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Nonroad Engine and Vehicle Emission Study—Report

NATIONAL VEHICLE AND FUEL EMISSIONS LABORATORY
OFFICE OF TRANSPORTATION AND AIR QUALITY
ANN ARBOR MI

Nonroad Engine and Vehicle Emission Study Report

November 1991

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Certification Division
Office of Mobile Sources
Office of Air & Radiation
U.S. Environmental Protection Agency

ACKNOWLEDGEMENTS

The Nonroad Engine and Vehicle Emission Study relied extensively on the participation of numerous organizations both within and outside of the U.S. Environmental Protection Agency. A Technical Review Group consisting of industry and state-level government representatives was convened to provide a forum for resolving discrepancies in data used in the analysis. Members of this group are listed in Appendix F. The authors and editors of this report wish to express their sincere appreciation for the efforts of all participants.

The study also relied on analyses developed by EPA contractors. Under the direction of Mr. Charles T. Hare, a review of existing data on the emission characteristics of nonroad engines[*,†] was conducted by the Southwest Research Institute, which also tested the emissions of several lawn and garden engines that had been used in the field.[‡] The EPA Project Officer for this contract was Mr. Craig A. Harvey of the Emission Control Technology Division. The EPA Technical Work Assignment Managers were Mr. Todd L. Sherwood and Mr. Kenneth L. Zerafa, both of the Certification Division. Estimates of local area equipment populations and usage for most nonroad engines and vehicles were developed by Energy and Environmental Analysis, Inc. (EEA) under the direction of Mr. K.G. Duleep.[§] An analysis of commercial marine vessel emissions in six nonattainment areas was developed by Booz - Allen & Hamilton, Inc. (BA&H) under the direction of Ms. Barbara Kuryk.[£] The EPA Project Officers for these two contracts were Ms. Celia Shih (EEA) of the Emission Control Technology Division and Ms. Patricia L. Cox (BA&H) of the Health and Environmental Management Division. The EPA Technical Work Assignment Manager for the EEA and BA&H analyses was Mr. Kevin A.H. Green of the Certification Division.

Many members of the Certification Division in Ann Arbor, MI were instrumental in the completion of this study. Ms. Gay MacGregor, Assistant Director, and Mr. John M. German, Project Manager, provided general and technical oversight, respectively, for the study. Ms. Cheryl F. Adelman provided legal interpretation and guidance in the area of nonroad equipment classification. Ms. Kathy E. Carter managed the production of the draft report and accompanying appendices. Mr. Kevin A.H. Green developed estimates of total emissions from nonroad engines and vehicles for the areas included in the study. Ms. Betsy Lyons McCabe coordinated revisions and additions to the draft and managed the production of the final report and appendices. Ms. Deanne R. North and Ms. Sujan V. Srivastava analyzed state estimates of emissions from nonroad sources. Ms. Clare Ryan coordinated communications inside and outside EPA. With technical guidance from Mr. Michael A. Sabourin, Project Manager, Mr. Jeffrey T. Prince and Mr. Kenneth L. Zerafa developed a data base of evaporative and tailpipe emission factors for nonroad engines and vehicles. Ms. Paula Van Lare reviewed studies of ozone formation and transport and considered their implications for nonroad engines and vehicles. All of the above staff members are especially appreciative of the typing and production assistance provided by Ms. Rae Benedetti and by Ms. Janis S. Hagen, a contractor with the Computer Science Corporation, and of the general assistance from Mr. Donald J. Kachman and Ms. Sherie N. Williams, both student aides in the Certification Division, and also of the assistance with file sharing and printing provided by the Computer Support Section.

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[*] Ingalls, Melvin N. *Nonroad Emission Factors*. Southwest Research Institute, San Antonio, TX, February 1991.

[†] Ingalls, Melvin N. *Nonroad Emission Factors of Air Toxics*, Southwest Research Institute, San Antonio, TX, June 1991.

[‡] Carroll, J.N. *Emission Tests of In-Use Small Utility Engines*, Report 3426-006. Southwest Research Institute, San Antonio, TX, September 1991.

[§] Energy and Environmental Analysis, Inc. *Methodology to Estimate Nonroad Equipment Populations by Nonattainment Areas*. Arlington, VA, September 1991.

[£] Booz - Allen & Hamilton, Inc. *Commercial Marine Vessel Contributions to Emission Inventories*. Los Angeles, CA, October 1991.

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Reading and Using the Study Report and Appendixes

The Nonroad Engine and Vehicle Emission Study has been bound into two volumes - the report and its appendixes. The report contains five chapters which provide information on the purpose and goals of the study, the approach, the results, and a discussion and analysis of those results. Throughout the report, the reader is provided with the basic information needed to understand what was done to obtain the results presented. More detailed information has been put into a series of sixteen appendixes, which are bound separately from the report.

In both the report and the appendixes, the reader will find annotated notes, indicated by a superscript symbol, at the bottom of the page. These notes are provided where it was felt some explanatory information might be needed. Reference citations are indicated by a superscript number. A list of the references cited in the report is located on the last page of the report. In the appendixes, a list of references can be found at the end of each appendix.

Many acronyms are used in the report. While they are defined when first used, a list of acronyms and their meanings is also provided in Appendix A. Appendix A also contains a glossary of some of the terms used in the report.

Executive Summary

Congressional Mandate

This study is a response to the Congressional directive** that EPA quantify the contribution of nonroad sources to ozone and carbon monoxide air pollution and to other pollutants believed to endanger public health. The Clean Air Act (CAA), as amended, directs EPA to complete a study of emissions from nonroad engines and vehicles by November 15, 1991. The CAA further requires EPA to regulate emissions from nonroad engines and vehicles within twelve months after completion of the study if the Agency determines that these sources are significant contributors to ozone or carbon monoxide (CO) concentrations in more than one area which has failed to attain the National Ambient Air Quality Standards (NAAQS) for these pollutants. This report does not constitute EPA's determination of significance. Any determination EPA makes relative to the significance of nonroad contributions to air quality will be included as part of any regulations proposed for nonroad engines and vehicles. Opportunities for public comment on any determination of significance will be provided through the regulatory process if the Agency proposes nonroad regulations.

