Quantification of Pennsylvania Heavy-Duty Diesel Vehicle Idling and Emissions

Final Report

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Table of Contents

Exhibits

Section 1

Introduction

Heavy-Duty Diesel Vehicle (HDDV) engine idling has significant impacts on national and local air quality. State environmental and transportation agencies and advocacy groups are investigating the potential for idle reduction measures, which may include idling restrictions or a focus on the use of alternative energy sources for reducing long-duration HDDV idling. The potential benefits of idling alternatives in Pennsylvania, overall and in specific counties, depends on vehicle activity levels including the number of idling trucks or buses, specific idling locations, and typical idling durations.

This report serves as an addendum to the February, 2004 report submitted to DEP entitled "*Stakeholder-Recommended Control Measures Evaluation – Reduced Idling Measures*" by E.H Pechan & Associates, Inc. and Michael Baker Jr., Inc. The updates have focused on utilizing new and enhanced data to estimate and quantify HDDV idling activity and emissions across the state, with a specific emphasis on long-duration idling (considered 15 minutes or greater for this report). Specific enhancements include an overview of truck travel in the state, a more robust analysis of statewide idling at warehouses and intermodal terminals, idling related to tour buses, and a qualitative assessment of idling at other locations. The report also expands all calculations to annual totals and provides an assessment of additional pollutant categories. As with the original study, this report does not include field collection or observations of local truck or bus idling activity within the state. All data and analyses were collected via an extensive literature research and using other existing public and private data sources. Local observations may be collected in the future to adjust the calculations included in this report.

The report summarizes HDDV idling activity in Pennsylvania and estimates volatile organic compounds (VOC), nitrous oxides (NOx), carbon monoxide (CO), fine particulate matter ($PM_{2.5}$) and carbon dioxide (CO_2) emissions related to long-duration idling. The specific HDDV vehicle classes that are addressed include Class 8 trucks (>33,001 lbs GVWR), transit and tour buses, and school buses. Emissions have been calculated for an average day in each season and summed to provide annual totals. In addition, data is compiled to assist in the spatial separation of the idling activity and emission totals to individual counties within the state. Long-duration idling has been separated in the following sub-groupings for the analysis:

- Long-haul truck travel rest (typically at truck stops or state rest areas)
- Loading and unloading of trucks (at warehouses and intermodal terminals)
- Transit and tour bus activity
- School bus activity
- Other idling activity – Landfills, Delivery trucks

Section 2 of this report addresses the quantification of HDDV idling activity across the state. While some items cannot be accurately quantified, they are addressed qualitatively to illustrate the potential locations of idling. **Section 3** provides an overview of the emission rates used for the analyses including an examination of how they change for future years, which provides important insights into future idling emission impacts and program credits. **Section 4** summarizes the HDDV idling emission quantities for each activity grouping. Emissions are quantified for long-duration idling, which is the focus of statewide anti-idling reduction measures. Emission quantities have been calculated for the 2005, 2009, and 2018 analysis years. **Section 5** summarizes anti-idling regulations proposed in other states and addresses limitations on the potential credits that can be used within Statewide Implementation Plans and Transportation Conformity related to idling measures, specifically Class 8 truck idle reduction technology.

Section 2

Idling Activity

This section provides estimates of idling activity for the following sources:

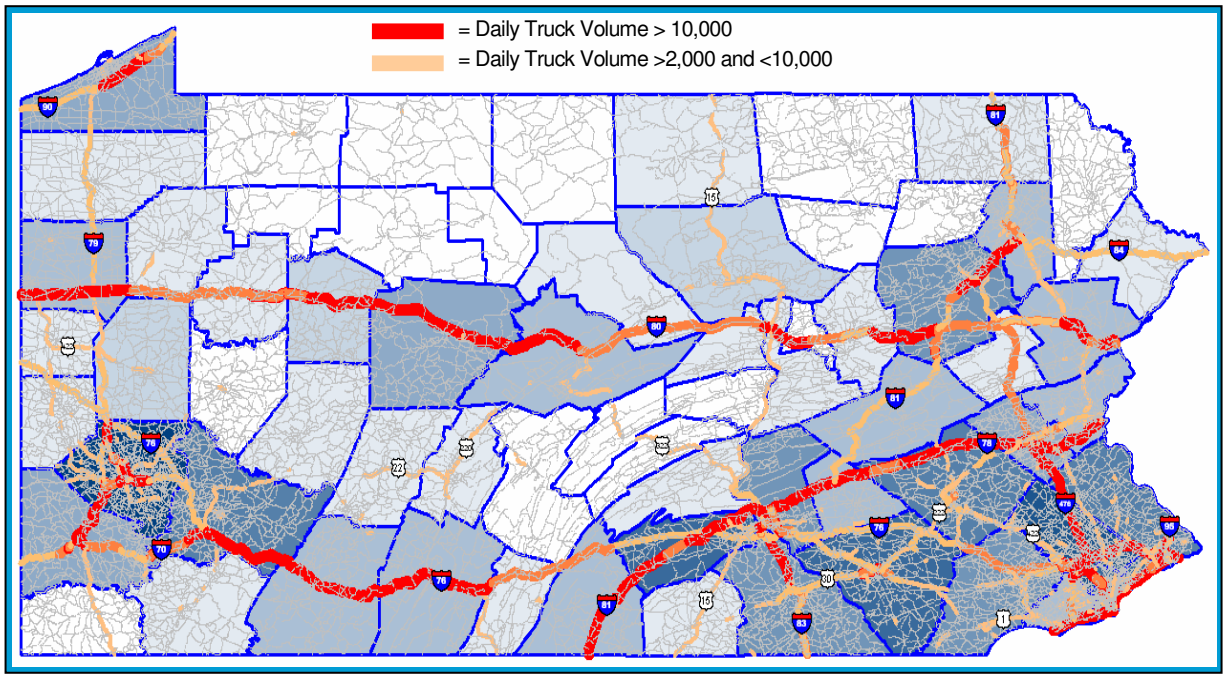
- Long-haul truck travel rest (typically at truck stops or state rest areas)
- Loading and unloading of trucks (at warehouses and intermodal terminals)
- Transit and tour bus activity
- School bus activity
- Other idling activity – Landfills, Delivery trucks

Idling estimates are based on a determination of the number of idling trucks or buses, specific idling locations, and typical idling durations. Local field observations and studies have not been conducted for this study; as a result, idling durations are based on a review of available research studies or assumptions. For each activity, the report attempts to identify the portion of idling considered to be more than 15 minutes, which this report considers to be long-duration idling.

Overview of Truck Activity in Pennsylvania

Before addressing specific idling locations, an overview of heavy-truck travel activity has been examined and summarized. The analyses are based on 2005 Pennsylvania Department of Transportation (PennDOT) Roadway Management System (RMS) traffic data. **Exhibit 1** provides a summary of facilities with significant heavy-truck travel throughout the state. As expected, the primary interstates (specifically I-81, I-80, I-78, and the Pennsylvania Turnpike) carry the most truck volume. The data provides important insights into the potential counties or corridors where significant truck idling may occur.

Exhibit 1: Roadways with High Truck Traffic

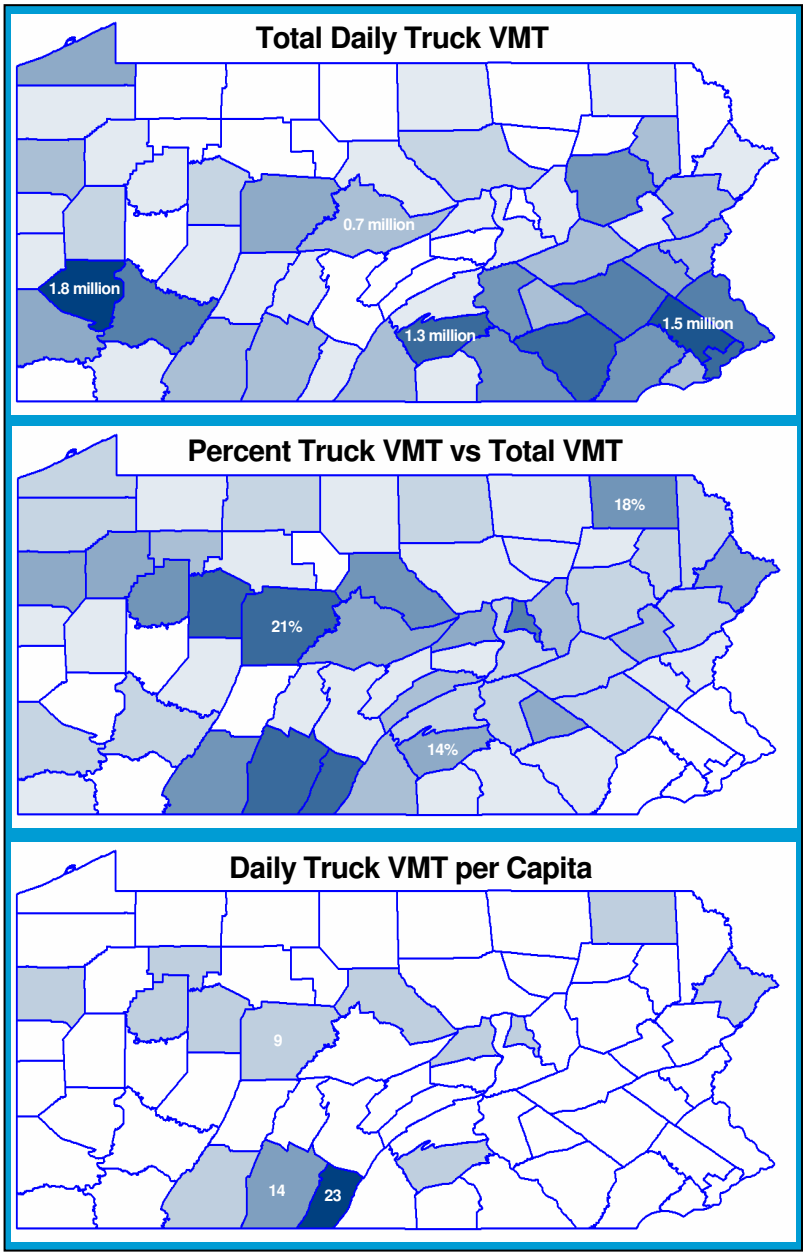


Several roadway sections including I-81 in Dauphin County, I-78 in Lehigh County, I-276 in Montgomery County, and I-95 in Philadelphia and Delaware Counties carry over 18,000 trucks per day.

The RMS truck travel data is aggregated to summarize the amount of heavy-truck vehicle miles of travel (VMT) in each Pennsylvania county. **Exhibit 2** summarizes this data for several performance measures: total truck VMT, the average percent of trucks in each county, and the truck VMT per capita (per population). The exhibit is useful for illustrating counties where truck travel constitutes a relatively significant portion of regional transportation activity and where potential truck idling may occur. Other regional studies and tools currently in development, including PennDOT's statewide traffic model, may assist in determining future forecasts of truck travel within the state.

Exhibit 2: County Thematic Maps of 2005 Truck Travel

(Darker shading = Higher Relative Values)



Quantification of Long-Haul Travel Rest Idling Activity

There are approximately 250,000 Class 7 (26,001-33,000 lbs. GVWR) and Class 8 (>33,001 lbs GVWR) trucks that travel long distances (>500 miles) across the country ***(1)***. Many of these long-haul truck drivers rest for extended periods in their cabs or leave the vehicle idling if resting elsewhere. The U.S. Department of Transportation's Federal Motor Carrier Safety Administration (FMCSA) requires truck drivers to drive no more than 11 hours after 10 consecutive hours off-duty. Engines are often kept idling during these rest periods to operate air conditioning, heat, and appliances such as refrigeration units. Truck drivers typically rest at truck stops (public and private) and rest areas. Pennsylvania has approximately 260 truck stops and 47 public rest areas throughout the state.

This study assumes the majority of long distance truck travel is related to Class 8 diesel trucks. According to MOBILE6 national defaults ***(2)***, over 42% of the national heavy duty vehicle fleet are Class 8 trucks; and, nearly all of those vehicles are powered by diesel fuel.

Travel Rest Locations

Truck stops and travel centers are full service rest areas that often provide overnight truck parking spaces, restaurants, restrooms, and other amenities. These locations can be considered key areas where long-duration truck idling occurs on a regular basis. An inventory was conducted of all truck stops and travel centers throughout Pennsylvania. The inventory included turnpike travel centers and other private truck stops. Since truck counts are not available for each truck stop location, the number of available overnight truck parking spaces is used as the primary determinant of the number of trucks at each location. The primary source for the truck stop locations and total overnight truck parking spaces is the 2003 and 2007 editions of the Truck Stop Parking Directory published by the "The Trucker's Friend" ***(3)***, a national resource for truckers that lists all major truck stops across the country.

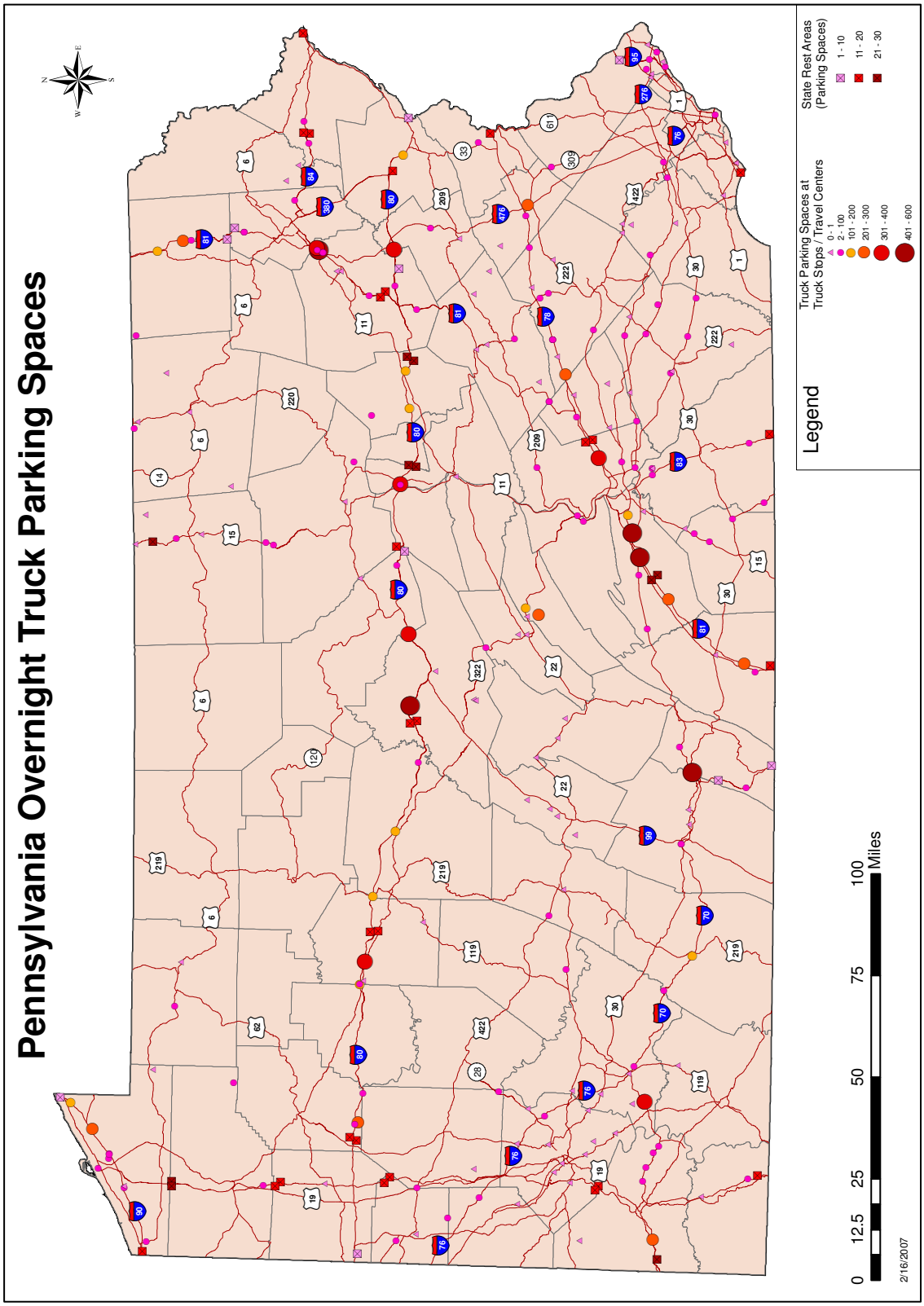
Public interstate highway rest areas are also key locations where truckers can rest for extended periods. Public rest areas are maintained by PennDOT and usually provide truck parking spaces, restrooms, vending machines and other amenities. The primary source for the rest area locations and the total truck parking spaces at each location is the PennDOT Roadside Specialist, which provided a listing of all locations throughout the state ***(4)***. One important feature distinguishes rest areas from truck stops or travel centers. The PennDOT-maintained rest areas have a 2-hour limit on parking duration, which includes trucks. As a result, it is expected that less long-duration idling occurs at these locations than at other truck stop locations. The parking duration limitation encourages turnover, but the overall occupancy of the spaces may be high and may exceed official capacity.

