MOVES-Based Mobile Source Emissions Modeling for the Atlanta Nonattainment Area

Table of Contents

Federal Clean Air Act Legislation and Transportation Conformity

The Clean Air Act requires the United States Environmental Protection Agency (USEPA) to set limits on how much of a particular pollutant can be in the air anywhere in the United States. National Ambient Air Quality Standards (NAAQS) are the pollutant limits set by the USEPA; they define the allowable concentration of pollution in the air for six different pollutants – Carbon Monoxide, Lead, Nitrogen Dioxide, Particulate Matter, Ozone, and Sulfur Dioxide.

The Clean Air Act specifies how areas within the country are designated as either "attainment" or "nonattainment" of an air quality standard, and provides USEPA the authority to define the boundaries of nonattainment areas. For areas designated as nonattainment for one or more NAAQS, the Clean Air Act defines a specific timetable to attain the standard and requires that nonattainment areas demonstrate reasonable and steady progress in reducing air pollution emissions until such time that an area can demonstrate attainment. Each state must develop and submit a State Implementation Plan (SIP) that addresses each pollutant for which it fails to meet the NAAQS. Individual state air quality agencies are responsible for defining the overall regional plan to reduce air pollution emissions to levels that will enable attainment and maintenance of the NAAQS. This strategy is articulated through the SIP. In Georgia, the agency responsible for SIP development is the Georgia Environmental Protection Division (GA EPD).

The delineation and implementation of strategies to control emissions from on-road[1] mobile sources is a significant element of the state plan to improve air quality, thereby creating a direct link between transportation and air quality planning activities within a nonattainment area. The process of ensuring that a region's transportation planning activities contribute to attainment of the NAAQS, or "conform" to the purposes of the SIP, is referred to as transportation conformity.   In order to receive federal transportation funds within the nonattainment area, the area must demonstrate through a federally mandated transportation conformity process that the transportation investments, strategies and programs, taken as a whole, contribute to the air quality goals defined in the State's air quality plan.

To ensure that conformity requirements are met, Section 176(c) of the Clean Air Act authorizes the USEPA Administrator to "promulgate criteria and procedures for demonstrating and assuring conformity in the case of transportation plans, programs, and projects." This is accomplished through the Transportation Conformity Rule, developed by the USEPA to outline all federal requirements associated with transportation conformity.   The Transportation Conformity Rule in conjunction with the Metropolitan Planning Regulations direct transportation plan and program development as well as the conformity process. The final conformity rule (last updated in March 2010) incorporates revisions

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[1] On-road, or highway, sources include vehicles used on roads to transport passengers or freight.

resulting from the passage of the Safe, Accountable, Flexible, Efficient Transportation Equity Act: A Legacy for Users (SAFETEA–LU); the latest transportation funding legislation which specifies the process for development of metropolitan transportation plans and programs for urbanized areas.

Mobile source modeling is required to establish emissions inventories that are used by GA EPD to demonstrate progress towards, or attainment of, air quality standards. Emission inventories are incorporated into these SIP demonstrations for air quality planning purposes. They are also used in the transportation conformity process to establish the maximum level of mobile source emissions that an area can produce and still "conform" to the SIP; these maximum levels are referred to as Motor Vehicle Emissions Budgets (MVEB). The modeling process used to develop emissions inventories utilizes the latest Interagency approved planning assumptions and modeling techniques to prepare an emissions inventory for all pollutants (or pollutant precursors) for which a region is in nonattainment.

The Atlanta Regional Commission (ARC) is the federally designated Metropolitan Planning Organization (MPO) for all or portions of 18 counties within the 19-county Atlanta Urbanized Area.[2] ARC is directly responsible for developing both a long-range Regional Transportation Plan (RTP) and a short-range Transportation Improvement Program (TIP) that conform to the air quality goals established in the SIP, according to the guidelines outlined in the Metropolitan Planning Regulations and Transportation Conformity Rule.

A small portion of the Atlanta Urbanized Area extends into Hall County. In February 2003, the Gainesville-Hall County MPO (GHMPO) was designated for the Gainesville Urbanized Area; the planning boundary for the GHMPO covers Hall County in its entirety. Hall County is included both in Atlanta's ozone and fine particulate nonattainment areas. The ARC performs the planning and technical work required by the Transportation Conformity Rule, including, by agreement with the GHMPO, the emissions modeling for Hall County. ARC documents the analysis in a combined Conformity Determination Report (CDR). The United States Department of Transportation (USDOT) approves or disapproves the conformity analysis in consultation with the USEPA. A positive conformity determination is required in order for the RTP and TIP to advance. In addition, all of Carroll County, which is not within an MPO boundary, is included within the Atlanta nonattainment area and included in the travel and emissions modeling effort.

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[2] The ARC metropolitan planning area comprises the City of Atlanta and the counties of Cherokee, Clayton, Cobb, Coweta, DeKalb, Douglas, Fayette, Forsyth, Fulton, Gwinnett, Henry, Paulding and Rockdale, as well as portions of the counties of Barrow, Bartow, Newton, Spalding and Walton.

Current Attainment Status

1997 Eight-Hour Ozone Standard

Effective June 15, 2004, 20 counties (see Figure 1) in the Atlanta area were designated as nonattainment under the eight-hour ozone standard with an initial classification of Marginal. Ozone is not emitted directly by any source; it is formed when Nitrogen Oxides (NO_x) and Volatile Organic Compounds (VOC) combine in the atmosphere in the presence of sunlight. Air pollution control strategies are aimed at controlling NO_x and VOC since they are precursors to ozone formation. The eight-hour ozone nonattainment area encompasses the previous 13-county one-hour ozone maintenance area[3] plus seven additional "ring" counties.[4]

Since designation, the region was reclassified as a moderate ozone nonattainment area in April 2008 with an attainment date of June 15, 2010. MVEBs were established for the 20-county region as part of the Atlanta Early Progress State Implementation Plan for the year 2008. The GA EPD submitted a Reasonable Further Progress Plan in 2009, extending the attainment deadline by one year, due to clean data observations. In the fall of 2009, GA EPD submitted an Attainment Plan for the 1997 eight-hour ozone standard to the USEPA.

