Technical Memorandum

1999 and 2000 Vehicle Miles of Travel in the Delaware Valley Region

May 2002

Delaware Valley Regional Planning Commission
The Bourse Building
111 South Independence Mall East
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Created in 1965, the Delaware Valley Regional Planning Commission (DVRPC) is an interstate, intercounty, and intercity agency which provides continuing, comprehensive, and coordinated planning to shape a vision for the future growth of the Delaware Valley region. The region includes Bucks, Chester, Delaware, and Montgomery counties as well as the City of Philadelphia, in Pennsylvania; and Burlington, Camden, Gloucester, and Mercer counties in New Jersey. DVRPC provides technical assistance and services, conducts high priority studies that respond to the request and demands of member state and local governments, fosters cooperation among various constituents to forge a consensus on diverse regional issues, determines and meets the needs of the private sector, and practices public outreach efforts to promote two-way communication and public awareness of regional issues and the commission.

Our logo is adapted from the official DVRPC seal, and is designed as a stylized image of the Delaware Valley. The outer ring symbolizes the region as a whole while the diagonal bar signifies the Delaware River. The two adjoining crescents represent the Commonwealth of Pennsylvania and the State of New Jersey.

DVRPC is funded by a variety of funding sources including federal grants from the U.S. Department of Transportation's Federal Highway Administration (FHWA) and Federal Transit Administration (FTA), the Pennsylvania and New Jersey departments of transportation, as well as by DVRPC's state and local member governments. This report was primarily funded by the Pennsylvania and New Jersey Departments of Transportation and the Federal Highway Administration (FHWA). The authors, however, are solely responsible for its findings and conclusions, which may not represent the official views or policies of the funding agencies.

TABLE OF CONTENTS

LIST OF TABLES

I. INTRODUCTION

As the Delaware Valley region continues to add new residents and jobs, the amount of highway travel in the region will also increase. Highway travel is usually expressed in terms of daily Vehicle Miles of Travel (VMT). A vehicle mile is defined as one vehicle traveling a distance of one mile. Regional estimates of VMT are equivalent to all the miles driven by all the vehicles in the Delaware Valley region on a typical day. Since it is not possible to directly measure all the miles driven by every vehicle in an area, VMT must be estimated, either through large numbers of traffic counts or with computer models that simulate regional travel patterns. Estimates of VMT are important for monitoring changes in travel and for evaluating the effectiveness of transportation projects, programs, and policies. Of particular concern is the link between VMT and the air quality effects of pollutants emitted through automobile exhaust. While trip length, traffic flow characteristics, fuel composition, and automobile design also influence emissions, the more VMT growth there is in an area, the more effort is required to attain the air quality standards mandated by the U.S. Environmental Protection Agency (EPA). VMT may also be used in combination with other variables to identify and analyze changes in urban form.

VMT estimates also play a major role in proportioning federal highway funds under the Transportation Equity Act for the 21st Century (TEA-21). This law defines the various federal transportation programs, sets funding levels, and apportions highway and mass transit dollars to the states for federal fiscal years 1998 - 2003. To a far greater extent than previous transportation bills, TEA-21 makes use of highway information, including VMT, in the formulas that allocate state funds. Along with freeway and arterial lane-miles and diesel fuel sales, certain components of VMT are used to set funding levels for the Interstate Maintenance (IM), the National Highway System (NHS), and the Surface Transportation Program (STP) components of TEA-21. Together, these three programs account for nearly 40 percent of the $217 Billion authorized in the six-year TEA-21 legislation. Thus, it is necessary to develop accurate estimates of VMT.

This memo provides VMT estimates for the nine-county Delaware Valley region. The region includes Bucks, Chester, Delaware, and Montgomery counties as well as the City of Philadelphia, in Pennsylvania; and Burlington, Camden, Gloucester, and Mercer counties in New Jersey. VMT estimates for the region come from two principal sources: the federal Highway Performance Monitoring System and the Delaware Valley Regional Planning Commission's (DVRPC's) travel simulation models.

II. VMT ESTIMATION METHODS

Every year, the Delaware Valley Regional Planning Commission (DVRPC) estimates and monitors VMT in the nine-county Delaware Valley region. VMT estimates are derived from two primary sources: the federal Highway Performance Monitoring System (HPMS) and DVRPC's regional travel simulation models.