Nonroad Engines and Vehicles

The terms "nonroad engines" and "nonroad vehicles" cover a diverse collection of equipment ranging from small equipment like lawnmowers and chain saws, to recreational equipment, to farm equipment and construction machinery. EPA considered more than 80 different types of equipment in this report. To ease analysis and reporting EPA has grouped equipment into 10 equipment categories listed in Table ES-01.††

**Section 213(a) of the Clean Air Act, as amended, directs EPA to conduct a study of emissions from nonroad engines and vehicles and to determine if such emissions cause, or significantly contribute to, air pollution which may be reasonably anticipated to endanger public health or welfare.

††Locomotives and aircraft are not included in this study because the CAA provides for them separately

Table ES-01. Equipment Categories Included in Study

Nonroad Equipment Categories	
Lawn and Garden Equipment	Industrial Equipment
Airport Service Equipment	Construction Equipment
Recreational Equipment	Agricultural Equipment
Recreational Marine Equipment	Logging Equipment
Light Commercial Equipment	Commercial Marine Vessels

Nonroad engines are not regulated for emissions, and very few nonroad engines currently use emission control technology. Because of the diversity of nonroad equipment, characterization of the emissions from nonroad engines is a complex task. A comprehensive analysis of the air quality benefits potentially available from reducing nonroad engine emissions has never before been undertaken.

Congress asked EPA to focus on quantifying emissions from unregulated nonroad sources after 20 years of highway mobile sources regulation and increasingly costly controls on the automotive industry. As a group, nonroad engines represent the last uncontrolled mobile source. Potential emission reductions from this source may help resolve local air quality problems. A comparison between pollution emitted by individual pieces of new nonroad equipment and pollution emitted by today's typical in-use passenger car illustrates the logic behind the Congressional mandate.

Table ES-02. Examples of Emissions from New Nonroad Equipment Relative to a Typical *In-Use* Passenger Car

1 Hour of Use	Pollutant	Car Miles
1 lawnmower	VOC	50
1 chain saw	VOC	200
1 outboard motor	VOC	800
1 crawler tractor	NO_x	900

State and Industry Participation

EPA's ability to complete this study has been greatly enhanced by contributions of the nonroad equipment industry and by many state air quality planners. A public workshop was held April 3-4, 1991, and individual meetings were held with many nonroad manufacturing groups. An informal group of technical experts, including industry and state representatives, provided valuable data and technical feedback throughout this study process. In many cases the nonroad manufacturers invested resources to provide detailed information to help construct nonroad emission inventories. On October 30, 1991, EPA held a public meeting on the full draft of this report.

Study Approach

To estimate the contribution of nonroad sources to air pollution, EPA constructed national emission inventories of nonroad sources, as well as local inventories for 19 ozone and 16 carbon monoxide (CO) nonattainment areas. Since it was not possible to construct inventories for all nonattainment areas within the time allowed for this study, these areas were selected to represent a spectrum of demographic and geographic characteristics. They also represent most of the nation's most severe air pollution problems.

Because Congress specified that EPA study the nonroad source contribution to ozone and CO nonattainment, the study primarily focuses on CO and on the pollutants that contribute to ozone formation, volatile organic compounds (VOC) and oxides of nitrogen (NO_x). However, the study addresses all the pollutants listed in Table ES-03.

Table ES-03. Pollutants Included in the Study

Pollutants	
Volatile Organic Compounds (VOCs)	Benzene
Oxides of Nitrogen (NO_x)	Aldehydes
Carbon Monoxide (CO)	1,3-butadiene
Particulate Matter (PM)	Gasoline Vapors
Sulfur Dioxide (SO_2)	Nitrosamines

Constructing Emission Inventories

Emission inventories are detailed listings of the amount of pollution generated by different sources in a given area over a specific period of time. In constructing nonroad inventories, several factors must be estimated: (1) equipment populations in a given nonattainment area, (2) annual hours of use of each type of equipment adjusted for geographic region and for the season of interest for each pollutant studied, (3) average rated horsepower of each type of equipment, (4) typical load factor for each type of equipment, and (5) an emission factor (EF), or average emissions of each pollutant per unit of use (e.g., g/hp-hr) for each category of equipment.

Given the number of engine types and equipment included in the study and the limited amount of data available characterizing emissions from nonroad sources, EPA chose to construct two sets of inventories. In the first set, EPA constructed inventories that incorporate commercially and publicly available data so that the method could be repeated by interested states. The second set of inventories incorporated industry-provided data that might not be publicly available to states (e.g., confidential sales data to estimate populations), but would give EPA a valuable cross check for the first set of inventories. This report presents both sets of inventories:

> **Inventory A** which relies heavily on a commercially available marketing research data base[‡‡] and publicly available indices of commercial activity to estimate equipment populations;
>
> and
>
> **Inventory B** which incorporates manufacturer-provided data in almost all high usage categories.

Both inventories use the same emission factors for all pollutants except particulates. EPA and its contractors, with the assistance of industry, updated nonroad emission factors for this study using all available test data, including evaporative and refueling (spillage) emission data. Most of the emission data for nonroad engines are based on tests of new engines. The limited information EPA does have on in-use nonroad engines shows that in-use emissions

[‡‡]Power Systems Research maintains a marketing research data base that includes most types of nonroad equipment.

could be as much as two times higher for some types of equipment than emission estimates using emission factors based on new engine test data. Consequently, inventories calculated using new engine emission factors (new engine EFs) will underestimate the contribution of nonroad engines to air pollution. EPA has developed a second set of emission factors (in-use EFs) for VOC and CO that includes a gross adjustment for in-use deterioration. Because of the uncertainty involved in making in-use adjustments, the report presents estimates for both Inventories A and B with and without the adjustment. In-use adjustments assume very little deterioration by diesel engines. Hence, category-specific inventories (e.g., Construction Equipment) for categories dominated by diesel engines show very little difference between the inventories estimated using new engine EFs and in-use EFs. The estimates using the new engine EFs should be considered the conservative lower bound of nonroad contribution in each nonattainment area.

