# HIGHWAY SOURCE EMISSIONS INVENTORY

*A 1988 inventory of the highway sources of pollutant emissions in the Pennsylvania and Maryland portions of the Philadelphia Nonattainment Area for Ozone*

January 1993 Delaware Valley Regional Planning Commission

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January 1993

Delaware Valley Regional Planning Commission
The Bourse Building
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# DELAWARE VALLEY REGIONAL PLANNING COMMISSION

## Publication Abstract

| TITLE | Date Published: January 1993 |
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| HIGHWAY SOURCE EMISSIONS INVENTORY | |
| *A 1988 inventory of the highway sources of pollutant emissions in the Pennsylvania and Maryland portions of the Philadelphia Nonattainment Area for Ozone* | Publication No. 93009 |

### Geographic Area Covered:

The five counties within the Pennsylvania portion of the region—Bucks, Chester, Delaware, Montgomery, and Philadelphia—and Cecil County, Maryland.


### Key Words:

Air Quality, Emissions Inventory, Mobile Sources, Clean Air Act Amendments of 1990, MOBILE4.1


## ABSTRACT


The purpose of this report is to quantify emissions from highway sources (cars and trucks) within the Pennsylvania and Maryland portions of the Philadelphia Nonattainment Area for Ozone on a typical summer weekday in 1988. Levels of non-methane hydrocarbons, carbon monoxide, and oxides of nitrogen are estimated for 5×5 kilometer grid cells, as well as at county and state levels. The study methodology was based on UTPS, a traffic simulation model which estimates traffic volumes, and MOBILE4.1, a computer-based model for developing emissions factors.


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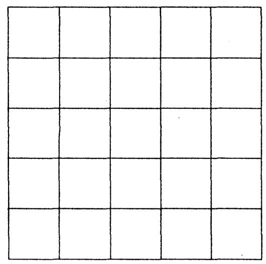
DELAWARE VALLEY REGIONAL PLANNING COMMISSION

*Executive Summary*

# HIGHWAY SOURCE EMISSIONS INVENTORY

***A 1988 inventory of the highway sources of pollutant emissions in the Pennsylvania and Maryland portions of the Philadelphia Nonattainment Area for Ozone***



## INTRODUCTION

The Clean Air Act Amendments of 1990 require severe ozone nonattainment areas, such as Philadelphia, to conduct current, comprehensive and accurate inventories of all sources of emissions. This study documents an inventory of carbon monoxide (CO), oxides of nitrogen ($NO_x$) and non-methane hydrocarbon (NMHC) emissions resulting from highway sources (i.e., cars and trucks) in the Pennsylvania and Maryland portions of the Philadelphia Nonattainment Area (NAA) on a typical summer weekday in 1988. The area covered in the inventory includes Bucks, Chester, Delaware, Montgomery, and Philadelphia counties in Pennsylvania and Cecil County in Maryland.

The results of this study are ultimately to be combined with emissions estimates from other sources to calibrate the Urban Airshed Model (UAM). The UAM relates the level of emissions to the resulting exceedances of the ozone standard. UAM can be used to determine the emissions reductions which will be required to reduce exceedances in the Philadelphia NAA to an average of one per year—the standard for ozone. Calendar year 1988 is appropriate for this purpose because the hot, sunny summer that year resulted in many ozone violations.

The UAM requires that emissions be quantified in cells measuring $5 \times 5$ kilometers. These cells are set by coordinates of the Universal Transverse Mercator (UTM) system. Portions of the "modelling domain" used in the Philadelphia area overlap with those of the Baltimore and New York regions. Combining emissions inventories of these regions may be used to study the interactive effects of emissions throughout the Northeast Corridor.

## ESTIMATION PROCESS

Estimates of highway source emissions are based on measures of vehicle travel and emissions factors. These elements are derived independently of one another and are then combined to produce emissions estimates.

Travel data is expressed in terms of vehicle miles of travel (VMT) and the speeds at which the travel occurs. In Pennsylvania, a travel simulation model, the Urban Transportation Planning System (UTPS), is employed to estimate the traffic volumes and speeds on each of some 20,000 roadway segments in the nine-county DVRPC area. The resulting volumes are then multiplied by the link length to obtain vehicle miles of travel. VMT on links in the highway system is then allocated to grid cell and summed. VMT and speed estimates are differentiated by the following functional classifications of highway facilities: freeway, arterial, and local.

About 12% of travel in the Pennsylvania counties occurs off the simulation network on local roads. For this study, estimates of off-network travel is based on the number of off-network route-miles and available traffic counts.

In Cecil County, traffic volumes are estimated on the basis of current traffic counts recorded by the Maryland State Highway Administration. Speeds are estimated for several classes of roads. Allocation of VMT and speeds to grid cell is performed manually.

VMT and speed estimates for Pennsylvania and Cecil County are merged into a single file for the six county study area. Within each 5×5 kilometer grid cell, travel estimates are accounted for separately by functional classification. For 1988, the seasonally adjusted daily VMT is estimated as follows:

**1988 Average Summer Daily VMT (millions)**

| *Facility type* | *Pennsylvania* | *Cecil Co.* |
|---|---|---|
| Freeway | 14.9 | 0.9 |
| Arterial | 33.4 | 1.3 |
| Local | 11.1 | 0.4 |

The next step in the process is the estimation of "emissions factors" which embody salient local mobile source parameters. Emissions factors are generated by the EPA model "MOBILE" of which Version 4.1, the most recent, was used in this study. Inputs to MOBILE4.1, which may be differentiated by state or county, include the volatility of gasoline sold locally, the age of the vehicle fleet, the parameters of the state inspection and maintenance program, and minimum and maximum summer temperatures. MOBILE-4.1 produces a series of emission rates at each mile per hour of speed for a composite of all vehicles. Emissions factors at the regional average speed of 20 mph are:

**1988 Composite Emissions Factors at the Regional Average Speed (grams/mile)**

| *Pollutant* | *Pennsylvania* | *Cecil Co.* |
|---|---|---|
| Carbon monoxide | 31.43 | 35.26 |
| Non-methane hydrocarbons | 5.21 | 5.10 |
| Oxides of nitrogen | 2.66 | 2.80 |

In the final part of this process, an emissions processor produced by DVRPC applies the emissions factors to the travel data and produces emissions for each grid cell, in addition to county and state summaries. MOBILE4.1 inputs can be varied within the processor to examine some alternatives. In addition, seasonal adjustment factors for each of the three classes of highways can be altered.

The emissions data file can be formatted as input for the UAM as well as the geographic information mapping system maintained by DVRPC. Maps may be produced which will graphically portray the existing conditions and the effect of various changes in MOBILE4.1 parameters.

## EMISSIONS RESULTS

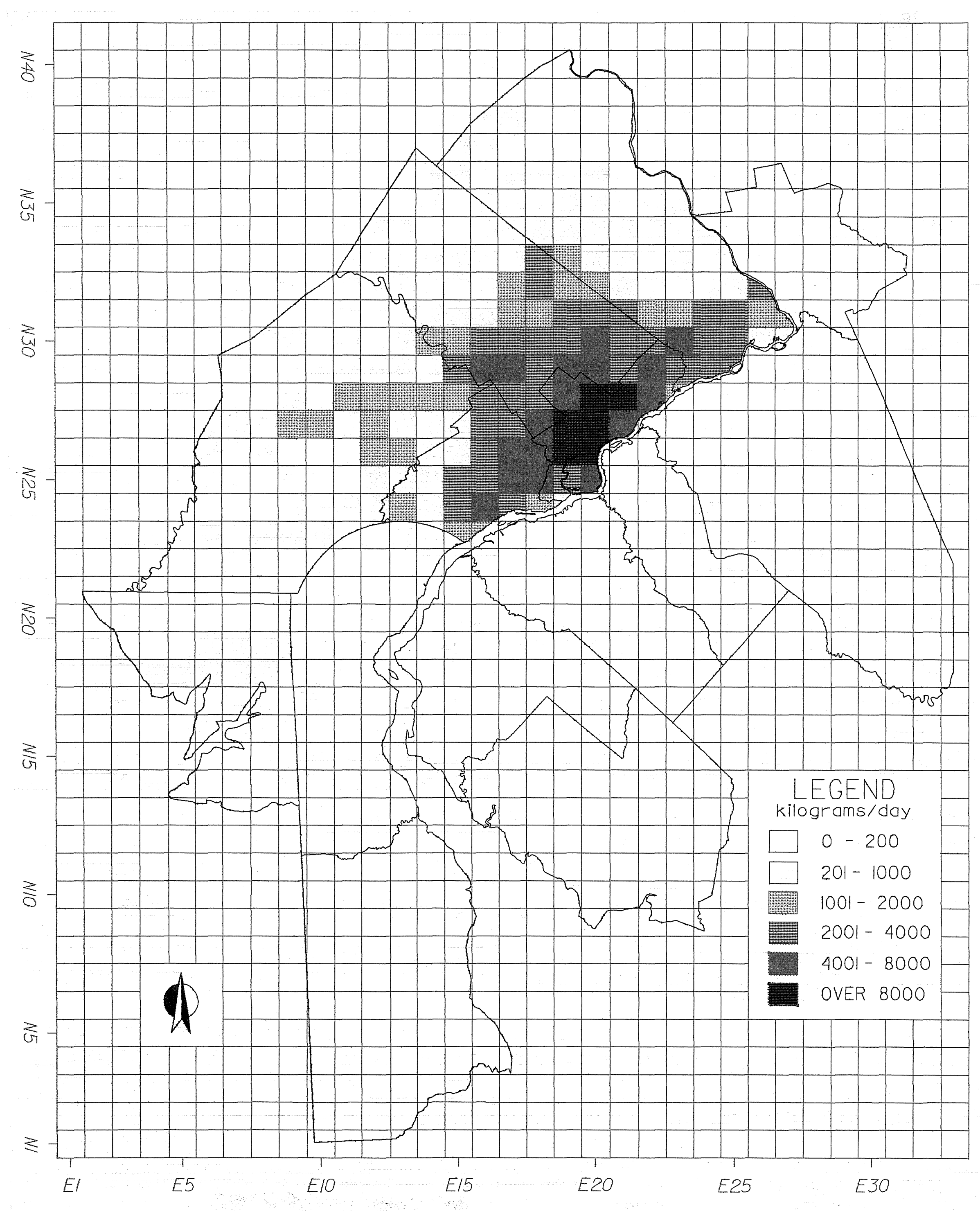
The emissions processor yields the following results for a typical summer day in 1988:

**1988 Average Summer Highway Source Emissions (kilograms/day)**

| *Pollutant* | *Pennsylvania* | *Cecil Co.* |
|---|---|---|
| Carbon monoxide | 1,938,000 | 58,000 |
| Non-methane hydrocarbons | 323,000 | 8,000 |
| Oxides of nitrogen | 162,000 | 8,000 |

Levels of non-methane hydrocarbons (NMHC) are of particular interest because they are precursors to the formation of ozone. Highway sources may contribute up to one-half of the total emissions of NMHC. Figure 1 (Page 3) depicts the distribution of highway source non-methane hydrocarbons by UTM grid cell.

**Figure 1: Areal Distribution of 1988 Highway Source Non-methane Hydrocarbon Emissions**



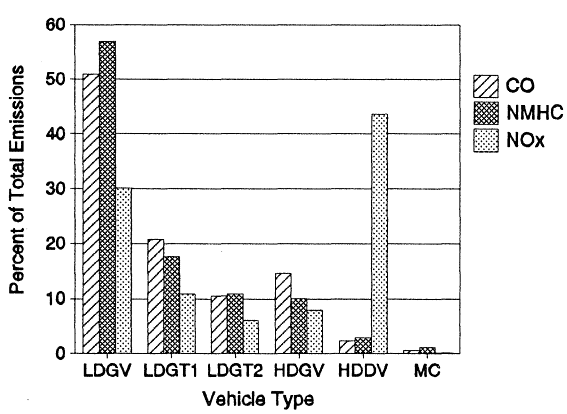

*Prepared by the Delaware Valley Regional Planning Commission*

Cells are differentiated by six categories of concentrations of NMHCs. These categories do not necessarily pinpoint violations of the national ozone standard. Ozone may be formed at a point distant from the emission of its precursors.

The inventory indicates that highway source emissions by cell vary greatly depending upon the amount of traffic and its speed. The highest emissions come from the dense urban core of Philadelphia, where streets are closely spaced, traffic volumes are high, and speeds are low.

The preponderant source of emissions is cars (i.e., light duty gasoline vehicles) (Figure 2). They account for approximately half of highway source NMHCs and CO. For $NO_x$, which is also a precursor to ozone, large trucks contribute the most of any type of vehicle, in excess of 40%.

**Figure 2: Highway Source Emissions by Vehicle Type**

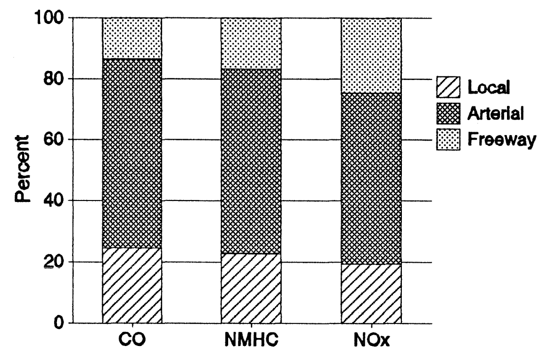



LDGV: Light-Duty Gasoline Vehicle
LDGT1: Light-Duty Gasoline Truck under 6000 lbs
LDGT2: Light-Duty Gasoline Truck 6000 lbs to 8000 lbs
HDGV: Heavy-Duty Gasoline Vehicle
HDDV: Heavy-Duty Diesel Vehicle
MC: Motorcycle

*Prepared by DVRPC*

Most emissions occur on the region's arterial facilities (Figure 3). Arterials carry the most traffic in the region (56%) and average operating speeds are low. Speeds and emissions are essentially inversely related, and are particularly sensitive under 20 mph, which is typical of local arterial travel.

**Figure 3: Shares of Highway Source Emissions by Functional Class**




*Prepared by DVRPC*

Improving air quality in the Philadelphia NAA will rely in part on reducing highway source emissions. Reductions can be achieved through improvements to transportation facilities or changes in travel patterns. This inventory, and future ones, provide valuable information about the nature of highway source emissions including the point of origin and source. The information is particularly useful in formulating effective transportation control measures. □

DELAWARE VALLEY
REGIONAL PLANNING COMMISSION

This report was written by the Delaware Valley Regional Planning Commission under contract to the Pennsylvania Department of Environmental Resources with funds provided by the United States Environmental Protection Agency.

# 1 INTRODUCTION

The purpose of this study is to produce a 1988 highway source emissions inventory for the Maryland and Pennsylvania portions of the Philadelphia ozone nonattainment area. The study will furnish estimates of the amount of non-methane hydrocarbons, carbon monoxide, and oxides of nitrogen produced by vehicular traffic on a typical summer weekday according to the relevant prevailing conditions of 1988. Emissions will be estimated for 5×5 kilometer grid cells (coinciding with Universal Transverse Mercator grid coordinates) within the study area and aggregated at county and state levels. The study will also lead to the development of analytic tools for testing the impacts of various transportation policies and scenarios on air quality.

The area covered in the 1988 inventory includes six counties in two states: Bucks, Chester, Delaware, Montgomery, and Philadelphia in Pennsylvania and Cecil in Maryland (Figure 4). Emissions occurring in the remaining counties within the Philadelphia nonattainment area (i.e., those in New Jersey and Delaware) are not estimated.

Emissions inventories represent an integral element of the Clean Air Act Amendments of 1990 (CAAA). Inventories are designed to establish benchmarks of emissions and to permit the testing of various initiatives and alternatives which may lead to improvements in air quality and, ultimately, attainment of the national ambient air quality standards. Due to the transport of ozone resulting from mobile and stationary source emissions, emissions inventories will also be employed to analyze air quality in adjacent regions of the northeastern United States.

The succeeding text of this report is divided into five sections. Chapter 2 describes the process used to conduct the emissions inventory. Chapter 3 details the methods used to estimate vehicle miles of travel and speeds on roadways in Cecil County and Pennsylvania. Air quality parameters for highway sources of emissions, expressed as emissions factors, are discussed in Chapter 4. Chapter 5 provides estimates of highway source emissions and a discussion of the results and the emissions processor developed in conjunction with this study. Finally, the appendices located in the back of the report contain detailed study data such as highway source emissions estimates by grid cell.

The methodology employed for the 1988 emissions inventory is consistent with the stipulations of the CAAA for highway source inventories. According to the CAAA and available technical guidance, highway source emissions inventories are subject to the following guidelines:

- perform for severe ozone nonattainment areas such as Philadelphia
- perform comprehensive, current, and accurate inventories
- adjust for the peak ozone season
- perform in format appropriate for the Urban Airshed Model
- perform with the most current available version of MOBILE, the mobile source emissions estimation model

The emissions estimated in this study are largely derived through computer modelling. Traffic volumes and speeds are primarily obtained from DVRPC's Urban Transportation Planning System, a traffic simulation model which incorporates the four traditional steps of transportation planning. MOBILE4.1, a highway source emissions model promulgated by the Environmental Protection Agency, is employed to calculate emissions factors for application to vehicle volume and speed estimates.

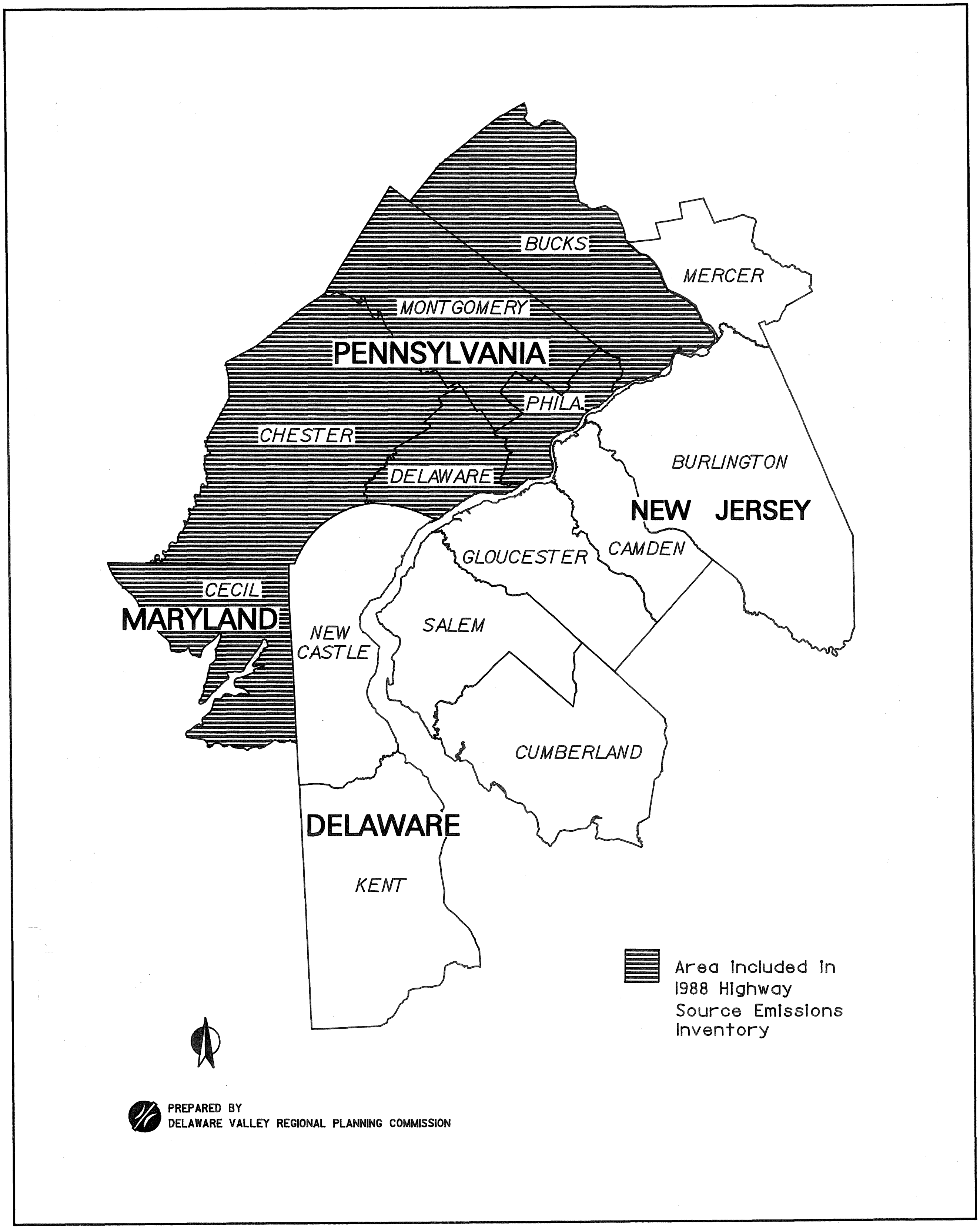
According to the CAAA, a baseline inventory for 1990 and for several milestone years will be required for mobile and stationary sources of emissions. The 1990 baseline inventory will form part of the revisions to the state implementation plans of New Jersey and Pennsylvania.

