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 a 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 this study was to develop a mobile source emission inventory by county for the State of Tennessee. The mobile source emission inventory utilized the final version of the U.S.EPA MOBILE6 (January 2002). 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. Emission calculations were made for the base year of 1999 and for future years out to 2030 and included the effects of all promulgated on-road mobile source emission standards. The effect of Inspection and Maintenance (I/M) programs on emissions was also included for all counties which currently require I/M.

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 (CAAA) 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 dioxide (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.

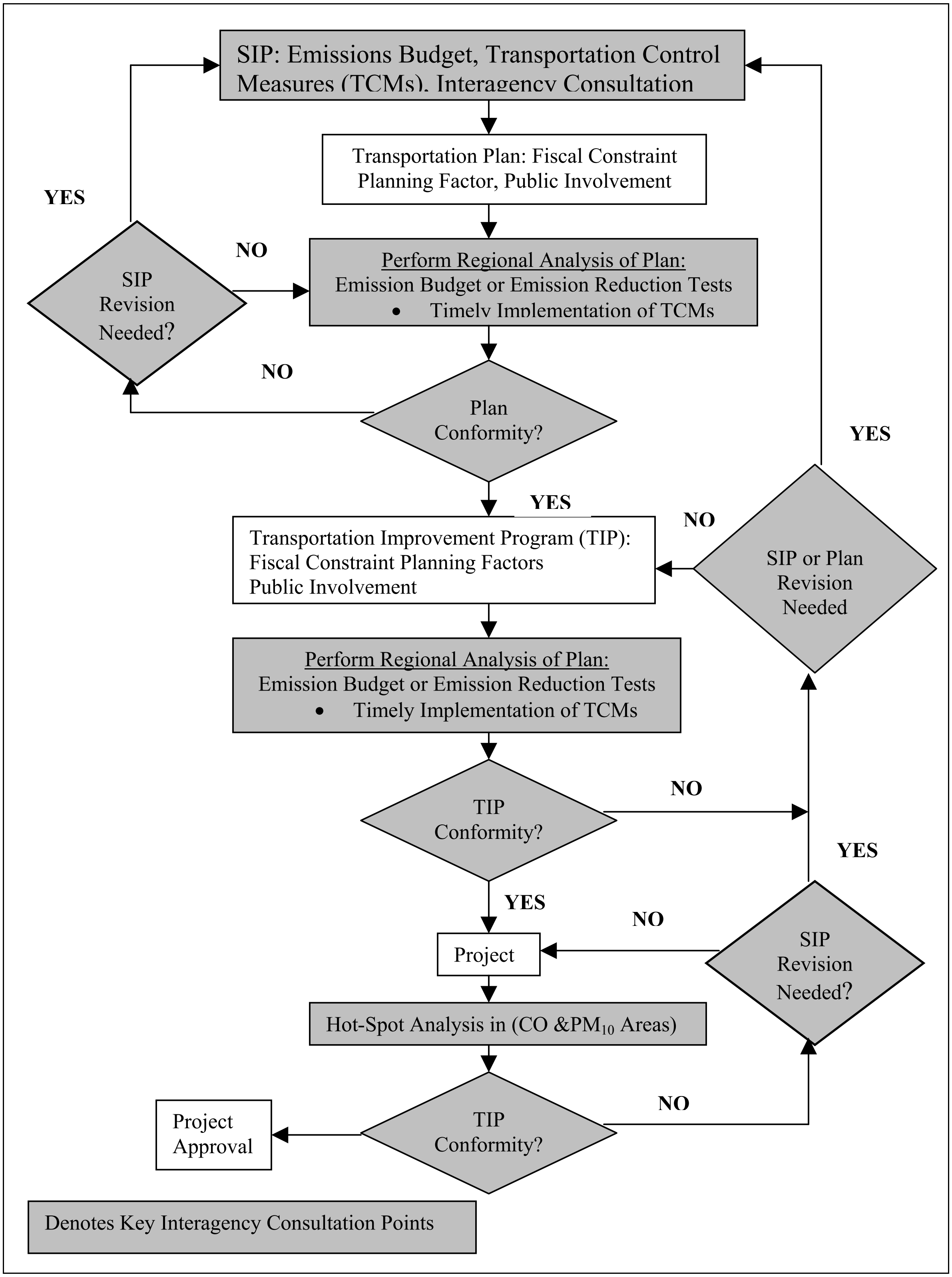

Figure 2-1. Transportation Conformity Process (U.S DOT, 2000)

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 have been 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 (January 2002)	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. Includes additional options for I/M programs, etc.