Exhibit 3 and **Exhibit 4** provide a summary of the truck stop and rest area locations throughout the state and the number of corresponding truck parking spaces available. The map provides an overall view at the potential locations of significant long-duration truck idling related to travel rest throughout the state of Pennsylvania. There are over 13,000 truck parking spaces in Pennsylvania where significant long-duration idling may occur. The counties with the highest number of truck parking spaces include Cumberland, Luzerne, Erie, Bedford, Centre, Susquehanna, and Berks counties which together comprise over 41% of the state's total number of truck spaces. Cumberland and Luzerne counties each have over 1,300 truck parking spaces, which is more than double any other county. As expected, nearly all of the major truck rest plazas are adjacent to the major interstates.

Exhibit 3: Pennsylvania Truck Stops and Rest Areas by County

County	Truck Stops		Public Rest Areas	
	# Locations	Truck Parking Spaces	# Locations	Truck Parking Spaces
Cumberland	12	1,469	2	46
Luzerne	12	1,279	3	36
Erie	12	605	2	27
Bedford	7	625		
Centre	8	450	2	40
Susquehanna	7	475	1	6
Berks	13	470		
Dauphin	7	401	2	30
Washington	6	402	1	22
Northumberland	2	420		
Clearfield	4	415		
Carbon	4	410		
Jefferson	4	370	2	39
Clinton	5	380	2	26
Columbia	5	350	2	56
Westmoreland	7	355		
Juniata	4	347		
Venango	6	265	2	38
Franklin	3	260	1	13
Lehigh	3	265		
Lackawanna	4	220	1	6
Somerset	3	190		
Bucks	9	175	1	8
Monroe	2	150	2	26
Lancaster	10	170		
York	7	146	1	12
Chester	4	150		
Clarion	2	145		
Lebanon	7	145		
Fulton	2	125	2	15
Perry	2	117		
Philadelphia	1	100		
Tioga	4	75	1	21
Allegheny	11	50	2	40
Adams	3	83		
Crawford	2	36	2	46
Lawrence	3	40	2	40
Butler	4	75		
Cambria	2	75		
Pike	2	38	3	36
Lycoming	4	65		
Greene	2	50	1	13
Montour			2	53
Beaver	2	50		
Mercer	1	0	3	50
Montgomery	2	50		
Northampton	2	12	1	20
Bradford	5	25		
Mifflin	3	25		
Indiana	1	20		
Delaware	3	0	1	11
Warren	2	10		
Schuylkill	6	8		
Blair	4	0		
Fayette	1	0		
Huntingdon	3	0		
Snyder	1	0		
Wayne	3	0		
Statewide Totals	**260**	**12,633**	**47**	**776**

Exhibit 4: Map of Truck Stop and Rest Area Truck Parking Spaces



Estimation of Number of Idling Trucks

Although the location of truck stop and rest area parking spaces is useful for identifying the potential locations of long-duration idling, they, alone, may not provide an accurate estimate of the actual number of trucks using those facilities. According to NCHRP 317 ***(5)***, a national study on state truck parking supply and demands, many Pennsylvania private truck stop parking spaces are under-utilized while public truck stops (on Turnpike) and PennDOT rest areas have higher demand levels. For this analysis, rest areas and turnpike travel plazas are grouped together since data obtained from the Pennsylvania Turnpike Commission indicates a high demand for the truck parking spaces at many of the turnpike rest plazas ***(6)***. **Exhibit 5** provides the assumptions of parking space utilization obtained from NCHRP 317 and used for this analysis

Exhibit 5: Parking Space Utilization Assumptions (Demand/Supply Ratio)

Location	Demand/Supply Ratio	Category
Turnpike Travel Plazas	1.82:1	Shortage
PennDOT Rest Areas	1.82:1	Shortage
Other Private Truck Stops / Travel Centers	0.65:1	Surplus

Estimation of Truck Idling Activity

The above sections have quantified the number and location of Class 8 trucks that idle long durations for travel rest. To quantify the amount of idling delay at each location, typical long-duration idling times are needed for the analysis. Unfortunately, there have not been a significant number of data collection efforts or truck travel surveys that have identified such idling times. The national Truck Inventory and Use Survey (TIUS) does not collect any information regarding idling durations. Recent truck stop electrification efforts by IdleAire Technologies have produced average durations, but these numbers have not been officially documented or verified. This analysis draws on several resources to determine typical idling durations. Idling times due to travel rest are based on:

- USDOT required resting standards
- National truck survey data
- 2003 local observations/interviews
- Rest area time restrictions

The Department of Transportation requires that a truck driver rest for specified time periods. Effective in 2005, the U.S. Department of Transportation's Federal Motor Carrier Safety Administration (FMCSA) requires truck drivers to drive no more than 11 hours after 10 consecutive hours off-duty. These standards provide guidelines for typical idle durations based on the total travel time. The actual amount of rest would depend on the typical travel times and the number of truckers that typically adhere to these standards.

The above data does not provide how long truck drivers typically travel nor does it account for any violations of this rule (suspected violations are noted throughout the literature). A 2004 TRB paper prepared by the University of California, Davis ***(7)*** provides results from a truck survey conducted in January, 2003 at six locations nationwide. A total of 365 questionnaires were obtained to help provide insight into current idling durations and their variance with season and route. **Exhibit 6** summarizes the reported seasonal idling times from the survey. As expected, idling times are higher during the summer and winter months due to the increased requirements for heating and air conditioning.

Exhibit 6: University of California, Davis National Truck Survey Results

Season	Average Daily Idle Duration (Hrs/Day)	Idling % of Total Engine Run Time
Winter	7.3	39%
Spring	5.1	29%
Summer	6.7	36%
Fall	5.1	29%

In addition to the above studies, a local interview of the owner of the Walt Whitman truck stop was conducted in November of 2003 for the development of the original DEP truck idling report ***(8)***. This truck stop is located near downtown Philadelphia and contains approximately 100 overnight truck parking spaces adjacent to a major interstate highway. Although no studies have been conducted at the truck stop, the owner indicated that typical resting times averaged between 5 and 8 hours. This is consistent with the data provided by the national study. On the day of the field visit, where the outdoor temperature was about 40ºF, the consultant observed that approximately 60% of the trucks were idling. The owner also indicated that fleet companies were more likely to follow DOT standards for travel rest; while, private operators tend to drive for longer durations without rest.

Location-specific restrictions also influence potential idling durations. Most truck stops or travel centers do not have restrictions on truck rest periods or idling. However, PennDOT rest areas throughout the state have a 2-hour time limit for truck parking. Although per truck idling durations are less at rest areas, they generally have higher turnover and occupancy rates than many truck stops and travel centers as discussed previously.

Applicable Travel Rest Idling Durations for Analysis

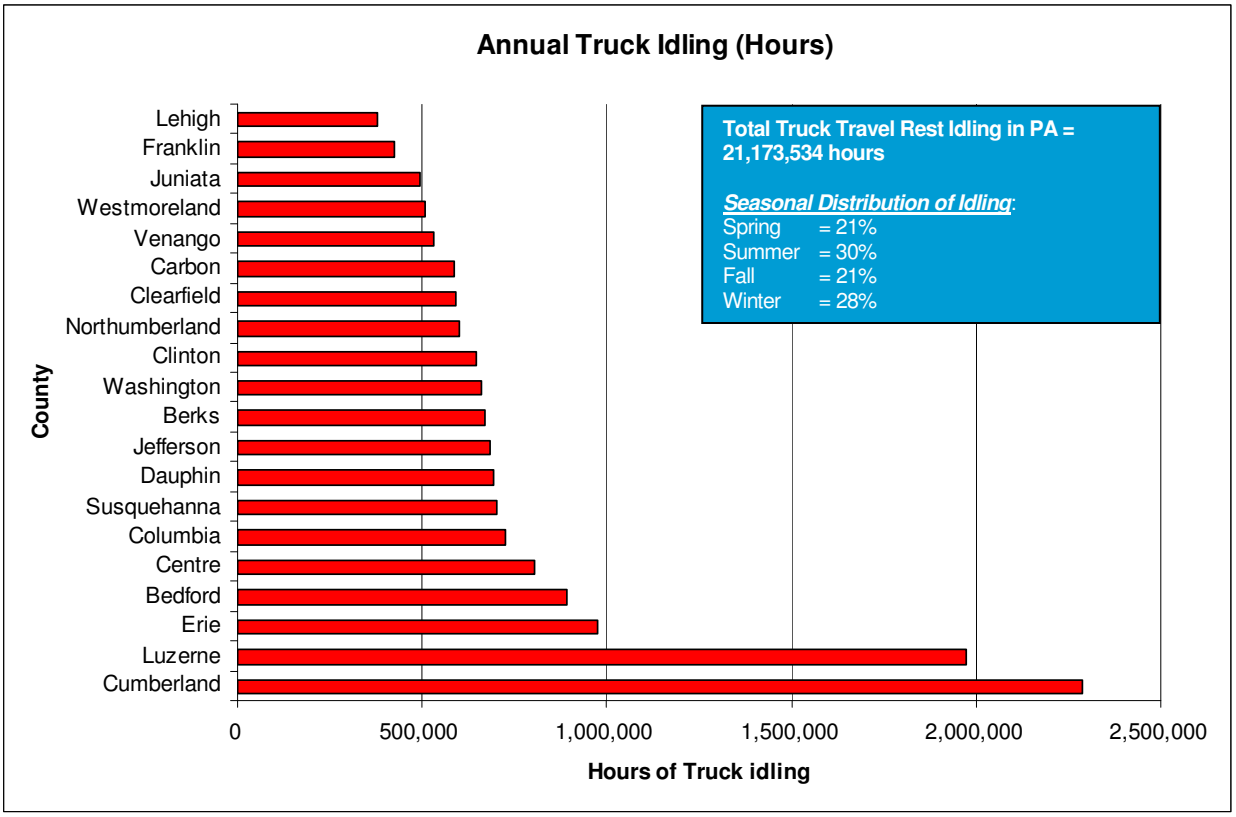
This report's analysis estimates idling activity for an average season in each day and then expands the seasonal estimates to annual totals. The seasonal idling duration estimates from **Exhibit 6** were used for the analysis. Although the University of California study was conducted before the most recent USDOT travel rest standards (which increased mandatory rest times), this study continues to use the data since no additional survey or observation studies are available.

Calculation of Truck Idling Activity

Total truck idling was calculated for each travel plaza and rest area using the methodology as illustrated in **Exhibit 7**. To estimate annual activity, truck stops were assumed to operate 365 days per year. 2005 PennDOT truck traffic data was used to calculate truck idling activity for each season; and the results were then aggregated to annual totals. The total statewide idling related to truck travel rest is calculated as 21,173,534 annual hours. The idling activity for the highest 20 counties is provided in **Exhibit 8.** The spatial distribution of resultant emissions is directly correlated to the truck stop and rest area location as presented earlier. The exhibit illustrates that Cumberland and Luzerne counties have significantly higher idling durations than any other county. For this analysis, all of the truck idling related to travel rest is assumed to be long-duration idling over 15 minutes.

Exhibit 7: Methodology for Calculating Truck Idling Activity

Exhibit 8: Annual Truck Travel Rest Idling For Highest 20 Counties



Quantification of Warehouse / Intermodal Idling Activity

Another major source of long-duration idling are locations where trucks wait to load or unload their cargo. These locations include warehouses, distribution centers, and port terminals throughout the state. Truck engines are often allowed to idle before, during, and after loading/unloading to maintain air conditioning and heat in the truck compartment.

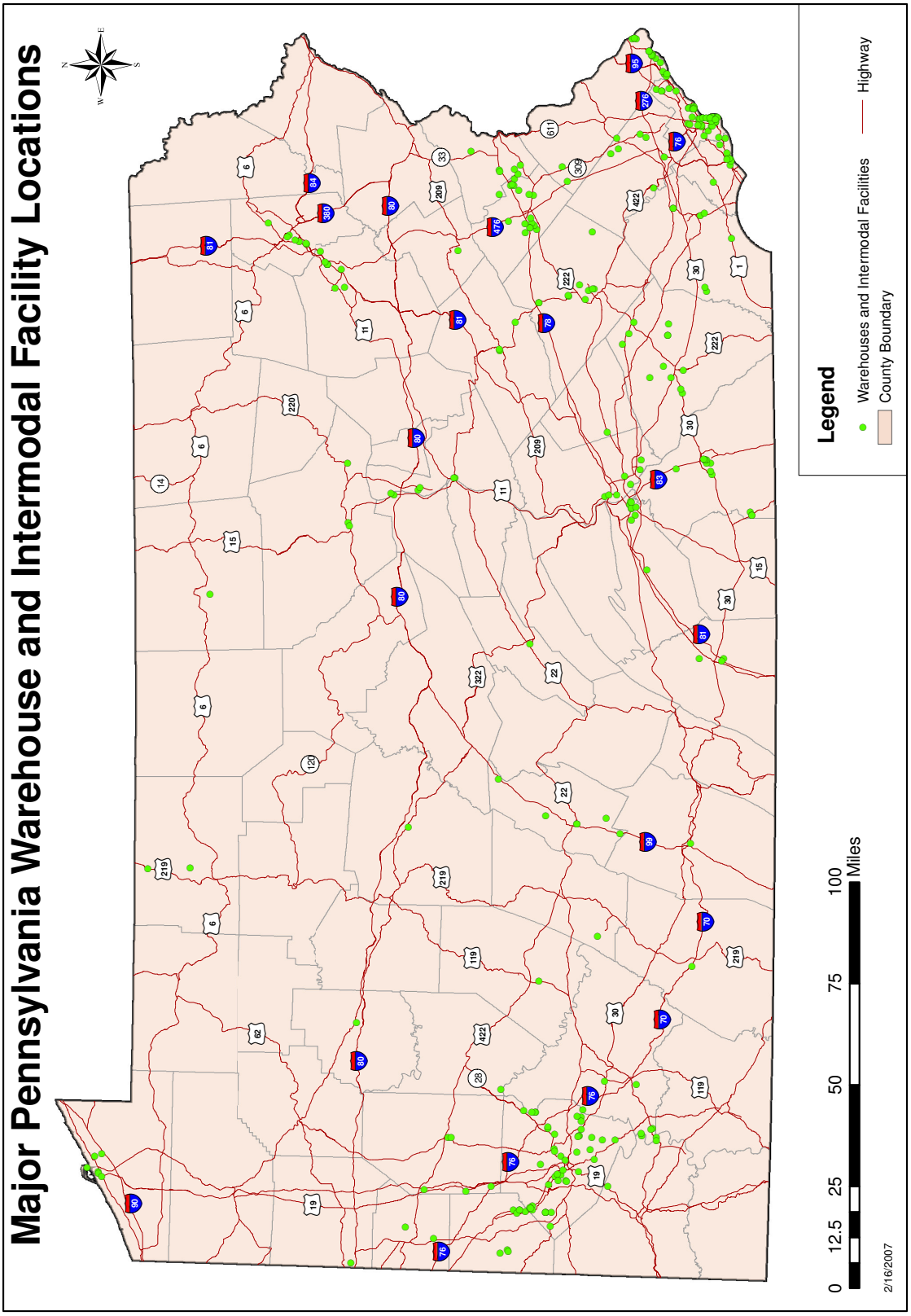
Warehouse and Intermodal Terminal Locations

Warehouses, distribution centers, and port terminals are key locations where truck idling related to loading and unloading occurs on a regular basis. The large number of facilities, their variability in size, and their wide distribution make a 100% inventory very difficult. This study relied on several sources to develop a list of facilities which potentially service a large number of trucks. These sources included:

- 2006 Leonard's Guide Online National Warehouse Directory
- Bureau of Transportation Statistics' 2006 National Transportation Atlas Database
- Southwestern Pennsylvania Freight Transportation Guidebook, 2002
- Philadelphia Regional Port Authority website: http://www.philaport.com
- Port of Pittsburgh Commission website: http://www.port.pittsburgh.pa.us
- Norfolk Southern Distribution Network website: http://www.nscorp.com/nscorp

Exhibit 9 summarizes the location of 300 facilities identified in Pennsylvania.

Exhibit 9: Pennsylvania Warehouse and Intermodal Facility Locations



The available resources on warehouse and intermodal facility locations do not directly provide truck activity estimates for the listed locations. Such data remains scarce and is apparently outside of the public domain. As a result, this study relies on estimates of facility area (in square footage), which is used to estimate the number of annual trucks using each facility. Several of the resources including the Leornard's Guide provide this information for most of the facilities. For locations where data was not available, county averages were used. If county averages were not available, statewide averages were applied to ensure that trucks were estimated for all 300 facilities. **Exhibit 10** summarizes the total facility area in square footage by county.

