To the Graduate Council:

I am submitting herewith a thesis written by Anna Mei Yong Tang entitled "Effects of Growth in VMT and New Mobile Source Emission Standards on NO_x and VOC Emissions in Tennessee 1999-2030". I have examined the final copy of this thesis for form and content and recommend that it be accepted in partial fulfillment of the requirements for the degree of Master of Science, with a major in Environmental Engineering.

Wayne T Davis

Dr. Wayne T. Davis, Major Professor

We have read this thesis and
recommend its acceptance:

Terry L Miller

Dr. Terry L. Miller

Joshua S. Fu

Dr. Joshua Fu

Accepted for the Council:

Vice Provost and
Dean of Graduate Studies

EFFECTS OF GROWTH IN VMT AND NEW MOBILE SOURCE EMISSION STANDARDS ON NO_x AND VOC EMISSIONS IN TENNESSEE 1999-2030

A Thesis Presented for the Master of Science Degree
The University of Tennessee, Knoxville

Anna Mei Yong Tang
December 2001

ACKNOWLEDGEMENTS

I wish to thank my major professor, Dr. Wayne Davis, for his patience and steadfast guidance throughout the course of this project. I am also particularly grateful to the committee members, Dr. Terry Miller and Dr. Joshua Fu for their invaluable comments and kind assistance. A special thanks goes to the Tennessee Department of Transportation's Planning Division in conjunction with the Federal Highway Administration and the University of Tennessee Transportation Research Center for sponsoring the project. Another special thanks goes to colleagues whose knowledge and experience were invaluable. Without the help of these people, I would not have been able to bring this project to fruition.

I wish to express my sincere gratitude to my parents, Lee Khing Tang and Houng Guik Ding, and my brothers and sisters, Allan, Eric, Amy, Su Ching, and Lily for their love and encouragement. Finally and not the least, I want to express my appreciation to all my friends, especially Chie Min, for their love, contribution and support through the years toward my studies and especially towards the completion of this thesis.

ABSTRACT

The relative importance of on-road emissions as a participant in ozone formation depends in large part on the total vehicle miles traveled (VMT) per day in a given area. In the future, the relative importance of on-road emissions will be affected by the growth in VMT, which results in increased emissions, and the implementation of motor vehicle emissions controls, which will reduce the emissions associated with each mile of travel. This study evaluates the combined effects of VMT growth and the national LEV, HDDVNO_x, Tier2/Sulfur and HDDV/Sulfur vehicle emission standards on NO_x and VOC emissions for the State of Tennessee.

The new LEV, HDDVNO_x, Tier2/Sulfur and HDDV/Sulfur standards, which will be fully in-place by 2001, 2004, 2006, and 2007, respectively, will significantly reduce the emissions of NO_x and VOC from individual on-road vehicles. The implementation of the new regulations will have less effect on VOC emissions compared to NO_x emissions. There is a 68% reduction in NO_x emissions and a 37% reduction in VOC emissions without an I/M program compared to a reduction of 78% in NO_x emissions and 46% reduction in VOC emissions with an I/M program by year 2025. On the other hand, the year to year emission reduction with and without an I/M program is 2% to 38% for NO_x emissions and 23 to 35% reduction for VOC emissions for 1999 and 2030, respectively.

With the potential of increasing NO_x and VOC emissions in the future due to increasing growth of DVMT, there is a need to develop strategies which will decrease the current growth rate of DVMT or improve emission control technologies, or utilize alternative lesser polluting vehicles in order to maintain the lower emissions which will be achieved during the next 10 to 15 years.

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CHAPTER 1

INTRODUCTION

On-road vehicular traffic is a significant source of air pollution emissions, particularly with regard to the emission of Nitrogen Oxides (NO_x) and Volatile Organic Compounds (VOCs). These pollutants, commonly referred to as ozone precursor pollutants, are photochemically reactive, and thus participate in the formation of ozone. The relative importance of on-road emissions as participant in ozone formation depends in large part on total vehicle miles traveled (VMT) per day in a given area. In 1998, on-road vehicles were responsible for 32% and 14% of the nationwide emissions of NO_x and VOCs, respectively (1). In the future the relative importance of on-road emissions will be affected by the growth in VMT, which will result in increased emissions, and the implementation of improved motor vehicle emission controls, which reduce the emissions associated with each mile of travel.

The objective of the study is to develop a mobile source emission inventory by county for the State of Tennessee. To develop the mobile source emission inventory, the draft MOBILE6 model was used, as it is the latest U.S EPA model available for conducting transportation conformity analysis. MOBILE6 generates emission factors in terms of grams/mile of travel. These factors are then multiplied by the daily vehicle miles traveled (DVMT) to determine highway emissions in terms of mass/day. The effects of new emission standards and inspection and maintenance programs on NO_x and VOC emissions were also analyzed in this study.

CHAPTER 2

BACKGROUND

Estimation of the emissions for on-road motor vehicle is important as the values are used to develop regional emission inventories which gives an indication of progress made toward meeting (or maintaining compliance with) ambient air quality standards. It is also used to determine if regional transportation plans and projects are consistent with, and conform to, the State Implementation Plan (SIP) (2). This section explains the need for generating emission inventories by reviewing literature published.

2.1. CONFORMITY REQUIREMENTS

According to the Clean Air Act Amendments (CAA) of 1990, transportation conformity is a way to ensure Federal funding and approval are given to those transportation activities that are consistent with air quality goals and to ensure that the transportation activities do not worsen air quality or interfere with the "purpose" of the SIP, which is to meet the National Ambient Air Quality Standard (NAAQS) (3).

Transportation conformity applies to all EPA-designated nonattainment and maintenance areas (areas previously designated nonattainment and subsequently redesignated to attainment) for transportation related criteria or precursor pollutants. Criteria pollutants include ozone, carbon monoxide (CO), nitrogen dioxide (NO_2), and particles with an aerodynamic diameter less than or equal to 10 microns (PM-10). Precursor pollutants include volatile organic compounds (VOCs) and nitrogen oxides (NO_x) in ozone nonattainment areas, NO_x in nitrogen oxide (NO_2) areas, and VOC, NO_x and particulate matter in PM-10 areas (3).

The Metropolitan Planning Organizations (MPOs) are required to conduct transportation conformity analyses in their long range transportation plan for areas within MPO planning areas. The State Departments of Transportation (DOT) are responsible for planning and conformity outside the MPO areas. Figure 2-1 shows the transportation conformity process. One of the major requirements of the transportation conformity process includes regional emissions analysis to assess the impacts that transportation investments will have on emissions within the nonattainment or maintenance area (3). The latest EPA-approved emissions models (e.g., MOBILE5b and MOBILE6 for all states other than California and EMFAC7F and EMFAC7G for California) must be used to estimate regional emissions.

2.2. MOBILE MODEL

The Clean Air Act (CAAA) of 1990 included new lower emission standards for on-road vehicles. As a result, the U.S. Environmental Protection Agency (EPA) was required to revise and improve the predictive capability of the highway vehicle emission factor model (2). The highway vehicle emission factor model, MOBILE, is an analytical tool that calculates emissions from highway mobile sources. MOBILE is a Fortran program that provides average in-use fleet emission factors for three criteria pollutants (volatile organic compounds (VOC); carbon monoxide (CO); and oxides of nitrogen (NO_x)), for each of twenty eight categories of vehicles, for any calendar year between 1952 and 2050 and under various conditions affecting the emission levels (e.g., temperatures, speeds) specified by the model user for more detailed and specific modeling requirements.

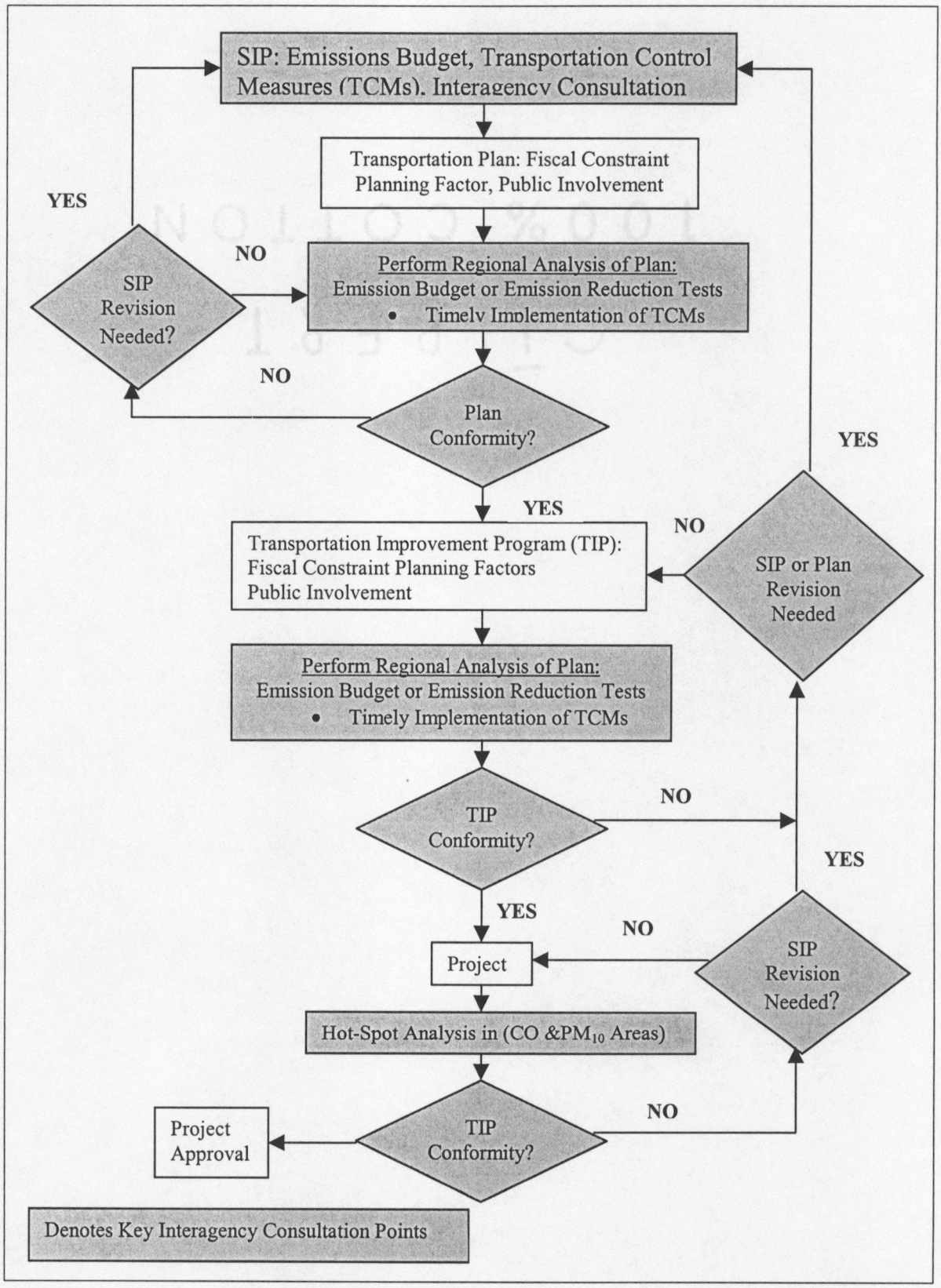


Figure 2-1. Transportation Conformity Process (U.S DOT, 2000)

The output from the model is in the form of emission factors expressed in terms of grams per vehicle miles traveled (g/mi). Thus, emission factors from MOBILE can be combined with estimates of total vehicle miles traveled (VMT) to develop highway vehicle emission inventories (in terms of mass per day, per month, per season, or per year) (4). EPA's MOBILE model has become more sophisticated in its approach to modeling average in-use emissions and has provided the model user with additional options for estimating emission factors for specific times and geographic locations. A brief history of the Mobile model and its development is tabulated in Table 2-1.

2.3. REGULATORY STATUS OF MOBILE SOURCE EMISSION CONTROLS

Four regulations were promulgated in the U.S. that will reduce emissions from on-road vehicles during the next ten years. These include the National Low Emission Vehicle (NLEV) Standards for Light-Duty Gasoline-Fueled Vehicles, the 2004 NO_x Standards for Heavy-Duty Diesel Engines, the Tier 2/Sulfur Standards and the HDDV Sulfur Standard. These regulations are described briefly below. Table 2-2 shows a schedule for implementation of each of the regulations.

2.3.1. National Low Emission Vehicle (NLEV) Standards

The NLEV program, signed into law in March 1998, was patterned after the California LEV program that went into effect in 1997. The NLEV program was initially implemented in nine northeastern states that were a part of the Ozone Transport Region as follows (5, 6, 7):

Table 2-1. Brief History of the MOBILE Model (U.S. EPA, April 1999)

MOBILE MODEL	UPDATES
MOBILE1 (1978)	First model for highway vehicle emission factor that includes modeling of exhaust emission rates as function of vehicle age/mileage (zero-mile levels and deterioration rates)
MOBILE2 (1981)	Updated with substantial data (available for the first time) on emission controlled vehicles (i.e., catalytic converters, model years 1975 and later) at higher ages/mileages; provided additional use control of input options
MOBILE3 (1984)	Updated with substantial new in-use data; elimination of California vehicle emission rates (continue to model low- and high-altitude emissions); addition of tampering (rates and associated emission impacts) and anti-tampering program benefits; in-use emission factor estimates for non-exhaust emissions adjusted for "real world" fuel volatility as measured by Reid Vapor Pressure (RVP)
MOBILE4 (1989)	Updated with in-use data; addition of running losses as distinct emission source from gasoline powered vehicles; model fuel volatility (RVP) effects on exhaust emission rates; continued expansion of user controlled options for input data
MOBILE4.1 (1991)	Updated with new in-use data; addition of numerous features allowing user control of more parameters affecting in-use emission levels; including more inspection/maintenance (I/M) program design; inclusion of effect of various new emission standards and related regulatory changes (e.g., test procedures); inclusion of impact of oxygenated fuels (e.g., gasohol) on CO emissions
MOBILE5&5a (1993)	Updated with new in-use data; including basing new basic emission rate equation on much larger database derived from State implemented IM240 test programs; include effects of new evaporative emission test procedure (impact on in-use non-exhaust emission levels); include effects of reformulated gasoline (RFG); include effects of new NOx standard of 4.0 g/bhp-hr for heavy duty engines; inclusion of impact of oxygenated fuels on HC emissions; inclusion of Tier 1 emission standards under 1990 Clean Air Act Amendments; addition of July 1 evaluation option; inclusion of impact of low emitting vehicle (LEV) programs patterned after California regulations; revision to speed corrections used to model emission factor over range of traffic speeds. MOBILE5a was issued about 4 months after MOBILE5 to correct a number of minor errors detected under certain specific conditions, and as of today continues to be the "latest official release" of the highway vehicle emission factor model

Table 2-1. Continued.

MOBILE MODEL	UPDATES
MOBILE5b (1996)	Updated to reflect impacts on new regulations promulgated since release of MOBILE5 and MOBILE5a, including: onboard refueling vapor recovery systems, detergent gasoline additives, and Phase II reformulated gasoline (RFG) requirements; reactivates calculation of idle emission factors and expands calendar year range for which emission factors can be calculated from 2020 to 2050; greatly increases flexibility of modeling of inspection/maintenance (I/M) programs, providing for easier modeling of retest based hybrid I/M programs, evaporative emission system pressure and purge test, technician training and certification (TTC) credits, and acceleration simulation mode (ASM) tests (ASM1 and ASM2); corrects phase-in of emission benefits for first cycle of I/M program operation.
MOBILE6 (2001)	Updated to include facility based emission factor estimates (different average emission for different roadway types, even at similar average speeds), needed for transportation conformity determinations and more sophisticated application of results (e.g., photochemical air quality modeling, as versus simple inventory tabulation); "real-time" diurnal emission factors; updates on effects of oxygenated fuels on CO emissions; and effects of in-use fuel sulfur content on all emissions; separation of "start" and "running" emissions, to permit more precise temporal and spatial allocation of emissions; updates to many other areas on basis of new data. The model incorporates the effects of the most recent regulations: LEV, Tier2/Sulfur, HDDVNO_x and HDDV/Sulfur Fuel for future year emissions, as discussed in the next section.

TABLE 2-2. Relative Phase-in of Various Mobile Source Emission Standards

	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010 + later
NLEV	Northeastern States		Nationwide									
	30% Tier 1 40% TLEV 30% LEV	40% TLEV 60% LEV	100% LEV	100% LEV	100% LEV	100% LEV	100% LEV					
	Applies to LDV less than 6000 lb Gross vehicle weight (GVW).											
HDDVNO_x						Applies to HDDV. Begins in year 2004.						
Tier 2						LDGV & LLDT (< 6000 lb GVW)- Phase-in begins	LDGV & LLDT- Complete phase in by year 2007.			HLDT & MDPV- Phase-in begins.	HLDT & MDPV- Complete Phase-in	→
Sulfur in Gasoline						Meet Avg: 120ppm; Cap: 300ppm	Phase-in; lower sulfur content	Meet Avg: 30ppm; Cap: 80ppm	→			
Sulfur in Diesel								Meet Avg: 15 ppm	→			

LDV: Light duty vehicles
LDGV: Light Duty Gasoline Vehicles
LLDT: Light light Duty Trucks (< 6000 lb GVW); HLDT: Heavy Light Duty Trucks (> 6000 and < 8500 lb GVW)
MDPV: Medium Duty Passenger Vehicles- SUVs and minivans between 8500 and 10,000 lb GVW.

1999: 30% Tier 1, 40% TLEV, 30% LEV

2000: 0% Tier 1, 40% TLEV, 60% LEV

2001+: 100% LEV

where TLEV refers to a transitional low emission vehicle status. All other states, as shown in Table 2-2, were required to fully participate in the NLEV program beginning in year 2001. Consequently, beginning in 2001, all new cars and light-duty trucks up to 6000 pounds gross vehicle weight have to meet the National Low Emission Vehicle standards. The NLEV NO_x emission standard for light duty vehicles is 0.20 g/mile. This is a 50% reduction from the existing Tier 1 standard of 0.40 g/mile that was phased in nationally in the period of 1994-1996. The TLEV standard for NO_x remained the same as the Tier 1 standard. The NLEV VOC emission standard is 0.075 g/mi of non-methane organic gases (approximately a 70% reduction from the Tier 1 standard of 0.25 g/mile). The TLEV standard for VOCs was 0.125 g/mi. The NLEV standards remain in effect until they are replaced by the Tier 2/Sulfur standards that begin to phase-in beginning in 2004.

2.3.2. 2004 NO_x Standard for Heavy-Duty Diesel Engines

The U.S. EPA promulgated a new NO_x Standard for Heavy-Duty Diesel Engines to take effect beginning in model year 2004. The Standard is referred to in this study as HDDVNO_x. The new rule has a combined emission standard for NO_x emissions and non-methane hydrocarbons (NMHC). As per the rule, the manufacturers of such engines have the choice of certifying their new engines to either a 2.4 g/bhp-hr NMHC plus NO_x standard, or to a 2.5 g/bhp-hr NMHC plus NO_x standard with a limit of 0.5 g/bhp-hr for

NMHC. This standard is expected to reduce the NO_x emissions from highway heavy-duty engines by almost 50% (8).

2.3.3. Tier 2 Vehicle Emission Standard and Gasoline Sulfur Requirements

The Tier 2 standard and the sulfur rule were promulgated to help reduce both ozone and particulate matter (PM) levels. This rule treats both vehicles and fuels as a single system resulting in cleaner vehicles using fuels with lower sulfur content. Tier 2 Vehicle Emission Standards, to be phased in beginning in 2004, will apply to all new passenger cars, light trucks and medium-duty passenger vehicles. Light trucks consist of Light Light-Duty Trucks (LLDTs) that are less than 6000 pound gross vehicle weight and Heavy Light-Duty Trucks (HLDTs) that are greater than 6000 pound gross vehicle weight. Medium-Duty passenger vehicle (MDPV) is a new category of cars in the Tier 2 standard that includes SUVs, and passenger vans with between 8500 to 10000 pound gross vehicle weight. For passenger cars and LLDTs, the standards will be phased in over a three year period (2004-2007). For HLDTs and MDPVs, the phase-in begins in the year 2008 with 100% phase-in by year 2009. Upon completion of the phase-in period, all new passenger cars, LLDTs, HLDTs and MDPVs would be subjected to the same set of emission standards.

The other requirement of this rule is the restriction on the sulfur content of gasoline. It affects all gasoline-fueled vehicles that have a catalytic converter, regardless of vehicle age. All refineries will be required to meet the average gasoline sulfur standard of 120 ppm and a cap of 300 ppm beginning in 2004. By 2006, an average of no more

than 30 ppm sulfur with a cap of 80 ppm must be met (9). The combined effect of the Tier 2/Sulfur rule is to reduce NO_x emissions to an average of 0.07 grams per mile (9) for new vehicles. The rule does not have a significant effect on VOC emissions.

2.3.4. Heavy-Duty Engine and Vehicle Standards and Highway Diesel Fuel Sulfur Control Requirement

The Heavy-Duty Engine and Vehicle emission standards and the sulfur rule were promulgated to help reduce both ozone and particulate matter (PM) levels. The U.S EPA is establishing a comprehensive national control program that will regulate the heavy-duty vehicle and its fuel as a single system (10). As a part of this program, new emission standards for heavy-duty engines and vehicles will begin to take effect in model year 2007. These standards are based on the use of high-efficiency catalytic exhaust emission control devices or comparably effective advanced technologies (11).

The other requirement of this rule is the restriction on the sulfur content of diesel fuel. Sulfur in diesel fuel must be lowered to enable the high-efficiency catalytic exhaust emission control devices or comparably effective advanced technologies to be effective. In order to meet these more stringent standards for diesel engines, a 97% reduction in the sulfur content of highway diesel fuel from its current level of 500 ppm to 15 ppm is to be implemented (10). Refiners will be required to start producing diesel fuel for use in highway vehicles beginning June 1, 2006.

2.4. GROWTH OF VEHICLE MILES TRAVELED (VMT) IN TENNESSEE

The relative importance of on-road emissions as a participant in ozone formation depends in large part on the total VMT per day in a given area. In the future, the relative importance of on-road emissions will be affected by the growth in VMT, which results in increased emissions, and the implementation of motor vehicle emission controls, which reduce the emissions associated with each mile of travel. While current VMT data compiled by DOTs provides the basis for estimating current emissions, it is necessary to estimate the growth in VMT in order to predict future growth and projections of on-road emissions. This chapter provides the estimation of the current growth rate in VMT for the State of Tennessee on a county-level basis.

2.4.1. Statewide VMT Equations and Growth

The statewide vehicle miles traveled (VMT) was obtained from the Federal Highway Administration's annual report *Highway Statistics Series* that is available at the FHWA website: www.fhwa.dot.gov/ohim/ohimstat.htm for 1967 through 1998. All statewide VMT are reported as annual vehicle miles traveled by functional road classification for both urban and rural area.

Based on the data available in the *Highway Statistic Series* the state wide annual VMT for Tennessee is summarized in Table 2-3 and shown graphically in Figure 2-2. An analysis of the data indicated that VMT growth in Tennessee was not linear, but generally grew at a compound rate of 3.5% between 1967 and 1998. Since county wide data by roadway classification (rural and urban) were only available for the nine year period of

Table 2-3. State Wide Annual VMT (million mi)

Year	VMT (million mi)
1967	18002
1968	18824
1969	19236
1970	20719
1971	27224
1972	29830
1973	32513
1974	31442
1975	32926
1976	31579
1977	32949
1978	34562
1979	34084
1980	33505
1981	34729
1982	34793
1983	36261
1984	36523
1985	36307
1986	39521
1987	42126
1988	44193
1989	45639
1990	46024
1991	47267
1992	49994
1993	52112
1994	54524
1995	56214
1996	57884
1997	60526
1998	61665

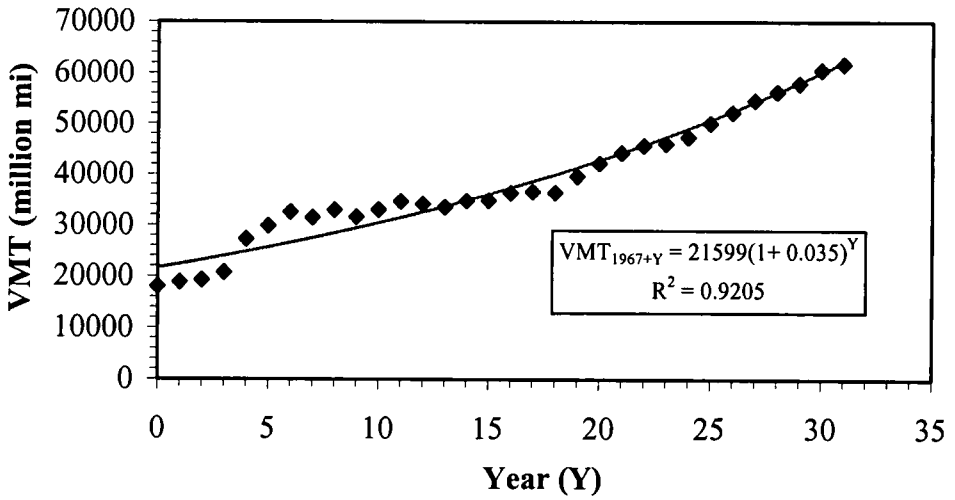


Figure 2-2. State Wide Annual VMT vs Year (1967-1998)

1990-1998 at the on-set of this study, the statewide annual VMT growth rate was recalculated to be 3.9% for that period and shown in Figure 2-3. The best-fit equation for VMT (based on the annual compound growth) is of the following form:

$$VMT_{1990+Y} = K\left(1+\frac{r}{100}\right)^{Y} \qquad (2.1)$$

where

VMT_{1990+Y} is the Annual Vehicle Miles Traveled in the 1990 + *Y* year

r is the growth rate in percent such that the fractional growth is *r*/100

K is a constant associated with the best fit

Y is the number of years since 1990, i.e. if *Y*= 8, then $VMT_{1990+Y} = VMT_{1998}$

R^2 is the coefficient of determination for the best fit

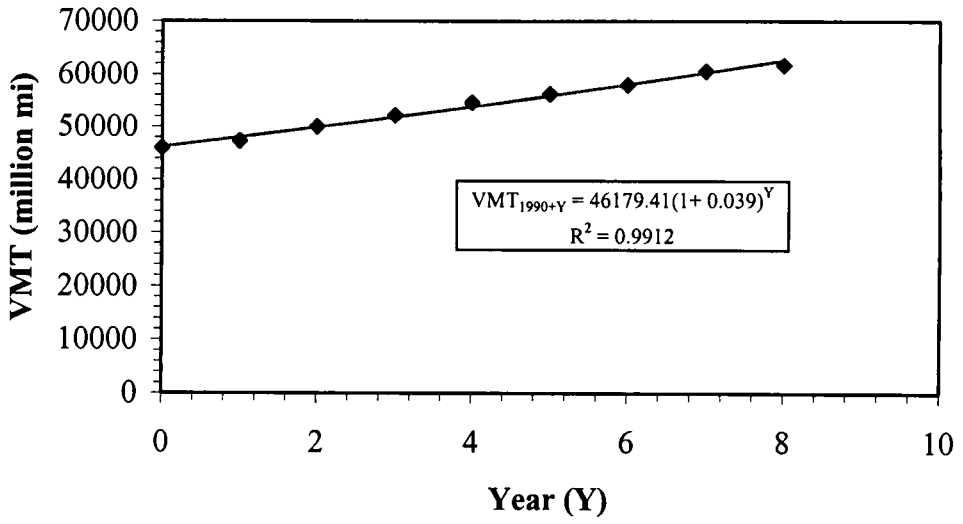


Figure 2-3. State Wide Annual VMT vs Year (1990-1998)

All annual VMT values include the VMT contribution from the local traffic category since these were included as an estimate in the FHWA report. The best fit equation is shown in Figure 2-3 for the 1990 through 1998 period.

A more detailed analysis of the annual statewide VMT was done to provide equations and compound annual growth rates by rural and urban categories and by functional road classifications. The overall annual VMT and compound growth rates for rural and urban areas for 1980-1998 are shown in Table A1 and Figures A1-A2. Figures A3-A4 show the growth rate for 1990-1998. The statewide annual growth rates and equations for urban and rural by roadway classifications are shown in Table A2 and Figures A5-A19.

2.4.2. County Level DVMT Equations and Growth

The county level VMT data were obtained from the annual summaries of *TN Vehicle of Travel* and *TN Vehicle Miles of Travel by County* that were prepared by the Transportation Department of Tennessee (TDOT) each year. The data include 1990-1998, with the exception of 1997 (not available), and were reported as daily vehicle miles traveled (DVMT) by county by functional road classification for both urban and rural areas.

The growth rate and equations describing the county level DVMT are summarized in Table 2-4. The equations follow the same nomenclature as described in the previous section, except that all equations are for DVMT in millions of miles. The DVMT equation does not include the contribution from local DVMT since this category is not directly measured by TDOT. The exclusion of local traffic does not affect the calculation of the growth, however, since local traffic is generally estimated by TDOT to be a fraction of the other categories. In Table 2-4, the equations for DVMT on a county level generally had an R^2 values in the 0.8+ range.

Growth of DVMT for 1990-1998 for Davidson, Hamilton, Knox, Shelby, and Sullivan Counties are shown in Figures 2-4 to 2-8 respectively. The figures indicate that the compound growth equation provided a very good fit for the data with R^2 values ranging from 0.87 to 0.99; the growth rates were 4.7, 3.9, 4.2, 4.7 and 3.3% for these counties respectively. Figure 2-9 shows a state map by county indicating the annual compound growth rate in percent for each county to provide a visual indication of the growth rate occurring in various regions within Tennessee.