The study area contains 3.8 million persons and approximately two million jobs. Philadelphia and its immediate suburbs are the most densely developed portions of the region, although the core urban area has become more dispersed over recent decades. Travel trends indicate trips in the region are increasing in both frequency and length, with the greatest gains in the suburbs. Auto is the predominant form of travel, and average vehicle occupancy region-wide stands at 1.4 persons.

This study was performed by the Delaware Valley Regional Planning Commission (DVRPC) for the Pennsylvania Department of Environmental Resources (PennDER). Due to the multi-jurisdictional nature of the study area, efforts were made to coordinate the study with appropriate federal, state, and local transportation and environmental professionals. This level of coordination is consistent with the spirit of the CAAA which encourages the coordination of transportation-air quality planning activities in multi-state nonattainment areas.

DVRPC, the metropolitan planning organization (MPO) for the Philadelphia region, has historically performed many planning activities which link transportation and air quality issues. Its ongoing role in the transportation-air quality process largely owes to DVRPC's special expertise in transportation modelling and planning. In 1982, during the previous cycle of intensified transportation-air quality planning, DVRPC completed an emissions inventory comparable to the current effort. In that study, *Delaware Valley Highway Vehicle Emissions Inventory*, quantities of six pollutant categories were estimated for 1979 and 1980 and forecasted to 1987. □

**Figure 4: Philadelphia Ozone Nonattainment Area**



# 2 OVERVIEW OF THE EMISSIONS INVENTORY PROCESS

## Emissions Inventory of All Sources

The emissions estimated in this report represent only a part of the comprehensive inventory required by the Clean Air Act Amendments of 1990 (CAAA). This inventory includes only non-methane hydrocarbons, carbon monoxide and oxides of nitrogen produced by automobiles, trucks, taxis, and motorcycles travelling on the region's roadway system. The estimation of emissions from other mobile, area, biogenic, and point sources are not included.

Other mobile sources of pollution include aircraft, railroads, marine vessels, snowmobiles and off-road motor bikes. These mobile sources, as well as area sources, are estimated by surrogates, using population or other measures which best represent their geographic distribution. Area sources of pollution are those which are generally associated with the distribution of residences, examples of which include certain paints, home barbecues, lawn mowers, and dry-cleaning operations. Point sources are large emitters whose specific location is known, usually industrial facilities. Permitting procedures which are a part of the CAAA will help to locate and characterize point sources. Lastly, biogenic sources are naturally occurring sources such as plants.

This inventory of highway source emissions will be combined with those from New Jersey and Delaware and with inventories of other mobile, stationary and biogenic sources to produce a comprehensive accounting of total emissions in the Philadelphia nonattainment area. The combined inventory will be entered into the Urban Airshed Model for the purpose of determining the emissions reduction required to attain the national ambient air quality standard for ozone.

It is important to remember that the highway source non-methane hydrocarbons (NMHCs) which are tabulated and mapped in this report account for one third to one half of total NMHC emissions. Within a given five-kilometer grid cell, the portion of total emissions attributable to highway sources may vary significantly depending upon the nature of the stationary and other mobile sources also found in the cell.

## Highway Source Emissions Inventory

The basis for an inventory of highway source emissions is the estimation of link traffic volumes and speeds. In the Pennsylvania counties included in this inventory, these data were obtained from the DVRPC travel simulation model. The model is based upon the federally-sponsored Urban Transportation Planning System (UTPS). In 1985, this forecasting process was recalibrated and validated based on data from the 1980 Census and on traffic counts taken along a series of screenlines. For an air quality analysis, daily highway link traffic volumes and speeds are the primary outputs of the model.

EPA's MOBILE4.1 model was used to prepare emissions factors (grams per mile of vehicle travel) representative of a composite of traffic found on the region's freeways, arterials and local streets.

Emissions factors vary significantly with the speed of travel. The MOBILE model's meteorological parameters were set to reflect conditions in Pennsylvania or Cecil County on a hot summer day. Basically, emissions were calculated by multiplying vehicle miles of travel (simulated traffic volumes times link length) by the appropriate emissions factor for the prevailing speed of travel. The process of estimating emissions from highway sources is briefly depicted in Figure 5, *Overview of Procedures*. In the description of the process which follows, reference is made to the numbered steps in the figure.

The emissions inventory for the Pennsylvania counties was based on a 1987 travel simulation for the Delaware Valley Region. The regional simulation [1] uses population and employment data to generate trips which are distributed on the basis of the spatial location of trip attractions and the time and cost of travel. Trips are split into transit and auto trips according to the relative service levels provided by each mode. Ultimately, the highway trips are assigned to the highway links in the system. The model predicts average annual daily volumes of traffic on each link, based on simulated travel patterns and the capacity of the highway. The simulated volume-to-capacity ratio is then used to estimate speed. These volumes and speeds are then aggregated to grid cell for each of three functional classes of highways [2].

DVRPC's travel simulation does not include low-volume local roads. Total travel on these links has been estimated at the county level of detail. These volumes are assigned to specific grid cells in proportion to the simulated volume of travel on arterials and local roads (i.e., non-freeway links) included in the simulation [3].

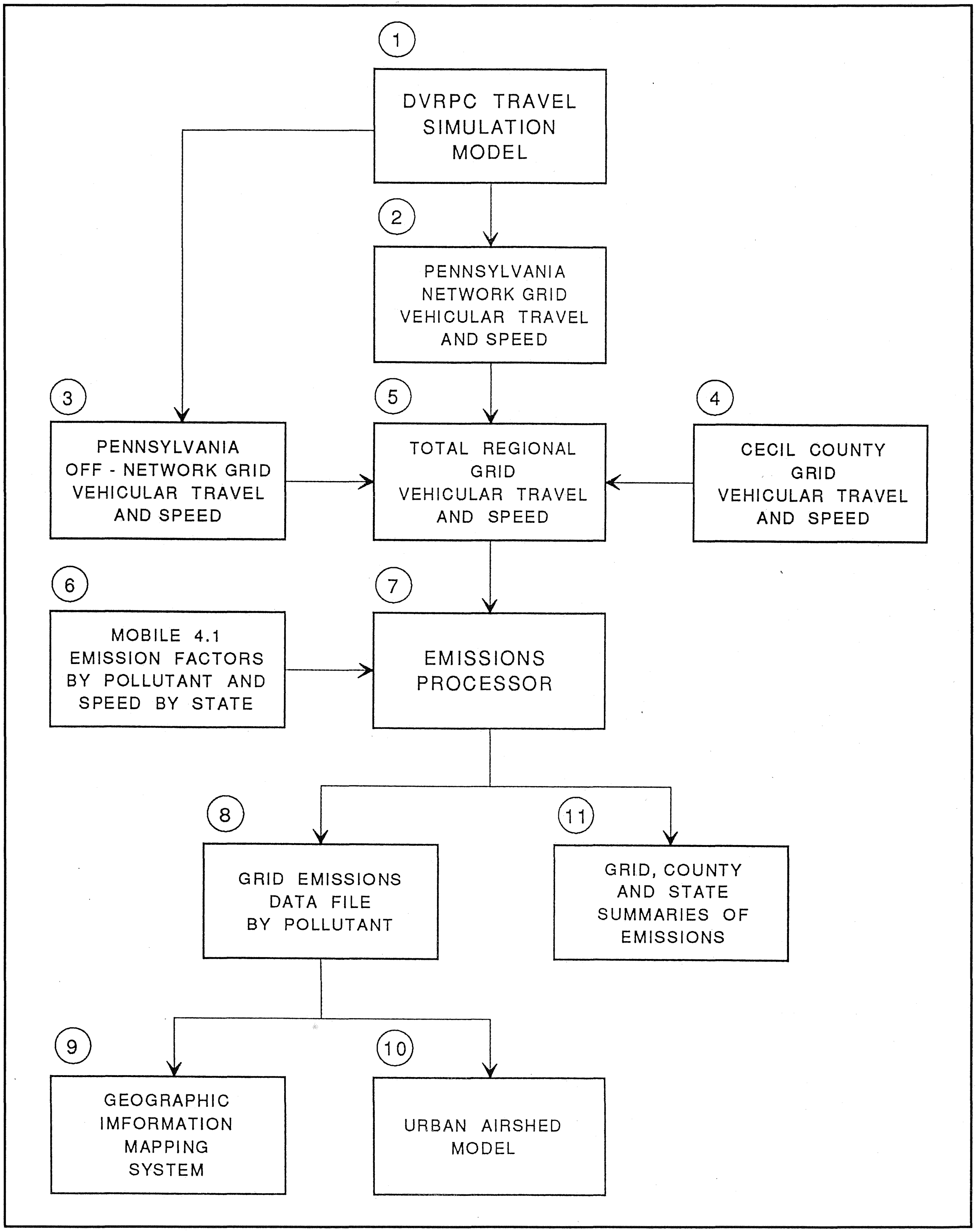
In Cecil County, Maryland, 1987 vehicular volumes were based on traffic counts [4], since there is no simulation model available. Speeds are estimated, as are traffic volumes, where no counts were available. In both Pennsylvania and Maryland, each link is classified as a freeway, arterial or local road.

The Urban Airshed Model (UAM) requires that emissions inventories be based on a grid, the cells of which measure five kilometers on a side. The simulated link volumes and speeds were allocated to grids based on the length of the link within a cell. This VMT and speed grid file was created for the Pennsylvania and Cecil County portions of the nonattainment area.

The network, off-network and Cecil County travel data were combined into a single file of vehicle miles of travel (VMT) and average speeds for all streets and roads in the six-county area by grid [5]. These data were adjusted to reflect 1988 average daily traffic instead of 1987, and also a summer weekday, when traffic volumes are highest during the ozone season.

In cooperation with EPA and the state environmental departments, input parameter settings for MOBILE4.1 have been developed for Pennsylvania and Cecil County. The states differ primarily in inspection and maintenance programs and the higher volatility of gasoline sold in Pennsylvania. Emissions factors are produced [6] by MOBILE4.1 by vehicular operating speed.

**Figure 5: Overview of Procedures**



An emissions processor [7] has been created which combines the grid VMT and speed data with MOBILE4.1 emissions factors to calculate the total highway source emissions for each pollutant generated within each grid cell. A data file [8] is created which will be input into a geographic information system [9], from which maps for presentation and analysis can be produced. The data file will also be input to the UAM [10], together with emissions from other mobile and stationary sources. The processor also produces grid, county and state summaries for analytical and informational purposes [11].

**Link Emissions Compared to Cell Emissions**

EPA guidance for highway source emissions inventories indicates that a computation of emissions on each link is preferred to a computation applied to aggregate travel within grids. However, because of the size and complexity of link-level emissions computation in a large urbanized area like Philadelphia, a streamlined emissions processor based on five-kilometer grid aggregates of network VMT and speed was designed. Results from this processor were compared to the link-level results to determine if significant errors or biases are introduced into the estimates. The results of this analysis clearly show that the processor is adequate to calculate emissions when the VMT and speeds are stratified by the three functional classes.[1] □

[1] This research is summarized in the report *The Impact of Preaggregation of Highway Network Travel Data on the Accuracy of MOBILE4-Based Emissions*, available from DVRPC.

## 3 VEHICLE MILES OF TRAVEL AND SPEED ESTIMATION

The existence of a regional travel simulation model for the five Pennsylvania counties in the nonattainment area, and the absence of such a model in Cecil County led to separate methods to estimate vehicle miles of travel (VMT) and speeds. The approaches used in the two states are discussed in turn below. Actual estimates of VMT and speed are presented at the end of this section.

### Pennsylvania

Travel Simulation

A 1987 travel simulation was prepared by a straightforward application of the travel simulation process developed by DVRPC's staff to evaluate long-range plans and corridor-level studies. In 1985, this forecasting process was subjected to extensive validation and recalibration, based on the data from the 1980 U.S. Census Urban Transportation Planning Package (UTPP).[2] The population and employment assumptions used in the 1987 simulation are presented in Table 1, along with U.S. Census figures and estimates for other years from which comparisons can be made. The resulting simulated traffic volumes form the basis for the highway source emissions estimates.

The travel simulation models at DVRPC follow the traditional steps of trip generation, trip distribution, modal split, and travel assignment. They utilize computer programs included in the federally sponsored Urban Transportation Planning System (UTPS). Some statistics on the 1987 highway simulation network are shown in Table 2. The extent of the network is shown in Figure 6. The following is a description of the steps in the modeling process:

*Trip Generation*

Trip generation is the first step in the modeling process. Person, truck, and taxi travel is generated from census tract estimates of households and employment through the use of trip rates disaggregated by trip purpose (home based work, home based non-work, and non-home based), auto ownership, and area type (CBD, fringe, urban, suburban, rural, and open rural). Estimates of external and through highway and transit travel are developed from population and employment estimates in counties surrounding the Delaware Valley Region.

*Trip Distribution*

Travel from census tracts within the region is allocated to destinations within the region with a gravity model. This model assumes that the propensity to travel to a tract of destination increases

[2]DVRPC, Testing and Adjusting DVRPC Travel Simulation Models with 1980 Census Data, (1985).

**Table 1: Pennsylvania Population and Employment (in thousands)**

| Population | 1980 (1) | 1987 (2) | 1988 (3) | 1990 (1) |
|---|---|---|---|---|
| Bucks | 479 | 525 | 529 | 541 |
| Chester | 317 | 346 | 364 | 376 |
| Delaware | 555 | 559 | 549 | 548 |
| Montgomery | 643 | 667 | 671 | 678 |
| Philadelphia | 1,688 | 1,624 | 1,606 | 1,586 |
| **Total** | **3,683** | **3,721** | **3,720** | **3,729** |
| **Employment** | **1980 (1)** | **1987 (2)** | **1988 (4)** | **1990 (4)** |
| Bucks | 196 | 230 | 236 | 244 |
| Chester | 146 | 169 | 174 | 181 |
| Delaware | 212 | 229 | 233 | 235 |
| Montgomery | 392 | 462 | 467 | 480 |
| Philadelphia | 858 | 836 | 835 | 846 |
| **Total** | **1,804** | **1,926** | **1,944** | **1,986** |

Sources:
(1) US Census
(2) Estimate used in 1987 travel simulation
(3) Estimate based on 1990 US Census
(4) DVRPC Estimate

Delaware Valley Regional Planning Commission

with the attractiveness of the destination (as measured by employment) and decreases as the difficulty of traveling between zones increases. This travel effort (impedance) is measured by travel time and cost for both the highway and transit modes.

*Modal Split*

The modal split model divides the travel between census tracts within the region into transit and highway components. Generally, the propensity to use public transit increases with the relative transit-to-highway service levels. The relative service levels are estimated through highway and transit out-of-vehicle time and in-vehicle time, highway operating costs and parking charges, and

**Table 2: DVRPC 1987 Highway Simulation Network Statistics** (Includes 4 Counties in New Jersey)

**Network Links**

| | |
|---|---|
| Area Covered | 3,846.8 Square Miles |
| Traffic Centroids | 1,449 |
| Nodes | 12,533 (including centroids) |
| Two-way Link Cards | 22,508 (including centroid connectors) |
| One-way Link Cards | 2,211 |
| Network Arcs | 47,227 |

**Highway Route Miles**

| Functional Class | Computerized Network | Total Open to Traffic | % in Network |
|---|---|---|---|
| Freeway | 739 | 739 | 100.0 |
| Arterial | 4,348 | 4,348 | 100.0 |
| Local | 1,580 | 14,464 | 10.9 |
| **TOTAL** | **6,667** | **19,551** | **34.1%** |

Source: Delaware Valley Regional Planning Commission

transit fares. In addition, auto ownership, transit submode, household income, trip purpose, and the consumer price index further define the trip-maker's choice between highway and transit.

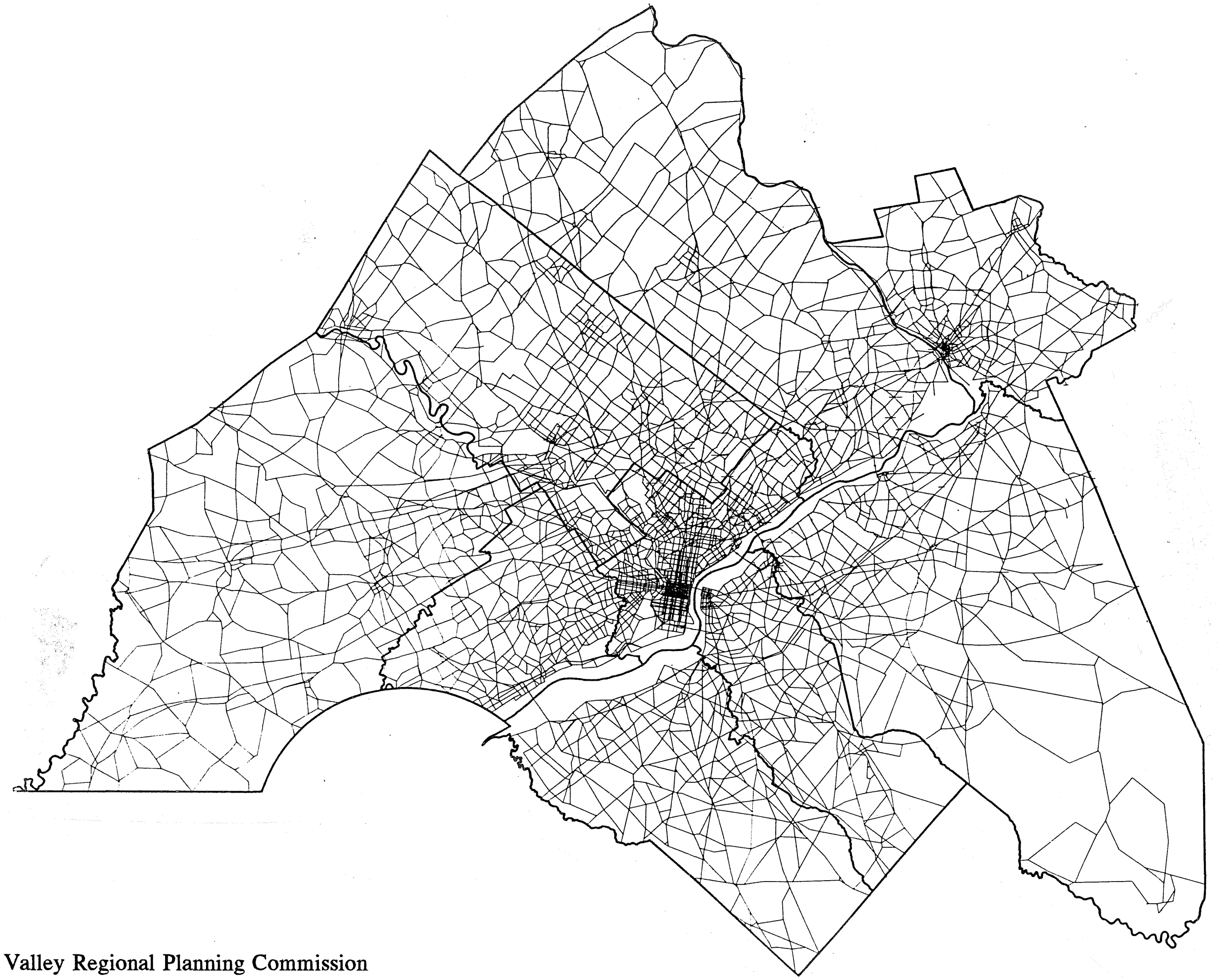
The factors influencing transit use cited above are reflected in significant differences between the suburban counties and Philadelphia. About 800,000 transit trips are made per day in the five Pennsylvania counties (Table 3). These represent about 7.5% of total person-trips.