Exhibit 10: County Warehouse and Intermodal Facility Area (Square Footage)

County	Number of Facility Locations in County	Total Storage Facility Area (Square Feet)
Philadelphia	57	21,732,561
Cumberland	10	17,560,000
Montgomery	7	16,114,000
Allegheny	42	14,526,380
York	14	14,439,460
Luzerne	9	10,919,999
Lackawanna	7	9,657,135
Washington	4	7,493,333
Beaver	8	7,364,693
Lehigh	16	6,902,827
Butler	5	6,519,250
Bucks	17	5,171,400
Franklin	3	4,500,000
Lawrence	2	3,937,000
Westmoreland	8	2,505,520
Blair	6	2,475,000
Berks	10	2,322,480
Northumberland	5	2,317,935
Indiana	1	2,056,800
Northampton	7	1,883,259
Chester	7	1,658,883
Lancaster	12	1,653,333
Delaware	9	1,372,500
McKean	2	1,182,514
Clearfield	1	1,121,200
Lycoming	3	690,750
Erie	6	614,000
Cambria	1	591,257
Carbon	1	591,257
Lebanon	1	591,257
Somerset	1	591,257
Mercer	1	565,000
Schuylkill	3	520,000
Armstrong	1	467,800
Dauphin	7	437,500
Bedford	1	360,000
Union	1	210,500
Clarion	1	180,000
Mifflin	1	120,000
Fayette	1	100,000
Tioga	1	30,000
Statewide Totals	**300**	**174,048,041**

Estimation of Number of Idling Trucks

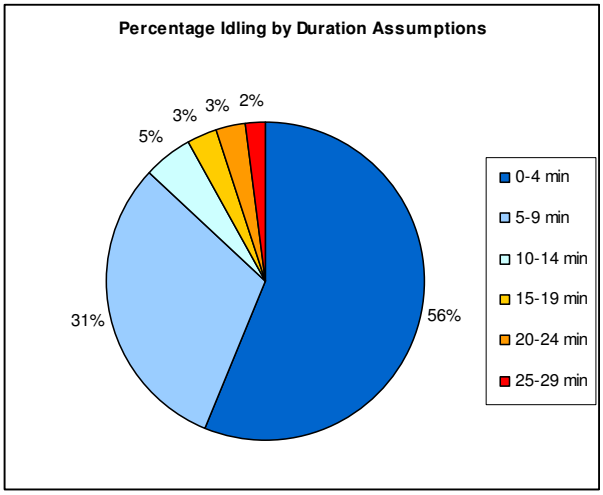
The number of trucks utilizing the warehouse and intermodal terminals is estimated based on the facility area (square footage). For this study, all trucks are assumed to be Class 8 diesel trucks consistent with the travel rest idling calculations. Several sources were examined to determine a truck trip rate. The ITE Trip Generation manual is a comprehensive reference that provides trip rates for various land use types. Unfortunately, the ITE manual has limited information on the generation of truck trips. For this analysis, rates from an ITE article on truck trip generation characteristics ***(9)*** were determined to be the most applicable and correspond well to rates referenced in other reports and presentations. This resource indicated that approximately 0.21 daily Class 8 truck trips are generated per 1,000 square feet of facility space.

Estimation of Truck Idling Activity

There have not been many studies that have identified truck idling at warehouse or intermodal facilities across the country. This report relies on field studies that were conducted for a 2004 Texas study prepared for the Texas Commission on Environmental Quality, *Heavy-Duty Vehicle Idle Activity and Emissions Characterization Study* ***(10)***.

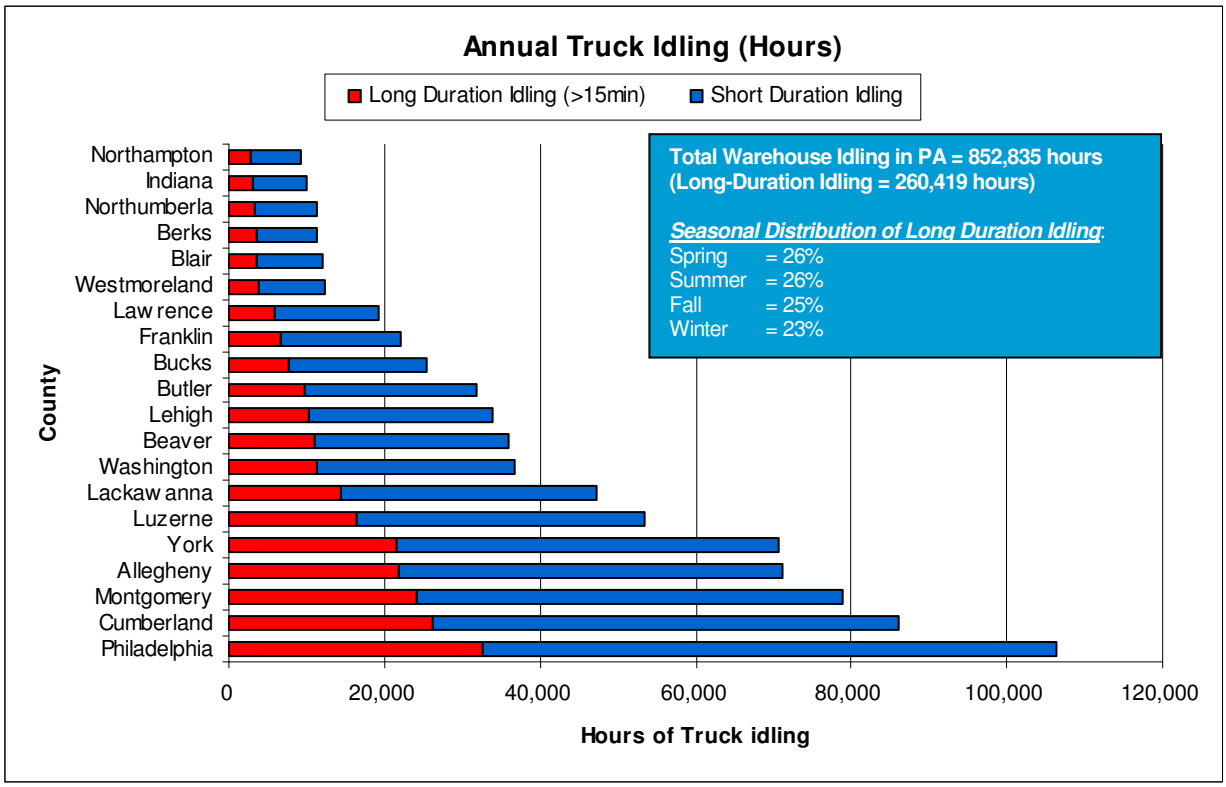
Exhibit 11 illustrates the distribution of idling durations from intermodal rail terminal observations as reported in the Texas study. These results have been used for this study. The Texas study indicates that intermodal facilities generally do not experience significant extended truck idling during typical operations. However, some terminals were determined to have higher idling durations. These facilities included those that operate at high capacities and involve the transferring of goods from rail to truck. Since data is not available on the capacity and goods at each facility, the assumptions in **Exhibit 11** were applied to all locations.

Exhibit 11: Warehouse and Intermodal Truck Idling Activity Distribution Assumptions



For this study, long-duration idling greater than 15 minutes has been calculated separately. Based on **Exhibit 11**, 8 percent of the trucks at warehouse and intermodal terminals are assumed to idle for periods greater than 15 minutes. Annual idling activity was calculated assuming that warehouses and intermodal terminals operate 250 days per year. 2005 PennDOT truck traffic distributions were used to estimate seasonal idling which was then aggregated to annual totals. **Exhibit 12** summarizes the aggregate annual county totals for warehouse/intermodal terminal truck idling. Idling has been divided into both total and long-duration idling.

Exhibit 12: Annual Truck Warehouse/Intermodal Terminal Idling For Highest 20 Counties



Quantification of Transit and Tour Bus Idling Activity

This section quantifies potential transit bus idling in Pennsylvania for each of the major transit agencies in the state. These calculations can provide reasonable expectations for potential credits of strategies aimed at reducing transit bus idling. Transit buses often idle to warm-up engines and to pick-up or drop-off passengers. Tour buses may also idle for significant durations. Due to the difficulty in identifying the locations of tour bus idling, this report provides tour bus company locations and statewide (not by county) estimates of idling.

Transit Agency and Tour Bus Data

An inventory of transit buses for each transit agency was obtained from the 2004 and 2005 National Transit Database (NTD). The NTD provides the number of transit buses operating during maximum service as well as other key activity information that was used for idle activity calculations for buses operating in urban areas only. In addition, the NTD provides data on engine fuel types and model years that was used to determine transit bus emission factors for the emission analysis section of this report. This study relied on two web-based sources to develop a list of tour bus companies, locations, and fleet size. Assumptions were made for companies whose fleet sizes were not available. These sources are:

- BusRates.com website: http://www.busrates.com/
- Greyhound Lines, Inc. website: http://www.greyhound.com/

Exhibit 13 summarizes the primary transit agencies and fleet sizes in Pennsylvania. The fleet sizes represent the number of buses operated during maximum (peak) service. The activity and emission calculations are based on these estimated bus numbers. **Exhibit 14** illustrates a map of the locations of each transit agency and tour

bus company in the state. Tour bus companies and locations were determined via internet research of various websites.

Exhibit 13: Transit Agencies in Pennsylvania

Transit Agency	County	# Diesel Buses*	# CNG Buses*
Southeastern Pennsylvania Transportation Authority	Philadelphia	1,184	
Port Authority of Allegheny County	Allegheny	995	2
Lehigh and Northampton Transportation Authority	Lehigh	65	
Cumberland-Dauphin-Harrisburg Transit Authority	Dauphin	61	
Erie Metropolitan Transit Authority	Erie	40	12
Berks Area Reading Transportation Authority	Berks	37	7
Trans-Bridge Lines, Inc.	Northampton	42	
Centre Area Transportation Authority	Centre	0	42
Red Rose Transit Authority	Lancaster	37	
Luzerne County Transportation Authority	Luzerne	31	
York County Transportation Authority	York	26	2
County of Lackawanna Transit System	Lackawanna	27	
Altoona Metro Transit	Blair	26	
Cambria County Transit Authority	Cambria	23	
Mid Mon Valley Transit Authority	Washington	23	
Westmoreland County Transit Authority	Westmoreland	22	
Beaver County Transit Authority	Beaver	21	
Williamsport Bureau of Transportation	Lycoming	19	
Fayette Area Coordinated Transportation	Fayette	7	
G G & C Bus Company, Inc.	Washington	4	
Shenango Valley Shuttle Service	Mercer	4	

** Data is for buses only and may exclude mini-buses and smaller vehicles used for demand-responsive service*

The tour bus locations illustrated in **Exhibit 14** may not represent the locations of actually idling. Tour bus idling will often occur during travel (e.g. to stop for meals or at destination). Destinations may include locations outside of Pennsylvania.

Transit and Tour Bus Idling Activity

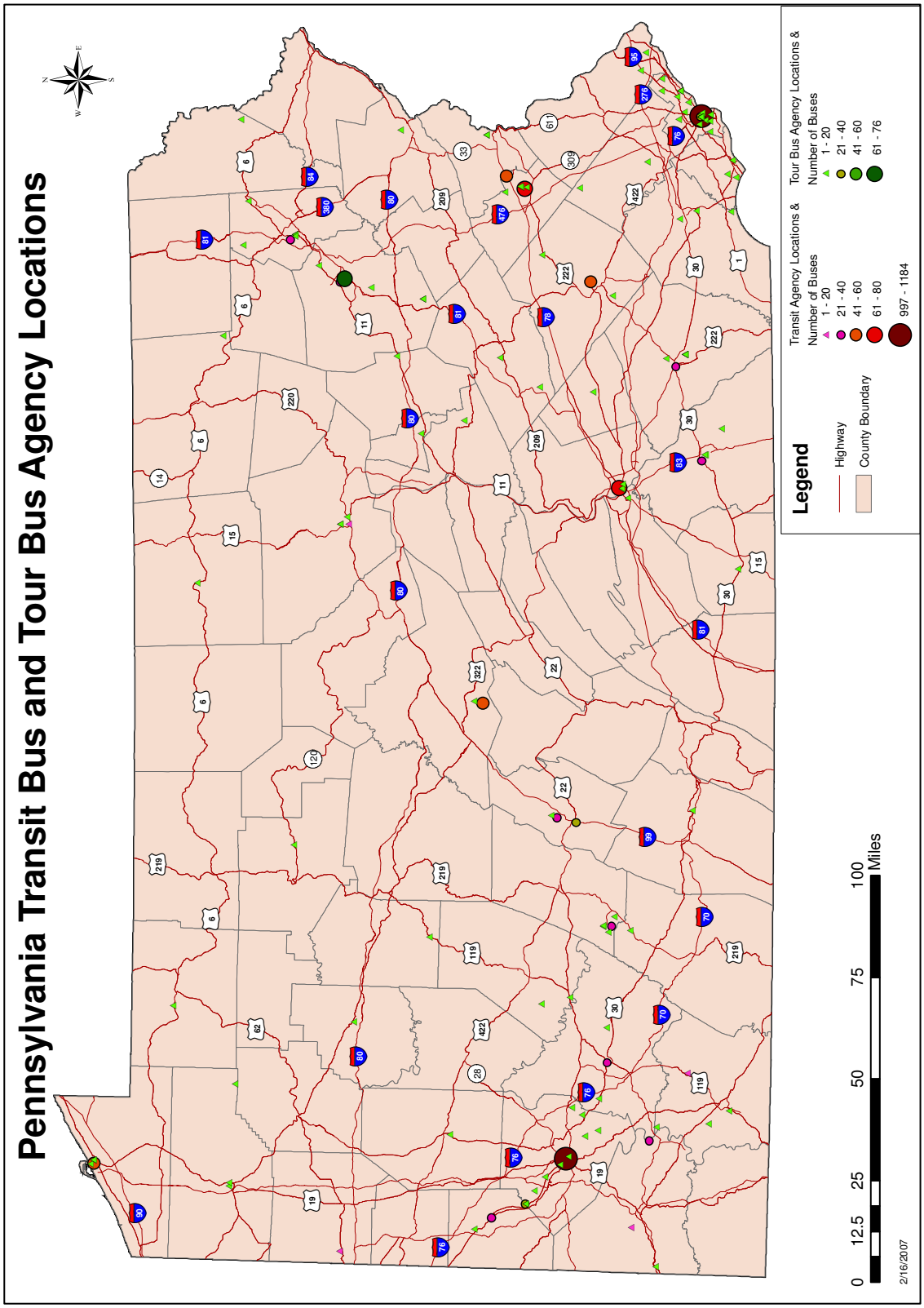
The total amount of transit bus idling delay was determined from separate estimations of the following components:

- Non-Route Idling
- Transit Bus Route Idling

Non-Route Idling

The non-route idling relates to transit bus engine operation before or after the vehicle commences service to the public and during layovers between runs. This typically occurs as bus drivers warm the bus engines or wait at the transit facility. A certain amount of idling, usually between three and five minutes, is needed to properly warm up engines and build pressure in air brake systems. Additional idling time may be necessary in the summer and winter to allow air conditioners or heaters to cool or warm the buses before the passengers board. Based on a literature research, there have not been many studies indicating the potential non-route idling times of transit buses.

Exhibit 14: Map of Transit Agencies and Tour Bus Companies



Based on information from EPA, diesel bus engines require about 5 minutes to warm up ***(11)***. A study conducted by the Tompkins Consolidated Area Transit agency in Ithaca, New York indicated that 74% of the intercity buses idled for less than 10 minutes and 26% idled for 11-20 minutes ***(12)***. Michael Baker, Jr., Inc. performed observations of the Kirk Avenue Division bus facility in Baltimore, Maryland in 2004. Observations indicated that buses kept their engines idling between 9-12 minutes during the spring and summer seasons, while idling 12-20 minutes during the fall and winter seasons. In the winter, overnight and weekend idling may be conducted to avoid freeze-up, especially for locations where no heated indoor storage or block heaters are available.

It is expected that many transit agencies limit idling durations for financial purposes. For this study, it is assumed that the average non-route idling time per bus is 10.5 minutes per start for the spring and summer seasons and 16 minutes for the fall and winter seasons. A literature research could not provide estimates of the typical number of engine starts per day for intra-city bus travel. Although MOBILE6 incorporates estimates of starts per day for light-duty vehicles, start emissions are not directly calculated for heavy trucks and buses. As a result, the MOBILE6 software does not have any values for the number of daily starts for transit buses. For this study, it is assumed that there is no more than 2 engine starts per day for each transit bus.

