APPENDIX C

Maintenance Plan Update for the
Allentown-Bethlehem-Easton
1997 Eight-Hour Ozone Maintenance Area:
Motor Vehicle Emission Budget Revisions
Using MOVES2010a

Technical Support Document
Mobile Source Highway Emissions Inventory

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Allentown-Bethlehem-Easton Maintenance Area:
Motor Vehicle Emission Budget Revisions

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EXECUTIVE SUMMARY

This technical appendix supports the revised maintenance plan for the Allentown-Bethlehem-Easton Area under the 1997 8-hour National Ambient Air Quality Standards (NAAQS) for ozone[1]. Section 107 of the Clean Air Act (CAA) establishes requirements for an area to be considered for redesignation. One of those requirements includes the development of an emissions inventory of ozone precursors, volatile organic compounds (VOC) and nitrogen oxides (NOx), for a base year, the year the region attains the ozone standard, and projection years including a year at least 10 years following redesignation. The emissions inventory is used to demonstrate that projected emission levels are sufficient to maintain the ozone standard. U.S. EPA's redesignation guidance states, "A state may generally demonstrate maintenance of the NAAQS by either showing that future emissions of a pollutant or its precursors will not exceed the level of the attainment inventory, or by modeling to show that the future mix of sources and emission rates will not cause a violation of the NAAQS."

A maintenance plan and corresponding emissions inventory for the Allentown-Bethlehem-Easton Area was originally approved by EPA on March 4, 2008 as documented in the Federal Register (*72 FR 48559*) and was effective on April 3, 2008. At that time, EPA also approved the motor vehicle emission budgets (MVEBs) for VOC and NOx that were contained in the maintenance plan document. The original budgets were developed using MOBILE6.2, the latest EPA-approved emission model at that time. On March 2, 2010, EPA officially released MOVES2010a to be used for all SIP submittals and future transportation conformity analyses after a grace period through March 2, 2013. This maintenance plan update revises the 2009 and 2018 MVEBs using MOVES2010a.

Appendix C has been provided to summarize the methodology and analysis results for the motor vehicle emissions inventory. To complement this executive summary, attachments have been provided with additional detail regarding the analysis methodology, the MOVES input parameters, and the output vehicle miles of travel (VMT) and emission results for the *Allentown-Bethlehem-Easton Maintenance Area*. A summary of the appendices is shown below in Exhibit 1:

Exhibit 1: Summary of Appendices

Appendix	Title	Description
C-1	Explanation of Methodology	Provides a detailed summary of the methodology used to calculate the VMT and emissions.
C-2	Ozone (VOC, NOx) Emission Results	Provides emission exhibits by county, road type, and source type categories for a *July weekday* in 2009 and 2018.
C-3	MOVES Sample Input File	Provides examples of the MOVES input files.

Revised Emissions Inventory

A summary of the revised motor vehicle emissions for the Allentown-Bethlehem-Easton Area is provided in **Exhibit 2**. Both VOC and NOx emission estimates have been developed using the MOVES2010a emission model and latest planning assumptions. Emissions have been estimated for the 2004 attainment year, 2009 and 2018. The MOBILE6.2 emission estimates from the original maintenance plan have been included in the exhibit to illustrate relative changes in emissions.

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[1] Prepared for the Pennsylvania Department of Environmental Protection by Michael Baker Jr. Inc. in 2012

Exhibit 2: Revised Motor Vehicle Emissions Using MOVES2010a
(Short Tons/Day)

Pollutant	Sub Area	Original MOBILE6.2 Emissions			Revised MOVES2010a Emissions		
		2004	**2009**	**2018**	**2004**	**2009**	**2018**
VOC	*Lehigh Valley MPO*	26.32	20.60	12.40	20.37	17.47	9.53
	Carbon	4.23	3.40	2.30	2.89	2.36	1.30
	Total	30.55	24.00	14.70	23.26	19.83	10.83
NOx	*Lehigh Valley MPO*	40.39	28.90	12.40	49.83	37.48	18.71
	Carbon	7.95	5.90	3.00	9.55	6.60	3.24
	Total	48.34	34.80	15.40	59.38	44.08	21.95

Analysis Methodology

Guidance documents from EPA were used to develop the base and future year emissions inventories for the *Allentown-Bethlehem-Easton Maintenance Area*. They include:

- *Policy Guidance on the Use of MOVES2010 for SIP Development, Transportation Conformity, and Other Purposes*, US EPA Office of Air and Radiation, EPA-420-B-09-046, December 2009.