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 on-road emissions. This chapter provides the basis for the estimation of the growth rate in VMT for the State of Tennessee on a county-level basis for the period of 1999-2030.

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 1999. 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 1999. Since county wide data by roadway classification (rural and urban) were only available for the ten 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	58435
1997	60526
1998	62562
1999	64755

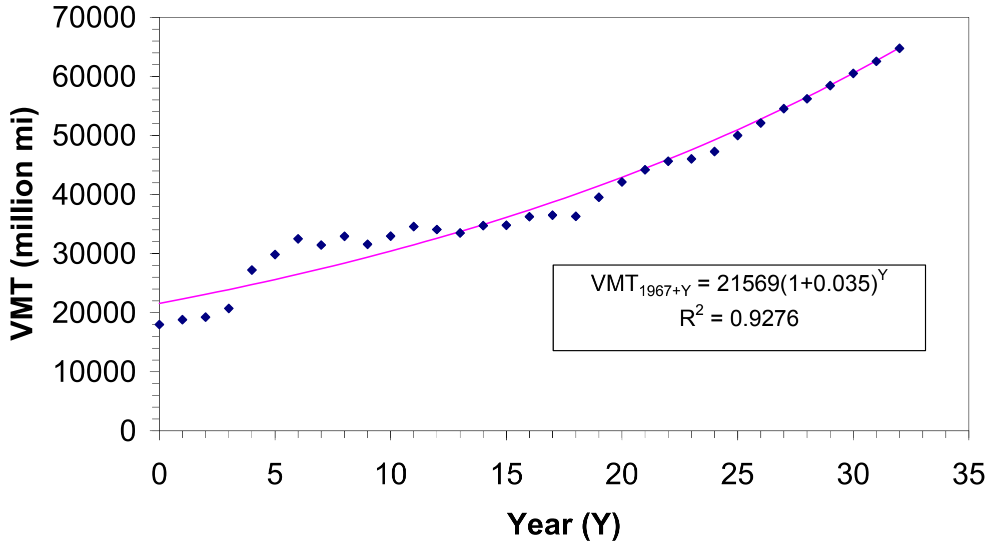

Figure 2-2. State Wide Annual VMT vs Year (1967-1999)

1990-1999 at the on-set of this study, the statewide annual VMT growth rate was recalculated to be 3.9% for that period and is shown in Figure 2-3(a). The best-fit equation for VMT (based on the annual compound growth) is of the following form:

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

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

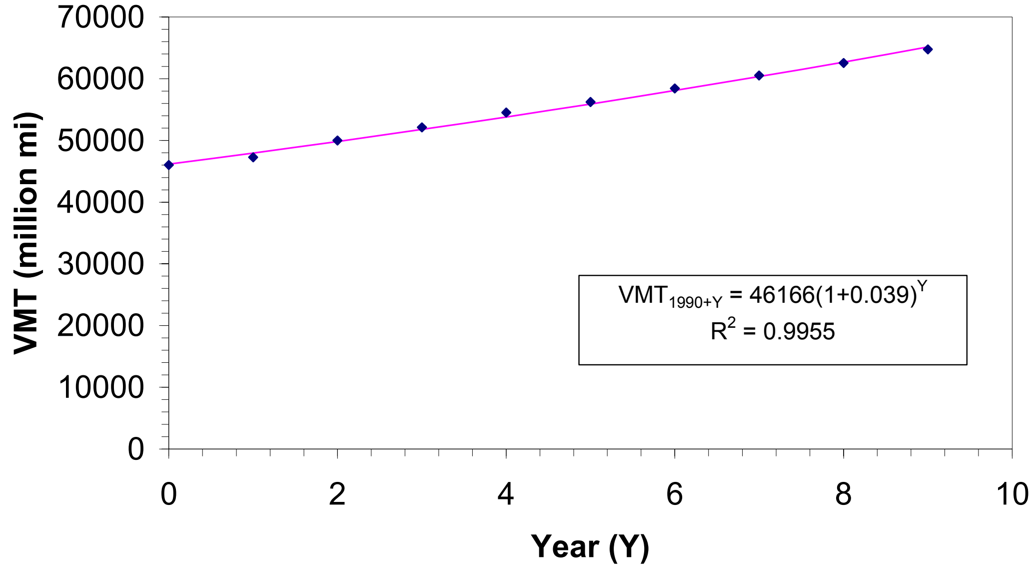

Figure 2-3(a). State Wide Annual VMT vs Year (1990-1999) (compound fit)

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(a) for the 1990 through 1999 period.