Highway Performance Monitoring System

The Federal Highway Administration (FHWA) requires that both Pennsylvania and New Jersey participate in the federal HPMS, a nationwide roadway inventory system that includes all federal-aid public road mileage. The HPMS is an ongoing program, with annual reporting requirements for the states. Traffic counts from the HPMS are used to calculate VMT estimates. A panel of representative locations is selected from a state's roadway network through a simple random sample. The state Departments of Transportation (DOTs) stratify their highway systems according to three variables: area type, functional classification, and volume group. The state DOT allocates the sample sections throughout the state, and specifies the location and date of the individual counts. The sample sections are randomly selected from the universe of arterial and collector roads (excluding rural minor collectors). The HPMS does not require states to monitor non-federal aid local roads, although both PennDOT and NJDOT include estimates of local road VMT in their statewide HPMS panels. Federal guidelines are used to determine the appropriate number of counts to be taken in each area type, functional class, and volume group strata.

Each section in the HPMS sample panel is counted once every three years. Daily traffic on the sample section is recorded using an automatic counting machine. After the volumes along each sample section are obtained, the raw counts are factored to determine average annual daily traffic (AADT). Appropriate factors are used to adjust the counts for the day of week and the month during which the count was taken to account for the seasonal variation in traffic levels. Axle correction factors adjust the count to correct for over counting of vehicles caused by the presence of multi-axle vehicles. Growth factors are used to adjust traffic counts according to the growth in traffic over a certain time period during which actual counts have not been recorded. If the link volume was counted in the current year a growth factor is not applied.

The states derive VMT from the AADT estimates. The daily VMT for a roadway segment is simply the product of its AADT and segment length. The total VMT for any given stratum is the sum of VMT on all counted segments in that stratum multiplied by a stratum expansion factor to account for roadway segments that were not included in the sample. HPMS data are available at the county level for rural and urban area types.

Table 1 shows the 1999 and 2000 daily VMT estimates derived from the states' HPMS data. Overall, VMT in the Delaware Valley Region grew by 0.5 percent to about 104 million vehicle-miles per day. Nearly two-thirds (64 percent) of regional travel occurs in Pennsylvania. Montgomery County is the most heavily traveled county, while Gloucester County has the least travel. The New Jersey portion of the region grew at 1.5 percent, while the Pennsylvania side of the region was essentially unchanged from 1999 to 2000.

In the New Jersey portion of the Delaware Valley Region, Mercer County exhibited the largest growth in both absolute and relative terms at 333,200 miles per day and 4.2 percent, respectively. Gloucester and Burlington counties also exhibited significant growth in VMT; however, Camden County travel decreased by nearly one percent, or 100,800 miles per day from 1999 to 2000.

On the Pennsylvania side of the region, only Bucks and Chester counties showed growth from 1999 to 2000. Montgomery and Philadelphia counties exhibited slight declines in daily travel. Delaware County, however, showed a significant decrease in daily VMT from 1999 to 2000 at 133,800 vehicle miles, or 1.4 percent. Bucks County was the fastest growing county in both absolute and percent terms, although its growth was much smaller than the growth in the New Jersey suburbs.

Table 1. Daily VMT Estimates from HPMS Data

	Daily VMT (000s)		1999 - 2000 Growth	
	1999	2000	Absolute	Percent
New Jersey				
Burlington	11,997.4	12,170.9	173.5	1.4%
Camden	10,784.8	10,684.0	-100.8	-0.9%
Gloucester	6,467.0	6,615.8	148.8	2.3%
Mercer	7,914.2	8,247.4	333.2	4.2%
Sub-Total	**37,163.4**	**37,718.1**	**554.7**	**1.5%**
Pennsylvania				
Bucks	12,844.3	12,926.8	82.5	0.6%
Chester	10,862.5	10,920.8	58.3	0.5%
Delaware	9,455.4	9,321.6	-133.8	-1.4%
Montgomery	17,867.9	17,866.0	-1.9	0.0%
Philadelphia	15,206.7	15,177.5	-29.2	-0.2%
Sub-Total	**66,236.8**	**66,212.7**	**-24.1**	**0.0%**
REGION TOTAL	**103,400.2**	**103,930.8**	**530.6**	**0.5%**

VMT estimates can be disaggregated by functional class. Functional classification is the process by which streets and highways are grouped into classes, or systems, according to the character of service they are intended to provide. The Federal-Aid Highway Act of 1973 required that highways be classified by function and suggested procedures for classification in rural, small urban, and urbanized areas. HPMS estimates are also reported according to these federal functional classes.

