	other	other	other	specialty
Utility	all	all	all	all	all except reefer	flatbed, combination flatbed, other	flatbed, combination flatbed, other	combination flatbed, specialty, 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 were 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 "Orange" 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.

Data Processing

The validation range recommendations are based upon a distributional analysis performed on the 2011 Truck Partner input and performance data. Fleet level data was input into SAS and grouped by truck class, bin category, and fuel type combinations. 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 26 groupings, as shown in Table 10. 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, Moving, Package, (Groups 5, 7, 8, and 9).

Table 10. Truck Fleet Groupings Used for Distributional Analysis

Group #	Name	# Fleets
1	2B_Mixed	90
2	3_Mixed	67
3	4_Mixed	59
4	5_Mixed	49
5	6_LTL/Dry Van_Diesel	52
6	6_Mixed	98
7	6_Moving	24
8	6_Package_Diesel	29
9	6_TL/Dry Van_Diesel	29
10	7_LTL/Dry Van_Diesel	56
11	7_Mixed	129
12	7_TL/Dry Van_Diesel	31
13	8A_LTL/Dry Van_Diesel	57
14	8A_Mixed	164
15	8A_Refrigerated_Diesel	24
16	8A_TL/Dry Van_Diesel	70
17	8B_AutoCarrier_Diesel	22
18	8B_Dray_Diesel	84
19	8B_Flatbed_Diesel	150
20	8B_Heavy/Bulk_Diesel	29
21	8B_LTL/Dry Van_Diesel	95
22	8B_Mixed	463
23	8B_Refrigerated_Diesel	408
24	8B_Specialized_Diesel	61
25	8B_TL/Dry Van_Diesel	719
26	8B_Tanker_Diesel	74
	Sum	3,133

ERG then performed a distributional assessment 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 Biofuel
- Percent Capacity Utilization
- 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 11.

Table 11. 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 Capacity Utilization	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 49 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 12.

Table 12. Values Flagged as Outliers

Group	Value	Mean	Parameter
1	121,133	30,058	Mi/Veh
1	121,108	30,058	Mi/Veh
3	86,827	25,894	Mi/Veh
7	111,401	31,584	Mi/Veh
9	124,685	33,782	Mi/Veh
10	115,287	38,540	Mi/Veh
12	118,006	37,498	Mi/Veh
14	166,342	38,957	Mi/Veh
14	143,660	38,957	Mi/Veh
15	184,305	45,563	Mi/Veh
16	113,448	38,336	Mi/Veh
18	157,713	54,525	Mi/Veh
20	185,244	54,430	Mi/Veh
20	186,529	54,430	Mi/Veh
32	228,151	94,557	Mi/Veh
32	209,269	94,557	Mi/Veh
32	205,840	94,557	Mi/Veh
3	18.9	10.0	MPG
4	30	11.5	MPG
19	8	6.3	MPG

Group	Value	Mean	Parameter
20	8.7	6.3	MPG
20	9	6.3	MPG
32	7.8	6.0	MPG
32	7.9	6.0	MPG
32	7.9	6.0	MPG
1	1,560	345	Avg Idle hrs/yr
1	1,785	345	Avg Idle hrs/yr
3	1,267	328	Avg Idle hrs/yr
7	1,462	441	Avg Idle hrs/yr
8	1,825	414	Avg Idle hrs/yr
8	1,680	414	Avg Idle hrs/yr
10	1,500	473	Avg Idle hrs/yr
10	1,505	473	Avg Idle hrs/yr
12	1,615	350	Avg Idle hrs/yr
14	1,835	494	Avg Idle hrs/yr
14	1,825	494	Avg Idle hrs/yr
14	2,077	494	Avg Idle hrs/yr
15	1,440	346	Avg Idle hrs/yr
16	1,400	430	Avg Idle hrs/yr
16	1,505	430	Avg Idle hrs/yr
18	2,574	694	Avg Idle hrs/yr
19	2,071	443	Avg Idle hrs/yr
19	2,050	443	Avg Idle hrs/yr
20	2,100	525	Avg Idle hrs/yr
20	2,000	525	Avg Idle hrs/yr
20	1,986	525	Avg Idle hrs/yr
32	3,024	918	Avg Idle hrs/yr
32	3,410	918	Avg Idle hrs/yr
33	2,816	853	Avg Idle hrs/yr

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 3 and 4.

Figure 3. Annual Miles Per Vehicle Distribution, Class 8b TL/Dry Van Diesel Fleets

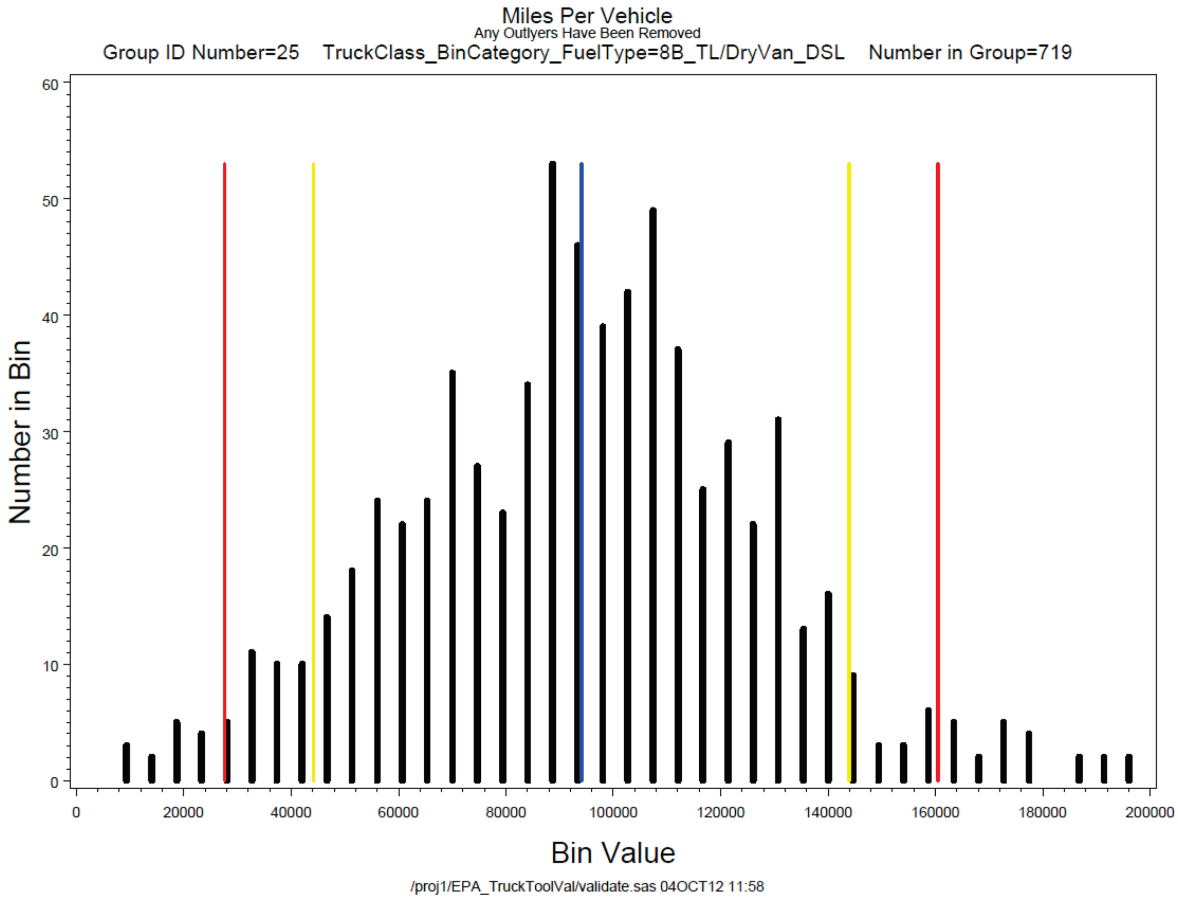
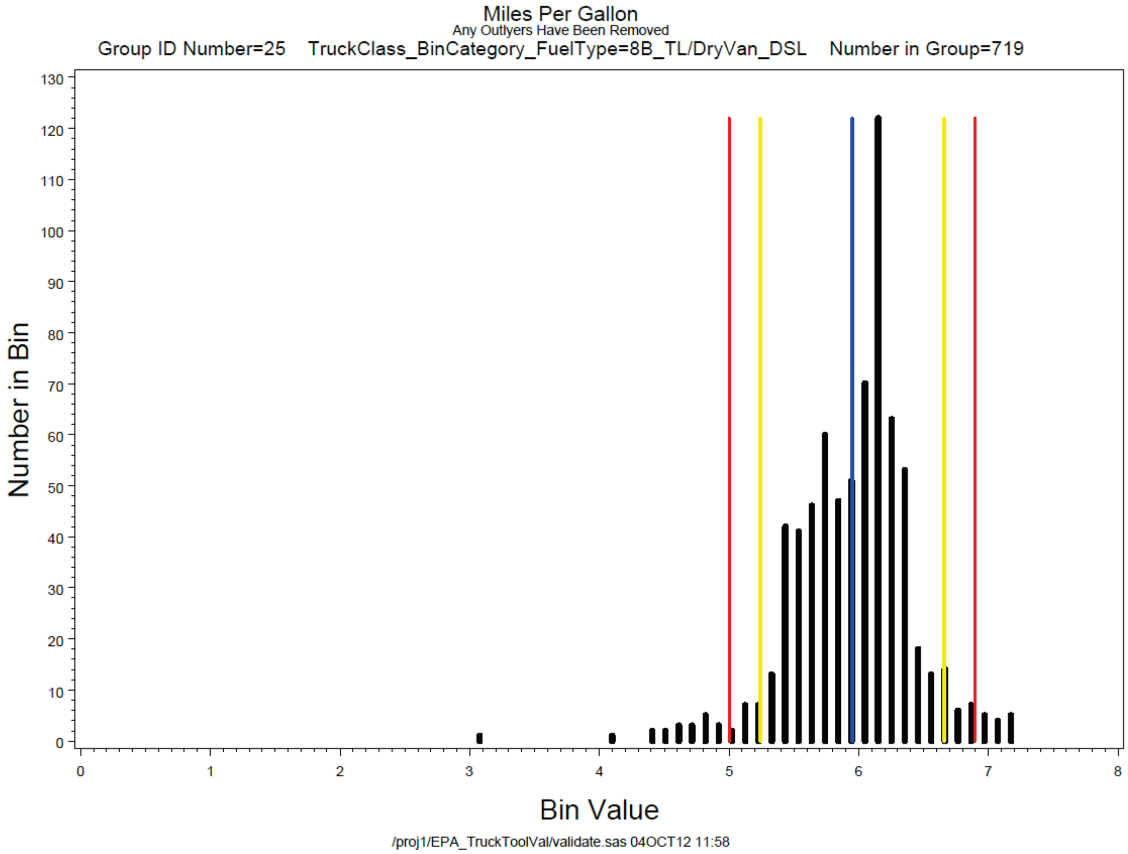


Figure 4. Miles per Gallon Distribution, Class 8b TL/Dry Van Diesel Fleets



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.[31] Finally, % Urban and % Highway Operation data showed no clear distributions, with values ranging from 0 % to 100 %.

Based on this preliminary assessment, red and yellow flag areas were defined for each fleet group/metric combination as shown in Table 13.

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

Table 13. "Red" and "Yellow" Flag Criteria

Metric	Low Red Flag	Low Yellow Flag	High Yellow Flag	High Red Flag
Miles per Vehicle	Mean – 2StD^	Mean-1.5StD^	Mean+1.5StD	Mean+2StD
MPG	Mean – 2StD	Mean-1.5StD	Mean+1.5StD	Mean+2StD
% Revenue Miles	variable^^	variable^^	None	None
% Empty Miles	1	5	variable^^	variable^^
% Biofuel	None	None	None	None
% Capacity Utilization	Mean – 2StD	Mean-1.5StD	variable*	variable*
% Urban Operation	None	None	None	None
% Highway Operation	None	None	None	None
Average Idle Hours	Mean – 2StD^	Mean-1.5StD^	Mean+1.5StD	Mean+2StD

^ If the calculated values are < 0 for a particular fleet category/metric combination, an alternate cutoff is applied based on expert judgment.
* Cutoffs developed based on expert judgment.
^^ Values selected in consultation with SmartWay support staff.

For six of the metrics,[32] 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 10-15% of the values for these metrics being flagged as either red or yellow for partner attention (although the flag rates associated with % Revenue and % Empty Miles is substantially higher). Selecting cutoffs at this level 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. Tables 14-19 present the actual yellow and red flag values for each fleet group/metric combination, given the decision criteria presented in Table 13. Tables 20-25 present the number of observations that would be flagged with yellow and red warnings for these combinations.

[32] Standard deviations are only used on the low end to determine red/yellow cutoffs for the % Capacity Utilization metric, due to a number of carriers utilizing 100% of available space. Upper end cutoffs are based on expert judgment for LTL categories.

Table 14. Yellow/Red Criteria by Fleet Group/Metric Combination
Annual Miles per Vehicle

Group	Name	Low Red	Low Yellow	Mean	High Yellow	High Red
1	2B_Mixed	2,000	4,000	28,884	62,834	74,151
2	3_Mixed	6,000	8,000	30,479	62,193	72,764
3	4_Mixed	2,000	6,000	27,133	55,662	65,171
4	5_Mixed	2,000	4,000	29,922	60,351	70,494
5	6_LTL/Dry Van_Diesel	3,000	9,000	32,000	61,481	71,308
6	6_Mixed	5,000	10,000	35,838	68,836	79,835
7	6_Moving	3,000	8,000	33,908	68,107	79,506
8	6_Package_Diesel	7,376	14,188	34,622	55,057	61,869
9	6_TL/Dry Van_Diesel	5,000	10,000	33,738	69,723	81,718
10	7_LTL/Dry Van_Diesel	5,000	10,000	43,040	85,533	99,697
11	7_Mixed	4,000	8,000	36,778	69,979	81,046
12	7_TL/Dry Van_Diesel	2,000	6,000	31,764	65,241	76,399
13	8A_LTL/Dry Van_Diesel	4,000	10,000	49,990	94,443	109,260
14	8A_Mixed	4,000	8,000	52,847	102,878	119,555
15	8A_Refrigerated_Diesel	10,000	20,000	66,376	120,026	137,909
16	8A_TL/Dry Van_Diesel	4,000	7,433	74,532	141,631	163,997
17	8B_AutoCarrier_Diesel	39,712	49,944	80,640	111,335	121,567
18	8B_Dray_Diesel	4,000	12,344	56,782	101,219	116,032
19	8B_Flatbed_Diesel	34,715	47,250	84,858	122,465	135,001
20	8B_Heavy/Bulk_Diesel	7,717	23,515	70,909	118,303	134,101
21	8B_LTL/Dry Van_Diesel	16,801	30,898	73,188	115,477	129,574
22	8B_Mixed	12,171	29,882	83,016	136,150	153,861
23	8B_Refrigerated_Diesel	38,363	55,515	106,968	158,422	175,573
24	8B_Specialized_Diesel	1,705	23,589	89,242	154,895	176,780
25	8B_TL/Dry Van_Diesel	27,591	44,207	94,054	143,902	160,518
26	8B_Tanker_Diesel	32,467	44,793	81,769	118,745	131,071

Table 15. Yellow/Red Criteria by Fleet Group/Metric Combination Miles per Gallon[33]

Group	Name	Low Red	Low Yellow	Mean	High Yellow	High Red
1	2B_Mixed	4.6	6.7	12.9	19.1	21.1
2	3_Mixed	5.0	6.3	10.2	14.1	15.4
3	4_Mixed	5.4	6.4	9.3	12.2	13.1
4	5_Mixed	4.5	5.5	8.4	11.4	12.4
5	6_LTL/Dry Van_Diesel	5.7	6.3	8.0	9.7	10.3
6	6_Mixed	5.2	5.8	7.8	9.7	10.3
7	6_Moving	5.8	6.2	7.3	8.5	8.9
8	6_Package_Diesel	6.1	6.7	8.7	10.6	11.3
9	6_TL/Dry Van_Diesel	4.9	5.6	7.7	9.8	10.5
10	7_LTL/Dry Van_Diesel	5.6	6.1	7.6	9.1	9.6
11	7_Mixed	4.5	5.2	7.3	9.4	10.1
12	7_TL/Dry Van_Diesel	5.3	5.9	7.7	9.4	10.0
13	8A_LTL/Dry Van_Diesel	5.3	5.5	6.3	7.0	7.2
14	8A_Mixed	4.4	4.8	6.2	7.6	8.1
15	8A_Refrigerated_Diesel	4.8	5.0	5.9	6.7	7.0
16	8A_TL/Dry Van_Diesel	5.0	5.3	6.3	7.3	7.6
17	8B_AutoCarrier_Diesel	4.2	4.5	5.2	5.8	6.1
18	8B_Dray_Diesel	4.9	5.1	5.8	6.5	6.7
19	8B_Flatbed_Diesel	4.4	4.7	5.7	6.6	6.9
20	8B_Heavy/Bulk_Diesel	3.4	3.8	5.0	6.3	6.7
21	8B_LTL/Dry Van_Diesel	5.1	5.4	6.0	6.7	6.9
22	8B_Mixed	4.8	5.0	5.8	6.6	6.9
23	8B_Refrigerated_Diesel	4.8	5.1	5.7	6.4	6.6
24	8B_Specialized_Diesel	3.8	4.3	5.5	6.8	7.2
25	8B_TL/Dry Van_Diesel	5.0	5.2	5.9	6.7	6.9
26	8B_Tanker_Diesel	4.8	5.0	5.8	6.6	6.9

[33] 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 16. Yellow/Red Criteria by Fleet Group/Metric Combination
% Revenue Miles

Group	Name	Low Red	Low Yellow	Mean	High Yellow	High Red
1	2B_Mixed	55	60	84.9	N/A	N/A
2	3_Mixed	50	60	84.4	N/A	N/A
3	4_Mixed	50	60	87.8	N/A	N/A
4	5_Mixed	50	60	85.7	N/A	N/A
5	6_LTL/Dry Van_Diesel	50	60	89.7	N/A	N/A
6	6_Mixed	55	65	82.8	N/A	N/A
7	6_Moving	55	65	84.5	N/A	N/A
8	6_Package_Diesel	55	65	95.5	N/A	N/A
9	6_TL/Dry Van_Diesel	55	65	86.1	N/A	N/A
10	7_LTL/Dry Van_Diesel	55	65	90.4	N/A	N/A
11	7_Mixed	55	65	83.6	N/A	N/A
12	7_TL/Dry Van_Diesel	55	65	84.4	N/A	N/A
13	8A_LTL/Dry Van_Diesel	55	60	90.5	N/A	N/A
14	8A_Mixed	55	60	82.6	N/A	N/A
15	8A_Refrigerated_Diesel	55	60	81.8	N/A	N/A
16	8A_TL/Dry Van_Diesel	55	60	87.1	N/A	N/A
17	8B_AutoCarrier_Diesel	50	55	70.6	N/A	N/A
18	8B_Dray_Diesel	55	60	84.9	N/A	N/A
19	8B_Flatbed_Diesel	60	65	81.6	N/A	N/A
20	8B_Heavy/Bulk_Diesel	50	55	65.1	N/A	N/A
21	8B_LTL/Dry Van_Diesel	60	70	90.3	N/A	N/A
22	8B_Mixed	50	60	85.6	N/A	N/A
23	8B_Refrigerated_Diesel	60	70	87.7	N/A	N/A
24	8B_Specialized_Diesel	55	60	64.5	N/A	N/A
25	8B_TL/Dry Van_Diesel	55	65	87.4	N/A	N/A
26	8B_Tanker_Diesel	45	50	66.8	N/A	N/A

Table 17. Yellow/Red Criteria by Fleet Group/Metric Combination
% Empty Miles

Group	Name	Low Red	Low Yellow	Mean	High Yellow	High Red
1	2B_Mixed	1	5	14.3	40	45
2	3_Mixed	1	5	18.9	40	50
3	4_Mixed	1	5	13.4	40	50
4	5_Mixed	1	5	24.0	40	50
5	6_LTL/Dry Van_Diesel	1	5	9.6	40	50
6	6_Mixed	1	5	19.0	40	50
7	6_Moving	1	5	15.0	40	50
8	6_Package_Diesel	1	5	18.5	40	50
9	6_TL/Dry Van_Diesel	1	5	12.1	40	50
10	7_LTL/Dry Van_Diesel	1	5	17.0	40	45
11	7_Mixed	1	5	15.4	40	45
12	7_TL/Dry Van_Diesel	1	5	4.5	40	45
13	8A_LTL/Dry Van_Diesel	1	5	17.1	40	45
14	8A_Mixed	1	5	18.5	40	45
15	8A_Refrigerated_Diesel	1	5	12.0	40	45
16	8A_TL/Dry Van_Diesel	1	5	15.5	40	45
17	8B_AutoCarrier_Diesel	1	5	18.2	45	50
18	8B_Dray_Diesel	1	5	21.2	40	45
19	8B_Flatbed_Diesel	1	5	11.3	40	45
20	8B_Heavy/Bulk_Diesel	1	5	16.8	50	60
21	8B_LTL/Dry Van_Diesel	1	5	20.7	35	45
22	8B_Mixed	1	5	14.2	45	50
23	8B_Refrigerated_Diesel	1	5	11.3	40	45
24	8B_Specialized_Diesel	1	5	32.0	45	50
25	8B_TL/Dry Van_Diesel	1	5	22.4	45	50
26	8B_Tanker_Diesel	30	40	18.6	65	75

Table 18. Yellow/Red Criteria by Fleet Group/Metric Combination
% Capacity Utilization

Group	Name	Low Red	Low Yellow	Mean	High Yellow^	High Red^
1	2B_Mixed	30	40	69.7	N/A	N/A
2	3_Mixed	37	47	74.8	N/A	N/A
3	4_Mixed	37	47	75.7	N/A	N/A
4	5_Mixed	39	48	77.1	N/A	N/A
5	6_LTL/Dry Van_Diesel	48	54	74.0	90	95
6	6_Mixed	46	54	77.3	N/A	N/A
7	6_Moving	36	42	59.8	80	90
8	6_Package_Diesel	53	60	83.1	N/A	N/A
9	6_TL/Dry Van_Diesel	40	49	76.3	N/A	N/A
10	7_LTL/Dry Van_Diesel	52	58	77.1	90	95
11	7_Mixed	43	51	75.0	N/A	N/A
12	7_TL/Dry Van_Diesel	49	56	80.1	N/A	N/A
13	8A_LTL/Dry Van_Diesel	55	61	79.5	90	95
14	8A_Mixed	48	56	80.5	N/A	N/A
15	8A_Refrigerated_Diesel	40	50	77.5	N/A	N/A
16	8A_TL/Dry Van_Diesel	50	58	81.0	N/A	N/A
17	8B_AutoCarrier_Diesel	69	75	91.4	N/A	N/A
18	8B_Dray_Diesel	55	63	85.7	N/A	N/A
19	8B_Flatbed_Diesel	62	69	87.2	N/A	N/A
20	8B_Heavy/Bulk_Diesel	60	67	88.4	N/A	N/A
21	8B_LTL/Dry Van_Diesel	58	64	81.3	90	95
22	8B_Mixed	55	62	82.6	N/A	N/A
23	8B_Refrigerated_Diesel	58	65	85.0	N/A	N/A
24	8B_Specialized_Diesel	61	69	90.1	N/A	N/A
25	8B_TL/Dry Van_Diesel	59	65	85.2	N/A	N/A
26	8B_Tanker_Diesel	63	69	89.1	N/A	N/A

^ “N/A” indicates calculated flag value > 100. Any value ≤100 is acceptable for these group/metric combinations. Other values based on expert judgment.

