Methodology for Developing Input Datasets for the MOVES Model

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16. Abstract

In April 2004, the U.S. Environmental Protection Agency (EPA) released a new regulatory (computer) model for estimating emissions from on-road motor vehicles called the Motor Vehicle Emission Simulator (MOVES). Since the EPA must periodically update their regulatory models, as stipulated by the Clean Air Act, it was in-line to replace the Mobile Source Emission Factor Model (MOBILE).

The EPA strongly recommends states use the latest version of MOVES that is available instead of relying on previous versions of the model. The EPA also recommends that states derive input data for the model from local sources rather than relying on default data which is included with the model. At the moment, adequate data in the appropriate format to run MOVES are not available for many states in the country including Tennessee. The purpose of this project was to develop several of these input datasets for the state.

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Introduction

In April 2004, the U.S. Environmental Protection Agency (EPA) released a new regulatory (computer) model for estimating emissions from on-road motor vehicles called the MOtor Vehicle Emission Simulator (MOVES). Since the EPA must periodically update their regulatory models, as stipulated by the Clean Air Acts, it was in-line to replace the Mobile Source Emission Factor Model (MOBILE). MOVES is considered to be vastly superior to MOBILE because it incorporates the most recent advances in the science to better estimate vehicle emissions. More importantly, it has new input data requirements that are not only different but much larger in scope than the data requirements necessary to run the older model.

As of March 2, 2013, the EPA requires that MOVES is used for inventory development in State Implementation Plans (SIP) and regional emissions analysis for showing transportation conformity by all states except for California. Currently several versions of the model exist for these purposes: MOVES2010, MOVES2010a, and MOVES2010b. Each version in the series incorporated certain performance enhancements which did not significantly impact any changes on emissions in computer runs at the County or Project Level Scales. However, a newer version of the model (MOVES2014) was released in July 31, 2014 that contains modifications which may impact changes in emissions. Likewise, certain modifications occurred in the format of the MySQL tables that receive the input data between the 2010 and 2014 versions of the model. Also, MOVES2014 is the first version of the model to include the ability to estimate emissions from non-road sources. Non-road include combustion engine or turbines used for other purposes than being an engine of a vehicle operated on public roadways. Examples of non-road sources are construction, agriculture, railroad, marine, and aviation equipment. Currently non-road emissions from MOVES2014 are essentially equivalent to those produced from NONROAD2008 and NMIM2008 (National Mobile Inventory Model).

On November 4, 2014, EPA released still another version of the model (MOVES2014a) that contains minor revisions to the previously released model (MOVES2014). Since significant changes in criteria pollution emissions did not result, MOVES2014a is not considered to be a new model for SIP and transportation conformity purposes. In the future, MOVES2014 and the minor revisions (currently, only MOVES2014a) will replace MOVES2010 and its minor revisions (MOVES2010a and MOVES2010b) for regulatory purposes. The grace period

between using MOVES2010 and MOVES2014 ended on October 7, 2016. Nonetheless, the EPA strongly recommends states use the latest version of MOVES that is available instead of relying on previous versions of the model. The EPA also recommends that states derive input data for the model from local sources rather than relying on default data which is included with the model. At the moment, adequate data in the appropriate format to run MOVES are not available for many states in the country, and the State of Tennessee is not an exception.

The purpose of this project was to develop several of these input datasets for the State of Tennessee which are listed in Table 1. (Note: all tables mentioned in this document are included in Appendix A.) These input files will also be formatted to MOVES2014a, which is the most recent version of the model, as of the writing of this document. Thereafter, MOVES2014a will be referred to simply as MOVES.

The CDM (County Data Manager) tab is the dialog box of the importer tool in MOVES; it allows the user to import data into MySQL, which is the data management software package included with the model. Other input datasets, located in the CDM, such as the Average Speed Distribution, Meteorological Data, Fuel, and I/M Programs, will not be discussed in this report; these datasets will be developed by other entities. It is assumed that the reader of this document has some familiarity with using MOVES, so only a minimal discussion of the mechanics of the model will be forthcoming in the following paragraphs. For the interested reader, details concerning MOVES can be found in the EPA documentation on the Internet: http://www.epa.gov/otaq/models/moves/index.htm

Input data developed and discussed in this document are based on the calendar years 2015 and 2016. Equations or formulas showing how the datasets were developed in mathematical layout will be presented. Microsoft Excel files are included to exhibit sample calculations or data manipulation in spreadsheet format using data for Knox County, Tennessee. These Excel files are supplied in a single compressed (zip) file for each year. The input data that are intended for running MOVES will also be supplied in separate compressed (zip) files containing a total of 95 Excel files (one for each county in Tennessee). These files are named by the county and year in which the data are intended. The names of zip files will be listed in the Summary section of this document. The input data will be provided in the appropriate format for use with the CDM importer tool in MOVES. The following methodology will describe the

preparation of these input datasets, as well as any quality assurance measures that were taken to ensure the integrity of the data.

It should be noted that MOVES input data from this project will not be provided for the calendar year 2017 which of note corresponds to a reporting year for the EPA National Emission Inventory (NEI). Air emissions based on data provided by state and local air agencies from sources located in their jurisdiction are used to create the NEI which is released publically via the Internet every three years by EPA. In part, the MOVES model is used to compute on-road source emissions based on model inputs provide by state and local air agencies. Typically, a higher level of quality assurance measures should be taken to ensure the integrity of the input data for NEI. In closing this section, the input data provided by this project are not intended for developing mobile source emission inventories using MOVES for the EPA 2017 NEI.

Source Type Population

The source type population is the actual number of vehicles of each source type in the modeling domain. Vehicles in MOVES are categorized into 13 source types: Motorcycle, Passenger Car, Passenger Truck, Light Commercial Truck, Intercity Bus, Transit Bus, School Bus, Refuse Truck, Single Unit Short-haul Truck, Single Unit Long-haul Truck, Motor Home, Combination Short-haul Truck, and Combination Long-haul Truck. Vehicles are called source types in MOVES because the model relies more heavily on the activity or use of the vehicles to simulate emissions rather than on engine and/or body style configurations.

Two methods were used to develop the source type populations: the vehicle registration data method and the national default-local data method. The former utilizes statewide motor vehicle registration data or other reliable databases at the state or federal level. This is the EPA preferred procedure when actual road count data are not available. The latter method utilizes the ratio of default population and vehicle miles traveled (VMT) data generated by MOVES, as well as local VMT and vehicle classification data via a calculation procedure. This method is also acceptable by EPA but is used only when motor vehicle registration data are not available and/or inappropriate to use for the source types.

Vehicle Registration Data Method

Motor vehicle registration data were provided by the Tennessee Department of Revenue (TDOR) in the format of text files. These files contained the vehicles currently registered or scheduled for a license renewal in the state at the time the database query was executed. For the calendar years 2015 and 2016, data were extracted July 2015 and January 2016, respectively. In the best case scenario, a snapshot of registration data is required mid-year, but this was not possible for 2016. Therefore, a growth factor embedded in the MOVES model was used to project data from January 2016 to mid-year 2016.

Each record or row of data in the text file indicated a single motor vehicle. The start- and end-length of each record contains 49 integers and/or spaces; these represented coded or abbreviated information that could be used to identify or clarify source types. Information contained in the record are vehicle identification number (VIN), year, make, model, use, type, body style, fuel, county of registration, and license plate class. Descriptions of the coding were provided by TDOR for interpretation of the information contained in the text file. Several of the codes, such as use, type, body style, and license class are specific to the state. These codes can change over time as manufacturing adapts to meet the varying consumer demand for different body or frame styles and as road tax legislation may alter classifications which are based on gross vehicle weight and other factors.

Several group discussions were held with TDOR personnel to explain the source type population requirements for MOVES before the motor vehicle data were extracted to the text file. States typically report to the Federal Highway Administration (FHWA) on the operating characteristic of their road systems using Highway Performance Monitoring System (HPMS) of classifications, so personnel were somewhat familiar applying these terms. Therefore, the text file contained preliminary MOVES source type and HPMS designations for each record.

Presently, 13 vehicle classes are contained in HPMS, but these should not be confused with the 13 source types used in MOVES. The HPMS classes rely more heavily on frame or body style, number of wheels and/or axles, and gross vehicle weight. The HPMS classes can be reordered into six general categories: Motorcycle, Passenger Car, Other 2-axle 4-tire Vehicles, Buses, Single Unit Trucks, and Combination Trucks. More details of the HPMS format can be

found in the FHWA documentation on the Internet:
https://www.fhwa.dot.gov/policyinformation/hpms.cfm

Starting with the 2014 release of MOVES, the EPA decided that only five subsets of HPMS will be used because of trouble distinguishing between all types of light-duty vehicles using traffic or road tube counters. For this situation, the two HPMS classes (i.e., Passenger Car and Other 2-axle 4-tire Vehicles) were combined into a single class called Light Duty Vehicles. This HPMS (defined by EPA) will include both short and long wheelbases. More will be said later in the paper about this effect on developing the input data for MOVES.

The total number of vehicles in the initial data extractions for July 2015 and January 2016 were 5,536,391 and 5,399,414, respectively. The source types associated with MOVES and the HPMS vehicle categories are listed in Table 2 and Table 3. Heavy-duty freight trucks, utility trailers, and special government vehicles were not included in the extraction. As may be the case, county registered heavy duty vehicles used for hauling freight over short or long distances are not necessarily representative of that portion of the fleet because these vehicles may typically transport freight across state and county borders.

The information shown in the tables reveal a large disparity between the number of Passenger Cars (HPMS 20 or MOVES 21) and Other 2 axle-4 tire Vehicles (HPMS 30) or Passenger Trucks with the addition of Light Commercial Truck (MOVES 32 & 33). That is approximately 76% versus 16%, respectively. Therefore, it is believed that the number of vehicles initially assigned to Passenger Car in the data extractions for 2015 and 2016 were overstated by TDOR because the percentages of Passenger Car and Passenger Truck for states less urbanized like Tennessee are typically between 40% and 50% each. For example, FHWA highway statistics compiled for Tennessee during 2015 and 2016 were about 42% automobiles and 52% pickups, vans and sport utility vehicles. Several factors may account for the disagreement in the data provided by TDOR and data reported by FHWA. However, a discussion of these factors is not the subject of this document. On the other hand, further action was needed to transform the state's motor vehicle registration data into results that were more in line with the reported data from FHWA.

Using a VIN decoder on the Internet and other abbreviated or coded information contained in the text file, such as make, model, type, use, class, body, etc., the vehicles were rearranged into source types by a repetitive trial-and-error procedure using database query software (i.e., Microsoft Access®). Additionally, vehicles registered as antique or show cars and vehicles older than 1961 for 2015 or older than 1962 for 2016 were removed from the database since it is assumed that these vehicles are rarely driven on the public roads. From this activity, Passenger Car (MOVES 21), Passenger Truck (MOVES 32), and Light Commercial Truck (MOVES 33) are approximately 46%, 40%, and 7%, respectively.

It was more difficult to distinguish between buses (Intercity, Transit, and School Buses), Refuse Truck, and Motor Home with a high level of certainty because these vehicles had similar engine, body, and weight configurations, so other methods were used to develop population data for these source types. Also, computer coding that was applied to these vehicle types by the County Clerks in Tennessee were highly inconsistent within the motor vehicle registration database. Even though codes are provided in the registration database for these vehicle types. It should be noted that this problem has been brought to the attention of TDOR, but it has not been resolved. In the following paragraphs, the approach is discussed for the two bus source types where other reliable data were available. These are Transit Bus and School Bus.

Transit Bus

Transit buses are owned by a public transit organization for the primary purpose of transporting passengers on fixed routes and schedules with a capacity of at least 15 or more persons as per EPA. To meet the needs of the public transportation system, the Federal Transit Administration (FTA) maintains a National Transit Database (NTD). Recipients or beneficiaries of grants for public transportation from the FTA are required to submit operating and financial data to the NTD. Among other information, fleet size, vehicle model and year, fuel type, seating and standing capacity, and average mileage per vehicle on a county basis are contained in the database. Data are available at https://www.transit.dot.gov/ntd. Statistics from the NTD were used to determine source type population data for Transit Bus. Thus, it was estimated that a total of 731 transit buses, as classified by EPA, were operating in the state during 2015, and 1,092 during 2016. These buses were operated in only 16 counties of the state.