Because urban and rural areas have fundamentally different characteristics with regard to the density, types of land use, and the nature of travel patterns they serve, a separate federal functional classification system is employed for each.

Rural roads consist of those facilities that are outside of small urban and urbanized areas. They are classified into four major systems: principal arterials, minor arterial roads, collector roads, and local roads. The rural principal arterial system consists of a connected rural network of continuous routes. They serve corridor movements having trip length and travel density characteristics indicative of substantial statewide or interstate travel. The principal arterial system is stratified into two subsystems, Interstates and Other Principal Arterials, which may or may not be limited access.

Rural minor arterials link cities and larger towns (and other traffic generators, such as major resort areas, that are capable of attracting travel over similarly long distances) and form an integrated network providing interstate and intercounty service. Rural collector roads generally serve travel of primarily intracounty, rather than statewide importance. Major Collector roads provide service to county seats, larger towns, and to other traffic generators that are not served by arterials. Minor Collector roads collect traffic from local roads and provide service to the remaining smaller communities. The rural local road system serves primarily to provide access to adjacent land.

The four functional systems for urbanized areas are urban principal arterials, minor arterial streets, collector streets, and local streets. The differences in the nature and intensity of development between rural and urban areas cause these systems to have characteristics that are somewhat different from the correspondingly named rural systems.

The urban principal arterial system serves the major centers of activity of a metropolitan area, the highest traffic volume corridors, and the longest trip desires. In order to preserve the identification of controlled access facilities, the principal arterial system is stratified into Interstate, Other Freeways and Expressways, and Other Principal Arterials (with no control of access).

For principal arterials, the concept of service to abutting land is subordinate to the provision of travel service to major traffic movements. Only facilities within the "other principal arterial" system are capable of providing any direct access to adjacent land. The minor arterial street system interconnects with and augments the urban principal arterial system and provides service to trips of moderate length at a somewhat lower level of travel mobility than principal arterials.
The minor arterial system includes all arterials not classified as principal and contains facilities that place more emphasis on land access than the higher system. The urban collector system provides both land access service and traffic circulation within residential neighborhoods, commercial and

industrial areas, distributing trips from the arterials through the area to the ultimate destination. The local street system comprises all facilities not on one of the higher systems. It serves primarily to provide direct access to abutting land and access to the higher order systems.

Tables 2 and 3 provide 1999 and 2000 VMT estimates from HPMS by federal functional class for New Jersey and Pennsylvania, respectively. In both states, the vast majority of travel (78 to 87 percent) occurs in urban areas. Approximately 80 percent of this urban travel occurs on the arterial system. Other Principal Arterials, followed by Interstates, serve the most urban traffic. In rural areas, the arterial system carries a smaller proportion of travel, about 65 to 70 percent, but still accounts for the majority of vehicular travel.

Of the New Jersey counties, Gloucester has the highest percentage of rural travel, at about 37 percent. Camden County, at six percent, has the lowest. On the Pennsylvania side, Chester County exhibits the largest proportion of rural travel at 35 percent, while Philadelphia County, has no rural facilities or travel within its borders.

Table 2. New Jersey's Daily HPMS VMT Estimates by Federal Functional Class (000s)