Table 19. Yellow/Red Criteria by Fleet Group/Metric Combination
Annual Average Idle Hours per Truck

Group	Name	Low Red	Low Yellow	Mean	High Yellow	High Red
1	2B_Mixed	50	100	323	693	817
2	3_Mixed	40	100	371	778	914
3	4_Mixed	50	100	364	695	806
4	5_Mixed	50	100	420	808	937
5	6_LTL/Dry Van_Diesel	50	80	311	574	662
6	6_Mixed	50	80	425	875	1,025
7	6_Moving	20	40	275	519	601
8	6_Package_Diesel	10	20	305	741	887
9	6_TL/Dry Van_Diesel	20	50	514	1,217	1,451
10	7_LTL/Dry Van_Diesel	70	100	326	578	662
11	7_Mixed	60	100	413	825	963
12	7_TL/Dry Van_Diesel	20	70	288	523	601
13	8A_LTL/Dry Van_Diesel	50	100	384	762	888
14	8A_Mixed	40	100	574	1,268	1,499
15	8A_Refrigerated_Diesel	100	200	713	1,538	1,813
16	8A_TL/Dry Van_Diesel	40	80	629	1,391	1,645
17	8B_AutoCarrier_Diesel	300	400	1,154	2,278	2,653
18	8B_Dray_Diesel	100	200	672	1,377	1,612
19	8B_Flatbed_Diesel	100	200	911	1,735	2,010
20	8B_Heavy/Bulk_Diesel	100	200	601	1,102	1,270
21	8B_LTL/Dry Van_Diesel	100	200	518	1,048	1,225
22	8B_Mixed	100	200	782	1,636	1,921
23	8B_Refrigerated_Diesel	100	200	843	1,705	1,993
24	8B_Specialized_Diesel	100	220	760	1,613	1,897
25	8B_TL/Dry Van_Diesel	100	200	912	1,786	2,077
26	8B_Tanker_Diesel	100	150	826	1,745	2,051

Table 20. Number of Values Flagged by Fleet Group/Metric Combination
Annual Miles per Vehicle

Group	Name	# Low Red	# Low Yellow	# High Yellow	# High Red
1	2B_Mixed	4	3	7	2
2	3_Mixed	6	2	1	4
3	4_Mixed	1	5	2	3
4	5_Mixed	3	0	1	2
5	6_LTL/Dry Van_Diesel	0	0	3	3
6	6_Mixed	6	5	4	3
7	6_Moving	1	1	0	1
8	6_Package_Diesel	0	0	0	2
9	6_TL/Dry Van_Diesel	2	2	1	1
10	7_LTL/Dry Van_Diesel	1	2	0	4
11	7_Mixed	4	1	3	5
12	7_TL/Dry Van_Diesel	2	0	1	0
13	8A_LTL/Dry Van_Diesel	0	1	1	4
14	8A_Mixed	4	3	11	3
15	8A_Refrigerated_Diesel	0	1	1	0
16	8A_TL/Dry Van_Diesel	1	1	6	1
17	8B_AutoCarrier_Diesel	1	1	0	0
18	8B_Dray_Diesel	0	2	4	4
19	8B_Flatbed_Diesel	4	7	6	3
20	8B_Heavy/Bulk_Diesel	0	2	3	0
21	8B_LTL/Dry Van_Diesel	2	2	5	3
22	8B_Mixed	4	27	20	13
23	8B_Refrigerated_Diesel	14	19	10	11
24	8B_Specialized_Diesel	0	3	2	4
25	8B_TL/Dry Van_Diesel	19	31	20	22
26	8B_Tanker_Diesel	2	2	3	2
	Sum	81	123	115	100
		2.6%	3.9%	3.7%	3.2%

Table 21. Number of Values Flagged by Fleet Group/Metric Combination
Miles per Gallon

Group	Name	# Low Red	# Low Yellow	# High Yellow	# High Red
1	2B_Mixed	1	2	4	3
2	3_Mixed	0	3	1	2
3	4_Mixed	3	0	0	1
4	5_Mixed	0	2	1	1
5	6_LTL/Dry Van_Diesel	0	4	3	0
6	6_Mixed	4	0	5	1
7	6_Moving	0	0	3	0
8	6_Package_Diesel	1	1	1	0
9	6_TL/Dry Van_Diesel	1	0	1	1
10	7_LTL/Dry Van_Diesel	2	4	0	1
11	7_Mixed	3	2	3	1
12	7_TL/Dry Van_Diesel	0	2	1	1
13	8A_LTL/Dry Van_Diesel	1	5	0	1
14	8A_Mixed	3	5	4	8
15	8A_Refrigerated_Diesel	0	2	0	2
16	8A_TL/Dry Van_Diesel	2	1	2	2
17	8B_AutoCarrier_Diesel	0	0	0	1
18	8B_Dray_Diesel	3	4	5	0
19	8B_Flatbed_Diesel	2	4	3	1
20	8B_Heavy/Bulk_Diesel	1	3	2	0
21	8B_LTL/Dry Van_Diesel	3	2	0	2
22	8B_Mixed	15	15	7	7
23	8B_Refrigerated_Diesel	13	10	29	5
24	8B_Specialized_Diesel	3	1	1	0
25	8B_TL/Dry Van_Diesel	22	14	20	21
26	8B_Tanker_Diesel	3	2	2	1
	Sum	86	88	99	63
		2.7%	2.8%	3.2%	2.0%

Table 22. Number of Values Flagged by Fleet Group/Metric Combination Revenue Miles

Group	Name	# Low Red	# Low Yellow	# High Yellow	# High Red
1	2B_Mixed	6	3	N/A	N/A
2	3_Mixed	1	5	N/A	N/A
3	4_Mixed	0	2	N/A	N/A
4	5_Mixed	0	1	N/A	N/A
5	6_LTL/Dry Van_Diesel	0	1	N/A	N/A
6	6_Mixed	7	9	N/A	N/A
7	6_Moving	1	2	N/A	N/A
8	6_Package_Diesel	0	1	N/A	N/A
9	6_TL/Dry Van_Diesel	2	2	N/A	N/A
10	7_LTL/Dry Van_Diesel	2	3	N/A	N/A
11	7_Mixed	11	9	N/A	N/A
12	7_TL/Dry Van_Diesel	2	2	N/A	N/A
13	8A_LTL/Dry Van_Diesel	1	0	N/A	N/A
14	8A_Mixed	16	4	N/A	N/A
15	8A_Refrigerated_Diesel	2	1	N/A	N/A
16	8A_TL/Dry Van_Diesel	4	1	N/A	N/A
17	8B_AutoCarrier_Diesel	1	2	N/A	N/A
18	8B_Dray_Diesel	7	6	N/A	N/A
19	8B_Flatbed_Diesel	4	8	N/A	N/A
20	8B_Heavy/Bulk_Diesel	1	7	N/A	N/A
21	8B_LTL/Dry Van_Diesel	2	5	N/A	N/A
22	8B_Mixed	1	19	N/A	N/A
23	8B_Refrigerated_Diesel	13	14	N/A	N/A
24	8B_Specialized_Diesel	25	5	N/A	N/A
25	8B_TL/Dry Van_Diesel	10	21	N/A	N/A
26	8B_Tanker_Diesel	1	5	N/A	N/A
	Sum	120	138	0	0
		3.8%	4.4%	0.0%	0.0%

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

Group	Name	# Low Red	# Low Yellow	# High Yellow	# High Red
1	2B_Mixed	21	14	3	6
2	3_Mixed	19	4	5	1
3	4_Mixed	18	8	2	0
4	5_Mixed	13	1	1	0
5	6_LTL/Dry Van_Diesel	14	12	1	0
6	6_Mixed	23	10	9	0
7	6_Moving	6	0	0	0
8	6_Package_Diesel	18	4	0	0
9	6_TL/Dry Van_Diesel	7	5	2	0
10	7_LTL/Dry Van_Diesel	15	12	1	2
11	7_Mixed	26	15	1	11
12	7_TL/Dry Van_Diesel	8	2	1	3
13	8A_LTL/Dry Van_Diesel	16	11	0	1
14	8A_Mixed	27	17	2	18
15	8A_Refrigerated_Diesel	3	1	1	3
16	8A_TL/Dry Van_Diesel	13	6	2	4
17	8B_AutoCarrier_Diesel	1	1	2	0
18	8B_Dray_Diesel	12	13	7	16
19	8B_Flatbed_Diesel	6	5	1	3
20	8B_Heavy/Bulk_Diesel	1	1	0	0
21	8B_LTL/Dry Van_Diesel	10	24	3	1
22	8B_Mixed	60	59	15	1
23	8B_Refrigerated_Diesel	27	51	7	11
24	8B_Specialized_Diesel	2	2	5	0
25	8B_TL/Dry Van_Diesel	43	103	9	3
26	8B_Tanker_Diesel	4	0	0	0
	Sum	413	381	80	84
		13.2%	12.2%	2.6%	2.7%

Table 24. Number of Values Flagged by Fleet Group/Metric Combination
% Capacity Utilization

Group	Name	# Low Red	# Low Yellow	# High Yellow	# High Red
1	2B_Mixed	2	4	N/A	N/A
2	3_Mixed	2	4	N/A	N/A
3	4_Mixed	2	1	N/A	N/A
4	5_Mixed	0	5	N/A	N/A
5	6_LTL/Dry Van_Diesel	1	4	3	3
6	6_Mixed	5	3	N/A	N/A
7	6_Moving	0	0	3	0
8	6_Package_Diesel	1	3	N/A	N/A
9	6_TL/Dry Van_Diesel	0	1	N/A	N/A
10	7_LTL/Dry Van_Diesel	3	2	4	6
11	7_Mixed	3	14	N/A	N/A
12	7_TL/Dry Van_Diesel	0	2	N/A	N/A
13	8A_LTL/Dry Van_Diesel	3	4	10	5
14	8A_Mixed	6	9	N/A	N/A
15	8A_Refrigerated_Diesel	1	2	N/A	N/A
16	8A_TL/Dry Van_Diesel	1	7	N/A	N/A
17	8B_AutoCarrier_Diesel	2	0	N/A	N/A
18	8B_Dray_Diesel	7	5	N/A	N/A
19	8B_Flatbed_Diesel	7	9	N/A	N/A
20	8B_Heavy/Bulk_Diesel	3	0	N/A	N/A
21	8B_LTL/Dry Van_Diesel	5	4	5	11
22	8B_Mixed	28	12	N/A	N/A
23	8B_Refrigerated_Diesel	22	10	N/A	N/A
24	8B_Specialized_Diesel	4	2	N/A	N/A
25	8B_TL/Dry Van_Diesel	35	30	N/A	N/A
26	8B_Tanker_Diesel	6	1	N/A	N/A
	Sum	149	138	25	25
		4.8%	4.4%	0.8%	0.8%

Table 25. Number of Values Flagged by Fleet Group/Metric Combination Average Annual Idle Hours per Truck

Group #	Name	# Low Red	# Low Yellow	# High Yellow	# High Red
1	2B_Mixed	3	4	2	5
2	3_Mixed	2	7	7	2
3	4_Mixed	0	1	3	4
4	5_Mixed	1	2	2	1
5	6_LTL/Dry Van_Diesel	0	2	3	3
6	6_Mixed	6	2	3	6
7	6_Moving	0	2	1	0
8	6_Package_Diesel	1	1	2	1
9	6_TL/Dry Van_Diesel	1	1	0	2
10	7_LTL/Dry Van_Diesel	0	4	2	2
11	7_Mixed	2	2	1	8
12	7_TL/Dry Van_Diesel	1	1	3	0
13	8A_LTL/Dry Van_Diesel	0	5	1	3
14	8A_Mixed	3	3	3	13
15	8A_Refrigerated_Diesel	0	2	1	2
16	8A_TL/Dry Van_Diesel	1	4	4	5
17	8B_AutoCarrier_Diesel	1	0	1	1
18	8B_Dray_Diesel	1	5	9	2
19	8B_Flatbed_Diesel	0	1	15	6
20	8B_Heavy/Bulk_Diesel	0	1	1	2
21	8B_LTL/Dry Van_Diesel	3	6	3	7
22	8B_Mixed	15	10	21	31
23	8B_Refrigerated_Diesel	8	15	29	21
24	8B_Specialized_Diesel	0	2	0	6
25	8B_TL/Dry Van_Diesel	8	6	72	23
26	8B_Tanker_Diesel	2	1	7	3
	Sum	59	90	196	159
		1.9%	2.9%	6.3%	5.1%

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.[34] 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 dataset (prior to cleaning) are presented in Table 26.

Table 26. Maximum and Minimum Miles per Gallon

Group #	Name	Min	Mean	Max
1	2B_Mixed	2.0	12.9	21.6
2	3_Mixed	5.4	10.2	30.0[35]
3	4_Mixed	5.0	9.3	14.9
4	5_Mixed	4.8	8.4	13.7
5	6_LTL/Dry Van_Diesel	5.7	8.0	10.3
6	6_Mixed	4.2	7.8	10.4
7	6_Moving	6.4	7.3	8.9
8	6_Package_Diesel	5.7	8.7	10.8
9	6_TL/Dry Van_Diesel	4.4	7.7	11.6
10	7_LTL/Dry Van_Diesel	5.6	7.6	9.8
11	7_Mixed	1.2	7.3	11.9
12	7_TL/Dry Van_Diesel	5.8	7.7	10.8
13	8A_LTL/Dry Van_Diesel	4.9	6.3	8.0
14	8A_Mixed	2.8	6.2	9.0
15	8A_Refrigerated_Diesel	4.9	5.9	7.1
16	8A_TL/Dry Van_Diesel	4.4	6.3	8.3

[34] While DOT regulations limit drivers' daily hours, some companies utilize driver teams to maximize on-road time.
[35] Value for a hybrid electric truck. Hybrids are subject to separate validation ranges for the 2014 version of the Truck Tool as discussed below. The maximum value for non-hybrid Class 3 diesel trucks was 14.4 mpg.

Group #	Name	Min	Mean	Max
17	8B_AutoCarrier_Diesel	4.5	5.2	6.3
18	8B_Dray_Diesel	4.7	5.8	6.6
19	8B_Flatbed_Diesel	0.6	5.7	7.0
20	8B_Heavy/Bulk_Diesel	3.4	5.0	6.4
21	8B_LTL/Dry Van_Diesel	4.4	6.0	7.1
22	8B_Mixed	3.0	5.8	7.3
23	8B_Refrigerated_Diesel	4.3	5.7	7.1
24	8B_Specialized_Diesel	2.8	5.5	6.8
25	8B_TL/Dry Van_Diesel	3.1	5.9	7.9
26	8B_Tanker_Diesel	3.8	5.8	7.0

[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 27 by truck class.

Table 27. 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 all substantially higher than the maximum value observed for non-hybrid diesel trucks in the 2011 Truck Tool data.

Non-Diesel MPG

The 2011 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.[36] 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 27 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),[37] thereby adjusting mpg values for volumetric energy density. Table 28 presents the corresponding upper bound MPG values for non-diesel vehicles by truck class.

Table 28. 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

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

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

Class	Gasoline/CNG	LPG	LNG
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.

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	0.146	0.1202	0.1130

Gal/Mi - Urban

Group #	Name	Low Red	Low Yellow	Mean	High Yellow	High Red
				7		
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

Gal/Mi – Highway

Group #	Name	Low Red	Low Yellow	Mean	High Yellow	High Red
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 dataset (prior to cleaning) are presented in Table 29.

Table 29. Maximum and Minimum Observed Payloads (Short Tons)

Group #	Name	Min	Mean	Max
1	2B_Mixed	0.1	1.0	1.9[38]
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
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

[38] 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
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.[39] Accordingly, the absolute upper bound payload levels were set equal to 3 times the maximum observed values shown in Table 29.

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.

Average Volume

The maximum and minimum observed volumes from the dataset (prior to cleaning) are presented in Table 30.

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

Table 30. 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[40]
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.

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.

[40] One Class 6 LTL fleet with an extreme outlier volume of 12,000 cubic feet was dropped for the purposes of this analysis.

Percent Capacity Utilization
Capacity utilization 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 new Truck Tool adds a new Data Source option for Dray carriers allows them to select an industry average capacity utilization 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 capacity utilization was calculated for Body Type tag, weighted by the number of trucks. (This approach assumes that none of the capacity utilization 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 capacity utilization values for non-dray carriers were as follows.

Chassis	90.5%
Dry Van	84.8%
Mixed	85.4%

3) The weighted average capacity utilization values from Step 2 were combined with the body type percentage distribution from Step 1 to obtain a single, industry average capacity utilization 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 "I don't know my cap utilization" Data Source selection. Also note that the default option is only available to carriers that specified a non-zero Dray operations percentage in the Fleet Characterization section - otherwise the new Data Source selection 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.

Average Annual Idle Hours per Truck
The maximum and minimum observed idle hours from the dataset (prior to cleaning) are presented in Table 31.

Table 31. Maximum and Minimum Observed Idle Hours per Truck

Group #	Name	Min	Mean	Max
1	2B_Mixed	0	323	1,785
2	3_Mixed	20	371	1,267
3	4_Mixed	50	364	1,524
4	5_Mixed	30	420	1,462
5	6_LTL/Dry Van_Diesel	0	311	720
6	6_Mixed	2	425	1,825
7	6_Moving	22	275	576
8	6_Package_Diesel	8	305	1,196
9	6_TL/Dry Van_Diesel	0	514	1,820
10	7_LTL/Dry Van_Diesel	75	326	1,440
11	7_Mixed	55	413	2,077
12	7_TL/Dry Van_Diesel	3	288	598
13	8A_LTL/Dry Van_Diesel	61	384	2,071
14	8A_Mixed	0	574	2,574
15	8A_Refrigerated_Diesel	130	713	2,000
16	8A_TL/Dry Van_Diesel	25	629	2,016
17	8B_AutoCarrier_Diesel	240	1,154	3,380
18	8B_Dray_Diesel	78	672	2,080
19	8B_Flatbed_Diesel	100	911	2,100
20	8B_Heavy/Bulk_Diesel	161	601	1,401
21	8B_LTL/Dry Van_Diesel	61	518	1,675
22	8B_Mixed	0	782	2,475
23	8B_Refrigerated_Diesel	41	843	2,349
24	8B_Specialized_Diesel	140	760	2,200
25	8B_TL/Dry Van_Diesel	17	912	3,410
26	8B_Tanker_Diesel	54	826	2,816

Absolute bounds on idle hours are based on simple operational constraints: a truck can idle no more than 24 hours per day, 7 days a week, or 8,760 hours per year. Zero hours are also acceptable values with explanations.