Table 2-4. Summary of Compound Annual Growth Rates for TN Counties, based on 1990-1998 DVMT Data

County	Growth Rate, r(%)	R^2	K
Anderson	2.0	0.90	1.678
Bedford	4.1	0.90	0.587
Benton	2.7	0.91	0.483
Bledsoe	3.1	0.83	0.175
Blount	5.0	0.95	1.457
Bradley	3.2	0.86	1.757
Campbell	3.4	0.93	1.184
Cannon	3.1	0.95	0.221
Carroll	2.2	0.67	0.575
Carter	2.5	0.58	0.887
Cheatham	4.0	0.85	0.746
Chester	3.8	0.97	0.259
Claiborne	3.8	0.83	0.512
Clay	1.9	0.62	0.128
Cocke	3.4	0.92	0.838
Coffee	3.2	0.92	1.393
Crockett	3.5	0.92	0.311
Cumberland	4.2	0.95	1.328
Davidson	4.7	0.92	12.530
Decatur	4.7	0.92	0.308
DeKalb	3.3	0.96	0.287
Dickson	3.1	0.81	1.067
Dyer	2.7	0.92	0.870
Fayette	3.8	0.95	0.926
Fentress	3.7	0.85	0.283
Franklin	1.3	0.72	0.656
Gibson	2.3	0.94	0.890
Giles	3.9	0.93	0.795
Grainger	4.4	0.90	0.402
Greene	4.6	0.94	1.532
Grundy	2.1	0.55	0.348
Hamblen	3.7	0.91	1.126
Hamilton	3.9	0.99	6.399
Hancock	4.3	0.85	0.072
Hardeman	2.1	0.91	0.521
Hardin	3.3	0.85	0.458
Hawkins	2.3	0.74	0.851
Haywood	2.9	0.88	0.841
Henderson	4.6	0.94	0.925
Henry	2.6	0.79	0.619
Hickman	3.3	0.80	0.580
Houston	3.2	0.80	0.099
Humphreys	4.1	0.98	0.596
Jackson	2.1	0.48	0.192
Jefferson	4.2	0.94	1.380
Johnson	2.9	0.73	0.263
Knox	4.2	0.97	7.758
Lake	0.6	0.10	0.101
Lauderdale	1.2	0.33	0.501
Lawrence	4.2	0.97	0.585
Lewis	4.4	0.96	0.135
Lincoln	1.9	0.90	0.583
Loudon	3.1	0.93	1.337
McMinn	3.4	0.91	1.453
McNairy	3.5	0.91	0.560

County	Growth Rate, r(%)	R^2	K
Macon	1.9	0.43	0.284
Madison	3.9	0.97	2.189
Marion	4.7	0.95	1.217
Marshall	4.1	0.95	0.614
Maury	4.0	0.97	1.562
Meigs	0.9	0.15	0.205
Monroe	3.6	0.95	0.776
Montgomery	4.5	0.96	1.979
Moore	1.9	0.60	0.111
Morgan	3.0	0.80	0.287
Obion	2.2	0.76	0.759
Overton	3.8	0.93	0.357
Perry	5.0	0.94	0.144
Picket	4.5	0.94	0.072
Polk	1.9	0.48	0.352
Putnam	4.4	0.96	1.579
Rhea	2.6	0.76	0.513
Roane	2.2	0.80	1.459
Robertson	4.2	0.79	1.441
Rutherford	4.8	0.96	3.111
Scott	4.8	0.91	0.305
Sequatchie	5.0	0.95	0.216
Sevier	5.3	0.94	1.523
Shelby	4.7	0.91	14.443
Smith	3.6	0.93	0.691
Stewart	3.0	0.91	0.225
Sullivan	3.3	0.87	2.986
Sumner	3.6	0.90	1.990
Tipton	3.3	0.94	0.668
Trousdale	1.7	0.70	0.163
Unicoi	4.7	0.90	0.307
Union	3.7	0.91	0.219
Van Buren	6.5	0.95	0.094
Warren	2.9	0.88	0.688
Washington	4.2	0.88	1.796
Wayne	3.8	0.88	0.250
Weakley	2.5	0.65	0.598
White	4.3	0.93	0.381
Williamson	5.1	0.94	2.194
Wilson	4.2	0.97	1.987

***$DVMT_{1990+Y} = K(1+r/100)^Y$**

where,

$DVMT_{1990+Y}$ = DVMT (million miles) in year 1990+Y

K = best fit constant

r = growth rate compounded annually in percent

Y = years; ie y=0 is 1990, y=8 is 1998

R^2 = coefficient of determination for best fit

* DVMT values do not include local road classification

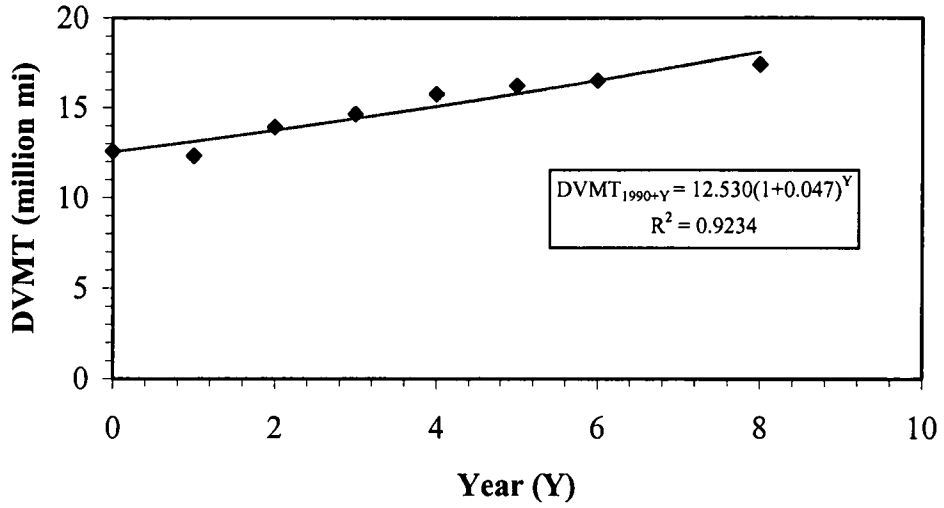


Figure 2-4. Davidson DVMT vs Year (1990-1998)

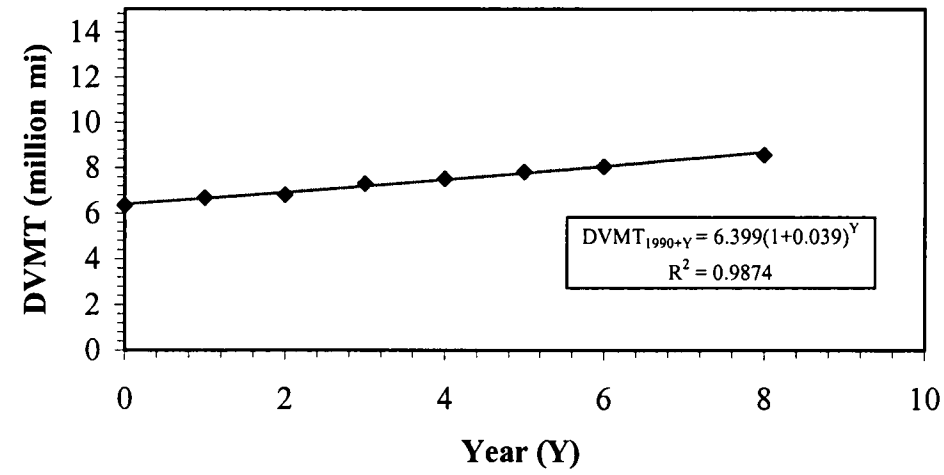


Figure 2-5. Hamilton DVMT vs Year (1990-1998)

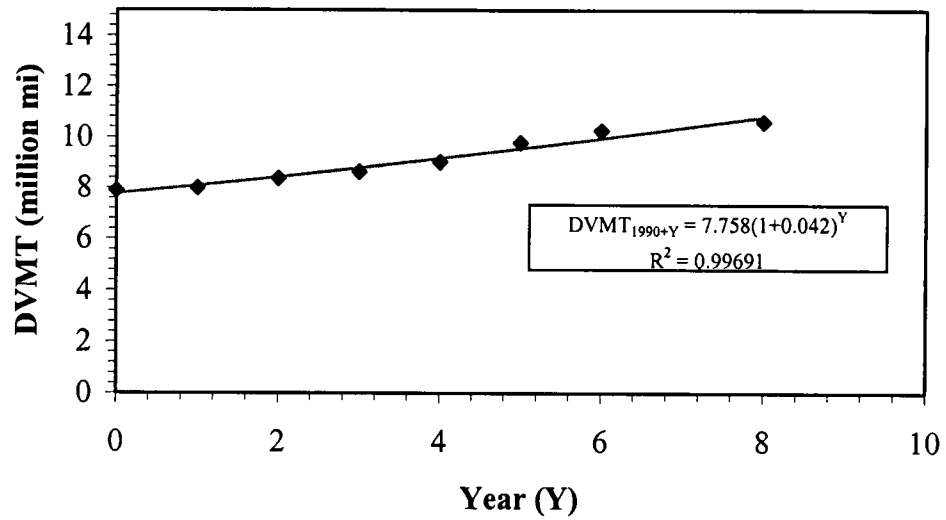


Figure 2-6. Knox DVMT vs Year (1990-1998)

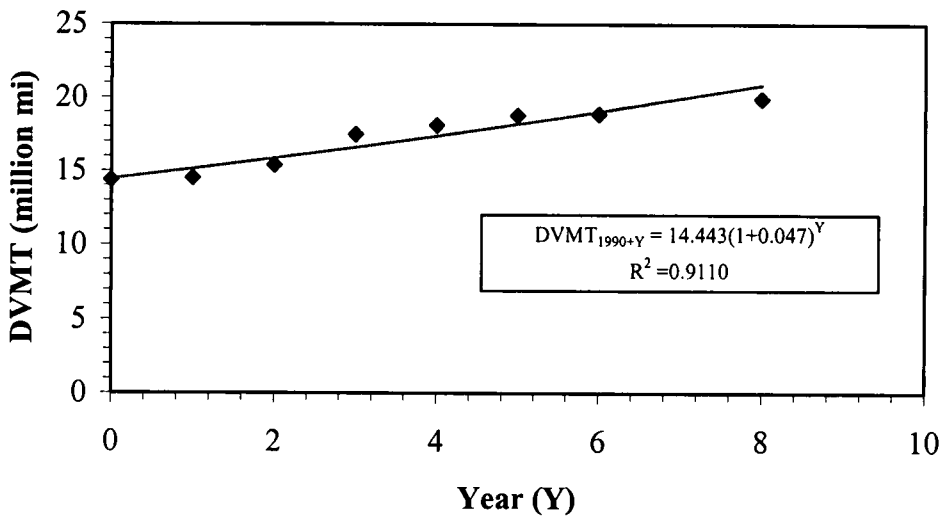


Figure 2-7. Shelby DVMT vs Year (1990-1998)

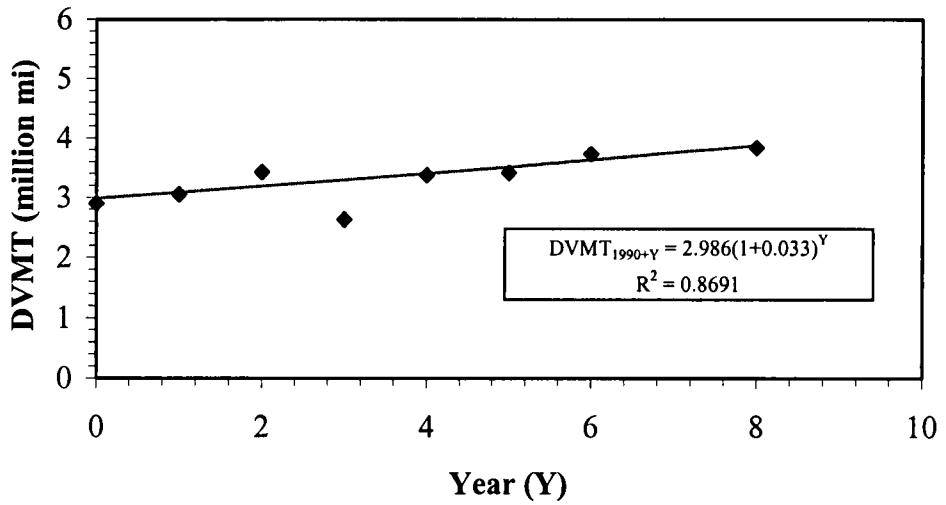


Figure 2-8. Sullivan DVMT vs Year (1990-1998)

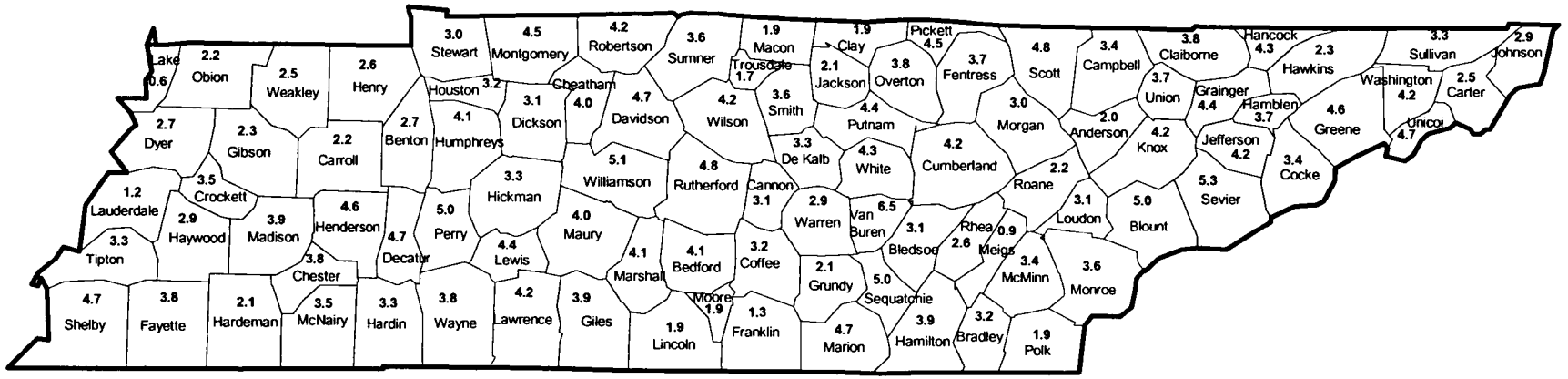


Figure 2-9. Compound Annual Growth Rate for TN Counties Based on 1990-1998 DVMT Data

CHAPTER 3

METHODOLOGY

This chapter reviews the methodology for developing the on-road mobile sources emission inventory for the State of Tennessee. Emissions from highway mobile sources were predicted with the latest available mobile source model, MOBILE6 (draft version) that was released in late March 2001. MOBILE6 is an update to the MOBILE5b model that incorporates the effects of the most recent regulations that were promulgated after the release of MOBILE5b, including LEV, Tier2/Sulfur, HDDVNOx and HDDV/Sulfur regulations. MOBILE6 not only includes new regulations but also various updates such as the ability to predict facility-based emission factor emissions for more sophisticated application of results, "real-time" diurnal emission factors, separation of "start" and "running" emissions and other relevant factors (3). This chapter also summarizes the input parameters used in the modeling and calculations of the on-road mobile sources emission projection for year 1999 through 2030.

Most of the required input parameters were set to "default" values built in to the MOBILE6 model. Locality specific input parameters were used in the MOBILE model such as VMT fractions, registration distributions, daily minimum and maximum temperatures, absolute humidity, fuel reid vapor pressure (RVP) and the option of a Inspection and Maintenance (I/M) program. In the next two sections, detailed explanation of these input parameters will be included.

3.1. DEVELOPMENT OF REGISTRATION DISTRIBUTION BY AGE FOR TENNESSEE

3.1.1. Introduction

Registration distribution by age is a required input to the MOBILE6 model. It is the fraction of vehicles on the road by vehicle class and age. Although the model allows the use of a national default distribution, inventory guidance requires the use of locality specific distributions where these are available. The MOBILE6 model uses the registration distribution along with annual mileage accumulation rates to evaluate the travel fractions, which in turn are used to weight the emission factors according to the age distribution of the fleet. Hence area specific values may make a difference in the mobile source emission values. For the purpose of this study it is more appropriate to use values developed specifically for the State of Tennessee. Specific registration distribution by age may be developed from different sources such as the registration data, inspection and maintenance data and so on. For this study, area specific registration distributions were developed from the registration data obtained from the Tennessee Department of Safety, Title and Registration Division.

3.1.2. Methodology

Registration data provided by the Tennessee Department of Safety, Title and Registration Division were received on a 3480 cartridge and were in the form of a text file format which was then imported into Microsoft Access®, a database software, to be analyzed further. The data contained information on the county, registration class, make code, model year and body type for vehicles of model year 2001 and earlier. For the

purpose of this study, only the following information was used: county, model year and the body type. Each county is represented by a two-digit number. Model year is another field in the database that shows the last two digits of the year the vehicle was manufactured. Lastly the body type code field differentiates the types of vehicles within the main categories of passenger cars, trucks and motorcycles.

For purpose of calculations, the count data of each county were grouped into six area subgroupings (most of which corresponded to a Metropolitan Statistical Area (MSA)):

1. Shelby/Tipton/Fayette Counties (denoted as "*Shelby* +")
2. Davidson/Sumner/Wilson/Williamson/Rutherford Counties (denoted as "*Davidson* +")
3. Hamilton/Marion Counties (denoted as "*Hamilton* +")
4. Knox/Anderson/Loudon/Blount/Sevier/ Union MSA + Jefferson County (denoted as "*Knox* +")
5. Sullivan/Hawkins/Washington/Carter/Unicoi Counties (denoted as "*Sullivan* +")
6. All Other TN Counties (denoted as "*All Other Counties*")

The county code information was used to identify and group the data into the different Area Subgroupings. Registration distributions were developed only for three major vehicle categories: light-duty vehicle (LDV, passenger cars less than 8500 lbs GVW), light-duty trucks 1 and 2 (LDT1 and LDT2, less than 6000 lbs GVW) and light-duty trucks 3 and 4 (LDT3 and LDT4, 6001-8500 lbs GVW). Body type codes were used to identify the vehicle classification (LDV, LDT1 and 2, LDT3 and 4). Since no detailed

information was available to evaluate the fractions separately for LDT1 and LDT2 or for LDT3 and LDT4, LDT1 and 2 were grouped together as were LDT3 and 4. Table 3-1 lists the body type codes used to identify and group the three vehicle classifications.

After the vehicles were grouped into the three vehicle categories within each Area Subgroup, the registration fraction was calculated as follows: actual counts of vehicle were collected for each age vehicle starting with two year old vehicles to thirty year old vehicles. The age, for purpose of evaluation, was defined as the year that the vehicle is in service; for example, model year 2000 (for the database of year 2001) was taken as a two year old vehicle. The thirty year old vehicle included all vehicles that were thirty years old and greater. The one year old vehicles were taken to be 75% of the two year old vehicle counts. This is to account for the fact that the new cars were assumed to enter into the market in the month of October and they have been through only 75% of a year by July 1 (the evaluation month). Using the vehicle counts, the fraction of vehicles in each age category were calculated and plotted. These fractions represent the registration distribution by age. However, the plots do not follow a smooth curve and reflect socio-economical changes that might have occurred over the last thirty years. Since this same data will also be used for estimation of the registration for future years, a Best-fit curve was fitted to each registration distribution to smooth out the year to year fluctuations. Since the plots depicted curves similar to bell-shaped or a gaussian curve, a gaussian distribution equation was chosen to fit the data set. Sigma Plot® software was used for this purpose.

Table 3-1. Body Type Code for Different Vehicle Classifications

LDV	LDT1 & LDT2	LDT3 & LDT4
CP- Coupe	CB- Cab & Chassis (Luv)	AM- Ambulance
CV- Convertible	PK- Pickup	PN- Panel
HT- Hardtop	WW- Wide Wheel Wagon	SV- Sports Van
HB- Hatchback	SP- Sport Pickup	UT- Utility (Blazer, Jimmy, Scout, etc.)
IN- Incomplete Passenger	ST- Stake or Rack	CC- Conventional Cab
LB- Liftback	S1- One Seat	CG- Cargo Van
NB- Notchback	S2- Two Seat	CH- Crew Chassis
RD- Roadster	VN- Van	CL- Club Chassis
SB- Sport Hatchback	VT- Vanette (including Metro and Handy Van)	CS- Super Cab or Chassis Pickup
SC- Sport Coupe	VW- Window Van	CU- Custom Pickup
SD- Sedan	YY- Cutaway	CW- Crew Pickup
SW- Station Wagon	3B- 3-Dr Extended Cab or Chassis	CY- Cargo Cutaway
2D- Sedan 2-Dr	3C- 3-Dr Extended Cab Pickup	EC- Extended Cargo Van
2F- Formal Hardtop 2-Dr		ES- Extended Sports Van
2H- Hatchback 2-Dr		EV- Extended Van
2L- Liftback 3-Dr		EW- Extended Window Van
2P- Pillard Hardtop 2-Dr		FB- Flat-bed or Platform
2T- Hardtop 2-Dr		IE- Incomplete Extended Van
2W- Wagon 2-Dr		LL- Suburban & Carry All
3D- Runabout 3-Dr		MP- Multi-purpose
3P- Coupe 3-Dr		MV- Maxi Van
4D- Sedan 4-Dr		MY- Motorized Cutaway
4H- Hatchback 4-Dr		PC- Club Cab Pickup
4L- Liftback 4-Dr		PM- Pickup with camper mounted on bed
4P- Pillard Hardtop 4-Dr		PN- Panel
4T- Hardtop 4-Dr		PS-Super Cab Pickup
5D- Sedan 5-Dr		SN- Step Van
		SW- Station Wagon (Jeep Wagoneer, Toyota Land Cruiser)
		VC- Van Camper
		VD- Display Van
		WK- Tow Truck Wrecker
		XT- Travelall
		4B- 4-Dr Extended Cab or Chassis
		4C- 4-Dr Extended Cab Pickup
		4W- 4-Dr Wagon/Sport Utility
		8V- 8 Passenger Sport Van

This method is based on the formula shown below:

$$y = \frac{k}{s} \exp\left(-\frac{1}{2}\left(\frac{x-m}{s}\right)^2 \right) \qquad (3.1)$$

where:

y = fraction of vehicles at age x, unitless

k = constant (empirically derived age), years

s = standard deviation of the distribution, years

m = mean of the distribution; represents the age with the highest fraction (where the curve peaks), years

x = age of the vehicle, years

The curve fit function in Sigma Plot® was used to generate best fit values for k, s and m. Since the registration fractions are required to sum up to 1.0, the 'k' value was adjusted until this was achieved. This final 'k' value and the earlier generated 's' and 'm' values, along with coefficient of determination for best fit (R^2), for the various Area Subgroups and vehicle classifications are listed in Table 3-2.

The registration distribution developed for each Area Subgroup for the three major vehicle classifications is tabulated in Tables 3-3, 3-4 and 3-5. The graphs showing the raw fractions and best-fit curves are shown in Appendix B in Figures B1 through B6.

Table 3-2. Gaussian Equation Parameters

LDV:

County	k	m	s	R^2
Shelby +	0.6876	2.5364	8.7744	0.9883
Davidson +	0.6287	3.4146	8.0397	0.9861
Hamilton +	0.5042	7.0022	7.8926	0.9702
Knox +	0.5754	5.2684	8.9947	0.9731
Sullivan +	0.4703	8.6537	7.7997	0.9551
All counties	0.4637	8.4824	7.1557	0.9747

LDT1 and LDT2:

County	k	m	s	R^2
Shelby +	0.8861	-0.4917	10.8307	0.9756
Davidson +	0.69675	2.4349	9.0318	0.9712
Hamilton +	0.6156	5.1648	10.5419	0.8874
Knox +	0.6211	5.0958	11.0115	0.9443
Sullivan +	0.5295	8.2319	10.2772	0.8922
All counties	0.5165	8.3190	9.6409	0.9051

LDT3 and LDT4:

County	k	m	s	R^2
Shelby +	0.57085	4.0472	6.7764	0.9143
Davidson +	0.9380	-0.9483	8.7871	0.9689
Hamilton +	3.2148	-15.3669	14.0761	0.9694
Knox +	6.0525	-25.4150	17.3490	0.9269
Sullivan +	1.0211	-2.6893	12.2959	0.9195
All counties	0.74785	1.5431	10.5450	0.9238

Table 3-3. Age Distributions for LDV

Age	Shelby +	Davidson +	Hamilton +	Knox +	Sullivan +	All Other Counties
1	0.0593	0.0642	0.0448	0.0481	0.0355	0.0300
2	0.0781	0.0770	0.0523	0.0599	0.0419	0.0430
3	0.0781	0.0781	0.0562	0.0620	0.0464	0.0483
4	0.0772	0.0780	0.0594	0.0633	0.0505	0.0533
5	0.0753	0.0767	0.0619	0.0639	0.0540	0.0576
6	0.0724	0.0743	0.0634	0.0638	0.0569	0.0610
7	0.0688	0.0708	0.0639	0.0628	0.0590	0.0634
8	0.0645	0.0665	0.0634	0.0611	0.0601	0.0647
9	0.0597	0.0614	0.0619	0.0587	0.0602	0.0646
10	0.0545	0.0559	0.0594	0.0557	0.0594	0.0634
11	0.0492	0.0501	0.0562	0.0522	0.0576	0.0609
12	0.0438	0.0442	0.0523	0.0483	0.0550	0.0574
13	0.0385	0.0384	0.0479	0.0442	0.0516	0.0531
14	0.0333	0.0329	0.0431	0.0399	0.0477	0.0481
15	0.0285	0.0277	0.0382	0.0356	0.0433	0.0428
16	0.0241	0.0230	0.0334	0.0314	0.0387	0.0373
17	0.0201	0.0188	0.0286	0.0273	0.0340	0.0319
18	0.0166	0.0151	0.0242	0.0235	0.0294	0.0268
19	0.0135	0.0119	0.0201	0.0199	0.0250	0.0220
20	0.0108	0.0093	0.0165	0.0167	0.0209	0.0177
21	0.0086	0.0071	0.0133	0.0139	0.0172	0.0140
22	0.0067	0.0054	0.0105	0.0113	0.0139	0.0109
23	0.0052	0.0040	0.0082	0.0092	0.0111	0.0083
24	0.0039	0.0029	0.0063	0.0073	0.0087	0.0062
25	0.0030	0.0021	0.0047	0.0058	0.0067	0.0045
26	0.0022	0.0015	0.0035	0.0045	0.0051	0.0032
27	0.0016	0.0011	0.0026	0.0035	0.0038	0.0023
28	0.0012	0.0007	0.0019	0.0026	0.0028	0.0016
29	0.0008	0.0005	0.0013	0.0020	0.0020	0.0011
30	0.0006	0.0003	0.0009	0.0015	0.0014	0.0007
Total	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000

Table 3-4. Age Distributions for LDT1 and 2

Age	Shelby +	Davidson +	Hamilton +	Knox +	Sullivan +	All Other Counties
1	0.0562	0.0563	0.0312	0.0386	0.0328	0.0294
2	0.0797	0.0771	0.0558	0.0542	0.0429	0.0432
3	0.0777	0.0770	0.0572	0.0554	0.0453	0.0460
4	0.0751	0.0760	0.0580	0.0561	0.0473	0.0485
5	0.0719	0.0741	0.0584	0.0564	0.0490	0.0505
6	0.0684	0.0714	0.0582	0.0562	0.0503	0.0520
7	0.0644	0.0679	0.0575	0.0556	0.0512	0.0531
8	0.0602	0.0638	0.0563	0.0545	0.0515	0.0535
9	0.0557	0.0592	0.0547	0.0530	0.0514	0.0534
10	0.0512	0.0543	0.0526	0.0511	0.0508	0.0528
11	0.0466	0.0492	0.0501	0.0489	0.0497	0.0515
12	0.0421	0.0440	0.0473	0.0463	0.0482	0.0498
13	0.0377	0.0389	0.0443	0.0436	0.0463	0.0476
14	0.0334	0.0340	0.0411	0.0407	0.0440	0.0450
15	0.0294	0.0293	0.0378	0.0376	0.0415	0.0421
16	0.0257	0.0250	0.0344	0.0345	0.0387	0.0390
17	0.0222	0.0210	0.0311	0.0314	0.0358	0.0357
18	0.0190	0.0175	0.0278	0.0284	0.0328	0.0324
19	0.0162	0.0143	0.0247	0.0254	0.0298	0.0290
20	0.0137	0.0116	0.0217	0.0226	0.0267	0.0257
21	0.0114	0.0093	0.0189	0.0199	0.0238	0.0226
22	0.0095	0.0074	0.0163	0.0174	0.0210	0.0196
23	0.0078	0.0058	0.0140	0.0150	0.0183	0.0168
24	0.0063	0.0045	0.0118	0.0129	0.0159	0.0143
25	0.0051	0.0034	0.0099	0.0110	0.0136	0.0120
26	0.0041	0.0026	0.0083	0.0093	0.0116	0.0100
27	0.0033	0.0019	0.0068	0.0078	0.0097	0.0082
28	0.0026	0.0014	0.0056	0.0065	0.0081	0.0067
29	0.0020	0.0010	0.0045	0.0053	0.0067	0.0054
30	0.0016	0.0007	0.0036	0.0044	0.0055	0.0043
Total	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000

Table 3-5. Age Distributions for LDT3 and 4

Age	Shelby +	Davidson +	Hamilton +	Knox +	Sullivan +	All Other Counties
1	0.0748	0.0829	0.0749	0.0936	0.0705	0.0653
2	0.0805	0.1009	0.1067	0.1001	0.0772	0.0709
3	0.0832	0.0965	0.0975	0.0912	0.0746	0.0702
4	0.0842	0.0911	0.0886	0.0829	0.0716	0.0690
5	0.0834	0.0849	0.0802	0.0750	0.0683	0.0672
6	0.0808	0.0781	0.0722	0.0677	0.0647	0.0649
7	0.0766	0.0709	0.0646	0.0609	0.0609	0.0620
8	0.0711	0.0636	0.0576	0.0546	0.0569	0.0588
9	0.0645	0.0562	0.0510	0.0488	0.0529	0.0552
10	0.0573	0.0491	0.0450	0.0434	0.0488	0.0514
11	0.0498	0.0424	0.0395	0.0385	0.0447	0.0474
12	0.0423	0.0360	0.0345	0.0341	0.0407	0.0434
13	0.0352	0.0303	0.0300	0.0301	0.0368	0.0393
14	0.0286	0.0251	0.0259	0.0264	0.0331	0.0353
15	0.0228	0.0206	0.0223	0.0231	0.0295	0.0314
16	0.0178	0.0166	0.0191	0.0202	0.0262	0.0277
17	0.0136	0.0133	0.0162	0.0176	0.0230	0.0242
18	0.0101	0.0104	0.0138	0.0152	0.0202	0.0210
19	0.0074	0.0081	0.0116	0.0132	0.0175	0.0180
20	0.0053	0.0062	0.0097	0.0113	0.0151	0.0153
21	0.0037	0.0047	0.0081	0.0097	0.0130	0.0129
22	0.0025	0.0035	0.0067	0.0083	0.0111	0.0108
23	0.0017	0.0026	0.0056	0.0071	0.0094	0.0089
24	0.0011	0.0019	0.0046	0.0060	0.0079	0.0073
25	0.0007	0.0014	0.0037	0.0051	0.0066	0.0060
26	0.0004	0.0010	0.0030	0.0043	0.0055	0.0048
27	0.0003	0.0007	0.0025	0.0036	0.0045	0.0038
28	0.0002	0.0005	0.0020	0.0030	0.0037	0.0030
29	0.0001	0.0003	0.0016	0.0025	0.0030	0.0024
30	0.0001	0.0002	0.0013	0.0021	0.0024	0.0019
Total	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000

3.1.3. Use of Developed Registration Fractions in MOBILE6 Model

The developed registration fractions were used for mobile source emission calculations using the MOBILE6 model for areas within Tennessee. For those Area Subgroups listed above, the corresponding calculated fractions were used for the LDV, LDT1and LDT2, LDT3 and LDT4 vehicle categories; national default values were used for the remaining 11 vehicle categories. For the case of "All Other Counties" the following approach was used: when the total interstate (freeway + interstate) DVMT exceeded 50% of the total DVMT for a particular county, national default values were used instead of the generated fractions. This is based on the assumption that, in a rural county that has a major interstate flowing through it, the majority of vehicles on the interstate may not necessarily be those that are registered in that county and are most likely a part of the "through" traffic. Hence, the registration data for that county would not provide information that would be representative of the actual vehicle mix that is on the road. For counties that had interstate DVMT traffic that is less than 50% of the total DVMT for the county, the "All Other Counties" calculated fractions were used for the LDV, LDT1 and 2, LDT3 and 4 categories; national default values were used for the rest.