- *Technical Guidance on the Use of MOVES2010 for Emission Inventory Preparation in State Implementation Plans and Transportation Conformity*, US EPA Office of Air and Radiation, and Office of Transportation and Air Quality, EPA-420-B-10-023,   April 2010.

- *Motor Vehicle Emission Simulator, User Guide for MOVES2010a,* EPA-420-B-10-036, August 2010.

The highway mobile source emission inventory was developed using available travel data and EPA's MOVES2010a emission model. The methodologies used to produce the emission data conform to the recommendations provided in EPA's *Technical Guidance*. A mix of local data and national default (internal to MOVES2010a) data has been used for this submission. Local data has been used for the primary data items that have a significant impact on emissions. These include:

- Vehicle miles of travel (VMT) by vehicle type.
- Average speed distribution.
- Vehicle type mixes.
- Source type population (for light-duty vehicles).
- Vehicle age distribution.
- Hourly distributions.
- Meteorology data.
- Inspection/Maintenance program.
- Fuel supply.

Most local data inputs to the analysis process reflect the latest planning assumptions based on 2008 data obtained from the Pennsylvania Department of Transportation (PennDOT), the Bureau of Motor Vehicles, and other local/national sources.   Newer data was available and was used for traffic forecast growth rates,

control strategies (e.g. Inspection-Maintenance programs), vehicle age distributions and fuel characteristics.

The analysis methodology is consistent with past statewide inventory efforts including the 2008 National Emissions Inventory (NEI) submission. This includes the use of custom post processing software to calculate hourly speeds and prepare key traffic input files to the MOVES2010a emission model. A detailed methodology is provided in **Appendix C-1**. The following sections address the key input data sources and analysis tools used for the emissions inventory for the Allentown-Bethlehem-Easton Area.

DATA SOURCES AND ANALYSIS TOOLS

This section provides a summary of the key input data and analysis tools used for producing the *Allentown-Bethlehem-Easton Maintenance Area* emissions inventory. The key elements to the modeling protocol are described in the sections below. A more detailed description of the analysis process and tools is provided in the methodology reports in **Appendix C-1** through **C-3**.

Analysis Tools

The mobile vehicle emissions inventory analysis utilizes several key software/programs for producing the county emissions totals. These tools are outlined in **Exhibit 3**.

Exhibit 3: Summary of Analysis Tools

Tool	Purpose
MOVES2010a	Produces emission rates for each ozone precursor, VOC and NOx.
PPSUITE	Processes the highway data; Calculates hourly congested speeds for each state roadway segment; Prepares MOVES2010a input files; Processes MOVES2010a output files into a summary report.
CENTRAL	Provides a batch menu driven process to execute PPSUITE, MOVES2010a and other MYSQL steps.

The *Allentown-Bethlehem-Easton Maintenance Area* inventory reflects the highway mobile source emission estimations using EPA's MOVES2010a emission model. EPA's MOVES model was officially released on March 2, 2010 and was followed with a revised version (MOVES2010a) in August 2010. The MOVES2010a model provides a more robust estimate of emissions as compared to its predecessor MOBILE6.2. MOVES2010a has been integrated with local traffic, vehicle fleet, environmental, fuel, and control strategy data to estimate emissions.

PPSUITE represents an enhanced version of the Post Processor for Air Quality (PPAQ) software system that has been used for previous inventory and conformity submissions in Pennsylvania. The software has undergone significant revisions to ensure consistency with the MOVES2010a. PPSUITE was used to calculate hourly congested speeds for each roadway link, apply vehicle type fractions, aggregate VMT, prepare MOVES2010a traffic-related input files and process MOVES2010a outputs.