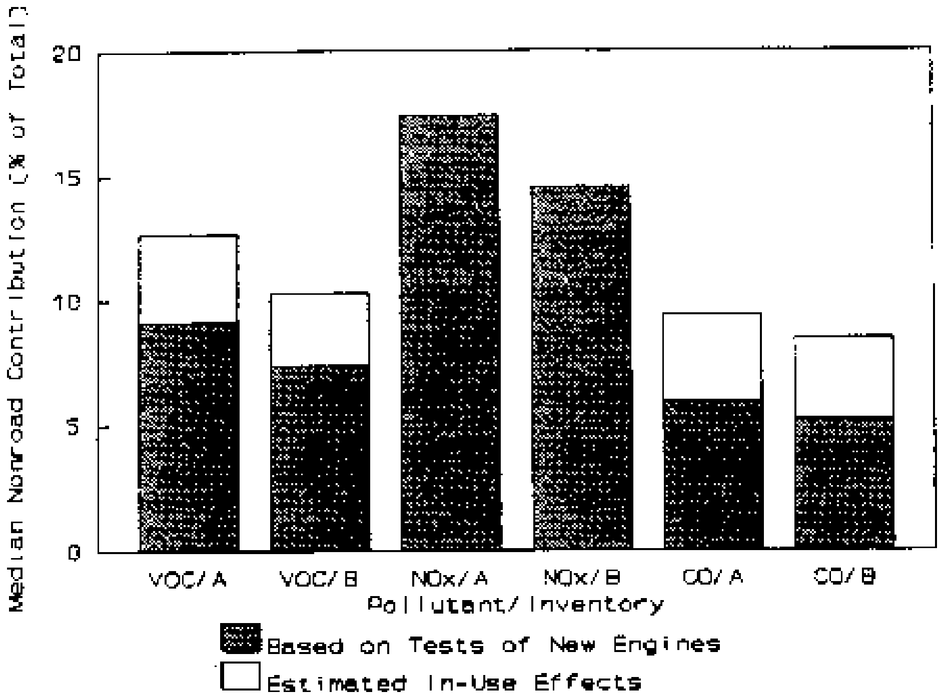
Highlights of Study Results

Results are presented for all nonroad sources and for each equipment category.

Aggregate Nonroad Contributions to Inventories

The results of Inventories A and B are similar. Chart ES-01 shows the median contributions to total inventories in the 19 ozone and 16 CO nonattainment areas studied. In general, Inventory B estimates lower emissions than Inventory A.

Chart ES-01. Comparison of Median Contributions - Inventory A & B



Under the most conservative assumptions, using the new engine EFs and choosing the lowest estimate from Inventories A and B combined, minimum contributions by pollutant for all cities studied were as follows: 2.9% VOC, 7.6% NO_X, and 2.2% CO. It is often useful to look at the second highest and second lowest values in the range to avoid any "outliers" that might skew the data. For example, the second lowest contribution of VOC in any nonattainment area studied was 4.5%, for NO_X 9.7%, and for CO 2.3%.

It is also useful to look at the nonattainment area with the second highest contribution since Congress requires EPA to regulate nonroad engines if it finds that nonroad engines are significant contributors to pollution in more than one nonattainment area. Chart ES-02 shows, for VOC, NO_X, and CO, the level of contribution in the nonattainment area with the second highest contribution from nonroad sources.

light-duty trucks, heavy-duty vehicles). Most large sources, like motor vehicles, have substantially reduced emissions because of regulatory requirements over the past two decades. Because many of the technologically and economically feasible reductions available from large sources have already been realized, a number of emission control programs recently mandated by Congress are aimed at achieving marginal inventory reductions. These reductions are relatively small compared to past reductions taken from an uncontrolled baseline. Since marginal reductions tend to be costly, the EPA has begun to focus on controlling many small sources of pollution. Because nonroad engines are uncontrolled, it is reasonable to expect that introduction of controls on sources emitting 1% of the total inventory would at least achieve benefits in the range of many other control programs now mandated by Congress in the CAA.

Table ES-05 shows, using the new engine EFs, the number of nonattainment areas in Inventories A and B in which specific nonroad categories contribute at least 1% of total inventory. Many of these areas exceed the 1% contribution by a wide margin.

Table ES-05. Number of Areas in Which Category Contributes at Least 1% of Total Inventory in the 19 Ozone and 16 CO Nonattainment Areas Studied

Nonroad Category	Number of Areas > 1% Inventory A/B		
	VOC	NO_x	CO
Lawn and Garden	19-18	0-0	5-3
Recreational Marine	17-17	2-1	0
Commercial Marine	1-1	10-9	2-2
Recreational Equipment	2-0	0	3-2
Light Commercial Equipment	2-2	0	15-15
Construction Equipment	11-5	19-19	3-0
Agricultural Equipment	1-1	12-13	0
Airport Service Equipment	0	12-12	0
Industrial Equipment	0	13-13	12-10

Charts ES-03 through ES-08 show VOC, NO_x, and CO emission inventories for nonattainment areas typical of those included in the study.[ff] For comparison, the national emission inventories are also shown.