School Bus

Annual Statistical Reports of the Tennessee Department of Education (TDOE) are published annually that contain data for school buses operating in the state at the county level for the scholastic year. Data are available at https://www.tn.gov/education/data/department-reports.html. From this source, it was estimated that a total of 8,858 school buses operated throughout the state during 2015, and 9006 buses operated during 2016.

National Default-Local Data Method

Local vehicle data were not available for the Single Unit Long-haul Truck and the Combination Short- and Long-haul Trucks. Population data for the Intercity Bus, Refuse Truck, and Motor Home also were not adequately resolved using motor vehicle registration data. In these circumstances, the EPA recommends using other auxiliary methods. For this situation, population data were derived by a ratio computation method using national default data in conjunction with local VMT and statewide vehicle classification summaries.

The ratio factor is the population data for the source type (numerator) by the distance traveled for the road type (denominator). Activity data are obtained by running MOVES at the National Scale for the calendar year of interest (2015 or 2016) on a per county basis. The multiplying factor (numerator) is the local or county VMT data for the vehicle or source type. Local data are obtained from the Tennessee Department of Transportation (TDOT) in the form of the annual average daily vehicle miles traveled (DVMT) and the statewide vehicle classification summaries. Samples of these data are shown in Table 4, Table 5, Table 6, and Table 7. Two comments concerning the data are necessary: (1) the exact DVMT for 2016 was not available from TDOT, so amended data between 2014 and 2016 were used; (2) the road classification for Rural Freeway is not used in Tennessee, so the DVMT is zero for all counties, however, DVMT data for 2016 are shown for several counties. They are Fayette, Maury, Shelby, and Sumner. Since the statewide vehicle classification summary did not contain data for the Rural Freeway, the DVMT were added to the values for Rural Interstate.

The vehicle and road data for the state are categorized by HPMS, and as mentioned earlier, MOVES does not directly use the HPMS based classifications. Thus, additional preprocessing is required to distribute or map HPMS to MOVES. In HPMS, six (general)

functional road classifications exist: Interstate & Freeways, Principal Arterial, Minor Arterial, Major Collector, Minor Collector, and Local, which are further subdivided into Urban and Rural. In MOVES, only four primary road types are used: Rural Restricted, Rural Unrestricted, Urban Restricted, and Urban Unrestricted. A fifth road type is Off-network, but it accounts for locations where the predominant vehicle activity is essentially not conducted on the roadway, such as starting, parking, and idling. A summary of the mapping scheme between the HPMS and MOVES classifications are shown in Table 8 for both source and road types.

To smooth out yearly fluctuations in the vehicle classification summaries, a five-year average (i.e., years 2011 through 2015 for calendar year 2015 and years 2012 through 2016 for calendar year 2016) were used. The raw data from these previous years are not shown in this document, however a summary of the data is built-into the Excel files that will demonstrate the sample calculations in spreadsheet format. The name of this spreadsheet is called "5-Year Average". The final averages were adjusted proportionally across the EPA five HPMS vehicle types, so that the sum of the averaged percentages would equal 100%. In several instances, TDOT did not include a road category in the dataset, so data from the next higher category was used if this data were applicable. For example, Rural Minor Collector data were used for Rural Local data because vehicle traffic on a Rural Minor Collector ultimately passes through a Rural Local road.

The general formula that was used to calculate population source type data is Equation 1. It has three parts represented by the symbols A, B, and C. (Note: all equations mentioned are included in the Appendix B of this document.) The "A" expression evaluates local DVMT for the HPMS vehicle type. The MOVES default population to VMT ratio is the "B" expression. The "C" expression (also a ratio) maps the HPMS vehicle type to the MOVES source type. The C value will equal unity (or 1.0) when the HPMS vehicle type is equivalent to the MOVES source type. Currently this is only the case for Motorcycle, otherwise it is equal to a fraction that sums to unity within MOVES source types that were mapped from the HPMS vehicle type. Sample calculations for the Combination Long-haul Truck using the equations for Knox County data are include in Appendix B for calendar years 2015 and 2016.

The supplemental Microsoft Excel file that will show all calculations or data manipulations in spreadsheet format for this section using Knox County data is named Sample

Calculations for SourceType Populations - Knox yyyy.xlsx. The symbols "yyyy" will represent the calendar year. This file contains two spreadsheets. The first spreadsheet is called "SourceType Population" which contains several tables that are used to calculate source type population data using the raw data received from TDOT. The second spreadsheet is called "5-Year Average". This spreadsheet demonstrates how the five-year averages were calculated also using raw data received from TDOT. The sample calculations for Knox County data (shown in Appendix B for Combination Long-haul Truck, mentioned above) will match the sample calculations shown in the Excel spreadsheets for Knox County. However due to rounding, the arithmetic calculations shown in Appendix B may appear to be incorrect by very small amounts when compare to the spreadsheet calculations.

Final Statewide Dataset

A summary of the final population data that will be used by source types are shown in Table 9 (2015) and Table 10 (2016). Motorcycle, Passenger Car, Passenger Truck, Light Commercial Truck, Transit Bus, School Bus, and Single Unit Short-haul Truck were derived from motor vehicle registration data and other useable datasets. Intercity Bus, Refuse Truck, Single Unit Long-haul Truck, Motor Home, and Combination Short- and Long-haul Trucks were determined using the ratio-calculation method. The data were distributed across counties as per county designation in the respective datasets. The final input data for MOVES are included in the compressed (zip) on a per county basis.

Age Distribution

Age distribution is the age fractions of fleet by age and source type. Vehicle ages in MOVES cover a range of 31 years with vehicles 30 years and older grouped together. States are encouraged by EPA to develop age distributions with local data. In the present study, local population data were available for only seven of the 13 source types using the motor vehicle registration data and/or other valid data sources. Since the motor vehicle registration data received from TDOT was just a snapshot of registrations for the end of the year, population data were adjusted. Age distribution data for school buses were not available for 2015 and 2014, so 2014 data were used. In other situations, where local population were not available to determine the age distributions, the default age distributions for the year in question (i.e., 2015 or 2016)

were used instead. These distributions were obtained from the EPA Default Age Distributions for MOVES2014 file. This file is available via the Internet MOVES site. Default age distributions were used for Intercity Bus, Refuse Truck, Single Unit Long-haul Truck, Motor Home, and Combination Short- and Long-haul Trucks. The final input data for MOVES are included in the compressed (zip) on a per county basis.

Road Type Distribution

Road type distribution is the fraction of source type VMT on each of the four road types. Once again, data in this format are not available for Tennessee, so a calculation method was used to convert HPMS road data into MOVES data. The five-year average vehicle summary classifications by road type for 2011-2015 and 2012-2016, as well as the 2015 and 2016 DVMT were used to develop the road type distributions. Note that local data are classified by HPMS, so the mapping scheme shown in Table 8 had to be applied.

Equation 2 is the overall formula that was used to calculate the VMT road type distributions. It has two parts which are represented by the symbols A and B. The "A" expression evaluates local DVMT for the MOVES road types per HPMS vehicle type. The "B" expression is the MOVES road type ratio that distributes the road type fractions across source types. Sample calculations for the Combination Long-haul Truck using the equations for Knox County data are include in Appendix B. Off-network was assigned a value of zero. It should be noted that the road type VMT fractions are the same for those source types that were mapped from the HPMS vehicle type. For example, Passenger Car, Passenger Truck, and Light Commercial Truck in MOVES were mapped together from Passenger Car, and Other 2-axle 4-tire Vehicles in HPMS, which are now under the EPA term Light Duty Vehicles - Short and Long Wheelbase, and thus, VMT fractions will be the same for these three source types.

The supplemental Microsoft Excel file showing calculations in spreadsheet format for this section using Knox County data is named Sample Calculations for RoadType VMT Distributions - Knox yyyy.xlsx. This file contains two spreadsheets. The first spreadsheet is called "SourceType Pop", which contains several tables that are used to calculate source type VMT distribution data using the raw data received from TDOT. The second spreadsheet is called "5-Year Average". It is the same spreadsheet which was mentioned earlier in the

discussion of source type population. The sample calculations for Knox County data (shown in Appendix B for Combination Long-haul Truck, mentioned above) will match the sample calculations shown in the Excel spreadsheets for Knox County. The final input data for MOVES are included in the compressed (zip) on a per county basis.

Vehicle Type VMT

Annual VMT by the HPMS vehicle classes are required by MOVES. Vehicle type VMT is the total annual or daily VMT by HPMS vehicle type or source type. It includes month, day, and hour VMT fractions. Month VMT fractions are the fraction of annual VMT (per source type) occurring per month. Day VMT fractions are the fraction of monthly VMT (per source type) occurring on one of the two day types (weekday or weekend-day). Hour VMT fractions are the fraction of daily VMT (per source type) occurring per hour.

Once again, the vehicle type VMT data in this format are not available for Tennessee. However, to help the user develop inputs for MOVES, the EPA created several Microsoft Excel spreadsheet-based converter or calculator tools. A modified version of the file named "aadvmtcalculator_hpms.xls" was used to develop the data for vehicle type VMT. First, some general information will be given about the original EPA file which can be downloaded from the MOVES Internet site listed earlier in the report.

The EPA tool uses annual average weekday (AAD) VMT at the HPMS level to calculate type of day, monthly and yearly VMT in terms of HPMS and/or MOVES source types. The tool contains default vehicle type VMT datasets for monthly, daily, and hourly VMT fractions and provides default monthly and weekend-day adjustment factors if local inputs are not available. However, the decision was made to modify the EPA converter tool after some discussion among stakeholders. The primary concern was that the annual VMT (i.e., the MOVES input for the HPMSBaseYearVMT as calculated via the tool) should equal 365 times the HPMS DVMT data (or 366 if the year for the model run was a leap year).

It is assumed this tool was designed to handle average annual weekday VMT (AAWDVMT) rather than average annual daily traffic (AADVMT). Raw HPMS data from TDOT are reported in terms of AADVMT and by definition represents an average day regardless of weekday or weekend. For their roads analysis, TDOT will normally apply a daily variation

factors to represent traffic for a particular weekday or weekend-day. Thus, the EPA tool was modified to essentially multiply daily VMT by 365 (because 2014 was not a leap year) to create the HPMSVTypeYear data. Also since TDOT determines seven-day adjustment factors by months of the year, the weekday and weekend-day adjustment factors could be determined separately. These factors were also added to the modified EPA calculator tool which originally included only default monthly and weekend-day adjustment factors.

A copy of the TDOT five year seasonal variation factors that were used for 2015 and 2016 are shown in Table 11 and Table 12, respectively. Note that the final factors used in the modified tool will be the inverse of the variation factors shown in the table. They are listed for Rural Interstate, Rural Other, Urban, and Recreational. This required preprocessing of the road categories into HPMS road types and averaging the results before the adjustment factors could be applied to the modified EPA calculator tool. The averaging pattern is represented in the Excel file showing the AADVMT sample calculations. It should be noted that the variation factors for Recreational were not used because they are for road traffic in state parks. In effect, weighting factors were created from the road categories that had been mapped to HPMS road types, and then these weighting factors were applied to the averaged adjustment factors to create monthly, weekday, and weekend-day factors for use in the modified calculator tool. The method of averaging these seasonal variation factors are shown in the Microsoft Excel preprocessing data file mentioned below. One final comment is in order: as of the writing of this document, the EPA has a new converter tool that permits entering ADDVMT data as average day or as an average weekday. This file is called "aadvmt-converter-tool-moves2014.xlsx", but it was decided to say with the original EPA tool because the modified version includes the monthly, weekday and weekend-day adjustment factors.