While the statewide growth rate in VMT over the 32 year period (1967-1999) is more of a compound growth rate (a non-linear increase), it is less clear as to whether the last 10 years is more of a linear increase or a compound increase as shown in Figure 2-3. Based on the current practice employed by the Tennessee Department of Transportation (TDOT) and their recommendation, future year VMT for use in this study were estimated by developing a linear best fit to the VMT data for the period 1990-1999 followed by a linear extrapolation of the best fit line for future years. The data in Figure 2-3(a) (1990-

1999) were re-analyzed to determine the linear best fit as shown in Figure 2-3(b), where it can be seen that the least squares fit yields an equation with a R^2 of 0.9985.

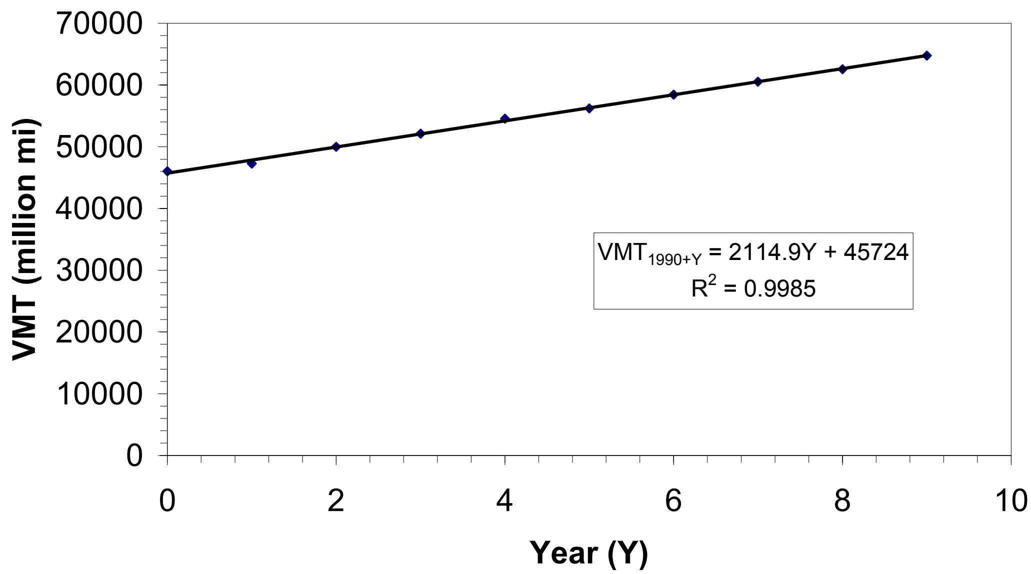

Figure 2-3(b). State Wide Annual VMT vs Year (1990-1999) (linear fit)

The linear equation has the following form:

$$VMT_{1990+Y} = m\,(Y) + b$$

where

‘VMT_{1990+Y}’ is the annual vehicle miles traveled in the (1990+Y) year

‘m’ is the slope of the line (increase in VMT per year) in units same as VMT

‘Y’ is the number of years since 1990

‘b’ is the intercept of the line, and is equivalent to the best fit value of the annual VMT for the base year of 1990.

In Figure 2-3(b), the linear equation implies that the statewide annual VMT increases by 2,115 million miles/year each year (the slope of the line). Thus, to obtain a future year VMT, this constant value would be added to the then current year's annual VMT. For example, the predicted annual VMT in the year 2000 is obtained by adding 2,115 million miles to the 1999 annual VMT (65,732 million miles), which results in 67,847 million miles. This is essentially a linear extension of the VMT curve shown in Figure 2-3(b) and is consistent with current TDOT practice for projecting VMT. An annual growth rate may be calculated by comparing this increase in VMT to the actual VMT for 1999; this yields a growth rate of 3.2% between 1999 and 2000. However, it must be remembered that this growth rate cannot be considered as being constant, since the actual growth rate decreases in future years (i.e., adding a constant VMT to each successive year's VMT results in a smaller percentage increase in each successive year). Hence in this report, the growth is referred to in terms of the actual increase in the vehicle miles traveled rather than as a percentage.