**Table 3: Daily Person Trips Made by Transit and Highway**

| | Daily person trips | Percent of total |
|---|---|---|
| **Transit** | 818,400 | 7.6 |
| **Highway** | 9,924,100 | 92.4 |
| **TOTAL** | 10,742,500 | 100.0 |

Source: Delaware Valley Regional Planning Commission

**Figure 6: DVRPC 1987 Highway Simulation Network**



Source: Delaware Valley Regional Planning Commission

*Auto Occupancy*

The auto occupancy model determines the average number of persons per automobile. This value is used to convert auto person trips to auto vehicle trips. Auto occupancy is estimated by trip purpose and trip length. On average, the occupancy rate was 1.43 persons per auto.

*Travel Assignment*

The final step in the process is to assign the estimated highway vehicle and transit person trips to specific facilities. This is accomplished by determining the best (minimum time and cost) route through the highway and public transit networks and allocating the transit travel to the transit facilities and highway travel to the highway facilities. Highway capacity is restrained in that congestion levels are considered in determining the best route. Traffic volumes on each link in the network are produced in this step.

The highway travel assignment results in average annual daily traffic (AADT) on each of the links in the simulation network—essentially for each of the lines shown in Figure 6. Vehicle miles of travel (VMT) is then calculated by multiplying the AADT from the travel simulation by the length of the link in miles.

Adjustment to Summer 1988

Recent interim year estimates of population by the US Census and employment estimates by BEA were used in this study to correct and update the 1987 demographics used in the simulation to 1988. VMT on each link was adjusted by a factor reflecting the growth in population and jobs within the municipality associated with that link. The adjustments in VMT made for 1988 are supported by a comparison of 1987 and 1988 counts taken at counting stations in the Highway Performance Monitoring System (HPMS).

The adjusted link VMT for 1988 are averages for the year. VMT for this inventory was adjusted to account for increased travel during the summer months. The Pennsylvania Department of Transportation provides adjustment factors for each day of the week during twelve months of the year and by several functional categories. These factors were combined in such a way as to reflect travel on the three functional classes used in this study and the three summer months of June through August during which most ozone exceedances occur. The seasonal VMT factors used for the Pennsylvania counties were: freeway, +5%; arterial, +7%; and local, +6%.

Estimation of Speeds

Emissions factors vary with vehicle operating speed to a very significant degree. For this reason, the amount and distribution of the highway source pollutants are influenced by the accuracy and sensitivity of the method used to convert network measures of highway congestion into operating speed. Highway travel time studies conducted by DVRPC have shown that the Federal Highway Administration Restraining Curve has a tendency to underestimate operating speeds in the Delaware

Valley Region by as much as 50 percent. This speed function is intended to facilitate the simulation of accurate link volumes more than to produce realistic operating speeds. The use of this function to estimate simulated operating speed would result in severely overestimated emissions.

A complex but more accurate set of curves was used to estimate simulated operating speed for this inventory. These curves were taken from a report prepared by Creighton, Hamburg, Inc. for the FHWA.[3] A separate set of curves was used for freeways and arterials. The freeway curves relate peak hour link operating speed to the link speed limit, capacity, and peak hour simulated vehicular volume. The arterial curves relate peak hour link speed to the speed limit, capacity, traffic signal density (per mile), a free flow speed, and the peak hour simulated link volume.

Peak hour link volumes were estimated from simulated daily volumes through the use of a peak hour percentage (by functional class and area type) taken from traffic counts. Speed limits, signal densities, and free flow speeds were input as a table lookup by functional class and area type. DVRPC travel time surveys have found that daily speeds are on average about 10 percent higher than peak hour speeds.

Recent travel time surveys seem to indicate that the original Creighton-Hamburg curves underestimate actual speeds by about five percent, as drivers may have become more acclimated to operating their vehicles under congested conditions.[4] For this reason the speeds output by the curves were increased by up to five percent (subject to the minimum speed and speed limit). Otherwise, the freeway curve required no modification for use in the DVRPC region. The arterial curve, however, also required the addition of a minimum speed of 8 to 10 mph (depending on area type) to the Creighton-Hamburg formulation to adequately replicate DVRPC's travel time survey data.

Allocation to Grid Cells

A grid specified by Region III of EPA was overlain on the counties which are the subject of this inventory. The entire grid constitutes the domain to be used for the Urban Airshed Model. The Philadelphia modelling domain overlaps with those for Baltimore/Washington and New York and is congruent in those sections. The southwestern reference point is East 390 kilometers and North 4305 kilometers. For ease in referencing grid cells, the first cell north and east of the reference point is referred to as N1, E1. Rows progressing northward are numbered N1, N2, N3...to N41. Columns progressing eastward from the reference point are numbered E1, E2, E3...to E33.

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[3]Creighton, Hamburg, Inc. Freeway-Surface Arterial VMT Splitter. Federal Highway Administration, Washington, D. C., 1971, pp. 22-24.

[4]1971-73 to 1986 Highway Travel Time and Speed Comparisons in the New Jersey Portion of the DVRPC Region. Transportation Planning Data Bulletin No. 9, Delaware Valley Regional Planning Commission, September, 1987.

The VMT on a link which crosses grid lines was apportioned to each cell through which the link passes. Links do not cross county boundaries, so that the links within a cell which include portions of more than one county can be summed to county as well as to cell. Speeds are assumed to be uniform throughout the link. Separate accounts are also maintained at this point for the three categories of highways—freeways, arterials and local roads.

Off-network Travel

Off-network travel on highways within each of the Pennsylvania counties was estimated based on [1] the number of miles of off-network route-miles and [2] available counts on local streets. Total route miles were estimated by the Pennsylvania Department of Transportation from which route-miles in the DVRPC network were subtracted. These off-network miles represent 68.6% of the total miles in the five counties, as seen in Table 4. Guided by counts on local (network or off-network) streets and roads, an average daily traffic rate was estimated and applied to the number of off-network route-miles in the county. Average off-network travel amounts to 11.8% in the region.

**Table 4: Comparison of Network and Off-network Route-miles and VMT**

| County | Network Miles | Off-network Miles | Off-network/ Total % | Network VMT (000) | Off-network VMT (000) | Off-network/ Total % |
|---|---|---|---|---|---|---|
| Bucks | 904 | 2,052 | 69.4 | 7,828 | 1,043 | 11.8 |
| Chester | 973 | 2,021 | 67.5 | 7,318 | 912 | 11.1 |
| Delaware | 472 | 1,206 | 71.9 | 7,304 | 1,189 | 14.0 |
| Montgomery | 1,002 | 2,069 | 67.4 | 13,004 | 1,532 | 10.5 |
| Philadelphia | 771 | 1,665 | 68.4 | 13,689 | 1,877 | 12.1 |
| **Pennsylvania** | 4,122 | 9,013 | 68.6 | 49,143 | 6,553 | 11.8 |

Source: Delaware Valley Regional Planning Commission

These county totals of off-network travel were allocated to grids in proportion to the VMT on non-freeway roads in the cell. That is, a fraction composed of grid arterial and (network) local VMT divided by county arterial and (network) local VMT is applied against the county off-network local total VMT to determine the part that occurs within each cell.

Speeds on the off-network local roads were assumed to be the same as that on any local roads included in the network within the same grid cell. If no network local roads existed to provide this guidance, then the speed on the local road was assumed to occur at the average speed for all local roads in the network within the county.

## Cecil County

The Baltimore Regional Council of Governments (BRCOG) prepared 1987 VMT and speed estimates, by functional classification at the grid level, for Cecil County independent of this study. BRCOG used a different methodology than was employed in the Pennsylvania portion of the nonattainment area. Unlike the five counties in Pennsylvania, Cecil County's road network has not been simulated in a travel model. This required formulating another method to estimate VMT and speeds.

The employed methodology largely entailed manual computations. It was reasoned that, because the county is largely rural in nature with relatively low density, manual computation would afford sufficient accuracy. The methodology is described in the study, *Methodology for Determining Vehicle Usage and Speeds for Mobile Source Emissions Inventories*, in which methods to estimate VMT and speeds for roads in seven Maryland counties and Baltimore City are described.

The first step taken to estimate VMT was to estimate roadway lengths in Cecil County. Grid boundaries of the 5×5 kilometer UTM cells were superimposed on maps of the county. Distances of roadways were measured on the map and tabulated under the appropriate functional classification for each grid cell.

Three classes of roadways were specified: primary, secondary, and local. These classifications were consistent with those employed in the Pennsylvania portion of the inventory (i.e., freeway, arterial, and local) with the exception that the "primary" category of the Cecil County inventory included freeways and major arterials. This variation was accounted for by breaking out data for major arterials and reassigning them to the arterial category.

Traffic volumes were also hand tabulated. A highway map containing 1987 average daily traffic volumes from the Maryland State Highway Administration (SHA) was consulted, and figures from the map were assigned to roads where available. Approximately 80 traffic counts in Cecil County are contained on the map. For portions of roadways between counts or without counts, volumes were interpolated or estimated, using the map as a guide and taking into account the proximity of other roads, towns, and other special features which influence traffic volumes.

With estimates of road mileage and average daily traffic volumes, VMT by road and grid cell was calculated by multiplication of the two factors. VMT, and road miles, were then summed by grid cell by functional classification.

VMT estimates were then subject to two adjustments. After estimation of VMT, the results were compared with 1987 SHA estimates of vehicle miles which are prepared annually by functional classification and county. The BRCOG aggregate VMT estimate for Cecil County was 6.99% higher than SHA estimates. As a result, the BRCOG estimates were adjusted by reducing them by the same percentage. Secondly, VMT on Cecil highways was increased 7% to convert average annual VMT to that expected on a summer weekday.

The travel speeds on Cecil County roads, shown in Table 5, were estimated by SHA and BRCOG staff. Essentially, standardized speeds were specified for different classifications of roads according to relevant conditions (e.g., average daily traffic volumes and composition of surrounding area). Within grid cells, and by functional classification, weighted averages of the speeds based on the length of individual roads were calculated.

**Table 5: Speed Assignments in Cecil County**

| Condition | Local | Secondary | Primary |
|---|---|---|---|
| ADT less than 500 | 25 | | |
| Dead-end Road | 25 | | |
| Road in Residential Development | 25 | 35 | 35 |
| Road in Incorporated Town | 35 | 40 | 40 |
| Other Conditions | 35 | 50 | 55 |

Source: *Methodology for Determining Vehicle Usage and Speeds for Mobile Source Emissions Inventories*, Baltimore Regional Council of Governments, 1990

1987 VMT and speed data by grid cell for Cecil County, derived from the process described above, were transmitted to DVRPC by the Maryland Department of the Environment. Mileage estimates by grid cell and functional classification were also obtained.

A final step taken by DVRPC to make the VMT estimates more representative of 1988 travel was to develop adjustment factors from 1987 to 1988. An analysis of the SHA VMT estimates produced the following 1987-1988 adjustment factors: freeways, +1.4%; arterials, -2.3%; and local and collector roads, +1.7%. 1987 VMT estimates were adjusted accordingly. The adjustments account for growth in travel and correct some inconsistencies found in the 1987 traffic counts.

The population and employment shown in Table 6 were not used in the estimation of VMT and speeds in Cecil County. They are presented here to indicate trends during the past decade and for comparison with demographic information for the counties in Pennsylvania.

**Table 6: Cecil County Population and Employment**

| | 1980 | 1987 | 1988 | 1990 |
|---|---|---|---|---|
| Population | 60,430[1] | 68,000[2] | 69,000[2] | 71,347[3] |
| Employment | 18,912[4] | 22,407[4] | 23,616[4] | NA |

Sources: (1) 1980 US Census; (2) Delaware Valley Regional Planning Commission; (3) 1990 US Census; and (4) Bureau of Economic Analysis.

## Results

Application of the methods described above for five counties in Pennsylvania and Cecil County, Maryland result in the vehicle miles of travel and speeds summarized in Table 7. Note that more than half of the travel in the region of the inventory occurs on arterial roads at about 17 MPH. About one-fourth of travel occurs on freeways at the much higher speed of 38 MPH. The remaining travel on local roads occurs at an average of 14 MPH.

The same data in Table 7 are disaggregated for 313 grid cells—those which include travel in any of the six counties in the region of the inventory (Appendix C).

**Table 7: Vehicle Miles of Travel and Average Speed by Functional Class**

| | Freeway | | Arterial | | Local | | TOTAL | |
|---|---|---|---|---|---|---|---|---|
| **County** | **VMT** (000) | **SPD** (mph) | **VMT** (000) | **SPD** (mph) | **VMT** (000) | **SPD** (mph) | **VMT** (000) | **SPD** (mph) |
| Bucks | 2,512.9 | 45.7 | 5,141.4 | 21.7 | 1,799.0 | 17.6 | 9,453.3 | 24.0 |
| Chester | 2,784.0 | 39.5 | 4,387.9 | 25.5 | 1,590.8 | 23.0 | 8,762.6 | 28.1 |
| Delaware | 1,445.2 | 42.4 | 5,841.4 | 15.5 | 1,786.8 | 13.5 | 9,073.5 | 16.7 |
| Montgomery | 4,041.8 | 33.7 | 8,293.9 | 16.4 | 3,157.6 | 13.6 | 15,493.3 | 18.1 |
| Philadelphia | 4,100.2 | 34.5 | 9,736.7 | 14.8 | 2,764.8 | 11.5 | 16,601.7 | 16.3 |
| **Total Pennsylvania** | 14,884.1 | 37.4 | 33,401.3 | 17.1 | 11,099.0 | 14.3 | 59,384.4 | 19.0 |
| Cecil | 901.2 | 55.0 | 1,305.5 | 50.4 | 376.0 | 33.7 | 2,582.6 | 48.3 |
| **TOTAL REGION** | 15,785.3 | 38.1 | 34,706.8 | 17.6 | 11,475.0 | 14.6 | 61,967.0 | 19.5 |

Source: Delaware Valley Regional Planning Commission December 1991

# 4 ESTIMATION OF EMISSIONS FACTORS

A critical step in estimating highway source emissions is the development of emissions factors. Emissions factors are rooted in various "real-world" conditions and characteristics which impact emissions levels. In effect, they serve as multipliers which are applied to VMT and speed estimates to produce emissions estimates. Emissions factors can vary significantly, based on factors such as type of pollutant, ambient temperature, and auto emissions programs.

## MOBILE4.1

MOBILE4.1 (revised November 4, 1991) is the latest version of the computer model promulgated by EPA for the purpose of estimating highway source emissions factors. MOBILE4.1 is comprised of various policy and climatic options so that emissions factors, which accurately reflect meteorological conditions and state and local emissions control programs, can be estimated. The model permits the estimation of emissions factors for NMHC, CO, and $NO_x$.

### Program Control Settings—Pennsylvania and Cecil County

Program control settings of MOBILE4.1 vary between Pennsylvania and Cecil County. This results in different emissions factors for each state. All MOBILE4.1 parameters were set in consultation with PennDER, Maryland Department of the Environment, and EPA Region III.

Table 8 presents a summary and comparison of MOBILE4.1 program control settings used for the Pennsylvania counties and Cecil County. For many of the parameters, default values, endogenous to MOBILE4.1, are utilized. This includes vehicle emission control device tampering rates, exhaust emissions rates and temperature control corrections, and VMT mix of highway travel by vehicle type (i.e., cars, various categories of trucks, and motorcycles).

Also, several of the parameters incorporated within MOBILE4.1 did not apply to Pennsylvania or Cecil County. This occurs because, in the year of the inventory, 1988, programs for anti-tampering, refueling, and oxygenated fuels were not in place.

In 1988, the details of the vehicle inspection and maintenance (I&M) programs for emissions differed by state. Cecil County did not have an inspection and maintenance program in operation, but Pennsylvania did. Pennsylvania's I&M program is summarized in Table 9.

Minimum and maximum daily temperatures were similar for the two states (reflecting the summer conditions of the peak ozone period), whereas fuel volatility was slightly different (i.e., a difference of 0.9 PSI Reid vapor pressure between the two states). In terms of operating mode and altitude, identical settings were employed.

The age distribution of vehicles for Cecil County and the Pennsylvania counties was differentiated based on available data. Figure 7 depicts the age distribution of vehicles for Maryland, New Jersey,

## Table 8: Pennsylvania and Cecil County MOBILE4.1 Program Control Settings

| | Pennsylvania | Cecil County |
|---|---|---|
| **Program Control Parameters** | | |
| Tampering Rates | Default | Default |
| VMT Mix (by vehicle type) | Default | Default |
| Vehicle Distributions by age: | | |
| Mileage Accumulation | Default | Default |
| Registration Distribution | (See Appendix) | (See Appendix) |
| Exhaust Emission Rates | Default | Default |
| Inspection and Maintenance Program | Yes (See Table 9) | No |
| Local Emissions Correction Factors | None | None |
| Anti-Tampering Program | None | None |
| Refueling Emissions: | None | None |
| Exhaust Temperature Correction | Default | Default |
| HC Factor Basis | Non-methane | Non-methane |
| **Local Area Parameters (Summer)** | | |
| Oxygenated Fuels | No | No |
| Minimum Daily Temperature | 75°F | 70°F |
| Maximum Daily Temperature | 95°F | 97°F |
| Fuel Volatility (Reid vapor pressure) | 11.5 PSI | 10.6 PSI |
| Operating Mode | 20.6/27.3/20.6 | 20.6/27.3/20.6 |
| Altitude | Low | Low |

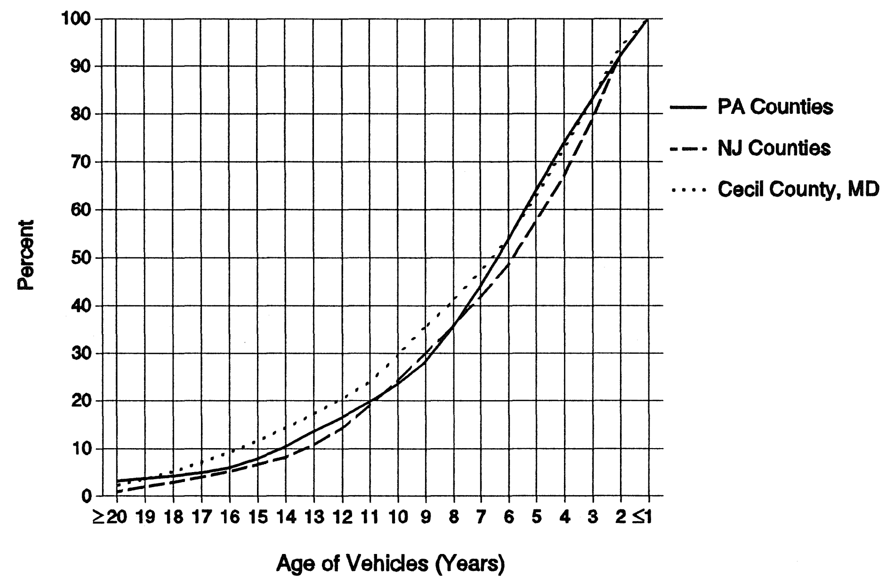
Source: EPA Regions II and III, PennDER, and Maryland Department of the Environment

## Table 9: Pennsylvania Inspection and Maintenance Parameters

| | |
|---|---|
| Start Year (January 1) | 1984 |
| Pre-1981 MYR Stringency Rate | 20% |
| First Model Year Covered | 1968 |
| Last Model Year Covered | 2020 |
| Waiver Rate (Pre-1981): | 1% |
| Waiver Rate (1981 and Newer) | 1% |
| Compliance Rate | 93% |
| Inspection Type | Computerized, Decentralized |
| Inspection Frequency | Annual |
| Vehicle Types Covered | LDGV—Yes<br>LDGT1—Yes<br>LDGT2—Yes<br>HDGV—No |
| 1981 & Later MYR Test Type | Idle |

Source: PennDER and EPA

**Figure 7: Cumulative Percentage of Age of Vehicle Fleet**






and the five southeastern Pennsylvania counties. Maryland data was employed in developing the MOBILE4.1 Cecil County control settings. For the five Pennsylvania counties in the study area, New Jersey data, which closely approximates Pennsylvania's vehicle age distribution, was employed. At the time of the analysis, Pennsylvania data had been unavailable for use.