3.2. DEVELOPMENT OF THE ON-ROAD MOBILE SOURCES EMISSION INVENTORY FOR THE STATE OF TENNESSEE

3.2.1. Emissions Calculation Methodology

Emission factors generated from the MOBILE6 draft model were in terms of grams/mile of travel. Therefore, when the factor is multiplied by the daily vehicle miles traveled (DVMT) it gives the emissions in units of mass/day (e.g. tons per day).

The baseline year calculations were done for 1999, the latest year for which Tennessee DVMT data by county for each functional roadway classifications were available at the time of study. The baseline DVMT were then projected using growth rates generated from the 1990 through 1998 DVMT by county in Tennessee as explained in Chapter 2 for the future year emission calculations. It was assumed in the calculations that the DVMT growth rate for each county would remain constant and equal to the growth rate determined for the period 1990 through 1998 for that county.

For each subgroup, the MOBILE runs were done separately for RURAL and URBAN roadway classifications. Also for counties which had an existing inspection and maintenance (I/M) program, it was also necessary to run the MOBILE model "with" and "without I/M" program in order to address the fact that not all vehicles which drive through a county were subject to the I/M requirement. Emission calculations were calculated according to the following equation:

Composite Emissions in tons/day =

$$\{[(EF \text{ with I/M}) * (f1)] + [(EF \text{ without I/M}) * (f2)]\} * DVMT * 1.102x10^{-6} / SAF \quad (3.2)$$

where

EF = composite emission factor from MOBILE runs with/without I/M, g/mile

f1 = fraction of vehicles that have been subject to I/M that drive through the county

f2 = fraction of vehicles that have not been subject to I/M that drive through the county

SAF = seasonal adjustment factor for DVMT

$1.102x10^{-6}$ = conversion factor to convert grams to tons.

Equation 3.2 was used to calculate the composite emissions in tons/day for counties that are subject to I/M program.

For those counties that are not subjected to the I/M program, Equation 3.3 was used for the emission calculation, as follows:

Composite Emissions in tons/day = (EF without I/M) * DVMT*$1.102x10^{-6}$/ SAF (3.3)

where

EF = emission factor from MOBILE runs without I/M, g/mile

SAF = seasonal adjustment factor for DVMT

$1.102x10^{-6}$ = conversion factor to convert grams to tons.

The composite emission factor in the equation is the sum of emissions by roadway type from the MOBILE runs. These emission factors from the MOBILE runs are weighted by vehicle type and VMT mix for each roadway classification and the emission factors were reported by roadway classification for each particular analysis year.

The SAF is a factor that is used to adjust the average daily vehicle miles traveled to that of a typical average summer day. The values were obtained from TDOT and were developed from the 1996 monthly variation factors that describe the changes in the VMT by day of the week for every month. The SAF factor used in this study was taken to be the average of the monthly variation factors for each of the seven days of the week for the three months: June, July and August. This was done so that the DVMT would be representative of a typical summer (weekend and weekdays combined) day. Table 3-6 shows a tabulation of the SAF values used in Equation 3.2 and 3.3.

MOBILE6 provides for the calculation of emission factors for interstate, ramp, arterial, and local roadway classification. However, DVMT for each county in Tennessee

Table 3-6. Seasonal Adjustment Factors (SAF)

Roadway Classification	SAF
Rural Freeway	0.912
All Other Rural Roadway Types	0.973
All Urban Roadway Types	0.985

(as provided by TDOT) does not include values for the "ramp" classification at the present time but includes interstate (interstate + freeway), principal and minor arterial, collector and local classification. To address this issue, it was assumed that the DVMT on "Urban Ramps" was 8% of the total DVMT allocated to the Urban Interstate/freeway category in the TDOT DVMT data. This was based on information provided in a recent EPA report (12). Consequently, the DVMT that was allocated to the "Urban Interstate/Freeway" was 92% of the total DVMT on Urban Interstate/Freeways and DVMT for "Urban Ramps" was 8%. For the case of "Rural Ramp," it was assumed that the DVMT on the ramps was insignificant when compared to the DVMT on the interstates on the basis that most of rural interstate VMT is thru traffic not using ramps, ramp lengths are very small compared to interstate length and ramps were less frequent and further apart than in urban areas. Therefore, DVMT on "Rural Ramp" was set to zero. The DVMT on the "Arterial" classification was taken to be the sum of the DVMT on the "Principal Arterial", "Minor Arterial" and "Collector" roadway types, since MOBILE6 only contains one "arterial" roadway classification.

3.2.2. MOBILE6 Input Parameters for Area Subgroups

MOBILE6 runs were done for all the area subgroups as mentioned in the previous section. For Shelby County, Knox County and the Davidson+ area subgroup, most of the input parameters were based on the information available from the respective MPO Long Range Transportation Plans. Locality specific temperature, absolute humidity, and registration distribution data were generated. Daily minimum and maximum temperature is a required input to the MOBILE model. These temperatures were determined by selecting the average of the maximums and the average of the minimums on those days that recorded the 10 highest 8-hr average ozone concentrations for the period of 1998-2000. This was done separately for East, Middle and West Tennessee. The absolute humidity (in terms of grains per pound) was calculated according to the following equations:

$$\text{Absolute Humidity} = \left(\frac{SH \times 15.43}{2.205}\right) \tag{3.4}$$

$$SH = \left(\frac{(0.62197 \times VPa)}{Pm - (0.37803 \times VPa)}\right) \times 1000 \tag{3.5}$$

$$VPa = 6.11 \times 10 \times \left(\frac{(7.5 \times Tdc}{(237.7 + Tdc)}\right) \tag{3.6}$$

where

SH = Daily Average Specific Humidity, g/kg

0.62197, 0.37803, 6.11, 7.5, 237.7 = constants, unitless

Pm = Atmospheric Pressure, milibars

VPa = Daily Average Actual Vapor Pressure, milibars

Tdc = Daily Average Dewpoint Temperature, Celsius

Absolute Humidity = Daily Average Absolute Humidity, grains/lb

15.43 = conversion factor to convert grams to grains

2.205 = conversion factor to convert kilograms to pounds

The results of the temperatures and absolute humidity analyses for East, Middle and West Tennessee are listed in Table 3-7a through 7c respectively for the period of 1998-2000. For the purpose of this study, the counties that were classified into East, Middle, and West Tennessee are illustrated in Figure 3-1 and a list of the counties included in each area is tabulated in Table C1.

3.2.3. Specific Input Parameters For MOBILE Runs

The input file to the MOBILE6 model consists of three sections: the Header Section, the Run Section, and the Scenario Section. The Header Section controls the overall input, output, and execution of the program. The Run Section defines parameter values that localize or customize the runs. Details and calculation of emission factors for individual scenarios are included in the Scenario Section.

3.2.3.1. Shelby + Subgroup

For Shelby+ subgroup, two runs were done separately for Shelby County and Tipton/Fayette County. This was because Shelby County had an ongoing I/M program and assumed future anti-tampering program, while the other two counties did not. Moreover, there were slight changes in parameters such as the fuel RVP etc. Most of the input parameters for Shelby County were developed based on the information available

Table 3-7. Highest 8-hr Maximum Ozone Levels

a. East Tennessee: 1998-2000

Rank	O_3 (ppb)	Date	Name of the Monitor	Tmax (°F)	Tmin (°F)	Specific Humidity (gr/lb)
1	123	Aug-25-98	Knox21	91	66	97
2	122	Jun-01-00	Knox102	86	63	91
3	121	Jun-23-99	Blount102	93	72	128
4	118	Aug-06-98	Knox21	88	66	96
5	117	Jun-26-98	Knox21	94	73	126
6	116	Sep-12-98	Blount101	89	57	66
7	116	Jul-03-99	Jefferson	90	69	111
8	115	Aug-28-98	Knox21	93	67	93
9	115	Jul-04-99	Jefferson	91	71	116
10	115	Jun-09-00	Sullivan3	85	58	80
Average				**90**	**66**	**100**

b. Middle Tennessee: 1998-2000

Rank	O_3 (ppb)	Date	Name of the Monitor	Tmax (°F)	Tmin (°F)	Specific Humidity (gr/lb)
1	120	Aug-17-99	Wilson	97	67	86
2	114	Sep-06-99	Lawrence	92	66	81
3	111	Aug-05-98	Sumner7	90	68	97
4	111	May-18-98	Williams	86	54	62
5	110	Aug-04-98	Sumner7	86	70	96
6	110	Sep-04-98	Sumner7	96	70	81
7	110	Sep-05-99	Sumner7	99	65	74
8	108	Jun-25-98	Sumner7	95	73	123
9	108	Sep-03-99	Lawrence	96	62	72
10	108	Jun-01-00	Sumner7	88	64	84
Average				**93**	**66**	**86**

c. West Tennessee: 1998-2000

Rank	O_3 (ppb)	Date	Name of the Monitor	Tmax (°F)	Tmin (°F)	Specific Humidity (gr/lb)
1	124	May-18-98	Shelby21	90	65	69
2	110	Jul-09-99	Shelby21	96	72	97
3	109	Aug-23-98	Shelby100	92	69	94
4	108	Aug-28-98	Shelby100	96	69	113
5	107	Jul-26-00	Shelby21	95	70	83
6	107	Sep-06-98	Shelby100	96	75	95
7	107	Sep-04-99	Shelby21	96	70	117
8	106	Sep-19-99	Shelby21	92	63	67
9	104	May-21-98	Shelby100	91	72	110
10	104	May-19-98	Haywood1	92	70	92
10	104	Aug-22-00	Shelby21	100	77	105
10	104	Aug-19-99	Shelby21	97	73	101
Average				**94**	**70**	**95**

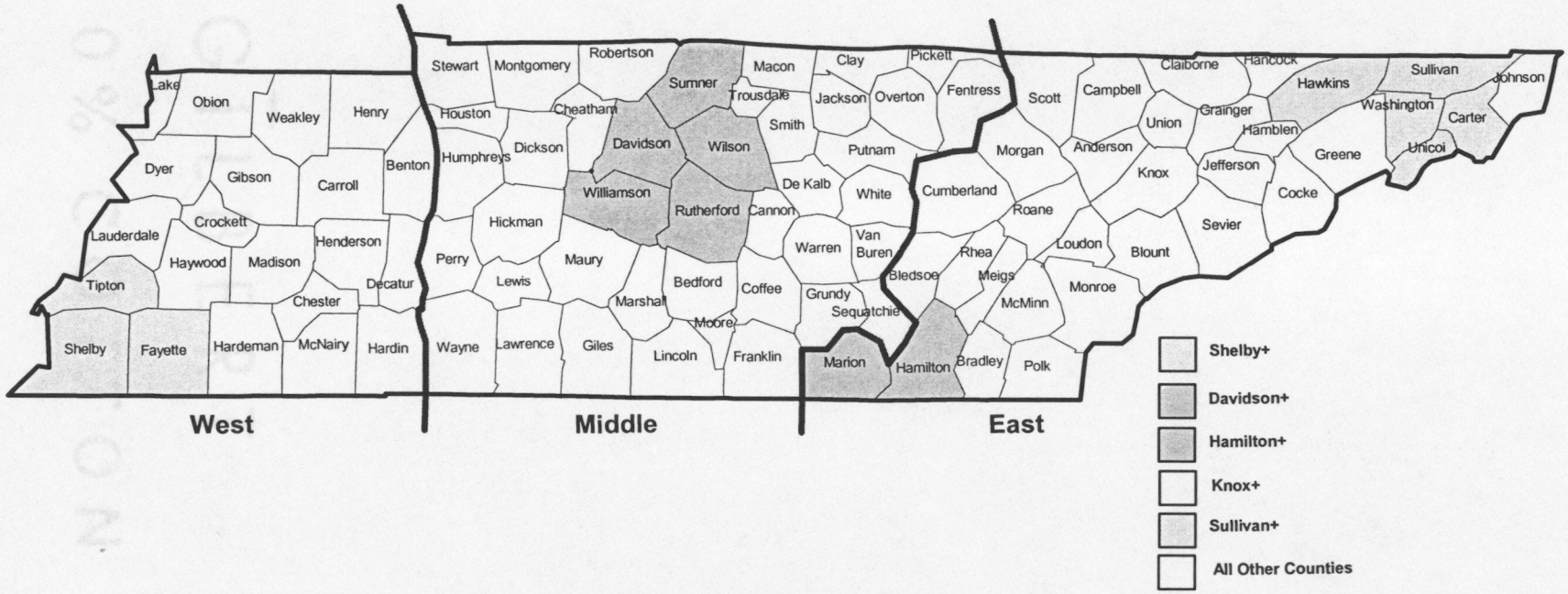


Figure 3-1. Map of the Area Subgroups and the Counties Classified as East, Middle and West Tennessee

from the Memphis MPO Long Range Transportation Plan. The input parameters are hence tabulated separately for Shelby County and for Tipton and Fayette Counties in Tables D2 and D3 respectively.

3.2.3.1a. Shelby County

Header Section: The input commands and their respective input parameters are shown in Table D1 of the appendix. The output for the runs were descriptive format by default therefore no input parameters are required.

Run Section: The Run Section containing the input commands and parameters are shown in Tables D2a through D2c of the appendix. Refueling emissions were not considered in the calculations. West Tennessee average absolute humidity and temperatures (average minimum and average maximum) were used in these runs.

Speed values were developed for different roadway classifications based on data obtained from MPO modeling and speed measurement studies. The speeds were developed for Freeway (interstate and freeway) and Arterials (principal arterials, minor arterials and collectors). For Ramps and Locals classifications, national default speeds were used. The speed values are shown in Table 3-8 in bold under Tennessee Harmonic Mean Speed column for both rural and urban roadway classification. A specific Shelby County VMT mix was used in the modeling listed under the command "VMT FRACTIONS". The VMT mix or fraction is the fraction of the VMT which is allocated to each vehicle classification (LDV, LDT1, LDT2, LDT3, LDT4, HDV2B, HDV3, HDV4, HDV5, HDV6, HDV7, HDV8, HDV8B, HDBS, HDBT, MC). TDOT provided the county specific VMT mix for the eight counties (Knox County, Shelby County, Hamilton

Table 3-8. Summary of Tennessee Highway Speed vs. MOBILE6 Defaults

Roadway Type	TDOT 1999 **Rural** VMT	Percent of Total	Arterial & Collector Fraction	UT Speed Summary (mph)	VMT Weighted Speed Component	Tennessee Harmonic Mean Speed (mph)	Mobile6 Default Speeds (mph)	3-Cities Measured Speeds M6.SPD.003 (mph)	5-Cities Modeled Speeds M6.SPD.004 (mph)	**Consolidated Roadway Types**
Interstate	25020954	30.6		63.8		**63.8**	36.5	52.6	50.1	**Freeway**
Prin Arterial	14983302	18.3	0.298	44.9	13.379					
Minor Arterial	15887047	19.5	0.316	41.9	13.239	**40.8**	31.2	22.8	34.9	**Arterial**
Collector	19412282	23.8	0.386	37.3	14.400					
Local	6353000	7.8		27.2		27.2	**12.9**	13.8	29.5	**Local**
Ramps						**NA**	NA	34.7		**Ramps**
Total	81656585	100.0	1.000	43.9		43.9	27.6			
						VMT Weighted Harmonic Mean Speed				
						NA = Not Applicable				
Arterial & Collector Total	50282631	61.6								

Roadway Type	TDOT 1999 **Urban** VMT	Percent of Total	Arterial & Collector Fraction	UT Speed Summary (mph)	VMT Weighted Speed Component	Tennessee Harmonic Mean Speed (mph)	Mobile6 Default Speeds (mph)	3-Cities Measured Speeds M6.SPD.003 (mph)	5-Cities Modeled Speeds M6.SPD.004 (mph)	**Consolidated Roadway Types**
Interstate	28244045	29.1		54.9		**54.9**	36.5	52.6	50.1	**Freeway**
Prin Arterial	28181182	29.1	0.505	33.5	16.906					
Minor Arterial	20810701	21.5	0.373	33.2	12.373	**32.8**	31.2	22.8	34.9	**Arterial**
Collector	6849480	7.1	0.123	29.3	3.594					
Local	12894000	13.3		20.9		20.9	**12.9**	13.8	29.5	**Local**
Ramps							**34.6**	34.7		**Ramps**
Total	96979408	100.0	1.000	34.2		34.2	27.6			
						VMT Weighted Harmonic Mean Speed				
Arterial & Collector Total	55841363	57.6								

County, Davidson County, Rutherford County, Sumner County, Williamson County and Wilson County) shown in Table 3-9. For those counties that did not have a county specific VMT fraction, an average of the eight county VMT mix was used. This average VMT mix is referred to henceforth as the "average VMT fraction'. In this study, it assumed that the vehicle speed and VMT fraction do not change in future years and remain the same throughout the modeling period. Locality specific registration distribution by age (Shelby+) was used and the data were developed as described earlier in the chapter. In accordance with the Memphis MPO Long Range Transportation Plan, it was assumed that an ongoing I/M program exist in the City of Memphis only, and would remain unchanged until the start year of 2020. It is also assumed that a more stringent county-wide I/M program would become effective in the analysis year 2020 and later. The traditional exhaust I/M program (IDLE) was used to cover pre-1995 model year vehicle and the On-Board Diagnostic (OBD) exhaust I/M program was used for 1996 and newer model year vehicles. The earliest model year that was subjected to I/M program was determined based on 25-year window. For example, if one is to model for analysis year 1999 then the earliest model year subjected to I/M program will be model year 1974. Hence, the "Exemption Age" input parameter was set to 25. Also, an Anti-Tampering Program (ATP) was assumed to be effective starting with year 2019. Other parameters for I/M and ATP program were also chosen based on the Memphis MPO Long Range Transportation Plan. The input parameters for I/M Programs (I/M Program 1 and I/M Program 2) are shown in Table D2a,b and c respectively. The I/M program had to be split up into two programs (I/M Program 1 and I/M Program 2) because the MOBILE

Table 3-9. VMT Fraction Data provided by TDOT for 8 Counties in Tennessee

Knox County, 1998.

LDV	LDT1	LDT2	LDT3	LDT4	HDV2B	HDV3	HDV4	HDV5	HDV6	HDV7	HDV8A	HDV8B	HDBS	HDBT	MC	TOTAL
0.671	0.033	0.111	0.024	0.010	0.034	0	0	0	0	0	0.027	0.088	0	0	0.002	1.000
0.611	0.030	0.102	0.021	0.010	0.050	0	0	0	0	0	0.039	0.129	0	0	0.008	1.000
0.754	0.037	0.125	0.026	0.012	0.010	0	0	0	0	0	0.008	0.026	0	0	0.002	1.000
0.724	0.036	0.120	0.025	0.011	0.018	0	0	0	0	0	0.014	0.047	0	0	0.005	1.000
0.778	0.038	0.129	0.027	0.012	0.003	0	0	0	0	0	0.003	0.008	0	0	0.002	1.000
0.763	0.038	0.126	0.026	0.012	0.008	0	0	0	0	0	0.006	0.019	0	0	0.002	1.000

Shelby County, 1998.

LDV	LDT1	LDT2	LDT3	LDT4	HDV2B	HDV3	HDV4	HDV5	HDV6	HDV7	HDV8A	HDV8B	HDBS	HDBT	MC	TOTAL
0.677	0.034	0.112	0.024	0.010	0.032	0	0	0	0	0	0.025	0.084	0	0	0.002	1.000
0.515	0.026	0.086	0.017	0.008	0.078	0	0	0	0	0	0.061	0.201	0	0	0.008	1.000
0.749	0.037	0.125	0.026	0.012	0.011	0	0	0	0	0	0.009	0.028	0	0	0.003	1.000
0.739	0.037	0.122	0.026	0.011	0.014	0	0	0	0	0	0.011	0.035	0	0	0.005	1.000
0.777	0.039	0.129	0.027	0.012	0.003	0	0	0	0	0	0.003	0.008	0	0	0.002	1.000
0.763	0.038	0.126	0.026	0.012	0.008	0	0	0	0	0	0.006	0.019	0	0	0.002	1.000

Hamilton County, 1998

LDV	LDT1	LDT2	LDT3	LDT4	HDV2B	HDV3	HDV4	HDV5	HDV6	HDV7	HDV8A	HDV8B	HDBS	HDBT	MC	TOTAL
0.639	0.032	0.106	0.022	0.010	0.043	0	0	0	0	0	0.034	0.112	0	0	0.002	1.000
0.578	0.029	0.096	0.020	0.009	0.060	0	0	0	0	0	0.046	0.154	0	0	0.008	1.000
0.752	0.037	0.125	0.026	0.012	0.010	0	0	0	0	0	0.008	0.027	0	0	0.003	1.000
0.729	0.036	0.122	0.026	0.011	0.016	0	0	0	0	0	0.013	0.042	0	0	0.005	1.000
0.778	0.038	0.129	0.027	0.012	0.003	0	0	0	0	0	0.003	0.008	0	0	0.002	1.000
0.763	0.038	0.126	0.026	0.012	0.008	0	0	0	0	0	0.006	0.019	0	0	0.002	1.000

Table 3-9. Continued.

Davidson County, 1998

LDV	LDT1	LDT2	LDT3	LDT4	HDV2B	HDV3	HDV4	HDV5	HDV6	HDV7	HDV8A	HDV8B	HDBS	HDBT	MC	TOTAL
0.668	0.033	0.112	0.024	0.010	0.035	0	0	0	0	0	0.027	0.089	0	0	0.002	1.000
0.000	0.000	0.000	0.000	0.000	0.000	0	0	0	0	0	0.000	0.000	0	0	0.000	0.000
0.746	0.037	0.124	0.026	0.011	0.012	0	0	0	0	0	0.009	0.032	0	0	0.003	1.000
0.720	0.036	0.119	0.025	0.011	0.019	0	0	0	0	0	0.015	0.050	0	0	0.005	1.000
0.778	0.038	0.129	0.027	0.012	0.003	0	0	0	0	0	0.003	0.008	0	0	0.002	1.000
0.763	0.038	0.126	0.026	0.012	0.008	0	0	0	0	0	0.006	0.019	0	0	0.002	1.000

Rutherford County, 1998

LDV	LDT1	LDT2	LDT3	LDT4	HDV2B	HDV3	HDV4	HDV5	HDV6	HDV7	HDV8A	HDV8B	HDBS	HDBT	MC	TOTAL
0.588	0.029	0.098	0.020	0.009	0.058	0	0	0	0	0	0.045	0.151	0	0	0.002	1.000
0.580	0.029	0.097	0.020	0.009	0.059	0	0	0	0	0	0.046	0.152	0	0	0.008	1.000
0.754	0.037	0.126	0.026	0.012	0.010	0	0	0	0	0	0.007	0.025	0	0	0.003	1.000
0.744	0.037	0.124	0.026	0.011	0.012	0	0	0	0	0	0.009	0.032	0	0	0.005	1.000
0.778	0.038	0.129	0.027	0.012	0.003	0	0	0	0	0	0.003	0.008	0	0	0.002	1.000
0.763	0.038	0.126	0.026	0.012	0.008	0	0	0	0	0	0.006	0.019	0	0	0.002	1.000

Sumner County, 1998

LDV	LDT1	LDT2	LDT3	LDT4	HDV2B	HDV3	HDV4	HDV5	HDV6	HDV7	HDV8A	HDV8B	HDBS	HDBT	MC	TOTAL
0.567	0.028	0.095	0.019	0.009	0.064	0	0	0	0	0	0.050	0.166	0	0	0.002	1.000
0.563	0.028	0.093	0.019	0.009	0.064	0	0	0	0	0	0.050	0.166	0	0	0.008	1.000
0.734	0.037	0.122	0.026	0.011	0.015	0	0	0	0	0	0.012	0.040	0	0	0.003	1.000
0.751	0.037	0.125	0.026	0.012	0.010	0	0	0	0	0	0.008	0.026	0	0	0.005	1.000
0.778	0.038	0.129	0.027	0.012	0.003	0	0	0	0	0	0.003	0.008	0	0	0.002	1.000
0.763	0.038	0.126	0.026	0.012	0.008	0	0	0	0	0	0.006	0.019	0	0	0.002	1.000

Table 3-9. Continued.

Williamson County, 1998

LDV	LDT1	LDT2	LDT3	LDT4	HDV2B	HDV3	HDV4	HDV5	HDV6	HDV7	HDV8A	HDV8B	HDBS	HDBT	MC	TOTAL
0.674	0.034	0.112	0.024	0.010	0.033	0	0	0	0	0	0.026	0.085	0	0	0.002	1.000
0.587	0.029	0.098	0.020	0.009	0.057	0	0	0	0	0	0.044	0.148	0	0	0.008	1.000
0.753	0.037	0.126	0.026	0.012	0.010	0	0	0	0	0	0.008	0.025	0	0	0.003	1.000
0.758	0.037	0.126	0.026	0.012	0.008	0	0	0	0	0	0.006	0.022	0	0	0.005	1.000
0.778	0.038	0.129	0.027	0.012	0.003	0	0	0	0	0	0.003	0.008	0	0	0.002	1.000
0.763	0.038	0.126	0.026	0.012	0.008	0	0	0	0	0	0.006	0.019	0	0	0.002	1.000

Wilson County, 1998

LDV	LDT1	LDT2	LDT3	LDT4	HDV2B	HDV3	HDV4	HDV5	HDV6	HDV7	HDV8A	HDV8B	HDBS	HDBT	MC	TOTAL
0.645	0.032	0.108	0.022	0.010	0.042	0	0	0	0	0	0.032	0.107	0	0	0.002	1.000
0.564	0.028	0.093	0.019	0.009	0.064	0	0	0	0	0	0.050	0.165	0	0	0.008	1.000
0.742	0.037	0.123	0.026	0.011	0.013	0	0	0	0	0	0.010	0.035	0	0	0.003	1.000
0.743	0.037	0.123	0.026	0.011	0.013	0	0	0	0	0	0.010	0.032	0	0	0.005	1.000
0.778	0.038	0.129	0.027	0.012	0.003	0	0	0	0	0	0.003	0.008	0	0	0.002	1.000
0.763	0.038	0.126	0.026	0.012	0.008	0	0	0	0	0	0.006	0.019	0	0	0.002	1.000

Average Results for 1998 for 8 Counties

LDV	LDT1	LDT2	LDT3	LDT4	HDV2B	HDV3	HDV4	HDV5	HDV6	HDV7	HDV8A	HDV8B	HDBS	HDBT	MC	TOTAL
0.641	0.032	0.107	0.022	0.010	0.043	0	0	0	0	0	0.033	0.110	0	0	0.002	1.000
0.571	0.028	0.095	0.020	0.009	0.062	0	0	0	0	0	0.048	0.159	0	0	0.008	1.000
0.748	0.037	0.124	0.026	0.012	0.011	0	0	0	0	0	0.009	0.030	0	0	0.003	1.000
0.739	0.037	0.123	0.026	0.011	0.014	0	0	0	0	0	0.011	0.036	0	0	0.005	1.000
0.778	0.038	0.129	0.027	0.012	0.003	0	0	0	0	0	0.003	0.008	0	0	0.002	1.000
0.763	0.038	0.126	0.026	0.012	0.008	0	0	0	0	0	0.006	0.019	0	0	0.002	1.000

model does not allow traditional I/M program to be modeled for model years 1996 and later. Hence vehicles prior to the 1996 model year were modeled according to the traditional I/M program and the model years 1996 and later were modeled according to the OBD I/M program. Anti-tampering Program (ATP) input parameters are shown in the run section input parameter tables (Table D2).

Though the last analysis year modeled in the Long Range Plan was 2020, it was assumed that the parameters shown for the analysis year 2020 in the Long Range Plan would remain valid and unchanged for analysis years 2025 and 2030. The Reid vapor pressure used in the model (RVP 7.8) was the same as was used by the Memphis MPO and corresponded to that recommended by ASTM guidance.

Scenario Section: The input commands and their respective input parameters are shown in Table D9 of the appendix. The scenario record was used as a label for individual scenario results. The calendar Year input parameter was used to identify the calendar year for which emission factors were to be calculated. The runs were modeled for calendar years 1999 through 2010, and for the years 2015, 2020, 2025, and 2030. The Evaluation Month for all the runs was set to July 1st to be representative of the ozone season.

Emission Calculations: Once the input files were prepared, the MOBILE6 model was run with inclusion of all regulations. In order to account for those vehicles that are not under the I/M program but which are registered within the county, it was assumed in the Memphis MPO report that 53.95% of the vehicles are subject to I/M program and 46.05% are not subjected to I/M program. The same assumption has been used in our

calculations. As a result, the model was run twice for each year of analysis (except for years 2020 and thereafter): once with an I/M program and once without. The weighted emissions were calculated using Equation 3.2 with f1 and f2 of 0.5395 and 0.4605 respectively. It should be noted that the factors of 53.95% and 46.05% were not used for years 2020 through 2030 analysis years because of the assumption of a county-wide I/M program.

3.2.3.1b. Tipton and Fayette County

These counties do not have an I/M program or an ATP program. Average VMT fractions were used for these counties as discussed earlier in the chapter. In addition, these two counties use a fuel with RVP of 9.0 psi. Registration distributions, as mentioned earlier, were developed for each subgroup. Hence they do not change between counties within a subgroup or between urban and rural roadway classifications. Speed values do not change between counties but only between urban and rural roadway classifications. Refueling emission were not considered in the calculations. Both Header and Scenario Section for these counties remain the same and are shown in Tables D1 and D9 of the appendix, respectively.

Emission Calculations: The emissions were calculated similar to that for Shelby County except that there was no need for an adjustment for the fraction of vehicles that were subject to and not subject to I/M as shown in Equation 3.3.

3.2.3.2. Davidson+ Subgroup

For the Davidson+ subgroup, most of the input parameters were developed based on the information provided in the Nashville MPO's Long Range Transportation Plan. Refueling emissions were not considered in the calculations. Locality specific VMT mix and temperature values were used and were determined as explained earlier. An RVP of 7.8 psi was used based on the ASTM guidance. The input parameters differed slightly for Davidson County and the other four counties. These differences are tabulated in Table D4a through D4c in the appendix. Both Header and Scenario Section for these counties remain the same as shown in Tables D1 and D9 of the appendix, respectively.

Emission Calculation: Calculations conducted by the Davidson County assumed that 76% of the vehicles are subjected to I/M and 24% are not. Hence, the emission calculations were similar to that of Shelby County using Equation 3.2 with the factors being, 0.76 and 0.24 instead of 0.5395 and 0.4605 respectively. This assumption, however, was not used for the other 4 counties. Hence, their calculations were similar to that of Tipton and Fayette counties using Equation 3.3.

3.2.3.3. Hamilton+ Subgroup

The input parameters for the Hamilton+ subgroup are shown in Table D5. Refueling emissions were not considered in the calculations. The calculations are based on a 9.0 psi RVP. Although most of the input parameters were the same for both counties, two separate runs were done for Hamilton County and Marion County. This is because Hamilton County uses county specific VMT fraction but Marion County uses the average

VMT fraction. Both Header and Scenario Section for these counties remain the same as shown in Tables D1 and D9 of the appendix, respectively.

Emission Calculation: Since there is no I/M program in Hamilton+ subgroup, the emission calculations remain similar to that of Tipton and Fayette Counties using Equation 3.3.