The PPSUITE software and process methodologies are consistent with that used for state inventories and transportation conformity analyses throughout Pennsylvania. **Exhibit 4** summarizes the key functions of PPSUITE.

Exhibit 4: PPSUITE Process
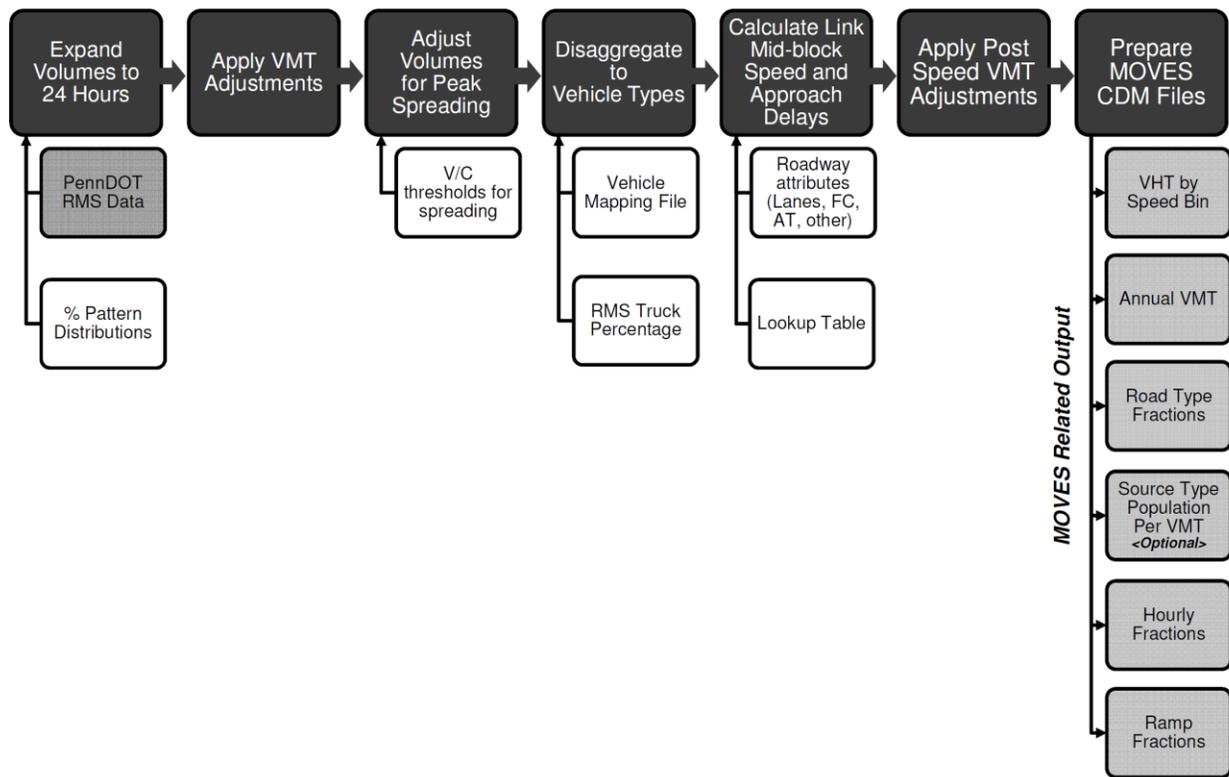
CENTRAL is a menu-driven software platform that executes the PPSUITE and MOVES2010a processes in batch mode. The software allows users to execute runs for a variety of input options and integrates custom MYSQL steps into the process. CENTRAL provides important quality control and assurance steps including file naming and storage automation.

Traffic Data Source/Fleet Data Inputs

Traffic Volume Data: The 2008 PennDOT Roadway Management System (RMS) data serves as the primary highway data source for the county and functional class VMT estimates. The data source has been updated to provide a "snapshot" of the regional roadway system and traffic volumes in 2008 and is also integrated with traffic signal locations. The data includes the 2008 average annual daily traffic (AADT) volumes for all state roadways in Pennsylvania. To account for additional local roadway VMT and to ensure consistency with reported Highway Performance Monitoring System (HPMS) VMT totals, the 2008 VMT totals are adjusted to match the 2008 HPMS VMT totals reported to FHWA.