Once more, it was necessary that local data be preprocessed before it could be used. The general formula that was applied to prepare AADVMT data is Equation 3. Note that this formula is identical to the "A" expression of Equation 1. (It was listed again only to maintain continuity in the narrative.) Sample calculations for Combination Long-haul Truck using the equation for Knox County data are include in Appendix B.

Two Microsoft Excel file will accompany this section. The names of these files are Sample Calculations for AADVMT - Knox yyyy.xlsx and Sample Modified AADVMT

Calculator HPMS - Knox yyyy.xlsx. The former file includes calculations in spreadsheet format for Knox County that were used to develop the AADVMT input data for the calculation tool. This file contains three spreadsheets. The first spreadsheet is called "AADVMT" which contains several tables that are used to calculate the AADVMT data. The second spreadsheet is called "Adjustment Factors" which contains several tables that are used to calculate the monthly, weekday, and weekend-day adjustment factors. Both of these spreadsheets use raw data received from TDOT. The third spreadsheet is called "5-Year Average". Calculation in this spreadsheet demonstrates how the five-year averages were calculated, using the yearly vehicle summaries by the functional road classes. It is the same spreadsheet that was mentioned earlier in the discussion of source type population and road type distribution. The Sample calculations for Knox County data (shown in Appendix B for Combination Long-haul Truck, mentioned above) will match the sample calculations shown in the Excel spreadsheets for Knox County.

The latter file is the modified EPA calculator tool that was run using the Knox County AADVMT data. This file contains eight spreadsheets. The main spreadsheet is called "Import HPMS AADVMT and Factors". This spreadsheet accepts the AADVMT and adjustment factor data generated by the former file (previously discussed). Calculations are shown in the spreadsheet called "Intermediate Calculations". The final calculations become the input data for MOVES which are shown in the three spreadsheets named: "HPMSVTypeYear", "monthVMTFraction-calculated", and "dayVMTFraction-calculated". For closure, the EPA default VMT fractions were included in the file as the following spreadsheets: "monthVMTFraction-default", "dayVMTFraction-default", and "hourVMTFraction-default". The modified tool will only generate the HPMS base year VMT data and the monthly and daily VMT fractions required by MOVES. Therefore, the default hourly VMT fractions are used as input data for MOVES because, at the moment, no hourly vehicle data are available at the local level to aid in calculating hourly fractions. The other two default VMT fractions (month and day) were included for comparison purposes. The final input data for MOVES are included in the compressed (zip) on a per county basis.

Summary

Four compressed (or zip type) files are included with this document. Two files named MOVES Input Data files for yyyy.zip contains the Excel input data files for the 95 counties of

Tennessee for 2015 and 2016. Each file contains eight spreadsheets; seven spreadsheets contain the input data listed in Table 1, and the last spreadsheet contains general comments about the input data. The prefix of the file name is the county name. For example, Knox Input File 2015.xlxs is the Excel file containing MOVES input data for Knox County for the calendar year 2015. The second zip or compressed file contains the Excel files that demonstrate all sample calculations in spreadsheet format for Knox County. The name of this file is Sample Calculations for Five Counties yyyy.zip; it contains a total of 4 files.

Conclusions

Two areas need improvement to enhance the quality of the input data: the motor vehicle registration database and the statewide vehicle classification summaries. A trial-and-error method was required to match vehicles with the MOVES and/or HPMS categories using motor vehicle registration data to generate source type population data. This method is time consuming and may produce inconsistent results because many of the vehicle categories listed in the registration database are labeled incorrectly and often require a judgment call. For example, vehicle type, use, and body codes exist for commercial bus, school bus, motor home, pick-up truck, and garbage truck in the database, but in many instances, these abbreviations do not match the information derived by querying the VIN. Additional evidence for this problem is shown by the initial data extraction which disclosed almost 80% passenger cars. This is not an attempt to fault TDOR because the purpose of vehicle registration is to collect title information, such as for the establishment of legal ownership of property and to collect road-use taxes, which in turn help finance the construction and/or maintenance of the public roadways. This is to say, the intent of motor vehicle registration data is not to serve as input for the MOVES model.

The final concern involves using statewide data to predict local (county) conditions. The EPA requires that states develop local data for MOVES. Although the quality of data received from TDOT is very high, much of the data have been abridged to generate statewide summaries. In this project, the abridged data were used in various calculation methods to predict local conditions that possibly do not represent the true local condition. The most reliable data are from physical traffic volume counts, which are actual counts of vehicles along a particular road way. However at present, it is very difficult to classify vehicles or distinguish between source types using pneumatic and/or electronic counters. Also the method would be costly and time

consuming to perform on all roadways. Therefore, sampling is typically performed on certain roadways on a seasonal basis, and the data are projected to similar locations (i.e., as statewide summaries). Inputs to MOVES require highly detailed data. Concluding: state and local agencies must use computer models for SIPs and transportation conformity analyses. Ultimately the results from these computer programs will influence policy decisions that can have significant economic effects on the community in which they are applied. Therefore, it is paramount that the highest quality of data is used to run the models.

References

1. U.S. Environmental Protection Agency. *Motor Vehicle Emission Simulator (MOVES): User Guide for MOVES2014a*. Assessment and Standards Division, Office of Transportation and Air Quality; EPA-420-B-15-095; November 2015.

2. U.S. Environmental Protection Agency. *MOVES2014 and MOVES2014a Technical Guidance: Using MOVES to Prepare Emission Inventories in State Implementation Plans and Transportation Conformity.* Assessment and Standards Division, Office of Transportation and Air Quality; EPA-420-R-15-093; November 2015.

3. U.S. Environmental Protection Agency. *Population and Activity of On-road Vehicles in MOVES2014a.* Assessment and Standards Division, Office of Transportation and Air Quality; EPA-420-R-16-003; January 2016.

4. U.S. Environmental Protection Agency. *MOVES2014a User Interface Reference Manual*. Assessment and Standards Division, Office of Transportation and Air Quality; EPA-420-B-16-085; November 2016.

5. U.S. Department of Transportation. *Traffic Monitoring Guide*. Federal Highway Administration (FHWA); Office of Highway Policy Information; Updated October 2016.

6. U.S. Department of Transportation. *Highway Performance Monitoring System – Field Manual*. Federal Highway Administration (FHWA); Office of Highway Policy Information; Office of Management & Budget (OMB) Control No. 2125-0028; December 2016.

Appendix

Appendix A - Tables mentioned in body of document

Table 1: Input Data Files

CDM (tab) Name	Data Source (file) Name
Source Type Population	sourceTypeYear
Age Distribution	sourceTypeAgeDistribution
Road Type Distribution	roadTypeDistribution
Vehicle Type VMT	HPMSVTypeYear
	monthVMTFraction
	dayVMTFraction
	hourVMTFraction

Table 2: Number of Vehicles in the TDOR July 2015 Initial Data Extraction

HPMS ID	HPMS Vehicle Type	TDOR Extraction	MOVES ID	MOVES Source Type	TDOR Extraction
10	Motorcycle	158,643	11	Motorcycle	158,643
20	Passenger Car	4,215,201	21	Passenger Car	4,215,201
30	Other 2 axle-4 tire Vehicles	872,451	31	Passenger Truck	872,247
			32	Light Commercial Truck	204
40	Buses	3,261	41	Intercity Bus	772
			42	Transit Bus	1,459
			43	School Bus	1,030
50	Single Unit Trucks	263,506	51	Refuse Truck	326
			52	Single Unit Short-haul Truck	256,030
			53	Single Unit Long-haul Truck	na
			54	Motor Home	7,150
60	Combination Trucks	na	61	Combination Short-haul Truck	na
			62	Combination Long-haul Truck	na
	Total	**5,513,062**		**Total**	**5,513,062**

Note: vehicle data from HPMS ID 20 & 30 will be combined, assigned ID 25, and called Light Duty Vehicles - Short and Long Wheelbase for evaluation in MOVES; na = not available

Table 3: Number of Vehicles in the TDOR January 2016 Initial Data Extraction

HPMS ID	HPMS Vehicle Type	TDOR Extraction	MOVES ID	MOVES Source Type	TDOR Extraction
10	Motorcycle	158,164	11	Motorcycle	158,164
20	Passenger Car	4,089,601	21	Passenger Car	4,089,601
30	Other 2 axle-4 tire Vehicles	885,908	31	Passenger Truck	885,721
			32	Light Commercial Truck	187
40	Buses	3,619	41	Intercity Bus	787
			42	Transit Bus	1,470
			43	School Bus	1,362
50	Single Unit Trucks	262,122	51	Refuse Truck	313
			52	Single Unit Short-haul Truck	254,456
			53	Single Unit Long-haul Truck	na
			54	Motor Home	7,353
60	Combination Trucks	na	61	Combination Short-haul Truck	na
			62	Combination Long-haul Truck	na
	Total	**5,399,414**		**Total**	**5,399,414**

Note: vehicle data from HPMS ID 20 & 30 will be combined, assigned ID 25, and called Light Duty Vehicles - Short and Long Wheelbase for evaluation in MOVES; na = not available

Table 4: HPMS 2015 DVMT for Rural and Urban Roads

Reg	Co #	County	Interstate		Freeways		Principal Arterial		Minor Arterial		Major Collector	Major Collector	Minor Collector	Minor Collector	Local		County Total
			Rural	Urban	Rural	Urban	Rural	Urban	Rural	Urban	Rural	Urban	Urban	Rural	Rural	Urban	
1	1	ANDERSON	405,665	156,382	0	0	33,097	774,241	0	272,853	129,441	117,058	66,351	62,737	59,018	404,647	2,481,490
3	2	BEDFORD	17,933	0	0	0	168,841	202,795	165,643	142,763	94,501	52,294	754	94,834	92,083	92,829	1,125,270
4	3	BENTON	303,774	0	0	0	132,956	0	64,727	0	90,597	0	0	47,986	41,116	0	681,156
2	4	BLEDSOE	0	0	0	0	117,380	0	40,796	0	24,459	0	0	48,562	44,092	0	275,289
1	5	BLOUNT	0	96,325	0	31,982	190,577	1,057,074	97,045	464,311	50,646	246,710	190,331	32,351	93,123	609,538	3,160,013
2	6	BRADLEY	159,002	847,726	0	147,763	0	571,847	37,343	496,066	62,060	185,730	53,041	33,679	56,761	658,236	3,309,254
1	7	CAMPBELL	591,072	484,165	0	0	32,000	278,309	35,103	14,263	84,321	32,932	43,344	73,766	68,862	117,834	1,855,971
2	8	CANNON	0	0	0	0	129,268	0	72,674	0	32,992	0	0	42,711	38,047	0	315,692
4	9	CARROLL	22,618	0	0	0	204,091	59,058	185,329	17,605	98,887	13,842	657	61,766	61,076	22,560	747,489
1	10	CARTER	0	52,993	0	0	73,197	345,325	120,725	223,420	46,000	65,234	7,301	28,201	43,670	100,080	1,106,146
3	11	CHEATHAM	545,573	0	0	0	0	0	336,028	0	176,560	0	0	99,147	112,768	0	1,270,076
4	12	CHESTER	0	0	0	0	44,954	78,444	85,624	21,260	41,489	40,641	3,916	33,046	31,833	42,501	423,708
1	13	CLAIBORNE	0	0	0	0	412,119	0	148,184	0	33,485	0	0	100,193	97,532	0	791,513
2	14	CLAY	0	0	0	0	72,070	0	40,520	0	12,053	0	0	18,400	28,978	0	172,021
1	15	COCKE	299,600	240,659	0	0	0	151,663	218,461	69,997	46,176	10,835	12,504	60,156	82,790	45,175	1,238,016
2	16	COFFEE	800,652	372,590	0	0	68,429	337,066	29,161	241,102	120,439	94,931	17,457	121,978	101,443	203,664	2,508,912
4	17	CROCKETT	0	0	0	0	259,551	0	43,904	0	118,326	0	0	46,952	36,062	0	504,795
2	18	CUMBERLAND	856,115	222,906	0	0	113,131	164,795	87,728	173,288	186,730	104,941	10,402	78,611	118,491	314,320	2,431,458
3	19	DAVIDSON	656,063	9,365,125	0	1,731,113	24,345	3,595,501	295,367	3,311,279	52,979	973,522	38,721	71,626	74,123	3,514,743	23,704,507
4	20	DECATUR	194,715	0	0	0	171,048	0	19,401	0	38,048	0	0	31,872	32,541	0	487,625
2	21	DE KALB	0	0	0	0	0	0	271,910	0	55,410	0	0	44,601	69,938	0	441,859
3	22	DICKSON	397,911	293,954	0	0	53,200	262,898	298,926	160,087	84,617	88,620	9,644	75,895	90,305	131,501	1,947,558
4	23	DYER	115,014	54,117	0	27,457	143,982	284,782	32,327	112,362	83,704	111,087	31,797	61,555	48,570	161,077	1,267,831
4	24	FAYETTE	495,946	0	0	0	275,010	247,083	232,386	36,508	124,521	39,119	0	85,611	81,473	76,349	1,694,006
2	25	FENTRESS	0	0	0	0	155,708	0	93,185	0	40,827	0	0	76,748	115,496	0	481,964
2	26	FRANKLIN	0	0	0	0	170,505	192,925	67,778	97,004	146,886	34,108	8,173	62,614	86,615	83,602	950,210
4	27	GIBSON	0	0	0	0	224,969	225,709	158,034	47,315	172,891	25,049	4,215	108,256	93,675	45,105	1,105,218
3	28	GILES	435,484	0	0	0	138,897	70,688	197,505	72,972	88,688	11,686	6,141	90,854	83,046	23,010	1,218,971
1	29	GRAINGER	0	0	0	0	240,941	0	169,053	0	75,875	0	0	60,003	72,718	0	618,590
1	30	GREENE	835,414	0	0	0	112,246	498,727	153,959	137,541	155,660	61,705	42,606	159,420	157,042	177,697	2,492,017
2	31	GRUNDY	256,599	0	0	0	276	0	132,017	0	79,423	0	0	13,533	34,813	0	516,661
1	32	HAMBLEN	263,580	27,872	0	0	564	680,015	0	257,022	57,631	141,933	23,800	36,880	48,858	259,123	1,797,278
2	33	HAMILTON	0	2,793,778	0	1,238,575	172,306	2,060,315	60,014	2,119,262	10,309	393,360	109,732	68,457	54,127	1,226,135	10,306,370
1	34	HANCOCK	0	0	0	0	0	0	57,391	0	15,447	0	0	13,872	14,410	0	101,120
4	35	HARDEMAN	0	0	0	0	147,035	93,987	188,868	14,076	27,448	6,836	1,683	83,795	59,145	15,303	638,176
4	36	HARDIN	0	0	0	0	91,489	124,923	196,000	56,006	61,540	25,781	2,400	49,773	53,189	57,142	718,243