	Burlington		Camden		Gloucester		Mercer		All NJ Counties	
	1999	2000	1999	2000	1999	2000	1999	2000	1999	2000
Rural										
Interstate	435.5	437.9	0.0	0.0	292.0	308.9	917.6	916.1	1,645.1	1,662.9
Other Principal Arterial	1,552.8	1,560.5	434.5	441.5	1,162.9	1,148.5	228.1	226.3	3,378.3	3,376.8
Minor Arterial	287.9	286.8	31.7	32.2	320.9	320.8	9.1	10.1	649.6	649.9
Major Collector	571.7	559.9	71.3	65.2	313.1	346.5	153.8	155.1	1,109.9	1,126.7
Minor Collector	88.9	92.0	21.7	24.5	33.6	35.0	43.5	45.5	187.7	197.0
Local	442.3	563.6	78.4	100.2	224.4	286.6	96.4	123.5	841.5	1,073.9
Sub-Total	**3,379.1**	**3,500.7**	**637.6**	**663.6**	**2,346.9**	**2,446.3**	**1,448.5**	**1,476.6**	**7,812.1**	**8,087.2**
Urban										
Interstate	1,729.8	1,662.0	1,682.5	1,749.3	532.6	561.4	1,609.6	1,670.6	5,554.5	5,643.3
Other Freeway & Expressway	810.1	754.7	1,261.7	1,303.6	1,022.3	1,092.2	556.8	488.1	3,650.9	3,638.6
Other Principal Arterial	2,880.7	3,047.3	3,057.0	2,831.1	596.0	606.4	1,842.0	1,987.6	8,375.7	8,472.4
Minor Arterial	1,598.6	1,656.2	2,178.9	2,268.8	1,152.6	1,141.2	1,228.3	1,307.3	6,158.4	6,373.5
Collector	449.7	467.3	644.5	622.8	290.1	272.9	445.6	419.5	1,829.9	1,782.5
Local	1,149.4	1,082.6	1,322.4	1,244.8	526.6	495.5	783.7	897.6	3,782.1	3,720.5
Sub-Total	**8,618.3**	**8,670.1**	**10,147.0**	**10,020.4**	**4,120.2**	**4,169.6**	**6,466.0**	**6,770.7**	**29,351.5**	**29,630.8**
Total	**11,997.4**	**12,170.8**	**10,784.6**	**10,684.0**	**6,467.1**	**6,615.9**	**7,914.5**	**8,247.3**	**37,163.6**	**37,718.0**

Table 3. Pennsylvania's Daily HPMS VMT Estimates by Federal Functional Class (000s)

	Bucks		Chester		Delaware		Montgomery		Philadelphia		All PA Counties	
	1999	2000	1999	2000	1999	2000	1999	2000	1999	2000	1999	2000
Rural												
Interstate	269.8	278.9	395.8	407.2	0.0	0.0	284.6	293.8	0.0	0.0	950.2	979.9
Other Principal Arterial	1,096.9	1,112.8	1,295.6	1,297.2	80.1	80.0	756.6	755.7	0.0	0.0	3,229.2	3,245.7
Minor Arterial	486.9	486.2	580.8	602.5	0.0	0.0	229.2	243.0	0.0	0.0	1,296.9	1,331.7
Major Collector	264.1	261.9	681.0	658.9	32.4	5.7	117.3	118.5	0.0	0.0	1,094.8	1,045.0
Minor Collector	348.1	348.4	322.6	330.6	0.0	0.0	63.6	62.7	0.0	0.0	734.3	741.7
Local	338.1	337.0	582.1	577.8	52.6	52.6	266.5	266.1	0.0	0.0	1,239.3	1,233.5
Sub-Total	**2,803.9**	**2,825.2**	**3,857.9**	**3,874.2**	**165.1**	**138.3**	**1,717.8**	**1,739.8**	**0.0**	**0.0**	**8,544.7**	**8,577.5**
Urban												
Interstate	1,813.4	1,850.9	625.1	645.7	2,752.3	2,747.0	4,180.7	4,199.5	4,092.2	4,094.3	13,463.7	13,537.4
Other Freeway & Expressway	953.3	957.4	1,887.3	1,908.2	218.4	230.9	1,456.2	1,459.1	416.9	466.6	4,932.1	5,022.2
Other Principal Arterial	2,860.4	2,840.5	1,551.5	1,525.4	2,827.8	2,793.5	3,631.5	3,614.3	4,931.7	4,931.2	15,802.9	15,704.9
Minor Arterial	2,063.9	2,072.5	1,216.0	1,219.4	1,443.4	1,369.9	3,287.3	3,282.0	2,685.0	2,699.3	10,695.6	10,643.1
Collector	1,276.9	1,303.2	963.7	983.5	957.2	951.7	1,841.7	1,824.9	1,365.1	1,302.6	6,404.6	6,365.9
Local	1,072.4	1,077.0	760.9	764.5	1,091.2	1,090.4	1,752.5	1,746.5	1,715.7	1,683.6	6,392.7	6,362.0
Sub-Total	**10,040.3**	**10,101.5**	**7,004.5**	**7,046.7**	**9,290.3**	**9,183.4**	**16,149.9**	**16,126.3**	**15,206.6**	**15,177.6**	**57,691.6**	**57,635.5**
Total	**12,844.2**	**12,926.7**	**10,862.4**	**10,920.9**	**9,455.4**	**9,321.7**	**17,867.7**	**17,866.1**	**15,206.6**	**15,177.6**	**66,236.3**	**66,213.0**

DVRPC’s Regional Travel Simulation Models

DVRPC also computes VMT within the region based on its travel simulation models. In addition to simulating existing conditions, these models are used to forecast future travel patterns, as well as quantify the effects of various transportation projects and policies. They rely on demographic and employment data, land use, and transportation network characteristics to simulate trip making patterns throughout the region.