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, payload, and loaded). 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 Capacity Volume
4. **g/avg utilized cubic foot: ∑E / (M × ACV) / CU**
   where E = Emissions, M = Miles Driven, ACV = Average Capacity Volume, CU = % Cube Utilization

For all four calculations:

Emissions = grams of pollutant (as specified above)
Miles Driven = Total Miles, Payload 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, divisions, and at the company level, as specified by the user.

5.0 Port Dray Program Inputs and Calculations

Those fleets with 75% or more of their operation in the Dray Operation Type category are eligible to participate in SmartWay's Port Drayage Program. This voluntary program recognizes Partners for reducing diesel emissions from port drayage trucks. Participating Partners must provide information on their drayage fleet's model year distribution, use of PM control equipment, auxiliary power units (APUs), SmartWay tires, and LNG trucks in order to obtain an Environmental Performance Rating for the program.

The following summarizes the calculations used in the Truck Tool to calculate Port Dray Program Environmental Performance Rating.

Baseline CO_2 Emissions from Average Dray Truck Fleet

To calculate baseline CO_2 emissions from the average dray truck fleet, the total number of trucks within a single model year group, as supplied by the user, is multiplied by an average model year distribution factor, as seen in Table 32.

Table 32. Average Model Year Distribution Factors by Model Year Group

Model Year Group	Average Model Year Distribution Factor
Pre-1988	0.061
1988 – 1993	0.190
1994 – 2002	0.632
2003 – 2006	0.083
2007 – 2009	0.033
Post 2009	0.000

Then, the fuel consumption is calculated by dividing the average miles per truck, also supplied by the user, by an assumed 5.47 miles per gallon.[41] This calculated fuel consumption is then multiplied by the CO_2 emission factor of 0.01015. CO_2 emissions across all model year groups are summed to obtain the total baseline CO_2 emissions.

Untreated and Controlled CO_2 Emissions

To calculate CO_2 emissions from untreated trucks (e.g., without PM retrofits), as well as trucks with diesel oxidation catalysts (DOCs), closed crankcase ventilation (CCVs), flow through filters, and diesel particulate filters in the fleet, the fuel consumption is

[41] This and other calculation elements used to derive the Dray Program Environmental Performance Score are completely independent of the performance metric calculations in other portions of the Truck Tool. For example, the truck fleet gram per mile and gram per ton-mile performance metrics are calculated using the fleet's actual fuel efficiency, not the 5.47 value used for the Dray Program calculations.

calculated by dividing the average miles per truck, supplied by the user, by the assumed value of 5.47 miles per gallon. This calculated fuel consumption is then multiplied by the CO_2 emission factor of 0.01015. CO_2 emissions across all model year bins are summed to obtain the total untreated plus controlled vehicle CO_2 emissions.

Baseline PM Emissions from Average Dray Truck Fleet

To calculate baseline PM emissions from the average dray truck fleet, the total number of trucks within a single model year group, as supplied by the user, is multiplied by an average model year distribution factor, as shown in Table 32. The resulting value is then multiplied by the average miles per truck, as supplied by the user, as well as the specified PM emission factor, as shown in Table 33. PM emissions across all model year bins are summed to obtain the total baseline PM emissions.

Table 33. PM Emission Factors by Model Year Group

Model Year Group	PM Emission Factor
Pre '88	3.428E-06
88-'93	2.535E-06
94-'02	1.157E-06
03-'06	6.834E-07
07-'09	9.921E-08
post 2009	7.716E-08

PM Emissions from Untreated Trucks

To calculate PM emissions from untreated trucks, the total number of untreated trucks within a single model year bin, as supplied by the user, is multiplied by the average miles per truck, also supplied by the user, as well as an appropriate PM emission factor, as shown in Table 33. PM emissions across all model year groups are summed to obtain the total PM emissions from untreated trucks within the fleet.

PM Emissions from Controlled Trucks

To calculate PM emissions from controlled trucks, the total number of controlled trucks within a single model year group, as supplied by the user, is multiplied by the average miles per truck, also supplied by the user, as well as an appropriate PM emission factor, as shown in Table 33. This value is then multiplied by a control factor, as shown in Table 34. PM emissions across all model year groups are summed to obtain the total PM emissions from untreated trucks within the fleet.

Table 34. PM Control Factors by Control Type

Control Type	PM Control Factor
DOC & CCVs	70%
Flow Through Filter	50%
Diesel Particulate	10%

Baseline NO_X Emissions from Average Dray Truck Fleet

To calculate baseline NO_x emissions from the average dray truck fleet, the total number of trucks within a single model year group, as supplied by the user, is multiplied by an average model year distribution factor, as seen in Table 32. The resulting value is then multiplied by the average miles per truck, as supplied by the user, as well as an appropriate NO_x emission factor, as shown in Table 35. NO_x emissions across all model year groups are summed to obtain the total baseline NO_x emissions.

Table 35. NO_x Emission Factors by Model Year Group

Model Year Group	PM Emission Factor
Pre '88	2.65E-05
88-'93	2.51E-05
94-'02	2.38E-05
03-'06	1.68E-05
07-'09	1.01E-05
post 2009	3E-06

NO_X Emissions from Untreated and Controlled Trucks

To calculate NO_x emissions from untreated trucks, the total number of untreated trucks within a single model year group, as supplied by the user, is multiplied by the average miles per truck, also supplied by the user, as well as an appropriate NO_x emission factor, as seen in Table 35. NO_x emissions across all model year groups are summed to obtain the total NO_x emissions from untreated trucks within the fleet.

Reductions in CO_2 Emissions from Auxiliary Power Units (APUs), SmartWay Approved Tires, and LNG Vehicles

The user-supplied number of vehicles with each control is divided by the total number of trucks in the fleet and multiplied by a control factor, as shown in Table 36.

Table 36. Control Strategy Control Factors

Control Type	PM Control Factor
APUs	11%
SmartWay Tires	2%
LNG	21%

The reductions are then summed across all control types and multiplied by the sum of CO_2 emissions for untreated trucks, and trucks with DOCs & CCVs, flow through filters, and diesel particulate traps installed. This value is then multiplied by -1 to indicate a reduction in emissions.

Reductions in PM Emissions from Auxiliary Power Units (APUs)

The user-supplied number of trucks with APUs installed is divided by the total number of trucks in the fleet and multiplied by a control factor of 8%. The reductions are then multiplied by the sum of PM emissions for untreated trucks, and trucks with DOCs & CCVs, flow through filters, and diesel particulate traps installed. This value is then multiplied by -1 to indicate a reduction in emissions.

Reductions in NO_X Emissions from Auxiliary Power Units (APUs) and SmartWay Tires

The user-supplied number of trucks with APUs and SmartWay Tires installed is divided by the total number of trucks in the fleet and multiplied by a control factor of 11% and 2% for APUs and SmartWay tires, respectively. The reductions are then multiplied by the sum of NO_x emissions for untreated trucks, and trucks with DOCs & CCVs, flow through filters, and diesel particulate traps installed. This value is then multiplied by -1 to indicate a reduction in emissions.

Total Fleet Emissions

The total fleet emissions are calculated by subtracting the reductions that were calculated for each pollutant from the sum of the emissions, by pollutant, for untreated trucks and trucks equipped with DOCs & CCVs, flow through filters, and diesel particulate traps.

Change in Emissions from Baseline

Total fleet emissions are subtracted from the baseline emissions for each pollutant to determine the change in emissions from baseline.

Percent Change in Emissions

The change in emissions from baseline is divided by the baseline emissions, by pollutant.

Fleet Composite Score and Environmental Performance Rating

The fleet composite score determines the dray fleet's Environmental Performance Rating, which is used by shippers to assess their status in the Port Dray Program. The fleet composite score is determined by the formula:

$$\frac{[\boldsymbol{CO2}\ \%\ \boldsymbol{C\quad ange\ in\ Emissions}}{\mathbf{40}} + \frac{\boldsymbol{NOX}\ \%\ \boldsymbol{C\quad ange\ in\ Emissions}}{\mathbf{80}} + \frac{\boldsymbol{PM}\ \%\ \boldsymbol{C\quad ange\ in\ Emissions}}{\mathbf{80}}] * \mathbf{-100}$$

The Environmental Performance Rating is assigned based on the value of the fleet composite score, as shown in Table 37.

Table 37. Environmental Performance Rating Assignments

Fleet Composite Score	Environmental Performance Rating
≤0.05	No Rating
>0.05 and ≤0.499	Average
>0.499 and ≤1.00	Good
>1.00 and ≤1.8	Very Good
>1.8	Outstanding

Appendix F shows a detailed breakdown of all equations in EPA's Drayage Calculator, which is used as the basis of the drayage calculations within the SmartWay Truck Tool.

Appendix A: MOVES2010b-based $NOx/PM_{2.5}$ Emission Factors (g/mi)

Year & Class	Diesel NOx Decel	Diesel NOx 0 to 25	Diesel NOx 25 to 50	Diesel NOx 50 +	Diesel NOx Highway	Diesel PM 2.5 Decel	Diesel PM 2.5 0 to 25	Diesel PM 2.5 25 to 50	Diesel PM 2.5 50 +	Diesel PM 2.5 Highway
1987-2b	2.642	29.256	40.433	9.849	16.539	0.066	1.533	2.467	0.849	1.200
1987-3	2.641	29.295	40.519	9.904	16.600	0.066	1.538	2.472	0.851	1.203
1987-4	2.646	29.268	40.817	9.937	17.551	0.061	1.333	2.011	0.684	1.003
1987-5	2.636	29.481	41.017	10.185	17.144	0.065	1.508	2.379	0.816	1.166
1987-6	2.583	31.740	45.323	12.753	22.447	0.071	1.836	2.715	0.926	1.457
1987-7	2.439	37.335	56.690	19.432	32.014	0.086	2.532	3.301	1.109	1.881
1987-8a	2.321	40.986	64.653	24.135	36.233	0.099	3.012	3.779	1.264	2.097
1987-8b	2.220	44.237	71.999	28.244	39.306	0.112	3.470	4.229	1.414	2.279
1988-2b	2.120	21.148	26.084	7.077	12.221	0.087	1.024	1.375	0.328	0.636
1988-3	2.619	30.215	42.254	10.937	19.073	0.066	1.174	1.533	0.418	0.734
1988-4	2.645	29.228	40.641	9.866	17.277	0.060	1.205	1.550	0.439	0.751
1988-5	2.594	31.331	44.512	12.243	21.836	0.068	1.247	1.576	0.429	0.774
1988-6	2.577	32.040	45.901	13.043	23.184	0.071	1.261	1.589	0.428	0.782
1988-7	2.519	34.331	50.541	15.786	27.487	0.078	1.377	1.661	0.439	0.833
1988-8a	2.357	39.930	62.514	22.738	35.170	0.099	1.631	1.841	0.467	0.920
1988-8b	2.203	44.946	73.879	29.051	40.040	0.124	1.871	2.026	0.501	0.980
1989-2b	2.298	27.752	36.925	11.298	21.474	0.086	1.241	1.537	0.384	0.765
1989-3	2.572	28.206	38.220	9.378	15.916	0.066	1.141	1.503	0.411	0.708
1989-4	2.645	29.216	40.602	9.848	17.242	0.060	1.216	1.554	0.443	0.756
1989-5	2.609	30.640	43.118	11.426	20.269	0.065	1.233	1.564	0.431	0.764
1989-6	2.563	32.605	47.009	13.697	24.387	0.072	1.317	1.617	0.437	0.806
1989-7	2.567	32.500	46.896	13.551	24.180	0.072	1.310	1.619	0.439	0.806
1989-8a	2.401	38.601	59.582	20.985	33.643	0.092	1.595	1.805	0.464	0.909
1989-8b	2.197	45.114	74.251	29.281	40.161	0.123	1.897	2.031	0.500	0.984
1990-2b	2.018	14.708	18.539	5.562	8.739	0.100	1.036	1.417	0.305	0.631
1990-3	2.063	19.526	25.458	6.989	12.071	0.085	1.146	1.506	0.373	0.705
1990-4	2.041	22.500	31.040	7.485	12.772	0.061	1.183	1.531	0.432	0.732
1990-5	2.031	22.980	32.013	8.052	14.064	0.062	1.219	1.553	0.437	0.754
1990-6	1.966	25.702	37.335	11.188	19.832	0.072	1.375	1.642	0.443	0.829
1990-7	1.961	25.846	37.636	11.388	20.075	0.072	1.385	1.648	0.444	0.833
1990-8a	1.786	31.997	50.853	18.995	28.438	0.099	1.772	1.896	0.474	0.957
1990-8b	1.672	35.501	58.917	23.508	31.541	0.118	2.010	2.055	0.496	1.007
1991-2b	1.706	12.403	15.672	4.754	7.485	0.234	0.667	0.681	0.136	0.375
1991-3	1.868	20.772	29.236	7.099	11.925	0.060	1.096	0.823	0.218	0.454
1991-4	1.760	25.239	38.232	12.325	21.283	0.083	1.473	1.065	0.343	0.756
1991-5	1.801	17.154	22.522	6.099	10.455	0.163	0.911	0.754	0.165	0.418
1991-6	1.810	23.303	34.345	10.018	17.877	0.073	1.310	0.963	0.291	0.649
1991-7	1.748	25.584	39.098	12.811	21.779	0.085	1.501	1.085	0.351	0.770
1991-8a	1.594	30.384	49.848	18.973	27.453	0.119	1.909	1.388	0.512	0.965
1991-8b	1.521	32.769	55.541	21.979	29.521	0.144	2.118	1.561	0.614	1.045
1992-2b	1.657	11.023	14.013	4.400	6.717	0.240	0.587	0.651	0.131	0.361
1992-3	1.801	18.234	24.218	6.204	10.523	0.127	0.952	0.790	0.214	0.448
1992-4	1.871	20.654	28.972	6.932	11.741	0.063	1.073	0.849	0.248	0.475
1992-5	1.870	20.752	29.343	7.101	12.314	0.060	1.080	0.822	0.218	0.459
1992-6	1.813	23.133	33.915	9.819	17.574	0.073	1.285	0.969	0.302	0.647

Year & Class	Diesel NOx Decel	Diesel NOx 0 to 25	Diesel NOx 25 to 50	Diesel NOx 50 +	Diesel NOx Highway	Diesel PM 2.5 Decel	Diesel PM 2.5 0 to 25	Diesel PM 2.5 25 to 50	Diesel PM 2.5 50 +	Diesel PM 2.5 Highway
1992-7	1.778	24.545	36.919	11.509	20.247	0.080	1.406	1.035	0.330	0.724
1992-8a	1.597	30.670	50.591	19.165	27.803	0.124	1.938	1.419	0.535	0.984
1992-8b	1.519	32.884	55.862	22.101	29.635	0.143	2.131	1.561	0.609	1.044
1993-2b	1.746	13.905	17.561	5.073	8.241	0.217	0.741	0.713	0.153	0.395
1993-3	1.819	19.323	26.224	6.502	11.064	0.094	1.012	0.789	0.209	0.442
1993-4	1.850	21.523	30.632	7.908	14.111	0.065	1.155	0.872	0.251	0.534
1993-5	1.868	20.709	29.127	7.022	11.989	0.060	1.084	0.821	0.219	0.455
1993-6	1.819	22.805	33.271	9.444	16.994	0.071	1.261	0.938	0.282	0.622
1993-7	1.793	23.840	35.458	10.673	18.899	0.077	1.351	1.001	0.316	0.688
1993-8a	1.596	30.559	50.355	19.079	27.704	0.122	1.929	1.408	0.527	0.978
1993-8b	1.520	32.899	55.942	22.099	29.675	0.142	2.137	1.555	0.602	1.043
1994-2b	1.695	12.643	15.932	4.766	7.580	0.169	1.408	1.027	0.193	0.519
1994-3	1.773	12.702	16.091	4.854	7.623	0.178	1.450	1.065	0.199	0.528
1994-4	1.870	20.600	28.826	6.857	11.664	0.098	1.618	1.249	0.267	0.623
1994-5	1.868	20.731	29.228	7.063	12.150	0.097	1.679	1.270	0.269	0.644
1994-6	1.838	22.012	31.716	8.539	15.237	0.106	1.743	1.334	0.286	0.712
1994-7	1.779	24.454	36.744	11.382	20.030	0.130	1.884	1.491	0.324	0.829
1994-8a	1.593	30.666	50.585	19.207	27.795	0.203	2.275	1.931	0.432	1.021
1994-8b	1.528	32.723	55.529	21.846	29.553	0.239	2.407	2.113	0.478	1.069
1995-2b	1.676	10.419	13.404	4.317	6.408	0.175	1.328	0.965	0.173	0.472
1995-3	1.838	19.478	26.499	6.610	11.194	0.113	1.588	1.206	0.254	0.608
1995-4	1.829	19.856	27.148	7.134	12.693	0.119	1.624	1.232	0.259	0.644
1995-5	1.851	21.965	31.598	8.399	15.090	0.106	1.749	1.334	0.285	0.710
1995-6	1.819	23.230	34.077	9.879	17.619	0.117	1.793	1.399	0.302	0.764
1995-7	1.778	24.870	37.526	11.837	20.567	0.133	1.894	1.508	0.329	0.837
1995-8a	1.591	31.145	51.670	19.714	28.230	0.214	2.266	1.980	0.447	1.031
1995-8b	1.535	32.907	55.902	21.972	29.699	0.244	2.385	2.134	0.486	1.071
1996-2b	1.677	12.148	15.255	4.656	7.313	0.163	1.368	0.988	0.183	0.495
1996-3	1.851	19.700	26.670	6.662	11.263	0.112	1.605	1.215	0.256	0.612
1996-4	1.861	21.956	31.147	8.246	14.733	0.105	1.719	1.316	0.282	0.697
1996-5	1.828	21.344	29.888	8.327	15.154	0.116	1.757	1.308	0.276	0.712
1996-6	1.820	23.747	34.923	10.330	18.482	0.123	1.834	1.443	0.313	0.793
1996-7	1.775	25.346	38.172	12.331	21.135	0.133	1.944	1.522	0.330	0.852
1996-8a	1.605	31.077	51.040	19.473	28.072	0.205	2.292	1.945	0.435	1.029
1996-8b	1.542	33.095	55.826	22.050	29.754	0.236	2.441	2.110	0.475	1.074
1997-2b	1.526	8.863	11.552	3.861	5.538	0.163	1.199	0.861	0.151	0.424
1997-3	1.729	18.692	24.687	6.953	12.766	0.127	1.594	1.172	0.245	0.638
1997-4	1.886	20.747	28.754	6.857	11.667	0.097	1.662	1.255	0.268	0.628
1997-5	1.874	21.423	30.264	7.684	13.756	0.100	1.762	1.311	0.278	0.687
1997-6	1.839	22.828	32.881	9.268	16.722	0.114	1.785	1.382	0.299	0.747
1997-7	1.806	24.176	35.684	10.861	19.280	0.127	1.857	1.473	0.322	0.809
1997-8a	1.609	31.093	51.030	19.427	28.076	0.218	2.236	1.993	0.454	1.029
1997-8b	1.545	32.981	55.522	21.907	29.648	0.249	2.350	2.150	0.493	1.069
1998-2b	1.459	8.758	11.132	3.864	5.555	0.200	0.408	0.388	0.114	0.257
1998-3	2.167	17.678	23.988	7.167	10.632	0.116	0.589	0.670	0.233	0.348