(continued)

Reg	Co #	County	Interstate		Freeways		Principal Arterial		Minor Arterial		Major Collector	Major Collector	Minor Collector	Minor Collector	Local		County Total
			Rural	Urban	Rural	Urban	Rural	Urban	Rural	Urban	Rural	Urban	Urban	Rural	Rural	Urban	
1	37	HAWKINS	0	0	0	0	208,225	351,137	143,870	62,162	73,910	38,764	18,360	72,706	117,699	90,573	1,177,406
4	38	HAYWOOD	788,757	29,118	0	0	27,110	63,176	109,184	49,921	96,338	15,271	1,378	38,532	36,929	27,272	1,282,986
4	39	HENDERSON	833,767	0	0	0	159,754	177,161	105,696	21,840	76,460	26,409	2,704	51,106	56,836	49,804	1,561,537
4	40	HENRY	0	0	0	0	281,141	176,003	25,643	42,972	136,439	32,828	7,679	46,937	71,477	58,435	879,554
3	41	HICKMAN	483,224	0	0	0	16,781	0	337,919	0	66,536	0	0	64,248	71,219	0	1,039,927
3	42	HOUSTON	0	0	0	0	0	0	83,914	0	36,733	0	0	14,606	19,536	0	154,789
3	43	HUMPHREYS	449,845	0	0	0	0	0	281,225	0	20,241	0	0	94,739	60,562	0	906,612
2	44	JACKSON	0	0	0	0	0	0	133,171	0	40,252	0	0	24,489	29,683	0	227,595
1	45	JEFFERSON	1,283,465	23,004	0	0	0	176,046	335,150	90,023	207,319	18,276	10,343	103,050	126,574	39,969	2,413,219
1	46	JOHNSON	0	0	0	0	4,322	0	178,724	0	89,510	0	0	29,393	42,292	0	344,241
1	47	KNOX	572,299	5,551,670	0	126,956	0	2,658,307	84,402	2,415,194	108,567	590,900	397,986	106,997	106,364	2,816,261	15,535,903
4	48	LAKE	0	0	0	0	0	0	56,796	0	10,964	0	0	11,802	8,861	0	88,423
4	49	LAUDERDALE	0	0	0	0	173,782	116,203	9,378	38,427	99,160	17,636	385	51,575	52,971	23,765	583,282
3	50	LAWRENCE	0	0	0	0	334,362	179,858	24,962	77,422	116,748	19,777	2,325	106,962	157,448	45,697	1,065,561
3	51	LEWIS	0	0	0	0	91,569	0	67,396	0	9,353	0	0	16,086	18,358	0	202,762
3	52	LINCOLN	0	0	0	0	209,325	260,873	37,452	20,614	104,355	34,813	27,185	82,840	84,313	85,258	947,028
1	53	LOUDON	451,103	746,266	0	0	118,777	314,065	61,725	200,671	38,927	50,709	41,217	71,275	51,266	168,173	2,314,174
2	54	MC MINN	873,669	161,312	0	0	101,677	157,658	227,134	149,595	120,807	81,006	9,386	99,080	119,480	125,792	2,226,596
4	55	MC NAIRY	0	0	0	0	423,869	0	108,589	0	87,392	0	0	90,491	71,351	0	781,692
3	56	MACON	0	0	0	0	188,768	0	41,019	0	87,990	0	0	72,049	66,529	0	456,355
4	57	MADISON	617,787	568,164	0	0	296,861	868,985	58,578	500,682	83,726	248,026	19,692	123,458	77,757	464,180	3,927,896
2	58	MARION	1,196,646	156,440	0	0	149,897	34,402	87,627	0	164,760	74,169	17,291	44,763	50,103	139,699	2,115,797
3	59	MARSHALL	278,356	22,163	0	0	0	90,823	263,256	82,185	74,129	26,460	1,023	47,734	65,598	40,057	991,784
3	60	MAURY	482,226	64,226	0	205,162	204,199	697,497	222,154	87,158	102,629	161,544	90,655	104,839	84,538	314,968	2,821,795
2	61	MEIGS	0	0	0	0	29,811	0	182,013	0	29,521	0	0	33,372	38,789	0	313,506
1	62	MONROE	203,611	75,573	0	0	160,845	141,207	236,694	75,670	85,715	16,277	42,683	105,171	136,346	57,451	1,337,243
3	63	MONTGOMERY	260,018	559,959	0	0	85,635	1,082,709	245,331	935,544	121,644	210,785	806	114,790	161,622	600,319	4,379,162
3	64	MOORE	0	0	0	0	93,870	1,112	0	0	24,213	9	0	31,470	26,462	0	177,136
1	65	MORGAN	0	0	0	0	97,818	0	129,982	1,594	37,849	0	71	65,584	51,411	0	384,309
4	66	OBION	0	0	0	0	327,222	140,654	97,817	38,591	108,497	25,248	486	69,865	74,253	28,519	911,152
2	67	OVERTON	0	0	0	0	296,368	0	98,505	0	60,032	0	0	52,674	68,552	0	576,131
3	68	PERRY	0	0	0	0	64,824	0	75,985	0	20,506	0	0	25,574	29,689	0	216,578
2	69	PICKETT	0	0	0	0	68,760	0	1,469	0	16,591	0	0	13,733	20,099	0	120,652
2	70	POLK	0	0	0	0	301,583	0	30,679	0	22,260	0	0	51,328	89,756	0	495,606
2	71	PUTNAM	1,079,260	519,231	0	158,237	13,333	301,277	91,954	310,776	107,927	139,811	32,841	72,566	101,018	343,970	3,272,201
2	72	RHEA	0	0	0	0	206,434	178,727	124,853	55,474	28,786	27,390	16,326	52,281	58,389	51,769	800,429

(continued)

Reg	Co #	County	Interstate		Freeways		Principal Arterial		Minor Arterial		Major Collector	Major Collector	Minor Collector	Minor Collector	Local		County Total
			Rural	Urban	Rural	Urban	Rural	Urban	Rural	Urban	Rural	Urban	Urban	Rural	Rural	Urban	
1	73	ROANE	266,705	617,474	0	0	59,706	346,963	61,641	186,201	56,628	29,185	43,369	54,508	55,059	121,567	1,899,006
3	74	ROBERTSON	830,040	503,616	0	0	0	292,433	238,846	128,306	174,167	123,299	25,178	83,312	100,010	212,866	2,712,073
3	75	RUTHERFORD	222,044	2,529,293	0	291,720	538,864	1,415,231	105,258	1,366,428	151,241	711,778	33,636	92,260	100,438	1,585,875	9,144,066
1	76	SCOTT	0	0	0	0	185,082	0	94,142	0	52,933	0	0	50,153	71,221	0	453,531
2	77	SEQUATCHIE	0	0	0	0	271,650	0	4,799	151	43,314	0	0	35,265	46,704	0	401,883
1	78	SEVIER	0	348,123	0	0	226,527	982,934	452,377	332,193	149,873	219,204	31,450	124,015	431,738	571,525	3,869,959
4	79	SHELBY	114,268	5,985,563	0	1,473,889	334,702	5,635,355	203,129	6,100,558	16,017	1,568,319	10,233	166,874	144,342	3,583,816	25,337,065
3	80	SMITH	676,833	0	0	0	0	0	225,831	0	63,693	0	0	47,826	39,916	0	1,054,099
3	81	STEWART	0	0	0	0	201,772	0	43,302	0	44,364	0	0	28,500	52,903	0	370,841
1	82	SULLIVAN	55,841	1,014,423	0	178,567	138,385	1,180,121	66,623	781,161	62,598	201,803	13,127	53,021	128,571	528,028	4,402,269
3	83	SUMNER	0	339,471	0	664,797	270,287	803,081	176,856	437,863	118,800	495,246	22,943	89,434	120,721	877,139	4,416,638
4	84	TIPTON	0	0	0	0	112,388	386,667	52,532	104,599	86,093	38,407	23,235	99,575	103,584	109,404	1,116,484
3	85	TROUSDALE	0	0	0	0	65,829	0	102,753	0	26,830	0	0	20,823	19,074	0	235,309
1	86	UNICOI	145,148	231,853	0	0	0	0	11,473	60,529	47,208	35,851	3,930	14,066	12,026	73,121	635,205
1	87	UNION	0	0	0	0	0	0	158,749	0	86,349	0	0	38,521	58,225	0	341,844
2	88	VAN BUREN	0	0	0	0	86,428	0	36,312	0	21,922	0	0	22,083	19,507	0	186,252
2	89	WARREN	0	0	0	47,807	203,211	189,780	87,044	105,901	93,952	26,145	5,346	63,544	92,978	65,118	980,826
1	90	WASHINGTON	138,169	708,542	0	0	125,426	713,809	146,951	547,144	66,319	186,271	20,564	78,932	88,722	400,230	3,221,079
3	91	WAYNE	0	0	0	0	84,817	0	103,995	0	47,966	0	0	51,993	53,522	0	342,293
4	92	WEAKLY	0	0	0	0	257,594	108,592	31,253	58,629	158,411	13,397	646	63,846	75,546	36,716	804,630
2	93	WHITE	0	0	0	0	103,164	211,838	81,107	50,269	48,460	29,594	16,431	57,859	47,228	65,807	711,757
3	94	WILLIAMSON	67,290	2,052,668	0	0	797,086	846,519	265,062	844,564	138,114	608,819	141,481	149,365	116,703	1,401,511	7,429,182
3	95	WILSON	382,402	1,246,687	0	36,345	313,368	687,794	217,144	470,596	143,295	255,208	61,177	143,115	86,269	436,167	4,479,567
STATE TOTALS			20,405,503	39,063,431	0	6,360,370	13,287,390	34,327,167	11,800,541	25,389,969	7,436,399	9,276,588	1,878,538	6,167,496	7,046,966	24,022,992	206,463,350
HPMS AREAWIDE DVMT			20,406	39,063	0	6,360	13,287	34,327	11,801	25,390	7,436	9,277	1,879	6,167	7,047	24,023	206,463