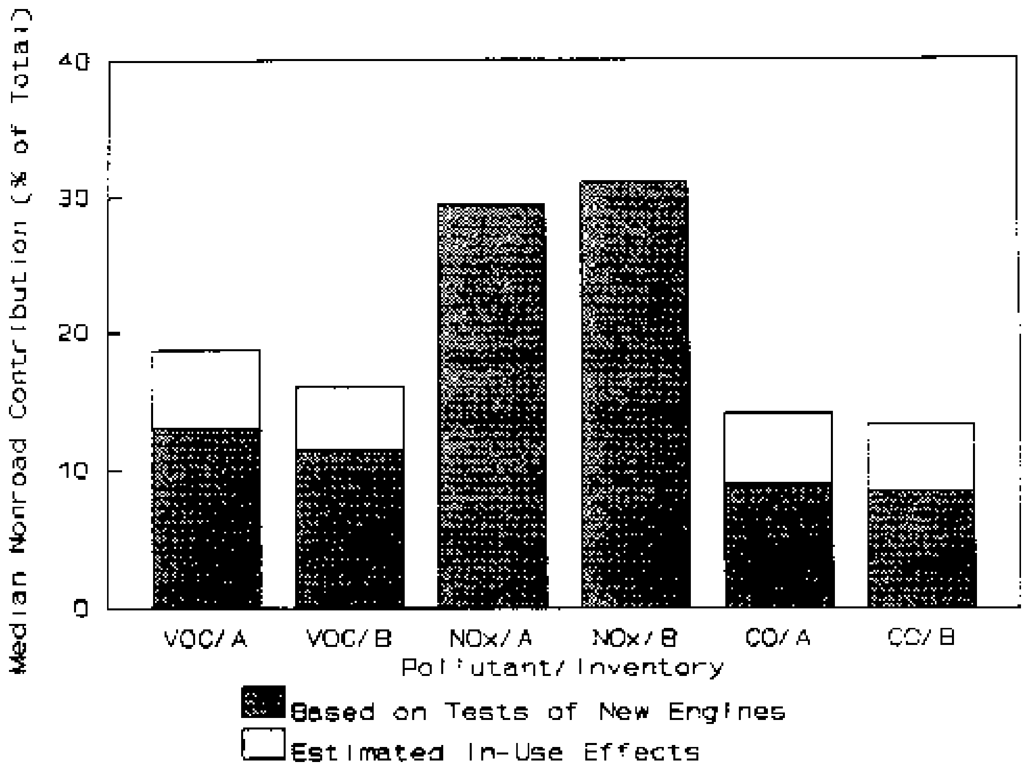
The nonroad portion of each chart is based on the average between Inventories A and B with and without adjustments for increased in-use emissions. The key at the bottom of each page lists the other sources included in the charts.

The nonroad contribution to the summertime VOC inventory for the New York CMSA/NECMA is greater than the combined contribution from all highway vehicles except light-duty gasoline vehicles. For the Philadelphia CMSA, the nonroad summertime NO_x contribution is larger than that from all heavy-duty highway vehicles. The nonroad contribution to the wintertime CO inventory for the Denver CMSA is greater than the combined contribution from all other sources except highway vehicles.

Nationally, the nonroad summertime VOC and NO_x contributions are greater than those from any other single source categories except solvent evaporation (VOC) and electrical generation (NO_x). The national nonroad CO contribution is greater than the combined contributions from all highway mobile sources except light-duty vehicles.

[ff] For each pollutant, the area shown is that for which the nonroad portion of the inventory was nearest to the median value for the different areas included in the study.

Chart ES-02. Percent Contribution from Nonroad Sources in the Nonattainment Area with the Second Highest Contribution Level



Nonroad Contribution to Inventories by Equipment Category

The individual nonroad categories contributing most heavily to the inventories vary by pollutant. Both Inventory A and B show substantial summertime VOC emissions from nonroad sources. These emissions are primarily from lawn and garden equipment and from the recreational marine category. About 7.5% of the lawn and garden contribution to nonroad VOC inventories is due to evaporative emissions from spilling fuel when refueling equipment.

The nonroad portion of total summertime NO_x emissions is estimated to be about the same, on a percentage basis, as the portion of total VOC emissions from nonroad sources. By far the largest contributor to nonroad NO_x emissions is construction equipment. Inventory A shows in all areas studied that construction equipment contributions exceed 6% of the total NO_x inventory. Inventory B shows that in 15 of the 19 areas, NO_x emissions from construction equipment exceed 5% of the total inventory. Agricultural, industrial, airport service, and commercial marine engines are also important contributors of NO_x in some areas.

Unlike VOC and NO_X emissions, no one category dominates the nonroad CO emission contribution. Light commercial, lawn and garden equipment, industrial, commercial marine, and recreational equipment categories each contribute a minimum 1.4-2.2% of total wintertime CO in at least two areas.

Table ES-04 shows the contributions of the different nonroad engine and vehicle categories to total inventories of VOC, CO, and NO_X emissions. The contributions are expressed in percent of total emissions from *all* sources. The values given are medians of the contributions in the various nonattainment areas studied. These are given for both inventories A and B, using emission factors first based on new engines and second incorporating EPA's estimate of in-use effects. Finally, the median contribution from all nonroad engines and vehicles is shown.

Table ES-04. Median Contributions of Nonroad Categories to VOC, NO_X and CO Emission Inventories A and B, with New Engine/In-use Estimate Emission Factors

	% Total VOC tpsd		% Total NO_X tpsd		% Total CO tpwd	
Source Category	Inv. A	Inv. B	Inv. A	Inv. B	Inv. A	Inv. B
Lawn and Garden	2.6-4.7	2.4-4.1	0.2	0.2	0.6-1.1	0.5-0.9
Airport Service	0.1-0.1	0.1-0.1	1.1	1.2	0.2-0.2	0.2-0.2
Recreational	0.2-0.4	0.2-0.3	0.0	0.0	0.4-0.8	0.4-0.7
Light Commercial	0.6-1.0	0.6-1.1	0.2	0.2	2.0-3.6	2.0-3.7
Industrial	0.4-0.5	0.4-0.4	1.7	1.3	1.3-1.5	1.1-1.4
Construction	1.0-1.1	0.8-0.8	9.7	8.4	0.5-0.6	0.4-0.5
Agricultural	0.2-0.2	0.2-0.2	1.6	1.7	0.1-0.1	0.1-0.1
Logging	0.0-0.0	0.0-0.0	0.0	0.01	0.0-0.0	0.0-0.0
Recreational Marine	3.4-4.0	2.2-2.5	0.3	0.2	0.1-0.1	0.1-0.1
Commercial Marine	0.1-0.1	0.1-0.1	0.7	1.0	0.1-0.1	0.1-0.1
Total Nonroad	9.1-12.6	7.4-10.3	17.3	14.5	5.9-9.4	5.2-8.5

Relative Contributions of Nonroad and Other Emission Sources

One of the difficulties in improving air quality is that a multitude of small sources contribute to air pollution. In fact, many of what are considered "large" sources are actually groups of smaller sources (e.g., motor vehicles are categorized into light-duty vehicles,