DVRPC recently completed a multi-year effort to update and enhance its travel simulation models. The 1999 and 2000 VMT estimates in this memo are the first simulated estimates produced by the enhanced model. Prior memos documenting simulated VMT estimates relied on a previous version of the travel simulation models and are not directly comparable to those in this memo.

Travel simulation models require extensive socioeconomic and demographic data, including population, employment, household size, auto ownership, and other household characteristics. They also require a detailed geographical distribution of households and jobs. Current data is tabulated from the US Census and other sources and is generally updated every 3-5 years. The most recent year for which this data are available at the necessary geographic level is 1997. While 2000 Census population estimates have been released, other necessary Census data (including employment by sector, auto ownership, etc) will not be released until 2003. Consequently, simulated VMT estimates for 1999 and 2000 are interpolated between 1997 and 2025 model runs. Model inputs for 2025 are projected by DVRPC, as part of its long-range planning process.

Socioeconomic Projections

DVRPC's long-range population and employment forecasts are revised periodically to reflect changing market trends, development patterns, local and national economic conditions, and available data. The completed forecasts reflect all reasonably known current information and the best professional judgment of predicted future conditions. The revised forecasts adopted by the DVRPC Board on February 28, 2002 reflect an update to municipal forecasts that were last completed in February 2000. Table 4 displays the updated socioecomonic forecasts at the county level for the Delaware Valley region.

DVRPC uses a multi-step, multi-source methodology to produce its population and employment forecasts at the county-level. County forecasts serve as control totals for municipal forecasts, which are disaggregated from county totals. Municipal forecasts are based on an analysis of historical data trends adjusted to account for infrastructure availability, environmental constraints to development, local zoning policy, and development proposals. Municipal forecasts are constrained using density ceilings and floors. County, and where necessary, municipal input is used throughout the process to derive the most likely population and employment forecasts for all geographic levels.

Table 4. Regional Population and Employment Estimates

	Population					Employment			
	DVRPC 1997	CENSUS 2000	DVRPC 2025	1997 - 2025 Growth Absolute	Percent	DVRPC 1997	DVRPC 2025	1997 - 2025 Growth Absolute	Percent
New Jersey									
Burlington	419,142	423,394	513,450	94,308	22.5%	201,144	250,550	49,406	24.6%
Camden	509,149	508,932	513,530	4,381	0.9%	230,778	264,160	33,382	14.5%
Gloucester	246,215	254,673	322,520	76,305	31.0%	97,868	122,650	24,782	25.3%
Mercer	335,034	350,761	404,850	69,816	20.8%	230,275	269,900	39,625	17.2%
Sub-Total	**1,509,540**	**1,537,760**	**1,754,350**	**244,810**	**16.2%**	**760,065**	**907,260**	**147,195**	**19.4%**
Pennsylvania									
Bucks	586,790	597,635	748,120	161,330	27.5%	264,010	338,310	74,300	28.1%
Chester	418,035	433,501	550,160	132,125	31.6%	224,178	289,000	64,822	28.9%
Delaware	547,843	550,864	547,784	-59	0.0%	234,406	269,890	35,484	15.1%
Montgomery	713,971	750,097	857,030	143,059	20.0%	485,435	567,700	82,265	16.9%
Philadelphia	1,555,000	1,517,550	1,500,000	-55,000	-3.5%	786,015	840,250	54,235	6.9%
Sub-Total	**3,821,639**	**3,849,647**	**4,203,094**	381,455	10.0%	**1,994,044**	**2,305,150**	311,106	15.6%
REGION TOTAL	**5,331,179**	**5,387,407**	**5,957,444**	**626,265**	**11.7%**	**2,754,109**	**3,212,410**	**458,301**	**16.6%**