1997 Annual PM$_{2.5}$ Standard

On December 17, 2004, the USEPA also designated 20 whole counties and two partial counties (Heard and Putnam, see Figure 1) near the metropolitan Atlanta area as nonattainment under the annual fine particulate matter ($PM_{2.5}$) standard. Particulate matter, or PM, is the term for particles found in the air, including dust, dirt, soot, smoke, and liquid droplets. The primary source of concern in air quality emissions analyses is direct motor vehicle PM emissions, both from the combustion process and from tire and brake wear, and a precursor to PM formation in the atmosphere, NO_x. Particles less than 2.5 micrometers in diameter are referred to as "fine" particles and are believed to pose the greatest health risks. The $PM_{2.5}$ nonattainment area encompasses the previous 13-county one-hour ozone maintenance area plus seven additional "ring" counties: Carroll, Bartow, Hall, Barrow, Walton, Newton, and Spalding counties; and parts of Heard and Putnam counties.

The $PM_{2.5}$ NAAQS has two standards associated with it – an annual standard of 15 micrograms per cubic meter (ug/m^3) averaged over the course of a year, and a daily standard of 35ug/m^3 measured over 24 hours.

Under the $PM_{2.5}$ standard, there is no classification system to determine stringency of emission control measures or attainment year. $PM_{2.5}$ nonattainment areas must attain as soon as possible, but no later

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[3] Cherokee, Clayton, Cobb, Coweta, DeKalb, Douglas, Fayette, Forsyth, Fulton, Gwinnett, Henry, Paulding and Rockdale Counties

[4] Barrow, Bartow, Carroll, Hall, Newton, Spalding and Walton Counties

than April 2010, with an additional five years provided if the state can demonstrate that it is warranted. The PM$_{2.5}$ attainment SIP was submitted to USEPA by GA EPD on July 6, 2010. The GA EPD plans on requesting this SIP not be processed as a result of the pending PM$_{2.5}$ clean data determination and the development of a Maintenance Plan. Until a finalized plan with MVEB is in place, an interim emissions methodology is used to determine conformity of the RTP and TIP.

Figure 1 – Atlanta Nonattainment Area Boundaries
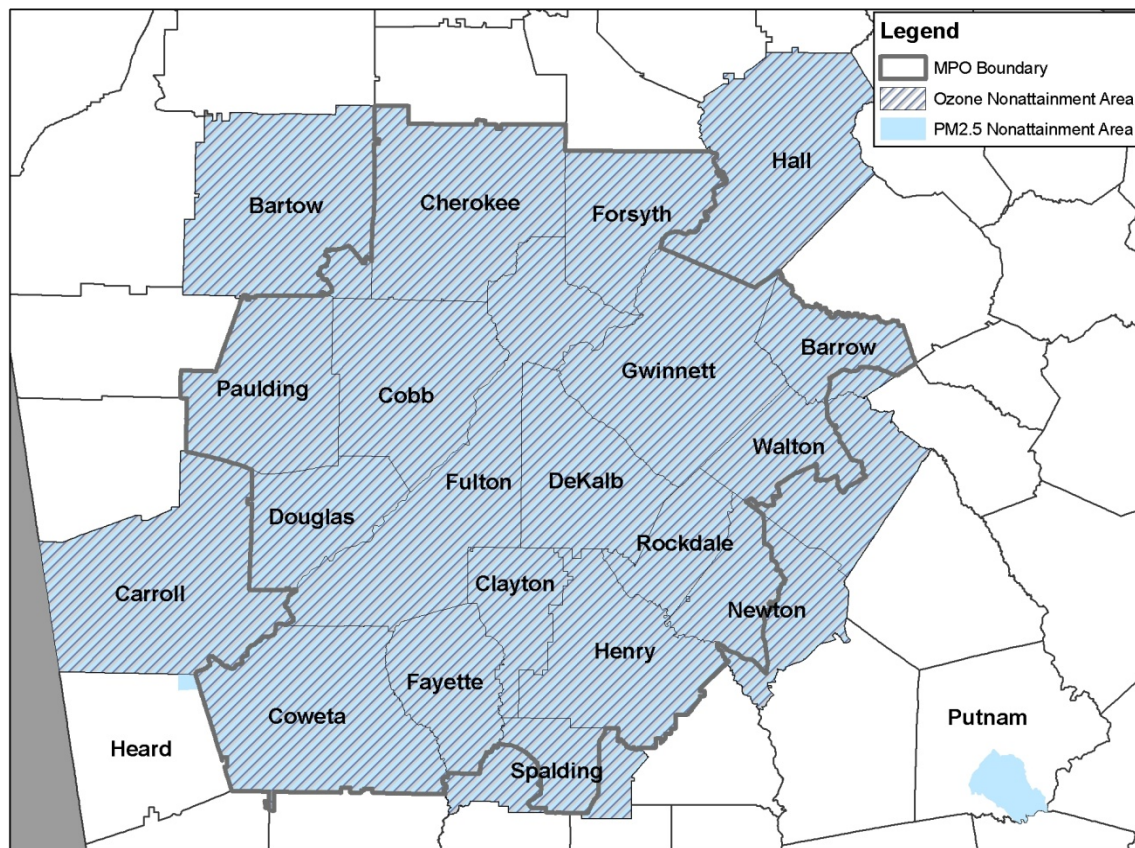
Modeling Assumptions

Emissions Modeling Assumptions

Section 93.105(c)(1)(i) of the Transportation Conformity Rule requires that Interagency partners be provided the opportunity for evaluating and choosing a model and associated methods and assumptions to be used in the regional emissions analysis needed to demonstrate conformity.