Table 5: Class Count 2015 Summary for the Rural and Urban Road System

Functional Class	(1) Rural Interstate	(2) Rural Principal Arterial	(3) Rural Freeway	(6) Rural Minor Arterial	(7) Rural Major Collector	(8) Rural Minor Collector	(11) Urban Interstate	(12) Urban Freeway	(14) Urban Principal Arterial	(16) Urban Minor Arterial	(17) Urban Major Collector	(18) Urban Minor Collector
Motorcycles (1)	0.64 %	1.15 %	0.00 %	0.68 %	0.65 %	0.49 %	0.56 %	0.41 %	0.79 %	0.66 %	0.50 %	0.61 %
Cars (2)	55.27 %	64.32 %	0.00 %	68.39 %	67.36 %	69.75 %	62.26 %	71.88 %	69.94 %	72.58 %	78.50 %	72.93 %
Pick-ups, Panels & Vans (3)	14.51 %	25.10 %	0.00 %	25.27 %	27.65 %	27.29 %	16.52 %	25.19 %	20.78 %	20.53 %	19.20 %	23.89 %
Total Passenger Vehicles (2 +3)	**69.78 %**	**89.42 %**	**0.00 %**	**93.66 %**	**95.01 %**	**97.04 %**	**78.78 %**	**97.07 %**	**90.72 %**	**93.11 %**	**97.70 %**	**96.82 %**
Buses (4)	0.23 %	0.07 %	0.00 %	0.03 %	0.04 %	0.02 %	0.14 %	0.03 %	0.03 %	0.03 %	0.02 %	0.02 %
Dual Rear Trucks (5)	1.21 %	1.12 %	0.00 %	0.90 %	1.11 %	0.76 %	0.83 %	1.01 %	0.75 %	0.78 %	0.68 %	0.71 %
3-Axle Trucks (6)	0.75 %	1.12 %	0.00 %	0.81 %	0.80 %	0.50 %	0.47 %	0.29 %	0.91 %	0.68 %	0.28 %	0.87 %
4-Axle Trucks (7)	0.33 %	0.39 %	0.00 %	0.27 %	0.22 %	0.14 %	0.10 %	0.03 %	0.82 %	0.53 %	0.06 %	0.25 %
Total Single Unit Trucks (5+6+7)	**2.29 %**	**2.63 %**	**0.00 %**	**1.98 %**	**2.13 %**	**1.40 %**	**1.40 %**	**1.33 %**	**2.48 %**	**1.99 %**	**1.02 %**	**1.83 %**
25-1, 35-1, 25-2 (8)	1.90 %	1.23 %	0.00 %	0.82 %	0.66 %	0.41 %	1.59 %	0.51 %	1.62 %	1.49 %	0.39 %	0.40 %
35-2, 25-3 (9)	21.80 %	4.09 %	0.00 %	2.48 %	1.16 %	0.42 %	16.00 %	0.59 %	1.42 %	0.77 %	0.12 %	0.19 %
35-3, 35-4 (10)	0.44 %	0.34 %	0.00 %	0.09 %	0.05 %	0.02 %	0.16 %	0.02 %	0.30 %	0.17 %	0.02 %	0.02 %
Total Semi Combination (8+9+10)	**24.14 %**	**5.66 %**	**0.00 %**	**3.39 %**	**1.87 %**	**0.85 %**	**17.75 %**	**1.12 %**	**3.34 %**	**2.43 %**	**0.53 %**	**0.61 %**
25-1-2 (11)	1.73 %	0.38 %	0.00 %	0.09 %	0.17 %	0.14 %	0.84 %	0.00 %	0.94 %	0.75 %	0.09 %	0.02 %
25-2-2, 35-1-2 (12)	0.80 %	0.11 %	0.00 %	0.07 %	0.03 %	0.01 %	0.43 %	0.01 %	0.51 %	0.35 %	0.03 %	0.03 %
Any 7 Axle (13)	0.38 %	0.57 %	0.00 %	0.12 %	0.09 %	0.06 %	0.10 %	0.04 %	1.19 %	0.69 %	0.10 %	0.07 %
Total Twin Trailer Trucks (11+12+13)	**2.91 %**	**1.06 %**	**0.00 %**	**0.28 %**	**0.29 %**	**0.21 %**	**1.37 %**	**0.05 %**	**2.64 %**	**1.79 %**	**0.22 %**	**0.12 %**
Total Tractor Trailer	**27.05 %**	**6.72 %**	**0.00 %**	**3.67 %**	**2.16 %**	**1.06 %**	**19.12 %**	**1.17 %**	**5.98 %**	**4.22 %**	**0.75 %**	**0.73 %**
Total Trucks	**29.34 %**	**9.35 %**	**0.00 %**	**5.65 %**	**4.29 %**	**2.46 %**	**20.52 %**	**2.50 %**	**8.46 %**	**6.21 %**	**1.77 %**	**2.56 %**
Total Vehicles	**99.99 %**	**99.99 %**	**0.00 %**	**100.02 %**	**99.99 %**	**100.01 %**	**100.00 %**	**100.01 %**	**100.00 %**	**100.01 %**	**99.99 %**	**100.01 %**

Table 6: HPMS 2016 DVMT for Rural and Urban Roads

Reg	Co #	County	Interstate		Freeways		Principal Arterial		Minor Arterial		Major Collector	Major Collector	Minor Collector	Minor Collector	Local		County Total
			Rural	Urban	Rural	Urban	Rural	Urban	Rural	Urban	Rural	Urban	Urban	Rural	Rural	Urban	
1	1	ANDERSON	408,099	156,513	0	0	35,977	805,654	0	286,929	139,133	115,657	67,852	65,937	61,345	400,191	2,543,287
3	2	BEDFORD	18,356	0	0	0	167,817	208,226	175,792	153,395	96,900	53,309	778	98,012	94,737	94,513	1,161,835
4	3	BENTON	272,154	0	0	0	134,578	0	65,657	0	94,946	0	0	50,902	42,935	0	661,172
2	4	BLEDSOE	0	0	0	0	106,514	0	40,466	0	24,840	0	0	48,769	44,440	0	265,029
1	5	BLOUNT	0	96,309	0	33,689	186,337	1,071,205	93,338	488,534	55,179	261,047	209,192	33,993	96,077	648,773	3,273,673
2	6	BRADLEY	157,517	801,190	0	156,443	0	577,343	38,265	506,624	66,341	182,662	54,463	34,102	57,551	650,073	3,282,574
1	7	CAMPBELL	594,898	481,182	0	0	33,134	282,345	35,773	14,444	88,344	37,506	41,985	74,875	69,527	132,218	1,886,231
2	8	CANNON	0	0	0	0	133,361	0	77,766	0	34,755	0	0	42,826	35,767	0	324,475
4	9	CARROLL	19,774	0	0	0	205,749	61,868	176,957	18,204	96,607	14,606	1,044	62,437	61,668	23,727	742,641
1	10	CARTER	0	50,572	0	0	77,346	343,085	126,814	178,510	56,750	113,746	7,906	29,224	44,813	144,696	1,173,462
3	11	CHEATHAM	563,411	0	0	0	0	0	350,406	0	182,260	0	0	101,272	114,669	0	1,312,018
4	12	CHESTER	0	0	0	0	47,099	79,514	88,157	21,967	38,622	38,664	3,961	34,125	32,557	40,569	425,235
1	13	CLAIBORNE	0	0	0	0	441,975	0	149,361	0	35,784	0	0	103,159	99,809	0	830,088
2	14	CLAY	0	0	0	0	74,154	0	41,273	0	11,608	0	0	18,349	28,826	0	174,210
1	15	COCKE	316,675	226,098	0	0	0	153,202	213,954	70,390	47,798	11,306	13,698	63,531	86,011	46,723	1,249,386
2	16	COFFEE	837,560	381,931	0	0	78,984	336,406	30,055	238,850	120,764	92,816	17,370	121,757	101,460	199,652	2,557,605
4	17	CROCKETT	0	0	0	0	262,936	0	44,940	0	124,268	0	0	46,971	36,128	0	515,243
2	18	CUMBERLAND	972,574	246,782	0	0	115,531	160,522	91,726	180,643	194,323	121,277	10,321	77,174	116,965	360,860	2,648,698
3	19	DAVIDSON	711,022	9,620,032	0	1,937,661	168,492	4,553,660	194,408	1,679,737	69,332	1,632,144	28,165	31,330	68,999	3,887,395	24,582,377
4	20	DECATUR	170,215	0	0	0	177,331	0	20,135	0	38,805	0	0	32,498	33,114	0	472,098
2	21	DE KALB	0	0	0	0	0	0	283,757	0	59,010	0	0	45,309	70,721	0	458,797
3	22	DICKSON	451,887	303,455	0	0	0	244,088	320,512	164,586	88,572	89,521	9,790	76,996	91,474	132,793	1,973,674
4	23	DYER	119,527	55,510	0	51,040	161,051	279,196	33,815	103,735	87,750	117,707	22,932	61,168	48,327	160,656	1,302,414
4	24	FAYETTE	535,558	0	64,643	36,216	247,104	207,540	210,318	42,492	124,805	29,189	0	85,763	81,098	70,651	1,735,377
2	25	FENTRESS	0	0	0	0	164,866	0	93,833	0	40,341	0	0	79,189	119,042	0	497,271
2	26	FRANKLIN	0	0	0	0	167,680	196,650	73,146	100,018	148,686	33,590	8,156	62,011	86,430	82,471	958,838
4	27	GIBSON	0	0	0	0	223,964	225,713	156,290	47,923	176,742	26,310	4,218	108,543	93,877	47,121	1,110,701
3	28	GILES	508,796	0	0	0	146,613	71,618	212,522	72,661	93,417	12,079	6,178	92,075	83,993	23,708	1,323,660
1	29	GRAINGER	0	0	0	0	227,181	0	179,640	0	79,538	0	0	60,909	73,548	0	620,816
1	30	GREENE	894,404	0	0	0	117,272	476,806	163,256	144,813	150,882	67,179	44,622	163,817	160,773	180,583	2,564,407
2	31	GRUNDY	257,105	0	0	0	268	0	133,128	0	77,381	0	0	12,046	31,590	0	511,518
1	32	HAMBLEN	281,342	29,216	0	0	918	704,464	0	252,435	57,939	140,536	24,242	37,359	49,346	257,483	1,835,280
2	33	HAMILTON	0	2,809,734	0	1,224,334	171,997	2,062,794	57,896	2,142,940	12,588	435,214	134,785	75,497	57,676	1,323,766	10,509,221
1	34	HANCOCK	0	0	0	0	0	0	58,006	0	15,689	0	0	14,151	14,614	0	102,460
4	35	HARDEMAN	0	0	0	0	148,392	93,999	198,015	14,555	28,019	6,611	1,623	85,105	59,871	14,865	651,055
4	36	HARDIN	0	0	0	0	103,934	147,894	210,705	58,337	46,405	43,916	2,442	50,137	53,485	70,886	788,141

(continued)