Transit Bus Route Idling

Transit buses also idle during the routes at the bus stop locations to pick-up or drop-off passengers. Idling during the actual transit bus route is usually much greater than the average Federal Test Procedure (FTP) drive cycle assumed for typical vehicles. Limited studies have been conducted tracking the average idling times of transit buses during their travel routes. This analysis draws on a California Air Resources Board (CARB) study conducted in 1994 of both school and transit buses ***(13)***. The study followed transit buses during their identified bus routes and provided samples of the amount of idling that occurred on these trips. **Exhibit 15** provides some of the key data from this study.

Exhibit 15: Data from CARB Transit Bus Study (Weekday Peak Service)

Summary Statistics	Urban Area	Small Urban Area
Average Bus Trip Speed	14.3 mph	17.0 mph
Average 1-Way Bus Route Distance	7.0 mi	8.9 mi
Average 1-Way Bus Route Duration	29.3 min	31.4 min
Percentage of Time in Idle	**32%**	**31%**

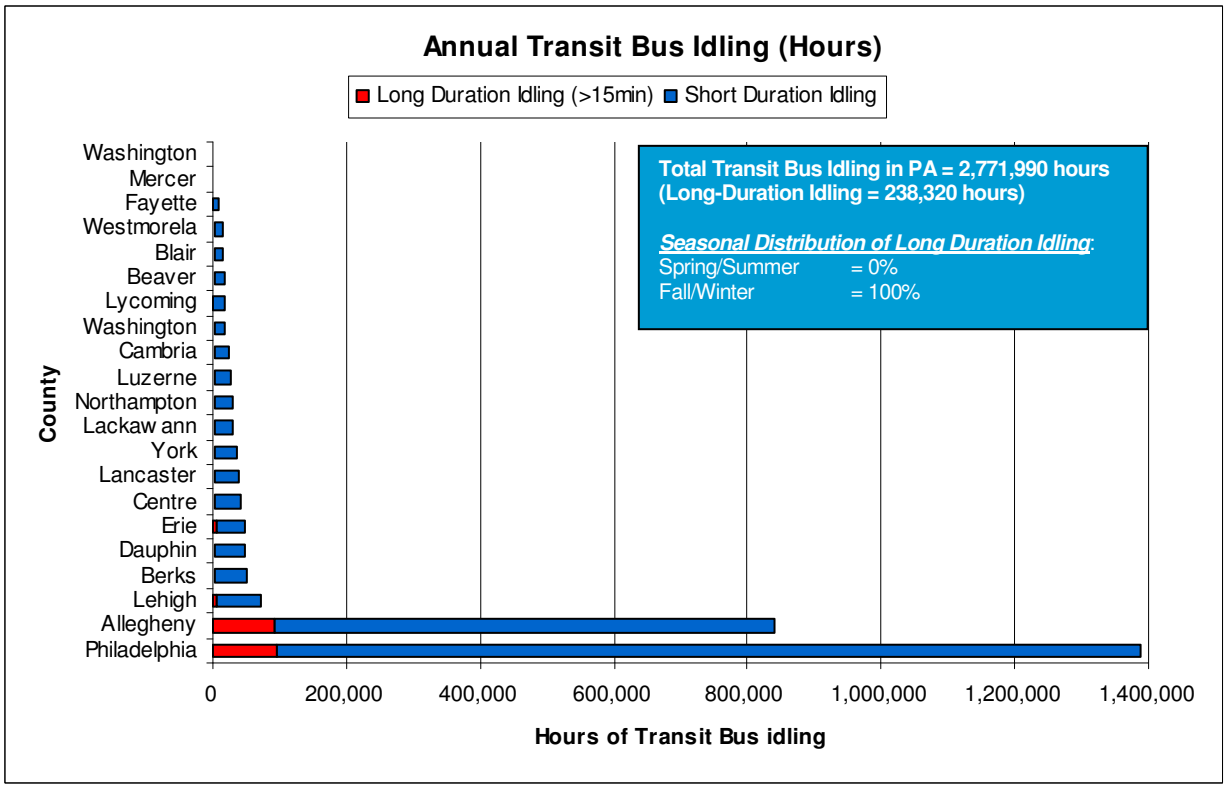
Idling Duration	Percentage Idling
Idle < 10 sec	4 %
Idle 10-60 sec	21 %
Idle >60 sec	7 %
Total	**32%**

Transit Bus Idling Calculations

The above information was used to calculate total idling for each transit agency. The 2004 NTD annual operation hours for each agency was factored by 2005 PennDOT seasonal traffic distributions to obtain seasonal idling activity, which was then aggregated to annual totals. **Exhibit 16** illustrates the total non-route plus on-

route idling estimates. Most of the transit bus idling has been estimated to be short-duration idling (<15 minutes in duration). The long-duration idling primarily is related to the engine start-up/warm-up during the fall and winter months. The only regions with significant long-duration idling are Pittsburgh and Philadelphia, which have large bus fleets. Note that all emissions have been attributed to the county of the transit agency's main office.

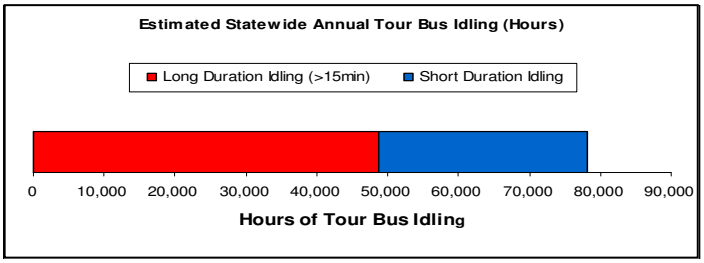
Exhibit 16: Annual Transit Bus Idling For Counties with Transit Service



Tour Bus Idling Calculations

Similar to transit bus idling, tour bus idling can also be represented by two components: non-route idling and tour route idling. Due to limited data, tour bus non-route idling calculations were based on the same idling assumptions used for transit buses. Tour buses also idle during the routes at bus terminals to pick-up or drop-off passengers; and idling may also occur at rest areas (e.g. to stop for meals). For this report, it is assumed each tour bus has two stops, including one short stop for 7.5 minutes and one long stop for 15 minutes, per operation day. A utilization rate of 50% and 300 operation days per year are also assumed to generate annual activity data. Since idling locations cannot be adequately determined, idling calculation were limited to statewide estimates as illustrated in **Exhibit 17**.

Exhibit 17: Statewide Annual Tour Bus Idling



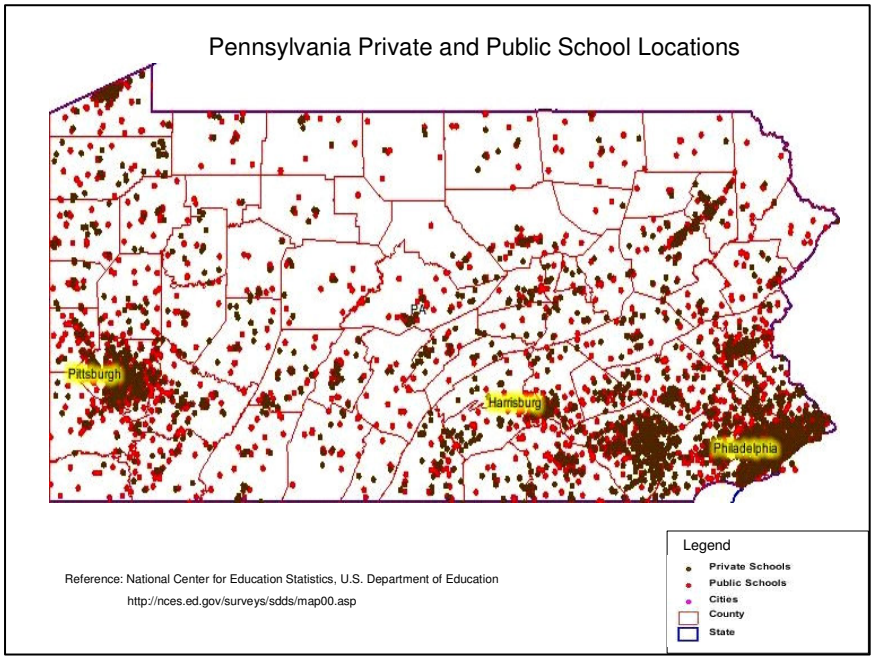
Quantification of School Bus Idling Activity

Environmental groups and air agencies have recently focused on the impact of school bus emissions on children's health. Diesel exhaust from idling school buses can accumulate on and around school buses and can potentially cause a health risk. EPA has established guidelines for reducing school bus idling ***(11)***; and, it is expected that state agencies and school districts will follow in the future with specific requirements to reduce the amount of bus idling throughout the state. Since idling reduction measures may be considered future regional pollutant control strategies, this section attempts to quantify the amount of statewide idling emissions related to school buses, thus providing reasonable expectations for potential emission credits from such strategies.

School Bus Data

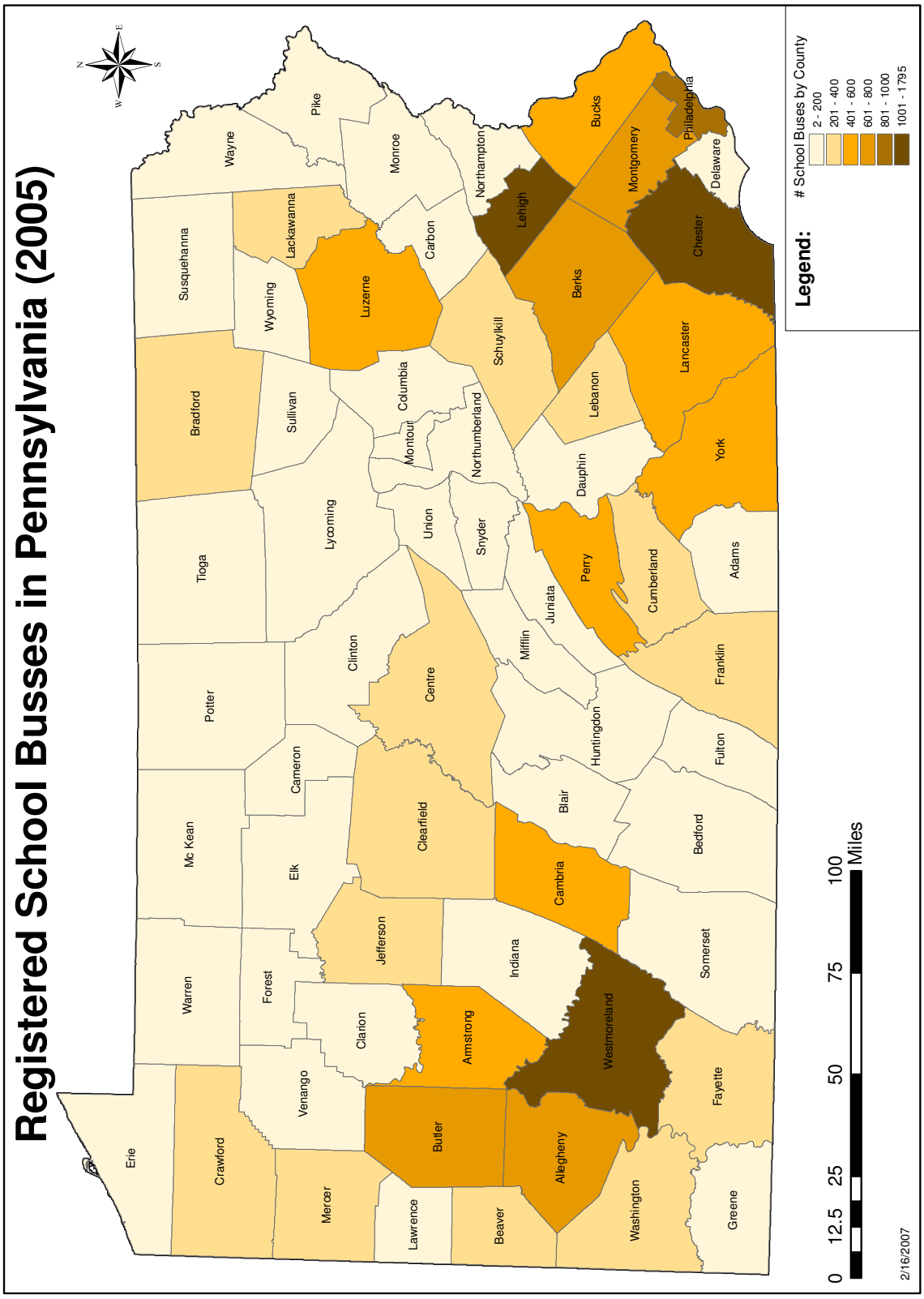
There are over 3,200 public and private schools across the state as illustrated in **Exhibit 18**. To determine the potential idling occurring at these locations, the number of school buses in each county were multiplied by potential idling activity.

Exhibit 18: Pennsylvania Private and Public School Locations



An inventory of school buses was obtained from 2005 Pennsylvania registration data obtained from PennDOT's Bureau of Motor Vehicles' registration database. The number of county-registered school buses was obtained by model year and fuel type (gas and diesel). The data indicates 18,156 registered school buses in the state with approximately 80% of them powered by diesel engines. **Exhibit 19** illustrates a thematic map of the distribution of school buses by county.

Exhibit 19: Map of Registered School Bus Numbers by County



School Bus Idling Activity

The total amount of school bus idling was determined from separate estimations of the following components:

- Non-Route Idling: Engine Start-up/Warm-up
- Non-Route Idling: At school
- School Bus Route Idling

The non-route idling relates to school bus engine operation before or after the bus is in service along its route. This typically occurs as school bus drivers warm the bus engines or wait for the start of the bus route (e.g. if they have arrived early to school). For analysis purposes, non-route idling was segmented into the following categories for school bus operation.

Non Route Engine Start-Up

Assumptions were made regarding the school bus idling related to engine start-up and warm-up. Based on information from EPA, bus engines require about 5 minutes to warm up ***(11)***. Additional idling time may be necessary in the summer and winter to allow air conditioners or heaters to warm the buses before the students board. The environmental group, Group Against Smog and Pollution (GASP), indicates that there are a significant number of buses that idle for unnecessarily extended periods of time ***(14)***. A review of the *School Bus Fleet Magazine Forum* ***(15)*** included comments from drivers indicating that buses were idled for about 20 minutes during the winter and 10 minutes for other seasons. This analysis used those assumptions and estimated two cold engine starts per day.

Non Route Idling at School

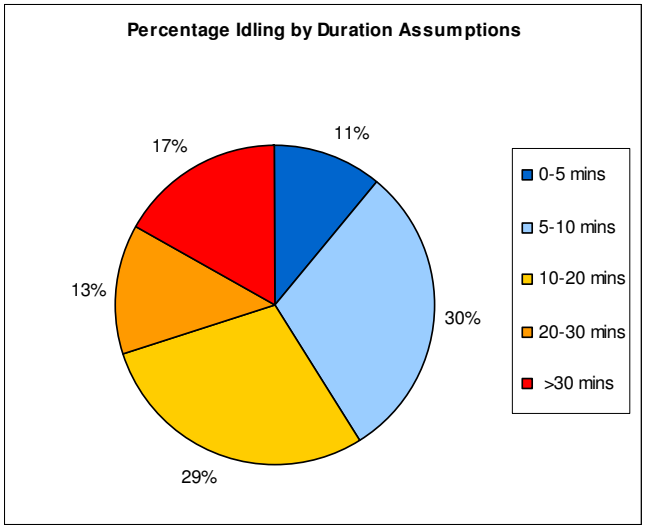
The non-route idling at school relates to school bus engine operation before or after children board or exit the bus. This typically occurs as school bus drivers warm the bus engines or wait for the start of the bus route (e.g. if they have arrived early to school). Because the engines are warm when buses arrive at schools, most should not require the long startup again if drivers shut them off while waiting for students. Some states (New Jersey, Connecticut, New York, Maryland, and California) have limited school bus idling to five-minutes or less. An example of the California Code of Regulations (CCR) Chapter 10, Section 2480 is shown in **Exhibit 20**.

Exhibit 20: California Code of Regulations: School Bus Idling

(*c) Idling Control Measure.*
(1) A driver of a school bus, school pupil activity bus, youth bus, or general public paratransit vehicle:
(A) must turn off the bus or vehicle engine upon stopping at a school or within 100 feet of a school, and must not turn the bus or vehicle engine on more than 30 seconds before beginning to depart from a school or from within 100 feet of a school; and
(B) must not cause or allow a bus or vehicle to idle at any location greater than 100 feet from a school for:
(i) more than five consecutive minutes; or
(ii) a period or periods aggregating more than five minutes in any one hour.