### Emissions Factors by Speed

Based on these parameters, the MOBILE4.1 computer program was executed to prepare separate 1988 emissions factors for CO, NMHC, and $NO_x$ for Pennsylvania and Cecil County. For each pollutant, composite emissions factors are produced for 53 speed entries, calculated by whole mile-per-hour increment from 3 to 55 mph (Appendix D). These factors are then applied to VMT and speed estimates to generate emissions estimates for 1988.

Emissions factors are very comparable between Pennsylvania and Cecil County. In general, emissions factors are inversely related to speed. Carbon monoxide is generally produced at the highest levels (grams per mile). Oxides of nitrogen are produced at substantially lower levels and are not as dramatically affected by changes in operating speed.

**Figure 8: Composite NMHC Emissions Factors by Vehicle Operating Speed (Five Pa. counties)**

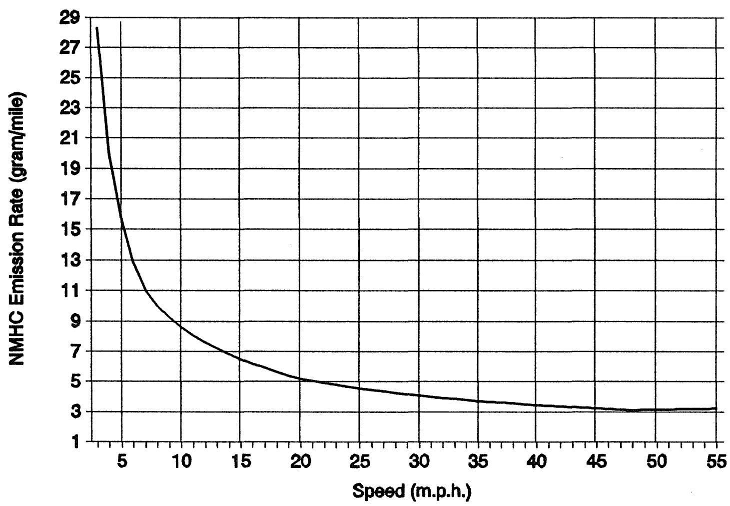





Figure 8 depicts the relationship of NMHC to speed, based on the MOBILE4.1 parameters and conditions specified for the five Pennsylvania counties. The figure demonstrates that emissions factors are highest at very low speeds and then decline markedly. The factors continue to decline up to vehicle operating speeds of 48 miles per hour, where they then turn slightly upward. □

## 5 EMISSIONS RESULTS

This study was undertaken to estimate the amount of emissions which resulted from vehicular traffic on a typical summer weekday in 1988 in the Pennsylvania and Maryland portions of the Philadelphia nonattainment area. A fundamental objective of the inventory was to specify levels of pollutants for 5×5 kilometer grid cells, in addition to county and state totals. The study methodology described heretofore, entailing the application of emissions factors to estimates of vehicle travel, affords the opportunity to attain these results.

Levels of NMHCs, CO, and $NO_x$ were estimated in kilograms for one summer weekday. Due to the severe ozone problem in the Philadelphia nonattainment area, the ensuing discussion is centered on NMHCs, a principal precursor of ozone. However, many of the following observations apply equally to CO and $NO_x$. Highway sources are believed to contribute between one-third to one-half of total NMHCs.

### County/State Emissions

It is estimated that, on a typical summer weekday in 1988, 330,000 kilograms of NMHCs were produced by highway sources in the study area (Table 10). Ninety-seven percent of the emissions originated in Pennsylvania, where vastly more residences and jobs are located.

**Table 10: 1988 Highway Source Emissions in Kilograms per Summer Weekday**

| COUNTY | CO | NMHC | $NO_x$ |
|---|---|---|---|
| Bucks | 249,131.1 | 44,238.0 | 25,386.8 |
| Chester | 196,025.2 | 37,177.4 | 22,918.8 |
| Delaware | 335,141.9 | 54,168.4 | 25,164.2 |
| Montgomery | 533,785.5 | 87,363.5 | 42,775.7 |
| Philadelphia | 623,924.8 | 100,405.4 | 46,191.5 |
| **TOTAL PENNSYLVANIA** | **1,938,008.5** | **323,352.7** | **162,437.0** |
| Cecil | 57,999.2 | 8,359.9 | 8,176.3 |
| **TOTAL REGION** | **1,996,007.7** | **331,712.6** | **170,613.3** |

Source: Delaware Valley Regional Planning Commission December 1991

On a county basis, Philadelphia accounts for 30% of NMHC emissions attributable to highway travel in the study area. Combining Philadelphia with Montgomery County, the two counties account for over half of total highway source NMHCs. NMHC emissions occurring in the remaining counties in the study area are of less magnitude, with Cecil County the smallest contributor (2.5% of total study area NMHCs).

The preponderant source of NMHC emissions is light duty gasoline vehicles, or cars. Collectively, they account for nearly half of total emissions (Figure 2, Page 4). Light duty trucks account for an additional third of emissions. Other types of vehicles, including heavy duty trucks, motorcycles, and remaining diesel vehicles, collectively contribute less than 20% of total emissions.

Most NMHC emissions (61%) occur on the region's arterial facilities (Figure 3, Page 4). Arterials carry the most traffic of any functional classification category in the region (56%); low average operating speeds are additional contributing factors. Speeds and emissions are essentially inversely related, with the highest emissions rates occurring under 20 miles per hour. In Pennsylvania, average operating speeds on arterials are 17 miles per hour.

**Grid Level Emissions**

After estimating vehicle travel data by grid cell, emissions could also be estimated at the 5×5 kilometer grid level (Appendix E). Among all grid cells, the amount of estimated NMHCs ranged from a high of 11,900 kilograms per day to a low of less than one. Levels of emissions per grid cell were grouped into six categories: 0-200 kilograms per day, 201-1,000, 1,001-2,000, 2,001-4,000, 4,001-8,000, and over 8,000. These emissions categories are for classification purposes only and are not indicative of ozone violations. Ozone may be formed at a point distant from the emission of its precursors.

Figure 1 (Page 3) demonstrates that on a grid level basis, NMHCs from highway sources vary greatly by area type. The highest levels occur in Philadelphia's urban core. An urban, suburban ring immediately surrounding the urban core has the second highest levels. Mature and newer suburbs have the third and fourth highest levels, respectively, while rural areas, such as Cecil County and outlying portions of Bucks, Chester, and Montgomery Counties, have the lowest emissions levels. As such, emissions levels are strongly reflective of the intensity of human activity.

Six cells occur in the highest level emissions category (over 8,000 kilograms per day). All are located, wholly or primarily, within the City of Philadelphia. These same cells are also the six highest in terms of daily VMT, although their exact ordering in terms of emissions and VMT are not totally identical. Vehicle speed, as already noted, also plays a determining role in the levels of emissions. In two of the cells falling in the highest emissions category, there are no roads classified as freeways. All travel occurs on slower moving arterials and local roads.

The cell with the greatest amount of daily NMHC emissions occurs in the virtual heart of the DVRPC region. This cell extends from West Philadelphia to portions of Center City. Significant highway facilities in the cell include the Schuylkill Expressway (I-76), the Vine Expressway (I-676), and the interchange between them.

All but two of the cells occurring in the second highest category of emissions (i.e., 4,001-8,000 kilograms per day) abut upon those cells with the highest levels of emissions or are found in groupings around the urban core. One notable exception to this general rule is two cells which occur in the King of Prussia-Norristown area. These cells are freestanding from Philadelphia and are indicative of intensive activity and travel.

**Emissions Processor**

In conjunction with this study, DVRPC has produced an emissions processor which applies emissions factors to travel data and calculates emissions estimates. The processor was employed to derive the emissions estimates described in this inventory. More importantly, the processor has also been recreated on computer disk in order that other agencies may perform calculations of emissions.

The processor allows for the manipulation of MOBILE4.1 inputs to examine the effects of various policy and program alternatives. The processor also permits the alteration of seasonal adjustment factors. One noteworthy attribute of the processor is that it preserves the ability to examine emissions at the level of the 5×5 kilometer grid cell, as well as at aggregate county and state levels.

**Observations**

This study indicates highway source emissions levels in the Maryland and Pennsylvania portions of the Philadelphia nonattainment area with geographic specificity for a typical summer weekday in 1988. The inventory estimates emissions at their point of production from vehicular sources. It does not reflect actual ambient air quality in terms of ozone or carbon monoxide.

Emissions inventories can be very useful to decision-makers and transportation professionals. Improving air quality in the Philadelphia Nonattainment Area will rely in part on reducing highway source emissions. Inventories such as this one render accurate data regarding the nature of highway source emissions and travel intensity with a high degree of geographic detail. Inventory results can be used to formulate and target effective strategies, such as transportation control measures, to improve air quality.

Ultimately, a desirable planning approach for the region may pursue two objectives in seeking to reduce highway source emissions: reduce emissions in areas with the highest concentrations and maintain the lowest possible levels in all areas. This approach would require implementing transportation improvements which either increase vehicle operating speeds or retard growth in volumes of auto travel. Such improvements must be coordinated with approaches to reduce non-mobile sources of emissions to produce measurable air quality improvements. □

# APPENDICES

## Appendix A: Glossary of Terms

**Air Quality** - expression of level of pollutants present in the atmosphere

**Annual Emissions Reductions** - yearly decrease in pollutants resulting from implementation of projects or programs designed to lower emissions

**Attainment Area** - area where level of pollutant is better than or equal to established federal standards; area may be in attainment for one pollutant but not others

**Attainment Status** - the relationship of the level of individual pollutants to established standards for those pollutants

**Carbon Monoxide (CO)** - colorless, odorless, toxic chemical compound which reduces oxygen in the blood

**Clean Air Act Amendments (CAAA)** - amendments to the Clean Air Act; the most recent in 1990

**Cold Start** - parameter used in the Mobile 4.1 model which accounts for additional emissions resulting from a cold-started engine

**Conformity** - matching the goals in the SIP with transportation plans and programs

**Congestion Estimates** - estimate of delay in vehicle travel time used for computer modelling purposes

**DER** - Pennsylvania Department of Environmental Resources; state agency responsible for monitoring environmental quality

**DEPE** - New Jersey Department of Environmental Protection and Energy; state agency responsible for monitoring environmental quality

**DOE** - Maryland Department of the Environment

**DOT** - United States Department of Transportation; federal agency responsible for administering federally funded transportation programs

**Emissions** - particulate matter and toxic gases released into the atmosphere through the burning of fossil fuels

**Emissions Factors** - outputs from the MOBILE4.1 model to account for local conditions such as weather, vehicle fleet and control programs

**Emissions Inventory** - listing of types of emissions and levels of those emissions present within an area

**Enhanced Inspection and Maintenance (Enhanced I&M)** - expanded program to further reduce emissions through auto maintenance procedures

**EPA** - Environmental Protection Agency; federal agency responsible for administering and monitoring environmental quality programs

**FHWA** - Federal Highway Administration; federal agency responsible for federally funded highway construction and maintenance

**FTA** - Federal Transit Administration (formerly known as the Urban Mass Transportation Administration); federal agency responsible for administering federally-funded public mass transportation projects

**Gasoline Volatility** - evaporation rate of gasoline, usually expressed in terms of Reid Vapor Pressure

**Guidance** - instructional documentation of requirements for meeting the specifications in the Clean Air Act as amended

**Hot Spots** - areas where traffic congestion causes a concentration of carbon monoxide emissions

**Hydrocarbon** - an organic compound containing hydrogen and carbon molecules, notably found in petroleum projects

**Inspection & Maintenance Program** - program to reduce emissions through periodic examination and repair of automobile emission systems; see also *Enhanced I & M*

**IPP** - Inventory Preparation Plan; description of plan for undertaking emissions inventories

**Mileage Accumulation Rate** - factor used to describe fleet travel characteristics; used in MOBILE4.1 model

**MOBILE4.1** - EPA computer model to determine highway source emissions factors; inputs include traffic conditions, weather and local control programs

**Mobile Source Emissions** - emissions created by vehicles with internal combustion engines

**Modal Split** - percentage of traffic using various transportation modes; usually transit and highway

**Modelling Domain** - geographical area encompassed by the various computer models which predict air quality based on levels of emissions

**Model Representation** - refers to a transportation improvement project, the impact of which can be seen in the results of a computer model

**MPO (Metropolitan Planning Organization)** - regional planning agency responsible for planning activities in a geographical area encompassing more than one municipality or county

**National Ambient Air Quality Standards (NAAQS)** - federal standards which establish the maximum concentration of various pollutants allowed in the atmosphere

**National Environmental Policy Act (NEPA)** - legislation which created the Environmental Impact Statement process

**NMHC** - non-methane hydrocarbons; methane is excluded because it does not react to form ozone

**Nonattainment Area** - area that does not meet standards for individual pollutants; areas may attain standards for certain pollutants but not for others

**Northeast Ozone Transport Commission** - organization created by the CAAA of 1990 and made up of representatives from 11 states in the northeast portion of the United States and Washington, DC, for the purpose of coordinating attainment strategies; the Commission may require measures beyond those which affect individual nonattainment areas

**$NO_x$ (Oxides of Nitrogen)** - chemical compounds containing nitrogen and oxygen; primary cause of acid rain; photochemically reacts with volatile organic compounds to form ozone

**Ozone** - primary component of smog; created through the photochemical reaction between $NO_x$ and Volatile Organic Compounds

**Ozone Standard** - maximum allowable concentration of ozone in the atmosphere at the surface; currently set at 0.12 parts per million, which cannot be exceeded more than one hour in a day

**Particulate, Particulate Matter** - particles of solid pollutants in the atmosphere
**PM-10** - standard for measuring particulate matter; refers to particles over 10 microns in diameter
**Point Sources** - large stationary (non-mobile) sources of emissions such as a factory

**Reactive Hydrocarbons** - hydrocarbon emissions which react with heat and sunlight to form ozone

**Sanctions** - actions taken by the federal government against local or state governments for failure to adopt or enforce SIPs
**Stage II Control** - devices on gasoline pumps to capture vapors during vehicle refueling
**State Implementation Plan (SIP)** - documents prepared by states to identify actions which will be taken in order to improve air quality

**TIP** - Transportation Improvement Program; program for implementation of transportation improvement projects; in the DVRPC region, adopted annually
**Transportation Air Quality Plan (TAQP)** - regional elements of a state implementation plan
**Transportation Control Measures (TCMs)** - steps taken to adjust traffic patterns and reduce vehicle use in order to reduce emissions
**Transportation Demand Management (TDM)** - programs to reduce commuter reliance on single-occupant vehicles
**Transportation Management Associations (TMAs)** - organizations made up of public and private sector participants which sponsor, promote, and administer TDMs
**Transportation Plan** - long range plan for transportation improvements
**Travel Estimates** - vehicle miles of travel based on census and other data

**Urban Airshed Model** - computer model used to predict pollutant concentrations on the basis of prevailing weather and emissions from mobile and stationary sources
**UTM System** - Universal Transverse Mercator System; a rectangular grid coordinate mapping system used to precisely locate sources when creating an emissions inventory
**UTPS** - Urban Transportation Planning System; the traffic simulation model which generates estimates of traffic volumes

**Vehicle Miles of Travel (VMT)** - measure of total miles traveled within a given geographic area within a given period of time
**Violation** - an instance in which a pollutant exceeds the standard
**Volatile Organic Compound** - any of a group of chemicals which react in the atmosphere with nitrogen oxides in the presence of sunlight to form ozone

## Appendix B-1: Vehicle Registration Distribution by Age of Vehicle for Penna. counties

| Age (years) → ↓ Vehicle type | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|---|---|---|---|---|---|---|---|---|---|---|
| LDGV | 0.079 | 0.133 | 0.118 | 0.095 | 0.090 | 0.068 | 0.059 | 0.057 | 0.057 | 0.053 |
| LDGT1 | 0.067 | 0.085 | 0.081 | 0.077 | 0.073 | 0.069 | 0.065 | 0.061 | 0.057 | 0.053 |
| LDGT2 | 0.067 | 0.085 | 0.081 | 0.077 | 0.073 | 0.069 | 0.065 | 0.061 | 0.057 | 0.053 |
| HDGV | 0.079 | 0.136 | 0.116 | 0.099 | 0.085 | 0.072 | 0.062 | 0.053 | 0.045 | 0.038 |
| LDDV | 0.079 | 0.133 | 0.118 | 0.095 | 0.090 | 0.068 | 0.059 | 0.057 | 0.057 | 0.053 |
| LDDT | 0.067 | 0.085 | 0.081 | 0.077 | 0.073 | 0.069 | 0.065 | 0.061 | 0.057 | 0.053 |
| HDDV | 0.091 | 0.151 | 0.126 | 0.105 | 0.088 | 0.073 | 0.061 | 0.051 | 0.043 | 0.036 |
| MC | 0.064 | 0.145 | 0.138 | 0.116 | 0.123 | 0.114 | 0.079 | 0.064 | 0.044 | 0.039 |

| Age (years) → ↓ Vehicle type | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 |
|---|---|---|---|---|---|---|---|---|---|---|
| LDGV | 0.047 | 0.036 | 0.026 | 0.015 | 0.014 | 0.013 | 0.010 | 0.010 | 0.010 | 0.010 |
| LDGT1 | 0.048 | 0.044 | 0.040 | 0.036 | 0.032 | 0.028 | 0.024 | 0.020 | 0.016 | 0.024 |
| LDGT2 | 0.048 | 0.044 | 0.040 | 0.036 | 0.032 | 0.028 | 0.024 | 0.020 | 0.016 | 0.024 |
| HDGV | 0.033 | 0.028 | 0.024 | 0.020 | 0.018 | 0.015 | 0.013 | 0.011 | 0.009 | 0.045 |
| LDDV | 0.047 | 0.036 | 0.026 | 0.015 | 0.014 | 0.013 | 0.010 | 0.010 | 0.010 | 0.010 |
| LDDT | 0.048 | 0.044 | 0.040 | 0.036 | 0.032 | 0.028 | 0.024 | 0.020 | 0.016 | 0.024 |
| HDDV | 0.030 | 0.025 | 0.021 | 0.017 | 0.014 | 0.012 | 0.010 | 0.008 | 0.007 | 0.031 |
| MC | 0.025 | 0.049 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |

LDGV: Light-Duty Gasoline Vehicle
LDGT1: Light-Duty Gasoline Truck under 6,000 lbs.
LDGT2: Light-Duty Gasoline Truck 6,000 lbs. to 8,000 lbs.
HDGV: Heavy-Duty Gasoline Vehicle
LDDV: Light-Duty Diesel Vehicle
LDDT: Light-Duty Diesel Truck
HDDV: Heavy-Duty Diesel Vehicle
MC: Motorcycle