Population forecasting at the regional level involves review and analysis of six major components: births, deaths, domestic in-migration, domestic out-migration, international immigration, and changes in group quarters populations (e.g. dormitories, military barracks, prisons, and nursing homes). DVRPC uses both the cohort survival concept to age individuals from one age group to the next, and a modified Markov transition probability model based on the most recent US Census and the US Census' recent Current Population Survey (CPS) research to determine the flow of individuals between the Delaware Valley and the outside world. For movement within the region, Census and IRS migration data coupled with CPS data are used to determine migration rates between counties. DVRPC relies on county planning offices to provide information on any known, expected, or forecasted changes in group quarters populations. These major population components are then aggregated and the resulting population forecasts are reviewed by member counties for final adjustments based on local knowledge.

Employment is influenced by local, national, and global political and socio-economic factors. The Bureau of Economic Analysis provides the most complete and consistent time series data on county employment by sector, and serves as DVRPC's primary data source for employment forecasting. Employment sectors include mining, agriculture, construction, manufacturing, transportation, wholesale, retail, finance/insurance, service, government, and military. Other supplemental sources of data include the U.S. Census, Dun & Bradstreet, Bureau of Labor Statistics, Occupational Privilege tax data, and other public and private sector forecasts. The OBERS shift-share model in combination with the Woods and Poole Economics' sectoral forecasts provides the basis for DVRPC's employment forecasts. As in the population forecasts, county level total employment is used as a control total for sector distribution and municipal level forecasts. Forecasts are then reviewed by member counties for final adjustments based on local knowledge.

DVRPC’s Travel Simulation Process

DVRPC's travel models follow the traditional steps of trip generation, trip distribution, modal split, and traffic assignment. However, an iterative feedback loop is employed from traffic assignment to the trip distribution step. The feedback loop ensures that the congestion levels used by the models when determining trip origins and destinations are equivalent to those that result from the traffic assignment step. Additionally, the iterative model structure allows trip making patterns to change in response to changes in traffic patterns, congestion levels, and improvements to the transportation system.

The DVRPC travel simulation process uses the Evans Algorithm to iterate the model. Evans re-executes the trip distribution and modal split models based on updated highway speeds after each iteration of highway assignment and assigns a weight to each iteration. This weight is then used to prepare a convex combination of the link volumes and trip tables for the current iteration and a running weighted average of the previous iterations. This algorithm converges rapidly to the equilibrium solution on highway travel speeds and congestion levels.

DVRPC's enhanced travel simulation model is disaggregated into separate peak period, midday, and evening time periods. This disaggregation begins in trip generation where factors are used to separate daily trips into peak and midday travel. Evening travel is then defined as the residual after peak and midday travel are removed from daily travel. The enhanced process utilizes completely separate model chains for peak, midday, and evening travel simulation runs. The peak period (combined AM and PM) is defined as 7:00 AM to 9:00 AM and 3:00 PM to 6:00 PM, midday is defined as 9:00 AM to 3:00 PM and evening as 6:00 PM to7:00 AM. Inputs sensitive to time of day such as highway capacities and transit service levels are disaggregated to be reflective of time-period specific conditions.

The first step in the process involves generating the number of trips that are produced by and destined for each traffic zone and cordon station throughout the nine-county region. Traffic analysis zones generally follow Census boundaries and vary in size from Block-Groups to Tracts. Cordon stations represent locations where a major highway facility crosses the region's outer boundary.

Trip Generation. Both internal trips (those made within the DVRPC region) and external trips (those which cross the boundary of the region) must be considered in the simulation of regional travel. Internal trip generation is based on zonal forecasts of population and employment, whereas external trips are estimated from cordon line traffic counts. The latter also include trips which pass through the Delaware Valley region. Estimates of internal trip productions and attractions by zone are established on the basis of trip rates applied to the zonal estimates of demographic and employment data.

Evans Iterations. The iterative portion of the Evans Algorithm involves updating the highway network restrained link travel speeds, rebuilding the minimum time paths through the network, and skimming the inter-zonal travel time for the minimum paths. Then the trip distribution, modal split, and highway assignment models are executed in sequence for each pass through the model chain

Trip Distribution. Trip distribution is the process whereby the zonal trip ends established in the trip generation analysis are linked together to form origin-destination patterns in the trip table format. Peak, midday, and evening trip ends are distributed separately. For each Evans iteration, a series of seven gravity-type distribution models are applied at the zonal level for each time period. These models follow the trip purpose and vehicle type stratifications established in trip generation.