The ARC has consulted with the Interagency group as to the required version of the USEPA's mobile source emissions model. This is documented along with the other planning assumptions and modeling inputs in Exhibits 1A and 1B. These documents were submitted to the Interagency consultation group in accordance with Section 93.105(c)(1)(i) of the Transportation Conformity Rule. The documents include assumptions for both the eight-hour ozone and the $PM_{2.5}$ emissions analyses. Interagency approval of these assumptions was granted on August 26, 2011.

Travel Demand Modeling Assumptions

The regional emissions analysis utilized to develop Maintenance Plan MVEBs for both the eight-hour ozone standard and the annual $PM_{2.5}$ standard relies on a methodology which utilizes ARC's 20-county regional travel demand model. A brief outline of the model structure follows. More specific information is available on the ARC's website.[5]

Travel Model Networks

Updated travel model networks were created for each required emissions inventory year (2008 and 2024) to reflect projects in the currently approved Regional Transportation Plan, PLAN 2040. This plan received a positive conformity determination from USDOT, with USEPA concurrence, on September 6, 2011. These projects have been identified by policy makers as the highest priority for transportation investments in the Atlanta region.

ARC's travel demand model was most recently calibrated to the year 2000, with some 2005 interim validations and benchmarking thereafter. Demographic data was developed for use in PLAN 2040 and is outlined in Exhibit 1C.

Within the ARC travel demand model and emissions modeling process, free flow speeds are adjusted to reflect the increase in delay and travel time on a roadway segment as traffic volumes build and congestion levels increase. Table 1 illustrates the speeds by facility and area type used in the travel demand model.

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[5] http://www.atlantaregional.com/transportation/travel-demand-model

Table 1 – Speeds by Facility and Area Type in the ARC Travel Demand Model

	Facility Type	Urban Very High Density	Urban High Density	Urban Medium Density	Urban Low Density	Suburban	Exurban	Rural	Metered Ramps
0	Zone Centroid Connectors	7	11	11	11	11	14	14	
1	Interstate / Freeway Free Flow	55	58	58	61	61	63	65	
2	Parkway	50	50	55	55	57	60	60	
3	HOV Buffer Separated	55	58	58	61	61	63	65	
4	HOV Barrier Separated	55	58	58	61	61	63	65	
5	High Speed Ramp / CD Road	50	50	55	55	57	60	60	15
6	Medium Speed Ramp	50	50	50	50	50	50	50	10
7	Low Speed Ramp	40	40	40	40	40	40	40	10
8	Loop Ramp	30	30	30	30	30	30	30	10
9	Off Ramp w/ Intersection	25	25	25	25	25	25	25	
10	On Ramp w/ Intersection	40	40	40	40	40	40	40	5
11	Expressway	40	42	45	48	52	55	60	
12	Principal Arterial - Class I	26	30	33	36	42	46	55	
13	Principal Arterial - Class II	24	27	30	34	40	44	48	
14	Minor Arterial - Class I	22	25	28	31	38	42	45	
15	Minor Arterial - Class II	20	23	26	29	34	38	42	
16	HOV - Arterial (all classes)	20	27	30	33	36	39	42	

	Facility Type	Urban Very High Density	Urban High Density	Urban Medium Density	Urban Low Density	Suburban	Exurban	Rural	Metered Ramps
17	Major Collector	18	22	25	28	31	34	38	
18	Minor Collector	15	18	21	24	27	30	35	
19	Planned Ramps w/ Intersections	30	30	30	30	30	30	30	5
20	Planned Directional Ramps	45	45	45	45	45	45	45	10

Transit Modeling

The transit portion of ARC's travel demand model was calibrated to 2000 transit ridership estimates, provided by regional transit operators. Results from the 2001-2002 Transit On-Board Survey, as well as preliminary adjustments from the 2009 Transit On-Board Survey, are reflected in the travel demand model's transit parameters. Current and projected transit routes are updated regularly to reflect operational plans for the transit providers.

ARC's travel demand model uses a mode choice model to determine the quantity of people that will utilize transit services, versus those that will drive to their destinations. Individual modal trips are estimated from the person trip movements developed in the trip distribution model. This model is composed of three nested logit models:

- Home based work trips, which include home based university trips

- Home based other trips, which include home based other, home based shopping and home based grade school

- Non-home based trips

From there, the final mode choice model is organized in terms of seven characteristics:

1) Mathematical structure

2) Trip purpose and choice sets

3) Limitations on choice sets

4) Analysis of transit access

5) Treatment of HOV lanes

6) Stratification by income groups

7) Analysis of alternative transit paths

Zero-Car Household Distribution

The auto ownership model was updated and validated using census data in 2008. New income coefficients were asserted using observed 2000 auto ownership shares as the basis. CTPP TAZ level data were processed to generate the expected auto-ownership levels for each respective income group. Densities were found to still play a role in the decision to own an automobile. As a result, the census calibrations were modified to include a coefficient for zone density, providing a more accurate prediction of auto-ownership in the regional model.

Survey Expansion

ARC conducted a regional transit on-board survey in 2009-2010 to get a better understanding of transit travel behavior. While the full expansion of the survey was not available in time for this model version update, the survey was used to make important updates to the mode choice model. A list of areas that were modified follows:

- New transit coefficients were generated by trip purpose, mode of access and socioeconomic class

- Use of kiss-and-ride facilities was adjusted

- Walking travel distance to transit was increased

- A pedestrian environment factor was introduced to adjust for easier walking conditions in more urban areas of the region

- The transfer penalty assignment was modified

Fare Changes

As a part of the transportation conformity analysis performed for PLAN 2040, assumptions about transit fares for the existing and planned regional transit system were made and coded in the regional travel demand model. Transit fares are used as supplied by the local transit operators and remain constant over time, throughout the life of the plan, across all network years. The fares reflect current operating plans, as provided to ARC by the various transit operators throughout the region. The transit fare structure used to develop the plan makes use of a fare matrix on a zone-to-zone level with a universal fare structure (flat fare) for all bus and rail lines.