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 Tennessee Department of Transportation (TDOT) each year. The data include 1990-1999, 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.

Linear least squares analyses were conducted to determine the increase in DVMT for each county. The additional increase in DVMT each year for each county, represented by the slope m, is summarized in Table 2-4. The concept of the equations is the same as described in the previous section, except that all equations are for DVMT (miles/day) rather than annual VMT. The DVMT equation includes the contribution from local DVMT even though this category is not directly measured by TDOT. The inclusion 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 R^2 values in the 0.8+ range.

Growth of DVMT for 1990-1999 for Davidson, Hamilton, Knox, Shelby, and Sullivan Counties are shown in Figures 2-4 to 2-8, respectively. The figures indicate that the linear equation provided a reasonable fit for the data with R^2 values ranging from 0.68 to 0.99. The actual increases in DVMT per year were 716,728; 300,461; 411,509; 828,327 and 132,975 miles/day for these counties, respectively. Figure 2-9 shows a state map by county indicating the increase in DVMT per year (in thousands) for each county to provide a visual indication of the VMT growth occurring in various regions within Tennessee.

Table 2-4. Summary of Linear Equations for Growth Rates for TN Counties, based on 1990-1999 DVMT Data

County	Slope, m	Intercept, b	R^2
Anderson	47,045	1,816,509	0.9
Bedford	32,900	625,948	0.91
Benton	22,128	499,811	0.86
Bledsoe	6,056	188,025	0.87
Blount	91,187	1,602,304	0.98
Bradley	71,732	1,899,588	0.92
Campbell	57,458	1,248,640	0.92
Cannon	8,198	236,157	0.95
Carroll	20,206	603,916	0.77
Carter	25,710	978,321	0.71
Cheatham	43,897	775,975	0.89
Chester	12,664	273,946	0.98
Claiborne	26,138	541,053	0.92
Clay	3,831	133,865	0.78
Cocke	35,699	897,436	0.95
Coffee	56,752	1,502,533	0.96
Crockett	14,920	326,485	0.93
Cumberland	78,792	1,400,316	0.95
Davidson	716,728	14,078,580	0.96
Decatur	22,456	315,150	0.9
DeKalb	12,052	305,076	0.98
Dickson	45,447	1,133,510	0.86
Dyer	27,526	946,115	0.93
Fayette	50,435	965,663	0.94
Fentress	12,046	302,795	0.89
Franklin	13,850	699,144	0.79
Gibson	24,941	961,331	0.98
Giles	40,014	847,358	0.97
Grainger	23,632	423,741	0.94
Greene	85,848	1,653,993	0.95
Grundy	10,122	368,276	0.76
Hamblen	46,871	1,245,577	0.92
Hamilton	300,461	7,144,386	0.99
Hancock	3,666	77,097	0.79
Hardeman	15,511	554,086	0.91
Hardin	20,919	485,599	0.89
Hawkins	25,477	917,705	0.85
Haywood	34,267	889,884	0.9
Henderson	61,803	965,509	0.92
Henry	21,242	664,217	0.86
Hickman	34,095	590,737	0.81
Houston	4,373	104,428	0.83
Humphreys	30,015	633,261	0.99
Jackson	5,913	202,893	0.69
Jefferson	79,423	1,455,403	0.97
Johnson	9,254	280,772	0.83
Knox	411,509	8,563,152	0.97
Lake	640	108,009	0.17
Lauderdale	10,771	531,515	0.56
Lawrence	31,536	628,509	0.98
Lewis	6,853	145,033	0.96
Lincoln	16,460	621,224	0.86
Loudon	56,676	1,415,941	0.95
McMinn	64,858	1,547,783	0.95
McNairy	24,440	594,817	0.93
Macon	8,399	298,821	0.65
Madison	123,307	2,346,684	0.95
Marion	69,848	1,294,809	0.93
Marshall	31,915	658,533	0.97
Maury	81,553	1,683,500	0.97
Meigs	3,661	215,991	0.44
Monroe	35,122	825,005	0.97
Montgomery	111,856	2,176,782	0.98
Moore	2,765	118,324	0.78
Morgan	8,843	309,912	0.81
Obion	21,524	816,412	0.84
Overton	19,284	373,745	0.95
Perry	8,728	153,473	0.93
Picket	4,625	75,051	0.93
Polk	10,821	368,340	0.67
Putnam	89,483	1,697,275	0.98
Rhea	15,853	554,354	0.85
Roane	37,885	1,583,967	0.89
Robertson	85,315	1,511,482	0.84
Rutherford	222,200	3,305,138	0.95
Scott	16,696	328,538	0.91
Sequatchie	14,077	227,579	0.97
Sevier	97,464	1,640,204	0.91
Shelby	828,327	16,160,069	0.94
Smith	34,866	724,139	0.96
Stewart	7,959	240,069	0.89
Sullivan	132,975	3,176,752	0.68
Sumner	118,906	2,102,851	0.86
Tipton	29,340	712,451	0.93
Trousdale	4,216	172,363	0.8
Unicoi	17,709	327,823	0.93
Union	9,399	234,228	0.95
Van Buren	7,809	99,473	0.95
Warren	23,547	746,824	0.95
Washington	89,651	1,989,188	0.93
Wayne	12,552	264,700	0.93
Weakley	16,721	644,750	0.75
White	20,624	404,390	0.93
Williamson	157,618	2,337,057	0.94
Wilson	122,098	2,100,606	0.95
Statewide	*5,812,981*	*123,920,748*	*0.99*