Maine's Department of Environmental Protection conducted a school bus idling survey in 2002 ***(16)***. The results of the estimated time a bus idles at school per day are summarized in **Exhibit 21**. For this analysis, it is assumed that each bus generates two trips (1 am + 1 pm) to school per day. The data indicates that 30% of the school buses idle at school for periods greater than 20 minutes (for each trip).

Exhibit 21: Maine Study on School Bus Idling Durations at School (Min/Day)



School Bus Route Idling

School buses also idle during the routes to pick-up or drop-off children. Idling during the actual school bus route is usually much greater than the average FTP drive cycle assumed for typical vehicles. Limited studies have been conducted tracking the average idling times of school buses during their travel routes. This analysis draws on a California Air Resources Board (CARB) study conducted in 1994 of both school and transit buses ***(13)***. This study followed school buses during their identified school routes and provided samples of the amount of idling that occurred on these sample trips. **Exhibit 22** provides some of the key data from this study, which serve as key assumptions for this report's idling calculations.

Exhibit 22: Data from CARB School Bus Study

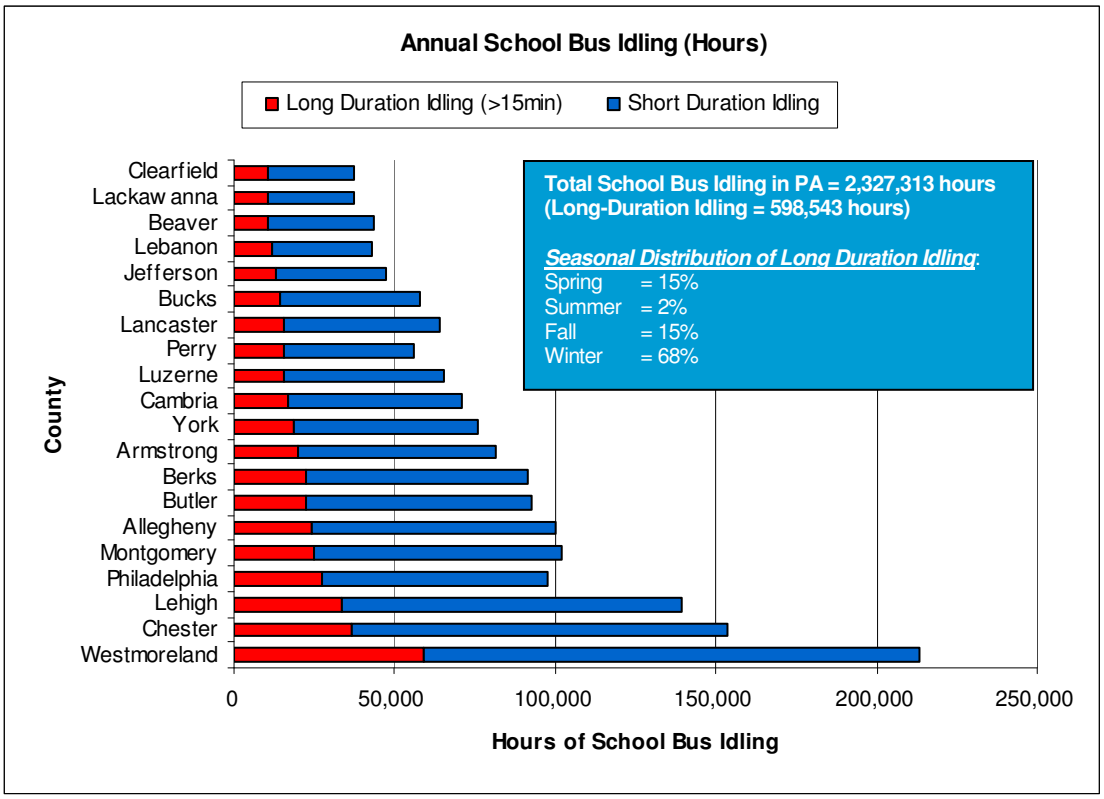
Summary Statistics	Urban / Small Urban Areas	Rural Areas
Average Bus Trip Speed	16.8 mph	24.9 mph
Average 1-Way Bus Route Distance	7.8 mi	11.1 mi
Average 1-Way Bus Route Duration	27.2 min	26.7 min
Percentage of Time in Idle	**31%**	**21%**

Idling Duration	Percentage Idling
Idle < 10 sec	3 %
Idle 10-60 sec	14 %
Idle >60 sec	14 %
Total	**31%**

School Bus Idling Calculations

The above assumptions were used to estimate school bus idling for each county in the state. Seasonal distributions were applied representing the average number of school days in each season to produce annual totals of idling delay. The results for the 20 highest counties are summarized in **Exhibit 23**.

Exhibit 23: Annual School Bus Idling For 20 Highest Counties



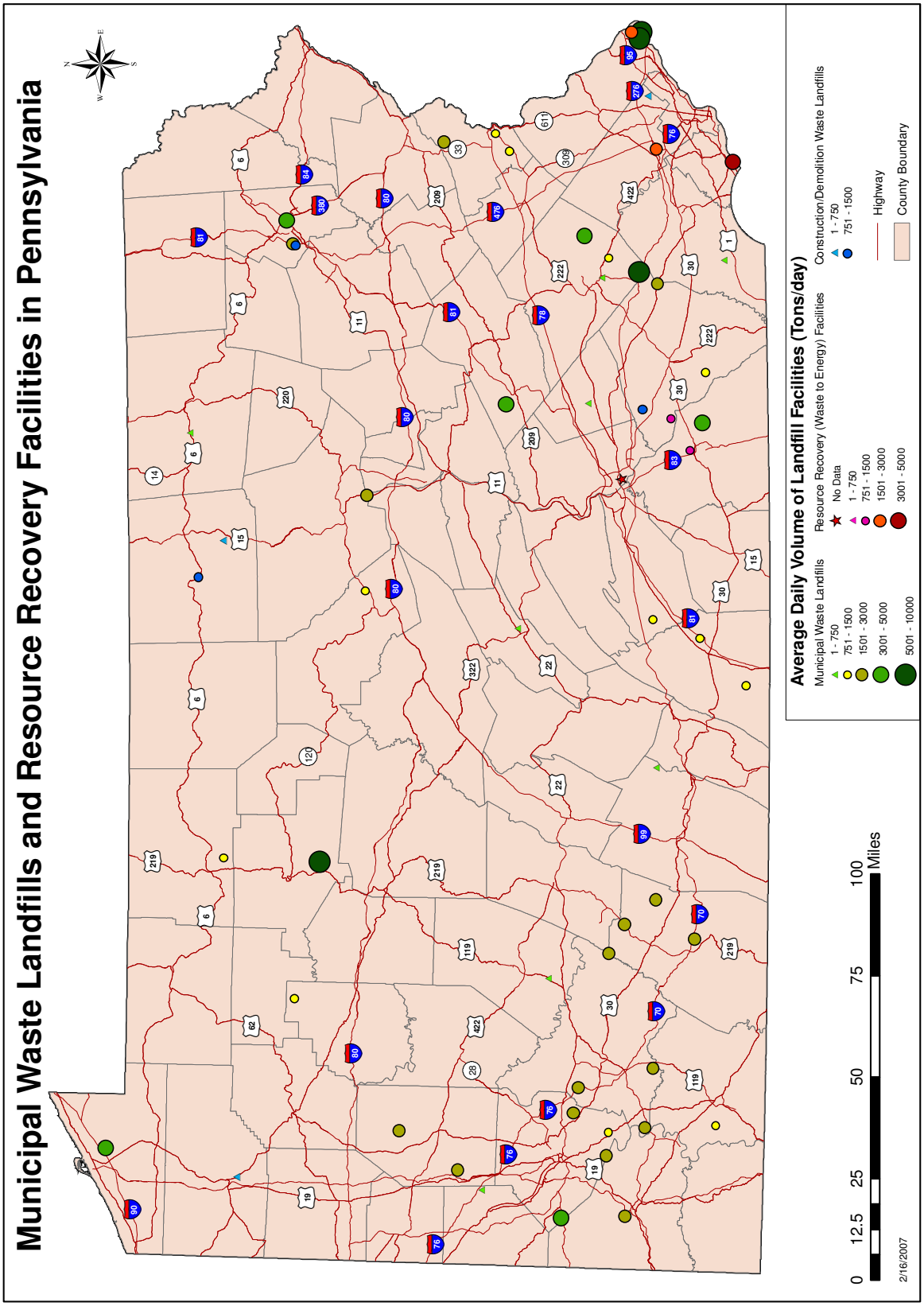
Other Heavy-Duty Diesel Vehicle Idling Activity

This report estimates statewide heavy-duty diesel vehicle idling activity related to truck travel rest, loading and unloading at warehouse and intermodal terminals, transit non-route and route idling, tour bus idling, and school bus idling. There are other sources of truck idling that have not been quantified due to the complexities in identifying the locations and amounts of such activity. Truck idling may also occur on side streets or highway ramps, which may be related to delays or scheduling at warehouse and distribution centers. In addition, trucks load and unload at various businesses resulting in significant truck idling in urban centers or large commercial areas. Very few, if any, studies have been completed to identify or quantify the amount of idling at such locations.

Another possible location of truck idling are landfills and waste transfer facilities where a large number of trucks (varying in size) deliver waste. Public groups have voiced opposition to such facilities due to potential impacts on local air quality. **Exhibit 24** illustrates the location and size of landfills across the state where truck idling may occur.

Additional analyses, observations, and studies may be needed to identify other key sources of truck idling and their potential contribution to regional or localized emission concentrations.

Exhibit 24: Landfill Locations in Pennsylvania



Summary of Idling Activity

The above sections illustrate key components of statewide HDDV idling. **Exhibit 25** summarizes the statewide contributions of each component. The estimate of statewide HDDV idling is approximately 27.2 million annual hours. The idling due to Class 8 truck travel rest at truck stops and rest areas accounts for nearly 78% of the total. Long-duration idling (trucks or buses idling for more than 15 minutes) has been calculated to be 22.3 million annual hours statewide, 95% of which has been estimated to be due from truck travel rest.

Exhibit 25: Summary of Statewide Annual Idling by Type

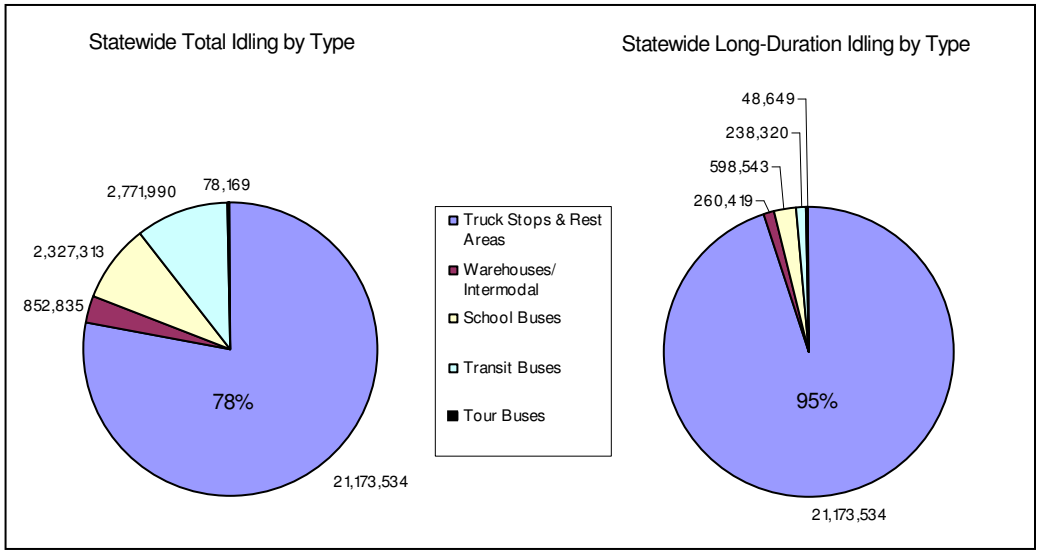
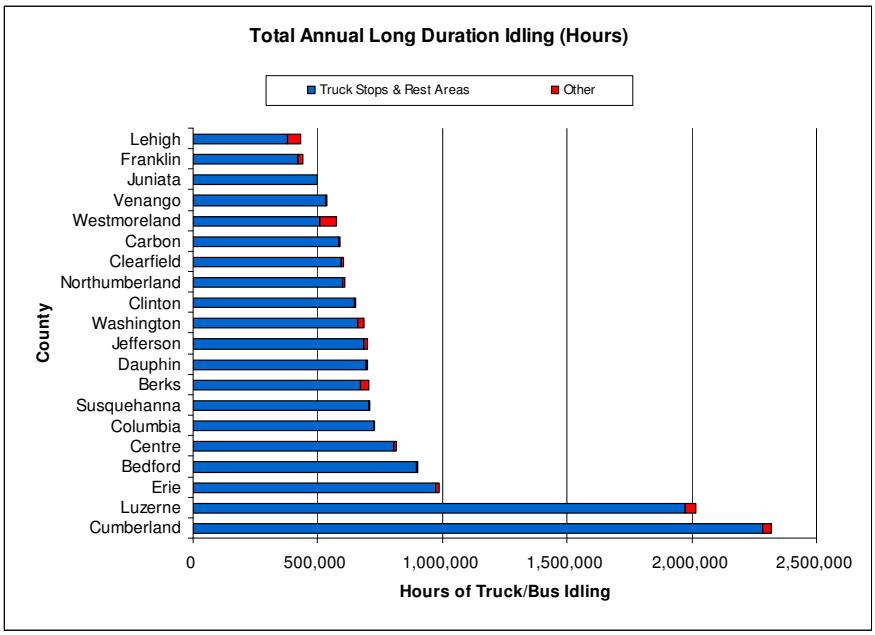


Exhibit 26 summarizes the counties with the highest long-duration truck idling within the state. The results are primarily determined by the amount of truck travel rest idling. Cumberland and Luzerne counties contain the most idling, nearly double any other county in the state.

Exhibit 26: Summary of Counties with Highest Long-Duration Idling



Section 3

Idle Emission Rates

The calculation of emissions due to HDDV idling activity requires idle emission factors by vehicle type (Class 8 trucks, school buses, transit buses) and analysis year. The emission factors have been prepared for the 2005, 2009, and 2018 analysis years to estimate current and future idling activity impacts on pollutants. Emission factors have been compiled for the following criteria and precursor pollutant categories:

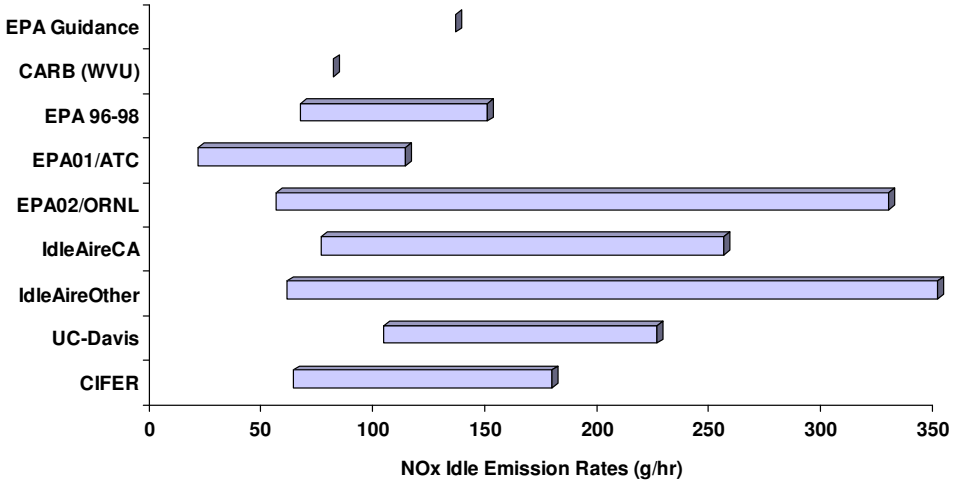
- VOC Volatile organic compounds
- **NOx Nitrous Oxides**
- CO Carbon Monoxide
- **$PM_{2.5}$ Fine Particulate Matter**
- CO_2 Carbon Dioxide

Most truck idling emission studies focus on NOx and $PM_{2.5}$ emissions, since heavy-duty diesel trucks are a significant contributor to each. The in-use emission factors related to the long-duration idling of diesel trucks and buses are highly dependent on a number of factors. These include the engine manufacturer, the vehicle age, engine RPM during idling and accessory load, and ambient temperature and humidity.