With the addition of new transit operators providing regional transit services, transfer fare agreements between different interconnecting systems and the need to plan for future transit modes, more specific transit coding was needed to accurately reflect the transit levels of service. The current ARC coding approach enables most of the fares to be coded universally for each mode, and all providers are allowed

to have different fares. In addition, a protocol was established in the model stream to allow transit fare to be coded by transit link.   The current fare values in the model are weighted according to the percentage of riders using a discounted fare pass, and changes to these assumptions can be incorporated directly into the model. The ARC model currently assumes that peak and off-peak fares are equivalent.

MOVES Overview

The Motor Vehicle Emissions Simulator (MOVES) is EPA's latest available, state-of-the-art tool for estimating mobile source emissions from highway vehicles. MOVES replaces the MOBILE6 emissions model for use in State Implementation Plans (SIPs) and transportation conformity analyses. It must be used for new SIP development and for all conformity determinations after a three year conformity grace period ending on March 2, 2013.[6] In preparation for the transition to MOVES, the ARC and GA EPD jointly developed MOVES-based methodologies to estimate emissions inventories for the Atlanta region.

The MOVES modeling platform is substantially different than MOBILE6 due to the availability of a graphical user interface (GUI) to set the general parameters for running MOVES and a County Data Manager to assist the user in managing data inputs and data format. In addition, MOVES provides two modes to estimate emissions – emissions rate mode and emissions inventory mode. Inventory mode was chosen over emission rate mode after extensive testing of both approaches. The following section provides detail on MOVES general parameters and data inputs, as applied in the $PM_{2.5}$ and Ozone Maintenance SIPs using MOVES in inventory mode.

The MOVES GUI is used to set the general parameters of a particular MOVES run, while the County Data Manager is used to tailor the MOVES inputs using local data. Table 2 shows the selections applied through the MOVES GUI to set the general parameters for each of the four types of MOVES runs needed to estimate emissions for the Atlanta PM2.5 and Ozone nonattainment areas. It should be noted that for $PM_{2.5}$ runs the month July is chosen as a "dummy month," but the fuel and meteorology inputs provided through the County Data Manager represent the entire year by providing average annual data.

Fulton County is chosen to represent the 13 I/M program counties included in the previous one-hour ozone nonattainment area and Bartow County is chosen to represent the 7 additional ring counties that were added with the transition to the eight-hour ozone standard and $PM_{2.5}$ standard. This distinction was needed to reflect different types of emission controls in place in the two geographies. Note that additional inputs imported through the County Data Manager represent the entire 13 or 7 county areas, respectively.

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[6] Based on the EPA's Direct Final Rule from October 13, 2011 to extend the MOVES grace period for regional conformity analysis for one year.

Table 2 – MOVES General Parameters

MOVES Screen	Input Item	13-County Ozone	13-County PM	7-County Ozone	7-County PM
Description	Description	User Choice			
Scale	Domain/Scale	County			
	Calculation Type	Inventory			
Time Spans	Time Agg. Level	Hour	Hour	Hour	Hour
	Year	Varies	Varies	Varies	Varies
	Months	July	July	July	July
	Days	Weekday	Weekday	Weekday	Weekday
	Hours	Select All	Select All	Select All	Select All
Geographic Bounds	Geographic Bounds	Fulton	Fulton	Bartow	Bartow
Vehicles	Vehicles	All Gas & Diesel Combinations + CNG Transit Buses			
Road Type	Road Type	Select All			
Pollutants/ Processes	Pollutants/Processes	VOC, NO_x, and supporting	$PM_{2.5}$ with all sub-species, NO_x	VOC, NO_x, and supporting	$PM_{2.5}$ with all sub-species, NO_x
General Output	Database Name	13-County Ozone [Year]	13-County PM [Year]	7-County Ozone [Year]	7-County PM [Year]
	Units	Select "Grams", "Joules", and "Miles"			
	Activity	No Selections Required			
Output Emissions Detail	On Road	Select "Source Use Type"			

MOVES Input Development – Travel Demand Post Processing Procedures

The Atlanta regional travel demand model produces estimates of travel and vehicle hours traveled (VHT) and for each link in the highway network for four separate time of day periods. The links from the highway assignment contain a variety of attributes such as the number of lanes, distance, speed, capacities and daily volumes. In order to account for travel conditions throughout the day, vehicle miles traveled (VMT) estimates, times and speeds by hour were produced. Other refinements to the network link data discussed below were performed to produce the files needed for MOVES. The highway and transit assignments were used in addition to Highway Performance Monitoring System (HPMS) counts, Georgia Department of Transportation (GDOT) vehicle classification counts[7] and MOVES defaults to develop input files for MOVES using Cube Voyager scripts.

VMT Adjustment Factors

Traffic volumes produced by the travel model are adjusted within the emissions modeling process by applying a VMT adjustment factor, which is a combination of HPMS adjustment factors, used to reconcile travel model VMT to HPMS VMT estimates,[8] and to reflect seasonal adjustment. For the purpose of ozone precursor emissions modeling,[9] seasonal adjustment factors are used to convert the average annual daily traffic produced by the travel model to average summer-time daily traffic. For the purpose of $PM_{2.5}$ emissions modeling, no seasonal adjustment is necessary since the HPMS data in the GDOT 445 report reflects annual average travel conditions and a direct adjustment factor between the model data and the HPMS data can be developed.

EPA requires[10] that reasonable methods be used to estimate VMT on off-network (off-model) roadways within the urban transportation planning area. Off-model VMT is travel that is accounted for within HPMS estimates, but not accounted for within the coded transportation network; it typically reflects travel on the local road system. EPA also recommends[11] for areas with travel demand models in place, that HPMS adjustments be made based on comparison of base year VMT from the transportation model to base year HPMS VMT estimates. The ARC calculates HPMS adjustment factors by comparing HPMS VMT to travel model VMT by HPMS functional classes for the 2000 calibration year. In the past, the adjustment factors were developed for the 12 functional classes which stratifies the facilities by urban versus rural designation. To be consistent with the new USDOT policy which eliminated the urban/rural stratification in the functional classification designations beginning with 2009 data reported in 2010,[12]

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[7] See Exhibit 2

[8] 40 CFR Sections 93.122(a)(7) and 93.122(b)(3)

[9] Section 3.4.2.6, *Procedures for Emission Inventory Preparation, Volume IV: Mobile Sources*, EPA420-R-92-009, USEPA Office of Air and Radiation, Office of Mobile Sources, 1992.