Seasonal Adjustments: Based on the requirements for ozone inventories, traffic volumes on each RMS roadway segment must be adjusted to a July weekday. The daily and monthly seasonal factors are developed from data contained in the document, *2008 Pennsylvania Traffic Data*, prepared by PennDOT's Bureau of Planning and Research (BPR). The seasonal and daily factors provided in this document are based on statistical analyses of 2008 traffic counts taken at permanent and in-pavement ATR (automatic traffic recorder) locations throughout the state. Based on these seasonal traffic volumes, the PPSUITE software calculates unique congested speeds for each roadway segment during an ozone summer weekday scenario.

Congested Speeds: PPSUITE calculates congested speeds by hour of the day for each roadway segment and provides the information as input to the MOVES2010a software. To disaggregate the daily RMS volumes to hourly volumes, auto and truck hourly pattern data from PennDOT's *2008 Pennsylvania Traffic Data* report are used to determine the temporal variations in traffic volumes.

Vehicle Population: Vehicle population is a key input that has an important impact on start and evaporative emissions. MOVES2010a requires the number of vehicles by 13 source types to determine evaporative emissions. State 2008 vehicle registration data was used to estimate vehicle population for light-duty vehicles and school buses. The data was split to source types using MOVES2010a default population data. For transit buses, data from PennDOT and the National Transit Database (NTD) was used to estimate transit bus populations by county. For all other heavy-duty vehicles, PPSUITE calculates vehicle population based on the analysis year VMT for each source type and default MOVES2010a ratios of VMT and source type population (e.g. the number of miles per vehicle by source type). Vehicle population is forecast based on projected household and population growth from Woods and Poole Inc. for each Pennsylvania county. The growth rate methodology includes:

- Choosing the highest growth rate between population and households
- Limiting growth as to not exceed the VMT growth assumptions

VMT by Source Type: The total VMT is disaggregated to the 13 MOVES2010a source types. For this inventory, the vehicle mix was calculated for each county and functional class grouping utilizing a combination of:

- 2008 RMS truck percentages
- PennDOT and 2008 NTD transit data
- 2008 school bus registration data

EPA's MOVES2010a default distribution of VMT by source type was used to determine the remaining source type VMT percentages. The development of vehicle type pattern data input to the MOVES2010a software is described in more detail in **Appendix C-1**.

Vehicle Age Distribution: Vehicle age distributions are required to be input by 13 source types. The distributions reflect the percentage of vehicles in the fleet up to 31 years old. A recent 2010 registration download from PennDOT's Bureau of Motor Vehicles Registration Database has indicated a substantially older fleet than recorded in the 2002-2008 period. The 2010 vehicle age distributions have been used for this inventory. Due to insufficient data, only data for light-duty vehicles are used as local inputs; and heavy-duty vehicle ages are calculated using the internal MOVES2010a defaults for each Pennsylvania County. The registration data download is based on MOBILE6.2 vehicle categories. The data was converted to source types using the EPA convertor spreadsheets provided with the MOVES2010a emission model.

Traffic Growth Assumptions

Traffic growth forecasting plays a pivotal role in estimating future year emissions for the region. There are many uncertainties affecting projections of traffic growth including the current economic conditions, potential fuel prices, the impacts of Marcellus Shale activities in many counties throughout the state, and the future growth in population and employment. Growth rates for this emissions inventory were based on an assessment of available data sources.

For the *Allentown-Bethlehem-Easton Maintenance Area*, the following data sources are available:

- PennDOT BPR Growth Rate forecasting system.
- Regional Travel Model.