Reg	Co #	County	Interstate		Freeways		Principal Arterial		Minor Arterial		Major Collector	Major Collector	Minor Collector	Minor Collector	Local		County Total
			Rural	Urban	Rural	Urban	Rural	Urban	Rural	Urban	Rural	Urban	Urban	Rural	Rural	Urban	
1	37	HAWKINS	0	0	0	0	208,710	349,178	150,934	62,693	75,259	38,916	21,721	74,168	119,051	90,113	1,190,743
4	38	HAYWOOD	793,182	28,313	0	0	25,824	64,392	113,561	49,359	97,587	15,294	1,410	38,946	37,246	27,312	1,292,426
4	39	HENDERSON	724,180	0	0	0	157,230	168,593	109,336	20,389	80,224	26,102	5,377	52,536	58,055	48,620	1,450,642
4	40	HENRY	0	0	0	0	282,586	175,500	26,570	42,792	143,768	32,902	7,642	46,450	70,928	58,545	887,683
3	41	HICKMAN	510,804	0	0	0	0	0	343,301	0	70,908	0	0	64,924	71,851	0	1,061,788
3	42	HOUSTON	0	0	0	0	0	0	85,245	0	37,036	0	0	14,750	19,700	0	156,731
3	43	HUMPHREYS	466,826	0	0	0	0	0	298,614	0	22,886	0	0	103,643	65,192	0	957,161
2	44	JACKSON	0	0	0	0	0	0	138,753	0	43,295	0	0	25,347	30,472	0	237,867
1	45	JEFFERSON	1,285,103	23,406	0	0	0	162,726	304,989	83,402	207,032	18,571	10,321	104,116	127,431	40,688	2,367,785
1	46	JOHNSON	0	0	0	0	4,531	0	172,892	0	88,262	0	0	29,706	42,520	0	337,911
1	47	KNOX	555,432	5,619,597	0	137,893	0	2,703,881	95,852	2,480,082	111,151	705,053	695,194	113,676	110,092	3,184,585	16,512,488
4	48	LAKE	0	0	0	0	0	0	61,710	0	10,675	0	0	12,652	8,943	0	93,980
4	49	LAUDERDALE	0	0	0	0	175,227	116,633	9,873	41,607	91,008	18,600	2,702	52,330	53,518	23,985	585,483
3	50	LAWRENCE	0	0	0	0	305,151	159,894	26,063	88,173	120,181	34,065	2,209	106,248	156,588	57,955	1,056,527
3	51	LEWIS	0	0	0	0	89,645	0	67,778	0	9,171	0	0	16,252	18,481	0	201,327
3	52	LINCOLN	0	0	0	0	206,508	261,374	39,259	19,577	108,874	32,873	25,816	81,613	83,267	80,505	939,666
1	53	LOUDON	419,270	724,444	0	0	122,113	320,926	62,311	204,895	41,455	52,583	46,320	72,552	52,026	173,630	2,292,525
2	54	MC MINN	834,634	151,577	0	0	106,905	159,912	229,001	153,657	119,086	85,955	9,945	101,150	121,172	131,365	2,204,359
4	55	MC NAIRY	0	0	0	0	474,834	0	108,051	0	97,523	0	0	90,569	71,456	0	842,433
3	56	MACON	0	0	0	0	191,497	0	41,993	0	89,626	0	0	72,449	66,833	0	462,398
4	57	MADISON	598,536	532,794	0	0	295,197	849,324	58,985	498,003	87,331	235,524	19,676	123,387	77,725	443,098	3,819,580
2	58	MARION	1,145,798	158,830	0	0	93,722	86,958	90,895	0	160,825	73,075	17,026	43,969	49,411	137,920	2,058,429
3	59	MARSHALL	323,470	25,702	0	0	0	92,581	276,655	77,551	81,740	26,782	1,026	48,645	66,664	40,509	1,061,325
3	60	MAURY	550,544	72,279	87,745	382,442	180,848	494,072	195,601	226,192	114,327	199,319	84,140	56,757	64,757	345,382	3,054,405
2	61	MEIGS	0	0	0	0	30,291	0	184,198	0	30,276	0	0	33,904	39,317	0	317,986
1	62	MONROE	184,933	71,071	0	0	154,708	135,151	233,174	75,942	83,886	14,757	41,132	102,031	132,805	52,554	1,282,144
3	63	MONTGOMERY	272,281	582,780	0	0	87,074	1,016,490	240,044	993,773	110,566	226,686	2,028	101,387	146,019	627,516	4,406,644
3	64	MOORE	0	0	0	0	92,635	1,053	0	0	25,990	8	0	31,918	26,780	0	178,384
1	65	MORGAN	0	0	0	0	97,799	0	133,342	1,677	38,607	0	58	67,855	53,013	0	392,351
4	66	OBION	0	0	0	0	312,319	136,861	100,442	39,965	109,636	26,416	529	71,828	75,717	29,634	903,347
2	67	OVERTON	0	0	0	0	288,446	0	101,215	0	58,692	0	0	52,615	68,487	0	569,455
3	68	PERRY	0	0	0	0	66,795	0	79,094	0	22,814	0	0	25,957	30,048	0	224,708
2	69	PICKETT	0	0	0	0	69,532	0	1,492	0	16,751	0	0	14,216	20,652	0	122,643
2	70	POLK	0	0	0	0	304,689	0	30,088	0	22,827	0	0	59,618	105,614	0	522,836
2	71	PUTNAM	1,074,586	507,261	0	156,196	11,733	290,496	91,353	307,813	109,969	139,817	31,830	74,633	103,399	343,871	3,242,957
2	72	RHEA	0	0	0	0	203,241	175,679	122,295	55,074	28,280	26,890	17,498	52,458	58,531	50,423	790,369

(continued)

Reg	Co #	County	Interstate		Freeways		Principal Arterial		Minor Arterial		Major Collector	Major Collector	Minor Collector	Minor Collector	Local		County Total
			Rural	Urban	Rural	Urban	Rural	Urban	Rural	Urban	Rural	Urban	Urban	Rural	Rural	Urban	
1	73	ROANE	270,100	627,765	0	0	60,414	362,836	63,335	193,592	57,449	28,640	43,733	54,704	55,212	119,644	1,937,424
3	74	ROBERTSON	915,077	540,537	0	0	96,420	315,296	196,422	143,868	119,242	85,491	26,899	74,362	103,173	124,856	2,741,643
3	75	RUTHERFORD	600,836	2,968,423	0	0	203,214	1,161,264	222,223	1,591,135	67,853	765,853	5,241	57,064	88,985	1,608,038	9,340,129
1	76	SCOTT	0	0	0	0	199,641	0	92,218	0	61,263	0	0	54,253	75,257	0	482,632
2	77	SEQUATCHIE	0	0	0	0	271,530	0	4,717	158	44,307	0	0	35,140	46,571	0	402,423
1	78	SEVIER	0	332,805	0	0	253,015	1,060,388	494,462	333,425	156,203	220,770	31,488	125,927	437,693	575,617	4,021,793
4	79	SHELBY	107,851	6,130,332	100,297	1,491,892	374,694	5,730,491	94,076	5,948,355	19,198	1,512,838	7,378	168,212	144,206	3,493,071	25,322,891
3	80	SMITH	692,374	0	0	0	0	0	214,828	0	64,342	0	0	47,755	39,855	0	1,059,154
3	81	STEWART	0	0	0	0	197,891	0	42,224	0	42,661	0	0	28,415	52,779	0	363,970
1	82	SULLIVAN	58,072	1,027,398	0	155,286	140,519	1,182,532	67,578	770,611	71,162	198,176	23,375	45,042	125,237	532,046	4,397,034
3	83	SUMNER	0	359,852	119,626	676,242	271,539	892,972	170,659	349,326	31,903	514,319	66,729	89,003	97,650	834,215	4,474,035
4	84	TIPTON	0	0	0	0	99,380	358,006	51,294	105,506	85,137	37,000	21,659	97,630	102,360	106,200	1,064,172
3	85	TROUSDALE	0	0	0	0	60,426	0	102,587	0	28,373	0	0	21,013	19,179	0	231,578
1	86	UNICOI	148,097	241,688	0	0	0	0	1,801	69,173	45,522	35,704	3,495	14,101	12,048	69,989	641,618
1	87	UNION	0	0	0	0	0	0	170,856	0	88,530	0	0	40,780	61,188	0	361,354
2	88	VAN BUREN	0	0	0	0	87,545	0	35,198	0	20,876	0	0	21,655	19,235	0	184,509
2	89	WARREN	0	0	0	41,213	182,669	182,738	84,212	102,698	89,927	24,181	5,331	62,083	79,240	55,817	910,109
1	90	WASHINGTON	153,909	741,403	0	0	132,493	697,532	148,183	540,512	70,088	185,512	56,386	76,758	89,520	399,215	3,291,511
3	91	WAYNE	0	0	0	0	103,292	0	112,721	0	51,270	0	0	51,375	53,025	0	371,683
4	92	WEAKLY	0	0	0	0	255,891	109,214	31,287	60,861	156,612	14,062	637	63,959	75,809	38,371	806,703
2	93	WHITE	0	0	0	0	99,623	203,958	81,201	49,558	45,989	28,688	17,261	59,838	48,160	63,838	698,114
3	94	WILLIAMSON	914,268	2,153,625	0	8,375	304,847	1,250,442	102,112	588,105	81,057	632,322	3,170	72,410	79,535	1,188,187	7,378,455
3	95	WILSON	555,839	1,412,250	0	74,751	178,885	648,775	237,752	420,887	168,728	289,897	8,323	51,797	52,537	395,896	4,496,317
STATE TOTALS			22,246,876	40,292,656	372,311	6,563,673	12,542,273	35,421,910	11,686,987	23,773,108	7,340,339	10,280,233	2,080,428	5,929,849	6,965,478	24,587,583	210,083,704
HPMS AREAWIDE DVMT			22,247	40,293	372	6,564	12,542	35,422	11,687	23,773	7,340	10,280	2,080	5,930	6,965	24,588	210,084