Source: NJ DEPE

## Appendix B-2: Vehicle Registration Distribution by Age of Vehicle for Cecil County

| Age (years) → ↓ Vehicle type | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|---|---|---|---|---|---|---|---|---|---|---|
| LDGV | 0.061 | 0.109 | 0.105 | 0.099 | 0.085 | 0.070 | 0.059 | 0.056 | 0.059 | 0.058 |
| LDGT1 | 0.070 | 0.092 | 0.088 | 0.083 | 0.077 | 0.072 | 0.067 | 0.062 | 0.057 | 0.051 |
| LDGT2 | 0.070 | 0.092 | 0.088 | 0.083 | 0.077 | 0.072 | 0.067 | 0.062 | 0.057 | 0.051 |
| HDGV | 0.065 | 0.131 | 0.113 | 0.097 | 0.084 | 0.072 | 0.062 | 0.054 | 0.046 | 0.040 |
| LDDV | 0.061 | 0.109 | 0.105 | 0.099 | 0.085 | 0.070 | 0.059 | 0.056 | 0.059 | 0.058 |
| LDDT | 0.070 | 0.092 | 0.088 | 0.083 | 0.077 | 0.072 | 0.067 | 0.062 | 0.057 | 0.051 |
| HDDV | 0.082 | 0.165 | 0.135 | 0.111 | 0.091 | 0.075 | 0.061 | 0.050 | 0.041 | 0.034 |
| MC | 0.144 | 0.168 | 0.135 | 0.109 | 0.088 | 0.070 | 0.056 | 0.045 | 0.036 | 0.029 |

| Age (years) → ↓ Vehicle type | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 |
|---|---|---|---|---|---|---|---|---|---|---|
| LDGV | 0.034 | 0.032 | 0.029 | 0.027 | 0.024 | 0.021 | 0.019 | 0.016 | 0.013 | 0.024 |
| LDGT1 | 0.047 | 0.041 | 0.036 | 0.031 | 0.026 | 0.021 | 0.016 | 0.011 | 0.007 | 0.044 |
| LDGT2 | 0.047 | 0.041 | 0.036 | 0.031 | 0.026 | 0.021 | 0.016 | 0.011 | 0.007 | 0.044 |
| HDGV | 0.034 | 0.030 | 0.026 | 0.022 | 0.019 | 0.016 | 0.014 | 0.012 | 0.010 | 0.052 |
| LDDV | 0.034 | 0.032 | 0.029 | 0.027 | 0.024 | 0.021 | 0.019 | 0.016 | 0.013 | 0.024 |
| LDDT | 0.047 | 0.041 | 0.036 | 0.031 | 0.026 | 0.021 | 0.016 | 0.011 | 0.007 | 0.044 |
| HDDV | 0.028 | 0.023 | 0.019 | 0.015 | 0.013 | 0.010 | 0.009 | 0.007 | 0.006 | 0.024 |
| MC | 0.023 | 0.097 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |

LDGV: Light-Duty Gasoline Vehicle
LDGT1: Light-Duty Gasoline Truck under 6,000 lbs.
LDGT2: Light-Duty Gasoline Truck 6,000 lbs. to 8,000 lbs.
HDGV: Heavy-Duty Gasoline Vehicle
LDDV: Light-Duty Diesel Vehicle
LDDT: Light-Duty Diesel Truck
HDDV: Heavy-Duty Diesel Vehicle
MC: Motorcycle

Source: Maryland Department of the Environment

## Appendix C: Vehicle Miles of Travel and Average Speed by Functional Class and Grid Cell

| UAM 5K GRID E | N | FREEWAY VEH MILES (000) | FREEWAY AVG SPEED (MPH) | ARTERIAL VEH MILES (000) | ARTERIAL AVG SPEED (MPH) | LOCAL VEH MILES (000) | LOCAL AVG SPEED (MPH) | TOTAL VEH MILES (000) | TOTAL AVG SPEED (MPH) |
|---|---|---|---|---|---|---|---|---|---|
| 2 | 20 | 0.0 | 0.0 | 15.6 | 51.8 | 2.5 | 31.2 | 18.1 | 47.5 |
| 2 | 21 | 0.0 | 0.0 | 3.9 | 50.0 | 1.7 | 29.7 | 5.6 | 41.4 |
| 3 | 18 | 0.0 | 0.0 | 6.0 | 50.0 | 1.4 | 35.0 | 7.5 | 46.2 |
| 3 | 19 | 0.0 | 0.0 | 0.0 | 0.0 | 15.4 | 35.0 | 15.4 | 35.0 |
| 3 | 20 | 0.0 | 0.0 | 32.6 | 54.4 | 14.3 | 34.9 | 46.8 | 46.5 |
| 3 | 21 | 0.0 | 0.0 | 5.5 | 50.0 | 5.5 | 34.2 | 11.0 | 40.7 |
| 4 | 17 | 0.0 | 0.0 | 21.0 | 40.0 | 10.2 | 32.2 | 31.3 | 37.1 |
| 4 | 18 | 166.5 | 55.0 | 82.8 | 47.4 | 20.5 | 34.3 | 269.8 | 50.2 |
| 4 | 19 | 0.0 | 0.0 | 21.0 | 50.0 | 6.3 | 29.9 | 27.3 | 43.3 |
| 4 | 20 | 0.0 | 0.0 | 45.2 | 48.6 | 14.2 | 34.2 | 59.4 | 44.1 |
| 4 | 21 | 0.0 | 0.0 | 12.2 | 55.0 | 6.6 | 34.3 | 18.8 | 45.4 |
| 4 | 22 | 0.0 | 0.0 | 2.3 | 33.7 | 0.4 | 24.1 | 2.7 | 31.7 |
| 5 | 13 | 0.0 | 0.0 | 0.0 | 0.0 | 0.2 | 25.0 | 0.2 | 25.0 |
| 5 | 14 | 0.0 | 0.0 | 0.0 | 0.0 | 2.5 | 31.4 | 2.5 | 31.4 |
| 5 | 15 | 0.0 | 0.0 | 2.5 | 50.0 | 1.0 | 25.0 | 3.5 | 39.2 |
| 5 | 16 | 0.0 | 0.0 | 0.0 | 0.0 | 0.1 | 25.0 | 0.1 | 25.0 |
| 5 | 17 | 0.0 | 0.0 | 0.0 | 0.0 | 2.4 | 26.5 | 2.4 | 26.5 |
| 5 | 18 | 159.2 | 55.0 | 80.1 | 54.3 | 8.0 | 35.0 | 247.4 | 53.8 |
| 5 | 19 | 23.9 | 55.0 | 1.5 | 50.0 | 10.8 | 34.9 | 36.2 | 46.8 |
| 5 | 20 | 0.0 | 0.0 | 18.9 | 50.0 | 16.1 | 35.0 | 35.0 | 41.8 |
| 5 | 21 | 7.7 | 54.4 | 33.3 | 47.5 | 13.9 | 32.3 | 54.9 | 43.1 |
| 5 | 22 | 34.9 | 38.6 | 8.9 | 29.7 | 5.2 | 26.6 | 49.0 | 35.0 |
| 5 | 23 | 0.0 | 0.0 | 6.9 | 29.6 | 2.3 | 22.1 | 9.2 | 27.3 |
| 5 | 24 | 0.0 | 0.0 | 1.2 | 33.9 | 0.2 | 24.1 | 1.4 | 31.8 |
| 6 | 13 | 0.0 | 0.0 | 0.0 | 0.0 | 0.2 | 25.0 | 0.2 | 25.0 |
| 6 | 14 | 0.0 | 0.0 | 0.3 | 50.0 | 5.5 | 33.2 | 5.8 | 33.7 |
| 6 | 15 | 0.0 | 0.0 | 18.9 | 50.0 | 1.1 | 28.8 | 20.0 | 48.1 |
| 6 | 16 | 0.0 | 0.0 | 8.2 | 50.0 | 2.4 | 26.7 | 10.7 | 41.8 |
| 6 | 17 | 0.0 | 0.0 | 7.1 | 50.0 | 7.3 | 33.8 | 14.4 | 40.2 |
| 6 | 18 | 0.0 | 0.0 | 145.4 | 52.0 | 14.7 | 30.9 | 160.2 | 48.9 |
| 6 | 19 | 159.2 | 55.0 | 43.4 | 50.0 | 22.3 | 35.0 | 224.9 | 51.1 |
| 6 | 20 | 0.0 | 0.0 | 27.6 | 50.0 | 10.4 | 34.4 | 38.1 | 44.5 |
| 6 | 21 | 0.0 | 0.0 | 19.0 | 41.2 | 7.6 | 31.0 | 26.6 | 37.6 |
| 6 | 22 | 2.8 | 38.2 | 22.7 | 27.9 | 10.6 | 27.9 | 36.1 | 28.5 |
| 6 | 23 | 29.4 | 44.3 | 25.0 | 32.5 | 5.1 | 28.2 | 59.5 | 36.9 |
| 6 | 24 | 0.0 | 0.0 | 9.3 | 33.5 | 2.3 | 28.2 | 11.5 | 32.3 |
| 6 | 25 | 0.0 | 0.0 | 16.3 | 40.7 | 5.0 | 24.3 | 21.3 | 35.1 |
| 6 | 26 | 0.0 | 0.0 | 60.5 | 34.0 | 36.7 | 22.3 | 97.2 | 28.4 |
| 6 | 27 | 0.0 | 0.0 | 43.1 | 21.3 | 21.6 | 18.9 | 64.7 | 20.4 |
| 6 | 28 | 0.0 | 0.0 | 3.4 | 33.5 | 0.7 | 24.1 | 4.1 | 31.5 |
| 6 | 29 | 0.0 | 0.0 | 2.2 | 29.9 | 0.4 | 24.1 | 2.7 | 28.8 |
| 7 | 13 | 0.0 | 0.0 | 20.7 | 55.0 | 1.5 | 35.0 | 22.2 | 53.0 |
| 7 | 14 | 0.0 | 0.0 | 14.9 | 52.2 | 6.3 | 33.4 | 21.2 | 44.7 |
| 7 | 15 | 0.0 | 0.0 | 0.0 | 0.0 | 6.1 | 32.1 | 6.1 | 32.1 |
| 7 | 16 | 0.0 | 0.0 | 0.0 | 0.0 | 4.5 | 33.2 | 4.5 | 33.2 |
| 7 | 17 | 0.0 | 0.0 | 0.0 | 0.0 | 27.8 | 34.9 | 27.8 | 34.9 |
| 7 | 18 | 0.0 | 0.0 | 99.1 | 54.4 | 6.6 | 35.0 | 105.7 | 52.6 |
| 7 | 19 | 159.2 | 55.0 | 0.8 | 50.0 | 12.3 | 34.8 | 172.3 | 52.8 |
| 7 | 20 | 0.0 | 0.0 | 21.0 | 50.0 | 6.8 | 35.0 | 27.8 | 45.3 |
| 7 | 21 | 0.0 | 0.0 | 5.9 | 36.0 | 5.1 | 30.6 | 10.9 | 33.3 |
| 7 | 22 | 0.0 | 0.0 | 7.0 | 33.2 | 13.0 | 27.8 | 20.0 | 29.4 |
| 7 | 23 | 33.1 | 49.7 | 17.0 | 33.6 | 3.3 | 24.1 | 53.5 | 40.8 |
| 7 | 24 | 0.0 | 0.0 | 30.8 | 36.6 | 6.0 | 24.1 | 36.7 | 33.7 |

| UAM 5K GRID E | N | FREEWAY VEH MILES (000) | FREEWAY AVG SPEED (MPH) | ARTERIAL VEH MILES (000) | ARTERIAL AVG SPEED (MPH) | LOCAL VEH MILES (000) | LOCAL AVG SPEED (MPH) | TOTAL VEH MILES (000) | TOTAL AVG SPEED (MPH) |
|---|---|---|---|---|---|---|---|---|---|
| 7 | 25 | 0.0 | 0.0 | 37.2 | 37.8 | 7.3 | 28.2 | 44.6 | 35.8 |
| 7 | 26 | 0.0 | 0.0 | 34.9 | 25.7 | 16.7 | 22.0 | 51.6 | 24.4 |
| 7 | 27 | 44.1 | 46.9 | 34.8 | 34.0 | 7.9 | 28.0 | 86.8 | 38.7 |
| 7 | 28 | 0.0 | 0.0 | 11.5 | 31.9 | 4.3 | 23.6 | 15.8 | 29.1 |
| 7 | 29 | 0.0 | 0.0 | 35.8 | 30.8 | 12.9 | 27.3 | 48.7 | 29.8 |
| 7 | 30 | 0.0 | 0.0 | 3.4 | 24.3 | 0.7 | 27.9 | 4.2 | 24.9 |
| 8 | 13 | 0.0 | 0.0 | 0.0 | 0.0 | 0.5 | 35.0 | 0.5 | 35.0 |
| 8 | 14 | 0.0 | 0.0 | 32.8 | 48.1 | 5.2 | 34.5 | 38.0 | 45.6 |
| 8 | 15 | 0.0 | 0.0 | 47.3 | 55.0 | 1.6 | 26.8 | 48.9 | 53.1 |
| 8 | 16 | 0.0 | 0.0 | 42.7 | 54.8 | 4.4 | 35.0 | 47.1 | 52.0 |
| 8 | 17 | 0.0 | 0.0 | 3.5 | 35.0 | 5.3 | 32.4 | 8.8 | 33.4 |
| 8 | 18 | 0.0 | 0.0 | 135.9 | 43.8 | 10.7 | 31.2 | 146.5 | 42.6 |
| 8 | 19 | 159.2 | 55.0 | 38.8 | 51.6 | 3.2 | 33.8 | 201.2 | 53.8 |
| 8 | 20 | 0.0 | 0.0 | 37.2 | 50.0 | 10.1 | 35.0 | 47.3 | 45.8 |
| 8 | 21 | 0.0 | 0.0 | 5.6 | 46.5 | 3.5 | 29.6 | 9.1 | 38.2 |
| 8 | 22 | 0.0 | 0.0 | 15.0 | 32.9 | 3.6 | 28.1 | 18.6 | 31.8 |
| 8 | 23 | 46.5 | 39.8 | 23.8 | 26.2 | 4.8 | 21.1 | 75.2 | 32.6 |
| 8 | 24 | 0.0 | 0.0 | 33.8 | 40.3 | 14.7 | 27.4 | 48.5 | 35.3 |
| 8 | 25 | 0.0 | 0.0 | 10.4 | 33.4 | 13.7 | 27.6 | 24.1 | 29.9 |
| 8 | 26 | 0.0 | 0.0 | 53.5 | 31.6 | 10.6 | 27.2 | 64.1 | 30.8 |
| 8 | 27 | 69.2 | 49.0 | 79.0 | 24.2 | 19.1 | 26.4 | 167.2 | 30.9 |
| 8 | 28 | 0.0 | 0.0 | 0.0 | 0.0 | 10.9 | 27.5 | 10.9 | 27.5 |
| 8 | 29 | 0.0 | 0.0 | 37.5 | 40.8 | 13.9 | 27.8 | 51.4 | 36.2 |
| 8 | 30 | 61.8 | 52.7 | 21.1 | 24.8 | 12.3 | 27.8 | 95.2 | 38.6 |
| 8 | 31 | 0.0 | 0.0 | 14.5 | 22.3 | 2.8 | 24.1 | 17.4 | 22.6 |
| 9 | 13 | 0.0 | 0.0 | 7.8 | 54.7 | 0.3 | 25.0 | 8.1 | 52.7 |
| 9 | 14 | 0.0 | 0.0 | 19.3 | 53.8 | 5.7 | 34.4 | 25.0 | 47.7 |
| 9 | 15 | 0.0 | 0.0 | 0.0 | 0.0 | 5.2 | 35.0 | 5.2 | 35.0 |
| 9 | 16 | 0.0 | 0.0 | 2.5 | 50.0 | 1.8 | 33.1 | 4.2 | 41.2 |
| 9 | 17 | 0.0 | 0.0 | 42.2 | 53.7 | 6.8 | 33.4 | 48.9 | 49.5 |
| 9 | 18 | 0.0 | 0.0 | 49.0 | 49.1 | 4.6 | 29.6 | 53.6 | 46.5 |
| 9 | 19 | 74.0 | 55.0 | 41.7 | 52.9 | 4.1 | 35.0 | 119.8 | 53.2 |
| 9 | 20 | 0.0 | 0.0 | 11.5 | 50.0 | 8.5 | 34.7 | 20.0 | 42.1 |
| 9 | 21 | 0.0 | 0.0 | 15.1 | 33.0 | 6.8 | 28.6 | 21.9 | 31.5 |
| 9 | 22 | 0.0 | 0.0 | 6.8 | 26.7 | 18.9 | 27.3 | 25.7 | 27.1 |
| 9 | 23 | 17.2 | 49.4 | 45.3 | 27.8 | 17.4 | 26.4 | 79.9 | 30.3 |
| 9 | 24 | 54.0 | 34.9 | 13.2 | 36.7 | 3.6 | 27.9 | 70.8 | 34.7 |
| 9 | 25 | 0.0 | 0.0 | 6.8 | 33.8 | 2.3 | 27.9 | 9.1 | 32.1 |
| 9 | 26 | 0.0 | 0.0 | 10.1 | 28.1 | 12.1 | 22.7 | 22.2 | 24.9 |
| 9 | 27 | 143.4 | 47.5 | 95.7 | 19.9 | 36.2 | 20.0 | 275.3 | 28.6 |
| 9 | 28 | 0.0 | 0.0 | 59.5 | 35.5 | 25.0 | 26.7 | 84.4 | 32.3 |
| 9 | 29 | 0.0 | 0.0 | 17.4 | 32.9 | 22.0 | 27.5 | 39.4 | 29.6 |
| 9 | 30 | 100.2 | 52.7 | 48.3 | 29.9 | 9.4 | 24.1 | 157.9 | 40.5 |
| 9 | 31 | 0.0 | 0.0 | 22.4 | 28.3 | 7.2 | 28.0 | 29.5 | 28.3 |
| 10 | 22 | 0.0 | 0.0 | 8.3 | 34.9 | 1.6 | 24.1 | 10.0 | 32.6 |
| 10 | 23 | 0.0 | 0.0 | 84.5 | 28.6 | 17.9 | 22.3 | 102.3 | 27.2 |
| 10 | 24 | 65.3 | 26.2 | 46.2 | 21.4 | 13.0 | 17.5 | 124.5 | 23.1 |
| 10 | 25 | 0.0 | 0.0 | 14.9 | 33.6 | 11.4 | 27.4 | 26.3 | 30.6 |
| 10 | 26 | 0.0 | 0.0 | 13.2 | 33.8 | 4.8 | 27.9 | 17.9 | 32.0 |
| 10 | 27 | 151.2 | 43.9 | 91.2 | 23.8 | 33.1 | 20.6 | 275.5 | 31.0 |
| 10 | 28 | 0.0 | 0.0 | 24.1 | 24.4 | 11.5 | 27.9 | 35.6 | 25.5 |
| 10 | 29 | 115.1 | 51.9 | 0.0 | 0.0 | 21.3 | 27.1 | 136.4 | 45.4 |
| 10 | 30 | 4.8 | 52.4 | 32.7 | 31.2 | 11.9 | 27.8 | 49.5 | 31.5 |
| 10 | 31 | 0.0 | 0.0 | 24.7 | 32.4 | 5.8 | 28.1 | 30.4 | 31.5 |
| 10 | 32 | 0.0 | 0.0 | 0.0 | 0.0 | 6.0 | 27.7 | 6.0 | 27.7 |
| 11 | 23 | 0.0 | 0.0 | 0.0 | 0.0 | 7.0 | 27.3 | 7.0 | 27.3 |