Modal Split. The modal split model is also run separately for the peak, midday, and evening time periods. The modal split model calculates the fraction of each person-trip interchange in the trip table which should be allocated to transit, and then assigns the residual to highway. The choice between highway and transit usage is made on the basis of comparative cost, travel time, and frequency of service, with other aspects of modal choice being used to modify this basic relationship. In general, the better the transit service, the higher the fraction assigned to transit, although trip purpose and auto ownership also affect the allocation.

Highway Assignment. The final step in the iterative simulation process is the assignment of vehicle trips to the highway network. For peak, midday, and evening travel, this assignment model produces traffic volumes for individual highway links that are required for planning analyses.

For each Evans iteration, highway trips are assigned to the network by determining the best (minimum time) route through the highway network for each zonal interchange and then allocating the interzonal highway travel to the highway facilities along that route. This assignment model is "capacity restrained" in that congestion levels are considered when determining the best route. The Evans equilibrium assignment method is used to implement the capacity restraint. When the assignment and associated trip table reach equilibrium, no path faster than the one actually assigned can be found through the network, given the capacity restrained travel times on each link.

Simulated VMT Estimates

VMT estimates are directly output from the highway traffic assignment step of the simulation models. These values are then adjusted to account for local streets that are not included in the simulation models' highway network. Estimates of 1999 and 2000 VMT from DVRPC's travel simulation models are provided in Table 5.

According to the simulation models, regional daily VMT is just over 106 million miles per day. Like the HPMS estimates, the simulated VMT also exhibits a 64 percent / 36 percent split between Pennsylvania and New Jersey. Again, like the HPMS estimates, the simulation models show that Montgomery County is the most heavily traveled and Gloucester County is the least traveled.

The simulated VMT show a 1.3 and 0.9 percent increase in the New Jersey and Pennsylvania portions of the region, respectively. In New Jersey, growth rates ranged from 0.3 percent in Camden County to 2.1 percent in Mercer County. Mercer County also had the highest absolute growth in VMT, increasing by 178,900 vehicle miles per day. Burlington County had an almost identical growth at 177,200 miles per day.

On the Pennsylvania side, Philadelphia grew by just 0.3 percent, while Chester County exhibited the highest growth rate at 1.4 percent. Bucks County had the highest absolute growth at 176,900 vehicle miles per day. Montgomery and Chester counties also had similar growth at 166,900 and 161,300 miles per day, respectively.

Table 5. Daily VMT Estimates from DVRPC's Travel Simulation Models

	Daily VMT (000s)		1999 - 2000 Growth	
	1999	2000	Absolute	Percent
New Jersey				
Burlington	11,684.8	11,862.0	177.2	1.5%
Camden	10,802.8	10,836.8	34.0	0.3%
Gloucester	6,727.0	6,839.4	112.4	1.7%
Mercer	8,692.2	8,871.1	178.9	2.1%
Sub-Total	**37,906.8**	**38,409.3**	**502.5**	**1.3%**
Pennsylvania				
Bucks	13,168.4	13,345.3	176.9	1.3%
Chester	11,808.8	11,970.1	161.3	1.4%
Delaware	9,066.7	9,128.6	61.9	0.7%
Montgomery	18,305.6	18,472.5	166.9	0.9%
Philadelphia	14,630.2	14,677.6	47.4	0.3%
Sub-Total	**66,979.7**	**67,594.1**	**614.4**	**0.9%**
REGION TOTAL	**104,886.5**	**106,003.4**	**1,116.9**	**1.1%**

III. COMPARISON OF VMT DATA

Table 6 displays a comparison of the VMT estimates derived from the two methods. As the table indicates, the difference between VMT estimates for the Delaware Valley Region based on the state HPMS data and the DVRPC travel simulation models is very small, with the simulated estimates only 2.0 percent higher than the HPMS estimates. In the New Jersey Portion of the region this difference is 1.8 percent, while in Pennsylvania it is 2.1 percent.

In Pennsylvania, the differences among individual counties range from -3.3 percent in Philadelphia County to 9.6 percent in Chester County. In New Jersey, these differences range from -2.5 percent in Burlington County to 7.6 percent in Mercer County.