Table 7: Class Count 2016 Summary for the Rural and Urban Road System

Functional Class	(1) Rural Interstate	(2) Rural Principal Arterial	(3) Rural Freeway	(6) Rural Minor Arterial	(7) Rural Major Collector	(8) Rural Minor Collector	(11) Urban Interstate	(12) Urban Freeway	(14) Urban Principal Arterial	(16) Urban Minor Arterial	(17) Urban Major Collector	(18) Urban Minor Collector
Motorcycles (1)	0.64 %	0.94 %	0.00 %	0.67 %	0.67 %	0.89 %	2.85 %	0.35 %	0.97 %	0.77 %	0.50 %	0.44 %
Cars (2)	55.27 %	62.93 %	0.00 %	67.21 %	67.19 %	67.73 %	72.50 %	67.03 %	66.27 %	71.45 %	75.87 %	72.99 %
Pick-ups, Panels & Vans (3)	14.51 %	26.16 %	0.00 %	26.22 %	27.92 %	28.36 %	8.31 %	24.21 %	22.44 %	21.49 %	20.42 %	23.67 %
Total Passenger Vehicles (2 +3)	**69.78 %**	**89.09 %**	**0.00 %**	**93.43 %**	**95.11 %**	**96.09 %**	**80.81 %**	**91.24 %**	**88.71 %**	**92.94 %**	**96.29 %**	**96.66 %**
Buses (4)	0.23 %	0.06 %	0.00 %	0.03 %	0.03 %	0.03 %	0.36 %	0.15 %	0.11 %	0.03 %	0.02 %	0.02 %
Dual Rear Trucks (5)	1.21 %	1.10 %	0.00 %	0.94 %	1.00 %	0.87 %	0.73 %	2.01 %	1.22 %	0.72 %	0.68 %	0.72 %
3-Axle Trucks (6)	0.75 %	1.04 %	0.00 %	0.82 %	0.85 %	0.59 %	0.69 %	0.74 %	1.01 %	0.67 %	0.47 %	0.85 %
4-Axle Trucks (7)	0.33 %	0.41 %	0.00 %	0.25 %	0.23 %	0.28 %	0.33 %	0.30 %	0.85 %	0.59 %	0.14 %	0.15 %
Total Single Unit Trucks (5+6+7)	**2.29 %**	**2.55 %**	**0.00 %**	**2.01 %**	**2.08 %**	**1.74 %**	**1.75 %**	**3.05 %**	**3.08 %**	**1.98 %**	**1.29 %**	**1.72 %**
25-1, 35-1, 25-2 (8)	1.90 %	1.39 %	0.00 %	0.86 %	0.64 %	0.54 %	0.65 %	1.42 %	2.01 %	1.46 %	0.56 %	0.59 %
35-2, 25-3 (9)	21.80 %	4.57 %	0.00 %	2.61 %	1.15 %	0.46 %	4.36 %	2.73 %	1.65 %	0.71 %	0.79 %	0.35 %
35-3, 35-4 (10)	0.44 %	0.31 %	0.00 %	0.09 %	0.05 %	0.03 %	1.95 %	0.22 %	0.41 %	0.18 %	0.08 %	0.03 %
Total Semi Combination (8+9+10)	**24.14 %**	**6.27 %**	**0.00 %**	**3.56 %**	**1.84 %**	**1.03 %**	**6.96 %**	**4.37 %**	**4.07 %**	**2.35 %**	**1.43 %**	**0.97 %**
25-1-2 (11)	1.73 %	0.39 %	0.00 %	0.11 %	0.14 %	0.12 %	3.18 %	0.32 %	0.95 %	0.80 %	0.18 %	0.05 %
25-2-2, 35-1-2 (12)	0.80 %	0.14 %	0.00 %	0.06 %	0.03 %	0.02 %	3.46 %	0.19 %	0.63 %	0.40 %	0.08 %	0.04 %
Any 7 Axle (13)	0.38 %	0.56 %	0.00 %	0.13 %	0.08 %	0.07 %	0.62 %	0.33 %	1.48 %	0.74 %	0.21 %	0.10 %
Total Twin Trailer Trucks (11+12+13)	**2.91 %**	**1.09 %**	**0.00 %**	**0.30 %**	**0.25 %**	**0.21 %**	**7.26 %**	**0.84 %**	**3.06 %**	**1.94 %**	**0.47 %**	**0.19 %**
Total Tractor Trailer	**27.05 %**	**7.36 %**	**0.00 %**	**3.86 %**	**2.09 %**	**1.24 %**	**14.22 %**	**5.21 %**	**7.13 %**	**4.29 %**	**1.90 %**	**1.16 %**
Total Trucks	**29.34 %**	**9.91 %**	**0.00 %**	**5.87 %**	**4.17 %**	**2.98 %**	**15.97 %**	**8.26 %**	**10.21 %**	**6.27 %**	**3.19 %**	**2.88 %**
Total Vehicles	**99.99 %**	**100.00 %**	**0.00 %**	**100.00 %**	**99.98 %**	**99.99 %**	**99.99 %**	**100.00 %**	**100.00 %**	**100.01 %**	**100.00 %**	**100.00 %**

Table 8: HPMS and MOVES Mapping Scheme

Item	HPMS	MOVES
Vehicle Class (Source Type)	Motorcycle	Motorcycle
	Light Duty Vehicles - Short and Long Wheelbases *	Passenger Car
		Passenger Truck
		Light Commercial Truck
	Buses	Intercity Bus
		Transit Bus
		School Bus
	Single Unit Trucks	Refuse Truck
		Single Unit Short-haul Truck
		Single Unit Long-haul Truck
		Motor Home
	Combination Trucks	Combination Short-haul Truck
		Combination Long-haul Truck
Functional Road System (Road Type)	Rural Interstate & Freeway	Rural Restricted
	Rural Principal Arterial	Rural Unrestricted
	Rural Minor Arterial	
	Rural Major Collector	
	Rural Minor Collector	
	Rural Local	
	Urban Interstate & Freeway	Urban Restricted
	Urban Principal Arterial	Urban Unrestricted
	Urban Minor Arterial	
	Urban Major Collector	
	Urban Minor Collector	
	Urban Local	

*** HPMS includes Passenger Cars and Other 2 axle-4 Tire Vehicles**

Table 9: Final Statewide Source Type Population Data for 2015

MOVES ID	MOVES sourceTypeName	TDOR Extraction
11	Motorcycle	161,235
21	Passenger Car	2,548,305
31	Passenger Truck	2,216,379
32	Light Commercial Truck	344,256
41	Intercity Bus	79
42	Transit Bus	731
43	School Bus	8,858
51	Refuse Truck	2,695
52	Single Unit Short-haul Truck	114,115
53	Single Unit Long-haul Truck	3,758
54	Motor Home	22,414
61	Combination Short-haul Truck	44,615
62	Combination Long-haul Truck	49,357
	Total	**5,516,797**

Table 10: Final Statewide Source Type Population Data for 2016

MOVES ID	MOVES sourceTypeName	TDOR Extraction
11	Motorcycle	160,221
21	Passenger Car	2,520,928
31	Passenger Truck	2,225,466
32	Light Commercial Truck	377,927
41	Intercity Bus	94
42	Transit Bus	1,092
43	School Bus	9,006
51	Refuse Truck	2,777
52	Single Unit Short-haul Truck	117,623
53	Single Unit Long-haul Truck	3,867
54	Motor Home	23,021
61	Combination Short-haul Truck	44,756
62	Combination Long-haul Truck	49,880
	Total	**5,536,658**

Table 11: 5-Year Average Monthly Variation Factors, by Day of Week for 2015

2015	JAN.	FEB.	MAR.	APR.	MAY	JUNE	JULY	AUG.	SEPT.	OCT.	NOV.	DEC.
Rural Interstate												
Sunday	1.29	1.22	1.03	1.01	1.06	0.98	0.95	1.03	1.10	0.99	1.01	1.10
Monday	1.16	1.12	1.03	1.06	1.03	0.98	1.00	1.07	1.08	1.05	1.08	1.07
Tuesday	1.16	1.12	1.05	1.04	1.02	0.98	1.00	1.05	1.06	1.05	1.01	1.02
Wednesday	1.11	1.10	1.00	1.01	0.98	0.94	0.96	1.00	1.05	1.01	0.94	1.01
Thursday	1.08	1.04	0.91	0.92	0.91	0.87	0.90	0.93	0.98	0.94	1.02	0.98
Friday	0.99	0.92	0.80	0.84	0.84	0.80	0.82	0.83	0.86	0.82	0.90	0.91
Saturday	1.17	1.20	0.97	1.03	1.08	0.92	0.92	0.99	1.09	1.03	1.02	1.01
Rural Other												
Sunday	1.50	1.44	1.32	1.22	1.21	1.19	1.18	1.21	1.24	1.25	1.35	1.42
Monday	1.10	1.04	1.02	0.97	0.98	0.94	0.97	0.94	1.01	0.96	0.98	1.04
Tuesday	1.07	1.02	0.98	0.94	0.92	0.93	0.94	0.93	0.93	0.95	0.97	1.02
Wednesday	1.07	1.01	0.96	0.94	0.91	0.92	0.93	0.93	0.93	0.93	0.95	1.01
Thursday	1.03	0.99	0.94	0.90	0.88	0.89	0.91	0.90	0.90	0.90	0.99	0.98
Friday	0.98	0.90	0.90	0.84	0.81	0.82	0.84	0.81	0.81	0.82	0.90	0.92
Saturday	1.24	1.15	1.12	1.02	0.99	0.97	0.98	0.98	1.00	0.99	1.09	1.17
Urban												
Sunday	1.46	1.35	1.21	1.20	1.19	1.14	1.14	1.18	1.22	1.19	1.23	1.33
Monday	1.09	1.03	1.00	0.98	0.99	0.94	0.96	0.96	1.02	0.97	0.99	1.01
Tuesday	1.08	1.00	0.97	0.96	0.94	0.93	0.93	0.94	0.96	0.96	0.95	0.99
Wednesday	1.05	1.01	0.94	0.94	0.92	0.91	0.91	0.92	0.94	0.94	0.93	0.97
Thursday	1.01	0.98	0.89	0.90	0.88	0.87	0.89	0.89	0.90	0.90	0.99	0.95
Friday	0.95	0.88	0.87	0.84	0.82	0.81	0.83	0.82	0.83	0.83	0.90	0.89
Saturday	1.24	1.16	1.08	1.05	1.05	0.99	1.00	1.02	1.06	1.05	1.08	1.14
Recreational												
Sunday	1.41	1.19	1.04	1.00	0.94	0.79	0.71	0.90	0.83	0.76	1.00	1.13
Monday	1.70	1.54	1.16	1.11	1.05	0.87	0.83	1.03	1.06	0.91	1.15	1.31
Tuesday	1.78	1.60	1.22	1.14	1.06	0.83	0.81	1.06	1.11	0.95	1.24	1.28
Wednesday	1.82	1.68	1.20	1.14	1.05	0.85	0.78	1.00	1.11	0.94	1.13	1.28
Thursday	1.61	1.52	1.21	0.99	1.03	0.84	0.76	0.95	1.05	0.89	1.04	1.25
Friday	1.26	1.04	0.97	0.88	0.91	0.73	0.71	0.83	0.91	0.74	0.81	0.95
Saturday	1.09	0.87	0.84	0.87	0.83	0.71	0.66	0.71	0.84	0.68	0.75	0.85

Table 12: 5-Year Average Monthly Variation Factors, by Day of Week for 2016

2016	JAN.	FEB.	MAR.	APR.	MAY	JUNE	JULY	AUG.	SEPT.	OCT.	NOV.	DEC.
Rural Interstate												
Sunday	1.21	1.18	1.01	1.00	1.02	0.93	0.89	0.99	1.05	0.92	0.97	1.05
Monday	1.19	1.19	1.09	1.09	1.04	1.00	0.99	1.08	1.07	1.04	1.09	1.08
Tuesday	1.17	1.14	1.06	1.10	1.07	1.01	1.02	1.05	1.09	1.03	1.00	1.04
Wednesday	1.14	1.11	1.03	1.05	1.01	0.95	0.98	1.01	1.05	1.00	0.98	1.01
Thursday	1.11	1.06	0.91	0.95	0.93	0.88	0.89	0.93	0.96	0.91	1.00	0.97
Friday	1.01	0.92	0.84	0.87	0.84	0.78	0.81	0.84	0.86	0.81	0.89	0.88
Saturday	1.17	1.15	0.94	1.02	1.02	0.88	0.94	0.96	1.06	0.99	0.98	0.99
Rural Other												
Sunday	1.40	1.34	1.23	1.17	1.15	1.15	1.17	1.17	1.19	1.22	1.28	1.31
Monday	1.14	1.07	1.04	1.01	1.00	0.97	0.98	0.97	1.03	0.99	1.02	1.05
Tuesday	1.10	1.04	1.01	0.98	0.95	0.97	0.97	0.95	0.96	0.97	0.99	1.03
Wednesday	1.11	1.06	1.00	0.97	0.94	0.95	0.96	0.94	0.96	0.95	0.98	1.02
Thursday	1.08	1.04	0.96	0.93	0.91	0.92	0.95	0.91	0.92	0.93	1.00	1.00
Friday	1.01	0.94	0.93	0.87	0.85	0.85	0.89	0.84	0.84	0.85	0.91	0.94
Saturday	1.19	1.12	1.08	1.00	0.98	0.98	1.01	0.98	0.99	0.99	1.07	1.11
Urban												
Sunday	1.46	1.40	1.24	1.23	1.24	1.24	1.24	1.26	1.26	1.27	1.32	1.34
Monday	1.08	1.02	1.00	0.98	1.01	0.97	0.99	0.97	1.02	0.98	0.99	1.02
Tuesday	1.05	0.99	0.97	0.95	0.94	0.96	0.96	0.95	0.95	0.96	0.96	1.00
Wednesday	1.06	1.00	0.95	0.94	0.93	0.94	0.97	0.94	0.94	0.94	0.96	1.00
Thursday	1.03	0.98	0.92	0.91	0.90	0.91	0.94	0.92	0.91	0.91	0.99	0.97
Friday	0.96	0.90	0.92	0.87	0.85	0.86	0.90	0.85	0.84	0.85	0.93	0.93
Saturday	1.23	1.14	1.11	1.04	1.04	1.04	1.08	1.04	1.05	1.06	1.10	1.13
Recreational												
Sunday	1.27	1.23	1.04	0.92	0.88	0.73	0.76	0.82	0.81	0.81	1.04	1.19
Monday	1.52	1.58	1.25	1.22	1.13	0.95	0.97	1.17	1.10	1.05	1.34	1.28
Tuesday	1.49	1.73	1.22	1.22	1.15	0.90	0.92	1.13	1.16	1.07	1.43	1.52
Wednesday	1.57	1.66	1.25	1.15	1.15	0.89	0.91	1.12	1.14	1.04	1.38	1.43
Thursday	1.57	1.63	1.20	1.05	1.11	0.85	0.86	1.03	1.07	0.96	1.20	1.35
Friday	1.40	1.26	1.01	0.90	0.94	0.76	0.76	0.88	0.89	0.81	1.06	1.11
Saturday	1.07	0.97	0.86	0.79	0.82	0.65	0.69	0.70	0.76	0.69	0.89	0.94