$DVMT_{1990+Y} = m(Y) + b$

where

DVMT1990+Y = DVMT (miles/day) in year (1990+Y)

m = slope of line (increase in DVMT per year)

Y = number of years since 1990

b = intercept (best fit DVMT of base year)

R^2 = coefficient of determination for best fit

m and b are in miles/day

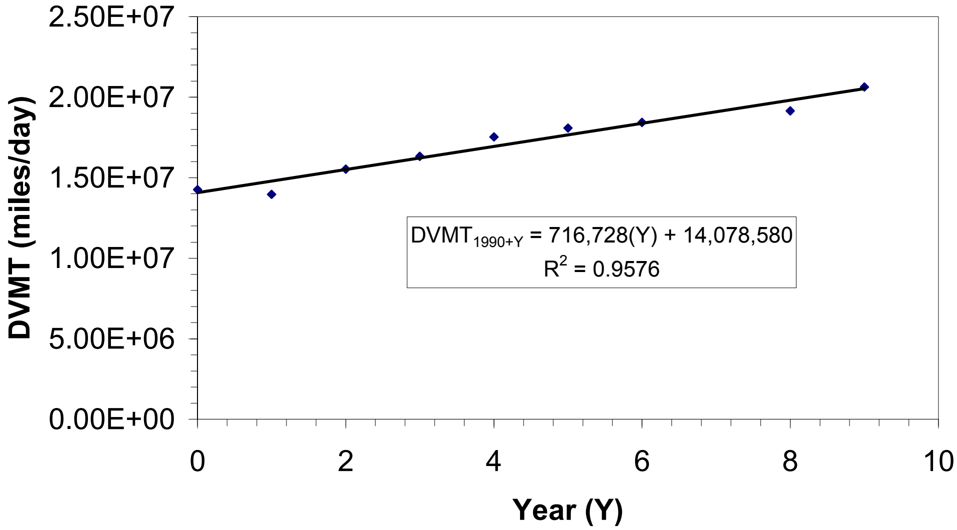

Figure 2-4. Davidson DVMT vs Year (1990-1999)