[10] 40 CFR Section 93.122(a)(7)

[11] 40 CFR Section 93.122(b)(3)

[12] *Guidance for the Functional Classification of Highways (updated), Federal Highway Administration,* October 14, 2008

the aggregate functional classification level was used. The resulting factors are then applied to travel model VMT estimates for future analysis years. The following equation was used to calculate the HPMS adjustment factors:

$$\text{HPMS Adjustment Factor}_i = 2000\ \text{HPMS VMT}_i\ /\ 2000\ \text{MODEL VMT}_i$$

Where i = HPMS functional class

To determine the 2000 HPMS VMT, average daily VMT for the year 2000 were summarized by the aggregate HPMS functional classes for the 13 and 7-county areas separately. County-level HPMS data by functional class was taken from the GDOT Office of Transportation Data 445 Report. GDOT's 445 Report provides information on mileage and VMT by route type and road system and contains county-specific State Route, County Road and City Street mileage and VMT broken down by functional classification. VMT by county and functional class were aggregated to total VMT by HPMS functional class. 2000 Travel Demand Model VMT at the HPMS functional class level was derived from the recalibrated 2000 travel model network. HPMS adjustment factors for the 13- and 7-county areas are listed below which are used for PM$_{2.5}$ emission modeling.

Table 3 – 13-County PM$_{2.5}$ HPMS Adjustment Factors

Functional Class Name	Functional Class No.	HPMS Data	Model Data	VMT HPMS Adjustment
Interstates/Frwy	1,11,12	47,171,325	46,049,179	1.02
Arterials	2,6,14,16	39,900,297	40,382,825	0.99
Collectors	7,8,17	12,242,686	11,240,938	1.09
Local	9,19	18,734,189	21,040,927	0.89
Total		118,048,497	118,713,869	0.99

Table 4 – 7-County PM$_{2.5}$ HPMS Adjustment Factors

Functional Class Name	Functional Class No.	HPMS Data	Model Data	VMT HPMS Adjustment
Interstates/Frwy	1,11,12	4,482,987	5,247,292	0.85
Arterials	2,6,14,16	7,776,636	8,016,746	0.97
Collectors	7,8,17	3,517,297	1,955,582	1.80
Local	9,19	3,133,469	2,868,633	1.09
Total		18,910,389	18,088,253	1.05

Summer (seasonal) adjustment factors are used to convert from average annual daily VMT to average summer-season daily VMT for the purposes of ozone precursor emissions modeling.[13] Seasonal adjustment factors reflect the latest factors provided by the GDOT Office of Transportation Data on August 9, 2006. Summer-adjustment factors for the 13- and 7-county geographies are listed below.

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[13] *Procedures for Emission Inventory Preparation, Volume IV: Mobile Sources*, Section 3.4.2.6, EPA420-R-92-009, USEPA Office of Air and Radiation, Office of Mobile Sources, 1992.

Table 5 – Summer Adjustment Factors

Functional Class Name	Functional Class No.	13 Counties	7 Counties
Interstates/Freeways	1,11,12	1.02	1.04
Arterials	2,6,14,16	1.00	1.02
Collectors	7,8,17	0.99	1.01
Local	9,19	0.98	1.01
Total		1.00	1.02

HPMS adjustment factors were multiplied by the seasonal adjustment factors for the HPMS functional classification categories to produce a set of VMT adjustment factors by HPMS functional classification for 13-county and 7-county portions of the 20-county eight-hour ozone nonattainment area, separately. The final VMT adjustment factors listed below are used for ozone precursor modeling.

Table 6 – VMT Adjustment Factors for Ozone

Functional Class Name	Functional Class No.	13 Counties	7 Counties
Interstates/Frwy	1,11,12	1.05	0.89
Arterials	2,6,14,16	0.98	0.99
Collectors	7,8,17	1.07	1.81
Local	9,19	0.87	1.10
Total		1.00	1.06

Network Refinements

The following refinements were performed on the final highway assignment:

- Transit volumes from the daily transit assignment reflecting bus service were added to the highway network
- Links with missing or out of range HPMS code were assigned a code based on the link facility and area type
- Centroid connector speeds were set based on area type to represent speeds on local roads
  - Urban Very High Density = 15
  - Urban High Density = 18
  - Urban Medium Density = 21
  - Urban Low Density = 24
  - Suburban = 27
  - Exurban = 30

o   Rural = 35

VMT by Hour

MOVES requires the stratification of the VMT, VHT and speeds by hour to provide more accurate information for use in estimating emissions. The regional travel demand model produces VMT estimates and speeds by the four time-of-day periods listed below:

- AM Period   6:00 am – 10:00 am   4 hours
- Midday Period   10:00 am – 3:00 pm   5 hours
- PM Period   3:00 pm – 7:00 pm   4 hours
- Night Period   7:00 pm – 6:00 am   11 hours

To allocate the VMT by time period from the assignment, the MOVES national factors that stratify VMT by hour and source type were used. First, the hourly shares of the VMT based on the MOVES factors were normalized within the four time periods. Next, the hourly share of each associated time period was calculated and applied to each link to determine the hourly volumes. The sum of the hourly volumes by time of day matched the time of day volumes from the highway assignments. The hourly volumes were then processed through the volume/delay curves based on the time of day to estimate hourly speeds and times.

Roadtype Classification

The network link data was also classified by MOVES roadtype based on functional classification. The mapping of Federal Highway Administration (FHWA) highway functional system classifications to the appropriate MOVES roadtypes used for this modeling is listed in Table 7. Interstate and freeway ramps are functionally classified as local facilities in Georgia. Since these facilities operate with restricted access, the facility type definition variable (a unique variable in the highway network that defines the highway facilities based on their operation) was used to classify ramps as either rural or urban restricted facilities. Off-network activity is calculated within the MOVES process based on the source type vehicle population and is not an input from the travel demand model data.