3.2.3.4. Knox+ Subgroup

The input parameters for the Knox+ subgroup are shown in Table D6 of the appendix. MOBILE runs were done separately for Knox County and for the remaining 6 counties. This is because Knox County has county specific VMT fractions but the remaining 6 counties do not. While the Knoxville MPO has previously included refueling emissions in its plan, the calculations conducted herein do not include those emissions, in an effort to be consistent with all other counties. The calculations are based on a 9.0 psi RVP. Both Header and Scenario Section for these counties remain the same as shown in Tables D1 and D9 of the appendix, respectively.

Emission Calculations: The calculations are based on no I/M program therefore the emission calculations remain similar to that of Tipton and Fayette Counties using Equation 3.3.

3.2.3.5. Sullivan+ Subgroup

The input parameters for Sullivan+ subgroup are shown in Table D7 of the appendix. Refueling emissions were not considered in the calculations. The calculations are based

on a 9.0 psi RVP. Both Header and Scenario Section for these counties remain the same as shown in Table D1 and D9 of the appendix respectively.

Emission Calculations: The calculations are based on no I/M program therefore the emission calculations remain similar to that of Tipton and Fayette Counties using Equation 3.3.

3.2.3.6. All Other Counties

The input parameters for all other counties are shown in Table D8 of the appendix. The only differences in the input parameters between the counties within this subgroup were the min/max temperatures and the absolute humidity values depending on the region (east, middle or west) where the county is located, and in some cases a difference in the registration distribution. Most counties used a registration distribution that was developed for this subgroup. However, for those counties whose interstate traffic comprised more than 50% of the total DVMT, the national default registration distribution was used. The basis for this decision was that in those rural counties where the DVMT was dominated by interstate traffic, it is reasonable that the registration distribution (based on local vehicle registration data) would not be representative. These counties include Roane, Cumberland and Campbell Counties in the East Tennessee region; Putnam, Smith, Robertson and Coffee Counties in the Middle Tennessee region; and Henderson and Haywood Counties in the West Tennessee region. They are shown in italics in Table C1. The calculations are based on a 9.0psi RVP and no I/M program. Both Header and Scenario Section for these counties remain the same as shown in Table D1 and D9 of the appendix respectively.

Emission Calculations: Since the calculations are based on no I/M program therefore the emission calculations remain similar to that of Tipton and Fayette Counties using Equation 3.3.

CHAPTER 4

DISCUSSION OF RESULTS

This chapter summarizes the results of the analyses conducted to estimate emissions of NO_x and VOCs in the State of Tennessee for a typical high ozone summer day. The MOBILE6 draft model was used to generate emission factors, in terms of grams/mile of vehicle miles traveled. These emission factors, when multiplied by the daily vehicle miles traveled (DVMT), yield the emissions in units of mass/day. Emission projections were done for the years 1999 through 2030. This is to show the effects of new emission standards that will be implemented within the next ten years. Emissions were also projected out to year 2030 to show the effects if no other future standards were implemented. The projections are based on the continued implementation of I/M programs in those counties which currently have I/M programs as required in their respective Long Range Transportation Plans (Shelby, Davidson, Rutherford, Sumner, Williamson and Wilson County). In this study, emission projections were conducted for all 95 counties in the State of Tennessee. Tables E1 through E3 tabulate the emissions for NO_x and VOCs for all the counties according to East, Middle and West Tennessee, respectively.

For the purpose of discussion, graphical results of the emission projections are presented for one county from each of the five area subgroups as explained earlier, most of which correspond to a Metropolitan Statistical Area (MSA), and for the State of Tennessee as a whole. These counties are Shelby, Knox, Davidson, Hamilton and Sullivan Counties. The NO_x and VOC baseline emissions for 1999 and future year projections are shown for the five counties in Figures 4-1 through 4-5. Figure 4-6 shows

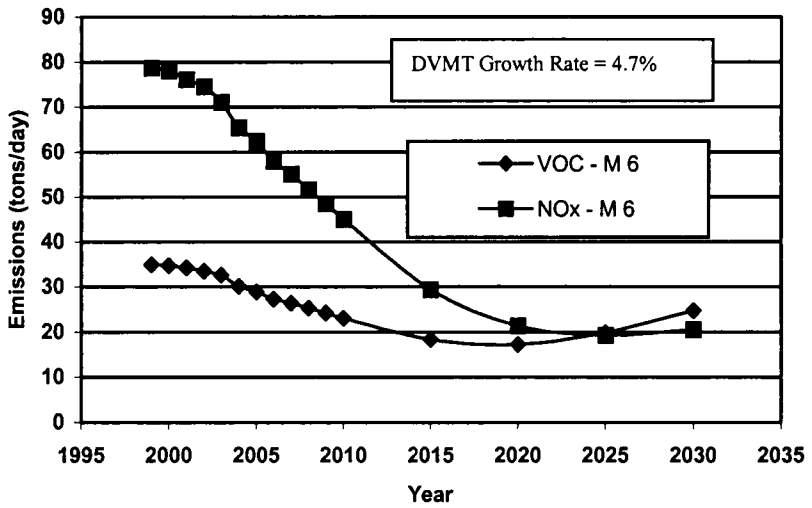


Figure 4-1. Davidson County - Mobile Source Emissions (MOBILE6)

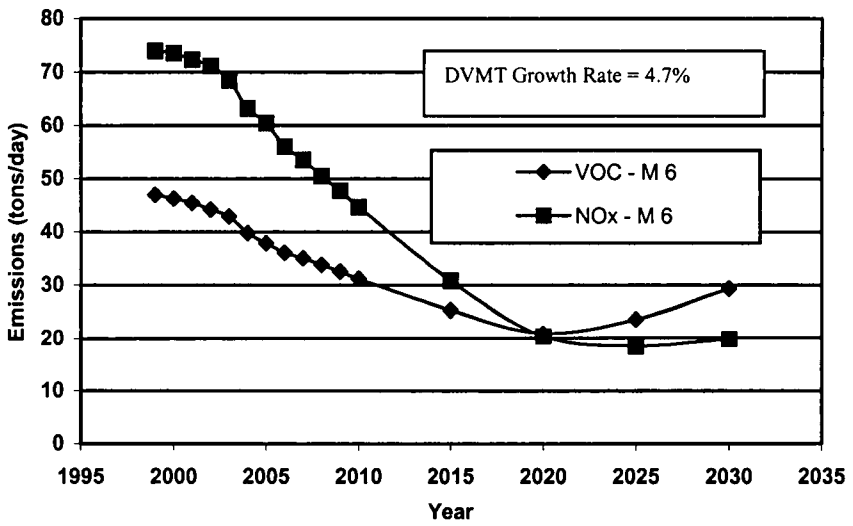


Figure 4-2. Shelby County - Mobile Source Emissions (MOBILE6)

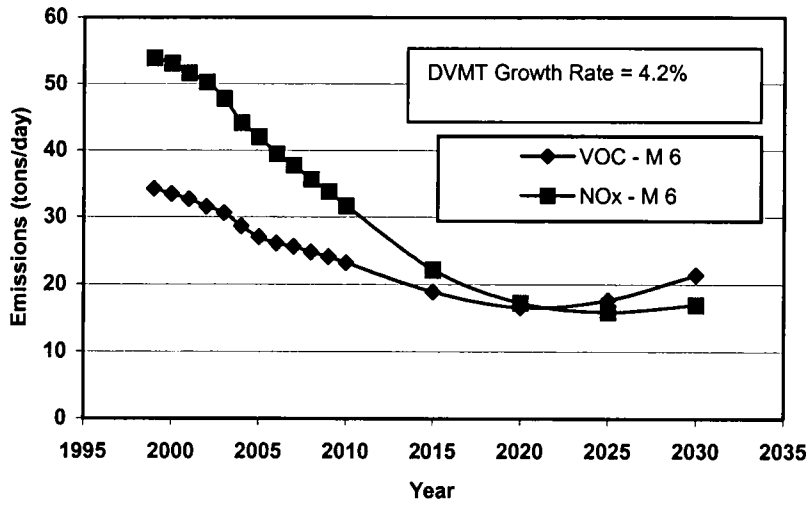


Figure 4-3. Knox County - Mobile Source Emissions (MOBILE6)

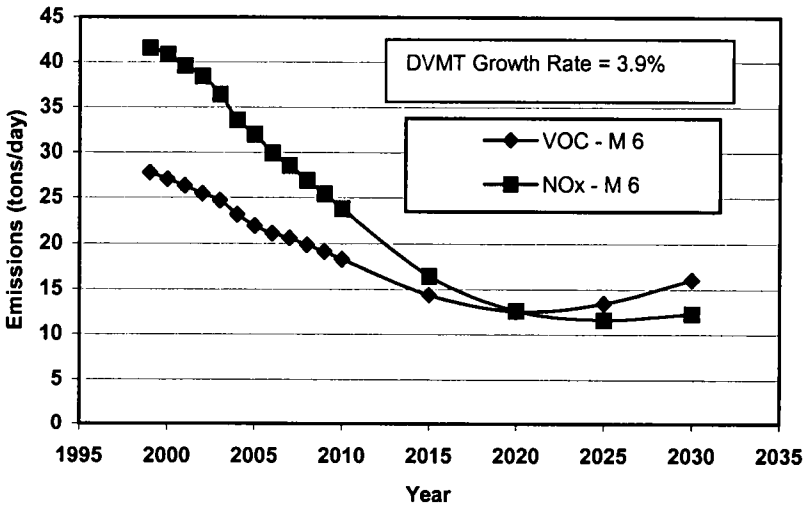


Figure 4-4. Hamilton County - Mobile Source Emissions (MOBILE6)

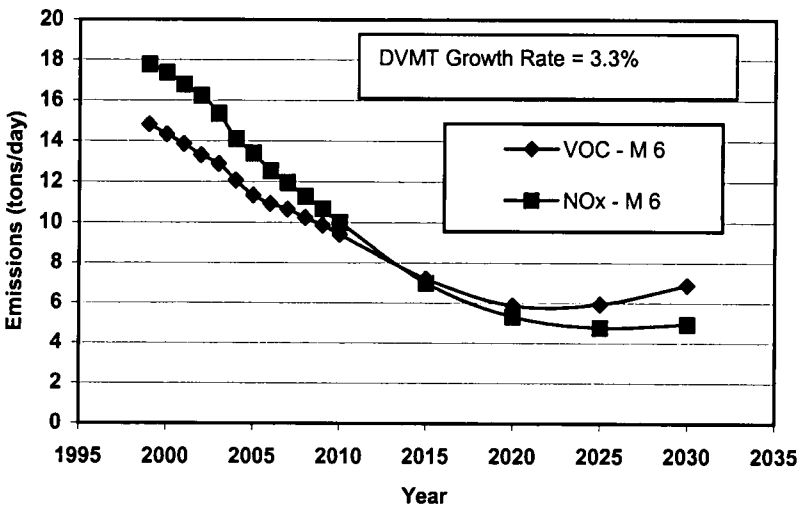


Figure 4-5. Sullivan County - Mobile Source Emissions (MOBILE6)

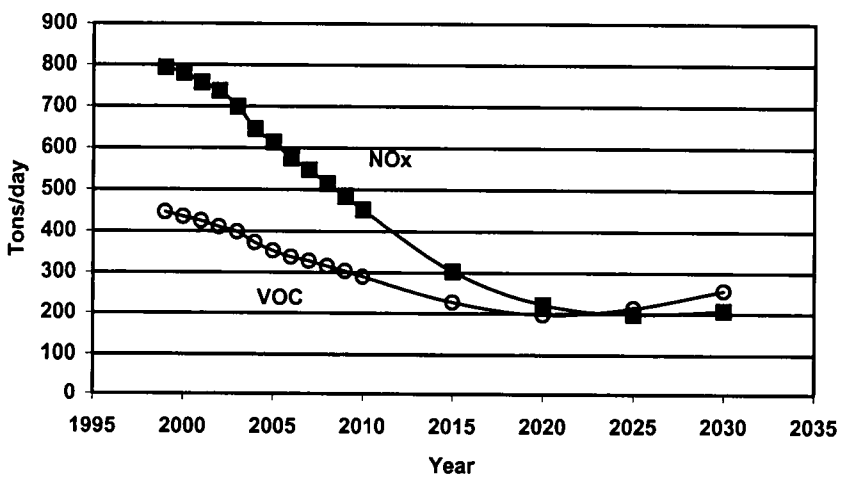


Figure 4-6. Total Projected Emissions in Tennessee

the statewide baseline and projected emissions. While the magnitude of the emission levels of these five counties varied considerably due to the different levels of DVMT that occurred in each county, the general trends (relative changes in emission levels in future years compared to the baseline year) for both NO_x and VOC emissions were found to be similar. It was also found that the relative trends were very similar to the other 90 counties in Tennessee. The DVMT growth rates (annual compound) for the five counties varied from 3.3% to 4.7% as shown in the figures, while the statewide growth rate was 3.9%. The growth rates were developed for the period of 1990-1998 based on the yearly DVMT reports provided from TDOT as explained in Chapter 2. It was assumed in the calculations that the DVMT growth rate for each county would remain constant and equal to the growth rate determined for the period 1990 through 1998.

As shown in the figures, NO_x emissions are projected to decrease from the baseline year 1999 to year 2025, followed by an increase in the emissions. Similarly, VOC emissions were projected to decrease but the emissions increase rapidly after 2020. Emissions of NO_x and VOCs are projected to decrease due to the four new emission standards (LEV, HDDVNO_x, Tier2/Sulfur and HDDV/Sulfur) being implemented during the next ten years. The negative effect of DVMT growth rate overcomes the positive effect of the standards causing projected increases in the emissions of NO_x and VOCs after year 2025 and 2020, respectively. It is apparent from the emission projections that implementation of the new regulations has less effect on VOC emissions than NO_x emissions.

Shelby County and Davidson County are two of the counties which are subject to I/M programs, whereas the other 3 counties are not currently required to have I/M

programs. Shelby County with an I/M program has a 50% projected reduction in VOC emissions and a 75% projected reduction in NO_x emissions by year 2025 and Davidson County with an I/M program has a 43% reduction in VOC and 76% reduction in NO_x emissions by year 2025 as shown in Figures 4-1 and 4-2, respectively. The other 3 counties (Knox, Hamilton and Sullivan County) with no I/M program have projected 48%, 52% and 60% reductions in VOC emissions, respectively and 71%, 72%, and 73% reductions in NO_x emissions by year 2025 as shown in Figures 4-3, 4-4, and 4-5, respectively.

In an effort to provide some insight into the potential for reducing emissions by implementation of I/M programs (as might be required in the future for counties not yet requiring I/M), a series of calculations was conducted using Davidson County. For illustrative purposes, emissions were recalculated for Davidson County assuming that it had no I/M program and an RVP of 9.0 psi, a scenario which is typical of the counties in Tennessee which have no required I/M program. The emissions were also calculated assuming the I/M program option in MOBILE6 with an RVP of 7.8 psi, a scenario characteristic of a county with an I/M program. For purpose of comparison, it was assumed that all vehicles were subjected to the I/M program. A comparison of these two different scenarios shows the potential benefit of implementing an I/M program. In Figures 4-7 and 4-8, the emission projections for both NO_x and VOC with and without an I/M program in Davidson County are shown, respectively. There is a 68% projected reduction in NO_x emissions and a 37% projected reduction in VOC emissions without an I/M program compared to a projected reduction of 78% in NO_x emissions and 46% projected reduction in VOC emissions with an I/M program by year 2025. For the period

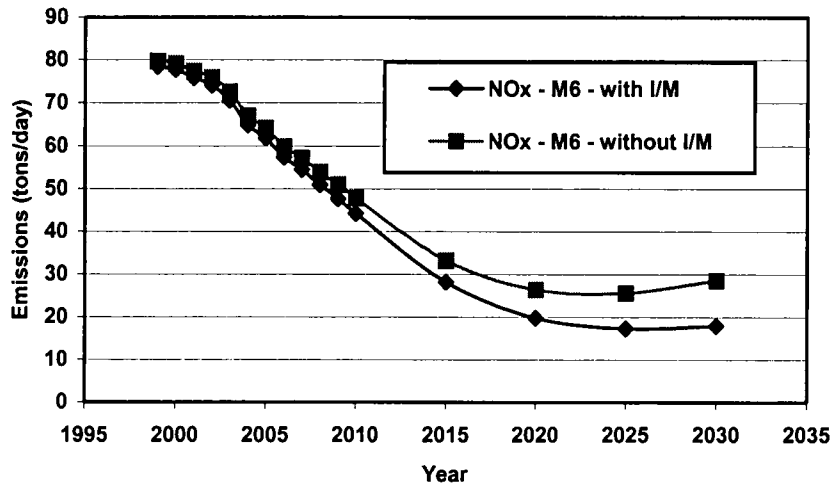


Figure 4-7. Davidson County - NO_x Emissions with and without I/M Program

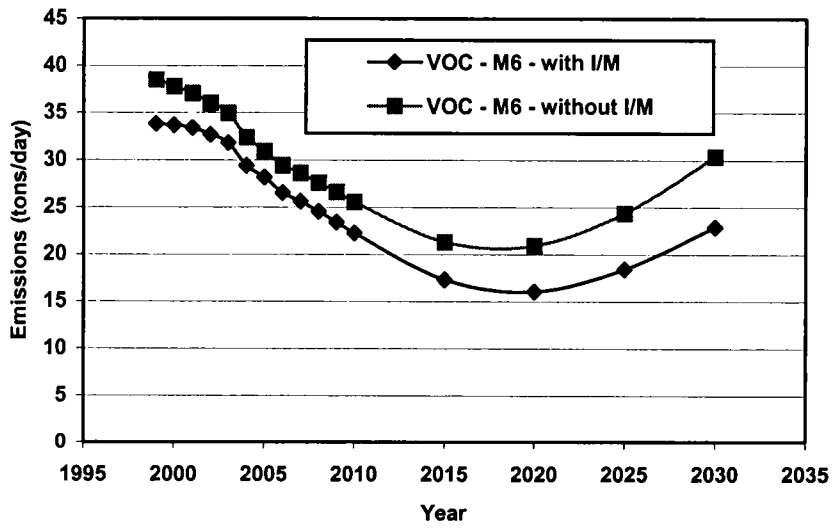


Figure 4-8. Davidson County - VOC Emissions with and without I/M Program

of 1999 –2030, the projected emission reduction per year with and without an I/M program is about 2% to 38% for NO_x emissions and about 23% to 35% reduction for VOC emissions as shown in Figures 4-7 and 4-8, respectively.

A key concern which is often raised is with regard to the rate of growth in VMT which could be sustained within a subsequent increase in emissions. In essence emissions for future years remain constant as long as the VMT growth rate does not exceed the rate at which the composite emission factor is decreasing due to emission standards being implemented. Figures 4-9 and 4-10 show the composite emission factor (g/mile) for 1999-2030 for the conditions shown for Davidson County in the case when I/M is fully implemented for all vehicles. The rapid decrease in 1999 followed by a flattening of the curve occurs because more and more of the fleet has been replaced by newer, more efficiently controlled vehicles. Since the current MOBILE model only contains those regulations which are already in place or already planned to go into effect, the curves, become very flat (no significant further reduction after 2025). The approximate rate of change in the composite emission factor (and thus grams/mile) for NO_x and VOC emissions between 2020 and 2030 is approximately –5.7% and –1.2% per year, respectively. Therefore if the DVMT growth rates remain lower than that of 5.7% and 1.2% for NO_x and VOC, respectively, the emissions will continue to decrease. For NO_x emissions, a 5.7% growth rate in DVMT is greater than that of the current DVMT growth rate of 4.7%. Therefore there would not be a problem maintaining the low projected emissions. On the other hand, a DVMT growth rate of less than 1.2% per year would be needed to maintain the decreasing emissions of VOCs based on current emission standards. If this lower growth rate cannot be achieved by 2020, then it is

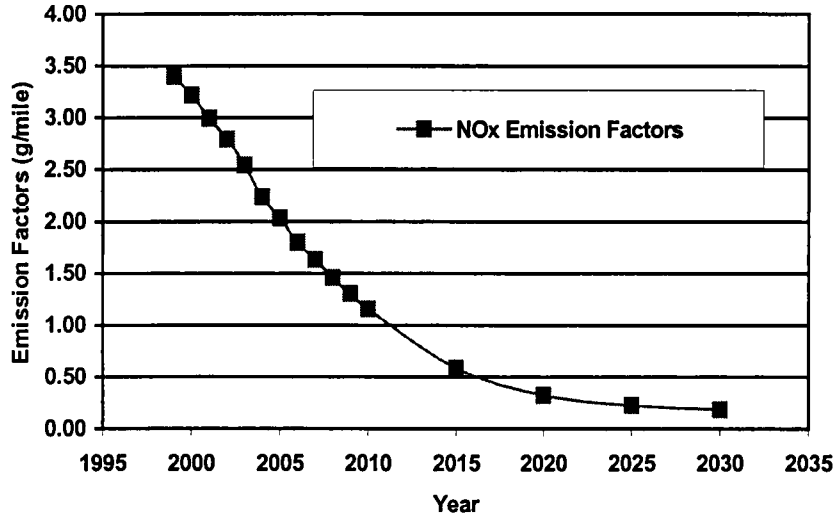


Figure 4-9. Davidson County (with I/M Program) NOx Emission Factors vs Year

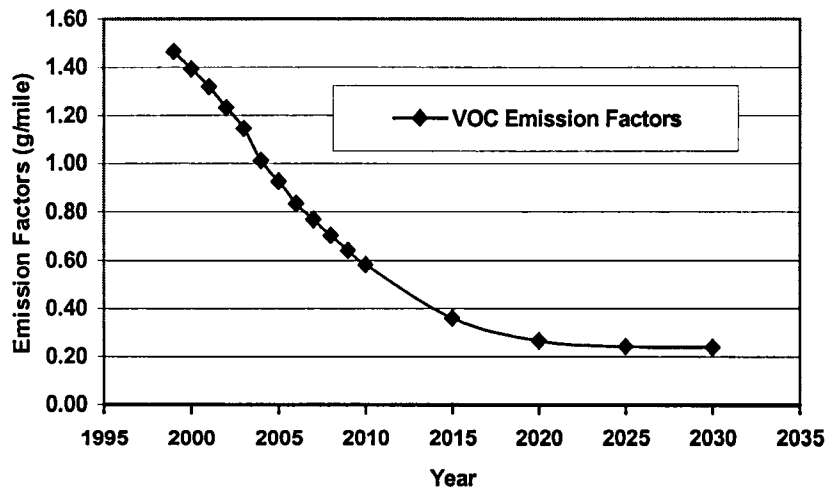


Figure 4-10. Davidson County (with I/M Program) VOC Emission Factors vs Year

apparent that other strategies would need to be implemented to maintain the VOC emissions at the level achieved by 2020. These include, but are not limited to further tightening of the federal emission standards, and the increased use of vehicles with emissions which are less than currently allowed under the emission standards such as hybrid electric and/or zero emission (electric and fuel cell-powered) vehicles.

CHAPTER 5

CONCLUSIONS AND RECOMMENDATIONS

This report has analyzed the effects that the new emission standards (LEV, $HDDVNO_x$, Tier2/Sulfur and HDDV/Sulfur) and DVMT growth will have on the emissions of VOCs and NO_x based on the draft MOBILE6 model. The study was conducted for the State of Tennessee. Emission estimations were made separately for all 95 counties in Tennessee. Example trends have been illustrated by analyzing one county from each area subgroup (Shelby, Knox, Davidson, Hamilton and Sullivan County). The following conclusion were reached in this study:

- Analysis of VMT data for the period 1990 – 1998 for all counties in the State of Tennessee have shown that the statewide annual compounded growth rate of VMT is 3.9%, whereas individual counties' DVMT growth rates ranged from 0.6 up to 6.5%
- The new LEV, $HDDVNO_x$, Tier2/Sulfur and HDDV/Sulfur standards, which will be fully in-place by 2001, 2004, 2009, and 2007, respectively, will significantly reduce the emissions of NO_x and VOC from individual on-road vehicles. The implementation of the new regulations will have less effect on VOC emissions compared to NO_x emissions.
- While the magnitude of the emission levels of each county vary considerably due to the different levels of DVMT that occur in each area, the general trends (relative changes in emission levels in future years compared to the baseline year 1999) for both NO_x and VOC emissions were found to be very similar.

- NO_x emissions are projected to reach a minimum in approximately 2025, whereas VOC emissions are expect to reach a minimum by approximately 2020.
- There is a potential for I/M programs to further reduce mobile source emissions of specific counties. There is a 68% reduction in NO_x emissions and a 37% reduction in VOC emissions without an I/M program compare to a reduction of 78% in NO_x emissions and 46% reduction in VOC emissions with an I/M program by year 2025. On the other hand, the year to year projected emission reduction with and without an I/M program is 2% to 38% for NO_x emissions and 23% to 35% projected reduction for VOC emissions for 1999 and 2030, respectively.

As a result from the study, the emission projections can be used for further and future analysis. With respect to transportation conformity, these emission projections can be used as a guidance to aid in establishing emission budgets with respect to the new 8-hour ozone standard. The study also shows the effect of an I/M program on the NO_x and VOC emissions. These results can be used as a decision tool for determining whether there is a need for a statewide I/M program versus county specific I/M programs. With the potential of increasing NO_x and VOC emissions in the future due to increasing growth of DVMT, there is also a continuing need to develop strategies which will decrease the current growth rate of DVMT, improve emission control technologies, and/or utilize alternative lesser polluting vehicles in order to maintain the lower emissions which are projected to be achieved during the next 10 to 15 years.

The results in this study assume a constant VMT growth rate over the next 30 years. The current statewide average growth rate of 3.9% causes a doubling of VMT every 18 years. This growth rate in VMT may not continue especially if population and the economy do not continue to grow. Future fuel price increases could also significantly affect the VMT growth rate. If VMT growth is reduced, and/or vehicles are utilized which have even less emissions than currently required, then NO_x and VOC emissions may continue to decline beyond 2020.

In addition, the results of this study are based on the draft MOBILE6 model. The U.S EPA has reported that the final version of MOBILE6 is anticipated to be released in October 2001. The results presented herein may change slightly if the emission estimation algorithms in the final version are different from the draft version.

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12. *Development of Methodology for Estimating VMT Weighting by Facility Type*, U.S. EPA Office of Mobile Sources, EPA420-P-99-066, M6.SPD.003, Feb 1999. Also found at http://www.epa.gov/otaq/m6.htm, accessed July 20, 2001.

APPENDICES

APPENDIX A

URBAN AND RURAL DVMT GRAPHS FOR TENNESSEE

Table A1. State Wide Total Annual VMT (million mi) for Rural and Urban

Year	Rural	Urban
1980	17248	16257
1981	18137	16592
1982	18118	16675
1983	18859	17402
1984	17659	18864
1985	17634	18673
1986	19312	20209
1987	20483	21643
1988	21446	22747
1989	22151	23488
1990	22880	23830
1991	23158	24109
1992	22601	27393
1993	23475	28637
1994	24597	29927
1995	25251	30963
1996	26957	30928
1997	27065	33461
1998	28862	32804

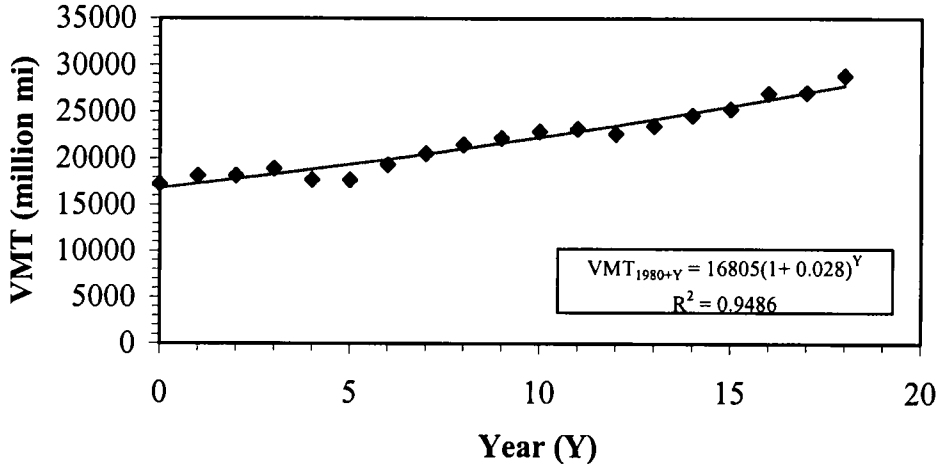


Figure A1. State Wide Rural Annual VMT vs Year (1980-1998)

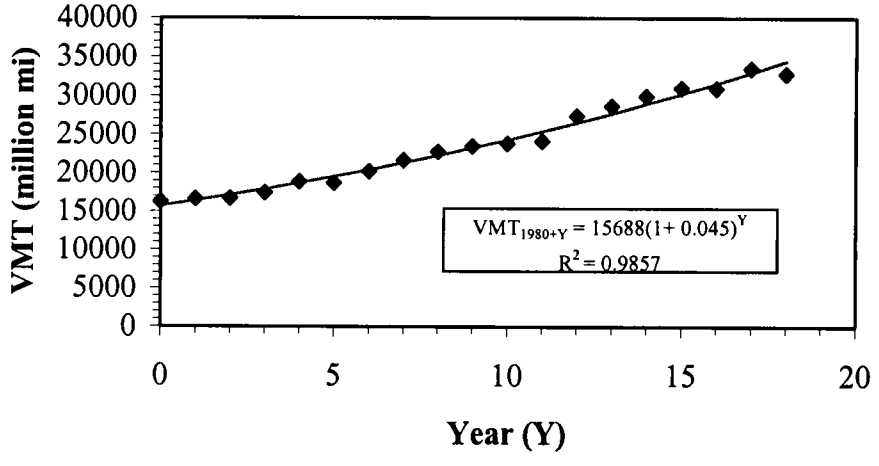


Figure A2. State Wide Urban Annual VMT vs Year (1980-1998)

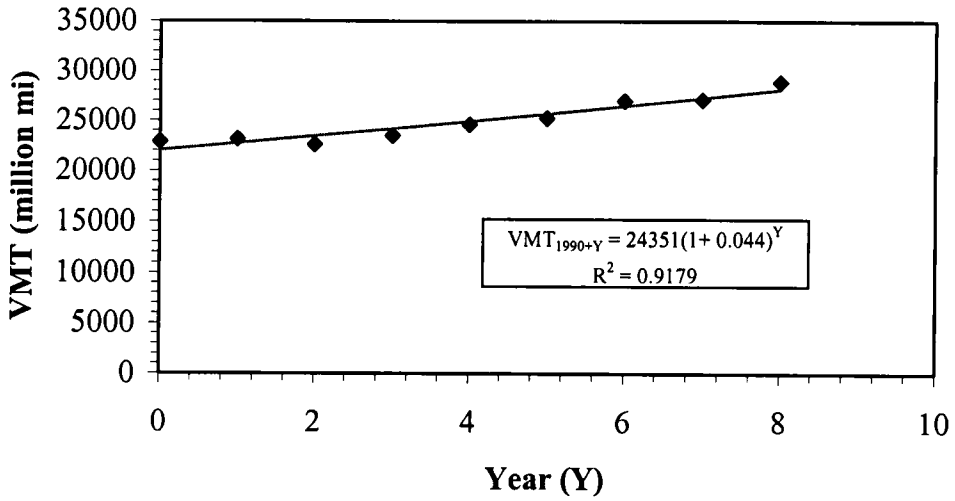


Figure A3. State Wide Rural Annual VMT vs Year (1990-1998)