Year & Class	Diesel NOx Decel	Diesel NOx 0 to 25	Diesel NOx 25 to 50	Diesel NOx 50 +	Diesel NOx Highway	Diesel PM 2.5 Decel	Diesel PM 2.5 0 to 25	Diesel PM 2.5 25 to 50	Diesel PM 2.5 50 +	Diesel PM 2.5 Highway
1998-4	2.234	18.206	25.069	7.417	10.926	0.107	0.600	0.694	0.242	0.353
1998-5	2.234	18.236	25.204	7.479	11.167	0.107	0.591	0.676	0.242	0.350
1998-6	2.233	18.240	25.160	7.476	11.032	0.107	0.600	0.691	0.242	0.353
1998-7	2.194	19.455	27.471	9.032	14.282	0.114	0.686	0.741	0.251	0.406
1998-8a	1.947	25.754	40.457	17.575	24.071	0.166	1.180	1.094	0.311	0.588
1998-8b	1.819	28.440	46.522	21.403	26.537	0.196	1.396	1.257	0.341	0.637
1999-2b	1.295	6.655	8.783	3.238	4.253	0.202	0.382	0.359	0.104	0.243
1999-3	1.224	10.808	12.599	4.709	6.457	0.127	0.562	0.610	0.220	0.334
1999-4	1.204	11.444	13.451	5.003	6.786	0.107	0.590	0.667	0.244	0.348
1999-5	1.203	11.476	13.503	5.031	6.819	0.107	0.592	0.668	0.244	0.349
1999-6	1.192	11.768	13.982	5.349	7.688	0.109	0.615	0.677	0.247	0.366
1999-7	1.188	12.948	15.681	6.260	9.583	0.115	0.689	0.729	0.254	0.407
1999-8a	1.143	21.409	29.040	13.371	18.280	0.174	1.245	1.142	0.320	0.605
1999-8b	1.132	23.978	33.502	15.672	19.933	0.201	1.425	1.285	0.346	0.647
2000-2b	1.225	6.262	8.317	3.081	4.034	0.190	0.361	0.338	0.097	0.231
2000-3	1.216	10.760	12.516	4.676	6.430	0.127	0.559	0.606	0.217	0.333
2000-4	1.207	11.551	13.604	5.060	6.861	0.108	0.595	0.674	0.243	0.350
2000-5	1.207	11.607	13.693	5.110	6.919	0.108	0.598	0.677	0.244	0.351
2000-6	1.196	11.613	13.758	5.205	7.294	0.108	0.604	0.673	0.245	0.358
2000-7	1.193	13.343	16.258	6.514	10.143	0.118	0.715	0.752	0.257	0.423
2000-8a	1.153	20.444	27.376	12.490	17.596	0.166	1.181	1.094	0.312	0.590
2000-8b	1.139	23.909	33.343	15.575	19.934	0.200	1.424	1.289	0.347	0.650
2001-2b	1.213	5.867	8.010	2.955	3.808	0.191	0.342	0.321	0.090	0.220
2001-3	1.200	10.725	12.466	4.680	6.422	0.123	0.559	0.604	0.220	0.332
2001-4	1.200	11.397	13.394	4.991	6.765	0.107	0.589	0.663	0.244	0.347
2001-5	1.200	11.424	13.436	5.015	6.792	0.108	0.590	0.664	0.244	0.348
2001-6	1.191	11.914	14.202	5.461	7.990	0.111	0.627	0.684	0.249	0.375
2001-7	1.190	12.471	14.977	5.886	8.866	0.113	0.661	0.709	0.252	0.393
2001-8a	1.153	21.260	28.764	13.186	18.252	0.174	1.241	1.143	0.322	0.609
2001-8b	1.138	23.857	33.246	15.541	19.887	0.199	1.418	1.283	0.346	0.648
2002-2b	1.258	6.260	8.404	3.092	4.026	0.197	0.362	0.340	0.096	0.232
2002-3	1.228	10.750	12.503	4.653	6.424	0.131	0.557	0.604	0.211	0.331
2002-4	1.217	11.662	13.737	5.068	6.892	0.107	0.597	0.684	0.242	0.351
2002-5	1.217	11.662	13.737	5.068	6.892	0.107	0.597	0.684	0.242	0.351
2002-6	1.206	11.736	13.902	5.218	7.313	0.108	0.606	0.683	0.244	0.359
2002-7	1.204	12.930	15.626	6.114	9.397	0.115	0.684	0.736	0.252	0.406
2002-8a	1.159	19.796	26.359	11.884	17.078	0.160	1.135	1.059	0.306	0.577
2002-8b	1.127	23.592	32.855	15.341	19.663	0.196	1.395	1.256	0.341	0.637
2003-2b	2.439	6.190	9.620	3.338	4.184	0.168	0.321	0.302	0.087	0.205
2003-3	1.995	9.200	10.561	4.047	5.221	0.113	0.509	0.556	0.196	0.302
2003-4	1.872	9.688	10.784	4.198	5.384	0.097	0.539	0.617	0.219	0.317
2003-5	1.872	9.688	10.784	4.198	5.384	0.097	0.539	0.617	0.219	0.317
2003-6	1.863	9.776	10.923	4.274	5.561	0.098	0.546	0.616	0.220	0.323
2003-7	1.843	10.191	11.431	4.494	6.161	0.103	0.608	0.658	0.227	0.361
2003-8a	1.670	12.928	15.081	6.130	8.709	0.142	1.000	0.938	0.273	0.514

Year & Class	Diesel NOx Decel	Diesel NOx 0 to 25	Diesel NOx 25 to 50	Diesel NOx 50 +	Diesel NOx Highway	Diesel PM 2.5 Decel	Diesel PM 2.5 0 to 25	Diesel PM 2.5 25 to 50	Diesel PM 2.5 50 +	Diesel PM 2.5 Highway
2003-8b	1.534	14.655	17.602	7.244	9.657	0.176	1.254	1.129	0.307	0.574
2004-2b	2.439	6.192	9.615	3.333	4.181	0.159	0.303	0.288	0.084	0.192
2004-3	1.998	9.188	10.556	4.043	5.217	0.111	0.505	0.552	0.195	0.299
2004-4	1.872	9.689	10.786	4.199	5.385	0.097	0.539	0.617	0.219	0.317
2004-5	1.872	9.689	10.786	4.199	5.385	0.097	0.539	0.617	0.219	0.317
2004-6	1.862	9.785	10.933	4.278	5.573	0.098	0.547	0.617	0.220	0.324
2004-7	1.841	10.231	11.481	4.517	6.214	0.103	0.613	0.662	0.228	0.364
2004-8a	1.663	13.024	15.216	6.192	8.770	0.143	1.014	0.948	0.275	0.517
2004-8b	1.532	14.674	17.631	7.258	9.665	0.177	1.257	1.131	0.307	0.574
2005-2b	2.444	6.131	9.610	3.330	4.166	0.159	0.298	0.283	0.082	0.189
2005-3	2.005	9.156	10.544	4.035	5.208	0.112	0.503	0.548	0.193	0.298
2005-4	1.872	9.690	10.787	4.199	5.385	0.097	0.539	0.617	0.219	0.317
2005-5	1.872	9.690	10.787	4.199	5.385	0.097	0.539	0.617	0.219	0.317
2005-6	1.863	9.788	10.935	4.278	5.574	0.098	0.548	0.617	0.220	0.324
2005-7	1.841	10.236	11.487	4.519	6.220	0.103	0.614	0.663	0.228	0.364
2005-8a	1.662	13.030	15.225	6.196	8.773	0.144	1.014	0.948	0.275	0.518
2005-8b	1.532	14.673	17.629	7.258	9.664	0.176	1.256	1.131	0.307	0.574
2006-2b	1.936	5.116	7.399	2.482	3.243	0.159	0.294	0.280	0.080	0.187
2006-3	1.888	9.023	10.106	3.885	5.083	0.111	0.504	0.549	0.193	0.299
2006-4	1.872	9.691	10.789	4.200	5.386	0.097	0.539	0.617	0.219	0.317
2006-5	1.872	9.691	10.789	4.200	5.386	0.097	0.539	0.617	0.219	0.317
2006-6	1.862	9.801	10.950	4.285	5.592	0.098	0.550	0.619	0.221	0.325
2006-7	1.838	10.294	11.559	4.551	6.295	0.104	0.622	0.668	0.229	0.369
2006-8a	1.653	13.152	15.398	6.276	8.850	0.146	1.031	0.961	0.277	0.522
2006-8b	1.530	14.697	17.665	7.275	9.674	0.177	1.259	1.133	0.307	0.575
2007-2b	0.902	2.382	3.437	1.158	1.518	0.007	0.015	0.020	0.010	0.011
2007-3	0.929	4.489	5.003	1.929	2.528	0.005	0.025	0.031	0.013	0.016
2007-4	0.936	4.846	5.395	2.100	2.693	0.004	0.027	0.034	0.014	0.016
2007-5	0.936	4.846	5.395	2.100	2.693	0.004	0.027	0.034	0.014	0.016
2007-6	0.932	4.880	5.449	2.130	2.763	0.004	0.027	0.034	0.014	0.017
2007-7	0.925	5.036	5.640	2.213	2.995	0.004	0.028	0.037	0.014	0.018
2007-8a	0.849	6.272	7.271	2.945	4.223	0.003	0.041	0.063	0.017	0.027
2007-8b	0.772	7.273	8.718	3.587	4.803	0.003	0.051	0.086	0.020	0.032
2008-2b	0.904	2.505	3.505	1.194	1.578	0.007	0.016	0.020	0.010	0.011
2008-3	0.931	4.579	5.098	1.971	2.570	0.005	0.025	0.032	0.013	0.016
2008-4	0.936	4.846	5.395	2.101	2.694	0.004	0.027	0.034	0.014	0.016
2008-5	0.936	4.846	5.395	2.101	2.694	0.004	0.027	0.034	0.014	0.016
2008-6	0.932	4.880	5.449	2.130	2.762	0.004	0.027	0.034	0.014	0.017
2008-7	0.925	5.033	5.636	2.211	2.990	0.004	0.028	0.037	0.014	0.018
2008-8a	0.850	6.257	7.251	2.936	4.212	0.003	0.041	0.063	0.017	0.027
2008-8b	0.772	7.268	8.710	3.583	4.800	0.003	0.051	0.086	0.020	0.032
2009-2b	0.904	2.585	3.550	1.218	1.617	0.007	0.016	0.020	0.010	0.011
2009-3	0.932	4.622	5.144	1.991	2.590	0.004	0.024	0.030	0.013	0.015
2009-4	0.936	4.846	5.396	2.101	2.694	0.004	0.025	0.032	0.013	0.016
2009-5	0.936	4.846	5.396	2.101	2.694	0.004	0.025	0.032	0.013	0.016

Year & Class	Diesel NOx Decel	Diesel NOx 0 to 25	Diesel NOx 25 to 50	Diesel NOx 50 +	Diesel NOx Highway	Diesel PM 2.5 Decel	Diesel PM 2.5 0 to 25	Diesel PM 2.5 25 to 50	Diesel PM 2.5 50 +	Diesel PM 2.5 Highway
2009-6	0.933	4.880	5.449	2.129	2.762	0.004	0.025	0.032	0.013	0.016
2009-7	0.926	5.032	5.634	2.210	2.988	0.004	0.027	0.035	0.014	0.018
2009-8a	0.851	6.251	7.242	2.932	4.207	0.003	0.040	0.061	0.017	0.027
2009-8b	0.772	7.265	8.705	3.582	4.798	0.003	0.051	0.085	0.020	0.031
2010-2b	0.353	0.974	1.402	0.483	0.626	0.006	0.015	0.019	0.010	0.011
2010-3	0.322	1.552	1.747	0.671	0.872	0.004	0.023	0.029	0.012	0.014
2010-4	0.315	1.630	1.814	0.704	0.905	0.004	0.024	0.030	0.013	0.015
2010-5	0.315	1.630	1.814	0.704	0.905	0.004	0.024	0.030	0.013	0.015
2010-6	0.314	1.640	1.831	0.713	0.927	0.004	0.024	0.031	0.013	0.015
2010-7	0.312	1.697	1.899	0.743	1.010	0.004	0.026	0.034	0.013	0.017
2010-8a	0.292	2.157	2.497	1.010	1.461	0.003	0.038	0.058	0.016	0.025
2010-8b	0.271	2.549	3.053	1.256	1.686	0.003	0.048	0.081	0.019	0.030
2011-2b	0.228	0.635	0.909	0.314	0.407	0.004	0.008	0.011	0.006	0.006
2011-3	0.210	1.017	1.144	0.440	0.571	0.003	0.015	0.018	0.008	0.009
2011-4	0.206	1.066	1.187	0.461	0.591	0.002	0.015	0.019	0.008	0.009
2011-5	0.206	1.066	1.187	0.461	0.591	0.002	0.015	0.019	0.008	0.009
2011-6	0.205	1.073	1.197	0.466	0.606	0.002	0.015	0.020	0.008	0.010
2011-7	0.204	1.112	1.244	0.486	0.661	0.002	0.016	0.021	0.008	0.011
2011-8a	0.193	1.427	1.651	0.667	0.969	0.002	0.024	0.037	0.010	0.017
2011-8b	0.181	1.703	2.039	0.839	1.127	0.002	0.031	0.053	0.012	0.020
2012-2b	0.228	0.643	0.913	0.316	0.410	0.004	0.009	0.011	0.006	0.006
2012-3	0.210	1.022	1.147	0.442	0.573	0.003	0.015	0.018	0.008	0.009
2012-4	0.206	1.066	1.187	0.461	0.591	0.002	0.015	0.019	0.008	0.009
2012-5	0.206	1.066	1.187	0.461	0.591	0.002	0.015	0.019	0.008	0.009
2012-6	0.205	1.073	1.197	0.466	0.606	0.002	0.015	0.020	0.008	0.010
2012-7	0.204	1.111	1.243	0.486	0.661	0.002	0.016	0.021	0.008	0.011
2012-8a	0.193	1.425	1.647	0.666	0.968	0.002	0.024	0.037	0.010	0.016
2012-8b	0.181	1.702	2.037	0.838	1.127	0.002	0.031	0.053	0.012	0.020
2013-2b	0.227	0.645	0.912	0.316	0.410	0.003	0.009	0.011	0.006	0.006
2013-3	0.206	1.003	1.127	0.434	0.562	0.002	0.014	0.018	0.008	0.009
2013-4	0.202	1.042	1.161	0.451	0.578	0.002	0.015	0.019	0.008	0.009
2013-5	0.202	1.042	1.161	0.451	0.578	0.002	0.015	0.019	0.008	0.009
2013-6	0.201	1.049	1.171	0.456	0.592	0.002	0.015	0.019	0.008	0.009
2013-7	0.200	1.085	1.214	0.475	0.644	0.002	0.016	0.021	0.008	0.010
2013-8a	0.188	1.378	1.593	0.644	0.934	0.002	0.023	0.036	0.010	0.016
2013-8b	0.174	1.638	1.961	0.807	1.084	0.002	0.030	0.050	0.012	0.019
2014-2b	0.227	0.652	0.915	0.318	0.413	0.003	0.009	0.011	0.006	0.006
2014-3	0.205	1.006	1.130	0.435	0.564	0.002	0.014	0.018	0.008	0.009
2014-4	0.202	1.042	1.161	0.451	0.579	0.002	0.015	0.019	0.008	0.009
2014-5	0.202	1.042	1.161	0.451	0.579	0.002	0.015	0.019	0.008	0.009
2014-6	0.201	1.050	1.171	0.456	0.592	0.002	0.015	0.019	0.008	0.009
2014-7	0.200	1.085	1.214	0.475	0.644	0.002	0.016	0.021	0.008	0.010
2014-8a	0.188	1.378	1.593	0.644	0.934	0.002	0.023	0.036	0.010	0.016
2014-8b	0.174	1.638	1.961	0.807	1.084	0.002	0.030	0.050	0.012	0.019

Year & Class	Gasoline NOx Decel	Gasoline NOx 0 to 25	Gasoline NOx 25 to 50	Gasoline NOx 50 +	Gasoline NOx Highway	Gasoline PM 2.5 Decel	Gasoline PM 2.5 0 to 25	Gasoline PM 2.5 25 to 50	Gasoline PM 2.5 50 +	Gasoline PM 2.5 Highway
1987-2b	0.341	3.719	7.901	4.026	4.544	0.010	0.045	0.115	0.067	0.077
1987-3	0.542	8.636	13.216	7.382	8.499	0.010	0.044	0.052	0.073	0.060
1987-4	0.537	8.539	13.238	7.404	8.515	0.010	0.044	0.052	0.073	0.060
1987-5	0.567	9.149	12.874	7.170	8.161	0.009	0.042	0.050	0.071	0.057
1987-6	0.551	8.974	12.998	7.253	8.230	0.009	0.043	0.051	0.072	0.058
1987-7	0.561	9.087	12.918	7.200	8.185	0.009	0.043	0.051	0.072	0.057
1987-8a	0.562	10.922	14.484	7.588	9.791	0.009	0.047	0.068	0.073	0.062
1987-8b	0.562	10.922	14.484	7.588	9.791	0.009	0.047	0.068	0.073	0.062
1988-2b	0.363	4.034	8.098	4.153	4.774	0.010	0.043	0.103	0.063	0.062
1988-3	0.542	8.734	13.267	7.394	8.583	0.011	0.051	0.061	0.084	0.061
1988-4	0.538	8.537	13.341	7.444	8.668	0.011	0.051	0.061	0.084	0.062
1988-5	0.554	9.548	13.412	7.352	8.789	0.011	0.051	0.063	0.083	0.060
1988-6	0.560	9.551	13.317	7.310	8.696	0.011	0.051	0.062	0.082	0.060
1988-7	0.577	9.378	12.869	7.138	8.255	0.011	0.050	0.059	0.082	0.058
1988-8a	0.584	11.858	14.982	7.651	10.112	0.011	0.052	0.076	0.077	0.062
1988-8b	0.584	11.858	14.982	7.651	10.112	0.011	0.052	0.076	0.077	0.062
1989-2b	0.363	4.268	8.259	4.274	4.953	0.010	0.043	0.102	0.064	0.062
1989-3	0.540	8.573	13.182	7.382	8.472	0.011	0.051	0.060	0.084	0.061
1989-4	0.538	8.452	13.272	7.427	8.579	0.011	0.051	0.060	0.084	0.061
1989-5	0.568	9.106	12.798	7.157	8.137	0.011	0.050	0.058	0.082	0.058
1989-6	0.555	8.956	12.902	7.228	8.193	0.011	0.050	0.059	0.083	0.059
1989-7	0.564	9.064	12.827	7.177	8.152	0.011	0.050	0.059	0.083	0.058
1989-8a	0.755	12.369	9.134	1.936	7.522	0.011	0.036	0.026	0.015	0.049
1989-8b	0.755	12.369	9.134	1.936	7.522	0.011	0.036	0.026	0.015	0.049
1990-2b	0.370	4.320	8.164	4.237	4.518	0.007	0.029	0.071	0.045	0.061
1990-3	0.382	6.083	9.290	5.205	5.398	0.004	0.018	0.022	0.031	0.040
1990-4	0.380	5.990	9.363	5.241	5.486	0.004	0.018	0.022	0.031	0.041
1990-5	0.392	6.319	9.124	5.113	5.241	0.004	0.018	0.022	0.030	0.038
1990-6	0.395	6.351	9.108	5.101	5.236	0.004	0.018	0.021	0.030	0.038
1990-7	0.415	6.586	8.980	5.004	5.203	0.004	0.018	0.021	0.030	0.037
1990-8a	0.557	9.123	6.737	1.428	5.022	0.004	0.012	0.008	0.005	0.031
1990-8b	0.557	9.123	6.737	1.428	5.022	0.004	0.012	0.008	0.005	0.031
1991-2b	0.385	3.772	7.932	4.017	4.277	0.007	0.033	0.078	0.049	0.036
1991-3	0.381	6.087	9.332	5.218	5.422	0.009	0.043	0.050	0.071	0.032
1991-4	0.380	6.042	9.355	5.232	5.450	0.009	0.043	0.050	0.071	0.032
1991-5	0.385	6.202	9.277	5.182	5.351	0.009	0.043	0.050	0.071	0.032
1991-6	0.389	6.333	9.213	5.141	5.269	0.009	0.043	0.050	0.071	0.031
1991-7	0.386	6.310	9.225	5.150	5.273	0.009	0.043	0.050	0.071	0.031
1991-8a	0.415	6.631	9.045	5.017	5.222	0.009	0.041	0.048	0.069	0.030
1991-8b	0.415	6.631	9.045	5.017	5.222	0.009	0.041	0.048	0.069	0.030
1992-2b	0.370	3.759	7.986	4.056	4.295	0.007	0.034	0.078	0.050	0.036
1992-3	0.379	6.014	9.364	5.239	5.468	0.009	0.043	0.050	0.071	0.032
1992-4	0.379	5.984	9.380	5.248	5.496	0.009	0.043	0.050	0.071	0.032