Chart ES-03. National Summertime VOC Inventory

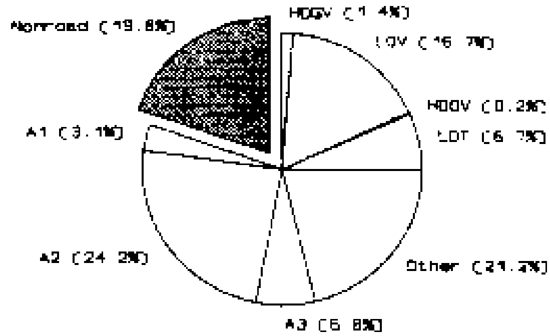
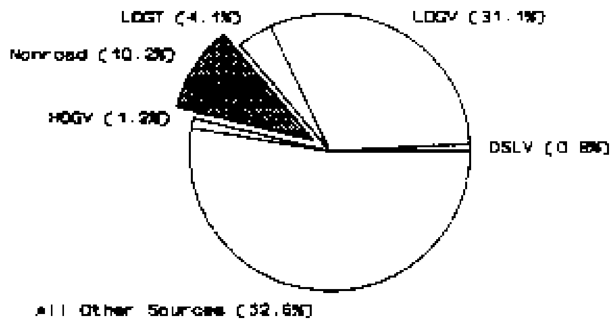


Chart ES-04. New York CMSA/NECMA Summertime VOC Inventory



<u>Highway Mobile Sources</u>

LDGV - light-duty gasoline vehicles
LDV - light-duty vehicles
LDGT - light-duty gasoline trucks
LDT - light-duty trucks
HDGV - heavy-duty gasoline vehicles
HDDV - heavy-duty diesel vehicles
DSLV - diesel vehicles

<u>Area and Point Sources</u>

A1 - petroleum refining
A2 - solvent evaporation
A3 - petroleum product storage/transfer
A4 - electrical generation
A5 - industrial combustion
A6 - industrial processes
A7 - residential fuel use

Chart ES-05. National Summertime NO_X Inventory

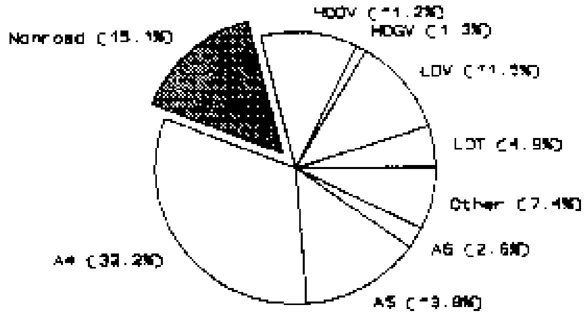
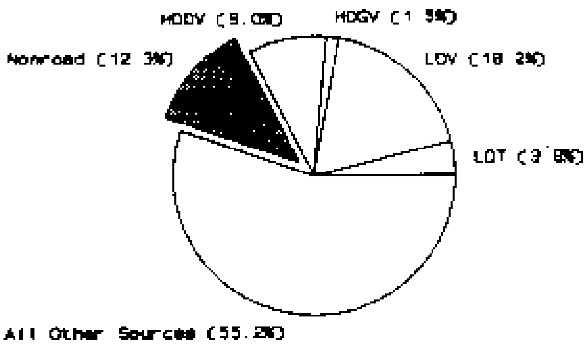


Chart ES-06. Philadelphia CMSA Summertime NO_X Inventory



Highway Mobile Sources

LDGV - light-duty gasoline vehicles
LDV - light-duty vehicles
LDGT - light-duty gasoline trucks
LDT - light-duty trucks
HDGV - heavy-duty gasoline vehicles
HDDV - heavy-duty diesel vehicles
DSLV - diesel vehicles

Area and Point Sources

A1 - petroleum refining
A2 - solvent evaporation
A3 - petroleum product storage/transfer
A4 - electrical generation
A5 - industrial combustion
A6 - industrial processes
A7 - residential fuel use

Chart ES-07. National Wintertime CO Inventory[ff]

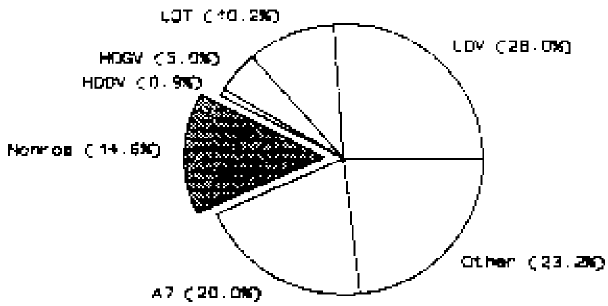
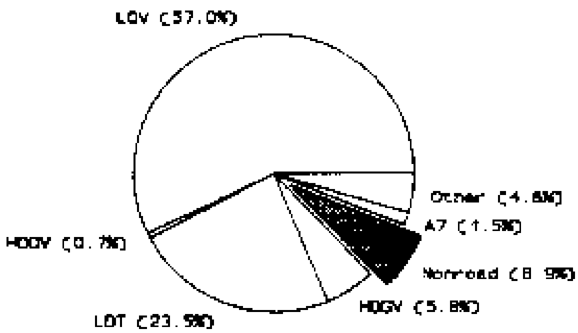


Chart ES-08. Denver CMSA Wintertime CO Inventory



Highway Mobile Sources

LDGV - light-duty gasoline vehicles
LDV - light-duty vehicles
LDGT - light-duty gasoline trucks
LDT - light-duty trucks
HDGV - heavy-duty gasoline vehicles
HDDV - heavy-duty diesel vehicles
DSLV - diesel vehicles

Area and Point Sources

A1 - petroleum refining
A2 - solvent evaporation
A3 - petroleum product storage/transfer
A4 - electrical generation
A5 - industrial combustion
A6 - industrial processes
A7 - residential fuel use

[ff]Corrections for wintertime increases in CO emission factors were not made for either nonroad sources or highway vehicles due to limitations in national-level data.