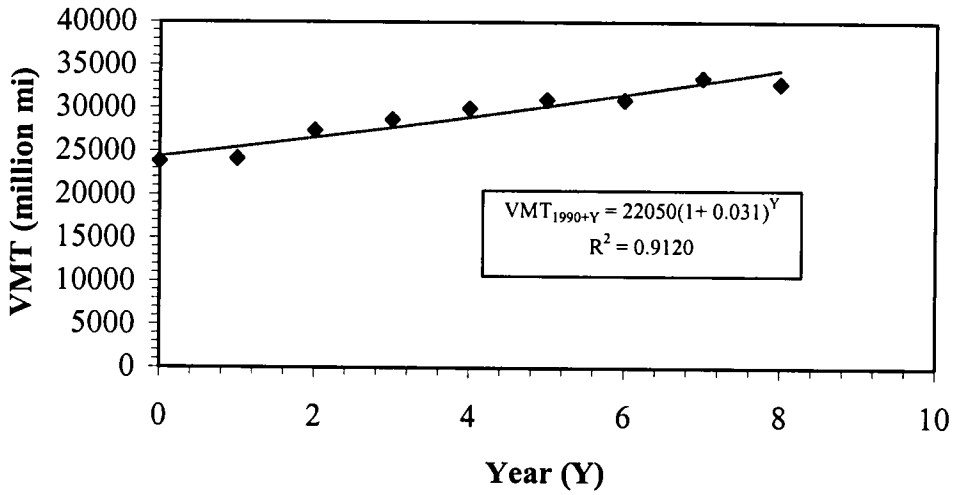


Figure A4. State Wide Urban Annual VMT vs Year (1990-1998)

Table A2. State Wide Road Classification Annual VMT (million mi) for Rural and Urban

RURAL						
YEAR	INTERSTATE	OTHER PRINCIPAL ARTERIAL	MINOR ARTERIAL	COLLECTOR	LOCAL	TOTAL
1990	6,731	2,747	6,200	5571	1,631	22,880
1991	6,772	2,788	6,266	5682	1,650	23,158
1992	6,603	4,165	4,572	5582	1,679	22,601
1993	7,070	4,164	4,974	5604	1,663	23,475
1994	7,350	4,445	5,138	5990	1,674	24,597
1995	7,658	4,594	5,236	6050	1,713	25,251
1996	8089	4860	5367	6257	1789	26,362
1997	8274	5034	5557	6254	1946	27,065
1998	8643	5298	5730	6567	2624	28,862

URBAN						
YEAR	INTERSTATE	OTHER PRINCIPAL ARTERIAL	MINOR ARTERIAL	COLLECTOR	LOCAL	TOTAL
1990	5663	8,864	3,678	2,387	3,238	23,830
1991	5778	8,838	3,797	2,421	3,275	24,109
1992	7344	8,734	5,266	2,837	3,212	27,393
1993	7728	8,844	6,602	2,147	3,316	28,637
1994	8218	9,214	6,867	2,224	3,404	29,927
1995	8647	9,446	7,007	2,281	3,582	30,963
1996	9033	9771	7191	2315	3763	32,073
1997	9487	9878	7440	2310	4348	33,463
1998	9910	10107	7395	2410	2982	32,804

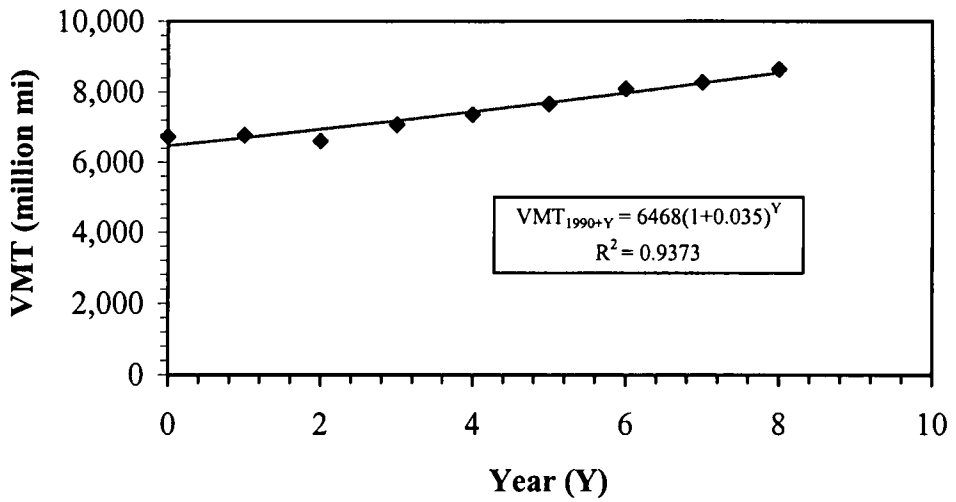


Figure A5. Rural Interstate Annual VMT vs Year (1990-1998)

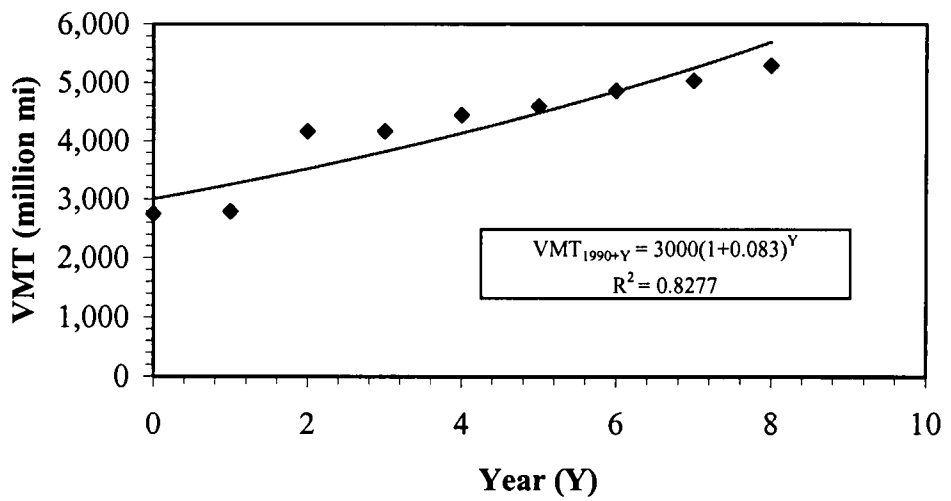


Figure A6. Rural Principal Arterial Annual VMT vs Year (1990-1998)

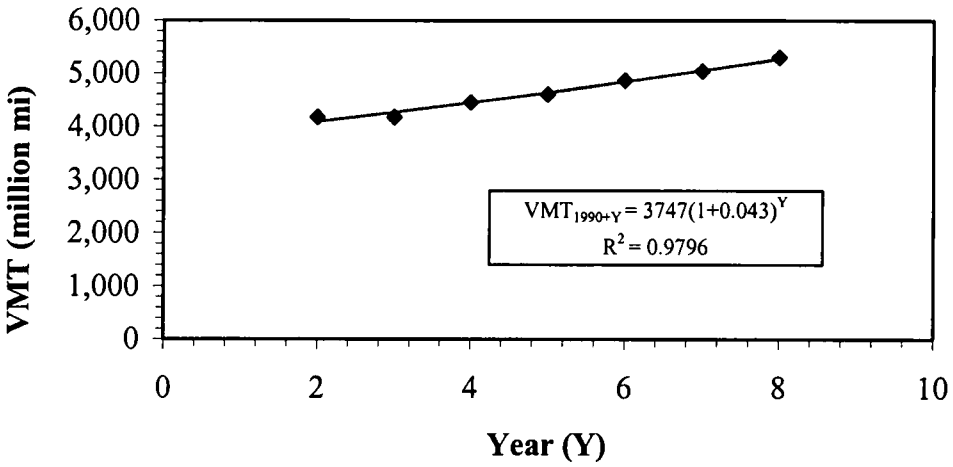


Figure A7. Rural Principal Arterial Annual VMT vs Year (1992-1998)

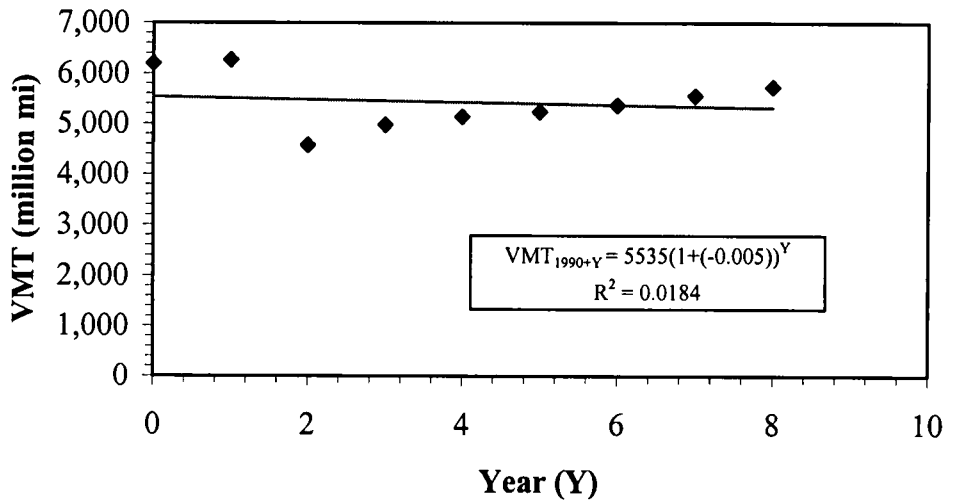


Figure A8. Rural Minor Arterial Annual VMT vs Year (1990-1998)

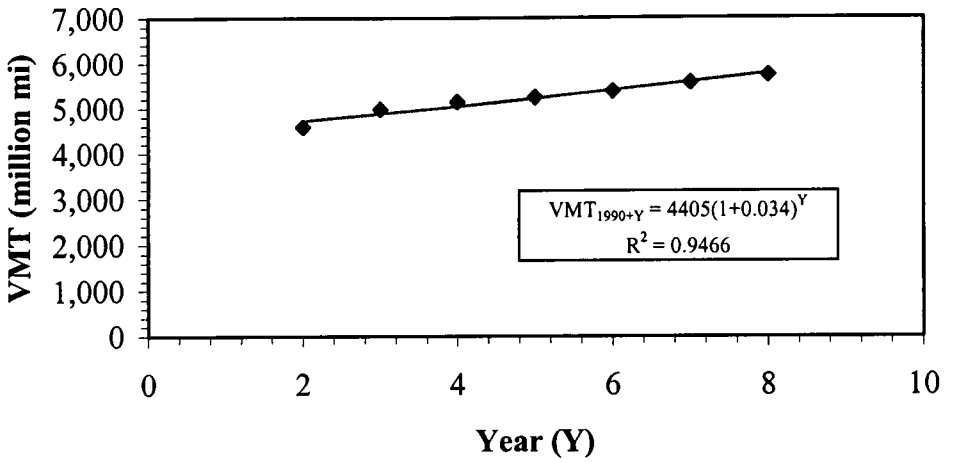


Figure A9. Rural Minor Arterial Annual VMT vs Year (1992-1998)

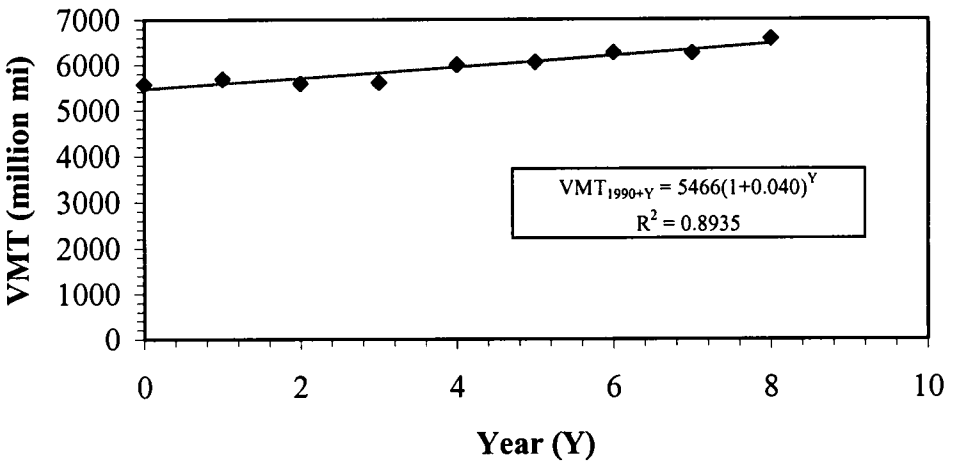


Figure A10. Rural Collector Annual VMT vs Year (1990-1998)

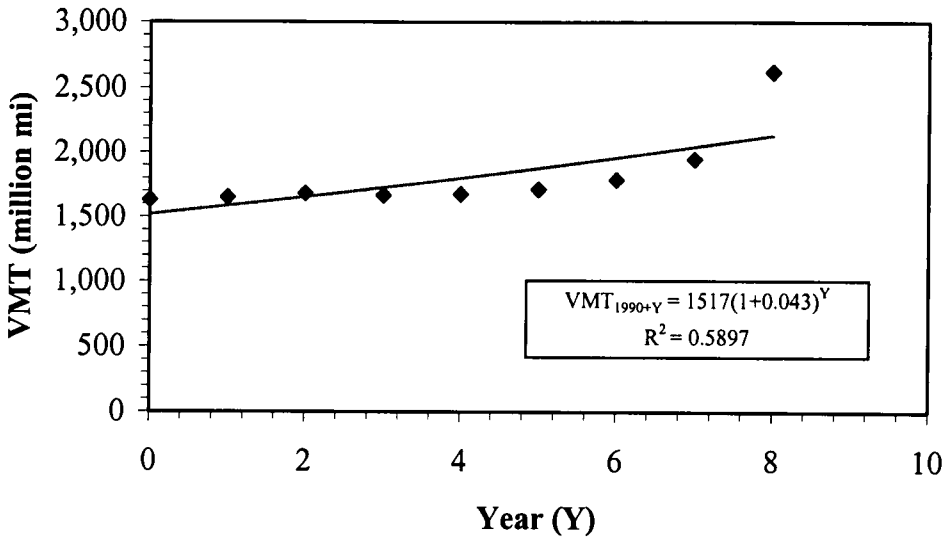


Figure A11. Rural Local Annual VMT vs Year (1990-1998)

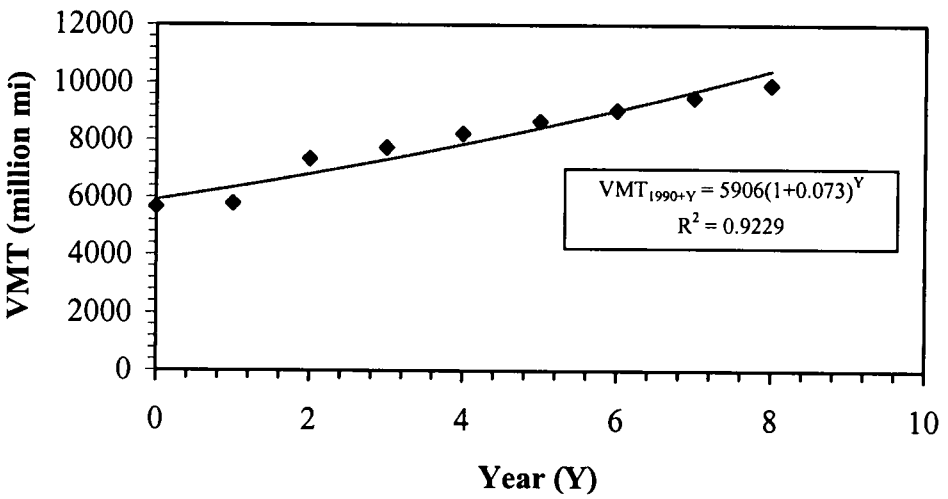


Figure A12. Urban Interstate Annual VMT vs Year (1990-1998)

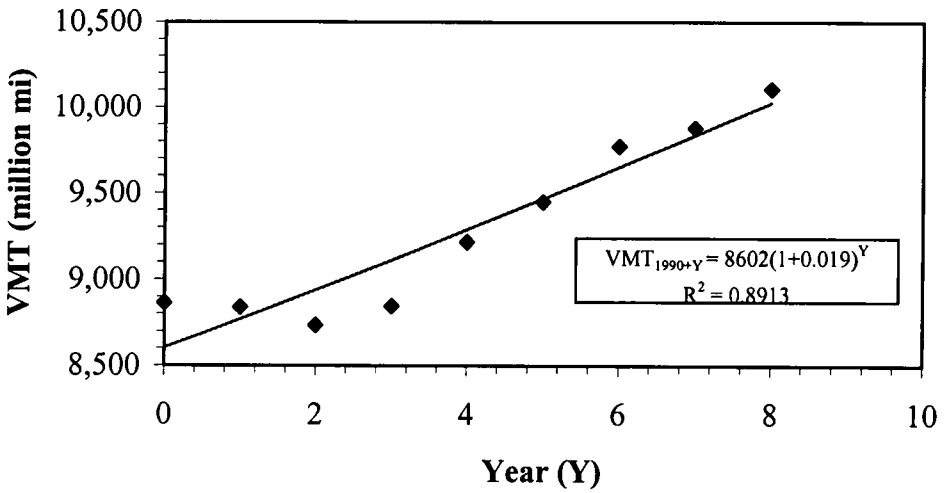


Figure A13. Urban Principal Arterial Annual VMT vs Year (1990-1998)

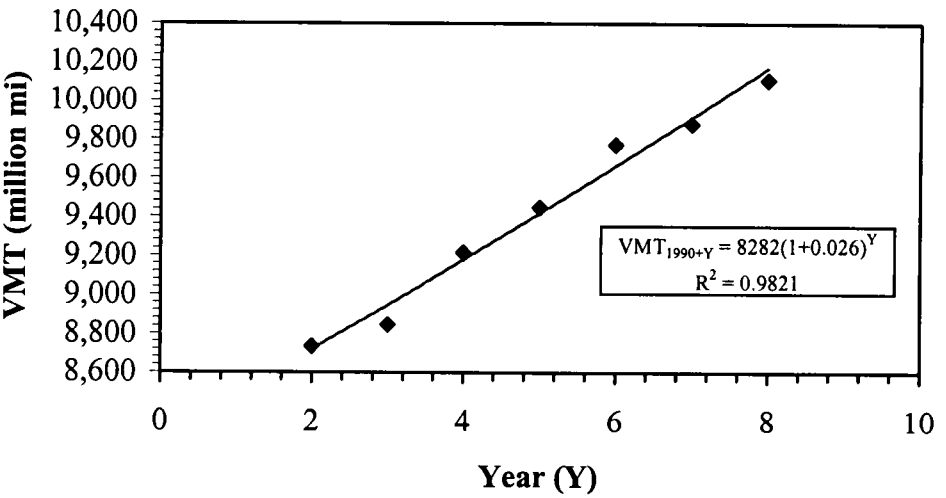


Figure A14. Urban Principal Arterial Annual VMT vs Year (1992-1998)

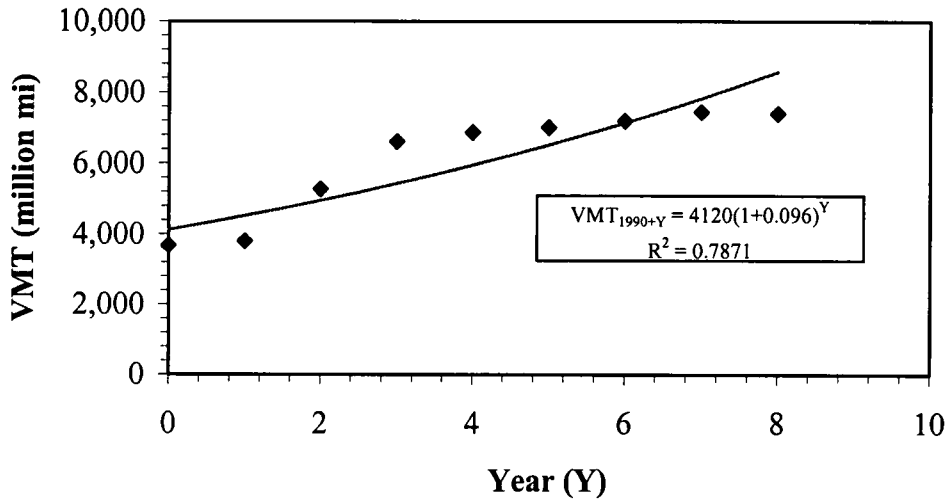


Figure A15. Urban Minor Arterial Annual VMT vs Year (1990-1998)

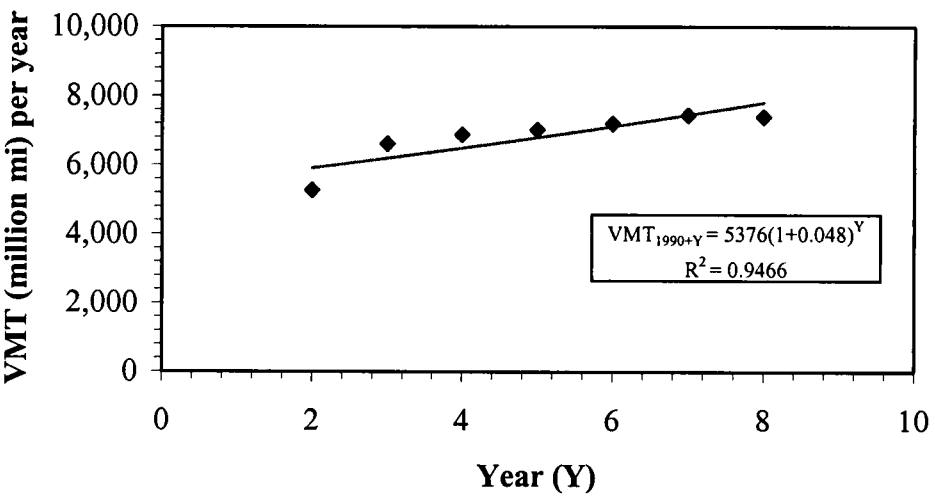


Figure A16. Urban Minor Arterial VMT vs Year (1992-1998)

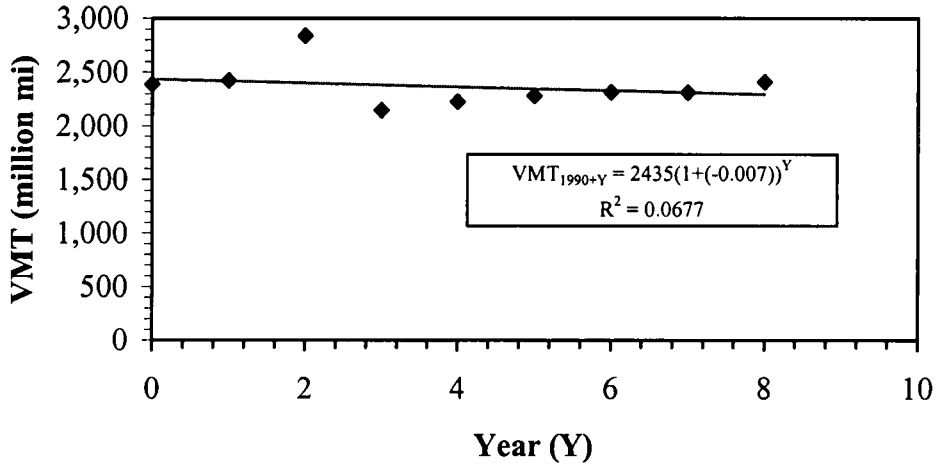


Figure A17. Urban Collector Annual VMT vs Year (1990-1998)

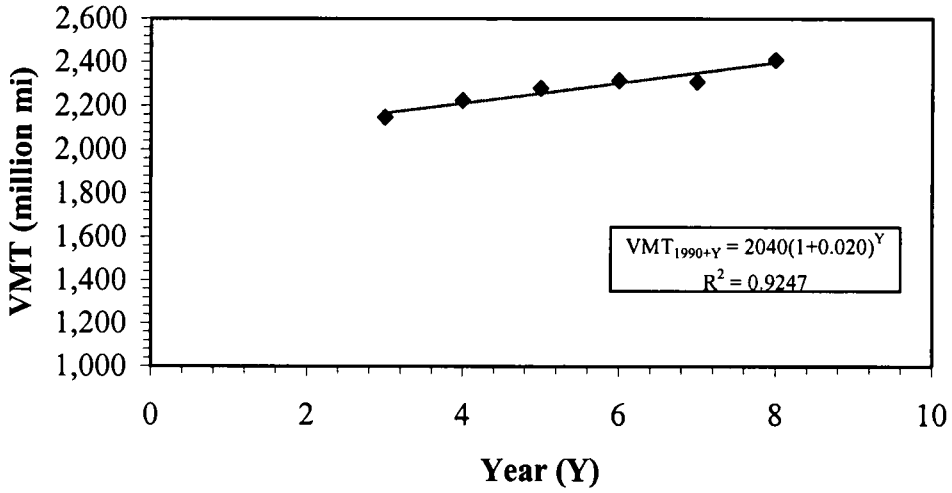


Figure A18. Urban Collector Annual VMT vs Year (1993-1998)

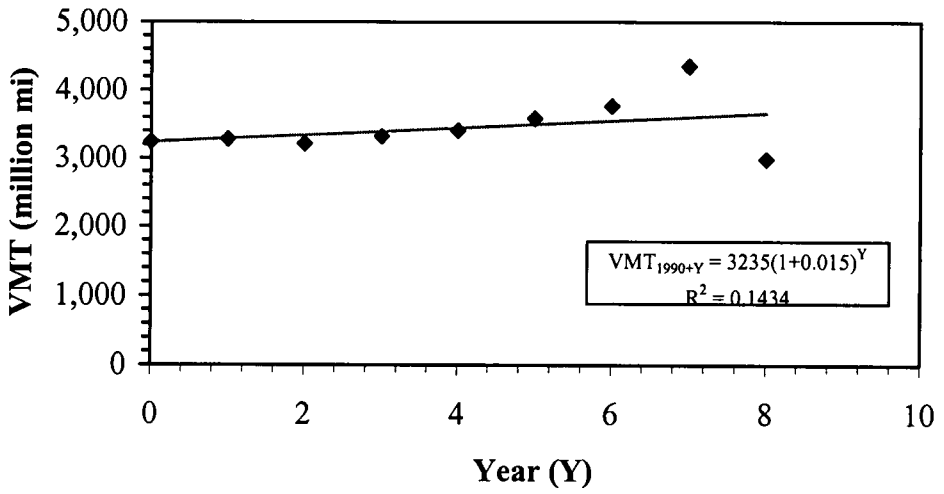
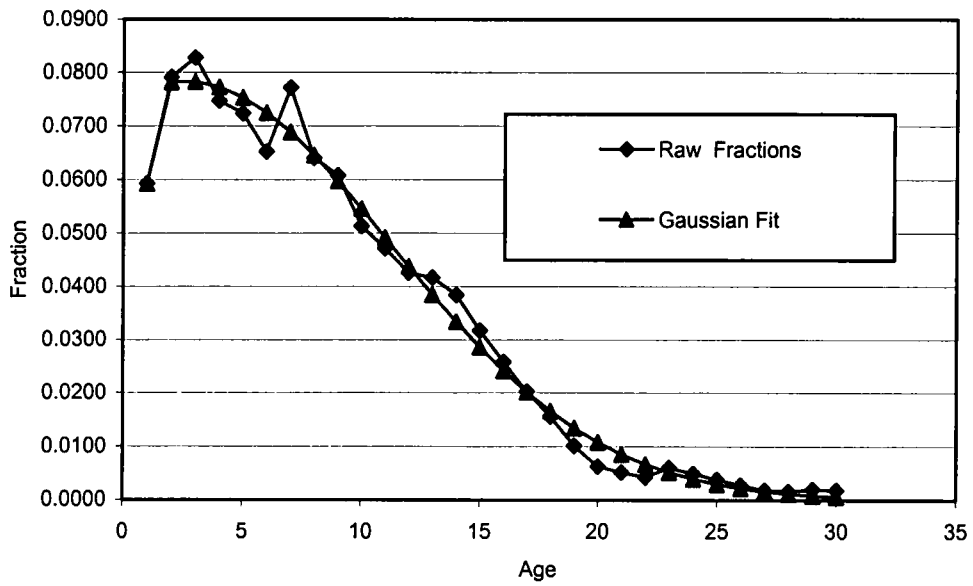


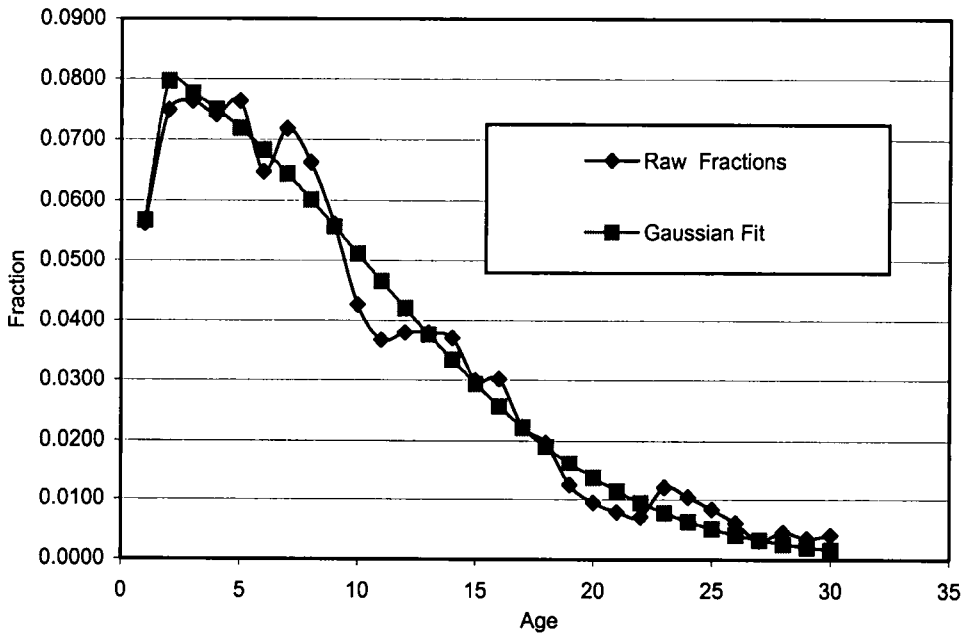
Figure A19. Urban Local Annual VMT vs Year (1990-1998)