EPA's MOBILE6.2 emission model is the required tool to produce emission estimates for statewide highway inventories and transportation conformity analyses. However, the emission factors within the model may not accurately reflect the actual idling emissions produced by diesel trucks and buses, especially those operating their engines for long-duration travel rest. In 2004, EPA released the document, *Guidance for Quantifying and Using Long-Duration Truck Idling Emission Reductions in State Implementation Plans and Transportation Conformity* ***(17)***, which provides guidance on quantifying emission reductions from technologies that reduce long-duration truck idling emissions from Class 8 diesel trucks. The guidance includes specific NOx and $PM_{2.5}$ emission factors by analysis year appropriate for long-duration idling calculations. **Exhibit 27** illustrates the range of heavy-duty truck idling NOx emission factors observed in the literature. The top point on this figure, labeled "EPA Guidance," shows the EPA recommended value of 135 grams per hour, which is the value used in the Pennsylvania NOx idling emission calculations presented in this report. This value falls within the range of observed emission factors in these studies.

Exhibit 27: HDDV NOx Idling Emission Rates from Various Studies

Per 2004 DEP Truck Idling Report ***(8)***



As these and other studies illustrate, emissions from diesel trucks and buses can vary significantly during idling due to a number of different factors. The idle engine speeds, accessory loads, and temperatures affect different trucks and buses in different ways. The NOx and $PM_{2.5}$ emission factors provided by EPA guidance fall within the observed range of diesel truck idling emission rates and, as such, appear to be reasonable default emission factors. However, actual emission rates from HDDV idling may vary significantly from this value. In order to make a rough determination of whether the Pennsylvania idling emissions will be over or under-estimated by using EPA's recommended factors, a survey of the idling speeds actually used at truck rest stops in Pennsylvania may be needed. If a majority of trucks are idling in the high RPM range, then emissions will likely be under-estimated. On the other hand, if a majority of the trucks are idling in the low RPM range, then idling emissions may be over-estimated.

Emission Factor Sources for Analyses

Exhibit 28 identifies the source of pollutant emission factors used for this study. The EPA guidance provides Class 8 truck long-duration idle emission factors for the NOx and $PM_{2.5}$ pollutant categories and has not yet identified emissions factors for other criteria pollutants or vehicle types. For other calculations, EPA recommends that an agency submit data supporting the use of other idling emission factors which will then be reviewed by EPA. For this analysis, MOBILE6.2 is used as the source of all other pollutant types and vehicle types not covered by the guidance.

Exhibit 28: Source of Pollutant Idle Emission Factors

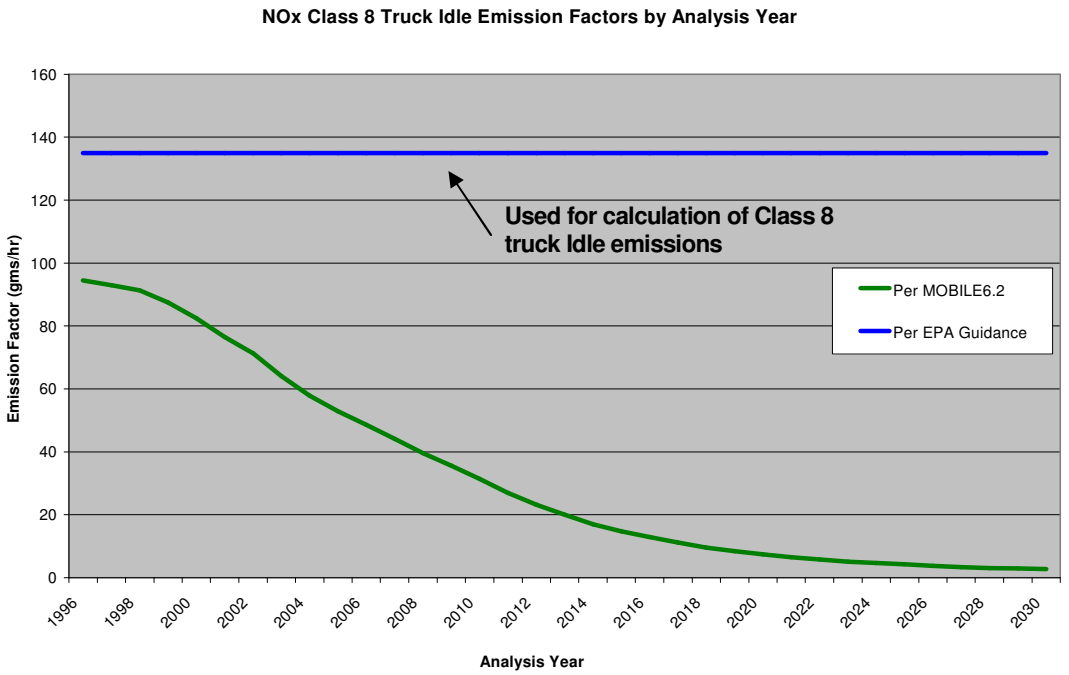
Pollutant Type	Vehicle Type	Source of Emission Factors	Varies by Year
VOC	Class 8 Trucks	MOBILE6.2	•
	Transit/Tour Buses	MOBILE6.2	•
	School Buses	MOBILE6.2	•
NOx	Class 8 Trucks	**EPA Guidance**	No change
	Transit/Tour Buses	MOBILE6.2	•
	School Buses	MOBILE6.2	•
$PM_{2.5}$	Class 8 Trucks	**EPA Guidance**	•
	Transit/Tour Buses	MOBILE6.2	•
	School Buses	MOBILE6.2	•
CO	Class 8 Trucks	MOBILE6.2	•
	Transit/Tour Buses	MOBILE6.2	•
	School Buses	MOBILE6.2	•
CO_2	Class 8 Trucks	MOBILE6.2	•
	Transit/Tour Buses	MOBILE6.2	•
	School Buses	MOBILE6.2	•

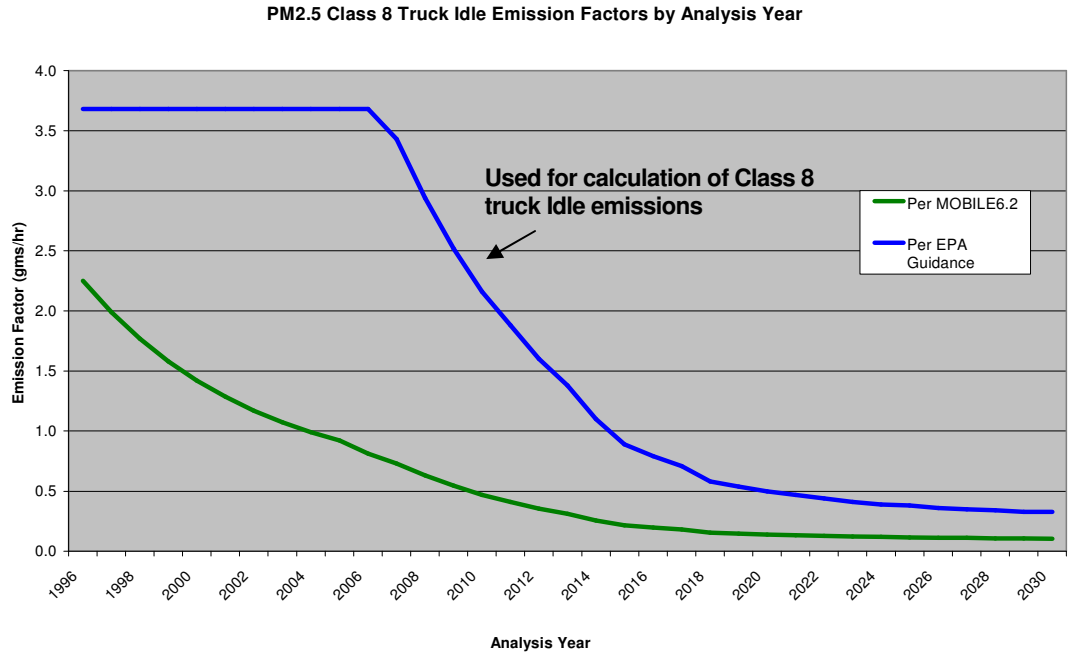
MOBILE6.2 outputs emission factors by vehicle type in grams per mile for different speeds (2.5 miles/hour is lowest speed in MOBILE). To estimate idle emission factors in grams/hour, the emission factors are multiplied by the lowest speed of 2.5mph. This methodology is documented in EPA's *Policy Guidance on the Use of MOBILE6 for SIP Development and Transportation Conformity* ***(18)***.

Summary of Idle Emission Factors

Exhibit 29 summarizes the NOx and $PM_{2.5}$ Class 8 truck idle emission factors used for this study and how they vary by analysis year. The graph also illustrates a comparison between the values from EPA guidance and the MOBILE6.2 analysis tool.

Exhibit 29: Idle Emission Factors by Analysis Year





Notes on NOx Emission Factors from EPA Guidance

Based on an analysis of test data, EPA has determined that for NOx emissions, an emission rate of 135 grams per hour is a reasonable average rate for long-duration truck idling. At this time, the impact of future NOx emission standards on long-duration idling emissions is uncertain. Control measures, such as catalytic converters, intended to reduce running emissions of diesel trucks in the future, may likely be less effective at controlling long-duration idle emissions. As a result, EPA has concluded that it is reasonable to use the emission rate of 135 grams per hour for NOx for analyses of both current and future calendar years ***(17)***. EPA will review these assumptions as emissions data on diesel trucks with more advanced control technology become available, and update the emission factors as appropriate.

Notes on PM Emission Factors from EPA Guidance

Based on an analysis of test data, EPA has determined that for PM emissions, emission rates will vary by analysis year. As in the case with NOx emissions, there is some uncertainty about the impact of future PM emission standards on long-duration idling. However, the control strategies used to control running PM emissions are based on filters and traps which are more likely to show increased effectiveness under long-duration idling conditions. Therefore, EPA expects long-duration idling emissions to decline in the future at a rate similar to the expected decline in running emissions. EPA will review this assumption as emissions data on diesel trucks when more advanced control technology becomes available and update these emissions factors as appropriate.

Section 4

Idling Emissions

This section applies the emission rates from **Section 3** to the idling activity summarized in **Section 2** to obtain the estimated emission impacts due to total and long-duration HDDV idling in Pennsylvania. Long-duration idling is a portion of the total idling and is related to trucks or buses idling for periods greater than 15 minutes.

Emission impacts have been calculated as annual totals in tons per year for the analysis years 2005, 2009, and 2018; however, idling activity is not forecasted. Thus, the forecasted emissions illustrate the impact of current activity with the expected distribution of future model-year trucks and their associated emission factors. Forecasting increasing idling activity is not feasible at this time. Several regional freight studies, as well as the expected completion of PennDOT's statewide model, may assist in projecting freight and truck travel for future studies. However, even those forecasts will need to be evaluated to determine their impact on idling activity, which is also related to the number and location of travel rest facilities and warehouse terminals in the state. **Exhibit 30** summarizes the annual statewide results for each pollutant.

Exhibit 30: Annual Statewide HDDV Idle Emissions by Analysis Year

Pollutant	Total Idling Emissions (tons/year)			Long-Duration Idling Emissions (tons/year)		
	2005	2009	2018	2005	2009	2018
VOC	145	112	72	115	90	59
NOx	3,592	3,506	3,337	3,238	3,225	3,199
$PM_{2.5}$	95	64	15	88	60	14
CO	1,231	856	289	994	669	192
CO_2	127,062	126,032	125,239	100,577	99,684	98,961

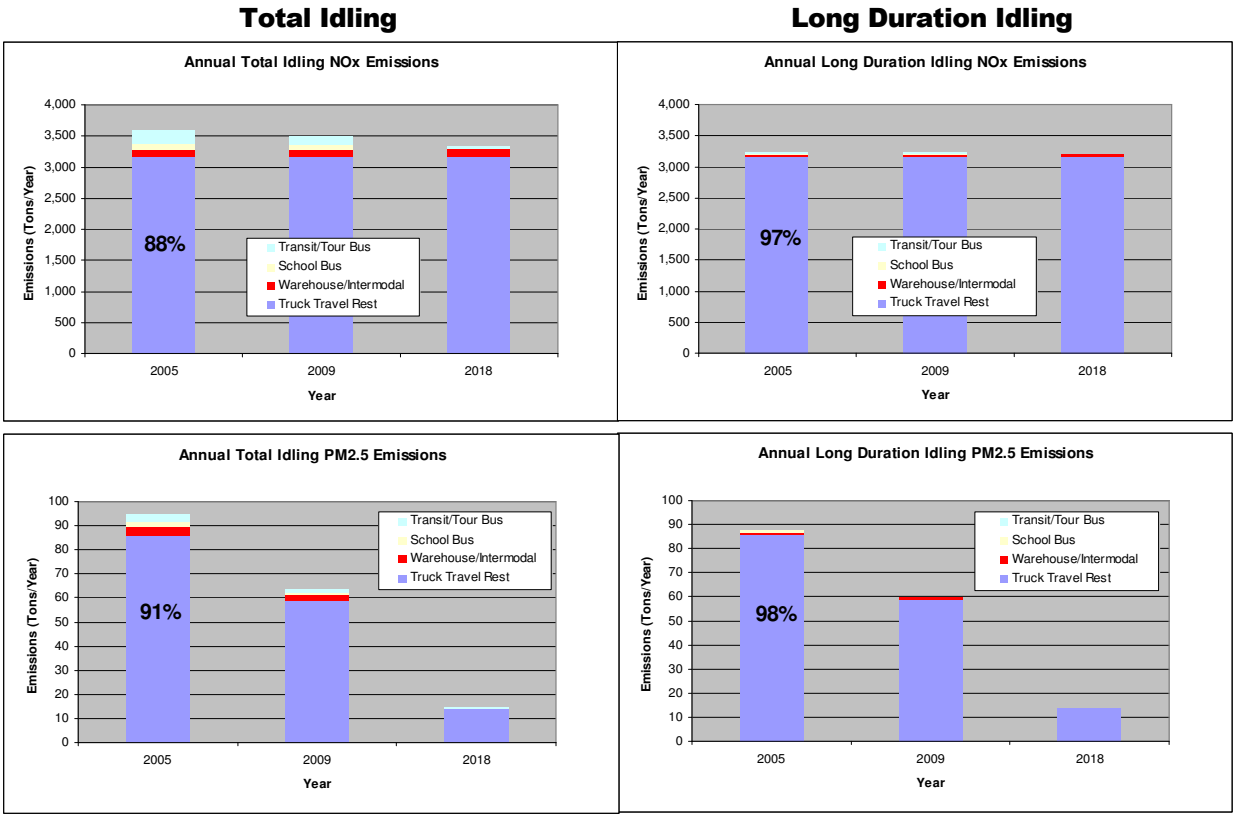
Relating the above estimates to the statewide 2005 highway inventory provides some perspective to the amount of idling emissions calculated. The total 2005 NOx truck idling emissions are approximately 1.2% of the total statewide highway emissions, which equates to nearly 4.2 million VMT of travel. These results are higher for counties which share a large proportion of the idling emissions. As an example, for Cumberland County, the NOx idle emissions represent nearly 4% of the county's mobile NOx emissions.

The above table illustrates significant reductions in future year emissions for the VOC, $PM_{2.5}$, and CO pollutants. Smaller reductions are seen for NOx and CO_2. As discussed in the previous section, NOx emission rates for Class 8 trucks are obtained from EPA's guidance document, which does not indicate reductions in future year NOx emission factors. MOBILE6.2 is EPA's first highway mobile source emissions model to include CO_2. These emissions are estimated in a very simple fashion based on fuel economy performance estimates built into the model or supplied by the user. The current fuel economy assumptions have minimal changes in future years, thus significant reductions in CO_2 are not estimated.

Emissions by Idling Activity

The calculated emissions by idling activity correspond closely to the results previously provided in **Section 1**. **Exhibit 31** summarizes the NOx and $PM_{2.5}$ emission breakdown by model year among the idling activities examined for this study: truck travel rest idling, warehouse/intermodal idling, school bus idling, and transit/tour bus idling. The results indicate that for total HDDV idling activity, 2005 truck travel rest contributes between 88-91% of the total idling emissions. When considering only long-duration idling (>15 minutes), 2005 Class 8 truck travel rest contributes between 97-98% of all HDDV emissions while at idle.

Exhibit 31: Annual Statewide HDDV Idle Emissions by Activity Category



Spatial Distribution of Emissions by Idling Activity

The spatial distribution of idling emissions is also closely correlated to the county idling activity summaries presented in **Section 1**. **Exhibits 32** and **33** provide thematic maps of the county emissions for NOx and $PM_{2.5}$ related to total HDDV idling. The other pollutant categories share similar spatial distributions. These results indicate the highest total emissions are obtained for Cumberland and Luzerne counties due to the large number of truck travel rest areas. The maps also illustrate the point locations of truck travel plazas, rest areas, and warehouse/intermodal terminals where concentrated Class 8 truck idling may occur.