All SIP mobile source highway inventories include the review and assessment of county-specific growth rates from a PennDOT study originally completed in 2005 and documented in the report, *Statistical Evaluation of Projected Traffic Growth, Traffic Growth Forecasting System: Final Report, March 14, 2005*. As part of that study, a statewide traffic growth forecasting system was developed that incorporates traffic data from PennDOT's Traffic Information System and socioeconomic forecasts. That forecasting system is maintained by the PennDOT BPR and is updated on a periodic basis. This system was last updated in December of 2009 to develop new statistical relationships between historic VMT growth and population (thru 2008). The forecast population was estimated from the Woods and Poole data "2010 State Profile". The results of the study have been shared between PennDOT, PaDEP, and other Interagency Consultation Group members, including the Pennsylvania Transportation - Air Quality Work Group (which also includes EPA, FHWA, and representatives from larger MPOs within the state).

The growth rates from the PennDOT BPR forecasting system are evaluated against other available data including travel model growth and other insights. For the development of MVEBs, upper estimates of the VMT growth range are used for the forecast analyses. From an air quality perspective, the use of the upper boundary is conservative, and provides for factors outside PennDOT or PaDEP control (e.g., potential socio-economic growth above current forecasts, fleet age distributions, vehicle type distribution) that influence motor vehicle emissions. **Exhibit 5** summarizes the assumed projected growth of VMT for future analysis years in the *Allentown-Bethlehem-Easton Maintenance Area*.

Exhibit 5: VMT Growth Assumptions

Analysis Year	Total Growth from 2004	Annualized Growth Rate from Previous Year
Lehigh Valley MPO		
2004	----	----
2009	2.5%	0.5%
2018	25.5%	1.8%
Carbon		
2004	----	----
2009	-2.7%	-0.5%
2018	23.8%	1.7%

Vehicle Population Growth Assumptions

Vehicle population growth forecasting plays an important key role in determining emissions for future years for the region. For this inventory, vehicle population was forecasted considering the growth from three different sources:

- Household growth
- Population Growth
- VMT Growth

The household and population data were obtained from the PennDOT study documented in the report as discussed above, *Statistical Evaluation of Projected Traffic Growth, Traffic Growth Forecasting System:*

Final Report, March 14, 2005. The forecast household and population were estimated from the Woods and Poole data "2010 State Profile". The highest growth between household and population data was obtained by county and compared with VMT growth and a factor was chosen limiting growth to VMT growth.

I/M and Fuel Parameters

I/M Program: The inspection maintenance (I/M) program inputs to the MOVES2010a model are based on past and current programs within each county (all PA I/M programs are based on county boundaries). All analysis years include Pennsylvania's statewide program. The MOVES2010a model has simplified the I/M program input parameters compared to MOBILE6.2. The default I/M program parameters included in MOVES2010a were examined for each county and necessary changes made to the defaults to match the actual local program.

In order to assure that emission controls are working properly, vehicle inspection and maintenance (I/M) programs have been adopted in some nonattainment areas. These programs have the added benefit of improving the fuel efficiency of vehicles. The Pennsylvania inspection and maintenance (I/M) program was upgraded and expanded throughout the state with a phase-in period starting in September 2003 and fully implemented by June 2004.

The program requirements vary by region (five regions) and include on-board diagnostics (OBD) technology that uses the vehicle's computer for model years 1996 and newer to identify potential engine and exhaust system problems that could affect emissions. The program, named PAOBDII, is implemented by region, as follows:

- *Philadelphia Region* - Bucks, Chester, Delaware, Montgomery and Philadelphia Counties
- *Pittsburgh Region* - Allegheny, Beaver, Washington and Westmoreland Counties
- *South Central and Lehigh Valley Region* - Berks, Cumberland, Dauphin, Lancaster, Lebanon, Lehigh, Northampton and York Counties
- *North Region* - Blair, Cambria, Centre, Erie, Lackawanna, Luzerne, Lycoming, and Mercer Counties
- *Other 42 Counties* – Includes Carbon County

The OBDII program is implemented in Philadelphia and Pittsburgh along with tailpipe (idle in Pittsburgh and idle and ASM in Philadelphia) and gas cap tests. Tests in other regions include:

- Subject vehicles registered in the South Central and Lehigh Valley counties receive the visual, OBD and gas cap tests.
- Subject vehicles registered in the North region receive a gas cap test and visual inspection.
- Subject vehicles registered in the other 42 counties (67 total counties) receive a visual inspection as part of the annual safety inspection.