APPENDIX B

REGISTRATION AGE DISTRIBUTION BEST-FIT GRAPHS

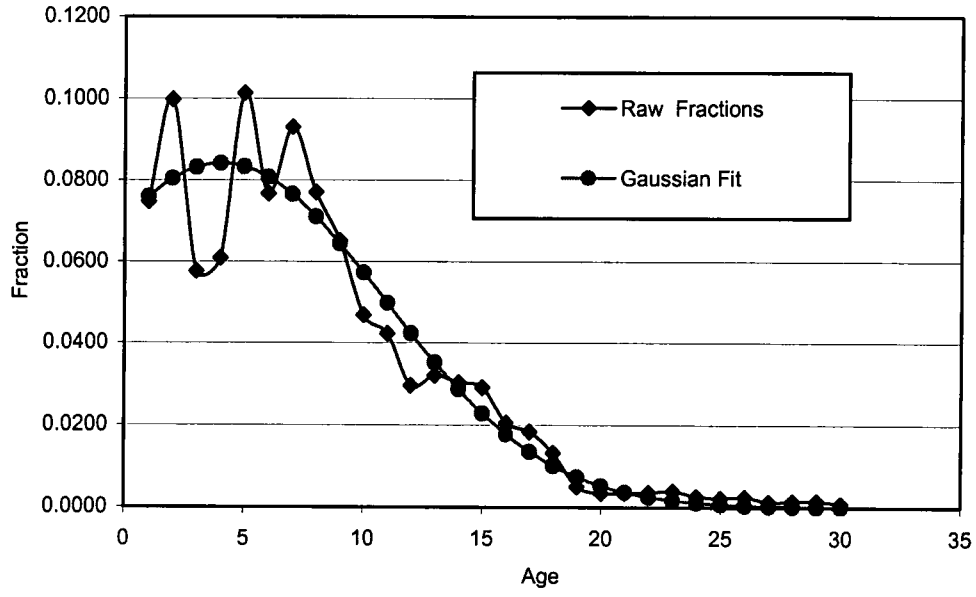


a. LDV Vehicle Classification



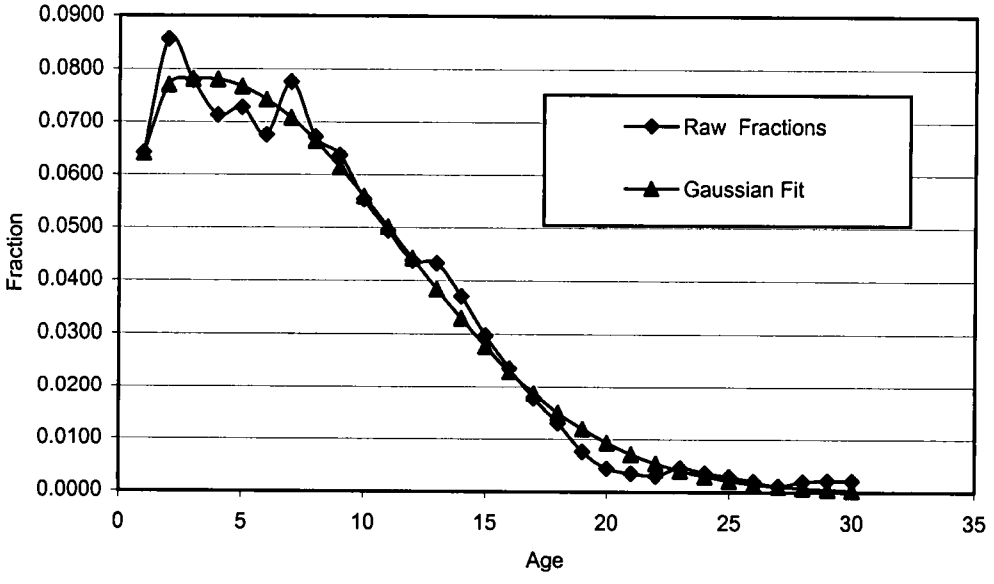
b. LDT1 and LDT2 Vehicle Classifications

Figure B1. Registration Distribution for Shelby +



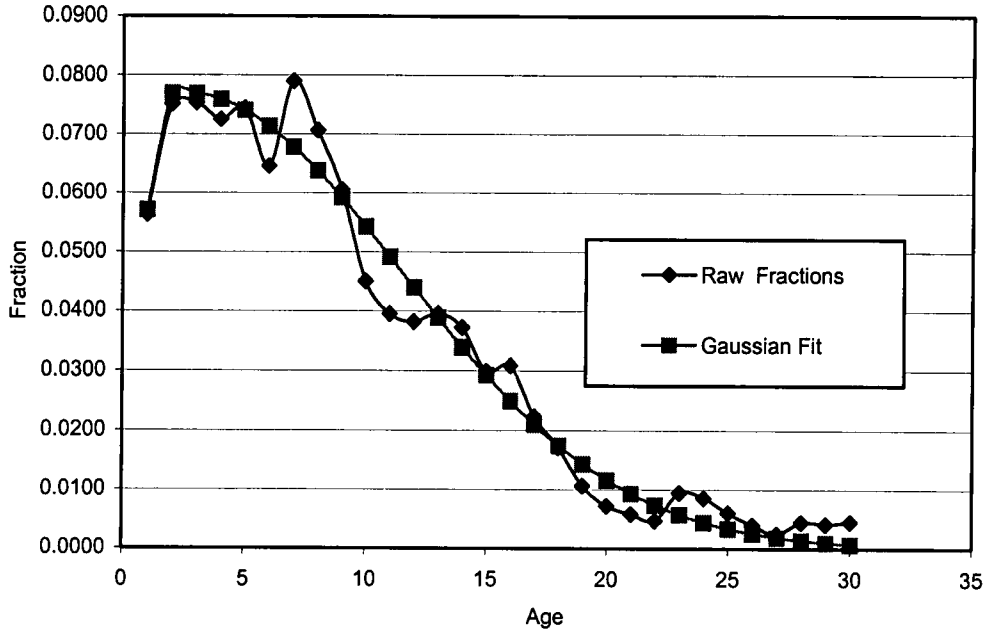
c. LDT3 and LDT4 Vehicle Classifications

Figure B1. Continued.

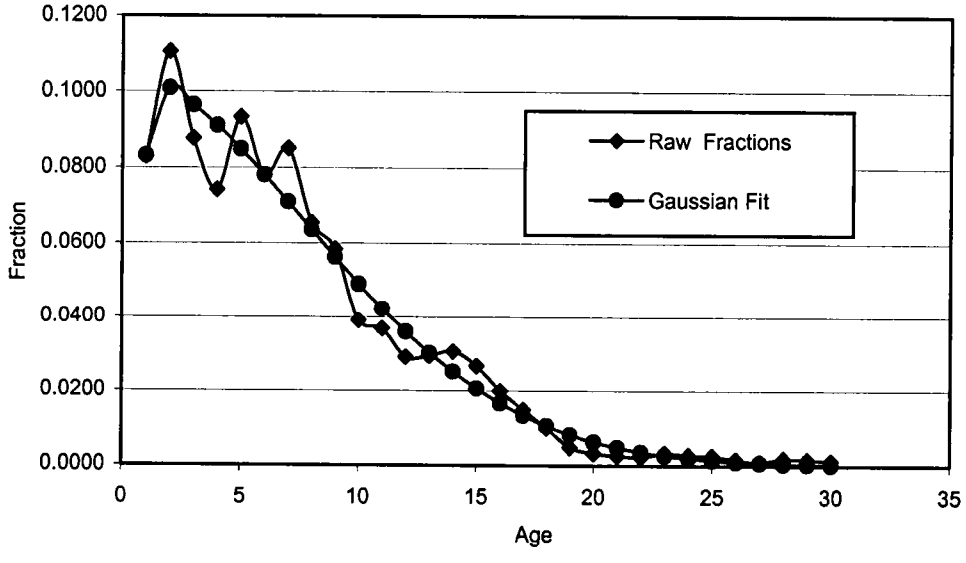


a. LDV Vehicle Classification

Figure B2. Registration Distribution for Davidson +

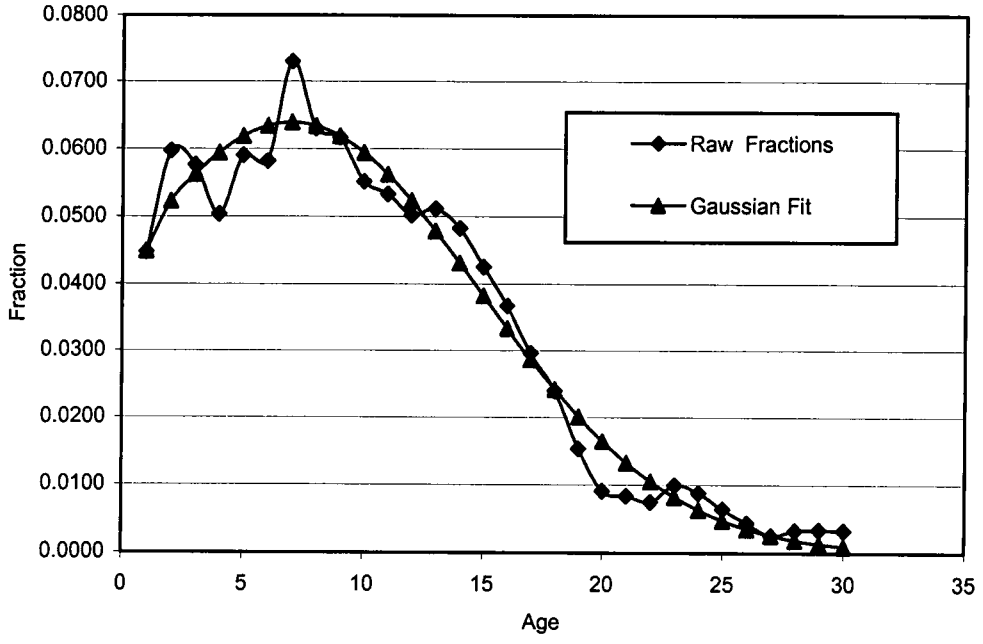


b. LDT1 and LDT2 Vehicle Classifications

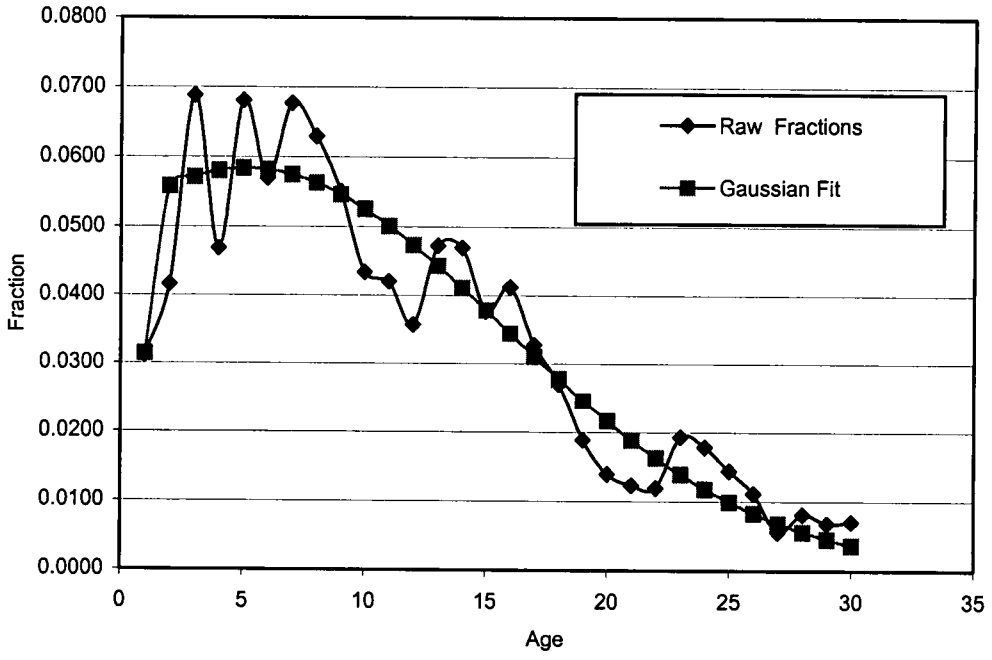


c. LDT3 and LDT4 Vehicle Classifications

Figure B2. Continued.

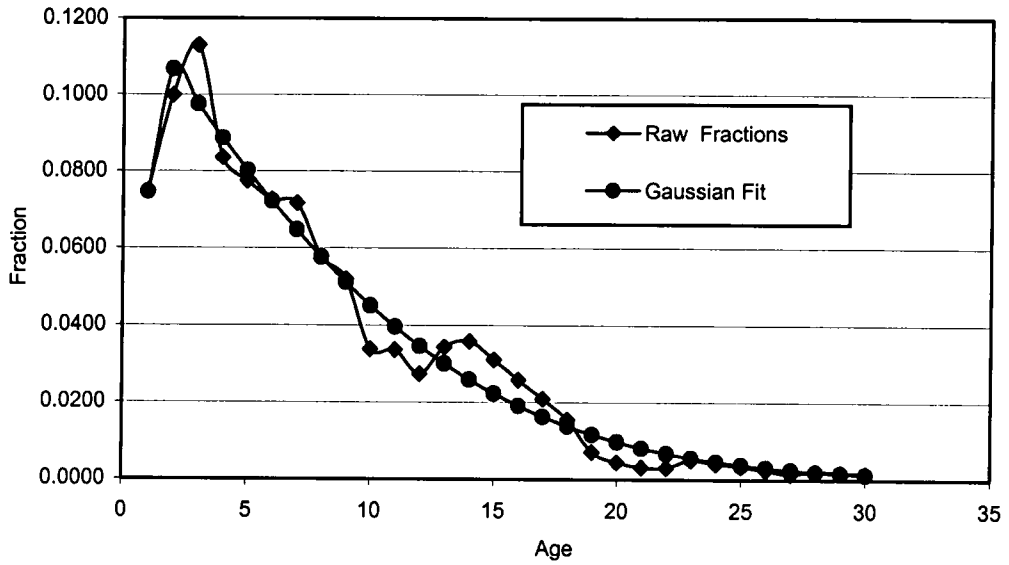


a. LDV Vehicle Classification



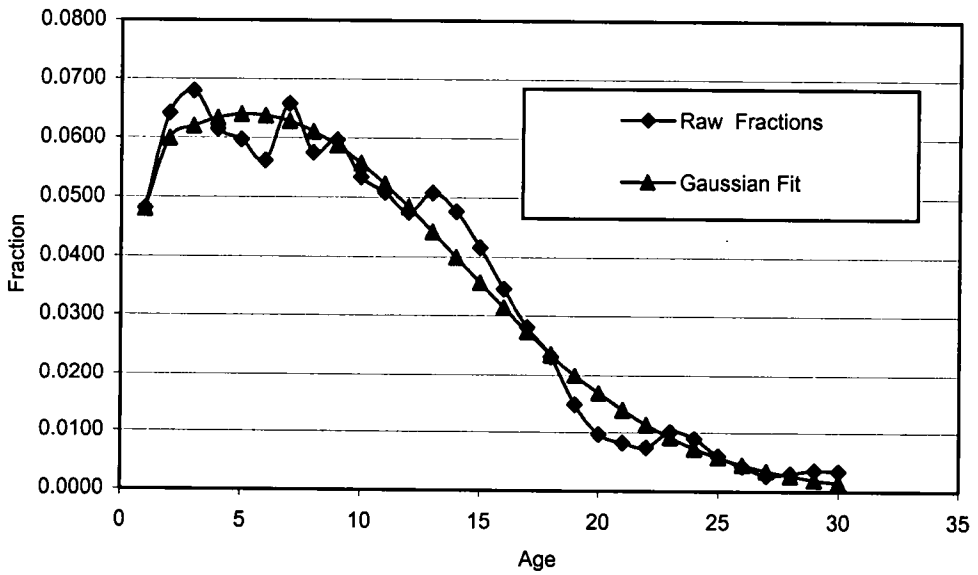
b. LDT1 and LDT2 Vehicle Classifications

Figure B3. Registration Distribution for Hamilton +



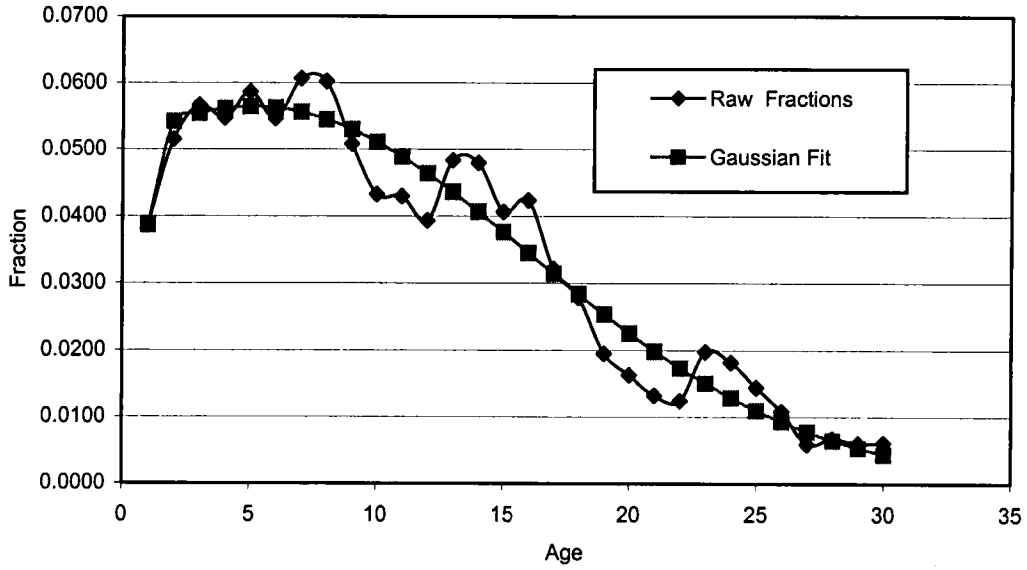
c. LDT3 and LDT4 Vehicle Classifications

Figure B3. Continued.

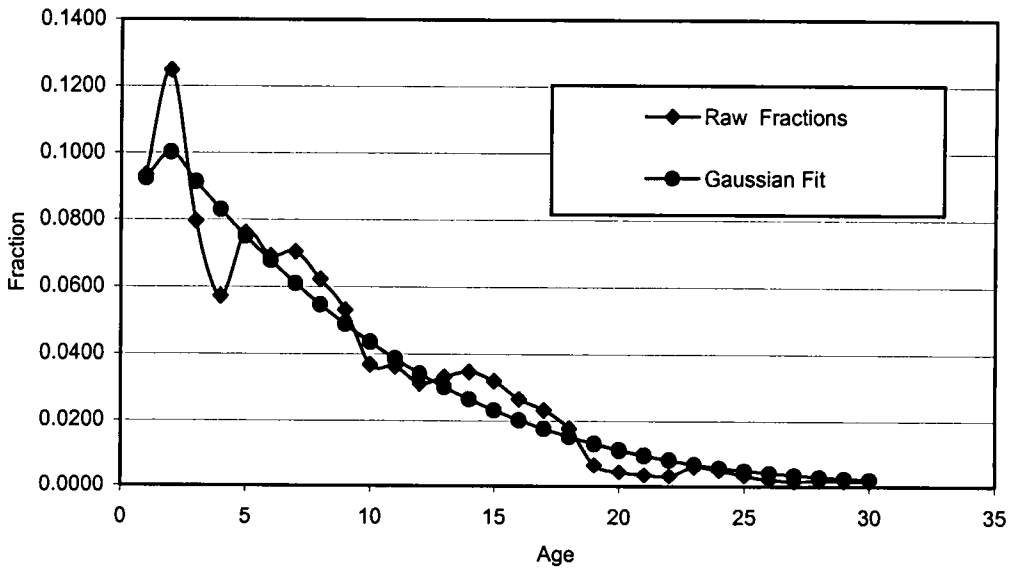


a. LDV Vehicle Classification

Figure B4. Registration Distribution for Knox +

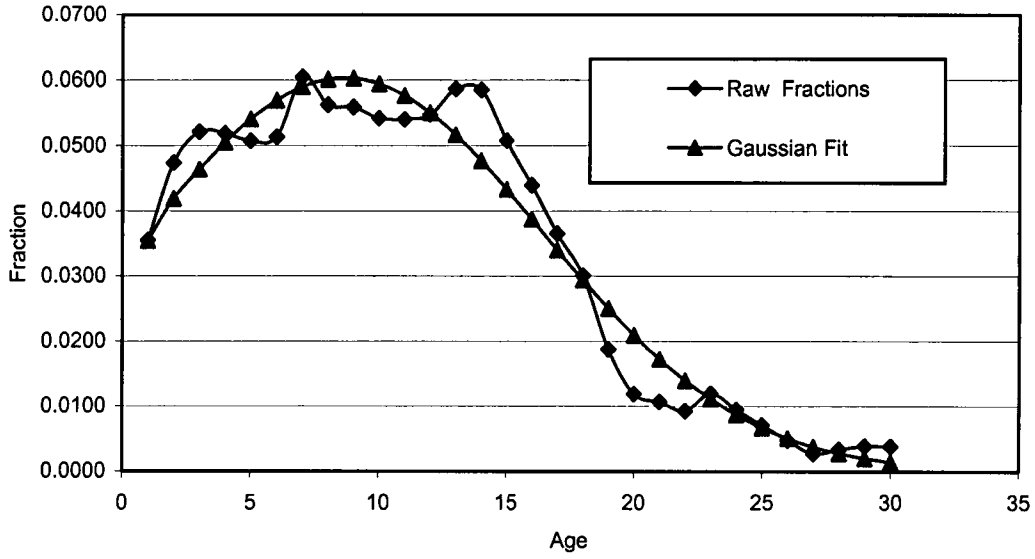


b. LDT1 and LDT2 Vehicle Classifications

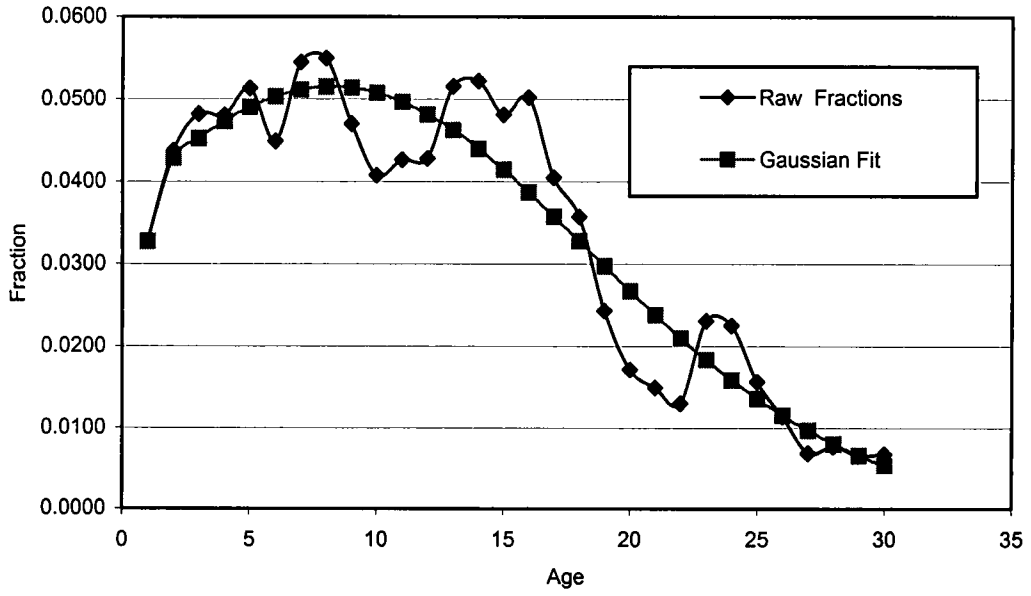


c. LDT3 and LDT4 Vehicle Classifications

Figure B4. Continued.

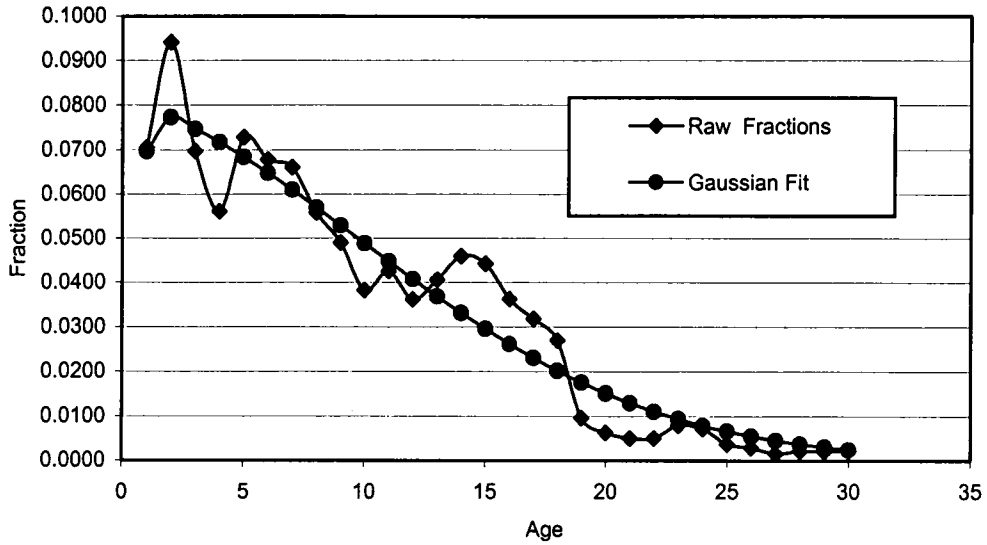


a. LDV Vehicle Classification



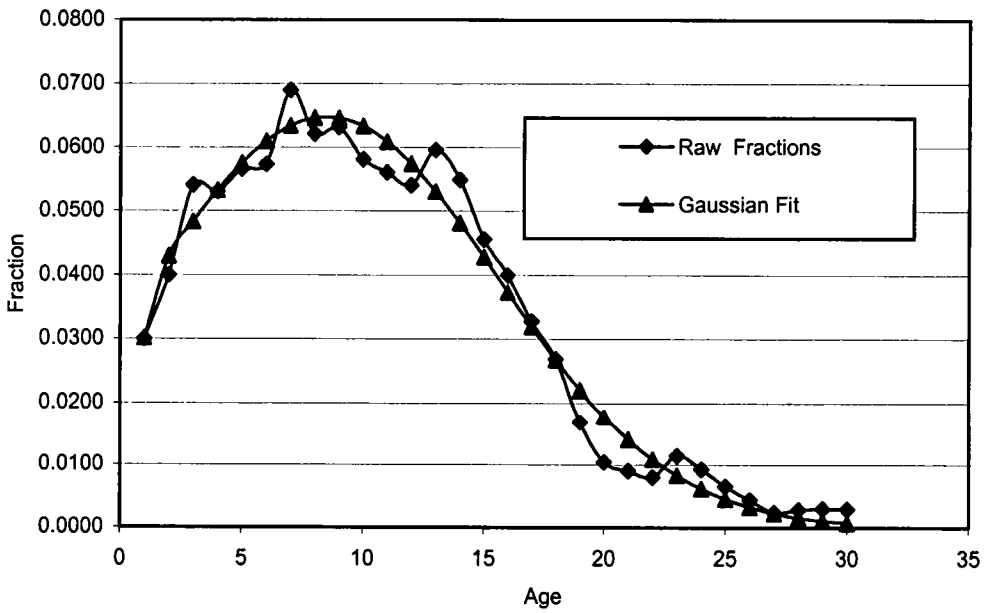
b. LDT1 & LDT2 Vehicle Classifications

Figure B5. Registration Distribution for Sullivan +



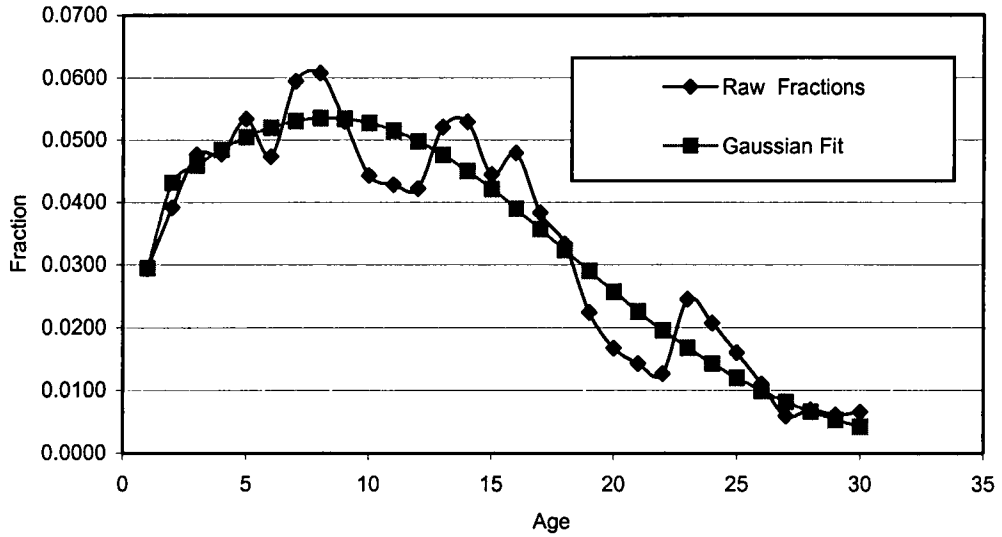
c. LDT3 & LDT4 Vehicle Classifications

Figure B5. Continued.

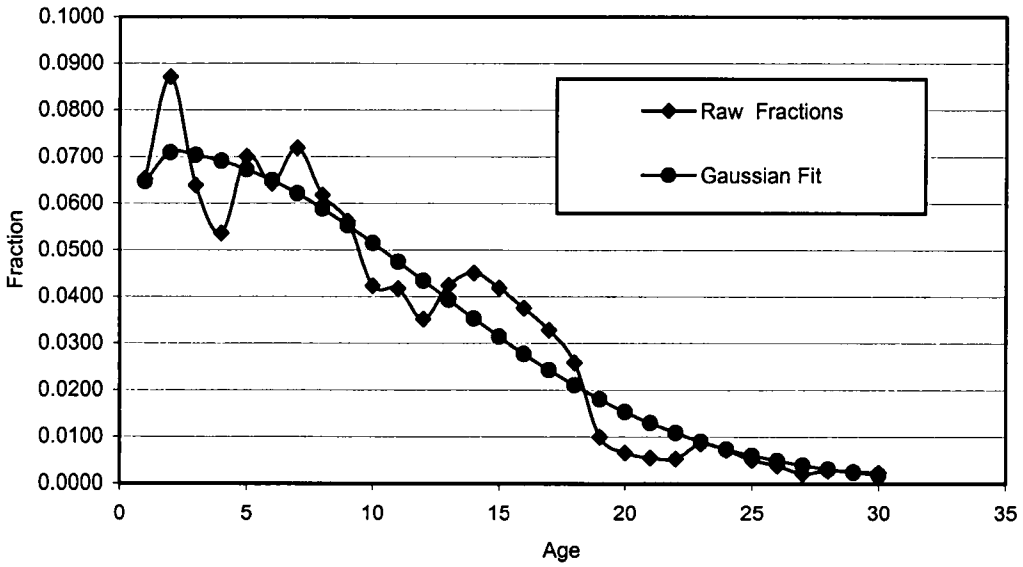


a. LDV Vehicle Classification

Figure B6. Registration Distribution for All Other Counties



b. LDT1 and LDT2 Vehicle Classifications



c. LDT3 and LDT4 Vehicle Classification

Figure B6. Continued.