Table 7 – Listing of FHWA Highway Functional Classifications Mapped to MOVES Road Types

FHWA Highway Functional System	MOVES Road Type	MOVES Value
Rural interstate	Rural restricted access	2
Rural other principal arterial	Rural restricted access	2
Rural minor arterial	Rural unrestricted access	3
Rural major collector	Rural unrestricted access	3
Rural minor collector	Rural unrestricted access	3
Rural local	Rural unrestricted access	3
Urban interstate	Urban restricted access	4
Urban other freeways	Urban restricted access	4
Urban other principal arterial	Urban unrestricted access	5
Urban minor arterial	Urban unrestricted access	5
Urban collector	Urban unrestricted access	5
Urban local	Urban unrestricted access	5

MOVES County Data Manger Input Files

The MOVES County Data Manager serves as the user interface to input locally derived data for an emissions analysis. Local data are derived using a variety of modeled and available sources. Table 8 outlines the range of local data incorporated into the MOVES model. An explanation of how these data are developed follows. In addition, Exhibit 3 provides a sample set of MOVES inputs used by ARC to develop the Maintenance Plan mobile source inventory.

Table 8 – County Data Manager Worksheets

County Data Manager Input	Worksheet Name
Age Distribution	sourceTypeAgeDistribution
Average Speed Distribution	avgSpeedDistribution
Fuel	FuelSupply
	FuelFormulation
I/M Programs	IMCoverage
Meteorology	DayMonthHour
Ramp Fraction	roadType
Road Type Distribution	roadTypeDistribution
Source Type Population	sourceTypeYear
Vehicle Type VMT	HPMSVTypeYear
	monthVMTFraction
	dayVMTFraction
	hourVMTFraction

Age Distribution

Latest available age distribution data for the Atlanta region was converted from a MOBILE6 to a MOVES format using an EPA converter.[14] MOBILE6 age distributions are shown over 25 years, but MOVES requires age distributions over 30 years. The EPA converter spreadsheet makes assumptions about how vehicles that are 25-30 years old are distributed over the oldest 5 years. MOBILE6 distributions were derived from 2002 R.L. Polk & Co. registration data for the 13 and 7 county areas separately for all vehicle types, except for HDV8B where MOBILE6 defaults were used.

Average Speed Distribution

To prepare this input the weekday link hourly vehicle hours travelled (VHT) is summarized by road type and speed bin. The MOVES defaults for the 13 source types by year are used to allocate to vehicle type. The fraction of time in each speed bin for each hour based on vehicle type, road type, and average speed is calculated where the fractions sum to one for each combination of vehicle type and road type by hour.

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[14] RegistrationDistributionConverter_Veh16 (XLS) available at
http://www.epa.gov/otaq/models/moves/tools.htm

Fuel

MOVES defaults for fuel characteristics in Fulton County (13-county) and Bartow County (7-county) were reviewed and determined to accurately reflect the local fuel in use, which has the following characteristics:

- Fuel - Phase 2 Low Sulfur, Low RVP Georgia Gasoline[15]
- 100% market share of 10% ethanol-blend gasoline (E10) assumed
- Volatility waiver for E10 allows 1.0 psi RVP increase

The following provides more details on the MOVES default values used:

- Ozone - MOVES defaults are used for a July weekday for Fulton County and Bartow County

- $PM_{2.5}$ – MOVES defaults are used for the 12 months of the year for Fulton County and Bartow County. The 12 months of fuel data are annualized by setting the single month market share equal to the fraction of time that fuel is used throughout the year (number of months in use divided by 12).

I/M Program

The 13-county area has an inspection/maintenance program that is modeled in MOVES, but the 7-county area does not. MOVES defaults for Fulton County were inspected and modified to provide the correct model years covered and testing methods used as summarized in the I/M program characteristics below:

- Stage II Refueling Vapor Recovery
  - Started in 1992
  - Three phase in years
  - 81% efficiency
- Exhaust and Evaporative (OBD and gas cap pressure test) for 1996 and newer vehicles
  - Annual inspection required
  - Computerized test and repair OBD – Exhaust
  - Computerized test and repair OBD & GC - Evaporative
  - Applies to all LDG vehicle types
  - Three year grace period
  - 3% waiver rate for all vehicles – Exhaust test
  - 0% waiver rate for all vehicles – Evaporative test
  - 97% compliance
- Exhaust and Evaporative test for 1975 – 1995 vehicles
  - Annual inspection required
  - Computerized test and repair ASM 2525/5015 Phase-in – Exhaust

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[15] In 2002, Georgia's two-phase gasoline sulfur control program limited average sulfur in gasoline sold in the 13-county Atlanta area and in 12 surrounding counties to 150 parts per million (ppm). In addition, there was a seasonal (June 1 to September 15) 7.0 pounds per square inch (psi) Reid vapor pressure cap on gasoline sold in this Phase 1 area. In 2003, Phase 2 of Georgia's gasoline rule reduced average sulfur to 30 ppm year-round and added 20 additional counties to the sulfur and RVP control program.

- o   Computerized test and repair GC – Evaporative
- o   Applies to all LDG vehicle types
- o   3% waiver rate for all vehicles – Exhaust
- o   0% waiver rate for all vehicles – Evaporative
- o   97% compliance
- o   25 year and older model years are exempt

Exhibit 4 documents the calculations of the emissions reductions credit loss from the senior I/M exemption[DK1][D2].

Meteorology

Meteorological data on hourly temperatures and relative humidity were obtained from the National Mobile Inventory Model (NMIM) County Database (version NCD20090531) for the year 2008. Temperature and humidity values were extracted for all 20 counties and averaged together to produce one set of values for the entire 20-county area. The following provides more details on the differences between meteorology data used for ozone and PM$_{2.5}$ analyses:

- Ozone – Meteorological data from July 2008 were used to represent the ozone season

- PM$_{2.5}$ – Meteorological data from all 12 months of the year in 2008 were extracted and averaged together to represent an average annual 2008 meteorological condition.