| UAM 5K GRID E | N | FREEWAY VEH MILES (000) | FREEWAY AVG SPEED (MPH) | ARTERIAL VEH MILES (000) | ARTERIAL AVG SPEED (MPH) | LOCAL VEH MILES (000) | LOCAL AVG SPEED (MPH) | TOTAL VEH MILES (000) | TOTAL AVG SPEED (MPH) |
|---|---|---|---|---|---|---|---|---|---|
| 11 | 24 | 9.3 | 26.6 | 142.7 | 32.9 | 35.3 | 25.0 | 187.2 | 30.7 |
| 11 | 25 | 0.0 | 0.0 | 18.9 | 31.5 | 24.6 | 26.5 | 43.5 | 28.5 |
| 11 | 26 | 0.0 | 0.0 | 50.2 | 35.4 | 21.4 | 27.2 | 71.6 | 32.5 |
| 11 | 27 | 53.4 | 52.0 | 92.9 | 22.9 | 18.0 | 24.1 | 164.3 | 28.2 |
| 11 | 28 | 0.0 | 0.0 | 186.6 | 22.3 | 64.5 | 19.3 | 251.1 | 21.4 |
| 11 | 29 | 110.3 | 52.1 | 82.5 | 32.4 | 30.5 | 19.3 | 223.4 | 35.7 |
| 11 | 30 | 0.0 | 0.0 | 50.5 | 36.9 | 11.2 | 28.0 | 61.6 | 34.9 |
| 11 | 31 | 0.0 | 0.0 | 82.6 | 35.8 | 16.3 | 28.2 | 98.9 | 34.2 |
| 11 | 32 | 106.2 | 53.3 | 55.6 | 28.7 | 26.3 | 20.5 | 188.1 | 36.1 |
| 11 | 33 | 40.4 | 53.5 | 17.6 | 24.5 | 28.4 | 15.6 | 86.3 | 26.2 |
| 11 | 34 | 0.0 | 0.0 | 0.0 | 0.0 | 0.7 | 27.3 | 0.7 | 27.3 |
| 12 | 23 | 0.0 | 0.0 | 6.7 | 32.2 | 1.3 | 24.1 | 8.0 | 30.6 |
| 12 | 24 | 0.0 | 0.0 | 122.2 | 39.3 | 24.5 | 27.7 | 146.7 | 36.7 |
| 12 | 25 | 6.7 | 10.8 | 52.1 | 29.6 | 32.1 | 26.0 | 90.9 | 25.1 |
| 12 | 26 | 56.8 | 18.8 | 143.6 | 18.7 | 39.3 | 17.0 | 239.6 | 18.4 |
| 12 | 27 | 171.0 | 46.3 | 114.4 | 23.3 | 28.7 | 27.5 | 314.1 | 32.6 |
| 12 | 28 | 28.6 | 30.0 | 238.7 | 29.4 | 47.2 | 20.6 | 314.5 | 27.7 |
| 12 | 29 | 92.1 | 52.4 | 42.8 | 30.5 | 8.9 | 28.1 | 143.8 | 41.4 |
| 12 | 30 | 0.0 | 0.0 | 17.0 | 33.1 | 9.3 | 27.6 | 26.4 | 30.9 |
| 12 | 31 | 0.0 | 0.0 | 22.6 | 33.3 | 5.2 | 28.1 | 27.8 | 32.2 |
| 12 | 32 | 90.9 | 43.7 | 73.9 | 25.8 | 34.5 | 17.2 | 199.4 | 28.7 |
| 12 | 33 | 22.6 | 54.0 | 14.9 | 23.0 | 66.9 | 20.4 | 104.5 | 24.1 |
| 12 | 34 | 46.3 | 53.9 | 44.6 | 39.1 | 24.8 | 27.0 | 115.7 | 39.6 |
| 12 | 35 | 0.0 | 0.0 | 0.0 | 0.0 | 4.3 | 27.4 | 4.3 | 27.4 |
| 13 | 23 | 5.8 | 49.1 | 0.7 | 33.9 | 2.1 | 27.1 | 8.5 | 39.8 |
| 13 | 24 | 106.5 | 49.0 | 144.7 | 31.7 | 37.3 | 27.1 | 288.5 | 35.5 |
| 13 | 25 | 71.6 | 34.2 | 52.5 | 32.0 | 48.8 | 26.9 | 172.9 | 31.1 |
| 13 | 26 | 76.7 | 49.0 | 129.7 | 30.2 | 52.4 | 25.1 | 258.7 | 32.5 |
| 13 | 27 | 35.7 | 39.6 | 94.2 | 31.3 | 22.5 | 27.8 | 152.4 | 32.2 |
| 13 | 28 | 207.4 | 40.7 | 167.5 | 20.7 | 34.8 | 20.5 | 409.7 | 27.5 |
| 13 | 29 | 92.8 | 52.3 | 49.1 | 25.9 | 14.8 | 27.0 | 156.7 | 37.2 |
| 13 | 30 | 0.0 | 0.0 | 90.3 | 26.4 | 26.9 | 25.0 | 117.2 | 26.1 |
| 13 | 31 | 6.0 | 52.4 | 89.3 | 19.4 | 22.9 | 18.6 | 118.1 | 19.9 |
| 13 | 32 | 134.8 | 49.0 | 51.4 | 32.1 | 12.3 | 26.6 | 198.5 | 41.2 |
| 13 | 33 | 0.0 | 0.0 | 30.1 | 26.8 | 19.9 | 21.0 | 50.1 | 24.1 |
| 13 | 34 | 0.0 | 0.0 | 49.2 | 37.1 | 12.4 | 27.8 | 61.5 | 34.7 |
| 13 | 35 | 0.0 | 0.0 | 10.7 | 32.9 | 17.2 | 27.6 | 28.0 | 29.4 |
| 13 | 36 | 0.0 | 0.0 | 2.6 | 21.8 | 3.2 | 28.0 | 5.8 | 24.8 |
| 13 | 37 | 0.0 | 0.0 | 4.2 | 21.8 | 0.7 | 13.9 | 4.9 | 20.2 |
| 14 | 23 | 0.0 | 0.0 | 42.5 | 17.1 | 13.0 | 17.2 | 55.6 | 17.2 |
| 14 | 24 | 0.0 | 0.0 | 141.3 | 28.8 | 38.8 | 26.8 | 180.1 | 28.3 |
| 14 | 25 | 0.0 | 0.0 | 121.5 | 35.4 | 37.1 | 26.1 | 158.6 | 32.7 |
| 14 | 26 | 0.0 | 0.0 | 163.6 | 36.4 | 69.2 | 25.2 | 232.9 | 32.1 |
| 14 | 27 | 0.0 | 0.0 | 30.5 | 32.2 | 59.4 | 26.8 | 89.9 | 28.4 |
| 14 | 28 | 196.1 | 37.8 | 157.6 | 20.6 | 64.8 | 16.6 | 418.5 | 25.0 |
| 14 | 29 | 93.2 | 52.3 | 54.3 | 26.4 | 61.6 | 20.7 | 209.0 | 30.7 |
| 14 | 30 | 14.9 | 48.5 | 138.6 | 19.0 | 36.8 | 14.1 | 190.2 | 18.6 |
| 14 | 31 | 150.2 | 50.4 | 96.0 | 29.8 | 17.2 | 20.6 | 263.4 | 37.4 |
| 14 | 32 | 0.0 | 0.0 | 78.5 | 33.7 | 17.7 | 27.2 | 96.2 | 32.3 |
| 14 | 33 | 0.0 | 0.0 | 26.4 | 39.8 | 21.8 | 20.8 | 48.2 | 28.2 |
| 14 | 34 | 0.0 | 0.0 | 18.5 | 33.5 | 11.8 | 25.7 | 30.3 | 30.0 |
| 14 | 35 | 0.0 | 0.0 | 30.4 | 26.9 | 16.9 | 20.8 | 47.3 | 24.3 |
| 14 | 36 | 0.0 | 0.0 | 49.5 | 23.0 | 16.5 | 20.5 | 66.0 | 22.3 |
| 15 | 23 | 193.8 | 47.6 | 111.1 | 19.3 | 44.2 | 8.6 | 349.1 | 23.3 |
| 15 | 24 | 25.3 | 52.8 | 231.1 | 16.6 | 90.1 | 15.4 | 346.5 | 17.1 |
| 15 | 25 | 25.1 | 35.6 | 277.7 | 20.4 | 81.6 | 18.4 | 384.4 | 20.5 |

| UAM 5K GRID E | N | FREEWAY VEH MILES (000) | FREEWAY AVG SPEED (MPH) | ARTERIAL VEH MILES (000) | ARTERIAL AVG SPEED (MPH) | LOCAL VEH MILES (000) | LOCAL AVG SPEED (MPH) | TOTAL VEH MILES (000) | TOTAL AVG SPEED (MPH) |
|---|---|---|---|---|---|---|---|---|---|
| 15 | 26 | 0.0 | 0.0 | 141.2 | 25.7 | 47.4 | 17.5 | 188.6 | 23.0 |
| 15 | 27 | 0.0 | 0.0 | 139.6 | 28.4 | 59.2 | 25.0 | 198.8 | 27.3 |
| 15 | 28 | 56.0 | 34.3 | 252.8 | 18.3 | 65.2 | 19.0 | 374.0 | 19.8 |
| 15 | 29 | 403.0 | 28.3 | 187.8 | 16.7 | 55.6 | 19.3 | 646.4 | 22.8 |
| 15 | 30 | 220.8 | 47.7 | 116.2 | 21.5 | 41.9 | 18.7 | 378.9 | 30.9 |
| 15 | 31 | 0.0 | 0.0 | 114.2 | 29.4 | 23.2 | 22.2 | 137.4 | 27.8 |
| 15 | 32 | 0.0 | 0.0 | 77.3 | 26.9 | 22.4 | 23.5 | 99.7 | 26.1 |
| 15 | 33 | 0.0 | 0.0 | 22.5 | 24.4 | 31.4 | 21.1 | 53.9 | 22.3 |
| 15 | 34 | 0.0 | 0.0 | 30.5 | 28.0 | 14.2 | 24.6 | 44.7 | 26.8 |
| 15 | 35 | 0.0 | 0.0 | 1.1 | 24.0 | 8.4 | 24.7 | 9.5 | 24.6 |
| 15 | 36 | 52.4 | 53.0 | 14.7 | 33.5 | 20.2 | 24.2 | 87.2 | 38.6 |
| 15 | 37 | 50.1 | 53.5 | 13.1 | 39.4 | 16.5 | 22.5 | 79.7 | 39.8 |
| 15 | 38 | 0.0 | 0.0 | 0.0 | 0.0 | 1.3 | 27.8 | 1.3 | 27.8 |
| 16 | 22 | 0.0 | 0.0 | 2.6 | 42.3 | 0.5 | 14.1 | 3.1 | 31.8 |
| 16 | 23 | 176.8 | 38.9 | 48.7 | 18.6 | 32.1 | 25.3 | 257.5 | 30.5 |
| 16 | 24 | 294.1 | 35.4 | 360.2 | 13.7 | 101.3 | 11.2 | 755.7 | 17.3 |
| 16 | 25 | 21.1 | 35.6 | 396.3 | 15.4 | 105.9 | 12.4 | 523.3 | 15.0 |
| 16 | 26 | 72.0 | 32.6 | 223.8 | 16.4 | 110.6 | 21.9 | 406.4 | 19.5 |
| 16 | 27 | 0.0 | 0.0 | 350.5 | 13.5 | 115.5 | 13.3 | 466.0 | 13.4 |
| 16 | 28 | 0.0 | 0.0 | 322.6 | 14.5 | 103.4 | 16.9 | 426.0 | 15.0 |
| 16 | 29 | 440.6 | 32.9 | 294.4 | 14.5 | 155.8 | 11.7 | 890.9 | 18.9 |
| 16 | 30 | 0.0 | 0.0 | 273.7 | 18.2 | 91.4 | 12.1 | 365.2 | 16.2 |
| 16 | 31 | 0.0 | 0.0 | 112.8 | 24.9 | 26.1 | 21.8 | 138.9 | 24.3 |
| 16 | 32 | 0.0 | 0.0 | 74.6 | 35.8 | 21.5 | 27.4 | 96.1 | 33.5 |
| 16 | 33 | 49.3 | 53.4 | 64.4 | 23.5 | 13.3 | 23.4 | 127.1 | 30.0 |
| 16 | 34 | 69.8 | 53.5 | 34.3 | 32.2 | 23.0 | 24.7 | 127.0 | 38.5 |
| 16 | 35 | 74.5 | 53.3 | 14.9 | 33.1 | 15.5 | 21.4 | 105.0 | 40.8 |
| 16 | 36 | 32.4 | 53.0 | 8.5 | 26.0 | 7.8 | 20.8 | 48.7 | 37.1 |
| 16 | 37 | 0.0 | 0.0 | 111.8 | 31.4 | 25.5 | 25.5 | 137.3 | 30.1 |
| 16 | 38 | 0.0 | 0.0 | 44.6 | 41.5 | 18.3 | 27.6 | 62.9 | 36.2 |
| 17 | 23 | 2.8 | 49.1 | 0.0 | 0.0 | 0.0 | 0.0 | 2.8 | 49.1 |
| 17 | 24 | 332.8 | 48.9 | 247.7 | 21.3 | 63.9 | 17.7 | 644.4 | 29.2 |
| 17 | 25 | 0.0 | 0.0 | 618.6 | 12.4 | 156.3 | 10.6 | 775.0 | 12.0 |
| 17 | 26 | 0.0 | 0.0 | 579.3 | 13.0 | 137.6 | 10.2 | 716.9 | 12.3 |
| 17 | 27 | 0.0 | 0.0 | 405.8 | 13.9 | 155.6 | 12.6 | 561.4 | 13.5 |
| 17 | 28 | 168.6 | 26.7 | 321.9 | 16.8 | 154.1 | 13.7 | 644.6 | 17.6 |
| 17 | 29 | 378.3 | 34.6 | 287.7 | 13.5 | 147.6 | 15.0 | 813.6 | 19.3 |
| 17 | 30 | 21.1 | 19.9 | 379.7 | 13.5 | 134.2 | 10.6 | 535.0 | 12.8 |
| 17 | 31 | 110.9 | 51.6 | 139.2 | 21.0 | 58.9 | 12.7 | 309.0 | 23.0 |
| 17 | 32 | 110.8 | 51.6 | 190.4 | 25.8 | 44.9 | 19.6 | 346.1 | 29.3 |
| 17 | 33 | 23.3 | 53.4 | 119.2 | 21.3 | 37.4 | 21.6 | 179.9 | 23.2 |
| 17 | 34 | 73.6 | 53.0 | 90.5 | 23.0 | 40.5 | 19.7 | 204.7 | 27.7 |
| 17 | 35 | 81.2 | 54.0 | 62.1 | 26.6 | 38.6 | 20.8 | 181.9 | 31.9 |
| 17 | 36 | 28.8 | 54.2 | 66.3 | 31.9 | 13.0 | 16.2 | 108.1 | 31.7 |
| 17 | 37 | 0.0 | 0.0 | 80.5 | 21.9 | 32.7 | 18.5 | 113.2 | 20.8 |
| 17 | 38 | 0.0 | 0.0 | 6.6 | 26.0 | 33.2 | 20.1 | 39.8 | 20.9 |
| 17 | 39 | 0.0 | 0.0 | 8.9 | 33.4 | 5.7 | 27.4 | 14.6 | 30.8 |
| 18 | 24 | 328.1 | 47.5 | 44.1 | 18.3 | 18.6 | 9.3 | 390.9 | 34.6 |
| 18 | 25 | 29.7 | 47.7 | 512.8 | 15.0 | 119.6 | 13.7 | 662.2 | 15.2 |
| 18 | 26 | 0.0 | 0.0 | 777.8 | 12.3 | 241.4 | 9.4 | 1019.1 | 11.5 |
| 18 | 27 | 0.0 | 0.0 | 542.9 | 14.6 | 226.0 | 11.5 | 768.9 | 13.6 |
| 18 | 28 | 300.3 | 21.3 | 118.2 | 15.8 | 74.9 | 14.6 | 493.4 | 18.5 |
| 18 | 29 | 114.4 | 30.8 | 396.4 | 16.3 | 89.8 | 15.3 | 600.6 | 17.7 |
| 18 | 30 | 243.3 | 50.9 | 197.6 | 19.7 | 83.4 | 11.4 | 524.4 | 23.7 |
| 18 | 31 | 0.0 | 0.0 | 163.4 | 17.4 | 49.6 | 18.1 | 213.0 | 17.5 |
| 18 | 32 | 0.0 | 0.0 | 324.5 | 15.1 | 94.2 | 11.3 | 418.7 | 14.0 |