APPENDIX C

CLASSIFICATION OF COUNTIES INTO EAST, MIDDLE AND WEST TENNESSEE

Table C1. Classification of Counties into East, Middle and West*

West Tennessee	Middle Tennessee	East Tennessee
1. Benton	1. Bedford	1. Anderson
2. Carroll	2. Cannon	2. Bledsoe
3. Chester	3. Cheatham	3. Blount
4. Crockett	4. Clay	4. Bradley
5. Decatur	*5. Coffee*	*5. Campbell*
6. Dyer	6. Davidson	6. Carter
7. Fayette	7. DeKalb	7. Claiborne
8. Gibson	8. Dickson	8. Cocke
9. Hardeman	9. Fentress	*9. Cumberland*
10. Hardin	10. Franklin	10. Grainger
11. Haywood	11. Giles	11. Greene
12. *Henderson*	12. Grundy	12. Hamblen
13. Henry	13. Hickman	13. Hamilton
14. Lake	14. Houston	14. Hancock
15. Lauderdale	15. Humphreys	15. Hawkins
16. McNairy	16. Jackson	16. Jefferson
17. Madison	17. Lawrence	17. Johnson
18. Obion	18. Lewis	18. Knox
19. Shelby	19. Lincoln	19. Loudon
20. Tipton	20. Macon	20. McMinn
21. Weakley	21. Marshall	21. Marion
	22. Maury	22. Meigs
	23. Montgomery	23. Monroe
	24. Moore	24. Morgan
	25. Overton	25. Polk
	26. Perry	26. Rhea
	27. Picket	*27. Roane*
	28. Putnam	28. Scott
	29. Robertson	29. Sevier
	30. Rutherford	30. Sullivan
	31. Sequatchie	31. Unicoi
	32. Smith	32. Union
	33. Stewart	33. Washington
	34. Sumner	
	35. Trousdale	
	36. Van Buren	
	37. Warren	
	38. Wayne	
	39. White	
	40. Williamson	
	41. Wilson	

* Counties in italics represent counties with interstate traffic more than 50% of total DVMT

APPENDIX D

INPUT PARAMETERS FOR MOBILE6 RUNS

Table D1. Header Section (same for ALL subgroups)

Input Command	Value / Description
MOBILE6 INPUT FILE	Identifies input file as a regular command input file rather than a batch file. Self-sufficient command*.
RUN DATA	Marks end of Header section and beginning of Run Section of a regular command input file. Self-sufficient command*.

* A command by itself - no further information required.

Table D2. Shelby + Subgroup

a. Shelby County: Run Section

Input Command	Value / Description
EXPRESS HC AS VOC	Directs model to output exhaust HC as volatile organic compound. Self-sufficient command*.
NO REFUELING	Exclude refueling (stage II) emission from all output values. Self-sufficient command*.
MIN/MAX TEMPERATURE	Minimum Temperature = 70 F Maximum Temperature = 94 F
ABSOLUTE HUMIDITY	Absolute Humidity = 95 grains/pound
REG DIST	Name of the external file that contains the registration distribution fractions. UShelby.reg (for urban) or RShelby.reg (for rural) Shelby specific registration distribution by age for LDV, LDT1, LDT2, LDT3, and LDT4 and national default distribution for the other 11 vehicles types.
SPEED VMT	Name of the external file that contains the speeds. Ushelby.spd (for urban) or RShelby.spd (for rural) **Rural:** Interstate = 64 mph Arterial = 41 mph Local = National default speed (12.9 mph) Ramps = Not applicable (assume no ramps in rural part of the county) (Filename: RShelby.spd) **Urban:** Interstate = 55 mph Arterial = 33 mph Local = National default speed (12.9 mph) Ramps = National default speed (34.6 mph) (Filename: Ushelby.spd)

* A command by itself - no further information required.

a. Continued.

Input Command	Value / Description
VMT BY FACILITY	Name of the external file that contains the VMT distribution fractions. Art-only.vmt (Arterial) or F-only.vmt (Freeway) or R-only.vmt (Ramps) or L-only.vmt (Local). Allocate all VMT to various roadway or facility types by vehicle class for both rural and urban.
VMT FRACTIONS	Shelby County specific VMT fractions by each of 16 combined vehicle types for rural and urban roadway classification. (From TDOT)
FUEL RVP	Average fuel Reid vapor pressure = 7.8
ANTI_TAMP PROG	19 75 30 22222 22222222 1 11 092 12211112 19 = Program Start Year 2019 75 = First Model Year 1975 - 25-year window; For example 1975 model year in analysis year 2000. 30 = Last Model Year 2030 Next set of 14 values - Vehicle Type subject/not subject to ATP Inspection (1 = NO, 2 = YES) in the following order LDGV, LDGT1, LDGT2, LDGT3, LDGT4, HDGV2B, HDGV3, HDGV4, HDGV5, HDGV6, HDGV7, HDGV8A, HDGV8B, GAS BUS 1 = must be entered, entering '2' will discontinue ATP benefits. 1 = Inspection Frequency -Annual 092 = Compliance Rate 92% 12211112 = Inspections Performed (1 = NO, 2 = YES) Air Pump System Disablement = NO Catalyst Removal = YES Fuel Inlet Restrictor Disablement = YES Tailpipe Lead Deposit Test = NO EGR Disablement = NO Evaporative System Disablement = NO PVC System Disablement = NO Missing Gas Cap = YES
I/M DESC FILE	Name of the external file that contains the I/M program specifications: IM99-15.d, *or* IM20-30.d

b. Shelby County: I/M Program "1" Parameters

Input Command	Value / Description*
I/M PROGRAM	1 1984 2030 1 T/O IDLE 1 = 1st I/M Program 1984 = Program Start Year 1984 2030 = Program End Year 2030 1 = Inspection Frequency - Annual T/O = Program Type - Test Only IDLE = Test Type - Idle Test
I/M MODEL YEARS	1 1974 1995 1974 = First Model Year 1974 1995 = Last Model Year 1995
I/M VEHICLES	1 22222 22222222 1 Vehicle Types subject/not subject to Inspection (1 = NO, 2 = YES) in the following order: LDGV, LDGT1, LDGT2, LDGT3, LDGT4 HDGV2B, HDGV3, HDGV4, HDGV5, HDGV6, HDGV7, HDGV8A, HDGV8B GAS BUS
I/M STRINGENCY	1 17.0 17.0 = Stringency level 17%
I/M COMPLIANCE	1 84.0 *or* 1 92.0 84.0 = Compliance rate of 84% for analysis years 1999 through 2010, and for 2015. 92.0 = Compliance rate of 92% for analysis years 2020, 2025, 2030
I/M WAIVER RATES	1 1.0 1.0 1.0 = waiver rate for pre-1981 model year vehicle 1.0 = waiver rate for 1981 and later model year vehicles
I/M CUTPOINTS	1 CUTPOINT.d CUTPOINT.d = file containing cutpoints – national default cutpoints
I/M EXEMPTION AGE	1 25 25 = vehicles 25 years and older exempt from I/M
I/M GRACE PERIOD	1 1 1 = 1 year grace period when I/M testing not required

* The first value of "1" in all records refers to the 1st I/M program type.

c. Shelby County: I/M Program "2" Parameters

Input Command	Value / Description*
I/M PROGRAM	2 1996 2030 1 T/O OBD I/M 2 = 2nd I/M Program 1996 = Program Start Year 1996 2030 = Program End Year 2030 1 = Inspection Frequency - Annual T/O = Program Type - Test Only OBD I/M= Test Type – OBD type I/M
I/M MODEL YEARS	2 1996 2030 1996 = First Model Year 1996 2030 = Last Model Year 2030
I/M VEHICLES	2 22222 22222222 2 Vehicle Types subject/not subject to Inspection (1 = NO, 2 = YES) in the following order: LDGV, LDGT1, LDGT2, LDGT3, LDGT4 HDGV2B, HDGV3, HDGV4, HDGV5, HDGV6, HDGV7, HDGV8A, HDGV8B GAS BUS
I/M STRINGENCY	2 17.0 17.0 = Stringency level 17%
I/M COMPLIANCE	2 84.0 *or* 2 92.0 84.0 = Compliance rate of 84% for analysis years 1999 through 2010, and for 2015. 92.0 = Compliance rate of 92% for analysis years 2020 2025, 2030
I/M WAIVER RATES	2 1.0 1.0 1.0 = waiver rate for pre-1981 model year vehicle 1.0 = waiver rate for 1981 and later model year vehicles

* The first value of "2" in all records refers to the 2nd I/M program type.

Filenames: IM99-15.d (Years 1999 to 2015 - 84% Compliance Rate)
IM20-30.d (Years 2020 to 2030 - 92% Compliance Rate)

Table D3. Shelby + Subgroup – Tipton & Fayette Counties: Run Section

Input Command	Value / Description
EXPRESS HC AS VOC	Directs model to output exhaust HC as volatile organic compound Self-sufficient command*
NO REFUELING	Exclude refueling (stage II) emission from all output values Self-sufficient command*
MIN/MAX TEMPERATURE	Minimum Temperature = 70 F Maximum Temperature = 94 F
ABSOLUTE HUMIDITY	Absolute Humidity = 95 grains/pound
REG DIST	Name of the external file that contains the registration distribution fractions. **County** / **Urban** / **Rural** Tipton & Fayette / UTip&Fay.reg / RTip&Fay.reg Area specific registration distribution by age for LDV, LDT1, LDT2, LDT3, and LDT4 and national default distribution for the other 11 vehicles types.
SPEED VMT	Name of the external file that contains the speeds. **County** / **Urban** / **Rural** Tipton & Fayette / UTip&Fay.spd / RTip&Fay.spd **Rural:** Interstate = 64 mph Arterial = 41 mph Local = National default speed (12.9 mph) Ramps = Not applicable (assume no ramps in rural part of the county) **Urban:** Interstate = 55 mph Arterial = 33 mph Local = National default speed (12.9 mph) Ramps = National default speed (34.6 mph)
VMT BY FACILITY	Name of the external file that contains the VMT distribution fractions. Art-only.vmt (Arterial) or F-only.vmt (Freeway) or R-only.vmt (Ramps) or L-only.vmt (Local). Allocate all VMT to various roadway or facility types by vehicle class for both rural and urban.
VMT FRACTIONS	County specific VMT fractions by each of 16 combined vehicle types for rural and urban roadway classification. (From TDOT).
FUEL RVP	Average fuel Reid vapor pressure = 9.0

* A command by itself - no further information required.

Table D4. Davidson + Subgroup

a. Run Section

Input Command	Value / Description
EXPRESS HC AS VOC	Directs model to output exhaust HC as volatile organic compound Self-sufficient command*
NO REFUELING	Exclude refueling (stage II) emission from all output values Self-sufficient command*
MIN/MAX TEMPERATURE	Minimum Temperature = 66 F Maximum Temperature = 93 F
ABSOLUTE HUMIDITY	Absolute Humidity = 86 grains/pound
REG DIST	Name of the external file that contains the registration distribution fractions. **County** / **Urban** / **Rural** Davidson / UDav.reg / RDav.reg Rutherford / URu.reg / RRu.reg Sumner / USum.reg / RSum.reg Wilson / UWn.reg / RWn.reg Williamson / UWil.reg / RWil.reg Area specific registration distribution by age for LDV, LDT1, LDT2, LDT3, and LDT4 and national default distribution for the other 11 vehicles types.
SPEED VMT	Name of the external file that contains the speeds. **County** / **Urban** / **Rural** Davidson / UDav.spd / RDav.spd Rutherford / URu.spd / RRu.spd Sumner / USum.spd / RSum.spd Wilson / UWn.spd / RWn.spd Williamson / UWil.spd / RWil.spd **Rural:** Interstate = 64 mph Arterial = 41 mph Local = National default speed (12.9 mph) Ramps = Not applicable (assume no ramps in rural part of the county) **Urban:** Interstate = 55 mph Arterial = 33 mph Local = National default speed (12.9 mph) Ramps = National default speed (34.6 mph)

* A command by itself - no further information required.

a. Continued.

Input Command	Value / Description
VMT BY FACILITY	Name of the external file that contains the VMT distribution fractions. Art-only.vmt (Arterial) or F-only.vmt (Freeway) or R-only.vmt (Ramps) or L-only.vmt (Local). Allocate all VMT to various roadway or facility types by vehicle class for both rural and urban.
VMT FRACTIONS	County specific VMT fractions by each of 16 combined vehicle types for rural and urban roadway classification. (From TDOT).
FUEL RVP	Average fuel Reid vapor pressure = 7.8
ANTI_TAMP PROG	95 75 30 22222 11111111 1 11 098 12211112 *or* 95 75 30 22222 11111111 1 11 095 12211112 95 = Program Start Year 1995 75 = First Model Year 1975 30 = Last Model Year 2030 Next set of 14 values - Vehicle Type subject/not subject to ATP Inspection (1 = NO, 2 = YES) in the following order LDGV, LDGT1, LDGT2, LDGT3, LDGT4, HDGV2B, HDGV3, HDGV4, HDGV5, HDGV6, HDGV7, HDGV8A, HDGV8B, GAS BUS 1 = must be entered, entering '2' will discontinue ATP benefits. 1 = Inspection Frequency -Annual 098 *or* 095 = Compliance Rate of 98% for Davidson County and 95% for other 4 Counties. 12211112 = Inspections Performed (1 = NO, 2 = YES) Air Pump System Disablement = NO Catalyst Removal = YES Fuel Inlet Restrictor Disablement = YES Tailpipe Lead Deposit Test = NO EGR Disablement = NO Evaporative System Disablement = NO PVC System Disablement = NO Missing Gas Cap = YES
I/M DESC FILE	Name of the external file that contains the I/M program specifications **County** — **I/M file name** Davidson — Dav_IM.d Rutherford — Ru_IM.d Sumner — Sum_IM.d Wilson — Wn_IM.d Williamson — Wil_IM.d

b. I/M Program "1" Parameters

Input Command	Value / Description*
I/M PROGRAM	1 1985 2030 1 T/O IDLE *or* 1 1995 2030 1 T/O IDLE 1 = 1st I/M Program 1985 *or* 1995 = Program Start Year 1985 for Davidson County and 1995 for other 4 Counties 2030 = Program End Year 2030 1 = Inspection Frequency - Annual T/O = Program Type - Test Only IDLE = Test Type - Idle Test
I/M MODEL YEARS	1 1975 1995 1975 = First Model Year 1975 1995 = Last Model Year 1995
I/M VEHICLES	1 22222 11111111 1 Vehicle Types subject/not subject to Inspection (1 = NO, 2 = YES) in the following order: LDGV, LDGT1, LDGT2, LDGT3, LDGT4 HDGV2B, HDGV3, HDGV4, HDGV5, HDGV6, HDGV7, HDGV8A, HDGV8B GAS BUS
I/M STRINGENCY	1 30.0 30.0 = Stringency level 30%
I/M COMPLIANCE	1 98.0 *or* 1 95.0 98.0 = Compliance rate of 98% for Davidson County 95.0 = Compliance rate of 95% for other 4 Counties
I/M WAIVER RATES	1 0.0 0.0 *or* 1 5.0 5.0 0.0 *or* 5.0 = Waiver rate for pre-1981 model year vehicle 0% for Davidson County and 5% for other 4 Counties 0.0 *or* 5.0 = Waiver rate for 1981 and later model year vehicles 0% for Davidson County and 5% for other 4 Counties
I/M CUTPOINTS	1 CUTPOINT.d CUTPOINT.d = file containing cutpoints – national default cutpoints
I/M EXEMPTION AGE	1 25 25 = vehicles 25 years and older exempt from I/M
I/M GRACE PERIOD	1 1 1 = 1 year grace period when I/M testing not required

* the first value of "1" in all records refers to the 1st I/M program type.

c. I/M Program "2" Parameters

Input Command	Value / Description*
I/M PROGRAM	2 1996 2030 1 T/O OBD I/M 2 = 2nd I/M Program 1996 = Program Start Year 1996 2030 = Program End Year 2030 1 = Inspection Frequency - Annual T/O = Program Type - Test Only OBD I/M= Test Type – OBD type I/M
I/M MODEL YEARS	2 1996 2030 1996 = First Model Year 1996 2030 = Last Model Year 2030
I/M VEHICLES	2 22222 22222222 2 Vehicle Types subject/not subject to Inspection (1 = NO, 2 = YES) in the following order: LDGV, LDGT1, LDGT2, LDGT3, LDGT4 HDGV2B, HDGV3, HDGV4, HDGV5, HDGV6, HDGV7, HDGV8A, HDGV8B GAS BUS
I/M STRINGENCY	2 30.0 30.0 = Stringency level 30%
I/M COMPLIANCE	2 98.0 *or* 2 95.0 98.0 = Compliance rate of 98% for Davidson County 95.0 = Compliance rate of 95% for other 4 Counties
I/M WAIVER RATES	2 0.0 0.0 *or* 2 5.0 5.0 0.0 *or* 5.0 = Waiver rate for pre-1981 model year vehicle 0% for Davidson County and 5% for other 4 Counties 0.0 *or* 5.0 = Waiver rate for 1981 and later model year vehicles 0% for Davidson County and 5% for other 4 Counties

* the first value of "2" in all records refers to the 2nd I/M program type.

Table D5. Hamilton + Subgroup: Run Section

Input Command	Value / Description
EXPRESS HC AS VOC	Directs model to output exhaust HC as volatile organic compound Self-sufficient command*
NO REFUELING	Exclude refueling (stage II) emission from all output values Self-sufficient command*
MIN/MAX TEMPERATURE	Minimum Temperature = 66 F Maximum Temperature = 90 F
ABSOLUTE HUMIDITY	Absolute Humidity = 100 grains/pound
REG DIST	Name of the external file that contains the registration distribution fractions. **County** **Urban** **Rural** Hamilton UHam.reg RHam.reg Marion UMa.reg RMa.reg Area specific registration distribution by age for LDV, LDT1, LDT2, LDT3, and LDT4 and national default distribution for the other 11 vehicles types.
SPEED VMT	Name of the external file that contains the speeds. **County** **Urban** **Rural** Hamilton UHam.spd RHam.spd Marion UMa.spd RMa.spd **Rural:** Interstate = 64 mph Arterial = 41 mph Local = National default speed (12.9 mph) Ramps = Not applicable (assume no ramps in rural part of the county) **Urban:** Interstate = 55 mph Arterial = 33 mph Local = National default speed (12.9 mph) Ramps = National default speed (34.6 mph)
VMT BY FACILITY	Name of the external file that contains the VMT distribution fractions. Art-only.vmt (Arterial) or F-only.vmt (Freeway) or R-only.vmt (Ramps) or L-only.vmt (Local). Allocate all VMT to various roadway or facility types by vehicle class for both rural and urban.
VMT FRACTIONS	County specific VMT fractions by each of 16 combined vehicle types for rural and urban roadway classification. (From TDOT).
FUEL RVP	Average fuel Reid vapor pressure = 9.0

* A command by itself - no further information required.

Table D6. Knox + Subgroup: Run Section

Input Command	Value / Description
EXPRESS HC AS VOC	Directs model to output exhaust HC as volatile organic compound Self-sufficient command*
NO REFUELING	Exclude refueling (stage II) emission from all output values. Not applicable for Knox County. Self-sufficient command*
MIN/MAX TEMPERATURE	Minimum Temperature = 66 F Maximum Temperature = 90 F
ABSOLUTE HUMIDITY	Absolute Humidity = 100 grains/pound
REG DIST	Name of the external file that contains the registration distribution fractions. **County** / **Urban** / **Rural** Knox / UKnox.reg / RKnox.reg Other 6 Counties / UA.reg / RA.reg Area specific registration distribution by age for LDV, LDT1, LDT2, LDT3, and LDT4 and national default distribution for the other 11 vehicles types.
SPEED VMT	Name of the external file that contains the speeds. **County** / **Urban** / **Rural** Knox / UKnox.spd / RKnox.spd Other 6 Counties / UA.spd / RA.spd **Rural:** Interstate = 64 mph Arterial = 41 mph Local = National default speed (12.9 mph) Ramps = Not applicable (assume no ramps in rural part of the county) **Urban:** Interstate = 55 mph Arterial = 33 mph Local = National default speed (12.9 mph) Ramps = National default speed (34.6 mph)
VMT BY FACILITY	Name of the external file that contains the VMT distribution fractions. Art-only.vmt (Arterial) or F-only.vmt (Freeway) or R-only.vmt (Ramps) or L-only.vmt (Local). Allocate all VMT to various roadway or facility types by vehicle class for both rural and urban.
VMT FRACTIONS	County specific VMT fractions by each of 16 combined vehicle types for rural and urban roadway classification. (From TDOT).
FUEL RVP	Average fuel Reid vapor pressure = 9.0

* A command by itself - no further information required.

Table D7. Sullivan + Subgroup: Run Section

Input Command	Value / Description
EXPRESS HC AS VOC	Directs model to output exhaust HC as volatile organic compound Self-sufficient command*
NO REFUELING	Exclude refueling (stage II) emission from all output values Self-sufficient command*
MIN/MAX TEMPERATURE	Minimum Temperature = 66 F Maximum Temperature = 90 F
ABSOLUTE HUMIDITY	Absolute Humidity = 100 grains/pound
REG DIST	Name of the external file that contains the registration distribution fractions. **County** / **Urban** / **Rural** All 5 Counties / USn.reg / RSn.reg Area specific registration distribution by age for LDV, LDT1, LDT2, LDT3, and LDT4 and national default distribution for the other 11 vehicles types.
SPEED VMT	Name of the external file that contains the speeds. **County** / **Urban** / **Rural** All 5 Counties / USn.spd / RSn.spd **Rural:** Interstate = 64 mph Arterial = 41 mph Local = National default speed (12.9 mph) Ramps = Not applicable (assume no ramps in rural part of the county) **Urban:** Interstate = 55 mph Arterial = 33 mph Local = National default speed (12.9 mph) Ramps = National default speed (34.6 mph)
VMT BY FACILITY	Name of the external file that contains the VMT distribution fractions. Art-only.vmt (Arterial) or F-only.vmt (Freeway) or R-only.vmt (Ramps) or L-only.vmt (Local). Allocate all VMT to various roadway or facility types by vehicle class for both rural and urban.
VMT FRACTIONS	County specific VMT fractions by each of 16 combined vehicle types for rural and urban roadway classification. (From TDOT).
FUEL RVP	Average fuel Reid vapor pressure = 9.0

* A command by itself - no further information required.

Table D8. All Other Counties Subgroup: Run Section

Input Command	Value / Description
EXPRESS HC AS VOC	Directs model to output exhaust HC as volatile organic compound Self-sufficient command*
NO REFUELING	Exclude refueling (stage II) emission from all output values Self-sufficient command*
MIN/MAX TEMPERATURE	Temperature (deg F) — West — Middle — East Minimum — 70 — 66 — 66 Maximum — 94 — 93 — 90
ABSOLUTE HUMIDITY	West — Middle — East Abs. Humidity (gr/lb) — 95 — 86 — 100
REG DIST	Name of the external file that contains the registration distribution fractions. Region — Urban — Rural West — UWest.reg — RWest.reg Middle — UMiddle.reg — RMiddle.reg East — UEast.reg — REast.reg Area specific registration distribution by age for LDV, LDT1, LDT2, LDT3, and LDT4 and national default distribution for the other 11 vehicles types.
SPEED VMT	Name of the external file that contains the speeds. Region — Urban — Rural West — UWest.spd — RWest.spd Middle — UMiddle.spd — RMiddle.spd East — UEast.spd — REast.spd **Rural:** Interstate = 64 mph Arterial = 41 mph Local = National default speed (12.9 mph) Ramps = Not applicable (assume no ramps in rural part of the county) **Urban:** Interstate = 55 mph Arterial = 33 mph Local = National default speed (12.9 mph) Ramps = National default speed (34.6 mph)

* A command by itself - no further information required.

Table D8. Continued.

Input Command	Value / Description
VMT BY FACILITY	Name of the external file that contains the VMT distribution fractions. Art-only.vmt (Arterial) or F-only.vmt (Freeway) or R-only.vmt (Ramps) or L-only.vmt (Local). Allocate all VMT to various roadway or facility types by vehicle class for both rural and urban.
VMT FRACTIONS	County specific VMT fractions by each of 16 combined vehicle types for rural and urban roadway classification. (From TDOT).
FUEL RVP	Average fuel Reid vapor pressure = 9.0

Table D9. Scenario Section (same for ALL subgroups)

Input Command	Value / Description
SCENARIO REC	Label/Title for each scenario
CALENDAR YEAR	1999 through 2010 every year, 2015,2020,2025 and 2030
EVALUATION MONTH	7 = July 1st of calendar year

APPENDIX E

MOBILE SOURCE EMISSIONS FOR EAST, MIDDLE AND WEST TENNESSEE

Table E1. East Tennessee

a. VOC Emissions (tons/day)

N°	County	GR(%)*	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2015	2020	2025	2030
1	Anderson	2.0	6.50	6.21	5.94	5.61	5.34	4.90	4.53	4.29	4.12	3.90	3.71	3.50	2.57	2.03	1.95	2.12
2	Bledsoe	3.1	0.71	0.68	0.66	0.64	0.61	0.58	0.54	0.52	0.51	0.48	0.46	0.44	0.33	0.27	0.28	0.32
3	Blount	5.0	7.25	7.13	7.01	6.83	6.70	6.33	6.03	5.87	5.80	5.65	5.53	5.36	4.51	4.11	4.57	5.75
4	Bradley	3.2	7.52	7.27	7.04	6.78	6.55	6.14	5.80	5.56	5.39	5.17	4.96	4.71	3.55	2.96	3.11	3.52
5	Campbell	3.4	3.64	3.56	3.48	3.35	3.22	2.97	2.77	2.62	2.52	2.39	2.28	2.16	1.75	1.61	1.71	1.99
6	Carter	2.5	4.18	4.01	3.85	3.67	3.53	3.28	3.06	2.93	2.83	2.70	2.58	2.45	1.79	1.40	1.36	1.52
7	Claiborne	3.8	2.37	2.30	2.24	2.17	2.11	1.99	1.89	1.83	1.78	1.72	1.66	1.58	1.22	1.04	1.10	1.30
8	Cocke	3.4	3.38	3.27	3.18	3.06	2.96	2.78	2.63	2.53	2.46	2.36	2.27	2.17	1.66	1.40	1.46	1.69
9	Cumberlan	4.2	4.45	4.38	4.31	4.18	4.05	3.77	3.54	3.37	3.27	3.12	2.99	2.86	2.40	2.30	2.53	3.07
10	Grainger	4.4	1.92	1.88	1.84	1.79	1.76	1.67	1.59	1.55	1.52	1.47	1.43	1.37	1.08	0.95	1.04	1.26
11	Greene	4.6	6.79	6.65	6.53	6.37	6.24	5.93	5.68	5.51	5.43	5.27	5.13	4.94	3.99	3.56	3.92	4.84
12	Hamblen	3.7	5.05	4.90	4.77	4.62	4.49	4.23	4.02	3.87	3.77	3.62	3.49	3.33	2.55	2.18	2.31	2.73
13	Hamilton	3.9	27.75	27.03	26.33	25.44	24.70	23.17	21.95	21.12	20.59	19.84	19.13	18.31	14.39	12.56	13.44	16.04
14	Hancock	4.3	0.32	0.31	0.30	0.29	0.29	0.27	0.26	0.25	0.25	0.24	0.23	0.22	0.18	0.15	0.17	0.20
15	Hawkins	2.3	3.92	3.75	3.60	3.42	3.28	3.05	2.83	2.71	2.61	2.49	2.38	2.25	1.63	1.26	1.22	1.34
16	Jefferson	4.2	5.56	5.43	5.31	5.12	4.97	4.65	4.39	4.24	4.16	4.04	3.93	3.80	3.14	2.77	2.95	3.56
17	Johnson	2.9	1.09	1.05	1.01	0.97	0.94	0.88	0.82	0.79	0.76	0.73	0.70	0.66	0.49	0.40	0.40	0.46
18	Knox*	4.2	36.70	35.09	34.99	33.77	32.77	30.68	28.90	27.83	27.17	26.22	25.38	24.37	19.68	17.21	18.30	22.12
19	Loudon	3.1	4.97	4.81	4.65	4.44	4.26	3.95	3.68	3.52	3.42	3.28	3.16	3.02	2.37	1.98	2.00	2.29
20	McMinn	3.4	6.03	5.85	5.68	5.47	5.29	4.97	4.70	4.51	4.39	4.22	4.06	3.87	2.96	2.50	2.62	3.02
21	Marion	4.7	4.54	4.45	4.37	4.26	4.16	3.92	3.74	3.63	3.58	3.49	3.40	3.29	2.74	2.50	2.77	3.42
22	Meigs	0.9	0.78	0.74	0.70	0.66	0.62	0.57	0.53	0.50	0.47	0.44	0.41	0.38	0.26	0.19	0.17	0.18
23	Monroe	3.6	3.29	3.20	3.11	3.00	2.92	2.74	2.60	2.50	2.44	2.35	2.26	2.16	1.65	1.40	1.47	1.73
24	Morgan	3.0	1.12	1.08	1.04	1.00	0.97	0.91	0.86	0.82	0.79	0.76	0.73	0.69	0.51	0.42	0.42	0.48
25	Polk	1.9	1.47	1.40	1.34	1.27	1.22	1.13	1.05	0.99	0.95	0.90	0.85	0.80	0.56	0.44	0.42	0.45
26	Rhea	2.6	2.14	2.06	1.98	1.89	1.82	1.70	1.60	1.52	1.47	1.40	1.33	1.26	0.91	0.73	0.73	0.82
27	Roane	2.2	4.09	3.95	3.81	3.62	3.44	3.15	2.90	2.71	2.57	2.41	2.26	2.12	1.60	1.40	1.40	1.54
28	Scott	4.8	1.37	1.35	1.33	1.30	1.28	1.22	1.17	1.14	1.12	1.09	1.06	1.02	0.82	0.74	0.82	1.02
29	Sevier	5.3	6.72	6.63	6.55	6.39	6.28	5.95	5.68	5.55	5.50	5.38	5.28	5.14	4.41	4.07	4.57	5.83
30	Sullivan	3.3	14.81	14.32	13.86	13.31	12.87	12.06	11.33	10.92	10.65	10.24	9.87	9.42	7.20	5.87	5.94	6.87
31	Unicoi	4.7	1.57	1.53	1.51	1.46	1.44	1.36	1.30	1.27	1.26	1.23	1.20	1.16	0.95	0.82	0.89	1.10
32	Union	3.7	0.86	0.84	0.82	0.79	0.76	0.71	0.67	0.64	0.63	0.60	0.58	0.56	0.44	0.38	0.39	0.46
33	Washingto	4.2	9.22	8.99	8.78	8.50	8.30	7.84	7.43	7.22	7.10	6.89	6.70	6.45	5.15	4.39	4.63	5.59
			192.07	186.11	181.92	175.45	170.12	159.44	150.46	144.83	141.27	136.10	131.39	125.82	99.44	85.98	91.05	108.63

b. NO_x Emissions (tons/day)