Year & Class	Gasoline NOx Decel	Gasoline NOx 0 to 25	Gasoline NOx 25 to 50	Gasoline NOx 50 +	Gasoline NOx Highway	Gasoline PM 2.5 Decel	Gasoline PM 2.5 0 to 25	Gasoline PM 2.5 25 to 50	Gasoline PM 2.5 50 +	Gasoline PM 2.5 Highway
1992-5	0.379	6.084	9.329	5.219	5.404	0.009	0.043	0.051	0.071	0.032
1992-6	0.379	6.232	9.255	5.175	5.284	0.009	0.043	0.051	0.071	0.032
1992-7	0.379	6.223	9.260	5.178	5.285	0.009	0.043	0.051	0.071	0.032
1992-8a	0.381	6.245	9.248	5.170	5.281	0.009	0.043	0.051	0.071	0.032
1992-8b	0.381	6.245	9.248	5.170	5.281	0.009	0.043	0.051	0.071	0.032
1993-2b	0.370	4.126	8.098	4.174	4.442	0.008	0.035	0.075	0.052	0.036
1993-3	0.381	6.060	9.301	5.212	5.412	0.009	0.043	0.050	0.071	0.032
1993-4	0.380	6.004	9.346	5.235	5.465	0.009	0.043	0.050	0.071	0.032
1993-5	0.392	6.181	9.241	5.169	5.386	0.009	0.042	0.050	0.070	0.032
1993-6	0.390	6.296	9.126	5.118	5.241	0.009	0.043	0.050	0.070	0.031
1993-7	0.407	6.483	9.027	5.044	5.214	0.009	0.042	0.049	0.069	0.031
1993-8a	0.414	6.572	8.978	5.006	5.202	0.009	0.041	0.048	0.069	0.031
1993-8b	0.414	6.572	8.978	5.006	5.202	0.009	0.041	0.048	0.069	0.031
1994-2b	0.354	3.515	7.148	3.649	3.922	0.005	0.022	0.048	0.033	0.044
1994-3	0.373	5.963	9.119	5.112	5.291	0.008	0.035	0.042	0.059	0.063
1994-4	0.373	5.893	9.179	5.140	5.366	0.008	0.036	0.042	0.059	0.063
1994-5	0.377	5.934	9.160	5.127	5.359	0.008	0.035	0.042	0.058	0.063
1994-6	0.377	6.116	9.000	5.052	5.158	0.008	0.035	0.041	0.058	0.063
1994-7	0.397	6.333	8.886	4.967	5.125	0.007	0.033	0.040	0.057	0.060
1994-8a	0.547	8.957	6.615	1.402	4.931	0.004	0.012	0.008	0.005	0.045
1994-8b	0.547	8.957	6.615	1.402	4.931	0.004	0.012	0.008	0.005	0.045
1995-2b	0.351	3.546	7.171	3.664	3.941	0.004	0.016	0.038	0.023	0.028
1995-3	0.373	5.998	9.125	5.109	5.278	0.003	0.014	0.017	0.024	0.022
1995-4	0.374	5.923	9.174	5.134	5.353	0.003	0.014	0.017	0.024	0.022
1995-5	0.375	5.962	9.151	5.121	5.327	0.003	0.014	0.017	0.024	0.022
1995-6	0.386	6.245	8.982	5.020	5.153	0.003	0.014	0.017	0.024	0.021
1995-7	0.384	6.214	8.998	5.032	5.158	0.003	0.014	0.017	0.024	0.021
1995-8a	0.547	8.957	6.615	1.402	4.931	0.003	0.008	0.006	0.003	0.017
1995-8b	0.547	8.957	6.615	1.402	4.931	0.003	0.008	0.006	0.003	0.017
1996-2b	0.213	2.270	4.321	2.241	2.424	0.004	0.016	0.040	0.024	0.021
1996-3	0.373	5.955	9.146	5.122	5.311	0.003	0.013	0.015	0.021	0.017
1996-4	0.373	5.895	9.187	5.143	5.370	0.003	0.013	0.015	0.021	0.017
1996-5	0.374	5.906	9.182	5.139	5.368	0.003	0.013	0.015	0.021	0.017
1996-6	0.373	6.102	9.046	5.070	5.174	0.003	0.013	0.015	0.021	0.016
1996-7	0.381	6.181	9.005	5.041	5.160	0.003	0.013	0.015	0.021	0.016
1996-8a	0.547	8.957	6.615	1.402	4.931	0.003	0.009	0.007	0.004	0.014
1996-8b	0.547	8.957	6.615	1.402	4.931	0.003	0.009	0.007	0.004	0.014
1997-2b	0.179	2.008	3.986	2.067	2.249	0.003	0.015	0.038	0.022	0.026
1997-3	0.372	5.957	9.086	5.104	5.266	0.003	0.013	0.015	0.022	0.023
1997-4	0.373	5.868	9.191	5.148	5.388	0.003	0.013	0.015	0.022	0.023
1997-5	0.373	5.897	9.158	5.134	5.350	0.003	0.013	0.015	0.022	0.023
1997-6	0.375	6.066	8.975	5.053	5.150	0.003	0.013	0.015	0.022	0.023
1997-7	0.380	6.124	8.947	5.032	5.141	0.003	0.013	0.015	0.022	0.022
1997-8a	0.547	8.957	6.615	1.402	4.931	0.003	0.008	0.006	0.003	0.018
1997-8b	0.547	8.957	6.615	1.402	4.931	0.003	0.008	0.006	0.003	0.018

Year & Class	Gasoline NOx Decel	Gasoline NOx 0 to 25	Gasoline NOx 25 to 50	Gasoline NOx 50 +	Gasoline NOx Highway	Gasoline PM 2.5 Decel	Gasoline PM 2.5 0 to 25	Gasoline PM 2.5 25 to 50	Gasoline PM 2.5 50 +	Gasoline PM 2.5 Highway
1998-2b	0.169	1.789	3.758	1.925	2.100	0.003	0.013	0.034	0.020	0.021
1998-3	0.246	3.956	5.995	3.371	3.784	0.002	0.011	0.013	0.018	0.016
1998-4	0.245	3.872	6.037	3.383	3.821	0.002	0.011	0.013	0.018	0.016
1998-5	0.246	3.956	5.995	3.371	3.784	0.002	0.011	0.013	0.018	0.016
1998-6	0.248	4.018	5.964	3.359	3.756	0.002	0.011	0.013	0.018	0.016
1998-7	0.251	4.046	5.949	3.348	3.742	0.002	0.011	0.013	0.018	0.016
1998-8a	0.360	5.897	4.355	0.923	3.287	0.002	0.007	0.005	0.003	0.012
1998-8b	0.360	5.897	4.355	0.923	3.287	0.002	0.007	0.005	0.003	0.012
1999-2b	0.163	1.679	3.478	1.784	1.956	0.002	0.008	0.022	0.012	0.016
1999-3	0.246	3.983	5.983	3.369	3.774	0.001	0.004	0.004	0.006	0.010
1999-4	0.245	3.947	6.001	3.374	3.790	0.001	0.004	0.004	0.006	0.010
1999-5	0.246	3.937	6.006	3.374	3.793	0.001	0.003	0.004	0.006	0.010
1999-6	0.246	3.940	6.004	3.373	3.791	0.001	0.003	0.004	0.006	0.010
1999-7	0.247	4.013	5.968	3.361	3.760	0.001	0.004	0.004	0.006	0.010
1999-8a	0.248	4.018	5.966	3.359	3.757	0.001	0.004	0.004	0.006	0.010
1999-8b	0.248	4.018	5.966	3.359	3.757	0.001	0.004	0.004	0.006	0.010
2000-2b	0.158	1.627	3.425	1.753	1.913	0.002	0.008	0.020	0.012	0.016
2000-3	0.246	3.984	5.984	3.369	3.774	0.001	0.003	0.003	0.005	0.009
2000-4	0.245	3.951	6.000	3.374	3.788	0.001	0.003	0.003	0.005	0.009
2000-5	0.246	3.941	6.005	3.374	3.792	0.001	0.003	0.003	0.005	0.009
2000-6	0.246	3.944	6.003	3.373	3.790	0.001	0.003	0.003	0.005	0.009
2000-7	0.247	4.012	5.970	3.361	3.761	0.001	0.003	0.003	0.005	0.008
2000-8a	0.248	4.017	5.967	3.360	3.758	0.001	0.003	0.003	0.005	0.008
2000-8b	0.248	4.017	5.967	3.360	3.758	0.001	0.003	0.003	0.005	0.008
2001-2b	0.108	1.183	2.360	1.222	1.445	0.002	0.008	0.020	0.011	0.014
2001-3	0.246	3.995	5.997	3.376	3.782	0.001	0.005	0.006	0.008	0.014
2001-4	0.246	3.963	6.012	3.380	3.795	0.001	0.005	0.006	0.008	0.014
2001-5	0.246	3.954	6.016	3.381	3.799	0.001	0.005	0.006	0.008	0.014
2001-6	0.246	3.957	6.014	3.379	3.797	0.001	0.005	0.006	0.008	0.014
2001-7	0.248	4.021	5.984	3.369	3.769	0.001	0.005	0.006	0.008	0.014
2001-8a	0.248	4.025	5.982	3.367	3.767	0.001	0.005	0.006	0.008	0.014
2001-8b	0.248	4.025	5.982	3.367	3.767	0.001	0.005	0.006	0.008	0.014
2002-2b	0.100	1.107	2.245	1.160	1.368	0.002	0.007	0.019	0.011	0.011
2002-3	0.246	3.996	5.997	3.376	3.782	0.001	0.006	0.007	0.009	0.007
2002-4	0.246	3.967	6.011	3.380	3.794	0.001	0.006	0.007	0.009	0.007
2002-5	0.246	3.958	6.015	3.380	3.797	0.001	0.006	0.007	0.009	0.007
2002-6	0.246	3.962	6.013	3.379	3.795	0.001	0.006	0.007	0.009	0.007
2002-7	0.247	4.020	5.986	3.369	3.770	0.001	0.006	0.007	0.009	0.007
2002-8a	0.248	4.024	5.984	3.368	3.768	0.001	0.006	0.007	0.009	0.007
2002-8b	0.248	4.024	5.984	3.368	3.768	0.001	0.006	0.007	0.009	0.007
2003-2b	0.106	1.171	2.369	1.224	1.441	0.002	0.007	0.019	0.011	0.012
2003-3	0.246	3.998	5.998	3.376	3.782	0.001	0.004	0.004	0.006	0.008
2003-4	0.246	3.970	6.011	3.380	3.793	0.001	0.004	0.004	0.006	0.008
2003-5	0.246	3.962	6.014	3.380	3.796	0.001	0.004	0.004	0.006	0.008
2003-6	0.246	3.965	6.013	3.378	3.794	0.001	0.004	0.004	0.006	0.008

Year & Class	Gasoline NOx Decel	Gasoline NOx 0 to 25	Gasoline NOx 25 to 50	Gasoline NOx 50 +	Gasoline NOx Highway	Gasoline PM 2.5 Decel	Gasoline PM 2.5 0 to 25	Gasoline PM 2.5 25 to 50	Gasoline PM 2.5 50 +	Gasoline PM 2.5 Highway
2003-7	0.247	4.020	5.987	3.370	3.771	0.001	0.004	0.004	0.006	0.008
2003-8a	0.248	4.023	5.985	3.368	3.769	0.001	0.004	0.004	0.006	0.008
2003-8b	0.248	4.023	5.985	3.368	3.769	0.001	0.004	0.004	0.006	0.008
2004-2b	0.061	0.817	1.419	0.760	0.927	0.001	0.006	0.016	0.009	0.009
2004-3	0.227	3.691	5.536	3.115	3.490	0.001	0.006	0.007	0.009	0.007
2004-4	0.227	3.668	5.547	3.119	3.500	0.001	0.006	0.007	0.009	0.007
2004-5	0.227	3.660	5.550	3.119	3.502	0.001	0.006	0.007	0.009	0.007
2004-6	0.227	3.663	5.548	3.118	3.501	0.001	0.006	0.007	0.009	0.007
2004-7	0.228	3.709	5.527	3.110	3.481	0.001	0.006	0.007	0.009	0.007
2004-8a	0.228	3.712	5.526	3.109	3.480	0.001	0.006	0.007	0.009	0.007
2004-8b	0.228	3.712	5.526	3.109	3.480	0.001	0.006	0.007	0.009	0.007
2005-2b	0.049	0.618	1.127	0.596	0.717	0.001	0.006	0.016	0.009	0.009
2005-3	0.227	3.692	5.537	3.115	3.490	0.001	0.006	0.007	0.009	0.007
2005-4	0.227	3.671	5.546	3.118	3.499	0.001	0.006	0.007	0.009	0.007
2005-5	0.227	3.664	5.549	3.118	3.501	0.001	0.006	0.007	0.009	0.007
2005-6	0.227	3.667	5.548	3.117	3.500	0.001	0.006	0.007	0.009	0.007
2005-7	0.228	3.709	5.529	3.111	3.482	0.001	0.006	0.007	0.009	0.007
2005-8a	0.228	3.711	5.528	3.110	3.481	0.001	0.006	0.007	0.009	0.007
2005-8b	0.228	3.711	5.528	3.110	3.481	0.001	0.006	0.007	0.009	0.007
2006-2b	0.042	0.567	0.970	0.521	0.640	0.001	0.006	0.015	0.008	0.008
2006-3	0.227	3.700	5.548	3.121	3.497	0.001	0.005	0.006	0.008	0.006
2006-4	0.227	3.681	5.556	3.124	3.505	0.001	0.005	0.006	0.008	0.006
2006-5	0.227	3.675	5.559	3.124	3.507	0.001	0.005	0.006	0.008	0.006
2006-6	0.228	3.677	5.558	3.123	3.505	0.001	0.005	0.006	0.008	0.006
2006-7	0.228	3.715	5.541	3.117	3.490	0.001	0.005	0.006	0.008	0.006
2006-8a	0.228	3.718	5.540	3.116	3.488	0.001	0.005	0.006	0.008	0.006
2006-8b	0.228	3.718	5.540	3.116	3.488	0.001	0.005	0.006	0.008	0.006
2007-2b	0.041	0.569	0.948	0.513	0.636	0.001	0.006	0.015	0.008	0.008
2007-3	0.225	3.671	5.504	3.096	3.469	0.001	0.005	0.006	0.008	0.006
2007-4	0.225	3.654	5.511	3.098	3.476	0.001	0.005	0.006	0.008	0.006
2007-5	0.225	3.648	5.514	3.098	3.478	0.001	0.005	0.006	0.008	0.006
2007-6	0.226	3.650	5.512	3.098	3.476	0.001	0.005	0.006	0.008	0.006
2007-7	0.226	3.685	5.497	3.092	3.462	0.001	0.005	0.006	0.008	0.006
2007-8a	0.226	3.687	5.496	3.091	3.461	0.001	0.005	0.006	0.008	0.006
2007-8b	0.226	3.687	5.496	3.091	3.461	0.001	0.005	0.006	0.008	0.006
2008-2b	0.034	0.547	0.817	0.455	0.582	0.001	0.005	0.013	0.008	0.007
2008-3	0.182	2.962	4.439	2.496	2.744	0.001	0.005	0.005	0.008	0.006
2008-4	0.182	2.949	4.444	2.498	2.751	0.001	0.005	0.005	0.008	0.006
2008-5	0.182	2.945	4.446	2.498	2.753	0.001	0.005	0.005	0.008	0.006
2008-6	0.182	2.947	4.445	2.498	2.752	0.001	0.005	0.005	0.008	0.006
2008-7	0.182	2.971	4.434	2.494	2.739	0.001	0.005	0.005	0.008	0.006
2008-8a	0.182	2.973	4.433	2.493	2.739	0.001	0.005	0.005	0.008	0.006
2008-8b	0.182	2.973	4.433	2.493	2.739	0.001	0.005	0.005	0.008	0.006
2009-2b	0.036	0.608	0.873	0.492	0.637	0.001	0.005	0.013	0.008	0.007
2009-3	0.182	2.962	4.439	2.496	2.744	0.001	0.005	0.005	0.008	0.006

Year & Class	Gasoline NOx Decel	Gasoline NOx 0 to 25	Gasoline NOx 25 to 50	Gasoline NOx 50 +	Gasoline NOx Highway	Gasoline PM 2.5 Decel	Gasoline PM 2.5 0 to 25	Gasoline PM 2.5 25 to 50	Gasoline PM 2.5 50 +	Gasoline PM 2.5 Highway
2009-4	0.182	2.951	4.445	2.498	2.750	0.001	0.005	0.005	0.008	0.006
2009-5	0.182	2.947	4.446	2.498	2.752	0.001	0.005	0.005	0.008	0.006
2009-6	0.182	2.949	4.445	2.498	2.752	0.001	0.005	0.005	0.008	0.006
2009-7	0.182	2.971	4.435	2.494	2.740	0.001	0.005	0.005	0.008	0.006
2009-8a	0.182	2.973	4.434	2.493	2.739	0.001	0.005	0.005	0.008	0.006
2009-8b	0.182	2.973	4.434	2.493	2.739	0.001	0.005	0.005	0.008	0.006
2010-2b	0.031	0.506	0.738	0.414	0.528	0.001	0.003	0.008	0.005	0.005
2010-3	0.182	2.963	4.440	2.496	2.744	0.001	0.003	0.003	0.005	0.004
2010-4	0.182	2.953	4.445	2.498	2.750	0.001	0.003	0.003	0.005	0.004
2010-5	0.182	2.949	4.446	2.498	2.752	0.001	0.003	0.003	0.005	0.004
2010-6	0.182	2.950	4.445	2.498	2.751	0.001	0.003	0.003	0.005	0.004
2010-7	0.182	2.971	4.436	2.494	2.740	0.001	0.003	0.003	0.005	0.004
2010-8a	0.182	2.972	4.436	2.494	2.740	0.001	0.003	0.003	0.005	0.004
2010-8b	0.182	2.972	4.436	2.494	2.740	0.001	0.003	0.003	0.005	0.004
2011-2b	0.031	0.523	0.756	0.425	0.543	0.001	0.003	0.008	0.005	0.005
2011-3	0.182	2.964	4.441	2.496	2.744	0.001	0.003	0.003	0.005	0.004
2011-4	0.182	2.954	4.445	2.498	2.749	0.001	0.003	0.003	0.005	0.004
2011-5	0.182	2.951	4.446	2.498	2.751	0.001	0.003	0.003	0.005	0.004
2011-6	0.182	2.952	4.446	2.498	2.751	0.001	0.003	0.003	0.005	0.004
2011-7	0.182	2.971	4.437	2.494	2.741	0.001	0.003	0.003	0.005	0.004
2011-8a	0.182	2.972	4.437	2.494	2.740	0.001	0.003	0.003	0.005	0.004
2011-8b	0.182	2.972	4.437	2.494	2.740	0.001	0.003	0.003	0.005	0.004
2012-2b	0.033	0.559	0.793	0.448	0.577	0.001	0.003	0.008	0.005	0.005
2012-3	0.182	2.965	4.441	2.496	2.744	0.001	0.003	0.003	0.005	0.004
2012-4	0.182	2.956	4.445	2.498	2.749	0.001	0.003	0.003	0.005	0.004
2012-5	0.182	2.953	4.446	2.498	2.751	0.001	0.003	0.003	0.005	0.004
2012-6	0.182	2.954	4.446	2.497	2.750	0.001	0.003	0.003	0.005	0.004
2012-7	0.182	2.971	4.438	2.495	2.741	0.001	0.003	0.003	0.005	0.004
2012-8a	0.182	2.972	4.438	2.494	2.741	0.001	0.003	0.003	0.005	0.004
2012-8b	0.182	2.972	4.438	2.494	2.741	0.001	0.003	0.003	0.005	0.004
2013-2b	0.034	0.586	0.820	0.466	0.601	0.001	0.003	0.008	0.005	0.005
2013-3	0.182	2.965	4.442	2.496	2.744	0.001	0.003	0.003	0.005	0.004
2013-4	0.182	2.957	4.446	2.498	2.749	0.001	0.003	0.003	0.005	0.004
2013-5	0.182	2.954	4.447	2.498	2.750	0.001	0.003	0.003	0.005	0.004
2013-6	0.182	2.955	4.446	2.497	2.750	0.001	0.003	0.003	0.005	0.004
2013-7	0.182	2.971	4.439	2.495	2.742	0.001	0.003	0.003	0.005	0.004
2013-8a	0.182	2.972	4.439	2.494	2.741	0.001	0.003	0.003	0.005	0.004
2013-8b	0.182	2.972	4.439	2.494	2.741	0.001	0.003	0.003	0.005	0.004
2014-2b	0.034	0.586	0.820	0.466	0.601	0.001	0.003	0.008	0.005	0.005
2014-3	0.182	2.965	4.442	2.496	2.744	0.001	0.003	0.003	0.005	0.004
2014-4	0.182	2.957	4.446	2.498	2.749	0.001	0.003	0.003	0.005	0.004
2014-5	0.182	2.954	4.447	2.498	2.750	0.001	0.003	0.003	0.005	0.004
2014-6	0.182	2.955	4.446	2.497	2.750	0.001	0.003	0.003	0.005	0.004
2014-7	0.182	2.971	4.439	2.495	2.742	0.001	0.003	0.003	0.005	0.004
2014-8a	0.182	2.972	4.439	2.494	2.741	0.001	0.003	0.003	0.005	0.004

Year & Class	Gasoline NOx Decel	Gasoline NOx 0 to 25	Gasoline NOx 25 to 50	Gasoline NOx 50 +	Gasoline NOx Highway	Gasoline PM 2.5 Decel	Gasoline PM 2.5 0 to 25	Gasoline PM 2.5 25 to 50	Gasoline PM 2.5 50 +	Gasoline PM 2.5 Highway
2014-8b	0.182	2.972	4.439	2.494	2.741	0.001	0.003	0.003	0.005	0.004

Note – highlighted cells are set equal to the row above (MOVES does not provide consistent outputs for Class 8b gasoline vehicles; therefore 8bs are set equal to 8as).