Exhibit 32: Map of Annual NOx HDDV Idle Emissions

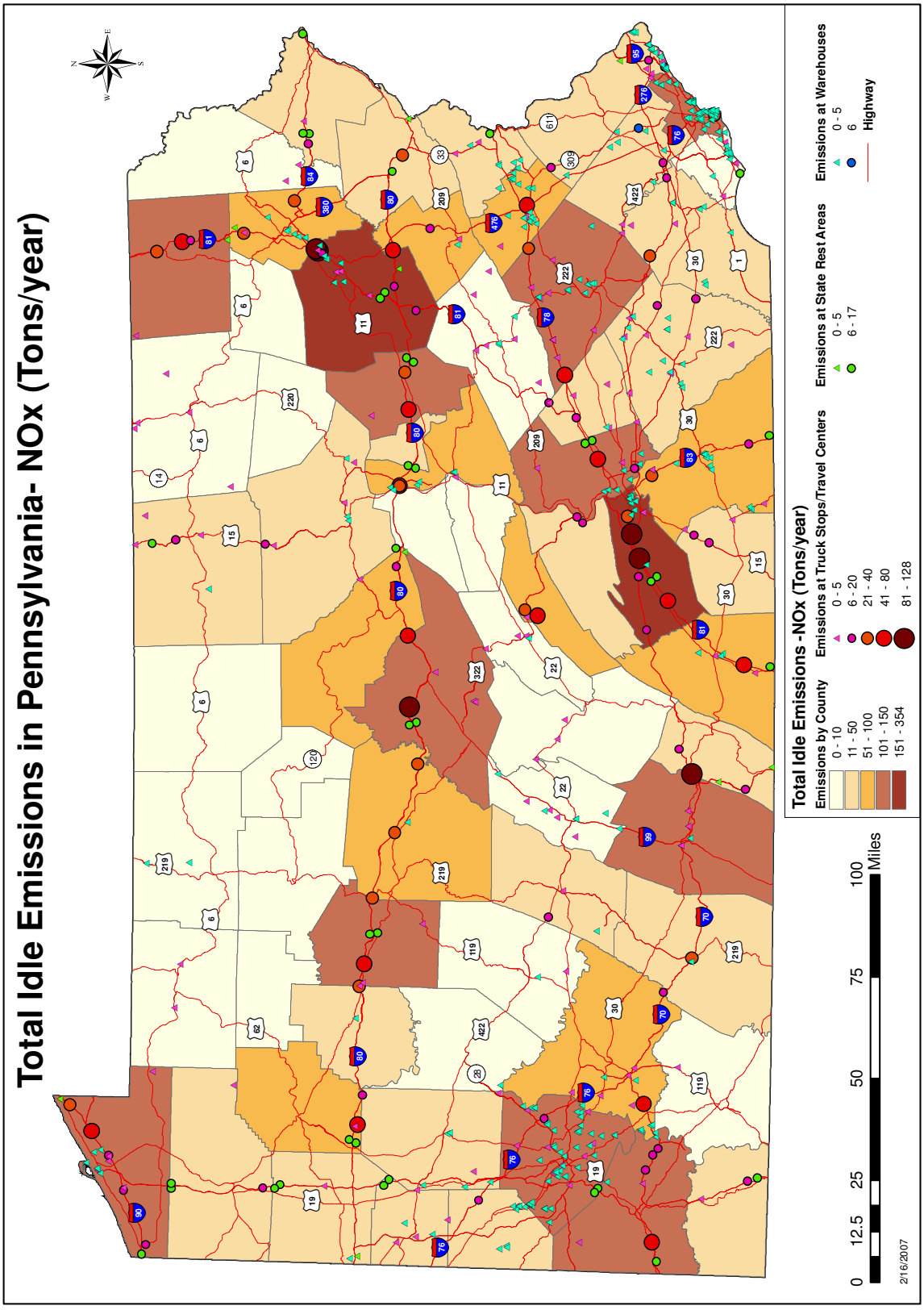
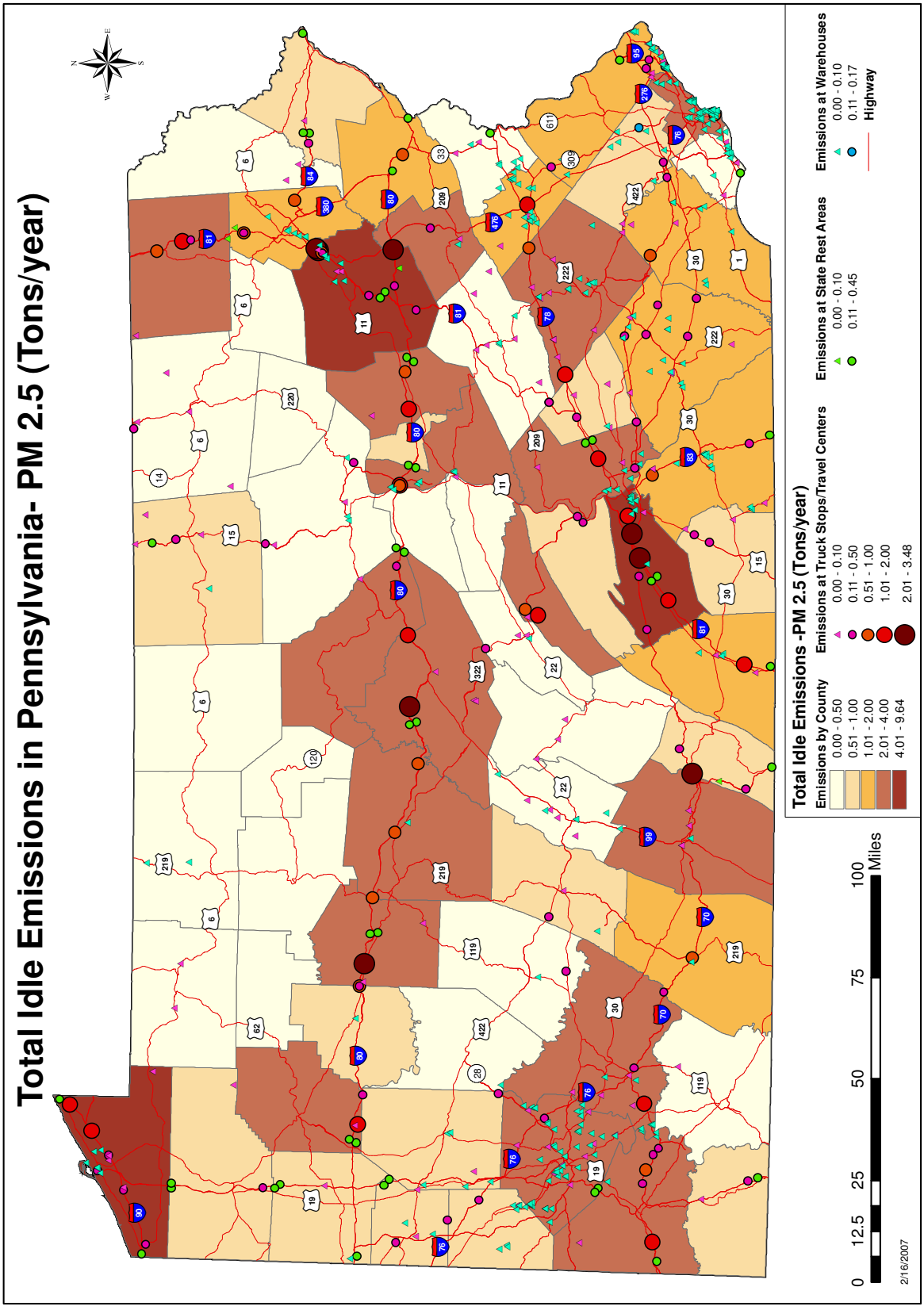


Exhibit 33: Map of Annual $PM_{2.5}$ HDDV Idle Emissions



Section 5

Idle Reduction Program Credits

Sections 1-4 of this report have attempted to quantify the amount of statewide long-duration HDDV idling and emissions for key activity categories. Idle reduction measures, including idling restrictions or the use of alternative energy sources, will focus on reducing a portion of the idling and emission totals. This section provides a brief overview of other states with anti-idling regulations and notes where emissions credits have been officially taken for such programs. In addition, a review of the EPA guidance methodology for calculating credits of idle reduction technologies is presented, including an overview of potential program credit limitations based on the Pennsylvania 2005 highway inventory.

Other States with Anti-Idling Regulations

A literature review indicates that thirteen states and the District of Columbia have state-wide anti-idling regulations in place. An additional eleven states, including Pennsylvania, have counties and/or municipalities that have created their own anti-idling regulations.

Seven states have included anti-idling regulations in their SIPs. The literature search was not able to identify any states that have applied emissions credits within the SIP for anti-idling regulations. However, two states (California and Texas) have applied emissions credits for the implementation of Truck Stop Electrification (TSE), which reduces heavy-duty diesel vehicle idle time at truck/rest stops.

Of the regulations researched, 40 percent include a maximum idle time of five minutes, which is the most common duration utilized. The majority of regulations also stipulate exemptions from the rule, including emergency vehicles or longer maximum idle limits in severe weather conditions. Nearly one-half of the researched regulations apply to all motor vehicles regardless of gasoline type or size while thirty percent apply only to heavy-duty diesel vehicles.

Methods for Taking Emission Credits of Idle Reduction Technologies

EPA's 2004 guidance document ***(17)*** provides guidance on quantifying emission reductions (and how they may be used to meet SIP requirements) from technologies which reduce long-duration truck idling emissions from Class 8 trucks included in the state's highway inventory. The guidance is not intended to apply to emissions reductions resulting entirely from state or local anti-idling laws, regulations, or ordinances that limit a vehicle's idling time since such regulations may apply to a broader range of vehicle types. Typical idle reduction technologies covered by the guidance include mobile auxiliary power units (APUs), stationary truck stop electrification (TSE) and others listed on the following EPA web link:

- http://www.epa.gov/otaq/retrofit/idlingtech.htm

For purposes of the guidance, long-duration idling is the operation of a truck's engine when not engaged in gear for a period greater than 15 consecutive minutes, except when associated with routine stoppages due to traffic movement or congestion. Guidance examples of long-duration idling include truck travel rest, the loading or unloading of trucks at warehouses, or idling at border crossings.

Steps for Quantifying Truck Idling Emission Reductions

The steps illustrated in **Exhibit 34** describe the EPA guidance methodology to estimate emissions reductions from a proposed idle reduction technology project. Step 8 highlights potential limitations on project impacts based on the proportion of long-duration truck idling considered to be part of the statewide highway inventory. The remaining sections address these potential limitations.

Exhibit 34: Steps for Quantifying Class 8 Truck Idling Emission Reductions

(Per EPA Guidance for Quantifying and Using Long-Duration Truck Idling Emission Reductions in State Implementation Plans and Transportation Conformity)

Step	Description	Data Needed
1	Determine the historic idling activity of the trucks involved in the project.	▪ Annual occupancy rate of truck parking spaces ▪ % trucks that idle in long-duration ▪ # idle hours per day per truck (avg summer weekday for Ozone, avg annual weekday for PM)
2	Select the emission factor for the criteria air pollutant or precursor.	▪ Guidance provides NOx and PM emissions factors
3	Multiply the emission factor in Step 2 by the number of hours per day the idle reduction technology is estimated to be used.	▪ Idle hours per day eliminated by idle reduction technology
4a	Determine emission factor for the mobile idle reduction technology	▪ Emission factor of idle reduction technology
4b	When using a mobile idle reduction technology, multiply emission factor from 4a by the average daily horsepower load of the mobile idle reduction technology. Skip this step for a stationary idle reduction technology.	▪ Average daily horsepower load of idle reduction technology
4c	When using a mobile idle reduction technology multiply the g/hr factor by the number of operating hours (per day) it is estimated to be used. Skip this step if stationary idle reduction technology.	▪ Number of daily operating hours of idle reduction technology
5	Determine the net emission reduction for the mobile technology. Skip this step for a stationary idle reduction technology.	
6	Sum all emission reductions for the project.	
7	Make sure net average daily emissions reduced from the idling reduction project do not exceed the historic idling activity of the trucks involved in the project as determined from Step 1.	▪ Historic idling activity
8	Make sure the net average daily emission reductions from all idling reduction projects do not exceed the total long-duration idle emissions accounted for in the SIP's regional highway inventory or regional conformity analysis.	▪ 3.4% of emission estimate of Class 8 trucks used in SIP highway inventory or conformity analysis

Idle Technology Credit Limitations

As described in Step 8 of **Exhibit 34**, EPA guidance has established limitations on the maximum credit that can be achieved from long-duration idling technology projects focused on Class 8 heavy-duty diesel trucks. As part of the analysis process, the net average daily emissions reductions from all idling reduction programs cannot exceed the total long-duration idle emissions accounted for in the SIP's regional highway inventory or regional conformity analysis. The guidance provides specific analysis recommendations, illustrated in the excerpt below:

> *Net average daily emissions reduced for all existing and new long-duration truck idling reduction programs in a nonattainment or maintenance area should be summed to determine the total reductions from all programs for a given year. The total reductions claimed for all programs cannot exceed 3.4% of the emission estimate for class 8 heavy duty diesel trucks for any criteria air pollutant or precursor used in the applicable SIP inventory or conformity analysis for the calendar year in question.*

Since the statewide highway inventory can provide constraints on the possible benefits obtained and credited for such measures, this report contains results from a draft 2005 statewide highway inventory. It is unclear how these limitations would impact the credits taken for statewide anti-idling regulations, since those projects are not specifically covered by the EPA guidance. However, the statewide highway inventory numbers do provide comparison numbers to the idling emissions calculated in **Section 4** of this report.

Amount of Class 8 Long-Duration Idling Emissions in Statewide Highway Inventory

MOBILE6.2 truck emission factors are not based upon the updated MOBILE6.2 drive cycles that are used for the light-duty vehicle types. Instead, truck emission factors are based on truck emission standards expressed in terms of grams per brake horsepower-hour (g/bhp-hr). For application in regional emission analyses, these emission standards must be converted to grams/mile units using conversion factors updated for MOBILE6.2. The MOBILE6 truck conversion factors are based on:

- Fuel Density
- Brake specific fuel consumption
- Fuel Economy (mi/gal)

The fuel economy conversion factors are based on data obtained from the 1992 Truck Inventory and Use Survey (TIUS). This survey contains a national sample of truck drivers and operators. A specific question asks for the typical fuel economy of the respondent's truck(s). Many respondents reported fuel economy as the total fuel cost divided by the miles traveled during the year. Fuel cost typically includes fuel used during long-duration idling, both for travel rest and loading/unloading. As a result, some fraction of long-duration truck idling emissions is included in inventories based on MOBILE6.2.

Based on the above issues, the main question is how to calculate the portion of emissions related to the long-duration truck idling. The EPA guidance answers this question by providing the 3.4% value, which indicates that 3.4% of the total Class 8 heavy duty diesel truck emissions is related to long-duration idling.

2005 Statewide Highway Inventory Estimates of Truck Long-Duration Idling Emissions

A draft 2005 statewide highway inventory has been completed to assist in identifying the total long-duration idling emissions statewide. The highway inventory follows the methodology documented for previous inventory efforts. Note that this highway inventory may produce different results than the final submitted 2005 statewide highway inventory.

Overview of Statewide Highway Inventory

The statewide highway inventory utilizes 2005 PennDOT Roadway Management System (RMS) data for all state roadways within Pennsylvania. The RMS data includes 2005 average annual daily traffic volumes and truck percentages that provide the portion of heavy-duty truck VMT. All fleet ages are based on 2005 vehicle registration data, except for heavy-duty trucks, which are based on national defaults. This sample highway inventory effort estimated emissions for a typical summer weekday using available 2005 temperature and humidity data. The results have been expanded to annual totals for comparisons to **Section 4** results.

Calculation of Class 8 Truck Long-Duration Idling Emissions

Per the EPA guidance, it is assumed that 3.4% of the total Class 8 heavy-duty diesel truck emissions are related to long-duration idling. **Exhibit 35** provides a summary of Class 8 truck emissions from the 2005 statewide highway inventory. The table shows that 3,207 tons/year of NOx emissions are related to long-duration truck idling, which includes both travel rest and idling related to loading and unloading.