Because nonroad sources are among the few remaining uncontrolled sources of pollution, their emissions appear large in comparison to the emissions from sources that are already subject to substantial emission control requirements. For example, the CAA requires extreme ozone nonattainment areas to employ Reasonably Available Control Technology (RACT) on all stationary sources with VOC or NO_x emissions above 10 tons per year (tpy). Annual operation of only 10 crawler tractors or 24 agricultural tractors will produce 10 tpy of NO_x. Typical annual operation of only 74-142 boats with outboard motors or 730-1,630 chain saws will emit 10 tpy of VOC.*** In contrast, it takes 700 new, current-technology passenger cars driving an average of 13,000 miles each in a year (a total of more than 9 million miles) to produce 10 tpy of VOC.

Areas of Further Study

In the process of constructing the study, EPA identified a number of areas where estimates were developed using limited data or were not developed at all because of lack of data altogether. While existing nonroad emission factors estimate tailpipe emissions from relatively new engines, more work needs to be done to quantify the effects of in-use deterioration, crankcase and evaporative emissions, toxic and particulate emissions, and emissions under cold start conditions. Because these emissions are not totally captured by the emission factors used in this study, the inventories presented in the study, particularly those calculated using the new engine emission factors, are likely to be conservative estimates of the nonroad contribution to air pollution.

*** These numbers indicate the range between data used to develop A and B national inventories.

Chapter 1. Overview and Background

The cornerstone of the Clean Air Act (CAA) is the effort to attain and maintain National Ambient Air Quality Standards (NAAQS).[1] ††† Prior to the enactment of the 1990 CAA Amendments (CAAA), efforts to achieve and maintain air quality standards focused on regulation of emissions from on-highway, area, and stationary sources. As a result of these efforts, significant progress has been made in reducing such emissions. However, due to the growth in air pollution sources, many air quality regions have failed to attain the NAAQS, particularly those for ozone and carbon monoxide (CO).

The CAAA contain numerous provisions that are intended to remedy these continuing air quality problems, through the application of new controls on currently regulated mobile and stationary sources of emissions and the promulgation of regulations for new sources. As part of the effort to identify and control unregulated sources of air pollution, the CAAA direct the U.S. Environmental Protection Agency (EPA) to study contributions to air quality from nonroad engines‡‡‡ and nonroad vehicles§§§ (other than locomotives or engines used in locomotives).£££ This study is the result of that directive.

1.1. The Air Pollution Problem

The CAA requires the EPA to set air quality standards for common and widespread pollutants after preparing "criteria documents" summarizing scientific knowledge on their health effects. Currently, six "criteria" pollutants are regulated by primary and secondary

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††† Reference citations are indicated by a superscripted number. A list of citations can be found at the end of the report.

‡‡‡ Section 216(10) of the CAA, as amended, defines "nonroad engine" as an internal combustion engine (including the fuel system) that is not used in a motor vehicle or a vehicle used solely for competition, or that is not subject to standards promulgated under section 111 (new stationary sources) or section 202 (motor vehicles) of the CAA. As defined in section 216(2) of the CAA, "motor vehicle" means any self-propelled vehicle designed for transporting persons or property on a street or highway.

§§§ Section 216(11) of the CAA, as amended, defines "nonroad vehicle" as a vehicle that is powered by a nonroad engine and that is not a motor vehicle or a vehicle used solely for competition.

£££ Emissions from locomotives and new engines used in locomotives are being addressed in a separate study, as required under section 213(a)(5) of the CAA, as amended.

NAAQS.**** As of 1989, over one-half of the population of the United States was still exposed to levels of these pollutants which were considered unhealthful by EPA.

Based on air quality data from 1988-1989, more than 33 million people resided in the 41 areas that failed to meet the NAAQQS for CO.[2] An area is considered to have failed to attain the NAAQS for CO if it exceeds 9 parts per million (ppm) two or more times in a two year period. Carbon monoxide, formed as a result of the incomplete combustion of fuel, is emitted during the combustion process.

In contrast to CO, ozone is formed in the atmosphere as a result of a complex series of chemical reactions between oxides of nitrogen (NO_X) and volatile organic compounds (VOCs). In most urban nonattainment areas, both NO_X and VOCs must be substantially reduced to bring the area into attainment of the ozone standard. Further, since airborne ozone and NO_X, and possibly VOCs, can be transported from one area to another, attainment of the ozone standard in some areas may require control of NO_X and VOC emissions in upwind regions.

An area is in nonattainment for ozone if it exceeds 0.12 ppm more than three times in a three year period. In 1987-1989, 96 U.S. cities exceeded the standard for ozone. Of these cities, nine were classified as "severely" polluted, experiencing peak ozone levels that exceeded the standard by 50 percent or more. Based on 1989 air quality data, over 66 million people lived in counties not meeting the ozone standard.[3] Appendix B contains a description of ozone formation and a bibliography of the literature on ozone. A list of carbon monoxide and ozone nonattainment areas can be found in Appendix C.

As with CO and ozone, many areas are in nonattainment for particulate matter (PM). At the time the CAAA were enacted, 73 areas failed to meet the NAAQS for PM. Over 28 million people lived in areas not meeting the particulate standard in 1989.[4] ††††

In addition to problems associated with nonattainment of the NAAQS, EPA is concerned with the health risks associated with air toxics. Most air toxics are hydrocarbon compounds capable of causing adverse health effects. Benzene, formaldehyde, and 1,3-

**** NAAQS have been established for particulate matter (PM), sulfur dioxide (SO_2), carbon monoxide (CO), nitrogen dioxide (NO_2), ozone, and lead.

†††† The estimate for particulate matter is considered a lower bound estimate, because the PM_{10} monitoring network is still evolving.

butadiene are emitted by motor vehicles and are considered to be human or probable human carcinogens. Some air toxics, such as benzene, are components of gasoline and can be emitted as unburned fuel or as fuel that evaporates. Other air toxics, such as formaldehyde, which results from the same reactions that form ozone, and 1,3-butadiene, are not present in fuel, but are by-products of incomplete combustion. A summary of cancer risk estimates associated with motor vehicle pollutants of most concern can be found in Appendix C.