Year & Class	E10 NOx Decel	E10 NOx 0 to 25	E10 NOx 25 to 50	E10 NOx 50 +	E10 NOx Highway	E10 PM 2.5 Decel	E10 PM 2.5 0 to 25	E10 PM 2.5 25 to 50	E10 PM 2.5 50 +	E10 PM 2.5 Highway
1987-2b	0.372	4.057	8.618	4.391	4.956	0.010	0.045	0.115	0.067	0.077
1987-3	0.591	9.420	14.415	8.052	9.270	0.010	0.044	0.052	0.073	0.060
1987-4	0.586	9.314	14.439	8.076	9.287	0.010	0.045	0.053	0.074	0.061
1987-5	0.618	9.979	14.042	7.821	8.902	0.009	0.043	0.050	0.072	0.057
1987-6	0.601	9.789	14.177	7.911	8.976	0.009	0.044	0.052	0.073	0.058
1987-7	0.612	9.912	14.090	7.853	8.927	0.009	0.043	0.051	0.072	0.057
1987-8a	0.613	11.912	15.798	8.276	10.679	0.009	0.047	0.069	0.073	0.063
1987-8b	0.613	11.912	15.798	8.276	10.679	0.009	0.047	0.069	0.073	0.063
1988-2b	0.396	4.400	8.832	4.530	5.207	0.010	0.043	0.103	0.063	0.062
1988-3	0.591	9.526	14.471	8.065	9.362	0.011	0.051	0.061	0.084	0.061
1988-4	0.586	9.312	14.551	8.120	9.454	0.011	0.051	0.061	0.085	0.062
1988-5	0.604	10.415	14.629	8.019	9.586	0.011	0.051	0.063	0.083	0.061
1988-6	0.610	10.417	14.526	7.973	9.485	0.011	0.051	0.063	0.083	0.060
1988-7	0.629	10.229	14.036	7.786	9.004	0.011	0.050	0.059	0.082	0.058
1988-8a	0.636	12.934	16.341	8.345	11.029	0.011	0.052	0.076	0.077	0.062
1988-8b	0.636	12.934	16.341	8.345	11.029	0.011	0.052	0.076	0.077	0.062
1989-2b	0.396	4.655	9.008	4.662	5.402	0.010	0.043	0.102	0.064	0.062
1989-3	0.589	9.351	14.377	8.051	9.240	0.011	0.051	0.060	0.085	0.061
1989-4	0.587	9.218	14.476	8.101	9.357	0.011	0.051	0.060	0.085	0.062
1989-5	0.619	9.932	13.959	7.807	8.875	0.011	0.050	0.059	0.083	0.059
1989-6	0.605	9.768	14.072	7.883	8.936	0.011	0.051	0.059	0.084	0.059
1989-7	0.615	9.887	13.991	7.828	8.892	0.011	0.050	0.059	0.083	0.059
1989-8a	0.824	13.491	9.963	2.112	8.204	0.011	0.036	0.026	0.015	0.049
1989-8b	0.824	13.491	9.963	2.112	8.204	0.011	0.036	0.026	0.015	0.049
1990-2b	0.403	4.712	8.905	4.621	4.928	0.007	0.029	0.072	0.045	0.061
1990-3	0.417	6.635	10.133	5.677	5.888	0.004	0.019	0.022	0.031	0.040
1990-4	0.415	6.534	10.212	5.717	5.984	0.004	0.019	0.022	0.031	0.041
1990-5	0.428	6.893	9.952	5.577	5.716	0.004	0.018	0.022	0.031	0.038
1990-6	0.431	6.927	9.934	5.563	5.711	0.004	0.018	0.022	0.030	0.038
1990-7	0.453	7.183	9.795	5.458	5.675	0.004	0.018	0.021	0.030	0.037
1990-8a	0.608	9.950	7.348	1.557	5.478	0.004	0.012	0.008	0.005	0.031
1990-8b	0.608	9.950	7.348	1.557	5.478	0.004	0.012	0.008	0.005	0.031
1991-2b	0.420	4.115	8.652	4.381	4.665	0.007	0.034	0.078	0.050	0.036
1991-3	0.416	6.640	10.179	5.691	5.914	0.009	0.043	0.051	0.071	0.032
1991-4	0.414	6.590	10.203	5.707	5.945	0.009	0.043	0.051	0.071	0.032
1991-5	0.420	6.764	10.119	5.653	5.836	0.009	0.043	0.051	0.071	0.032
1991-6	0.424	6.908	10.049	5.607	5.747	0.009	0.043	0.051	0.071	0.031

Year & Class	E10 NOx Decel	E10 NOx 0 to 25	E10 NOx 25 to 50	E10 NOx 50 +	E10 NOx Highway	E10 PM 2.5 Decel	E10 PM 2.5 0 to 25	E10 PM 2.5 25 to 50	E10 PM 2.5 50 +	E10 PM 2.5 Highway
1991-7	0.421	6.883	10.062	5.617	5.752	0.009	0.043	0.051	0.071	0.032
1991-8a	0.453	7.233	9.866	5.472	5.695	0.009	0.042	0.049	0.069	0.031
1991-8b	0.453	7.233	9.866	5.472	5.695	0.009	0.042	0.049	0.069	0.031
1992-2b	0.404	4.100	8.710	4.425	4.685	0.007	0.034	0.078	0.050	0.037
1992-3	0.414	6.560	10.214	5.714	5.964	0.009	0.043	0.051	0.071	0.032
1992-4	0.414	6.526	10.231	5.724	5.995	0.009	0.043	0.051	0.071	0.032
1992-5	0.413	6.636	10.176	5.692	5.894	0.009	0.043	0.051	0.071	0.032
1992-6	0.414	6.797	10.095	5.644	5.763	0.009	0.043	0.051	0.072	0.032
1992-7	0.413	6.787	10.100	5.648	5.765	0.009	0.043	0.051	0.072	0.032
1992-8a	0.415	6.812	10.087	5.639	5.760	0.009	0.043	0.051	0.071	0.032
1992-8b	0.415	6.812	10.087	5.639	5.760	0.009	0.043	0.051	0.071	0.032
1993-2b	0.404	4.500	8.832	4.553	4.845	0.008	0.035	0.075	0.052	0.036
1993-3	0.416	6.610	10.145	5.685	5.903	0.009	0.043	0.051	0.071	0.032
1993-4	0.414	6.548	10.195	5.710	5.961	0.009	0.043	0.051	0.071	0.032
1993-5	0.428	6.742	10.080	5.638	5.874	0.009	0.042	0.050	0.070	0.032
1993-6	0.426	6.868	9.954	5.582	5.717	0.009	0.043	0.050	0.071	0.031
1993-7	0.444	7.071	9.846	5.502	5.687	0.009	0.042	0.049	0.070	0.031
1993-8a	0.452	7.168	9.793	5.460	5.675	0.009	0.042	0.049	0.069	0.031
1993-8b	0.452	7.168	9.793	5.460	5.675	0.009	0.042	0.049	0.069	0.031
1994-2b	0.386	3.834	7.797	3.980	4.278	0.005	0.022	0.049	0.033	0.045
1994-3	0.407	6.504	9.946	5.576	5.771	0.008	0.036	0.042	0.059	0.063
1994-4	0.406	6.428	10.011	5.607	5.853	0.008	0.036	0.042	0.059	0.064
1994-5	0.411	6.473	9.991	5.592	5.845	0.008	0.035	0.042	0.059	0.063
1994-6	0.411	6.671	9.817	5.510	5.626	0.008	0.035	0.041	0.058	0.063
1994-7	0.432	6.908	9.692	5.418	5.590	0.007	0.033	0.040	0.057	0.060
1994-8a	0.597	9.770	7.215	1.529	5.379	0.004	0.012	0.008	0.005	0.045
1994-8b	0.597	9.770	7.215	1.529	5.379	0.004	0.012	0.008	0.005	0.045
1995-2b	0.383	3.867	7.822	3.996	4.299	0.004	0.016	0.038	0.024	0.028
1995-3	0.407	6.542	9.952	5.572	5.757	0.003	0.014	0.017	0.024	0.022
1995-4	0.407	6.460	10.006	5.600	5.838	0.003	0.014	0.017	0.024	0.022
1995-5	0.409	6.503	9.981	5.586	5.810	0.003	0.014	0.017	0.024	0.022
1995-6	0.422	6.812	9.796	5.475	5.621	0.003	0.014	0.017	0.024	0.021
1995-7	0.418	6.778	9.815	5.488	5.626	0.003	0.014	0.017	0.024	0.021
1995-8a	0.597	9.770	7.215	1.529	5.379	0.003	0.008	0.006	0.003	0.017
1995-8b	0.597	9.770	7.215	1.529	5.379	0.003	0.008	0.006	0.003	0.017
1996-2b	0.232	2.476	4.713	2.445	2.644	0.004	0.016	0.040	0.024	0.022
1996-3	0.406	6.496	9.976	5.587	5.793	0.003	0.013	0.015	0.021	0.017
1996-4	0.406	6.430	10.021	5.610	5.857	0.003	0.013	0.015	0.021	0.017
1996-5	0.408	6.442	10.016	5.606	5.855	0.003	0.013	0.015	0.021	0.017
1996-6	0.407	6.656	9.867	5.530	5.643	0.003	0.013	0.015	0.021	0.016
1996-7	0.416	6.742	9.822	5.498	5.628	0.003	0.013	0.015	0.021	0.016
1996-8a	0.597	9.770	7.215	1.529	5.379	0.003	0.009	0.007	0.004	0.014
1996-8b	0.597	9.770	7.215	1.529	5.379	0.003	0.009	0.007	0.004	0.014
1997-2b	0.196	2.191	4.348	2.255	2.453	0.003	0.015	0.038	0.022	0.026
1997-3	0.406	6.497	9.911	5.567	5.744	0.003	0.013	0.016	0.022	0.023

Year & Class	E10 NOx Decel	E10 NOx 0 to 25	E10 NOx 25 to 50	E10 NOx 50 +	E10 NOx Highway	E10 PM 2.5 Decel	E10 PM 2.5 0 to 25	E10 PM 2.5 25 to 50	E10 PM 2.5 50 +	E10 PM 2.5 Highway
1997-4	0.406	6.400	10.025	5.615	5.877	0.003	0.013	0.016	0.022	0.023
1997-5	0.407	6.432	9.989	5.600	5.836	0.003	0.013	0.016	0.022	0.023
1997-6	0.409	6.616	9.789	5.511	5.617	0.003	0.013	0.016	0.022	0.023
1997-7	0.414	6.679	9.758	5.488	5.607	0.003	0.013	0.015	0.022	0.023
1997-8a	0.597	9.770	7.215	1.529	5.379	0.003	0.008	0.006	0.003	0.018
1997-8b	0.597	9.770	7.215	1.529	5.379	0.003	0.008	0.006	0.003	0.018
1998-2b	0.184	1.951	4.099	2.100	2.291	0.003	0.013	0.034	0.020	0.022
1998-3	0.268	4.315	6.539	3.677	4.127	0.002	0.011	0.013	0.018	0.016
1998-4	0.267	4.223	6.585	3.690	4.167	0.002	0.011	0.013	0.018	0.016
1998-5	0.269	4.315	6.539	3.677	4.127	0.002	0.011	0.013	0.018	0.016
1998-6	0.270	4.383	6.505	3.664	4.097	0.002	0.011	0.013	0.018	0.016
1998-7	0.273	4.414	6.489	3.652	4.081	0.002	0.011	0.013	0.018	0.016
1998-8a	0.393	6.432	4.750	1.007	3.585	0.002	0.007	0.005	0.003	0.013
1998-8b	0.393	6.432	4.750	1.007	3.585	0.002	0.007	0.005	0.003	0.013
1999-2b	0.178	1.831	3.793	1.946	2.134	0.002	0.008	0.022	0.012	0.016
1999-3	0.268	4.344	6.526	3.675	4.117	0.001	0.004	0.004	0.006	0.010
1999-4	0.267	4.305	6.545	3.680	4.133	0.001	0.004	0.004	0.006	0.010
1999-5	0.268	4.294	6.551	3.681	4.137	0.001	0.004	0.004	0.006	0.010
1999-6	0.268	4.298	6.549	3.679	4.135	0.001	0.004	0.004	0.006	0.010
1999-7	0.270	4.377	6.510	3.666	4.101	0.001	0.004	0.004	0.006	0.010
1999-8a	0.270	4.382	6.507	3.664	4.098	0.001	0.004	0.004	0.006	0.010
1999-8b	0.270	4.382	6.507	3.664	4.098	0.001	0.004	0.004	0.006	0.010
2000-2b	0.172	1.775	3.736	1.912	2.086	0.002	0.008	0.021	0.012	0.016
2000-3	0.268	4.346	6.527	3.674	4.116	0.001	0.003	0.003	0.005	0.009
2000-4	0.267	4.309	6.544	3.680	4.132	0.001	0.003	0.003	0.005	0.009
2000-5	0.268	4.298	6.549	3.680	4.136	0.001	0.003	0.003	0.005	0.009
2000-6	0.268	4.302	6.547	3.679	4.134	0.001	0.003	0.003	0.005	0.009
2000-7	0.270	4.377	6.511	3.666	4.102	0.001	0.003	0.003	0.005	0.009
2000-8a	0.270	4.381	6.509	3.665	4.099	0.001	0.003	0.003	0.005	0.009
2000-8b	0.270	4.381	6.509	3.665	4.099	0.001	0.003	0.003	0.005	0.009
2001-2b	0.118	1.290	2.575	1.333	1.576	0.002	0.008	0.020	0.012	0.014
2001-3	0.268	4.357	6.541	3.682	4.125	0.001	0.005	0.006	0.008	0.014
2001-4	0.268	4.323	6.557	3.687	4.139	0.001	0.005	0.006	0.008	0.014
2001-5	0.268	4.312	6.562	3.687	4.143	0.001	0.005	0.006	0.008	0.014
2001-6	0.269	4.316	6.560	3.686	4.141	0.001	0.005	0.006	0.008	0.014
2001-7	0.270	4.385	6.527	3.675	4.111	0.001	0.005	0.006	0.008	0.014
2001-8a	0.270	4.390	6.525	3.673	4.109	0.001	0.005	0.006	0.008	0.014
2001-8b	0.270	4.390	6.525	3.673	4.109	0.001	0.005	0.006	0.008	0.014
2002-2b	0.109	1.207	2.449	1.265	1.492	0.002	0.007	0.019	0.011	0.011
2002-3	0.268	4.359	6.541	3.682	4.125	0.001	0.006	0.007	0.009	0.007
2002-4	0.268	4.327	6.556	3.687	4.138	0.001	0.006	0.007	0.009	0.007
2002-5	0.268	4.317	6.561	3.687	4.142	0.001	0.006	0.007	0.009	0.007
2002-6	0.269	4.321	6.559	3.685	4.139	0.001	0.006	0.007	0.009	0.007
2002-7	0.270	4.385	6.529	3.675	4.112	0.001	0.006	0.007	0.009	0.007
2002-8a	0.270	4.389	6.527	3.674	4.110	0.001	0.006	0.007	0.009	0.007

Year & Class	E10 NOx Decel	E10 NOx 0 to 25	E10 NOx 25 to 50	E10 NOx 50 +	E10 NOx Highway	E10 PM 2.5 Decel	E10 PM 2.5 0 to 25	E10 PM 2.5 25 to 50	E10 PM 2.5 50 +	E10 PM 2.5 Highway
2002-8b	0.270	4.389	6.527	3.674	4.110	0.001	0.006	0.007	0.009	0.007
2003-2b	0.115	1.277	2.584	1.335	1.572	0.002	0.007	0.019	0.011	0.012
2003-3	0.268	4.360	6.542	3.682	4.125	0.001	0.004	0.004	0.006	0.008
2003-4	0.268	4.330	6.556	3.686	4.137	0.001	0.004	0.004	0.006	0.008
2003-5	0.268	4.321	6.560	3.686	4.140	0.001	0.004	0.004	0.006	0.008
2003-6	0.269	4.325	6.558	3.685	4.138	0.001	0.004	0.004	0.006	0.008
2003-7	0.270	4.384	6.530	3.675	4.113	0.001	0.004	0.004	0.006	0.008
2003-8a	0.270	4.388	6.528	3.674	4.111	0.001	0.004	0.004	0.006	0.008
2003-8b	0.270	4.388	6.528	3.674	4.111	0.001	0.004	0.004	0.006	0.008
2004-2b	0.062	0.821	1.426	0.763	0.931	0.001	0.006	0.016	0.010	0.009
2004-3	0.228	3.708	5.563	3.130	3.507	0.001	0.006	0.007	0.009	0.007
2004-4	0.228	3.685	5.573	3.134	3.517	0.001	0.006	0.007	0.009	0.007
2004-5	0.228	3.678	5.576	3.134	3.519	0.001	0.006	0.007	0.009	0.007
2004-6	0.228	3.681	5.575	3.133	3.517	0.001	0.006	0.007	0.009	0.007
2004-7	0.229	3.727	5.554	3.125	3.498	0.001	0.006	0.007	0.009	0.007
2004-8a	0.229	3.730	5.552	3.124	3.497	0.001	0.006	0.007	0.009	0.007
2004-8b	0.229	3.730	5.552	3.124	3.497	0.001	0.006	0.007	0.009	0.007
2005-2b	0.050	0.621	1.133	0.599	0.721	0.001	0.006	0.016	0.010	0.009
2005-3	0.228	3.710	5.564	3.130	3.507	0.001	0.006	0.007	0.009	0.007
2005-4	0.228	3.689	5.573	3.133	3.516	0.001	0.006	0.007	0.009	0.007
2005-5	0.228	3.682	5.576	3.134	3.518	0.001	0.006	0.007	0.009	0.007
2005-6	0.228	3.684	5.575	3.132	3.517	0.001	0.006	0.007	0.009	0.007
2005-7	0.229	3.727	5.556	3.126	3.499	0.001	0.006	0.007	0.009	0.007
2005-8a	0.229	3.729	5.554	3.125	3.498	0.001	0.006	0.007	0.009	0.007
2005-8b	0.229	3.729	5.554	3.125	3.498	0.001	0.006	0.007	0.009	0.007
2006-2b	0.042	0.570	0.974	0.524	0.643	0.001	0.006	0.015	0.009	0.008
2006-3	0.228	3.718	5.575	3.136	3.514	0.001	0.005	0.006	0.008	0.006
2006-4	0.228	3.699	5.583	3.139	3.522	0.001	0.005	0.006	0.008	0.006
2006-5	0.228	3.692	5.586	3.139	3.524	0.001	0.005	0.006	0.008	0.006
2006-6	0.229	3.695	5.584	3.138	3.522	0.001	0.005	0.006	0.008	0.006
2006-7	0.229	3.733	5.568	3.132	3.507	0.001	0.005	0.006	0.008	0.006
2006-8a	0.230	3.736	5.566	3.131	3.505	0.001	0.005	0.006	0.008	0.006
2006-8b	0.230	3.736	5.566	3.131	3.505	0.001	0.005	0.006	0.008	0.006
2007-2b	0.041	0.572	0.953	0.515	0.639	0.001	0.006	0.015	0.009	0.008
2007-3	0.226	3.689	5.530	3.111	3.485	0.001	0.005	0.006	0.008	0.006
2007-4	0.226	3.672	5.538	3.113	3.492	0.001	0.005	0.006	0.008	0.006
2007-5	0.227	3.666	5.540	3.113	3.494	0.001	0.005	0.006	0.008	0.006
2007-6	0.227	3.668	5.539	3.112	3.493	0.001	0.005	0.006	0.008	0.006
2007-7	0.227	3.703	5.524	3.107	3.479	0.001	0.005	0.006	0.008	0.006
2007-8a	0.228	3.705	5.523	3.106	3.478	0.001	0.005	0.006	0.008	0.006
2007-8b	0.228	3.705	5.523	3.106	3.478	0.001	0.005	0.006	0.008	0.006
2008-2b	0.034	0.549	0.821	0.457	0.584	0.001	0.005	0.013	0.008	0.007
2008-3	0.183	2.976	4.460	2.508	2.757	0.001	0.005	0.005	0.008	0.006
2008-4	0.182	2.963	4.466	2.510	2.764	0.001	0.005	0.005	0.008	0.006
2008-5	0.183	2.959	4.468	2.510	2.766	0.001	0.005	0.005	0.008	0.006