Both the simulated and HPMS VMT estimates have a 64 percent/36 percent distribution of travel between the Pennsylvania and New Jersey portions of the region. Furthermore, the distribution of travel among the individual counties is also similar. Gloucester County, which has the least VMT in the region, accounts for 6.4 percent of the HPMS total and 6.5 percent of the simulated VMT total for the region. Montgomery County, which has the highest share of VMT, accounts for 17.2 percent of the regional HPMS and 17.4 percent of the simulated VMT. The largest difference occurs in Chester County, with 11.3 percent of regional simulated VMT, but only 10.5 percent of the HPMS total.

For most counties, the simulated daily VMT estimates are larger than those derived from HPMS data. Only Burlington, Delaware, and Philadelphia counties exhibit HPMS estimates that are greater than the simulated VMT estimates.

Table 6. Comparison of 2000 Daily VMT Estimates (000s)

	HPMS	DVRPC Simulation	Difference Absolute	Difference Percent
New Jersey				
Burlington	12,170.9	11,862.0	-308.9	-2.5%
Camden	10,684.0	10,836.8	152.8	1.4%
Gloucester	6,615.8	6,839.4	223.6	3.4%
Mercer	8,247.4	8,871.1	623.7	7.6%
Sub-Total	**37,718.1**	**38,409.3**	**691.2**	**1.8%**
Pennsylvania				
Bucks	12,926.8	13,345.3	418.5	3.2%
Chester	10,920.8	11,970.1	1,049.3	9.6%
Delaware	9,321.6	9,128.6	-193.0	-2.1%
Montgomery	17,866.0	18,472.5	606.5	3.4%
Philadelphia	15,177.5	14,677.6	-499.9	-3.3%
Sub-Total	**66,212.7**	**67,594.1**	**1,381.4**	**2.1%**
REGION TOTAL	**103,930.8**	**106,003.4**	**2,072.6**	**2.0%**

IV. CONCLUSIONS

According to the HPMS data, VMT in the Delaware Valley region during 2000 averaged just under 104 million vehicle miles per day. This is an increase of about 0.5 percent or 530,000 vehicle miles from 1999. The five Pennsylvania counties account for nearly two-thirds of the regional VMT total.

The majority of VMT in the region occurred in urban areas; just over 15 percent of the total VMT occurred in rural areas of the region. In New Jersey, VMT in Camden County has decreased from 1999. The other counties grew at 1.4 to 4.2 percent from 1999 to 2000. In Pennsylvania, Bucks and Chester counties are growing the fastest, although their growth rates were only 0.5 to 0.6 percent. Delaware and Philadelphia VMT declined from 1999 to 2000. Overall, Pennsylvania VMT declined by less than 0.1 percent; New Jersey VMT grew by 1.5 percent from 1999 to 2000.

VMT derived from DVRPC's travel simulation models display similar trends. These models estimate regional VMT at just over 106 million vehicle miles for 2000, an increase of about 1.1 million vehicle miles or 1.1 percent from 1999 levels. Simulated VMT in Pennsylvania grew by 0.9 percent from 1999 to 2000, while in New Jersey it grew by 1.3 percent.

Based on DVRPC traffic counts, the average annual growth rate in vehicle counts during the period 1995 - 2000 was about 1.4 percent. It seems that the growth rate has slowed from 1.4 percent per year during the late 1990s to about 1.1 percent from 1999 to 2000.

The differences between simulated VMT and VMT derived from HPMS are generally small. Only two of nine counties show differences greater than four percent. In most areas of the region, the simulated VMT is higher than the HPMS estimate.

The differences in growth rates between the HPMS and simulated VMT estimates are not large. In Pennsylvania, the HPMS growth rate is essentially zero while the simulated growth rate is 0.9 percent. This difference is largely attributable to Delaware County, which exhibits a significant decrease in VMT estimated from the HPMS, but shows a 0.7 percent increase in simulated VMT. On the New Jersey side, both the HPMS and simulated VMT show similar increases from 1999 to 2000 at 1.5 and 1.3 percent, respectively.

Simulated VMT estimates are within two percent of the HPMS estimates. Both the simulated and HPMS VMT estimates have a similar distribution of travel between the Pennsylvania and New Jersey portions of the region. The two sources also exhibit considerable agreement at the county-level. The good agreement between the model output and observed conditions makes it a robust and useful tool to evaluate proposed air-quality and transportation programs.