1.2. Congressional Mandate and Scope of Study

Section 213(a) of the CAA, as amended, directs EPA to conduct a study of emissions from nonroad engines and vehicles and to determine if such emissions cause, or significantly contribute to, air pollution which may reasonably be anticipated to endanger public health or welfare. Within 12 months after the completion of the study, the Administrator of EPA must determine whether the emissions of CO, NO_x, and VOCs from such new or existing engines or vehicles are significant contributors to ozone or CO concentrations in more than one area which has failed to attain the NAAQS for ozone or CO. If an affirmative determination is made, the Administrator is required to promulgate regulations containing standards applicable to emissions from those classes or categories of new nonroad engines and vehicles which in the Administrator's judgment cause, or contribute to, such air pollution.

This study is the result of the directive in section 213(a) that EPA conduct a study of nonroad emissions. The study quantifies, through the use of nonroad equipment emission inventories, the contributions of nonroad sources to air quality problems. The study does not make a determination of the significance of emissions from nonroad sources. Such a determination will be included as part of any regulations promulgated for nonroad engines and vehicles.

1.3. Nonroad Equipment Categories Included in the Study

EPA considered over 80 different types of equipment in this analysis. To ease analysis and reporting and to assist the disaggregation of national or state equipment populations to the local level, EPA grouped the equipment types into the 10 equipment categories listed in Table 1-01. Additional information on these equipment types and equipment categories can be found in Chapter 2. It should be noted that these categories were developed only for use in this study and are not intended to represent potential regulatory categories. Aircraft and locomotives were not included in this study.[####]

Table 1-01. Equipment Categories Included in Study

Categories
Lawn and Garden Equipment
Airport Service Equipment
Recreational Equipment
Recreational Marine Equipment
Light Commercial Equipment
Industrial Equipment
Construction Equipment
Agricultural Equipment
Logging Equipment
Commercial Marine Vessels

1.4. Pollutants Considered in the Study

Although numerous pollutants have the potential to meet the criteria set forth in the CAAA for inclusion in the study, EPA chose to limit the number of pollutants examined in this study to those listed in Table 1-02.

[####]Aircraft are already regulated under a separate subpart of the Clean Air Act and, hence, are not classified as nonroad engines or vehicles. Locomotives were specifically excluded from inclusion by Congress in the CAAA.

Table 1-02. Pollutants Included in Study

Pollutants
Volatile Organic Compounds (VOCs)
Oxides of Nitrogen (NO_x)
Carbon Monoxide (CO)
Particulate Matter (PM)
Sulfur Dioxide (SO_2)
Benzene
Aldehydes
1,3-butadiene
Gasoline Vapors
Nitrosamines

Section 213(a) of the CAA, as amended, requires that VOCs, CO, and NO_x be included in the nonroad study. Of the three other NAAQS criteria pollutants (PM, SO_2 and lead), EPA chose to include PM and SO_2, since both are currently regulated for on-highway sources and have been identified as contributing to air quality conditions that are dangerous to public health or welfare. The last criteria pollutant, lead, although highly toxic, was not included in the study because the CAAA prohibit the production of motor vehicle engines and nonroad engines that require leaded gasoline after model year 1992.

Nonroad sources also emit other pollutants commonly referred to as air toxics, which include carcinogens, mutagens, and reproductive toxins. Currently, little information exists regarding air toxic emissions from nonroad engines and vehicles or the health effects of such emissions. Moreover, none of these pollutants from on-highway sources have been regulated on the basis of carcinogenicity.

EPA's authority to include air toxics in this study is derived from section 213(a)(4) of the CAA. In determining which air toxics to examine, EPA considered three sources of information: compounds suggested by contractors which show the greatest cancer incidences and other risks,[3] pollutants to be included in EPA's CAA-mandated study of mobile source-related air toxics, and those pollutants emitted from nonroad sources which are found in Title III of the CAA. After reviewing the availability of data and the cancer risk incidences, EPA chose to address the following air toxics in this study: benzene; aldehydes; 1,3-butadiene; gasoline vapors; and nitrosamines. Appendix D contains a listing of the air toxics considered in this study.

1.5. Geographic Areas Considered in the Study

In determining which geographic areas to include in the study, EPA decided to focus on the 24 areas, listed in Table 1-03, which failed to attain the NAAQS for either ozone, CO, or both. Nineteen of the areas were evaluated for VOCs and NO_X, and 16 areas for CO. A primary reason for selecting these areas is the severity of their local air quality problems. EPA also believes these areas are representative of other urban areas with air pollution problems due to their diverse geographic and demographic characteristics.

Table 1-03. Geographic Areas Included in Study

Nonattainment Areas	
Atlanta, GA MSA	Minneapolis-St. Paul, MN-WI MSA
Baltimore, MD MSA	New York-Northern NJ-Long Island, NY-NJ-CT CMSA/NECMA[####]
Baton Rouge, LA MSA	Philadelphia-Wilmington-Trenton, PA-NJ-DE-MD CMSA
Boston-Lawrence-Salem-Lowell-Brockton, MA NECMA	Provo-Orem, UT MSA
Chicago-Gary-Lake County IL-IN-WI CMSA	St. Louis, MO-IL MSA
Cleveland-Akron-Lorain, OH CMSA	San Diego, CA Air Basin[****]
Denver-Boulder, CO CMSA	San Joaquin, CA Air Basin
El Paso, TX MSA	Seattle-Tacoma, WA CMSA
Hartford-New Britain-Middletown-Bristol, CT NECMA	South Coast, CA Air Basin
Houston-Galveston-Brazoria, TX CMSA	Spokane, WA MSA
Miami-Fort Lauderdale, FL CMSA	Springfield, MA NECMA
Milwaukee-Racine, WI CMSA	Washington, DC-MD-VA MSA

[####] Consolidated Metropolitan Statistical Area (CMSA) and North East County Metropolitan Statistical Area (NECMA) definitions are given in State and County Metropolitan Area Data Book, U.S. Bureau of the Census, 1986.

[****] California air basins are defined for the purposes of this study as in the 1990 version of the 1987 emission inventory prepared by the California Air Resources Board (CARB) for the State of California.