Year & Class	E10 NOx Decel	E10 NOx 0 to 25	E10 NOx 25 to 50	E10 NOx 50 +	E10 NOx Highway	E10 PM 2.5 Decel	E10 PM 2.5 0 to 25	E10 PM 2.5 25 to 50	E10 PM 2.5 50 +	E10 PM 2.5 Highway
2008-6	0.183	2.961	4.467	2.510	2.766	0.001	0.005	0.005	0.008	0.006
2008-7	0.183	2.985	4.455	2.506	2.753	0.001	0.005	0.005	0.008	0.006
2008-8a	0.183	2.987	4.455	2.505	2.752	0.001	0.005	0.005	0.008	0.006
2008-8b	0.183	2.987	4.455	2.505	2.752	0.001	0.005	0.005	0.008	0.006
2009-2b	0.036	0.611	0.878	0.495	0.640	0.001	0.005	0.013	0.008	0.007
2009-3	0.183	2.977	4.461	2.508	2.757	0.001	0.005	0.005	0.008	0.006
2009-4	0.182	2.965	4.466	2.510	2.763	0.001	0.005	0.005	0.008	0.006
2009-5	0.183	2.961	4.468	2.510	2.766	0.001	0.005	0.005	0.008	0.006
2009-6	0.183	2.963	4.467	2.510	2.765	0.001	0.005	0.005	0.008	0.006
2009-7	0.183	2.985	4.457	2.506	2.753	0.001	0.005	0.005	0.008	0.006
2009-8a	0.183	2.987	4.456	2.505	2.753	0.001	0.005	0.005	0.008	0.006
2009-8b	0.183	2.987	4.456	2.505	2.753	0.001	0.005	0.005	0.008	0.006
2010-2b	0.031	0.509	0.742	0.416	0.530	0.001	0.003	0.008	0.005	0.005
2010-3	0.183	2.977	4.462	2.508	2.757	0.001	0.003	0.004	0.005	0.004
2010-4	0.182	2.967	4.466	2.510	2.763	0.001	0.003	0.004	0.005	0.004
2010-5	0.183	2.963	4.468	2.510	2.765	0.001	0.003	0.004	0.005	0.004
2010-6	0.183	2.965	4.467	2.510	2.764	0.001	0.003	0.004	0.005	0.004
2010-7	0.183	2.985	4.458	2.506	2.754	0.001	0.003	0.004	0.005	0.004
2010-8a	0.183	2.987	4.457	2.506	2.753	0.001	0.003	0.004	0.005	0.004
2010-8b	0.183	2.987	4.457	2.506	2.753	0.001	0.003	0.004	0.005	0.004
2011-2b	0.031	0.526	0.760	0.427	0.546	0.001	0.003	0.008	0.005	0.005
2011-3	0.183	2.978	4.462	2.508	2.757	0.001	0.003	0.004	0.005	0.004
2011-4	0.182	2.969	4.466	2.510	2.763	0.001	0.003	0.004	0.005	0.004
2011-5	0.183	2.965	4.468	2.510	2.764	0.001	0.003	0.004	0.005	0.004
2011-6	0.183	2.966	4.467	2.510	2.764	0.001	0.003	0.004	0.005	0.004
2011-7	0.183	2.985	4.459	2.506	2.754	0.001	0.003	0.004	0.005	0.004
2011-8a	0.183	2.987	4.458	2.506	2.754	0.001	0.003	0.004	0.005	0.004
2011-8b	0.183	2.987	4.458	2.506	2.754	0.001	0.003	0.004	0.005	0.004
2012-2b	0.033	0.562	0.797	0.450	0.579	0.001	0.003	0.008	0.005	0.005
2012-3	0.183	2.979	4.463	2.508	2.758	0.001	0.003	0.004	0.005	0.004
2012-4	0.182	2.970	4.467	2.510	2.762	0.001	0.003	0.004	0.005	0.004
2012-5	0.183	2.967	4.468	2.510	2.764	0.001	0.003	0.004	0.005	0.004
2012-6	0.183	2.968	4.467	2.509	2.764	0.001	0.003	0.004	0.005	0.004
2012-7	0.183	2.985	4.460	2.507	2.755	0.001	0.003	0.004	0.005	0.004
2012-8a	0.183	2.987	4.459	2.506	2.754	0.001	0.003	0.004	0.005	0.004
2012-8b	0.183	2.987	4.459	2.506	2.754	0.001	0.003	0.004	0.005	0.004
2013-2b	0.034	0.588	0.824	0.468	0.604	0.001	0.003	0.008	0.005	0.005
2013-3	0.182	2.980	4.464	2.509	2.758	0.001	0.003	0.004	0.005	0.004
2013-4	0.182	2.971	4.467	2.510	2.762	0.001	0.003	0.004	0.005	0.004
2013-5	0.183	2.968	4.468	2.510	2.764	0.001	0.003	0.004	0.005	0.004
2013-6	0.183	2.969	4.468	2.509	2.763	0.001	0.003	0.004	0.005	0.004
2013-7	0.183	2.986	4.461	2.507	2.755	0.001	0.003	0.004	0.005	0.004
2013-8a	0.183	2.987	4.460	2.506	2.754	0.001	0.003	0.004	0.005	0.004
2013-8b	0.183	2.987	4.460	2.506	2.754	0.001	0.003	0.004	0.005	0.004
2014-2b	0.034	0.588	0.824	0.468	0.604	0.001	0.003	0.008	0.005	0.005

Year & Class	E10 NOx Decel	E10 NOx 0 to 25	E10 NOx 25 to 50	E10 NOx 50 +	E10 NOx Highway	E10 PM 2.5 Decel	E10 PM 2.5 0 to 25	E10 PM 2.5 25 to 50	E10 PM 2.5 50 +	E10 PM 2.5 Highway
2014-3	0.182	2.980	4.464	2.509	2.758	0.001	0.003	0.004	0.005	0.004
2014-4	0.182	2.971	4.467	2.510	2.762	0.001	0.003	0.004	0.005	0.004
2014-5	0.183	2.968	4.468	2.510	2.764	0.001	0.003	0.004	0.005	0.004
2014-6	0.183	2.969	4.468	2.509	2.763	0.001	0.003	0.004	0.005	0.004
2014-7	0.183	2.986	4.461	2.507	2.755	0.001	0.003	0.004	0.005	0.004
2014-8a	0.183	2.987	4.460	2.506	2.754	0.001	0.003	0.004	0.005	0.004
2014-8b	0.183	2.987	4.460	2.506	2.754	0.001	0.003	0.004	0.005	0.004

Note – highlighted cells are set equal to the row above (MOVES does not provide consistent outputs for Class 8b gasoline vehicles; therefore 8bs are set equal to 8as).

Appendix B – NOx and PM Idle Factors – g/hr
(MOVES2010b, 2014 Calendar Year, ULSD)

Short-duration Idle factors (g/hr) from MOVES2010b				*Source: David Brz, OTAQ, 11-1-13*		
average of Jan and July factors						
			Truck Class			
Month	**Pollutant**	**Model Year**	**HDGV**	**LHDDV**	**MHDDV**	**HHDDV**
Annual Av	NO_X	1987	15.38	142.96	192.00	192.01
Annual Av	NO_X	1988	15.41	131.91	192.01	192.01
Annual Av	NO_X	1989	15.45	146.29	192.01	192.01
Annual Av	NO_X	1990	7.79	178.06	148.28	148.28
Annual Av	NO_X	1991	7.81	143.79	139.42	139.42
Annual Av	NO_X	1992	7.81	140.09	139.42	139.42
Annual Av	NO_X	1993	7.79	151.56	139.42	139.42
Annual Av	NO_X	1994	7.79	151.33	139.42	139.42
Annual Av	NO_X	1995	7.84	148.06	139.42	139.42
Annual Av	NO_X	1996	7.61	147.36	139.42	139.42
Annual Av	NO_X	1997	7.37	129.61	139.42	139.42
Annual Av	NO_X	1998	14.86	129.00	117.07	117.07
Annual Av	NO_X	1999	14.72	121.78	119.15	144.96
Annual Av	NO_X	2000	14.43	119.90	118.96	144.68
Annual Av	NO_X	2001	14.25	107.30	110.87	146.87
Annual Av	NO_X	2002	14.10	117.06	116.25	144.26
Annual Av	NO_X	2003	14.28	74.26	49.35	54.88
Annual Av	NO_X	2004	12.65	74.26	49.16	54.81
Annual Av	NO_X	2005	12.29	74.26	48.94	54.69
Annual Av	NO_X	2006	11.98	54.11	48.94	54.71
Annual Av	NO_X	2007	12.01	25.14	24.45	27.35
Annual Av	NO_X	2008	12.17	25.15	24.48	27.38
Annual Av	NO_X	2009	6.63	25.15	24.49	27.38
Annual Av	NO_X	2010	6.68	9.97	8.28	9.62
Annual Av	NO_X	2011	6.69	6.48	5.42	6.43
Annual Av	NO_X	2012	6.93	6.48	5.42	6.42
Annual Av	NO_X	2013	7.06	6.48	5.29	6.19
Annual Av	NO_X	2014	6.87	6.48	5.29	6.19
Annual Av	Total PM_{10}	1987	0.33	4.38	4.34	4.34
Annual Av	Total PM_{10}	1988	1.03	4.41	4.34	4.34
Annual Av	Total PM_{10}	1989	1.02	4.39	4.34	4.34
Annual Av	Total PM_{10}	1990	0.32	4.37	4.34	4.34
Annual Av	Total PM_{10}	1991	0.36	4.11	4.34	4.34
Annual Av	Total PM_{10}	1992	0.36	3.96	4.34	4.34
Annual Av	Total PM_{10}	1993	0.36	4.19	4.34	4.34
Annual Av	Total PM_{10}	1994	0.12	7.29	7.12	6.87
Annual Av	Total PM_{10}	1995	0.11	6.67	7.08	6.81
Annual Av	Total PM_{10}	1996	0.24	6.58	7.16	6.83
Annual Av	Total PM_{10}	1997	0.26	5.80	7.21	6.78
Annual Av	Total PM_{10}	1998	0.15	6.58	6.82	6.51
Annual Av	Total PM_{10}	1999	0.07	6.23	6.82	6.48
Annual Av	Total PM_{10}	2000	0.03	6.15	6.82	6.48
Annual Av	Total PM_{10}	2001	0.02	5.55	6.93	6.45

Short-duration Idle factors (g/hr) from MOVES2010b				Source: David Brz, OTAQ, 11-1-13		
average of Jan and July factors						
			Truck Class			
Month	**Pollutant**	**Model Year**	**HDGV**	**LHDDV**	**MHDDV**	**HHDDV**
Annual Av	Total PM_{10}	2002	0.10	5.97	6.86	6.49
Annual Av	Total PM_{10}	2003	0.06	5.14	6.20	5.86
Annual Av	Total PM_{10}	2004	0.13	4.74	6.21	5.86
Annual Av	Total PM_{10}	2005	0.11	4.74	6.23	5.87
Annual Av	Total PM_{10}	2006	0.11	4.72	6.23	5.87
Annual Av	Total PM_{10}	2007	0.10	0.36	0.32	0.32
Annual Av	Total PM_{10}	2008	0.10	0.36	0.32	0.32
Annual Av	Total PM_{10}	2009	0.09	0.35	0.30	0.31
Annual Av	Total PM_{10}	2010	0.09	0.34	0.28	0.30
Annual Av	Total PM_{10}	2011	0.06	0.18	0.18	0.19
Annual Av	Total PM_{10}	2012	0.06	0.18	0.18	0.19
Annual Av	Total PM_{10}	2013	0.06	0.18	0.17	0.18
Annual Av	Total PM_{10}	2014	0.06	0.18	0.17	0.18
Truck Class Definitions						
HDGV	gasoline trucks - all classes					
LHDDV	diesel classes 2b - 5					
MHDDV	diesel classes 6 and 7					
HHDDV	diesel classes 8a and 8b					

Model Year	Long-duration Idle NOx g/hr	Long-duration Idle PM2.5 g/hr
1987	126.64	8.71
1988	126.15	7.77
1989	124.40	7.74
1990	115.16	7.61
1991	249.51	6.95
1992	249.90	6.96
1993	238.64	6.83
1994	251.65	3.92
1995	251.73	3.92
1996	247.95	3.97
1997	252.72	3.90
1998	250.60	4.18
1999	255.27	4.19
2000	257.83	4.19
2001	254.96	4.19
2002	253.88	4.18
2003	253.88	4.18
2004	253.88	4.18

Model Year	Long-duration Idle NOx g/hr	Long-duration Idle PM2.5 g/hr
2005	253.88	4.18
2006	253.88	4.18
2007	224.80	0.42
2008	224.69	0.36
2009	224.69	0.36
2010	224.69	0.36
2011	224.69	0.36
2012	224.69	0.36
2013	224.69	0.36
2014	224.69	0.36

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

From Argonne GREET Model Version 1 2011.

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

1. Electric Generation Mix (From Annual Energy Outlook 2010)

	U.S. Mix
Residual oil	1.0%
Natural gas	22.9%
Coal	46.4%
Nuclear power	20.3%
Biomass	0.2%
Others	9.2%

Biomass Type assumed = 100% forest residue
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: Woody	Biomass-Fired: Herbaceous	Biomass-Fired: Forest Residue	TOTAL based on US Mix
NOx	0.833	0.578	1.058	1.169	1.169	1.169	0.634
PM10	0.157	0.023	0.100	0.135	0.135	0.135	0.054
PM2.5	0.118	0.023	0.050	0.067	0.067	0.067	0.030
CO2	834	505	1,083	1,086	1,016	1,379	627
CO2 in burnt biomass from atmosphere				-1,086	-1,016	-1,379	

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
NOx	0.690
PM10	0.058
PM2.5	0.033
CO2	682

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
4	Conventional Van	Uhaul 14' Truck		Ford		733	Cu. Ft	6,190	14,050		http://www.uhaul.com/Reservations/EquipmentDetail.aspx?model=EL
4	Conventiona	Uhaul 17'		Ford		865	Cu. Ft	5,930	14,050		http://www.uhaul.com/Reservations/Eq

Class	Application	Body Type	VIUS Category	Manuf	Model	Cargo Space (cubic feet)	Unit	Max Payload	GVW	Notes or Comments	URL
	l Van	Truck									uipmentDetail.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 @ 120z cans	Cu. Ft/cases cans	11,601	21,150		http://www.hackneybeverage.com/bodycad5.htm
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

Class	Application	Body Type	VIUS Category	Manuf	Model	Cargo Space (cubic feet)	Unit	Max Payload	GVW	Notes or Comments	URL
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 Refrigerated	reefer	Supreme	28'	1,774	Cu. Ft				http://www.silvercrowncoach.com/supreme.php?page=product&body=refrigerated&product=21&section=specs
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	http://www.truckpaper.com/listingsdetail/detail.aspx?OHID=2379362

Class	Application	Body Type	VIUS Category	Manuf	Model	Cargo Space (cubic feet)	Unit	Max Payload	GVW	Notes or Comments	URL
										lbs (each add'l axle approx 12,000 lbs)	

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[42]. 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*[43] 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[44]. 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 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

[42] 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.
[43] FordF150.net. *F-250/F-350/F-450/F-550 Specifications.* Retrieved from http://www.fordf150.net/specs/05sd_specs.pdf
[44] Kenworth. *Kenworth T170/T270/T370 Body Builders Manual*. Retrieved from http://www.kenworth.com/brochures/2009_Hybrid_Body_Builders_Manual.pdf

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[45]. Values for C_d ranged from .45 for the 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

[45] 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.

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.

Appendix F
EPA Drayage Calculator Equations

Drayage Fleet Score and Emission Reductions for Generic Port													
Company Name	California Cartage Express												
Year 2008	Pre-1988	1988-1993	1994-2002	2003-2006	2007-2009	Post 2009	Total Trucks	CO_2 *Grams*	CO2 *Short tons*	PM *Short tons*	NOx *Short tons*	SmartWay SIF Score	Environmental Performance
Baseline Emissions From Average Dray Truck Fleet							1		**111**	**0.1**	**1.4**		
Untreated	1	0	0	0			1		**111**	**0.2**	**1.6**		
DOC & CCVS							0		**0**	**0.0**	**0.0**		
Flow Through Filter							0		**0**	**0.0**	**0.0**		
Diesel Particulate Filter/LNG			0	0	0	0	0		**0**	**0.0**	**0.0**		
Total Trucks Equipped with:	APUs	0	SW Tires		**0**	LNG	0		**0**	**0.0**	**0.0**		
2008 Total Fleet Emissions									**111**	**0.2**	**1.6**		
Change in Emissions from Baseline									**0.0**	**0.1**	**0.2**		
% Change in Emissions									**0%**	**131%**	**14%**		
Avg. Miles Per Truck	**60000**		Fuel Consumed (gal)			**10000**							
SmartWay FLEET Score and Environmental Performance for:							2008					No Rating	No Rating

I. CO_2 Short Tons

<u>A. CO_2 (Short tons) – Baseline Emissions From Average Dray Truck Fleet</u>

A_{CO2} = **(((BaselineEmissionsFromAverageDrayTruckFleet$_{Pre1988}$** + **BaselineEmissionsFromAverageDrayTruckFleet$_{1988to1993}$** + **BaselineEmissionsFromAverageDrayTruckFleet$_{1994to2002}$)** * AvgMilesPerTruck/**5.47)** + **((BaselineEmissionsFromAverageDrayTruckFleet$_{2003to2006}$** + **BaselineEmissionsFromAverageDrayTruckFleet$_{2007to2009}$** + **BaselineEmissionsFromAverageDrayTruckFleet$_{Post2009}$)** * AvgMilesPerTruck /**5.47))** * **0.01015**

NOTE: AvgMilesPerTruck =60000

<u>B. CO_2 (Short tons) – Untreated</u>

B_{CO2} = **(((Untreated$_{Pre1988}$** + **Untreated$_{1988to1993}$** + **Untreated$_{1994to2002}$)** * AvgMilesPerTruck **/5.47)** + **((Untreated$_{2003to2006}$** + **Untreated$_{2007to2009}$** + **Untreated$_{Post2009}$)** * AvgMilesPerTruck /**5.47))** * **0.01015**
NOTE: AvgMilesPerTruck =60000

C. CO_2 (Short tons) – DOCs & CCVs

C_{CO2} = **(((DOCs&CCVs$_{Pre1988}$** + **DOCs&CCVs$_{1988to1993}$** + **DOCs&CCVs$_{1994to2002}$)** * AvgMilesPerTruck **/5.47)** + **((DOCs&CCVs$_{2003to2006}$** + **DOCs&CCVs$_{2007to2009}$** + **DOCs&CCVs$_{Post2009}$)** * AvgMilesPerTruck **/5.47))** * **0.01015**
NOTE: AvgMilesPerTruck =60000

D. CO_2 (Short tons) – Flow Through Filter

D_{CO2} = **(((FlowThroughFilter$_{Pre1988}$** + **FlowThroughFilter$_{1988to1993}$** + **FlowThroughFilter$_{1994to2002}$)** * AvgMilesPerTruck **/5.47)** + **((FlowThroughFilter$_{2003to2006}$** + **FlowThroughFilter$_{2007to2009}$** + **FlowThroughFilter$_{Post2009}$)** * AvgMilesPerTruck **/5.47))** * **0.01015**
NOTE: AvgMilesPerTruck =60000

E. CO_2 (Short tons) – Diesel Particulate

E_{CO2} = **(((DieselParticulate$_{Pre1988}$** + **DieselParticulate$_{1988to1993}$** + **DieselParticulate$_{1994to2002}$)** * AvgMilesPerTruck **/5.47)** + **((DieselParticulate$_{2003to2006}$** + **DieselParticulate$_{2007to2009}$** + **DieselParticulate$_{Post2009}$)** * AvgMilesPerTruck **/5.47))** * **0.01015**
NOTE: AvgMilesPerTruck =60000