N°	County	GR(%)*	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2015	2020	2025	2030
1	Anderson	2.0	10.95	10.57	10.06	9.60	8.94	8.10	7.56	6.96	6.52	6.02	5.58	5.11	3.17	2.18	1.79	1.70
2	Bledsoe	3.1	0.65	0.64	0.62	0.61	0.58	0.54	0.52	0.48	0.46	0.44	0.41	0.39	0.28	0.22	0.21	0.22
3	Blount	5.0	6.46	6.45	6.42	6.38	6.22	5.80	5.59	5.27	5.13	4.93	4.75	4.55	3.60	3.14	3.22	3.74
4	Bradley	3.2	14.72	14.36	13.77	13.26	12.46	11.48	10.87	10.18	9.64	9.01	8.44	7.83	5.07	3.61	3.08	3.07
5	Campbell	3.4	14.74	14.40	13.77	13.24	12.36	11.36	10.71	10.03	9.42	8.73	8.13	7.46	4.52	3.06	2.49	2.36
6	Carter	2.5	3.50	3.40	3.30	3.19	3.04	2.78	2.63	2.44	2.33	2.20	2.08	1.96	1.40	1.07	0.96	0.99
7	Claiborne	3.8	2.17	2.14	2.11	2.07	2.00	1.87	1.79	1.68	1.63	1.55	1.48	1.41	1.05	0.85	0.82	0.91
8	Cocke	3.4	8.41	8.22	7.88	7.58	7.11	6.56	6.22	5.84	5.53	5.16	4.83	4.48	2.85	2.00	1.68	1.65
9	Cumberlan	4.2	15.44	15.21	14.68	14.24	13.41	12.42	11.81	11.12	10.54	9.85	9.25	8.57	5.45	3.89	3.35	3.35
10	Grainger	4.4	1.77	1.75	1.73	1.71	1.67	1.56	1.51	1.42	1.38	1.33	1.28	1.22	0.94	0.78	0.78	0.88
11	Greene	4.6	14.30	14.14	13.74	13.41	12.75	11.91	11.43	10.86	10.41	9.85	9.35	8.78	6.03	4.56	4.12	4.36
12	Hamblen	3.7	6.91	6.78	6.58	6.40	6.09	5.65	5.39	5.07	4.84	4.57	4.33	4.06	2.81	2.14	1.95	2.06
13	Hamilton	3.9	41.59	40.89	39.60	38.44	36.44	33.58	31.98	29.94	28.57	26.91	25.44	23.83	16.49	12.66	11.62	12.34
14	Hancock	4.3	0.29	0.29	0.28	0.28	0.27	0.26	0.25	0.23	0.23	0.22	0.21	0.20	0.15	0.13	0.12	0.14
15	Hawkins	2.3	3.19	3.10	3.01	2.91	2.77	2.53	2.39	2.22	2.12	2.00	1.89	1.77	1.26	0.96	0.86	0.88
16	Jefferson	4.2	16.99	16.72	16.13	15.63	14.72	13.64	12.98	12.26	11.65	10.92	10.28	9.55	6.20	4.44	3.78	3.77
17	Johnson	2.9	1.00	0.98	0.95	0.93	0.89	0.82	0.78	0.73	0.70	0.66	0.62	0.59	0.42	0.33	0.30	0.32
18	Knox*	4.2	53.87	53.11	51.63	50.26	47.78	44.11	42.03	39.46	37.74	35.62	33.75	31.68	22.18	17.24	15.89	16.95
19	Loudon	3.1	15.22	14.81	14.14	13.56	12.63	11.58	10.90	10.19	9.58	8.89	8.28	7.61	4.68	3.18	2.57	2.43
20	McMinn	3.4	14.75	14.41	13.81	13.30	12.48	11.51	10.91	10.25	9.70	9.06	8.49	7.86	5.02	3.52	2.96	2.91
21	Marion	4.7	15.94	15.76	15.25	14.84	14.03	13.08	12.51	11.90	11.35	10.68	10.09	9.41	6.18	4.48	3.86	3.91
22	Meigs	0.9	0.72	0.69	0.66	0.63	0.59	0.54	0.50	0.46	0.43	0.40	0.37	0.34	0.22	0.16	0.13	0.12
23	Monroe	3.6	5.50	5.39	5.21	5.05	4.79	4.43	4.22	3.97	3.78	3.56	3.35	3.13	2.11	1.57	1.39	1.43
24	Morgan	3.0	1.03	1.01	0.98	0.96	0.92	0.85	0.81	0.75	0.72	0.68	0.65	0.61	0.44	0.34	0.32	0.34
25	Polk	1.9	1.35	1.30	1.26	1.21	1.15	1.05	0.99	0.92	0.87	0.81	0.76	0.71	0.48	0.36	0.32	0.32
26	Rhea	2.6	1.87	1.82	1.77	1.72	1.65	1.52	1.44	1.34	1.28	1.20	1.14	1.07	0.76	0.58	0.53	0.56
27	Roane	2.2	12.10	11.70	11.10	10.57	9.79	8.89	8.29	7.65	7.12	6.53	6.02	5.48	3.20	2.11	1.68	1.55
28	Scott	4.8	1.26	1.26	1.25	1.24	1.21	1.14	1.10	1.05	1.02	0.98	0.95	0.91	0.71	0.61	0.61	0.71
29	Sevier	5.3	8.54	8.52	8.43	8.34	8.08	7.56	7.29	6.91	6.71	6.42	6.17	5.88	4.46	3.75	3.74	4.28
30	Sullivan	3.3	17.77	17.36	16.78	16.22	15.36	14.12	13.39	12.54	11.97	11.29	10.68	10.01	6.99	5.32	4.76	4.94
31	Unicoi	4.7	1.33	1.32	1.31	1.30	1.27	1.18	1.14	1.09	1.06	1.02	0.99	0.95	0.75	0.65	0.64	0.74
32	Union	3.7	0.83	0.81	0.80	0.79	0.76	0.70	0.67	0.62	0.60	0.57	0.54	0.51	0.38	0.31	0.29	0.32
33	Washingto	4.2	11.10	10.94	10.67	10.40	9.94	9.21	8.82	8.33	8.02	7.63	7.28	6.88	5.02	3.99	3.73	4.04
			326.23	320.23	309.70	300.28	284.14	262.33	249.42	234.12	223.02	209.68	197.87	184.80	125.27	94.19	84.55	88.28

Table E2. Middle Tennessee

a. VOC Emissions (tons/day)

Nº	County	GR(%)*	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2015	2020	2025	2030
1	Bedford	4.1	3.06	2.99	2.92	2.83	2.76	2.61	2.49	2.41	2.36	2.27	2.19	2.10	1.63	1.41	1.52	1.83
2	Cannon	3.1	0.95	0.92	0.89	0.85	0.82	0.77	0.73	0.70	0.68	0.65	0.62	0.59	0.43	0.36	0.36	0.42
3	Cheatham	4.0	3.41	3.32	3.24	3.13	3.05	2.88	2.74	2.64	2.59	2.50	2.42	2.32	1.82	1.58	1.68	2.02
4	Clay	1.9	0.55	0.52	0.50	0.48	0.45	0.42	0.39	0.37	0.36	0.34	0.32	0.30	0.21	0.16	0.16	0.17
5	Coffee	3.2	4.48	4.37	4.25	4.08	3.91	3.61	3.36	3.17	3.04	2.87	2.72	2.57	2.04	1.87	1.97	2.27
6	Davidson	4.7	34.94	34.66	34.27	33.47	32.56	30.10	28.84	27.24	26.36	25.29	24.19	23.05	18.27	17.23	19.85	24.68
7	DeKalb	3.3	1.29	1.24	1.21	1.16	1.12	1.06	1.00	0.96	0.93	0.89	0.85	0.81	0.61	0.50	0.52	0.60
8	Dickson	3.1	4.71	4.55	4.40	4.23	4.08	3.82	3.61	3.45	3.35	3.20	3.07	2.91	2.18	1.80	1.85	2.12
9	Fentress	3.7	1.26	1.22	1.19	1.15	1.12	1.05	1.00	0.96	0.94	0.90	0.87	0.83	0.63	0.53	0.56	0.66
10	Franklin	1.3	2.77	2.62	2.49	2.35	2.24	2.06	1.91	1.80	1.71	1.61	1.51	1.41	0.95	0.72	0.67	0.71
11	Giles	3.9	3.55	3.45	3.36	3.25	3.16	2.99	2.84	2.74	2.68	2.58	2.50	2.39	1.86	1.60	1.70	2.03
12	Grundy	2.1	1.34	1.28	1.23	1.17	1.12	1.03	0.97	0.92	0.88	0.84	0.79	0.75	0.53	0.42	0.41	0.45
13	Hickman	3.3	2.76	2.67	2.59	2.49	2.41	2.26	2.13	2.05	1.99	1.91	1.84	1.75	1.33	1.11	1.15	1.33
14	Houston	3.2	0.46	0.44	0.43	0.41	0.40	0.37	0.35	0.34	0.33	0.31	0.30	0.28	0.21	0.17	0.18	0.21
15	Humphreys	4.1	2.53	2.46	2.41	2.33	2.27	2.15	2.04	1.98	1.94	1.87	1.82	1.74	1.38	1.20	1.28	1.54
16	Jackson	2.1	0.82	0.79	0.75	0.72	0.69	0.64	0.60	0.57	0.54	0.51	0.49	0.46	0.32	0.25	0.25	0.27
17	Lawrence	4.2	2.95	2.88	2.81	2.73	2.67	2.53	2.41	2.34	2.29	2.21	2.13	2.04	1.59	1.38	1.49	1.81
18	Lewis	4.4	0.62	0.61	0.60	0.58	0.57	0.54	0.52	0.50	0.49	0.48	0.46	0.44	0.35	0.30	0.33	0.41
19	Lincoln	1.9	2.58	2.46	2.36	2.24	2.14	1.98	1.85	1.75	1.67	1.58	1.49	1.40	0.97	0.76	0.73	0.79
20	Macon	1.9	1.21	1.16	1.10	1.05	1.00	0.93	0.87	0.82	0.79	0.74	0.70	0.66	0.46	0.36	0.34	0.37
21	Marshall	4.1	2.86	2.79	2.72	2.64	2.57	2.43	2.32	2.24	2.19	2.12	2.05	1.96	1.54	1.34	1.44	1.73
22	Maury	4.0	7.60	7.40	7.22	7.00	6.82	6.44	6.13	5.92	5.79	5.58	5.39	5.16	4.00	3.45	3.70	4.44
23	Montgomery	4.5	10.36	10.14	9.94	9.68	9.48	9.00	8.62	8.36	8.20	7.94	7.69	7.39	5.85	5.17	5.69	7.00
24	Moore	1.9	0.45	0.43	0.41	0.39	0.37	0.35	0.32	0.31	0.29	0.28	0.26	0.25	0.17	0.13	0.13	0.14
25	Overton	3.8	1.76	1.71	1.66	1.61	1.56	1.48	1.40	1.35	1.32	1.27	1.22	1.17	0.89	0.76	0.80	0.96
26	Perry	5.0	0.70	0.69	0.68	0.66	0.65	0.62	0.60	0.58	0.58	0.56	0.55	0.53	0.43	0.39	0.43	0.54
27	Picket	4.5	0.37	0.37	0.36	0.35	0.34	0.32	0.31	0.30	0.30	0.29	0.28	0.27	0.21	0.19	0.20	0.25
28	Putnam	4.4	5.40	5.33	5.24	5.09	4.94	4.61	4.34	4.14	4.02	3.84	3.69	3.52	2.97	2.88	3.21	3.92
29	Robertson	4.2	4.87	4.79	4.71	4.56	4.42	4.11	3.87	3.68	3.57	3.40	3.27	3.12	2.61	2.50	2.76	3.35
30	Rutherford	4.8	9.34	9.26	9.15	8.93	8.68	8.04	7.72	7.29	7.06	6.77	6.48	6.17	4.88	4.58	5.29	6.61
31	Sequatchie	5.0	1.10	1.08	1.07	1.04	1.03	0.98	0.94	0.92	0.91	0.88	0.86	0.83	0.67	0.61	0.68	0.86
32	Smith	3.6	2.20	2.15	2.10	2.03	1.95	1.80	1.69	1.60	1.54	1.46	1.40	1.33	1.08	1.01	1.08	1.27
33	Stewart	3.0	0.95	0.92	0.89	0.85	0.82	0.77	0.73	0.70	0.67	0.64	0.61	0.58	0.43	0.35	0.36	0.41
34	Sumner	3.6	5.91	5.79	5.65	5.45	5.24	4.80	4.56	4.26	4.08	3.86	3.65	3.43	2.55	2.27	2.47	2.92
35	Trousdale	1.7	0.68	0.64	0.62	0.58	0.56	0.51	0.48	0.45	0.43	0.41	0.38	0.36	0.25	0.19	0.18	0.20
36	Van Buren	6.5	0.51	0.51	0.51	0.50	0.50	0.49	0.48	0.47	0.47	0.47	0.46	0.45	0.39	0.38	0.46	0.62
37	Warren	2.9	3.12	3.00	2.90	2.78	2.68	2.51	2.37	2.26	2.19	2.08	1.99	1.88	1.38	1.12	1.14	1.30
38	Wayne	3.8	1.19	1.16	1.13	1.09	1.06	1.00	0.95	0.92	0.89	0.86	0.83	0.79	0.61	0.51	0.54	0.65
39	White	4.3	1.81	1.77	1.73	1.69	1.65	1.56	1.49	1.45	1.42	1.37	1.33	1.27	1.00	0.87	0.94	1.15
40	Williamson	5.1	6.35	6.32	6.27	6.13	5.98	5.54	5.32	5.03	4.89	4.70	4.51	4.30	3.41	3.22	3.75	4.75
41	Wilson	4.2	5.49	5.42	5.32	5.16	4.99	4.59	4.38	4.11	3.96	3.78	3.60	3.40	2.62	2.39	2.67	3.25
			149.25	146.27	143.28	138.91	134.85	125.75	119.63	114.03	110.65	106.12	101.77	96.97	75.72	68.01	74.93	90.97

b. NO_x Emissions (tons/day)

N°	County	GR(%)*	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2015	2020	2025	2030
1	Bedford	4.1	2.74	2.71	2.68	2.64	2.56	2.39	2.30	2.17	2.10	2.01	1.93	1.84	1.39	1.15	1.12	1.26
2	Cannon	3.1	0.86	0.85	0.83	0.81	0.78	0.72	0.69	0.64	0.61	0.58	0.55	0.52	0.38	0.30	0.28	0.30
3	Cheatham	4.0	8.73	8.57	8.27	8.01	7.56	7.02	6.69	6.32	6.02	5.65	5.32	4.96	3.25	2.35	2.02	2.04
4	Clay	1.9	0.50	0.48	0.47	0.45	0.43	0.39	0.37	0.34	0.32	0.30	0.28	0.26	0.18	0.13	0.12	0.12
5	Coffee	3.2	13.80	13.47	12.90	12.41	11.60	10.64	10.02	9.33	8.77	8.12	7.55	6.94	4.25	2.93	2.44	2.36
6	Davidson	4.7	78.72	78.08	76.18	74.53	71.07	65.41	62.39	57.97	55.11	51.62	48.49	45.07	29.37	21.35	19.26	20.48
7	DeKalb	3.3	1.17	1.15	1.12	1.10	1.06	0.98	0.94	0.88	0.84	0.80	0.76	0.72	0.53	0.42	0.40	0.43
8	Dickson	3.1	9.34	9.11	8.73	8.41	7.89	7.27	6.88	6.44	6.09	5.69	5.33	4.94	3.18	2.26	1.91	1.90
9	Fentress	3.7	1.14	1.12	1.11	1.09	1.05	0.98	0.94	0.88	0.85	0.81	0.78	0.74	0.55	0.45	0.43	0.47
10	Franklin	1.3	2.39	2.30	2.22	2.13	2.01	1.83	1.72	1.57	1.48	1.38	1.29	1.20	0.80	0.58	0.50	0.49
11	Giles	3.9	7.68	7.55	7.28	7.06	6.67	6.20	5.91	5.57	5.31	4.99	4.70	4.39	2.91	2.13	1.86	1.90
12	Grundy	2.1	3.31	3.19	3.02	2.87	2.66	2.43	2.27	2.11	1.97	1.82	1.68	1.54	0.92	0.61	0.48	0.45
13	Hickman	3.3	7.06	6.89	6.60	6.35	5.95	5.49	5.19	4.88	4.61	4.30	4.02	3.72	2.36	1.65	1.37	1.34
14	Houston	3.2	0.41	0.41	0.40	0.39	0.37	0.35	0.33	0.31	0.30	0.28	0.27	0.25	0.18	0.15	0.14	0.15
15	Humphreys	4.1	6.51	6.40	6.18	5.99	5.66	5.26	5.01	4.74	4.52	4.25	4.01	3.73	2.46	1.78	1.54	1.57
16	Jackson	2.1	0.75	0.73	0.70	0.68	0.65	0.59	0.56	0.52	0.49	0.46	0.43	0.41	0.28	0.21	0.19	0.19
17	Lawrence	4.2	2.52	2.50	2.47	2.44	2.38	2.22	2.15	2.02	1.96	1.88	1.81	1.73	1.33	1.11	1.10	1.24
18	Lewis	4.4	0.57	0.56	0.56	0.55	0.54	0.50	0.49	0.46	0.45	0.43	0.41	0.39	0.30	0.25	0.25	0.29
19	Lincoln	1.9	2.22	2.15	2.08	2.01	1.91	1.75	1.65	1.52	1.44	1.35	1.27	1.19	0.82	0.61	0.54	0.55
20	Macon	1.9	1.10	1.06	1.03	0.99	0.94	0.86	0.81	0.75	0.71	0.67	0.63	0.58	0.40	0.30	0.26	0.26
21	Marshall	4.1	5.34	5.26	5.09	4.96	4.71	4.38	4.19	3.96	3.78	3.57	3.38	3.16	2.15	1.61	1.45	1.52
22	Maury	4.0	11.31	11.14	10.82	10.55	10.05	9.35	8.94	8.43	8.08	7.64	7.25	6.81	4.75	3.64	3.34	3.56
23	Montgomery	4.5	12.32	12.20	11.95	11.73	11.29	10.55	10.16	9.61	9.28	8.85	8.47	8.03	5.92	4.78	4.60	5.12
24	Moore	1.9	0.41	0.40	0.38	0.37	0.35	0.32	0.30	0.28	0.27	0.25	0.23	0.22	0.15	0.11	0.10	0.10
25	Overton	3.8	1.59	1.57	1.55	1.52	1.47	1.37	1.32	1.24	1.20	1.14	1.09	1.04	0.78	0.64	0.61	0.68
26	Perry	5.0	0.63	0.63	0.63	0.63	0.61	0.58	0.56	0.53	0.52	0.50	0.49	0.47	0.37	0.32	0.33	0.39
27	Picket	4.5	0.34	0.34	0.33	0.33	0.32	0.30	0.29	0.28	0.27	0.26	0.25	0.24	0.18	0.16	0.16	0.18
28	Putnam	4.4	18.62	18.38	17.77	17.27	16.30	15.12	14.40	13.58	12.90	12.08	11.36	10.55	6.79	4.90	4.28	4.32
29	Robertson	4.2	18.01	17.75	17.12	16.61	15.64	14.49	13.77	12.98	12.30	11.49	10.78	9.99	6.33	4.49	3.86	3.83
30	Rutherford	4.8	25.51	25.30	24.67	24.13	22.98	21.27	20.30	18.98	18.04	16.89	15.86	14.70	9.34	6.54	5.63	5.77
31	Sequatchie	5.0	1.00	1.00	0.99	0.99	0.97	0.91	0.89	0.84	0.82	0.79	0.77	0.74	0.59	0.51	0.52	0.61
32	Smith	3.6	8.89	8.70	8.34	8.04	7.52	6.93	6.55	6.14	5.78	5.37	5.01	4.61	2.82	1.93	1.59	1.53
33	Stewart	3.0	0.86	0.85	0.83	0.81	0.78	0.72	0.68	0.64	0.61	0.58	0.55	0.52	0.37	0.29	0.27	0.29
34	Sumner	3.6	12.87	12.63	12.22	11.84	11.19	10.21	9.64	8.87	8.33	7.72	7.17	6.58	3.99	2.69	2.24	2.23
35	Trousdale	1.7	0.61	0.59	0.57	0.55	0.52	0.48	0.45	0.41	0.39	0.37	0.34	0.32	0.22	0.16	0.14	0.14
36	Van Buren	6.5	0.46	0.47	0.47	0.48	0.47	0.45	0.45	0.43	0.43	0.42	0.41	0.40	0.34	0.32	0.35	0.44
37	Warren	2.9	2.64	2.58	2.52	2.46	2.37	2.19	2.09	1.94	1.86	1.76	1.67	1.58	1.14	0.90	0.83	0.89
38	Wayne	3.8	1.08	1.06	1.05	1.03	1.00	0.93	0.89	0.84	0.81	0.77	0.74	0.70	0.53	0.43	0.42	0.46
39	White	4.3	1.65	1.63	1.61	1.60	1.55	1.45	1.40	1.32	1.29	1.23	1.19	1.13	0.87	0.73	0.72	0.81
40	Williamson	5.1	13.65	13.60	13.36	13.15	12.64	11.70	11.20	10.42	9.94	9.33	8.79	8.18	5.35	3.87	3.50	3.75
41	Wilson	4.2	16.69	16.45	15.92	15.45	14.60	13.43	12.74	11.86	11.20	10.42	9.73	8.97	5.51	3.72	3.08	3.04
			306.00	301.80	293.01	285.39	271.07	250.40	238.50	222.98	212.06	198.83	187.06	174.05	114.33	83.43	74.22	77.43

Table E3. West Tennessee

a. VOC Emissions (tons/day)

No.	County	GR(%)*	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2015	2020	2025	2030
1	Benton	2.7	2.18	2.10	2.02	1.93	1.86	1.73	1.63	1.55	1.50	1.43	1.36	1.29	0.94	0.77	0.77	0.86
2	Carroll	2.2	2.62	2.51	2.41	2.29	2.20	2.04	1.91	1.81	1.74	1.65	1.56	1.47	1.04	0.81	0.80	0.88
3	Chester	3.8	1.24	1.20	1.17	1.13	1.10	1.04	0.99	0.95	0.93	0.89	0.86	0.82	0.63	0.53	0.56	0.67
4	Crockett	3.5	1.48	1.44	1.39	1.34	1.30	1.23	1.16	1.12	1.09	1.04	1.00	0.95	0.72	0.60	0.62	0.73
5	Decatur	4.7	1.58	1.55	1.53	1.49	1.46	1.38	1.33	1.29	1.27	1.24	1.20	1.16	0.94	0.83	0.92	1.14
6	Dyer	2.7	3.79	3.65	3.51	3.36	3.23	3.02	2.84	2.71	2.61	2.49	2.37	2.24	1.62	1.31	1.32	1.48
7	Fayette	3.8	3.09	3.01	2.93	2.82	2.72	2.51	2.38	2.26	2.18	2.10	2.01	1.92	1.54	1.42	1.55	1.85
8	Gibson	2.3	3.88	3.71	3.57	3.40	3.26	3.03	2.84	2.70	2.59	2.46	2.33	2.19	1.55	1.22	1.21	1.34
9	Hardeman	2.1	2.29	2.19	2.10	2.00	1.91	1.77	1.66	1.58	1.51	1.43	1.35	1.27	0.89	0.70	0.68	0.74
10	Hardin	3.3	2.25	2.17	2.11	2.03	1.96	1.84	1.75	1.68	1.63	1.56	1.49	1.41	1.05	0.87	0.90	1.05
11	Haywood	2.9	2.61	2.54	2.46	2.36	2.25	2.07	1.92	1.80	1.72	1.62	1.54	1.45	1.14	1.02	1.06	1.21
12	Henderson	4.6	3.39	3.35	3.30	3.22	3.12	2.92	2.75	2.63	2.55	2.44	2.35	2.25	1.92	1.87	2.10	2.60
13	Henry	2.6	2.86	2.75	2.65	2.53	2.44	2.27	2.13	2.03	1.96	1.86	1.77	1.67	1.20	0.96	0.96	1.08
14	Lake	0.6	0.36	0.34	0.32	0.30	0.28	0.26	0.24	0.22	0.21	0.19	0.18	0.17	0.11	0.08	0.07	0.07
15	Lauderdale	1.2	2.16	2.04	1.94	1.83	1.74	1.60	1.48	1.39	1.32	1.24	1.16	1.08	0.72	0.54	0.51	0.53
16	Madison	3.9	11.47	11.16	10.88	10.52	10.24	9.66	9.19	8.87	8.66	8.34	8.03	7.67	5.90	5.07	5.42	6.47
17	McNairy	3.5	2.56	2.48	2.41	2.33	2.26	2.12	2.01	1.94	1.88	1.81	1.73	1.65	1.24	1.04	1.08	1.27
18	Obion	2.2	3.35	3.20	3.07	2.93	2.80	2.60	2.44	2.32	2.22	2.10	1.99	1.87	1.32	1.04	1.02	1.12
19	Shelby	4.7	46.97	46.24	45.43	44.15	42.89	39.72	37.87	36.04	35.06	33.78	32.54	31.16	25.35	20.92	23.60	29.35
20	Tipton	3.3	2.30	2.22	2.15	2.06	1.98	1.82	1.72	1.62	1.56	1.49	1.42	1.34	1.04	0.93	1.00	1.16
21	Weakley	2.5	2.54	2.44	2.35	2.24	2.15	2.00	1.88	1.79	1.73	1.64	1.56	1.47	1.05	0.84	0.83	0.93
			104.97	102.29	99.70	96.24	93.15	86.65	82.11	78.31	75.92	72.80	69.82	66.51	51.89	43.36	47.00	56.53

b. NO_x Emissions (tons/day)

No.	County	GR(%)*	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2015	2020	2025	2030
1	Benton	2.7	4.79	4.65	4.44	4.25	3.97	3.64	3.43	3.20	3.01	2.80	2.61	2.40	1.50	1.03	0.84	0.81
2	Carroll	2.2	2.50	2.42	2.34	2.27	2.15	1.97	1.87	1.72	1.64	1.54	1.44	1.35	0.92	0.69	0.61	0.62
3	Chester	3.8	1.09	1.07	1.06	1.04	1.01	0.94	0.90	0.85	0.82	0.78	0.75	0.71	0.53	0.43	0.42	0.46
4	Crockett	3.5	1.30	1.28	1.26	1.24	1.19	1.11	1.06	0.99	0.96	0.91	0.87	0.82	0.61	0.49	0.47	0.51
5	Decatur	4.7	3.57	3.53	3.43	3.35	3.19	2.98	2.86	2.72	2.61	2.47	2.35	2.20	1.51	1.14	1.02	1.08
6	Dyer	2.7	4.66	4.54	4.37	4.22	3.99	3.67	3.48	3.23	3.07	2.87	2.70	2.51	1.68	1.24	1.09	1.10
7	Fayette	3.8	8.73	8.57	8.27	8.01	7.55	6.96	6.60	6.17	5.83	5.44	5.09	4.70	2.98	2.13	1.84	1.84
8	Gibson	2.3	3.23	3.14	3.05	2.96	2.83	2.60	2.46	2.28	2.17	2.04	1.93	1.81	1.27	0.97	0.87	0.90
9	Hardeman	2.1	1.96	1.90	1.84	1.78	1.70	1.56	1.47	1.36	1.29	1.21	1.14	1.07	0.74	0.56	0.50	0.51
10	Hardin	3.3	1.90	1.87	1.83	1.80	1.73	1.61	1.54	1.44	1.38	1.31	1.25	1.18	0.87	0.69	0.66	0.71
11	Haywood	2.9	9.83	9.56	9.10	8.72	8.10	7.41	6.96	6.48	6.06	5.59	5.18	4.73	2.81	1.86	1.49	1.38
12	Henderson	4.6	11.60	11.47	11.12	10.83	10.24	9.53	9.09	8.60	8.18	7.68	7.23	6.73	4.36	3.17	2.78	2.83
13	Henry	2.6	2.37	2.32	2.26	2.20	2.10	1.94	1.84	1.71	1.63	1.54	1.46	1.37	0.98	0.76	0.69	0.72
14	Lake	0.6	0.31	0.30	0.29	0.27	0.26	0.23	0.22	0.20	0.18	0.17	0.16	0.15	0.09	0.06	0.05	0.05
15	Lauderdale	1.2	1.78	1.71	1.65	1.58	1.49	1.36	1.27	1.16	1.10	1.02	0.95	0.89	0.59	0.42	0.36	0.36
16	Madison	3.9	17.91	17.61	17.06	16.59	15.75	14.63	13.97	13.16	12.58	11.86	11.23	10.52	7.21	5.44	4.91	5.16
17	McNairy	3.5	2.25	2.22	2.18	2.14	2.06	1.92	1.84	1.72	1.66	1.58	1.51	1.43	1.05	0.85	0.81	0.88
18	Obion	2.2	2.80	2.72	2.64	2.56	2.44	2.24	2.12	1.96	1.87	1.75	1.65	1.55	1.08	0.82	0.73	0.75
19	Shelby	4.7	74.01	73.57	72.32	71.16	68.48	63.16	60.40	56.04	53.58	50.46	47.71	44.69	30.88	20.34	18.39	19.73
20	Tipton	3.3	2.39	2.35	2.31	2.27	2.19	2.00	1.90	1.74	1.65	1.55	1.46	1.36	0.95	0.76	0.74	0.80
21	Weakley	2.5	2.15	2.09	2.04	1.98	1.89	1.74	1.66	1.53	1.47	1.38	1.31	1.23	0.87	0.67	0.61	0.63
			161.11	158.92	154.85	151.21	144.32	133.21	126.95	118.27	112.74	105.96	99.97	93.40	63.46	44.51	39.86	41.84

Table E4. Statewide Emissions

a. VOC Emissions (tons/day)

	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2015	2020	2025	2030
East	192.07	186.11	181.92	175.45	170.12	159.44	150.46	144.83	141.27	136.10	131.39	125.82	99.44	85.98	91.05	108.63
Middle	149.25	146.27	143.28	138.91	134.85	125.75	119.63	114.03	110.65	106.12	101.77	96.97	75.72	68.01	74.93	90.97
West	104.97	102.29	99.70	96.24	93.15	86.65	82.11	78.31	75.92	72.80	69.82	66.51	51.89	43.36	47.00	56.53
TOTAL	446.29	434.68	424.90	410.60	398.11	371.83	352.20	337.17	327.85	315.02	302.98	289.30	227.05	197.34	212.97	256.12

b. NO_x Emissions (tons/day)

	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2015	2020	2025	2030
East	326.23	320.23	309.70	300.28	284.14	262.33	249.42	234.12	223.02	209.68	197.87	184.80	125.27	94.19	84.55	88.28
Middle	306.00	301.80	293.01	285.39	271.07	250.40	238.50	222.98	212.06	198.83	187.06	174.05	114.33	83.43	74.22	77.43
West	161.11	158.92	154.85	151.21	144.32	133.21	126.95	118.27	112.74	105.96	99.97	93.40	63.46	44.51	39.86	41.84
TOTAL	793.34	780.95	757.56	736.88	699.52	645.94	614.87	575.37	547.82	514.47	484.89	452.25	303.06	222.12	198.64	207.55

VITA

Anna Mei Yong Tang was born in Perak, Malaysia on March 23, 1978. She attended primary school and high school at Anglo Chinese Methodist School in Perak, where she graduated high school in December, 1995. In January of 1996, she enrolled in the American Transfer Program at Metropolitan College, Subang Jaya, Malaysia. In Fall 1997, she transferred to University of Tennessee, Knoxville to further her education. She graduated from University of Tennessee, Knoxville with a B.S. degree in Industrial Engineering in Spring 1999.

In Fall 1999, she enrolled in the graduate program in the Department of Civil and Environmental Engineering at the University of Tennessee, Knoxville and accepted as a graduate research assistantship from the department. She received her M.S degree in Environmental Engineering, with a concentration in Air Quality from the University of Tennessee, Knoxville in December, 2001.