| UAM 5K GRID E | N | FREEWAY VEH MILES (000) | FREEWAY AVG SPEED (MPH) | ARTERIAL VEH MILES (000) | ARTERIAL AVG SPEED (MPH) | LOCAL VEH MILES (000) | LOCAL AVG SPEED (MPH) | TOTAL VEH MILES (000) | TOTAL AVG SPEED (MPH) |
|---|---|---|---|---|---|---|---|---|---|
| 18 | 33 | 0.0 | 0.0 | 253.3 | 17.9 | 101.2 | 18.1 | 354.5 | 18.0 |
| 18 | 34 | 0.0 | 0.0 | 83.0 | 28.8 | 14.3 | 14.8 | 97.3 | 25.3 |
| 18 | 35 | 0.0 | 0.0 | 29.4 | 25.5 | 9.5 | 22.6 | 38.9 | 24.7 |
| 18 | 36 | 0.0 | 0.0 | 57.9 | 35.3 | 16.7 | 27.8 | 74.6 | 33.3 |
| 18 | 37 | 0.0 | 0.0 | 23.8 | 33.7 | 9.1 | 21.7 | 33.0 | 29.3 |
| 18 | 38 | 0.0 | 0.0 | 10.4 | 33.5 | 2.0 | 17.7 | 12.4 | 29.3 |
| 18 | 39 | 0.0 | 0.0 | 5.7 | 34.0 | 1.1 | 17.7 | 6.8 | 29.6 |
| 18 | 40 | 0.0 | 0.0 | 1.0 | 34.1 | 0.2 | 17.7 | 1.2 | 29.7 |
| 19 | 24 | 42.8 | 52.2 | 14.6 | 30.3 | 2.8 | 10.7 | 60.2 | 38.6 |
| 19 | 25 | 510.3 | 41.5 | 295.0 | 17.3 | 64.1 | 11.8 | 869.4 | 25.0 |
| 19 | 26 | 424.5 | 25.2 | 957.3 | 13.1 | 356.2 | 9.7 | 1738.0 | 13.7 |
| 19 | 27 | 698.1 | 24.0 | 689.6 | 16.2 | 149.9 | 12.5 | 1537.6 | 18.4 |
| 19 | 28 | 50.6 | 16.3 | 501.1 | 14.0 | 174.2 | 12.5 | 725.9 | 13.7 |
| 19 | 29 | 105.6 | 12.0 | 408.3 | 13.1 | 126.7 | 12.2 | 640.6 | 12.7 |
| 19 | 30 | 371.0 | 30.2 | 233.3 | 16.6 | 111.7 | 12.3 | 716.0 | 20.2 |
| 19 | 31 | 146.3 | 46.9 | 199.9 | 19.9 | 83.5 | 14.7 | 429.6 | 22.8 |
| 19 | 32 | 0.0 | 0.0 | 203.2 | 17.8 | 76.5 | 12.5 | 279.8 | 16.0 |
| 19 | 33 | 0.0 | 0.0 | 178.8 | 21.2 | 44.8 | 17.9 | 223.6 | 20.5 |
| 19 | 34 | 0.0 | 0.0 | 42.9 | 23.0 | 9.8 | 20.8 | 52.7 | 22.6 |
| 19 | 35 | 0.0 | 0.0 | 54.4 | 29.8 | 11.8 | 20.9 | 66.2 | 27.7 |
| 19 | 36 | 0.0 | 0.0 | 13.4 | 37.7 | 4.0 | 21.4 | 17.4 | 32.1 |
| 19 | 37 | 0.0 | 0.0 | 1.2 | 34.1 | 4.4 | 28.0 | 5.6 | 29.1 |
| 19 | 38 | 0.0 | 0.0 | 10.0 | 34.0 | 1.9 | 28.1 | 11.9 | 32.9 |
| 19 | 39 | 0.0 | 0.0 | 17.4 | 41.0 | 3.8 | 28.1 | 21.2 | 37.9 |
| 19 | 40 | 0.0 | 0.0 | 24.7 | 41.2 | 5.4 | 27.4 | 30.1 | 37.8 |
| 19 | 41 | 0.0 | 0.0 | 1.0 | 42.0 | 0.2 | 17.7 | 1.2 | 34.4 |
| 20 | 25 | 437.8 | 48.3 | 224.9 | 17.5 | 141.3 | 16.8 | 804.0 | 26.5 |
| 20 | 26 | 358.0 | 46.6 | 973.7 | 12.5 | 285.7 | 10.9 | 1617.3 | 14.5 |
| 20 | 27 | 207.3 | 30.2 | 908.5 | 15.4 | 195.7 | 9.7 | 1311.4 | 15.2 |
| 20 | 28 | 0.0 | 0.0 | 925.8 | 13.4 | 241.8 | 9.7 | 1167.6 | 12.4 |
| 20 | 29 | 104.4 | 12.0 | 647.5 | 12.2 | 130.7 | 10.9 | 882.5 | 12.0 |
| 20 | 30 | 177.7 | 49.0 | 415.4 | 13.0 | 82.0 | 12.5 | 675.1 | 16.0 |
| 20 | 31 | 39.5 | 49.8 | 288.2 | 15.9 | 118.9 | 10.1 | 446.6 | 14.6 |
| 20 | 32 | 0.0 | 0.0 | 209.1 | 28.1 | 54.7 | 20.0 | 263.8 | 25.9 |
| 20 | 33 | 8.8 | 54.3 | 154.8 | 36.2 | 34.5 | 25.1 | 198.2 | 34.1 |
| 20 | 34 | 63.6 | 53.1 | 114.3 | 27.1 | 44.5 | 16.4 | 222.4 | 27.4 |
| 20 | 35 | 2.7 | 54.0 | 79.9 | 37.4 | 20.8 | 20.7 | 103.4 | 32.4 |
| 20 | 36 | 0.0 | 0.0 | 47.5 | 41.4 | 13.2 | 25.9 | 60.7 | 36.6 |
| 20 | 37 | 0.0 | 0.0 | 32.5 | 41.3 | 14.1 | 27.8 | 46.6 | 36.0 |
| 20 | 38 | 0.0 | 0.0 | 33.5 | 41.3 | 7.1 | 28.1 | 40.6 | 38.2 |
| 20 | 39 | 0.0 | 0.0 | 14.7 | 36.9 | 2.8 | 17.7 | 17.4 | 31.5 |
| 20 | 40 | 0.0 | 0.0 | 0.6 | 34.2 | 0.1 | 17.7 | 0.8 | 29.8 |
| 21 | 26 | 52.3 | 42.8 | 3.6 | 16.3 | 0.7 | 10.7 | 56.6 | 37.6 |
| 21 | 27 | 392.6 | 45.9 | 521.5 | 17.6 | 152.0 | 14.6 | 1066.2 | 22.0 |
| 21 | 28 | 0.0 | 0.0 | 991.7 | 14.3 | 217.9 | 13.1 | 1209.6 | 14.0 |
| 21 | 29 | 0.0 | 0.0 | 281.2 | 12.5 | 106.6 | 10.5 | 387.8 | 11.9 |
| 21 | 30 | 0.0 | 0.0 | 351.3 | 14.0 | 141.5 | 12.2 | 492.9 | 13.4 |
| 21 | 31 | 186.1 | 50.5 | 344.8 | 16.7 | 149.9 | 9.9 | 680.7 | 17.2 |
| 21 | 32 | 0.0 | 0.0 | 123.6 | 27.4 | 50.8 | 20.1 | 174.4 | 24.8 |
| 21 | 33 | 0.0 | 0.0 | 66.0 | 31.7 | 24.3 | 27.2 | 90.4 | 30.3 |
| 21 | 34 | 4.8 | 54.5 | 82.6 | 34.3 | 28.7 | 27.6 | 116.1 | 32.8 |
| 21 | 35 | 0.0 | 0.0 | 24.0 | 39.6 | 7.1 | 27.7 | 31.2 | 36.1 |
| 21 | 36 | 0.0 | 0.0 | 23.2 | 34.3 | 4.6 | 28.0 | 27.7 | 33.1 |
| 21 | 37 | 0.0 | 0.0 | 16.1 | 33.1 | 8.5 | 27.6 | 24.6 | 30.9 |
| 21 | 38 | 0.0 | 0.0 | 17.3 | 32.9 | 3.7 | 28.2 | 20.9 | 32.0 |
| 21 | 39 | 0.0 | 0.0 | 12.3 | 33.4 | 2.3 | 17.7 | 14.7 | 29.3 |

| UAM 5K GRID E | N | FREEWAY VEH MILES (000) | FREEWAY AVG SPEED (MPH) | ARTERIAL VEH MILES (000) | ARTERIAL AVG SPEED (MPH) | LOCAL VEH MILES (000) | LOCAL AVG SPEED (MPH) | TOTAL VEH MILES (000) | TOTAL AVG SPEED (MPH) |
|---|---|---|---|---|---|---|---|---|---|
| 21 | 40 | 0.0 | 0.0 | 1.1 | 33.9 | 0.4 | 27.1 | 1.6 | 31.6 |
| 22 | 27 | 196.7 | 38.4 | 68.5 | 20.1 | 57.2 | 23.9 | 322.4 | 29.5 |
| 22 | 28 | 241.7 | 48.3 | 562.6 | 18.6 | 136.3 | 13.2 | 940.6 | 20.6 |
| 22 | 29 | 0.0 | 0.0 | 557.0 | 17.0 | 139.6 | 11.0 | 696.6 | 15.3 |
| 22 | 30 | 153.2 | 50.5 | 344.2 | 12.5 | 112.6 | 11.9 | 610.0 | 15.3 |
| 22 | 31 | 42.8 | 50.7 | 229.4 | 16.9 | 69.3 | 17.1 | 341.5 | 18.5 |
| 22 | 32 | 0.0 | 0.0 | 90.3 | 26.2 | 17.4 | 27.6 | 107.7 | 26.4 |
| 22 | 33 | 0.0 | 0.0 | 24.0 | 34.2 | 13.4 | 27.8 | 37.4 | 31.6 |
| 22 | 34 | 0.0 | 0.0 | 59.5 | 39.0 | 19.5 | 27.7 | 79.0 | 35.4 |
| 22 | 35 | 0.0 | 0.0 | 42.4 | 37.3 | 13.2 | 27.7 | 55.7 | 34.5 |
| 22 | 36 | 0.0 | 0.0 | 5.9 | 33.9 | 1.2 | 28.2 | 7.1 | 32.8 |
| 23 | 28 | 224.9 | 38.8 | 56.2 | 27.2 | 13.2 | 18.7 | 294.3 | 34.3 |
| 23 | 29 | 198.2 | 34.4 | 261.1 | 20.6 | 71.1 | 15.4 | 530.4 | 23.0 |
| 23 | 30 | 357.0 | 35.0 | 380.6 | 12.7 | 174.1 | 12.5 | 911.6 | 16.9 |
| 23 | 31 | 0.0 | 0.0 | 160.2 | 14.8 | 74.4 | 21.5 | 234.6 | 16.4 |
| 23 | 32 | 0.0 | 0.0 | 137.0 | 26.5 | 26.0 | 17.7 | 163.1 | 24.5 |
| 23 | 33 | 0.0 | 0.0 | 50.1 | 36.8 | 19.4 | 27.4 | 69.5 | 33.6 |
| 23 | 34 | 0.0 | 0.0 | 12.1 | 28.1 | 8.2 | 27.8 | 20.3 | 28.0 |
| 23 | 35 | 1.6 | 54.5 | 62.2 | 27.1 | 13.7 | 27.7 | 77.6 | 27.5 |
| 23 | 36 | 0.0 | 0.0 | 8.4 | 33.9 | 2.3 | 27.1 | 10.7 | 32.2 |
| 24 | 29 | 233.6 | 50.0 | 163.3 | 13.7 | 50.1 | 19.0 | 447.0 | 23.2 |
| 24 | 30 | 204.8 | 51.8 | 197.2 | 18.8 | 62.4 | 14.9 | 464.4 | 24.9 |
| 24 | 31 | 287.5 | 46.9 | 241.4 | 18.2 | 96.7 | 11.1 | 625.6 | 22.3 |
| 24 | 32 | 0.0 | 0.0 | 119.7 | 24.4 | 56.0 | 14.9 | 175.7 | 20.3 |
| 24 | 33 | 0.0 | 0.0 | 28.3 | 26.1 | 23.7 | 27.2 | 52.0 | 26.6 |
| 24 | 34 | 0.0 | 0.0 | 43.7 | 32.4 | 10.6 | 28.0 | 54.3 | 31.5 |
| 24 | 35 | 0.0 | 0.0 | 3.1 | 24.9 | 0.6 | 17.7 | 3.6 | 23.4 |
| 25 | 29 | 25.0 | 23.3 | 119.9 | 15.3 | 56.0 | 14.2 | 200.9 | 15.6 |
| 25 | 30 | 81.2 | 52.6 | 245.7 | 18.8 | 85.2 | 17.2 | 412.2 | 21.0 |
| 25 | 31 | 196.6 | 46.1 | 259.6 | 18.7 | 57.2 | 13.1 | 513.4 | 22.8 |
| 25 | 32 | 135.2 | 49.0 | 48.9 | 32.6 | 15.0 | 27.1 | 199.1 | 41.4 |
| 25 | 33 | 81.3 | 50.8 | 29.0 | 30.9 | 19.6 | 22.4 | 129.9 | 38.1 |
| 25 | 34 | 0.0 | 0.0 | 7.2 | 37.5 | 1.4 | 17.7 | 8.5 | 31.8 |
| 26 | 30 | 12.7 | 37.9 | 33.5 | 24.8 | 6.4 | 17.7 | 52.5 | 25.7 |
| 26 | 31 | 181.2 | 42.0 | 62.4 | 23.6 | 27.0 | 14.0 | 270.5 | 30.5 |
| 26 | 32 | 31.6 | 47.7 | 94.8 | 23.4 | 36.4 | 22.9 | 162.7 | 25.9 |

## Appendix D-1: Composite Emissions Factors—Pa. counties

| Speed (MPH) | CO (gm/mi) | NMHC (gm/mi) | $NO_x$ (gm/mi) |
|---|---|---|---|
| 3 | 182.85 | 28.31 | 3.80 |
| 4 | 142.25 | 19.94 | 3.62 |
| 5 | 116.32 | 15.53 | 3.48 |
| 6 | 98.29 | 12.82 | 3.37 |
| 7 | 85.06 | 11.01 | 3.27 |
| 8 | 74.97 | 10.02 | 3.19 |
| 9 | 67.03 | 9.25 | 3.11 |
| 10 | 60.63 | 8.61 | 3.05 |
| 11 | 55.38 | 8.07 | 2.99 |
| 12 | 50.99 | 7.60 | 2.94 |
| 13 | 47.27 | 7.19 | 2.89 |
| 14 | 44.08 | 6.83 | 2.85 |
| 15 | 41.31 | 6.50 | 2.81 |
| 16 | 38.88 | 6.19 | 2.77 |
| 17 | 36.73 | 5.92 | 2.74 |
| 18 | 34.80 | 5.66 | 2.72 |
| 19 | 33.07 | 5.42 | 2.69 |
| 20 | 31.43 | 5.21 | 2.66 |
| 21 | 29.84 | 5.06 | 2.63 |
| 22 | 28.38 | 4.92 | 2.61 |
| 23 | 27.04 | 4.80 | 2.59 |
| 24 | 25.79 | 4.67 | 2.56 |
| 25 | 24.64 | 4.56 | 2.55 |
| 26 | 23.56 | 4.46 | 2.53 |
| 27 | 22.56 | 4.36 | 2.52 |
| 28 | 21.62 | 4.26 | 2.51 |
| 29 | 20.75 | 4.17 | 2.50 |
| 30 | 19.93 | 4.09 | 2.49 |
| 31 | 19.17 | 4.01 | 2.49 |
| 32 | 18.46 | 3.94 | 2.49 |
| 33 | 17.79 | 3.86 | 2.48 |
| 34 | 17.17 | 3.80 | 2.48 |
| 35 | 16.60 | 3.73 | 2.49 |
| 36 | 16.07 | 3.67 | 2.49 |
| 37 | 15.57 | 3.61 | 2.50 |
| 38 | 15.11 | 3.56 | 2.50 |
| 39 | 14.69 | 3.51 | 2.51 |
| 40 | 14.31 | 3.46 | 2.52 |
| 41 | 13.96 | 3.41 | 2.54 |
| 42 | 13.63 | 3.36 | 2.55 |
| 43 | 13.34 | 3.32 | 2.57 |
| 44 | 13.07 | 3.28 | 2.59 |
| 45 | 12.83 | 3.24 | 2.61 |
| 46 | 12.61 | 3.20 | 2.63 |
| 47 | 12.41 | 3.17 | 2.66 |
| 48 | 12.22 | 3.13 | 2.69 |
| 49 | 13.77 | 3.15 | 2.76 |
| 50 | 15.33 | 3.16 | 2.84 |
| 51 | 16.89 | 3.17 | 2.92 |
| 52 | 18.46 | 3.19 | 3.01 |
| 53 | 20.03 | 3.20 | 3.09 |
| 54 | 21.61 | 3.22 | 3.18 |
| 55 | 23.20 | 3.24 | 3.27 |

Source: Delaware Valley Regional Planning Commission December 1991

## Appendix D-2: Composite Emissions Factors—Cecil County

| Speed (MPH) | CO (gm/mi) | NMHC (gm/mi) | $NO_x$ (gm/mi) |
|---|---|---|---|
| 3 | 207.74 | 27.12 | 3.96 |
| 4 | 161.81 | 19.26 | 3.77 |
| 5 | 132.17 | 15.06 | 3.63 |
| 6 | 111.47 | 12.47 | 3.51 |
| 7 | 96.26 | 10.73 | 3.41 |
| 8 | 84.66 | 9.72 | 3.33 |
| 9 | 75.56 | 8.94 | 3.25 |
| 10 | 68.24 | 8.31 | 3.18 |
| 11 | 62.26 | 7.77 | 3.12 |
| 12 | 57.27 | 7.32 | 3.07 |
| 13 | 53.06 | 6.92 | 3.02 |
| 14 | 49.46 | 6.58 | 2.98 |
| 15 | 46.33 | 6.27 | 2.94 |
| 16 | 43.60 | 5.99 | 2.90 |
| 17 | 41.18 | 5.74 | 2.88 |
| 18 | 39.02 | 5.51 | 2.85 |
| 19 | 37.08 | 5.29 | 2.82 |
| 20 | 35.26 | 5.10 | 2.80 |
| 21 | 33.51 | 4.95 | 2.77 |
| 22 | 31.90 | 4.81 | 2.74 |
| 23 | 30.41 | 4.68 | 2.72 |
| 24 | 29.04 | 4.55 | 2.70 |
| 25 | 27.76 | 4.44 | 2.68 |
| 26 | 26.56 | 4.33 | 2.67 |
| 27 | 25.45 | 4.23 | 2.66 |
| 28 | 24.40 | 4.14 | 2.65 |
| 29 | 23.42 | 4.05 | 2.64 |
| 30 | 22.51 | 3.97 | 2.63 |
| 31 | 21.65 | 3.89 | 2.63 |
| 32 | 20.86 | 3.81 | 2.63 |
| 33 | 20.11 | 3.74 | 2.63 |
| 34 | 19.42 | 3.67 | 2.63 |
| 35 | 18.77 | 3.61 | 2.63 |
| 36 | 18.18 | 3.55 | 2.64 |
| 37 | 17.63 | 3.49 | 2.64 |
| 38 | 17.12 | 3.44 | 2.65 |
| 39 | 16.65 | 3.39 | 2.66 |
| 40 | 16.23 | 3.34 | 2.67 |
| 41 | 15.84 | 3.30 | 2.68 |
| 42 | 15.48 | 3.26 | 2.70 |
| 43 | 15.16 | 3.22 | 2.72 |
| 44 | 14.87 | 3.18 | 2.73 |
| 45 | 14.61 | 3.14 | 2.76 |
| 46 | 14.37 | 3.11 | 2.78 |
| 47 | 14.16 | 3.08 | 2.81 |
| 48 | 13.97 | 3.05 | 2.84 |
| 49 | 15.78 | 3.06 | 2.92 |
| 50 | 17.61 | 3.08 | 3.01 |
| 51 | 19.45 | 3.10 | 3.09 |
| 52 | 21.28 | 3.13 | 3.18 |
| 53 | 23.13 | 3.15 | 3.27 |
| 54 | 24.98 | 3.17 | 3.37 |
| 55 | 26.85 | 3.19 | 3.47 |

Source: Delaware Valley Regional Planning Commission December 1991

## Appendix E: Highway Source Emissions per Summer Weekday by Grid Cell

| UAM 5K GRID E | N | DAILY KILOGRAMS CO | NMHC | NOx |
|---|---|---|---|---|
| 2 | 20 | 385.6 | 58.4 | 56.1 |
| 2 | 21 | 107.8 | 18.9 | 16.3 |
| 3 | 18 | 132.9 | 23.7 | 21.9 |
| 3 | 19 | 289.2 | 55.6 | 40.5 |
| 3 | 20 | 1081.9 | 154.8 | 147.3 |
| 3 | 21 | 203.5 | 37.1 | 31.0 |
| 4 | 17 | 554.6 | 109.3 | 83.0 |
| 4 | 18 | 6040.6 | 861.6 | 863.6 |
| 4 | 19 | 511.2 | 89.7 | 79.6 |
| 4 | 20 | 989.0 | 190.6 | 169.3 |
| 4 | 21 | 455.2 | 63.2 | 59.6 |
| 4 | 22 | 49.9 | 10.6 | 6.7 |
| 5 | 13 | 4.9 | 0.8 | 0.5 |
| 5 | 14 | 53.9 | 9.7 | 6.5 |
| 5 | 15 | 71.2 | 12.1 | 10.2 |
| 5 | 16 | 4.0 | 0.6 | 0.4 |
| 5 | 17 | 60.1 | 10.0 | 6.3 |
| 5 | 18 | 6426.4 | 791.1 | 842.8 |
| 5 | 19 | 870.3 | 119.9 | 115.7 |
| 5 | 20 | 634.5 | 116.3 | 99.0 |
| 5 | 21 | 1135.1 | 186.9 | 161.7 |
| 5 | 22 | 806.6 | 181.2 | 122.9 |
| 5 | 23 | 201.7 | 39.4 | 23.1 |
| 5 | 24 | 25.6 | 5.4 | 3.4 |
| 6 | 13 | 4.7 | 0.7 | 0.4 |
| 6 | 14 | 115.9 | 21.5 | 15.3 |
| 6 | 15 | 357.8 | 62.6 | 59.6 |
| 6 | 16 | 206.6 | 35.6 | 31.2 |
| 6 | 17 | 266.4 | 48.6 | 40.4 |
| 6 | 18 | 3414.5 | 511.7 | 501.4 |
| 6 | 19 | 5456.0 | 722.4 | 740.7 |
| 6 | 20 | 689.3 | 123.5 | 110.5 |
| 6 | 21 | 493.1 | 94.9 | 72.3 |
| 6 | 22 | 761.6 | 151.7 | 90.5 |
| 6 | 23 | 939.1 | 214.7 | 150.9 |
| 6 | 24 | 208.3 | 44.9 | 28.7 |
| 6 | 25 | 356.6 | 78.9 | 54.2 |
| 6 | 26 | 2080.0 | 410.3 | 246.0 |
| 6 | 27 | 2000.7 | 335.2 | 171.7 |
| 6 | 28 | 75.5 | 16.0 | 10.2 |
| 6 | 29 | 55.4 | 11.1 | 6.6 |
| 7 | 13 | 583.4 | 71.4 | 75.6 |
| 7 | 14 | 444.4 | 70.2 | 64.0 |
| 7 | 15 | 127.2 | 23.2 | 16.0 |
| 7 | 16 | 90.5 | 16.8 | 11.8 |
| 7 | 17 | 521.2 | 100.2 | 73.0 |
| 7 | 18 | 2600.9 | 338.0 | 351.3 |
| 7 | 19 | 4518.5 | 555.0 | 586.5 |
| 7 | 20 | 497.8 | 89.4 | 81.0 |
| 7 | 21 | 207.8 | 41.5 | 28.2 |
| 7 | 22 | 406.3 | 82.6 | 50.1 |
| 7 | 23 | 885.3 | 184.7 | 144.9 |
| 7 | 24 | 633.1 | 139.1 | 92.1 |