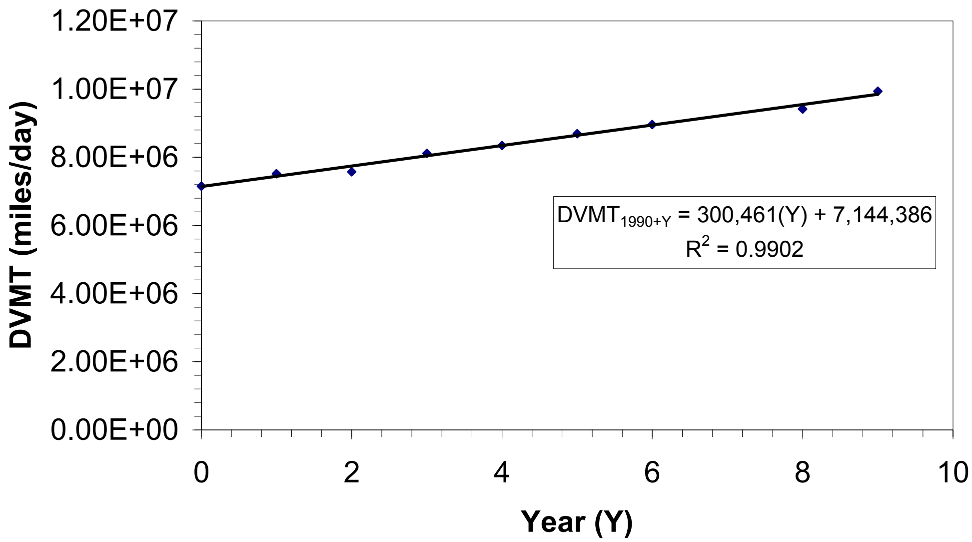

Figure 2-5. Hamilton DVMT vs Year (1990-1999)

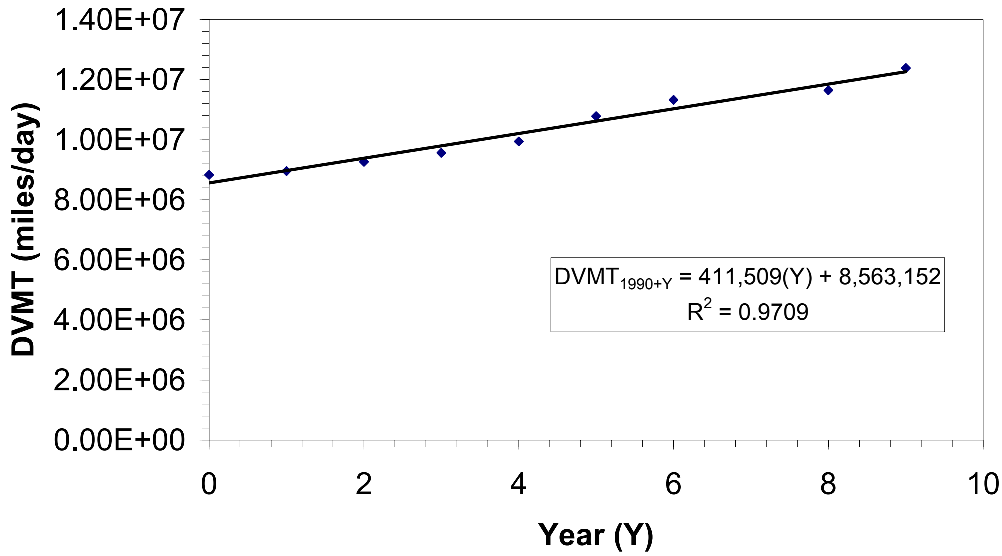

Figure 2-6. Knox DVMT vs Year (1990-1999)

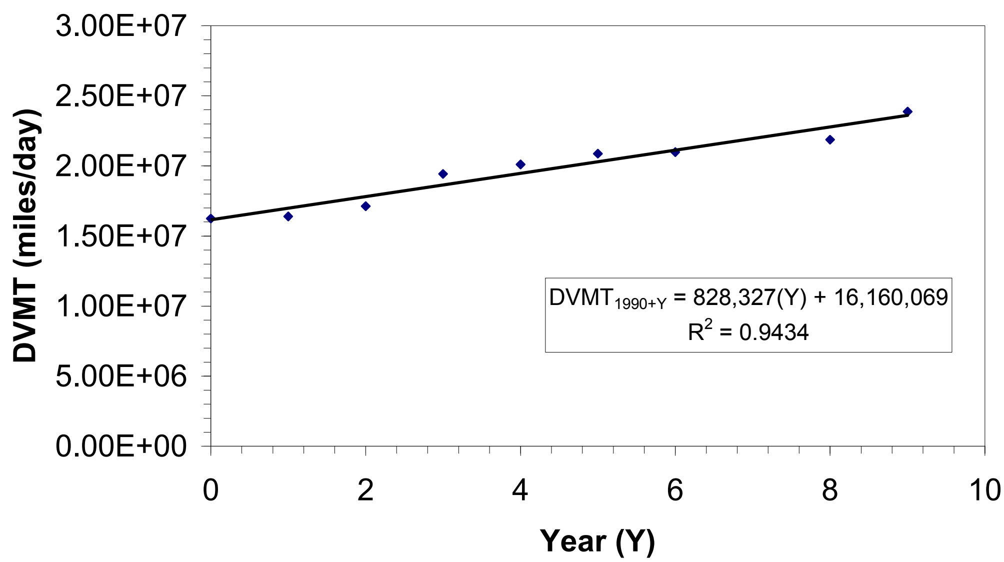

Figure 2-7. Shelby DVMT vs Year (1990-1999)