F. CO_2 (Short tons) – Total Trucks Equipped with APU/SWTires/LNG

F_{CO2} = **((TotalTruckEquipped$_{APU}$**/BaselineEmissionsFromAverageDrayTruckFleet$_{TotalTrucks}$ *** 0.11)** + **(TotalTruckEquipped$_{SWTires}$** / BaselineEmissionsFromAverageDrayTruckFleet$_{TotalTrucks}$ *** 0.02)** + **(TotalTruckEquipped$_{LNG}$** / BaselineEmissionsFromAverageDrayTruckFleet$_{TotalTrucks}$ *** 0.21)) * (**B_{CO2} + C_{CO2} **+** D_{CO2} + E_{CO2}**)** * **-1**

Where

BaselineEmissionsFromAverageDrayTruckFleet$_{TotalTrucks}$ = **BaselineEmissionsFromAverageDrayTruckFleet$_{Pre1988}$** + **BaselineEmissionsFromAverageDrayTruckFleet$_{1988to1993}$** + **BaselineEmissionsFromAverageDrayTruckFleet$_{1994to2002}$** + **BaselineEmissionsFromAverageDrayTruckFleet$_{2003to2006}$** + **BaselineEmissionsFromAverageDrayTruckFleet$_{2007to2009}$** + **BaselineEmissionsFromAverageDrayTruckFleet$_{Post2009}$**

B_{CO2} = **CO_2 (Short tons) – Untreated**

C_{CO2} = **CO_2 (Short tons) – DOCs & CCVs**

D_{CO2} = **CO_2 (Short tons) – Flow Through Filter**
E_{CO2} = **CO_2 (Short tons) – Diesel Particulate**

G. CO_2 (Short tons) – Total Fleet Emissions

$$G_{CO2} = B_{CO2} + C_{CO2} + D_{CO2} + E_{CO2} + F_{CO2}$$

Where

B_{CO2} = **CO_2 (Short tons) – Untreated**
C_{CO2} = **CO_2 (Short tons) – DOCs & CCVs**
D_{CO2} = **CO_2 (Short tons) – Flow Through Filter**
E_{CO2} = **CO_2 (Short tons) – Diesel Particulate**
F_{CO2} = **CO_2 (Short tons) – CO2 (Short tons) – Total Trucks Equipped with APU/SWTires/LNG**

H. CO_2 (Short tons) – Change in Emissions from Baseline

$$H_{CO2} = G_{CO2} - A_{CO2}$$

Where

G_{CO2} = **CO_2 (Short tons) – Total Fleet Emissions**
A_{CO2} = **CO_2 (Short tons) – Baseline Emissions From Average Dray Truck Fleet**

I. CO_2 (Short tons) – Percent Change in Emissions from Baseline

$$I_{CO2} = (G_{CO2} - A_{CO2}) / A_{CO2}$$

Where

G_{CO2} = **CO_2 (Short tons) – Total Fleet Emissions**
A_{CO2} = **CO_2 (Short tons) – Baseline Emissions From Average Dray Truck Fleet**

J. CO_2 (Short tons) – SmartWay Fleet Score and Environmental Performance

$$J_{CO2} = (I_{CO2} / 40) * -100$$

Where

I_{CO2} = **CO_2 (Short tons) – Percent Change in Emissions from Baseline**

II. PM Short Tons

A. PM (Short tons) – Baseline Emissions From Average Dray Truck Fleet

A_{PM} = **(((BaselineEmissionsFromAverageDrayTruckFleet**$_{Pre1988}$ * PMGramsPerMile$_{Pre1988}$ * **1.10E-06) +**
(BaselineEmissionsFromAverageDrayTruckFleet$_{1988to1993}$ * PMGramsPerMile$_{1988to1993}$ * **1.10E-06) +**
(BaselineEmissionsFromAverageDrayTruckFleet$_{1994to2002}$ * PMGramsPerMile$_{1994to2002}$ * **1.10E-06) +**
(BaselineEmissionsFromAverageDrayTruckFleet$_{2003to2006}$ * PMGramsPerMile$_{2003to2006}$ * **1.10E-06) +**
(BaselineEmissionsFromAverageDrayTruckFleet$_{2007to2009}$ * PMGramsPerMile$_{Pre1988}$ * **1.10E-06) +**
(BaselineEmissionsFromAverageDrayTruckFleet$_{Post2009}$ * PMGramsPerMile$_{Pre1988}$ * **1.10E-06))** * AvgMilesPerTruck**)**

NOTE: AvgMilesPerTruck =60000

Where

PMGramsPerMile$_{Pre1988}$ = **3.11**

B. PM (Short tons) – Untreated

B_{PM} = **(((Untreated**$_{Pre1988}$ * PMGramsPerMile$_{Pre1988}$ * **1.10E-06) + (Untreated**$_{1988to1993}$ * PMGramsPerMile$_{1988to1993}$ * **1.10E-06) + (Untreated**$_{1994to2002}$ * PMGramsPerMile$_{1994to2002}$ * **1.10E-06) + (Untreated**$_{2003to2006}$ * PMGramsPerMile$_{2003to2006}$ * **1.10E-06) + (Untreated**$_{2007to2009}$ * PMGramsPerMile$_{Pre1988}$ * **1.10E-06) + (Untreated**$_{Post2009}$ * PMGramsPerMile$_{Pre1988}$ * **1.10E-06))** * AvgMilesPerTruck**)**

NOTE: AvgMilesPerTruck =60000

C. PM (Short tons) – DOCs & CCVs

C_{PM} = **(((DOCs&CCVs**$_{Pre1988}$ * PMGramsPerMile$_{Pre1988}$ * **1.10E-06* 0.7) + (DOCs&CCVs**$_{1988to1993}$ * PMGramsPerMile$_{1988to1993}$ * **1.10E-06 * 0.7) + (DOCs&CCVs**$_{1994to2002}$ * PMGramsPerMile$_{1994to2002}$ * **1.10E-06 * 0.7) + (DOCs&CCVs**$_{2003to2006}$ * PMGramsPerMile$_{2003to2006}$ * **1.10E-06 * 0.7) + (DOCs&CCVs**$_{2007to2009}$ * PMGramsPerMile$_{Pre1988}$ * **1.10E-06 * 0.7) + (DOCs&CCVs**$_{Post2009}$ * PMGramsPerMile$_{Pre1988}$ * **1.10E-06 * 0.7))** * AvgMilesPerTruck**)**

NOTE: AvgMilesPerTruck =60000

D. PM (Short tons) – Flow Through Filter

D_{PM} = **(((FlowThroughFilter**$_{Pre1988}$ * PMGramsPerMile$_{Pre1988}$ * **1.10E-06* 0.5) + (FlowThroughFilter**$_{1988to1993}$ * PMGramsPerMile$_{1988to1993}$ * **1.10E-06 * 0.5) + (FlowThroughFilter**$_{1994to2002}$ * PMGramsPerMile$_{1994to2002}$ * **1.10E-06 * 0.5) + (FlowThroughFilter**$_{2003to2006}$ * PMGramsPerMile$_{2003to2006}$ * **1.10E-06 * 0.5) + (FlowThroughFilter**$_{2007to2009}$ * PMGramsPerMile$_{Pre1988}$ * **1.10E-06 * 0.5) + (FlowThroughFilter**$_{Post2009}$ * PMGramsPerMile$_{Pre1988}$ * **1.10E-06 * 0.5))** * AvgMilesPerTruck**)**

NOTE: AvgMilesPerTruck =60000

E. PM (Short tons) – Diesel Particulate

E_{PM} = **(((DieselParticulate$_{Pre1988}$** * PMGramsPerMile$_{Pre1988}$ *** 1.10E-06*** 0.1) + (DieselParticulate$_{1988to1993}$** * PMGramsPerMile$_{1988to1993}$ * **1.10E-06** * **0.1) + (DieselParticulate$_{1994to2002}$** * PMGramsPerMile$_{1994to2002}$ * **1.10E-06** * **0.1) + (DieselParticulate$_{2003to2006}$** * PMGramsPerMile$_{2003to2006}$ * **1.10E-06** * **0.1) + (DieselParticulate$_{2007to2009}$** * PMGramsPerMile$_{Pre1988}$ * **1.10E-06) + (DieselParticulate$_{Post2009}$** * PMGramsPerMile$_{Pre1988}$ * **1.10E-06))** * AvgMilesPerTruck**)**

NOTE: AvgMilesPerTruck =60000

F. PM (Short tons) – Total Trucks Equipped with APU/SWTires/LNG

F_{PM} = **((TotalTruckEquipped$_{APU}$**/BaselineEmissionsFromAverageDrayTruckFleet$_{TotalTrucks}$ * **0.08)** * **(**B_{PM} + C_{PM} **+** D_{PM} + E_{PM}**)** * **-1)**

Where

BaselineEmissionsFromAverageDrayTruckFleet$_{TotalTrucks}$ = **BaselineEmissionsFromAverageDrayTruckFleet$_{Pre1988}$** + **BaselineEmissionsFromAverageDrayTruckFleet$_{1988to1993}$** + **BaselineEmissionsFromAverageDrayTruckFleet$_{1994to2002}$** + **BaselineEmissionsFromAverageDrayTruckFleet$_{2003to2006}$** + **BaselineEmissionsFromAverageDrayTruckFleet$_{2007to2009}$** + **BaselineEmissionsFromAverageDrayTruckFleet$_{Post2009}$**

B_{PM} = **PM (Short tons) – Untreated**

C_{PM} = **PM (Short tons) – DOCs & CCVs**

D_{PM} = **PM (Short tons) – Flow Through Filter**

E_{PM} = **PM (Short tons) – Diesel Particulate**

G. PM (Short tons) – Total Fleet Emissions

$G_{PM} = B_{PM} + C_{PM} + D_{PM} + E_{PM} + F_{PM}$

Where

B_{PM} = **PM (Short tons) – Untreated**

C_{PM} = **PM (Short tons) – DOCs & CCVs**

D_{PM} = **PM (Short tons) – Flow Through Filter**

E_{PM} = **PM (Short tons) – Diesel Particulate**

F_{PM} = **PM (Short tons) – Total Trucks Equipped with APU/SWTires/LNG**

H. PM (Short tons) – Change in Emissions from Baseline

$H_{PM} = G_{PM} - A_{PM}$

Where

G_{PM} = **PM (Short tons) – Total Fleet Emissions**

A_{PM} = **PM (Short tons) – Baseline Emissions From Average Dray Truck Fleet**

<u>I. PM (Short tons) – Percent Change in Emissions from Baseline</u>

$I_{PM} = (G_{PM} - A_{PM}) / A_{PM}$

Where

G_{PM} = **PM (Short tons) – Total Fleet Emissions**

A_{PM} = **PM (Short tons) – Baseline Emissions From Average Dray Truck Fleet**

<u>J. PM (Short tons) – SmartWay Fleet Score and Environmental Performance</u>

$J_{PM} = (I_{PM} / 80) * -100$

Where

I_{PM} = **PM (Short tons) – Percent Change in Emissions from Baseline**

III. NO_X Short Tons

<u>A. NO_X (Short tons) – Baseline Emissions From Average Dray Truck Fleet</u>

A_{NOX} = **(((BaselineEmissionsFromAverageDrayTruckFleet$_{Pre1988}$** * PMGramsPerMile$_{Pre1988}$ * **1.10E-06) +**
(BaselineEmissionsFromAverageDrayTruckFleet$_{1988to1993}$ * PMGramsPerMile$_{1988to1993}$ * **1.10E-06) +**
(BaselineEmissionsFromAverageDrayTruckFleet$_{1994to2002}$ * PMGramsPerMile$_{1994to2002}$ * **1.10E-06) +**
(BaselineEmissionsFromAverageDrayTruckFleet$_{2003to2006}$ * PMGramsPerMile$_{2003to2006}$ * **1.10E-06) +**
(BaselineEmissionsFromAverageDrayTruckFleet$_{2007to2009}$ * PMGramsPerMile$_{Pre1988}$ * **1.10E-06) +**
(BaselineEmissionsFromAverageDrayTruckFleet$_{Post2009}$ * PMGramsPerMile$_{Pre1988}$ * **1.10E-06))** * AvgMilesPerTruck**)**
NOTE: AvgMilesPerTruck =60000

<u>B. NO_X (Short tons) – Untreated</u>

B_{NOX} = **(((Untreated$_{Pre1988}$** * PMGramsPerMile$_{Pre1988}$ * **1.10E-06) + (Untreated$_{1988to1993}$** * PMGramsPerMile$_{1988to1993}$ * **1.10E-06) + (Untreated$_{1994to2002}$** * PMGramsPerMile$_{1994to2002}$ * **1.10E-06) + (Untreated$_{2003to2006}$** * PMGramsPerMile$_{2003to2006}$ * **1.10E-06) + (Untreated$_{2007to2009}$** * PMGramsPerMile$_{Pre1988}$ * **1.10E-06) + (Untreated$_{Post2009}$** * PMGramsPerMile$_{Pre1988}$ * **1.10E-06))** * AvgMilesPerTruck**)**

NOTE: AvgMilesPerTruck =60000

<u>C. NO_X (Short tons) – DOCs & CCVs</u>

$$C_{NOX} = \mathbf{(((DOCs\&CCVs_{Pre1988}} * \text{PMGramsPerMile}_{Pre1988} * \mathbf{1.10E\text{-}06)} + \mathbf{(DOCs\&CCVs_{1988to1993}} * \text{PMGramsPerMile}_{1988to1993} * \mathbf{1.10E\text{-}06)} + \mathbf{(DOCs\&CCVs_{1994to2002}} * \text{PMGramsPerMile}_{1994to2002} * \mathbf{1.10E\text{-}06)} + \mathbf{(DOCs\&CCVs_{2003to2006}} * \text{PMGramsPerMile}_{2003to2006} * \mathbf{1.10E\text{-}06)} + \mathbf{(DOCs\&CCVs_{2007to2009}} * \text{PMGramsPerMile}_{Pre1988} * \mathbf{1.10E\text{-}06)} + \mathbf{(DOCs\&CCVs_{Post2009}} * \text{PMGramsPerMile}_{Pre1988} * \mathbf{1.10E\text{-}06))} * \text{AvgMilesPerTruck}\mathbf{)}$$

NOTE: AvgMilesPerTruck =60000

<u>D. NO_X (Short tons) – Flow Through Filter</u>

$$D_{NOX} = \mathbf{(((FlowThroughFilter_{Pre1988}} * \text{PMGramsPerMile}_{Pre1988} * \mathbf{1.10E\text{-}06)} + \mathbf{(FlowThroughFilter_{1988to1993}} * \text{PMGramsPerMile}_{1988to1993} * \mathbf{1.10E\text{-}06)} + \mathbf{(FlowThroughFilter_{1994to2002}} * \text{PMGramsPerMile}_{1994to2002} * \mathbf{1.10E\text{-}06)} + \mathbf{(FlowThroughFilter_{2003to2006}} * \text{PMGramsPerMile}_{2003to2006} * \mathbf{1.10E\text{-}06)} + \mathbf{(FlowThroughFilter_{2007to2009}} * \text{PMGramsPerMile}_{Pre1988} * \mathbf{1.10E\text{-}06)} + \mathbf{(FlowThroughFilter_{Post2009}} * \text{PMGramsPerMile}_{Pre1988} * \mathbf{1.10E\text{-}06))} * \text{AvgMilesPerTruck}\mathbf{)}$$

NOTE: AvgMilesPerTruck =60000

E. NO_X (Short tons) – Diesel Particulate

E_{NOX} = **(((DieselParticulate**$_{Pre1988}$ * PMGramsPerMile$_{Pre1988}$ * **1.10E-06) + (DieselParticulate**$_{1988to1993}$ * PMGramsPerMile$_{1988to1993}$ * **1.10E-06) + (DieselParticulate**$_{1994to2002}$ * PMGramsPerMile$_{1994to2002}$ * **1.10E-06) + (DieselParticulate**$_{2003to2006}$ * PMGramsPerMile$_{2003to2006}$ * **1.10E-06) + (DieselParticulate**$_{2007to2009}$ * PMGramsPerMile$_{Pre1988}$ * **1.10E-06) + (DieselParticulate**$_{Post2009}$ * PMGramsPerMile$_{Pre1988}$ * **1.10E-06))** * AvgMilesPerTruck**)**

NOTE: AvgMilesPerTruck =60000

F. NO_X (Short tons) – Total Trucks Equipped with APU/SWTires/LNG

F_{NOX} = **((TotalTruckEquipped**$_{APU}$/BaselineEmissionsFromAverageDrayTruckFleet$_{TotalTrucks}$ * **0.11)** + **(TotalTruckEquipped**$_{SWTires}$ / BaselineEmissionsFromAverageDrayTruckFleet$_{TotalTrucks}$ * **0.02)** * **(**B_{NOX} + C_{NOX} **+** D_{NOX} + E_{NOX}**)** * **-1**

Where

BaselineEmissionsFromAverageDrayTruckFleet$_{TotalTrucks}$ = **BaselineEmissionsFromAverageDrayTruckFleet**$_{Pre1988}$ + **BaselineEmissionsFromAverageDrayTruckFleet**$_{1988to1993}$ + **BaselineEmissionsFromAverageDrayTruckFleet**$_{1994to2002}$ + **BaselineEmissionsFromAverageDrayTruckFleet**$_{2003to2006}$ + **BaselineEmissionsFromAverageDrayTruckFleet**$_{2007to2009}$ + **BaselineEmissionsFromAverageDrayTruckFleet**$_{Post2009}$

B_{NOX} = **NO_X (Short tons) – Untreated**

C_{NOX} = **NO_X (Short tons) – DOCs & CCVs**

D_{NOX} = **NO_X (Short tons) – Flow Through Filter**

E_{NOX} = **NO_X (Short tons) – Diesel Particulate**

G. NO_X (Short tons) – Total Fleet Emissions

$G_{NOX} = B_{NOX} + C_{NOX} + D_{NOX} + E_{NOX} + F_{NOX}$

Where

B_{NOX} = **NO_X (Short tons) – Untreated**

C_{NOX} = **NO_X (Short tons) – DOCs & CCVs**

D_{NOX} = **NO_X (Short tons) – Flow Through Filter**

E_{NOX} = **NO_X (Short tons) – Diesel Particulate**

F_{NOX} = **NO_X (Short tons) – Total Trucks Equipped with APU/SWTires/LNG**

H. NO_X (Short tons) – Change in Emissions from Baseline

$H_{NOX} = G_{NOX} - A_{NOX}$

Where

G_{NOX} = **NO_X (Short tons) – Total Fleet Emissions**

A_{NOX} = **NO_X (Short tons) – Baseline Emissions From Average Dray Truck Fleet**

<u>I. NO_X (Short tons) – Percent Change in Emissions from Baseline</u>

$I_{NOX} = (G_{NOX} - A_{NOX}) / A_{NOX}$

Where

G_{NOX} = **NO_X (Short tons) – Total Fleet Emissions**

A_{NOX} = **NO_X (Short tons) – Baseline Emissions From Average Dray Truck Fleet**

<u>J. NO_X (Short tons) – SmartWay Fleet Score and Environmental Performance</u>

$J_{NOX} = (I_{NOX} / 80) * -100$

Where

I_{NOX} = **NO_X (Short tons) – Percent Change in Emissions from Baseline**

IV. SmartWay SIF Score and Environmental Performance

<u>A. Score Calculation</u>

$A_{SCORE} = I_{CO2} + I_{PM} + I_{NOX}$

Where

I_{CO2} = **CO_2 (Short tons) – Percent Change in Emissions from Baseline**

I_{PM} = **PM (Short tons) – Percent Change in Emissions from Baseline**

I_{NOX} = **NO_X (Short tons) – Percent Change in Emissions from Baseline**

<u>B. SmartWay SIF Ranking</u>

B_{rank} = **If $A_{SCORE} < 0.498$, then "No Rating"**

B_{rank} = **If $A_{SCORE} > 0.499$ and $A_{SCORE} \leq 1$, then "0.75"**

B_{rank} = **If $A_{SCORE} > 1$ and $A_{SCORE} \leq 1.8$, then "1.00"**

B_{rank} = **If $A_{SCORE} > 1.8$, then "1.25"**

Where

A_{SCORE} = **Score Calculation**

C. Environmental Performance

$C_{EnvPerf}$ = **If** $A_{SCORE} \leq$ **0.05, then “No Rating”**

$C_{EnvPerf}$ = **If** $A_{SCORE} >$ **0.05 and** $A_{SCORE} \leq$ **0.499, then “Average”**

$C_{EnvPerf}$ = **If** $A_{SCORE} >$ **0.499 and** $A_{SCORE} \leq$ **1, then “Good”**

$C_{EnvPerf}$ = **If** $A_{SCORE} >$ **1 and** $A_{SCORE} \leq$ **1.8, then “Very Good”**

$C_{EnvPerf}$ = **If** $A_{SCORE} >$ **1.8, then “Outstanding”**

Where

A_{SCORE} = **Score Calculation**