Appendix B - Equations and sample calculations mentioned in body of document

Equation 1: General formula used to convert default population/VMT data, local DVMT, and local vehicle count summaries into MOVES source type population data

$$Population_{Source\ Type} = A \cdot B \cdot C$$

where:

$$A = \sum (Vehicle\ Fraction_{Road} \cdot DVMT_{Road})_{HPMS}$$

$$B = \left(\frac{Default\ Population_{\ Source\ Type}}{Default\ VMT_{Source\ Type}}\right)_{MOVES}$$

$$C = \frac{(Default\ VMT_{Source\ Type})_{MOVES}}{\sum(Default\ VMT_{Source\ Type})_{HPMS\ to\ MOVES}}$$

Sample Calculations Source Type Population:

Knox County – Combination Long-haul Truck - 2015

$$\begin{aligned} A = [&(0.2551 \cdot 572{,}299) + (0.1597 \cdot 5{,}551{,}670\ ) + (0.0000 \cdot 0) + (0.0471 \cdot 126{,}956) \\ &+ (0.0639 \cdot 0) + (0.0494 \cdot 2{,}658{,}307) + (0.0368 \cdot 84{,}402) \\ &+ (0.0337 \cdot 2{,}415{,}194) + (0.0206 \cdot 108{,}567) + (0.0135 \cdot 590{,}900) \\ &+ (0.0165 \cdot 397{,}986) + (0.0135 \cdot 106{,}997) + (0.0165 \cdot 106{,}364\ ) \\ &+ (0.0135 \cdot 2{,}816{,}261\ )] \cong 1{,}312{,}621\ miles/day \end{aligned}$$

$$B = \left(\frac{2{,}248\ Combination\ Long - haul\ Truck}{209{,}825{,}600\ miles/year}\right)$$

$$\cong 1.07153 \cdot 10^{-5} \frac{Combination\ Long - haul\ Truck}{miles/year}$$

$$C = \frac{209{,}825{,}600\, miles/year}{(63{,}652{,}150 + 209{,}825{,}600)\, miles/year} \cong 0.7672$$

$$Local\ Population_{Combination\ Long-haul\ Truck}$$

$$= 1{,}312{,}621\ \frac{miles}{day} \cdot \left(\frac{1.07153 \cdot 10^{-5}\ CLh\ Truck}{miles/year}\right) \cdot 0.7672 \cdot \left(\frac{365\ days}{year}\right)$$

$$\cong\ 3{,}939\ Combination\ Long - haul\ Truck$$

Knox County - Combination Long-haul Truck - 2016

$$A = [(0.2619 \cdot 555{,}432) + (0.1453 \cdot 5{,}619{,}597\ ) + (0.0000 \cdot 0) + (0.0450\ \cdot 137{,}893)$$
$$+ (0.0633 \cdot 0) + (0.0484 \cdot 2{,}703{,}881) + (0.0366\ \cdot 95{,}852)$$
$$+ (0.0366 \cdot 2{,}480{,}082) + (0.0202 \cdot 111{,}151) + (0.0117\ \cdot 705{,}053)$$
$$+ (0.0160\ \cdot 695{,}194) + (0.0102 \cdot 113{,}676) + (0.0160\ \cdot 110{,}092\ )$$
$$+ (0.0102\ \cdot 3{,}184{,}585\ )]\ \cong 1{,}242{,}579\ miles/day$$

$$B = \left(\frac{2{,}349\ Combination\ Long - haul\ Truck}{216{,}964{,}100\ miles/year}\right)$$

$$\cong 1.08249 \cdot 10^{-5}\, \frac{Combination\ Long - haul\ Truck}{miles/year}$$

$$C = \frac{216{,}964{,}100\, miles/year}{(67{,}759{,}260 + 216{,}964{,}100)\, miles/year} \cong 0.7620$$

$$Local\ Population_{Combination\ Long-haul\ Truck}$$
$$= 1{,}242{,}579\ \frac{miles}{day} \cdot \left(\frac{1.08249 \cdot 10^{-5}\ CLh\ Truck}{miles/year}\right) \cdot 0.7620 \cdot \left(\frac{365\ days}{year}\right)$$
$$\cong 3{,}741\ Combination\ Long-haul\ Truck$$

Equation 2: General formula used to convert HPMS local DVMT and vehicle classification summaries into MOVES road type VMT distributions by source types

$$VMT\ Fraction_{\ MOVES\ Road\ Type\ for\ Source\ Type} = \left({}^{A}/_{B}\right)_{Road\ Type\ for\ Source\ Type}$$

$$A = \left(\sum Fraction_{Vehicle\ Type} \cdot Local\ DVMT\right)_{HPMS\ to\ MOVES}$$

$$B = \left(\sum A_{Road\ Types}\right)_{HPMS\ to\ MOVES}$$

Sample Calculations VMT Distribution:

Knox County – Combination Long-haul Truck - 2015

$$A_{Rural\ Restricted} = \left((0.2551 \cdot 572{,}299) + (0.0000 \cdot 0)\right) = 146{,}014\ miles/day$$

$$A_{Rural\ Unrestricted}$$
$$= \left((0.0639 \cdot 0) + (0.0368 \cdot 84{,}402) + (0.0206 \cdot 108{,}567)\right.$$
$$\left. + (0.0165 \cdot 397{,}986) + (0.0165 \cdot 106{,}364)\right) = 13{,}652\ miles/day$$

$$A_{Urban\ Restricted} = \left((0.1597 \cdot 5{,}551{,}670) + (0.0471 \cdot 126{,}956)\right) = 892{,}639\ miles/day$$

$$A_{Urban\ Unrestricted}$$
$$= \left((0.0494 \cdot 2{,}658{,}307) + (0.0337 \cdot 2{,}415{,}194) + (0.0135 \cdot 590{,}900)\right.$$
$$\left. + (0.0135 \cdot 106{,}997) + (0.0135 \cdot 2{,}816{,}261)\right) = 260{,}316\ miles/day$$

$$B = 146{,}014 + 13{,}652 + 892{,}639 + 260{,}316 = 1{,}312{,}621\ miles/day$$

$$VMT\ Fraction_{\ Rural\ Restricted} = \left(146{,}014\ miles/day \Big/ 1{,}312{,}621\ miles/day\right) = 0.1112$$

$$VMT\ Fraction_{\ Rural\ Unrestricted} = \left(13{,}652\ miles/day \Big/ 1{,}312{,}621\ miles/day\right) = 0.0104$$

$$VMT\ Fraction_{\ Urban\ Restricted} = \left(892{,}639\ miles/day \Big/ 1{,}312{,}621\ miles/day\right) = 0.6800$$

$$VMT\ Fraction_{\ Urban\ Unrestricted} = \left(260{,}316\ miles/day \Big/ 1{,}312{,}621\ miles/day\right)$$
$$= 0.1983$$

Knox County - Combination Long-haul truck - 2016

$$A_{Rural\ Restricted} = \left((0.2619 \cdot 555{,}432) + (0.0000 \cdot 0)\right) = 145{,}492\ miles/day$$

$$A_{Rural\ Unrestricted}$$
$$= \left((0.0633 \cdot 0) + (0.0366 \cdot 95{,}852) + (0.0202 \cdot 111{,}151)\right.$$
$$\left. + (0.0160 \cdot 695{,}194) + (0.0160 \cdot 110{,}092)\right) = 18{,}671\ miles/day$$

$$A_{Urban\ Restricted} = \left((0.1453 \cdot 5{,}619{,}597) + (0.0450 \cdot 137{,}893)\right) = 822{,}660\ miles/day$$

$$A_{Urban\ Unrestricted}$$
$$= \left((0.0484 \cdot 2{,}703{,}881) + (0.0336 \cdot 2{,}480{,}082) + (0.0117 \cdot 705{,}053)\right.$$
$$\left. + (0.0102 \cdot 113{,}676) + (0.0102 \cdot 3{,}184{,}585)\right) = 255{,}756\ miles/day$$

$$B = 145{,}492 + 18{,}671 + 822{,}660 + 255{,}756 = 1{,}242{,}579\ miles/day$$

$$VMT\ Fraction_{\ Rural\ Restricted} = \left(145{,}492\ miles/day \Big/ 1{,}242{,}579\ miles/day\right) = 0.1171$$

$$VMT\ Fraction_{\ Rural\ Unrestricted} = \left(18{,}671\ miles/day \Big/ 1{,}242{,}579\ miles/day\right) = 0.0150$$

$$VMT\ Fraction_{\ Urban\ Restricted} = \left(822{,}660\ miles/day \Big/ 1{,}242{,}579\ miles/day\right) = 0.6621$$

$$VMT\ Fraction_{\ Urban\ Unrestricted} = \left(255{,}756\ miles/day \Big/ 1{,}242{,}579\ miles/day\right)$$
$$= 0.2058$$

Equation 3: General formula used to calculate local AADVMT for HPMS vehicle types

$$AADVMT = \sum (Vehicle\ Fraction_{Road}\ \cdot\ DVMT_{Road})_{\ HPMS}$$

Sample Calculations AAVMT Distribution:

Knox County – Combination long-haul Truck - 2015

$$AADVMT = [(0.2551 \cdot 572{,}299) + (0.1597 \cdot 5{,}551{,}670\ ) + (0.0000 \cdot 0)$$
$$+ (0.0471\ \cdot 126{,}956) + (0.0638 \cdot 0) + (0.0494 \cdot 2{,}658{,}307)$$
$$+ (0.0368\ \cdot 84{,}402) + (0.0337 \cdot 2{,}415{,}194) + (0.0206 \cdot 108{,}567)$$
$$+ (0.0135\ \cdot 590{,}900) + (0.0165\ \cdot 397{,}986) + (0.0135 \cdot 106{,}997)$$
$$+ (0.0165\ \cdot 106{,}364\ ) + (0.0135\ \cdot 2{,}816{,}261\ )] \cong 1{,}312{,}583\ miles/day$$

Knox County – Combination Long-haul Truck - 2016

$$AADVMT = [(0.2619 \cdot 555{,}432) + (0.1453 \cdot 5{,}619{,}597\ ) + (0.0000 \cdot 0)$$
$$+ (0.0450\ \cdot 137{,}893) + (0.0633 \cdot 0) + (0.0484 \cdot 2{,}703{,}881)$$
$$+ (0.0366\ \cdot 95{,}852) + (0.0336 \cdot 2{,}480{,}082) + (0.0202 \cdot 111{,}151)$$
$$+ (0.0117\ \cdot 705{,}053) + (0.0160\ \cdot 695{,}194) + (0.0102 \cdot 113{,}676)$$
$$+ (0.0160\ \cdot 110{,}092\ ) + (0.0102\ \cdot 3{,}184{,}585\ )] \cong 1{,}242{,}579\ miles/day$$