Ramp Fraction

The weekday link VMT is summarized for interstate, freeway and ramp facilities by urban versus rural area type classifications. The percent of ramp VMT of the total interstate, freeway and ramp VMT was calculated by area type.

Road Type Distribution

The weekday link hourly VMT is summarized by roadtype. The MOVES defaults for the 13 source types by year are used to allocate to vehicle type. The fraction of VMT by road type and vehicle type is calculated, where the fractions sum to one for each vehicle type.

Source Type Population

Source Type Population (the number of each of 13 vehicle types) is an input that was not required with MOBILE6. Registration data, which were used to produce age distributions, are used to produce this input for most vehicle types. However, for long-haul combination trucks (source type 62) a VMT-based method is used since these types of trucks from around the country move through the region and are usually not registered here.

Source type population for source types 11-61 are derived from registration data and human population estimates and forecasts. The following data sources are used:

- 2002 R.L. Polk & Co. registration data each of the 20 counties

- Georgia registration data (2003 and 2007)[16]

- 2002 and 2007 Census human population estimates

- 2007-2040 ARC human population forecasts

After this data was accumulated, the following method is used to project future source type population:[DK3][D4]

1. Grow 2002 Polk registration data to 2007 using different growth factors that depend on vehicle type as shown in Table 9.

2. Convert the Polk registration data to MOVES vehicle types using a modified EPA converter spreadsheet[17]

3. Grow the 2007 source type population by county to the appropriate future year(s) using 2007-2040 ARC human population forecasts by county

4. Summarize the source type population by 13 and 7-county areas separately

Table 9 – 2002-2007 Growth Factors used

Vehicle types	Growth factor
HDBS	Georgia registration data (2003 and 2007), Buses
HDBT	Georgia registration data (2003 and 2007), Buses
MC	Georgia registration data (2003 and 2007), Motorcycles
All Others	Population 2002 and 2007

Vehicle population for source type 62 (long-haul trucks) was recalculated using corresponding VMT and national default ratios of VMT and vehicle population in order to account for activity from trucks not registered but run locally.

Vehicle Type VMT

Vehicle Type VMT is broken into four separate MOVES worksheets (HPMSVTypeYear, monthVMTFraction, dayVMTFraction and hourVMTFraction). These four variables define travel characteristics in the area of study and are calculated separately or derived from MOVES defaults.

HPMSVTypeYear

The weekday VMT is summarized by MOVES roadtype and then weighted by the vehicle classification counts[18] for the 13 or 7-county area by the 6 HPMS vehicle types. The fractions for vehicle type 20 and

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[16] Obtained from www.georgiastats.uga.edu

[17] A converter was developed by EPD based on the EPA RegistrationDistributionConverter_Veh16 (XLS) available at http://www.epa.gov/otaq/models/moves/tools.htm

[18] The summary of the vehicle classification counts is in Exhibit 3

30 are then re-distributed based on the MOVES source vehicle defaults for the year. This is because the vehicle classification counts are collected using counters which count vehicles by the number of axles and as a result, the counts do not accurately reflect the difference between passenger cars and SUVs. The daily VMT is annualized using the EPA AADVMT Calculator Excel workbook.

monthVMTFraction and dayVMTFraction

MOVES national defaults were used for these two inputs because reliable local data was not available. The regional travel demand model is developed for an average weekday. The vehicle classification counts used for some analyses were not collected to be statistically reliable by day of week or monthly basis.

hourVMTFraction

 The weekday link hourly VMT is summarized by roadtype and hour. The MOVES defaults for the 13 source types by year are used to allocate to vehicle type. The fraction of VMT by road type and vehicle type is calculated where the fractions sum to one for each vehicle type by roadtype. This variable must sum to 1 for each source type-road type-type of day combination.

Off-Model Putnam County Mobile Emissions Analysis

The Atlanta $PM_{2.5}$ Nonattainment Area includes small parts of two counties, Heard and Putnam, which fall outside of the core 20 whole counties which make up the eight-hour ozone and $PM_{2.5}$ nonattainment areas. A travel model is not in place for these counties. According to the Transportation Conformity Rule 93.122(a)(7), reasonable methods shall be used to estimate nonattainment or maintenance area VMT on off-network roadways within the urban transportation planning area, and on roadways outside the urban transportation planning area. Therefore, a revised off-travel model technique was developed to estimate average annual daily VMT for use in the MOVES model in the partial county areas.

For Heard County the roads identified are private roads that service Georgia Power's Plant Wansley. These roads do not experience through-traffic and, therefore, do not need to be included in the regional emission analysis. As such, this methodology only applies to Putnam County.

Like the 7 and 13-county portions, a MOVES run was prepared for Putnam County using the inputs described in Table 10. Travel characteristics in Putnam County were considered to be similar to the 7-county outer-portion of the Atlanta Nonattainment Area. These characteristics were mixed with data from GDOT's 445 VMT reports and state data to generate the necessary inputs to produce a MOVES run for the entirety of Putnam County.

**Table 10 – Putnam County MOVES County Data Manager Inputs[19]**

MOVES Input	Data Source
Age Distribution	Derived from the 139 county average of R.L. Polk Data
Source Type Population	Grown from the 2002 R.L. Polk data based on human population estimates from the Georgia Office of Planning and Budget
Fuel	Annualized MOVES Defaults for Putnam County
Meteorology	Annualized 20-county meteorology for 2008
Vehicle Type VMT	- HPMSvTypeYr – derived from the GDOT 445 workbooks with MOVES default source type fraction break outs and converted using the EPA provided AADVMT calculator - Month and Daily Fractions – MOVES defaults - Hourly Fractions – Taken from 7-county portion of travel model post-processing
Road Type Distribution	Taken from the 7-county portion of the travel model post-processing
Average Speed Distribution	Taken from the 7-county portion of the travel model post-processing
Ramp Fraction	Taken from the 7-county portion of the travel model post-processing

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[19] More detail on the development of MOVES Inputs is available in the chapter regarding the MOVES County Data Manager Input Files

After total emissions for Putnam County were calculated using MOVES, the value was scaled back to match the percent of human population in the PM$_{2.5}$ Nonattainment Area. 2010 Census TIGER files were imported into GIS and an analysis was performed to determine the Nonattainment Area's share of Putnam County's population (Figure 2). 3,484 of Putnam County's 21,218 citizens reside inside the boundary. Therefore, total Putnam County MOVES emission's results are multiplied by 16.4% to account for the ratio of population inside the Nonattainment Area to the total county's population.