| UAM 5K GRID E | N | DAILY KILOGRAMS CO | NMHC | NOx |
|---|---|---|---|---|
| 7 | 25 | 721.5 | 163.8 | 111.6 |
| 7 | 26 | 1295.9 | 237.7 | 131.9 |
| 7 | 27 | 1315.6 | 305.4 | 223.5 |
| 7 | 28 | 324.2 | 65.5 | 39.7 |
| 7 | 29 | 977.5 | 199.8 | 121.6 |
| 7 | 30 | 104.6 | 19.2 | 10.7 |
| 8 | 13 | 9.0 | 1.7 | 1.3 |
| 8 | 14 | 554.9 | 118.5 | 106.7 |
| 8 | 15 | 1310.6 | 157.8 | 168.2 |
| 8 | 16 | 1228.4 | 152.2 | 159.5 |
| 8 | 17 | 176.3 | 32.8 | 23.1 |
| 8 | 18 | 2251.3 | 473.3 | 399.6 |
| 8 | 19 | 5162.6 | 641.3 | 683.7 |
| 8 | 20 | 845.1 | 151.3 | 138.4 |
| 8 | 21 | 171.5 | 32.2 | 25.2 |
| 8 | 22 | 344.6 | 73.3 | 46.3 |
| 8 | 23 | 1370.8 | 291.3 | 190.4 |
| 8 | 24 | 815.2 | 180.9 | 122.3 |
| 8 | 25 | 480.7 | 98.5 | 60.1 |
| 8 | 26 | 1225.9 | 256.6 | 159.7 |
| 8 | 27 | 3439.5 | 671.7 | 441.9 |
| 8 | 28 | 234.8 | 46.3 | 27.2 |
| 8 | 29 | 823.8 | 187.1 | 130.0 |
| 8 | 30 | 2023.2 | 346.6 | 275.7 |
| 8 | 31 | 485.6 | 84.8 | 45.2 |
| 9 | 13 | 216.5 | 26.0 | 27.7 |
| 9 | 14 | 593.4 | 82.1 | 80.0 |
| 9 | 15 | 97.7 | 18.8 | 13.7 |
| 9 | 16 | 79.3 | 14.3 | 12.1 |
| 9 | 17 | 1189.7 | 159.0 | 159.8 |
| 9 | 18 | 876.8 | 168.4 | 155.3 |
| 9 | 19 | 3027.9 | 382.2 | 403.7 |
| 9 | 20 | 362.9 | 66.3 | 57.0 |
| 9 | 21 | 420.3 | 86.7 | 55.1 |
| 9 | 22 | 579.4 | 111.9 | 64.7 |
| 9 | 23 | 1626.6 | 324.7 | 205.2 |
| 9 | 24 | 1179.9 | 264.6 | 176.3 |
| 9 | 25 | 167.0 | 35.7 | 22.7 |
| 9 | 26 | 546.8 | 101.3 | 56.7 |
| 9 | 27 | 5923.2 | 1141.4 | 732.3 |
| 9 | 28 | 1550.0 | 330.6 | 210.8 |
| 9 | 29 | 786.0 | 161.1 | 98.5 |
| 9 | 30 | 3211.2 | 562.4 | 454.3 |
| 9 | 31 | 638.4 | 125.8 | 74.1 |
| 10 | 22 | 180.1 | 38.7 | 24.9 |
| 10 | 23 | 2258.9 | 440.4 | 257.7 |
| 10 | 24 | 3368.6 | 598.3 | 322.2 |
| 10 | 25 | 512.4 | 106.1 | 65.7 |
| 10 | 26 | 329.5 | 70.4 | 44.7 |
| 10 | 27 | 5316.9 | 1089.8 | 712.2 |
| 10 | 28 | 871.0 | 161.8 | 90.8 |
| 10 | 29 | 2605.1 | 459.9 | 399.7 |
| 10 | 30 | 974.4 | 197.5 | 125.9 |
| 10 | 31 | 579.7 | 121.6 | 75.8 |
| 10 | 32 | 128.9 | 25.4 | 15.0 |
| 11 | 23 | 157.9 | 30.5 | 17.6 |

| UAM 5K GRID E | N | DAILY KILOGRAMS CO | NMHC | NOx |
|---|---|---|---|---|
| 11 | 24 | 3616.8 | 752.6 | 467.6 |
| 11 | 25 | 917.9 | 183.1 | 109.1 |
| 11 | 26 | 1315.8 | 280.5 | 178.7 |
| 11 | 27 | 3962.3 | 700.0 | 446.9 |
| 11 | 28 | 7429.5 | 1268.2 | 660.3 |
| 11 | 29 | 4568.4 | 841.9 | 619.0 |
| 11 | 30 | 1027.6 | 230.0 | 154.0 |
| 11 | 31 | 1678.7 | 372.5 | 246.5 |
| 11 | 32 | 4129.2 | 708.3 | 542.8 |
| 11 | 33 | 2365.9 | 387.4 | 248.7 |
| 11 | 34 | 15.3 | 3.0 | 1.7 |
| 12 | 23 | 156.7 | 32.3 | 19.9 |
| 12 | 24 | 2324.8 | 532.7 | 368.3 |
| 12 | 25 | 2167.7 | 410.5 | 231.3 |
| 12 | 26 | 8069.0 | 1317.7 | 647.1 |
| 12 | 27 | 5869.3 | 1218.3 | 817.4 |
| 12 | 28 | 6931.8 | 1352.4 | 792.5 |
| 12 | 29 | 2712.7 | 503.3 | 405.7 |
| 12 | 30 | 504.9 | 105.6 | 65.7 |
| 12 | 31 | 514.7 | 109.5 | 69.2 |
| 12 | 32 | 4348.7 | 836.9 | 524.5 |
| 12 | 33 | 2997.4 | 493.6 | 289.0 |
| 12 | 34 | 2215.1 | 413.5 | 321.8 |
| 12 | 35 | 97.1 | 18.7 | 10.8 |
| 13 | 23 | 138.3 | 29.8 | 22.9 |
| 13 | 24 | 4978.2 | 1066.7 | 747.8 |
| 13 | 25 | 3292.0 | 690.1 | 431.3 |
| 13 | 26 | 4931.0 | 1010.4 | 668.6 |
| 13 | 27 | 2802.6 | 597.0 | 380.9 |
| 13 | 28 | 8929.8 | 1731.0 | 1058.7 |
| 13 | 29 | 3203.0 | 579.1 | 440.5 |
| 13 | 30 | 2790.3 | 525.0 | 297.1 |
| 13 | 31 | 3775.0 | 626.7 | 318.3 |
| 13 | 32 | 3073.0 | 678.4 | 531.5 |
| 13 | 33 | 1275.2 | 232.3 | 128.5 |
| 13 | 34 | 1033.3 | 230.4 | 153.8 |
| 13 | 35 | 563.8 | 115.0 | 69.9 |
| 13 | 36 | 143.0 | 26.5 | 14.8 |
| 13 | 37 | 150.0 | 25.5 | 12.9 |
| 14 | 23 | 2040.6 | 328.8 | 152.4 |
| 14 | 24 | 3807.5 | 758.9 | 451.1 |
| 14 | 25 | 2889.8 | 618.6 | 396.0 |
| 14 | 26 | 4325.7 | 915.4 | 584.1 |
| 14 | 27 | 1902.5 | 378.7 | 225.5 |
| 14 | 28 | 10048.8 | 1879.3 | 1083.8 |
| 14 | 29 | 4835.4 | 850.6 | 579.6 |
| 14 | 30 | 6377.4 | 1061.6 | 517.1 |
| 14 | 31 | 4723.9 | 953.6 | 711.5 |
| 14 | 32 | 1746.4 | 374.9 | 239.6 |
| 14 | 33 | 1028.5 | 201.6 | 124.0 |
| 14 | 34 | 595.7 | 122.8 | 75.9 |
| 14 | 35 | 1189.8 | 217.9 | 121.1 |
| 14 | 36 | 1829.8 | 320.7 | 171.3 |
| 15 | 23 | 9005.4 | 1617.6 | 956.9 |
| 15 | 24 | 12716.2 | 2033.9 | 965.1 |
| 15 | 25 | 11973.2 | 2002.0 | 1024.0 |

| UAM 5K GRID E | N | DAILY KILOGRAMS CO | NMHC | NOx |
|---|---|---|---|---|
| 15 | 26 | 5031.4 | 905.6 | 487.0 |
| 15 | 27 | 4391.8 | 856.1 | 500.6 |
| 15 | 28 | 11920.2 | 1996.7 | 1001.4 |
| 15 | 29 | 17446.2 | 3134.3 | 1675.5 |
| 15 | 30 | 7383.4 | 1490.8 | 1008.8 |
| 15 | 31 | 3027.6 | 590.9 | 346.0 |
| 15 | 32 | 2321.1 | 441.3 | 252.2 |
| 15 | 33 | 1518.1 | 264.3 | 140.5 |
| 15 | 34 | 1010.1 | 194.9 | 112.8 |
| 15 | 35 | 234.5 | 43.3 | 24.1 |
| 15 | 36 | 1818.0 | 317.5 | 250.2 |
| 15 | 37 | 1643.3 | 285.8 | 230.6 |
| 15 | 38 | 27.6 | 5.4 | 3.2 |
| 16 | 22 | 58.8 | 12.4 | 8.2 |
| 16 | 23 | 4996.8 | 1029.6 | 656.7 |
| 16 | 24 | 26372.4 | 4375.4 | 2059.4 |
| 16 | 25 | 22109.6 | 3457.5 | 1476.2 |
| 16 | 26 | 13121.3 | 2209.2 | 1088.1 |
| 16 | 27 | 22029.9 | 3352.6 | 1345.9 |
| 16 | 28 | 17485.2 | 2750.2 | 1194.2 |
| 16 | 29 | 28517.2 | 4862.8 | 2394.0 |
| 16 | 30 | 14189.1 | 2244.4 | 1011.9 |
| 16 | 31 | 3519.1 | 642.9 | 355.3 |
| 16 | 32 | 1684.0 | 367.6 | 240.1 |
| 16 | 33 | 3009.8 | 523.1 | 352.2 |
| 16 | 34 | 2596.9 | 463.4 | 359.5 |
| 16 | 35 | 2195.5 | 373.1 | 308.0 |
| 16 | 36 | 1081.6 | 181.1 | 142.2 |
| 16 | 37 | 2744.0 | 562.1 | 342.8 |
| 16 | 38 | 1003.7 | 228.0 | 159.6 |
| 17 | 23 | 38.5 | 8.8 | 7.7 |
| 17 | 24 | 14200.0 | 2662.5 | 1745.2 |
| 17 | 25 | 40200.3 | 5966.7 | 2283.4 |
| 17 | 26 | 35729.1 | 5353.1 | 2092.4 |
| 17 | 27 | 25457.4 | 3913.5 | 1607.0 |
| 17 | 28 | 22643.9 | 3726.0 | 1748.1 |
| 17 | 29 | 25974.8 | 4440.3 | 2186.1 |
| 17 | 30 | 24830.6 | 3785.8 | 1537.7 |
| 17 | 31 | 8983.9 | 1482.0 | 870.0 |
| 17 | 32 | 7942.9 | 1435.9 | 934.8 |
| 17 | 33 | 5084.8 | 862.2 | 483.5 |
| 17 | 34 | 5198.6 | 881.5 | 570.0 |
| 17 | 35 | 4308.2 | 727.7 | 516.6 |
| 17 | 36 | 2351.8 | 434.3 | 292.5 |
| 17 | 37 | 3365.1 | 573.3 | 297.8 |
| 17 | 38 | 1198.8 | 202.5 | 105.1 |
| 17 | 39 | 287.7 | 59.4 | 36.6 |
| 18 | 24 | 6711.2 | 1446.1 | 1051.9 |
| 18 | 25 | 26731.0 | 4214.2 | 1857.7 |
| 18 | 26 | 53003.0 | 7838.5 | 3000.0 |
| 18 | 27 | 34817.7 | 5343.6 | 2198.7 |
| 18 | 28 | 16758.2 | 2745.0 | 1328.8 |
| 18 | 29 | 21334.1 | 3501.1 | 1636.7 |
| 18 | 30 | 14942.5 | 2476.1 | 1486.8 |
| 18 | 31 | 7726.8 | 1247.4 | 582.9 |
| 18 | 32 | 18620.4 | 2868.6 | 1192.6 |

| UAM 5K GRID E | N | DAILY KILOGRAMS CO | NMHC | NOx |
|---|---|---|---|---|
| 18 | 33 | 12496.3 | 2040.5 | 964.8 |
| 18 | 34 | 2321.2 | 439.9 | 248.0 |
| 18 | 35 | 981.8 | 179.8 | 99.5 |
| 18 | 36 | 1322.4 | 287.3 | 185.9 |
| 18 | 37 | 668.9 | 135.5 | 83.1 |
| 18 | 38 | 253.7 | 51.4 | 31.2 |
| 18 | 39 | 135.1 | 27.7 | 17.0 |
| 18 | 40 | 23.7 | 4.8 | 3.0 |
| 19 | 24 | 1234.4 | 218.6 | 173.4 |
| 19 | 25 | 21058.5 | 3949.0 | 2298.6 |
| 19 | 26 | 77310.9 | 11891.7 | 4931.4 |
| 19 | 27 | 52311.0 | 8660.3 | 4141.8 |
| 19 | 28 | 32979.3 | 5063.3 | 2078.4 |
| 19 | 29 | 30651.4 | 4646.1 | 1854.7 |
| 19 | 30 | 21657.0 | 3747.1 | 1893.1 |
| 19 | 31 | 11544.6 | 2047.3 | 1155.4 |
| 19 | 32 | 10856.7 | 1717.0 | 775.0 |
| 19 | 33 | 6776.3 | 1154.3 | 589.9 |
| 19 | 34 | 1453.6 | 255.5 | 136.8 |
| 19 | 35 | 1436.5 | 282.2 | 166.7 |
| 19 | 36 | 322.5 | 68.0 | 44.1 |
| 19 | 37 | 116.1 | 23.4 | 14.1 |
| 19 | 38 | 212.7 | 46.0 | 29.6 |
| 19 | 39 | 325.2 | 75.5 | 53.7 |
| 19 | 40 | 467.2 | 107.9 | 76.3 |
| 19 | 41 | 19.9 | 4.4 | 3.0 |
| 20 | 25 | 18368.6 | 3480.1 | 2174.0 |
| 20 | 26 | 66287.0 | 10444.1 | 4616.7 |
| 20 | 27 | 53525.3 | 8435.8 | 3664.2 |
| 20 | 28 | 58066.1 | 8700.8 | 3405.7 |
| 20 | 29 | 45187.0 | 6730.2 | 2592.9 |
| 20 | 30 | 26265.3 | 4170.9 | 1931.2 |
| 20 | 31 | 18902.2 | 2921.0 | 1272.3 |
| 20 | 32 | 6276.1 | 1184.5 | 670.5 |
| 20 | 33 | 3529.0 | 754.3 | 501.7 |
| 20 | 34 | 5582.7 | 977.5 | 608.3 |
| 20 | 35 | 1922.9 | 402.7 | 262.8 |
| 20 | 36 | 973.8 | 220.8 | 153.9 |
| 20 | 37 | 759.4 | 171.1 | 117.9 |
| 20 | 38 | 620.8 | 144.4 | 102.8 |
| 20 | 39 | 325.2 | 68.7 | 44.2 |
| 20 | 40 | 15.1 | 3.1 | 1.9 |
| 21 | 26 | 876.0 | 201.6 | 146.3 |
| 21 | 27 | 29382.9 | 5196.4 | 2876.1 |
| 21 | 28 | 53647.0 | 8292.8 | 3446.6 |
| 21 | 29 | 19728.0 | 2935.1 | 1136.5 |
| 21 | 30 | 22703.1 | 3475.2 | 1415.4 |
| 21 | 31 | 25103.0 | 3940.2 | 1947.9 |
| 21 | 32 | 4384.7 | 803.2 | 446.7 |
| 21 | 33 | 1767.5 | 365.8 | 225.5 |
| 21 | 34 | 2150.7 | 451.5 | 293.0 |
| 21 | 35 | 498.1 | 113.5 | 78.5 |
| 21 | 36 | 496.6 | 107.4 | 69.0 |
| 21 | 37 | 470.6 | 98.5 | 61.4 |
| 21 | 38 | 386.7 | 82.4 | 52.1 |
| 21 | 39 | 300.7 | 60.9 | 37.0 |

| UAM 5K GRID E | N | DAILY KILOGRAMS CO | NMHC | NOx |
|---|---|---|---|---|
| 21 | 40 | 29.6 | 6.3 | 3.9 |
| 22 | 27 | 6601.2 | 1324.3 | 821.5 |
| 22 | 28 | 28004.3 | 4785.2 | 2557.1 |
| 22 | 29 | 28554.3 | 4462.7 | 1949.3 |
| 22 | 30 | 24978.0 | 3844.2 | 1774.5 |
| 22 | 31 | 11729.2 | 1907.8 | 944.9 |
| 22 | 32 | 2504.2 | 476.6 | 272.3 |
| 22 | 33 | 702.4 | 148.3 | 93.3 |
| 22 | 34 | 1296.1 | 291.7 | 198.4 |
| 22 | 35 | 946.7 | 209.7 | 139.1 |
| 22 | 36 | 127.9 | 27.6 | 17.8 |
| 23 | 28 | 5020.0 | 1105.9 | 742.2 |
| 23 | 29 | 14238.1 | 2538.4 | 1391.5 |
| 23 | 30 | 32977.8 | 5412.8 | 2500.2 |
| 23 | 31 | 8728.5 | 1407.0 | 643.8 |
| 23 | 32 | 4134.8 | 757.9 | 417.7 |
| 23 | 33 | 1218.4 | 265.6 | 174.0 |
| 23 | 34 | 439.6 | 86.6 | 51.0 |
| 23 | 35 | 1735.4 | 334.8 | 196.4 |
| 23 | 36 | 195.9 | 41.8 | 26.6 |
| 24 | 29 | 12434.9 | 2124.0 | 1263.2 |
| 24 | 30 | 12880.4 | 2126.9 | 1321.8 |
| 24 | 31 | 17325.4 | 3057.2 | 1708.6 |
| 24 | 32 | 5401.8 | 923.5 | 464.4 |
| 24 | 33 | 1200.6 | 229.2 | 131.3 |
| 24 | 34 | 1035.7 | 217.2 | 135.3 |
| 24 | 35 | 95.7 | 17.3 | 9.4 |
| 25 | 29 | 8096.0 | 1281.0 | 560.6 |
| 25 | 30 | 12884.9 | 2095.9 | 1146.5 |
| 25 | 31 | 13769.9 | 2447.5 | 1381.2 |
| 25 | 32 | 3070.2 | 679.5 | 532.7 |
| 25 | 33 | 2485.9 | 470.9 | 360.9 |
| 25 | 34 | 159.2 | 33.6 | 21.6 |
| 26 | 30 | 1238.3 | 233.9 | 134.3 |
| 26 | 31 | 5269.4 | 1085.2 | 698.8 |
| 26 | 32 | 3931.8 | 727.7 | 423.8 |