Exhibit 35: Draft Highway Inventory Estimate of Class 8 Long-Duration Idle Emissions

Year	Pollutant	Highway Inventory Emissions (tons/year)			Long Duration Idling Emissions (tons/year)		
		All Vehicle Types	Class 8 Trucks	% of Total Inventory	Class 8 Trucks	% of Total Inventory	% of Class 8 Inventory
2005	VOC	119,644	2,758	2%	94	0.1%	3.4%
	CO	1,407,752	19,159	1%	651	0.0%	3.4%
	NOx	248,726	94,318	38%	3,207	1.3%	3.4%
	$PM_{2.5}$	4,390	1,922	44%	65	1.5%	3.4%
	CO_2	45,080,546	6,164,892	14%	209,606	0.5%	3.4%
2009	VOC	93,699	2,343	3%	80	0.1%	3.4%
	CO	1,024,696	13,465	1%	458	0.0%	3.4%
	NOx	179,504	67,330	38%	2,289	1.3%	3.4%
	$PM_{2.5}$	3,252	1,198	37%	41	1.3%	3.4%
	CO_2	45,719,870	6,112,017	13%	207,809	0.5%	3.4%
2018	VOC	55,538	1,904	3%	65	0.1%	3.4%
	CO	798,420	4,371	1%	149	0.0%	3.4%
	NOx	72,218	20,886	29%	710	1.0%	3.4%
	$PM_{2.5}$	2,078	345	17%	12	0.6%	3.4%
	CO_2	48,090,034	6,058,325	13%	205,983	0.4%	3.4%

These values provide potential limitations on project credits (a project can not have more impact than the total amount of idling emissions). Because MOBILE6.2 projects a decrease in emissions from heavy-duty diesel Class 8 trucks in future years, the total allowable emissions will decrease in future years. EPA draft guidance is not clear on whether these limits apply at the statewide level or for individual nonattainment areas.

Comparison of Highway Inventory to Study Results

Exhibit 36 illustrates the comparison between the statewide highway inventory calculations of Class 8 long-duration idling emissions and those summarized in **Section 4** of this study. The statewide inventory calculations are inclusive of idling (per EPA MOBILE6.2 instructions) for both travel rest and loading/unloading. However,

the statewide highway inventory does not consider the location of travel plazas and rest areas. Instead, the truck emissions by region correspond to the distribution of RMS truck totals for the roadways in each county and not the locations of truck stop parking spaces. This methodological difference explains some differences between the inventory and **Section 4** calculations for the sample of counties provided in **Exhibit 35**. A specific example is Cumberland County which contains a large amount of overnight truck parking spaces; and, thus it would be expected that larger idling delays occur in that region. This is reflected in the study emission totals but not in the statewide highway inventory.

The differences between the study results and those from the inventory vary by pollutant. The inventory estimates lower statewide Class 8 truck idling emissions for the VOC, CO, and $PM_{2.5}$ pollutants. Credits from the statewide highway inventory decrease significantly in future years due to the reduction in MOBILE6.2 emission rates. However, for NOx, the EPA guidance provides one idling emission factor for all analysis years as discussed in **Section 3**. As a result, there are large differences between the inventory credits and study calculations for NOx emissions in future analysis years.

Exhibit 36: Highway Inventory vs. Study Calculations of Class 8 Idle Emissions

(Results Provided for Sample of Counties and Statewide Total)

Analysis Year = 2005

County	Highway Inventory Estimates of Class 8 Truck Long-Duration Idling Emissions (ton/year)					Study Calculations of Class 8 Truck Long-Duration Idling Emissions (ton/year)*				
	VOC	CO	NOx	$PM_{2.5}$	CO_2	VOC	CO	NOx	$PM_{2.5}$	CO_2
Cumberland	3	23	136	2	6,956	12	102	344	9	10,370
Luzerne	3	20	111	2	5,602	10	88	296	8	8,926
Erie	2	17	87	2	7,351	5	43	145	4	4,370
Bedford	2	13	76	1	1,985	5	39	133	4	4,010
Centre	2	13	70	1	5,933	4	35	120	3	3,604
Columbia	1	5	30	1	2,409	4	32	108	3	3,251
Susquehanna	1	7	36	1	2,923	4	31	105	3	3,154
Dauphin	3	19	97	2	5,639	4	31	103	3	3,115
Jefferson	1	7	41	1	3,255	3	30	102	3	3,073
Berks	3	20	109	2	5,656	3	30	101	3	3,031
Statewide Total	**94**	**651**	**3,207**	**65**	**209,606**	**108**	**944**	**3,189**	**87**	**96,137**

Analysis Year = 2009

County	VOC	CO	NOx	$PM_{2.5}$	CO_2	VOC	CO	NOx	$PM_{2.5}$	CO_2
Cumberland	3	18	101	2	8,010	9	68	344	6	10,275
Luzerne	2	14	77	1	5,834	8	58	296	6	8,844
Erie	2	11	61	1	4,763	4	29	145	3	4,330
Bedford	1	9	54	1	1,996	4	26	133	2	3,974
Centre	2	9	51	1	6,392	3	24	120	2	3,571
Columbia	1	4	21	0	2,554	3	21	108	2	3,221
Susquehanna	1	5	26	0	3,066	3	21	105	2	3,125
Dauphin	2	14	69	1	5,967	3	20	103	2	3,086
Jefferson	1	5	29	0	3,378	3	20	102	2	3,045
Berks	2	14	78	1	4,721	3	20	101	2	3,003
Statewide Total	**80**	**458**	**2,289**	**41**	**207,809**	**85**	**628**	**3,189**	**60**	**95,256**

Analysis Year = 2018

County	VOC	CO	NOx	$PM_{2.5}$	CO_2	VOC	CO	NOx	$PM_{2.5}$	CO_2
Cumberland	3	8	35	1	7,850	6	18	344	1	10,198
Luzerne	2	4	23	0	3,761	5	15	296	1	8,777
Erie	1	3	19	0	5,250	3	7	145	1	4,297
Bedford	1	3	17	0	2,072	2	7	133	1	3,944
Centre	1	3	17	0	3,686	2	6	120	1	3,544
Columbia	0	1	7	0	2,979	2	6	108	0	3,197
Susquehanna	1	1	8	0	3,508	2	5	105	0	3,102
Dauphin	2	5	21	0	6,868	2	5	103	0	3,063
Jefferson	1	1	9	0	3,768	2	5	102	0	3,022
Berks	2	4	24	0	5,300	2	5	101	0	2,980
Statewide Total	**65**	**149**	**710**	**12**	**205,983**	**56**	**164**	**3,189**	**14**	**94,538**

** Transit, School, and Tour Bus Idling Emissions not included for these comparisons*

Section 6

References

1. U.S. Department of Commerce, 2002. *Vehicle Inventory & Use Survey* EC02TV-US. December, 2004.
2. U.S. Environmental Protection Agency. *User's Guide to MOBILE6.1 and MOBILE6.2: Mobile Source Emission Factor Model,* EPA420-R-02-028. October, 2002.
3. The Trucker's Friend. *2007 National Truck Stop Directory.* (Electronic copy of 2003 version purchased from TR Information Publisher).
4. Data provided via 12/15/2003 Fax from PennDOT Roadway Specialist to Michael Baker Jr., Inc., Used for development of February, 2004 report submitted to DEP entitled "*Stakeholder-Recommended Control Measures Evaluation – Reduced Idling Measures*" by E.H Pechan & Associates, Inc. and Michael Baker Jr., Inc.
5. NCHRP Synthesis 317. *Dealing with Truck Parking Demands*, Transportation Research Board. 2003.
6. The Pennsylvania Turnpike Commission. *Service Plaza Needs Analysis*, January 7, 2002.
7. Lutsey, Brodrick, Sperling and Oglesby. *Heavy-Duty Truck Idling Characteristics – Results from a Nationwide Truck Survey,* Submitted to TRB 2004.
8. Pennsylvania Department of Environmental Protection, February 2004. "*Stakeholder-Recommended Control Measures Evaluation – Reduced Idling Measures*", E.H Pechan & Associates, Inc. and Michael Baker Jr., Inc.
9. ITE Journal. *Truck Trip Generation Characteristics of Nonresidential Land Uses*, July 1994.
10. Texas Commission on Environmental Quality, *Heavy-Duty Vehicle Idle Activity and Emissions Characterization Study, Final Report*, August 31, 2004.
11. U.S. Environmental Protection Agency. *What You Should Know About Diesel Exhaust and School Bus Idling.* EPA Brochure. November, 2002.
12. Tompkins Consolidated Area Transit. *Ithaca Downtown Transportation Center Working Paper #1: The Ithaca Intercity Bus Schedule.* August, 2001.
13. California Air Resources Board. *On-road Motor Vehicle Activity Data, Volume 1 – Bus Population and Activity Pattern, Final Report.* Prepared by Valley Research Corporation. September, 1994.
14. Pittsburgh Post Gazette. *Anti-smog Group Pushes to Stop School Bus Idling Outside Schools.* Newspaper Article. May 6, 2003.
15. School Bus Fleet Magazine Forum website. Accessed on February 7, 2007. http://66.218.69.11/search/cache?p=school+bus+idling+startup&fr=yfp-t-501&toggle=1&ei=UTF-8&u=www.schoolbusfleet.com/forum/topic.asp%3FTOPIC_ID%3D4457&w=school+bus+idling+startup&d=I1mB9OxsONDh&icp=1&.intl=us
16. Environmental Bulletin, A Maine DEP Informational Bulletin for Maine Citizens & School Officials, Fall 2002. http://www.maine.gov/dep/air/school/docs/Newsletter%20Fall_02.pdf
17. U.S. Environmental Protection Agency. *Guidance for Quantifying and Using Long Duration Truck Idling Emission Reductions in State Implementation Plans and Transportation Conformity.* EPA420-B-04-001, January, 2004.
18. U.S. Environmental Protection Agency. *Policy Guidance on the Use of MOBILE6 for SIP Development and Transportation Conformity.* Memorandum to EPA Regional Air Division Directors, January, 2002.

Appendix **A**

Summary of Study References

List of References and Data Sources Used for the Report

1. Idling Locations and Parking Spaces

Idling Category	Data Sources	Data Provided/Used
Overview	2005 PennDOT Roadway Management System (RMS) traffic data	Heavy-truck vehicle miles of travel (VMT) throughout PA
	U.S. Department of Commerce, 2002. *Vehicle Inventory & Use Survey,* EC02TV-US. December, 2004.	Number of class 7 and Class 8 trucks that travel long distances (>500 miles).
	U.S. Environmental Protection Agency. *User's Guide to MOBILE6.1 and MOBILE6.2: Mobile Source Emission Factor Model*, EPA420-R-02-028. October, 2002.	Percentage of national heavy duty vehicle fleet
Truck Stops and Travel Centers	The Trucker's Friend. *2003 Truck Stop Parking Directory*, Electronic copy purchased from TR Information Publisher.	Truck stop locations and overnight parking spaces
	The Trucker's Friend. *2007 National Truck Stop Directory*, 2007.	
	DieselBoss website: http://www.dieselboss.com	
	The Trucking Network.com website: http://truckingnetwork.com/	
	TravelCenters of America website: http://tatravelcenters.com	
	Petro Stopping Centers website: http://petrotruckstops.com	
	Pilot Travel Centers website: http://www.pilotcorp.com	
	Flying J website: http://flyingj.com/highway	
Rest Areas	PENNDOT Roadside Specialist	Publicly provided traveler rest area locations and parking spaces
Warehouses and Intermodal Facilities	Leonard's Guide Online National Warehouse Directory http://www.leonardsguide.com/	Warehouse and intermodal facility locations and storage square footage
	Bureau of Transportation Statistics' 2006 National Transportation Atlas Database http://www.bts.gov/publications/national_transportation_atlas_database/2006/	
	Southwestern Pennsylvania Freight Transportation Guidebook, 2002. http://www.spcregion.org/trans_freight.shtml	
	Philadelphia Regional Port Authority website: http://www.philaport.com/	
	Port of Pittsburgh Commission website: http://www.port.pittsburgh.pa.us	
	Norfolk Southern Distribution Network website: http://www.nscorp.com/nscorp	

Transit Bus	2004 and 2005 National Transit Database	Number of transit buses by agency, year and fuel type
Tour Bus	BusRates.com website: http://www.busrates.com/	Tour bus company locations and number of coach buses.
	Greyhound Lines, Inc. website: http://www.greyhound.com/	
School Bus	PennDOT's Bureau of Motor Vehicles registration database	July 2005 registration data with number of county-registered school buses by model year and fuel type (gas and diesel)
	National Center for Education Statistics, U.S. Department of Education http://nces.ed.gov/surveys/sdds/map00.asp	Pennsylvania private and public school locations map and number of schools
Landfills	Pennsylvania Department of Environmental Protection website: http://www.depweb.state.pa.us/landrecwaste	List of municipal waste landfills and resource recovery facilities

2. Estimation of Idling Activity

Idling Category	Data Sources	Data Provided/Used
Long-Haul Travel Rest	NCHRP Synthesis 317. *Dealing with Truck Parking Demands*, Transportation Research Board. 2003	Truck parking space utilization rates for truck stops and rest areas (to estimate number of idling trucks)
	The Pennsylvania Turnpike Commission. *Service Plaza Needs Analysis*, January 7, 2002.	A high demand for the truck parking spaces at turnpike rest plazas (to estimate number of idling trucks)
	U.S. Department of Transportation's Federal Motor Carrier Safety Administration (FMCSA)	DOT required resting standards
	University of California, Davis. *Heavy-Duty Truck Idling Characteristics – Results from a Nationwide Truck Survey*. Submitted to TRB November, 2003.	Truck average daily idling durations by season
	Interview of the owner of the Walt Whitman truck stop in November, 2003 .	Typical truck resting times at truck stops.
	PennDOT rest areas	Rest area time restrictions
Warehouses and Intermodal	ITE Journal. *Truck Trip Generation Characteristics of Nonresidential Land Uses*, July 1994.	Class 8 truck trip rate by facility space (to estimate number of idling trucks)
	Heavy-Duty Vehicle Idle Activity and Emissions Characterization Study, prepared for the Texas Commission on Environmental Quality. August, 2004.	Warehouse and intermodal truck idling activity distribution assumptions
Transit Bus	U.S. Environmental Protection Agency. *What You Should Know About Diesel Exhaust and School Bus Idling. EPA Brochure. November, 2002.*	Diesel bus engines require about 5 minutes to warm up
	Tompkins Consolidated Area Transit. *Ithaca Downtown Transportation Center Working Paper #1: The Ithaca Intercity Bus Schedule.* August, 2001	Intercity buses start-up idling durations
	Michael Baker, Jr., Inc.'s observations of the Kirk Avenue Division bus facility in Baltimore, Maryland in 2004	Transit bus start-up idling durations by season
	California Air Resources Board. *On-road Motor Vehicle Activity Data, Volume 1 – Bus Population and Activity Pattern, Final Report*. Prepared by Valley Research Corporation. September, 1994	Transit bus route idling durations

School Bus	U.S. Environmental Protection Agency. *What You Should Know About Diesel Exhaust and School Bus Idling. EPA Brochure. November, 2002.*	EPA guidelines for reducing school bus idling and non route engine start-up time
	Pittsburgh Post Gazette. *Anti-smog Group Pushes to Stop School Bus Idling Outside Schools.* Newspaper Article. May 6, 2003.	A significant number of buses idle for unnecessarily extended periods of time
	School Bus Fleet Magazine Forum website: http://66.218.69.11/search/cache?p=school+bus+idling+startup&fr=yfp-t-501&toggle=1&ei=UTF-8&u=www.schoolbusfleet.com/forum/topic.asp%3FTOPIC_ID%3D4457&w=school+bus+idling+startup&d=I1mB9OxsONDh&icp=1&.intl=us	School bus non route engine start-up durations by season
	California Code of Regulations (CCR) Chapter 10, Section 2480	An example of school bus idling regulation
	Tompkins Consolidated Area Transit. *Ithaca Downtown Transportation Center Working Paper #1: The Ithaca Intercity Bus Schedule.* August, 2001.	School bus non route idling durations at school

3. Iding Emission Rates and Statewide Highway Inventory

Category	Data Sources	Data Provided/Used
Idling Emission Rates	U.S. Environmental Protection Agency. *Guidance for Quantifying and Using Long-Duration Truck Idling Emission Reductions in State Implementation Plans and Transportation Conformity, EPA420-B-04-001.* January, 2004	Guidance on quantifying emission reductions from technologies that reduce long-duration truck idling emissions from Class 8 trucks. NOx and PM2.5 emission factors for long-duration truck idling
	U.S. Environmental Protection Agency. *Policy Guidance on the Use of MOBILE6 for SIP Development and Transportation Conformity.*	Emission factors calculation
Statewide Highway Inventory	*1992 Truck Inventory and Use Survey (TIUS)*	Fuel economy conversion factors

4. Other Idling Related References

1) Lutsey, Brodrick, Sperling and Oglesby. *Heavy-Duty Truck Idling Characteristics – Results from a Nationwide Truck Survey*, Submitted to TRB 2004

2) Yu, Qiao and Soltani. *Characteristics of Truck Idling Emissions under Real-World Conditions.* Submitted to TRB 2006

3) Gaines, Vyas and Anderson. *Estimation of Fuel Use by Idling Commercial Trucks.* Submitted to TRB 2006.

4) Zietsman and Perkinson. *Estimating Extended Idling Emissions of Heavy –Duty Diesel Trucks in Texas.* Submitted to TRB 2005.

5) NESCAUM. *Assessing the Regional Implications of Advanced Truck Stop Electrification: A Report to EPA.* February, 2003.