Figure 2 – Putnam County Nonattainment Area
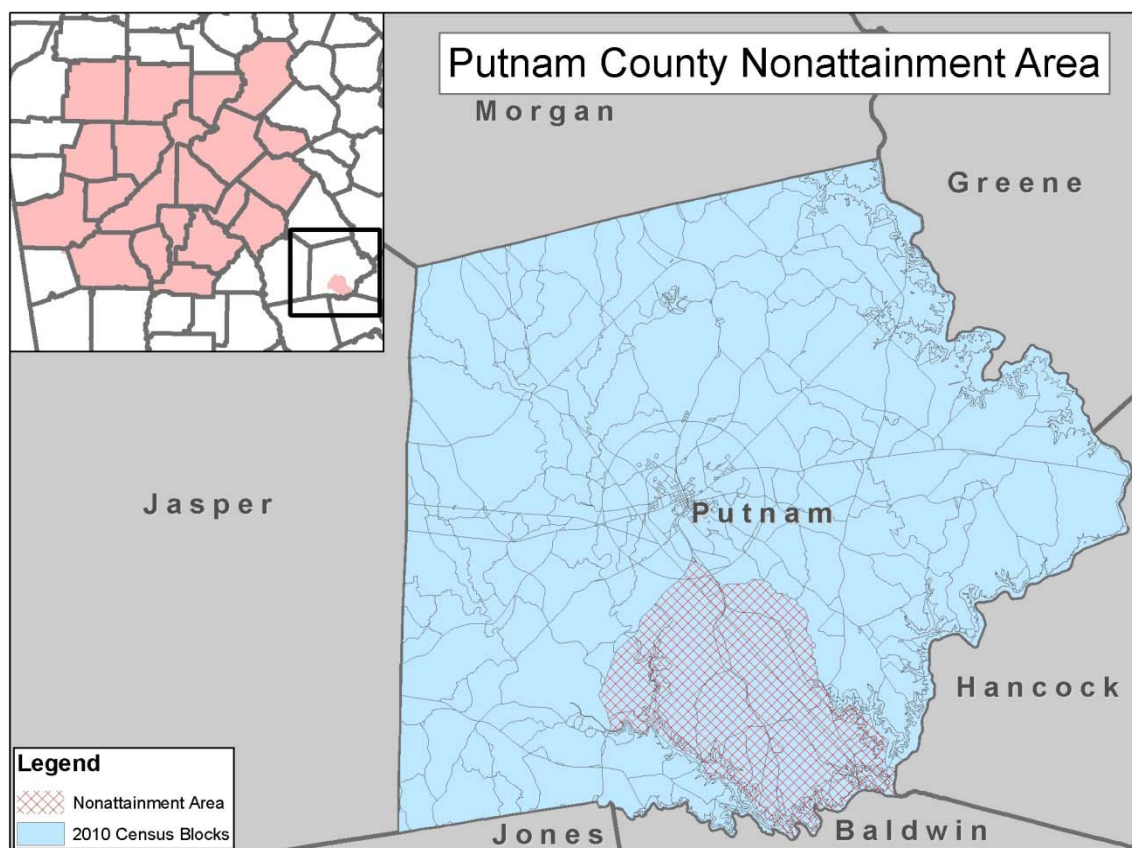
MOVES Model Output

The following sections contain the data output from running the MOVES model with the travel data and methodologies outlined in this document. In addition, Exhibit 5 discusses work the ARC underwent to determine required safety margins.

Eight-Hour Ozone Standard Maintenance Plan

Table 11 documents the results of the emissions analysis for the eight-hour ozone standard for the years 2008 and 2024. This table accounts for both running and nonrunning emissions estimated by the MOVES model. MOVES output in grams per day is converted to tons per day by dividing by the grams to tons conversion factor 907,184.74. Final emissions account for the senior I/M exemption.

Table 11 – Daily Ozone Precursor Emissions

Pollutant	2008 Emissions (tons/day)	2024 Emissions (tons/day)
NO_x	364.02	99.43
VOC	165.53	62.56

MOVES Model Output – Annual PM$_{2.5}$ Standard Maintenance Plan

Table 12 documents the results of the emissions analysis for the annual PM$_{2.5}$ standard for the years 2008 and 2024. This table accounts for both running and nonrunning emissions estimated by the MOVES model. MOVES output in grams per day is converted to tons per day by dividing by the grams to tons conversion factor 907,184.74. The result is then annualized by multiplying by the number of weekday equivalent days in a year (341.9809), which accounts for the MOVES urban weekend adjustment factor:

Weekday Equivalent = 365 x (5 weekdays/7days) + 365 x (2 weekends/7days) x 0.77927

Where 0.77927 is the MOVES Default Urban Weekend Adjustment Factor

Final values account for the weekday factorization, the partial Putnam County emissions and the senior I/M exemption. Outputs of PM$_{2.5}$ emissions include the sum of total PM$_{2.5}$ exhaust, brake wear and tire wear.

Table 12 –PM$_{2.5}$ Precursor Emissions

Pollutant	2008 Emissions (tons/day)	2024 Emissions (tons/day)
NO_x	128,954.56	35,271.63
$PM_{2.5}$	4,661.88	1,642.17
SO_2	725.14	469.08