Fuel Assumptions: The MOVES2010a default fuel formulation and fuel supply data were reviewed and updated based on available local volumetric fuel property information. The gasohol market penetration and RVP values were updated but MOVES2010a default data was used for the remaining parameters. Updated assumptions included:

- 8.7 RVP used for summer months.
- Conventional gasoline used throughout the year for analysis year 2004.
- 32% market share of conventional gasoline and 68% market share of 10% ethanol used throughout the year for analysis year 2009.

- 10% ethanol used throughout the year for analysis year 2018.

These assumptions, as well as the I/M program parameters, are summarized in **Appendix C-3**.

Meteorology Data

Updated weather information has been obtained from WeatherBank, Inc. (www.weatherbank.com). The 10-year average minimum and maximum monthly temperature and relative humidity values were obtained for each of the 9 airport locations in Pennsylvania.

The MOVES2010a model requires temperature and relative humidity data for each hour of the day. EPA's data converters were used to convert minimum and maximum daily temperatures to an hourly temperature profile that could be input to MOVES2010a. These assumptions are consistent with the 2008 NEI inventory submission.

Vehicle Technology Programs

Federal Programs

Current federal vehicle emissions control and fuel programs are incorporated into the MOVES2010a software. These include the National Program standards covering model year vehicles through 2016. Modifications of default emission rates are required to reflect the early implementation of the National Low Emission Vehicle Program (NLEV) program in Pennsylvania. To reflect these impacts, EPA has released instructions and input files that can be used to model these impacts. This inventory utilized the August 2010 version of the files (http://www.epa.gov/oms/models/moves/tools.htm).

State Programs

The Pennsylvania Clean Vehicles (PCV) Program, adopted in 1998, incorporated the California Low Emission Vehicle Program (CA LEVII) by reference, although it allowed automakers to comply with the NLEV program as an alternative to this Pennsylvania program until MY 2006. Beginning with MY 2008, "new" passenger cars and light-duty trucks with a gross vehicle weight rating (GVWR) of 8,500 pounds or less that are sold or leased and titled in Pennsylvania must be certified by the California Air Resources Board (CARB) or be certified for sale in all 50 states. For this program, a "new" vehicle is a qualified vehicle with an odometer reading less than 7,500 miles. PaDEP and PennDOT worked with the automobile manufacturers, dealers and other interested business partners and finalized procedures for complying with these new requirements. DEP focuses its outreach effort with the manufacturers and dealers regarding what vehicles can be offered for sale and how to certify that the vehicles are compliant. PennDOT's role is to ensure licensing and registration records include these certifications of compliance or that the vehicle owner qualifies for an exemption to the requirements. In all cases, DEP will use information obtained during PennDOT's title and registration process to oversee and audit, as needed, certain vehicle title transactions to determine compliance to the program.

The impacts of this program are modeled for all analysis years beyond 2008 using the same instructions and tools as downloaded for the early NLEV analysis. EPA provided input files to reflect the CAL LEVII program. Modifications to those files were made to reflect a 2008 start date for Pennsylvania.

RESOURCES

Motor Vehicle Emission Simulator, User Guide for MOVES2010a, EPA-420-B-10-036, August 2010.

Technical Guidance on the Use of MOVES2010 for Emission Inventory Preparation in State Implementation Plans and Transportation Conformity, US EPA Office of Air and Radiation, and Office of Transportation and Air Quality, EPA-420-B-10-023, April 2010.

2008 Pennsylvania Traffic Data, PENNDOT Bureau of Planning and Research, 2008.

Policy Guidance on the Use of MOVES2010 for SIP Development, Transportation Conformity, *and Other Purposes*, US EPA Office of Air and Radiation, EPA-420-B-09-046, December 2009.

Instructions for Using LEV and NLEV Inputs for MOVES, US EPA, EPA-420-B-10-003a, August 2010.

Statistical Evaluation of Projected Traffic Growth, Traffic Growth Forecasting System: Final Report, Michael Baker Jr., Inc., March 14, 2005.

Metrological Data from Weather Bank, Inc., www.weatherbank.com