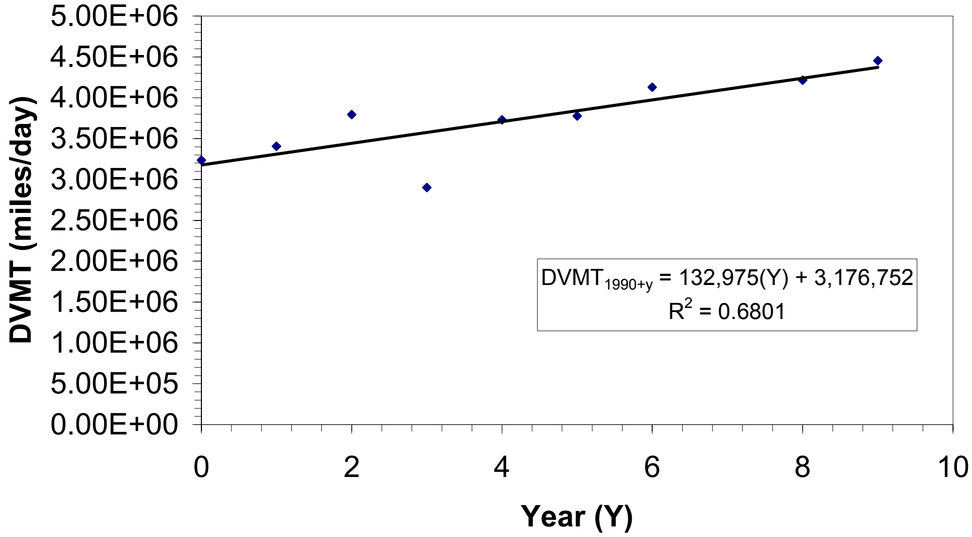

Figure 2-8. Sullivan DVMT vs Year (1990-1999)

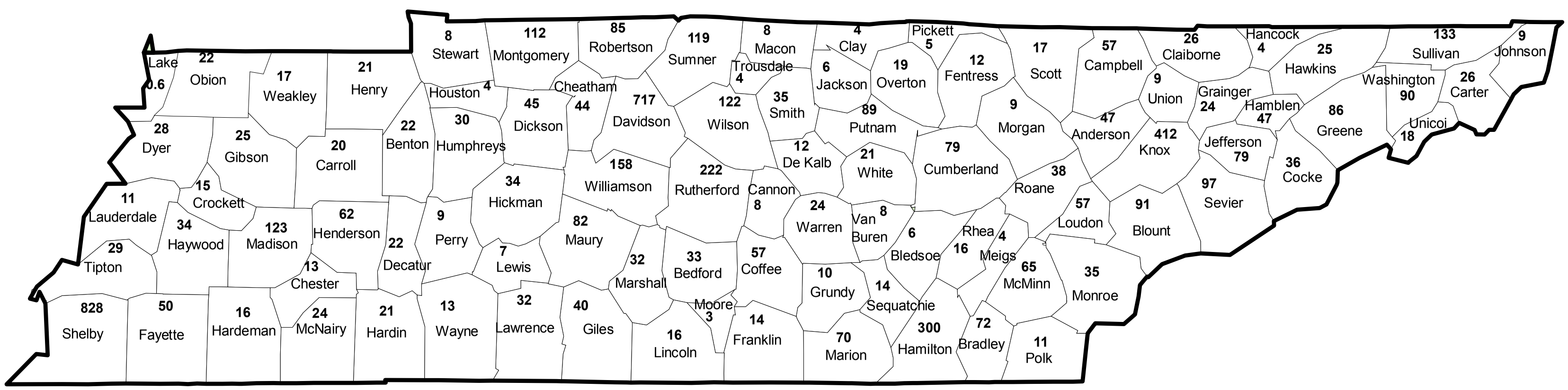

Figure 2-9. Increase in DVMT per year in Thousands of DVMT Based on 1990-1999 DVMT Data