1.6. Public Participation

EPA recognizes that involvement by the manufacturing and environmental communities is essential in ensuring the effective implementation and enforcement of any policies and regulations which may be developed. Therefore, throughout the nonroad engine and vehicle study process, EPA actively solicited information and comment from interested parties. The information supplied by these parties enabled EPA to use the best available data in developing estimates of the contribution of nonroad engines to air quality problems.

A public workshop was held on April 3-4, 1991, with over 200 persons in attendance. The purpose of the workshop was to discuss the nonroad engine and vehicle study and the Agency's regulatory process. Presentations were made by EPA, state agency representatives, and industry representatives.[*****] EPA requested that manufacturers submit population inventory and emission data for the nonroad equipment to be considered in the study. In addition, a briefing for environmental groups on general air quality issues held in Washington, D.C., on May 14, 1991, included a presentation on the nonroad study.

Following the public workshop, EPA held individual meetings with a number of manufacturers and manufacturer groups, including: Outdoor Power and Equipment Institute (OPEI), Industrial Truck Association (ITA), Engine Manufacturers Association (EMA), the Equipment Manufacturers Institute (EMI), Portable Power Equipment Manufacturers Association (PPEMA), John Deere Company, National Marine Manufacturers Association (NMMA), Manufacturers of Emission Controls Association (MECA), Ford Motor Company, Ford/New Holland, and Tecumseh Products Company. At these meetings, manufacturers provided EPA with up-to-date information which assisted EPA in the development of the inventories in the study. Association descriptions and membership lists are in Appendix E.

An informal external technical review group, composed of representatives from a variety of manufacturer associations and state agencies, was convened by EPA to provide technical review and feedback throughout the development of the study. The review group provided informal feedback on the nonroad population inventory methodology, emission factors, and per-source usage rates for the study. A complete list of the Technical Review Group members is included in Appendix F.

[*****] Presentation materials and other comments are available for public review in Docket #A-91-24.

EPA published a draft of this report for public review in October 1991, and held a public meeting on the nonroad study on October 30, 1991. This report reflects EPA's consideration of comments received on the draft report. A discussion of EPA's response to public comments is found in Appendix Q.

Chapter 2. Methods and Approach

The goal of the EPA Nonroad Engine and Vehicle Emission Study was to develop an inventory of nonroad engine and vehicle emissions within the Congressionally mandated time period. To achieve this goal, EPA used the limited data that was available. Where feasible, these data were updated or new data were developed.

In developing emission inventories for nonroad engines, EPA found that comparisons between existing data were not always direct or easy. One of the biggest challenges was to find a way to present, compare, and analyze data from a variety of sources. Given the number of types of engines and equipment included in the study, and the amount of data available that characterized emissions from nonroad sources, EPA chose to construct two sets of inventories, both of which are presented in this report.

In the first set of inventories (Inventory A), EPA incorporated commercially and publicly available data so that the method of inventory construction could be repeated by interested states. The second set of inventories (Inventory B) incorporated industry-provided data that might not be publicly available to states (e.g., confidential sales data to estimate populations) but which provided EPA with a means of validating the first set of inventories. A discussion of the methodology and data used for both inventories is presented later in this chapter. Each inventory is based, at least in part, on specific data sources:

- Inventory A relies primarily on data provided by contractor studies; in particular, on population and per-source usage rate data derived from recent work contracted by EPA for this study. For most categories of equipment, populations are drawn from a commercially available market research data base. Inventory A also includes some data supplied by states and manufacturers.

- Inventory B incorporates population and per-source usage rate data supplied to EPA by manufacturers and manufacturer associations. For most categories, population estimates were supplied by the manufacturers or are derived from confidential sales data provided by manufacturers. Where gaps existed, data from Inventory A were used, so that a complete inventory could be developed.

The study also considers a third set of inventories, Inventory C, which is based on data developed by individual states for their 1987 State Implementation Plans (SIPs).[†††††] At the time the study was initiated, SIPs provided the most comprehensive source of nonroad engine and vehicle emission data. Each SIP contains a state-developed inventory which considered population and per-source usage rate estimates. However, two factors restricted the ability of EPA to utilize this inventory as a basis of comparison with Inventories A and B. First, the SIPs considered a limited number of nonroad equipment types. Second, a substantial amount of new data on nonroad sources was developed after the states constructed their 1987 draft inventories. Nevertheless, the SIPs still constitute a valuable point of reference. Further discussion of this inventory is found in Appendix G.

2.1. Structure of Emission Inventories

Emission inventories are detailed listings of the amount of pollution generated by different sources in an area during a specific period of time and are used to account for the various sources of different air pollutants. For example, a CO emission inventory might appear as shown in Table 2-01.

Table 2-01. Sample CO Emission Inventory.

Source	1987 tpy*
Light-Duty Highway Vehicles	400
Other Highway Vehicles	200
Nonroad Mobile Sources	300
Other Area and Point Sources	100
Total (All Sources)	1000

* tons per year

††††† Title I of the CAA requires states to develop plans to demonstrate how they intend to meet the NAAQS.

In developing emission inventories for nonroad engines and vehicles, EPA used the following formula to calculate emissions from most nonroad sources[‡‡‡‡]:

$$M_i = N \times HRS \times HP \times LF \times EF_i$$

where:

M_i	=	mass of emissions of i^{th} pollutant during inventory period
N	=	source population (units)
HRS	=	annual hours of use
HP	=	average rated horsepower
LF	=	typical load factor
EF_i	=	average emissions of i^{th} pollutant per unit of use (e.g., grams per horsepower-hour)

For this study, the product of the annual hours of use, the average rated horsepower, and the load factor is referred to as the *per-source usage rate*. The product of the population and the per-source usage rate is referred to as the *activity level*. Nonroad engine emissions are expressed as tons per year (tpy), except when emissions are adjusted for seasonal usage patterns to reflect tons per summer day (tpsd) or tons per winter day (tpwd).

2.2. Developing Equipment and Engine Categories

The development of an emission inventory requires the estimation of activity levels, which is facilitated by the use of categories that group together types of *equipment*, such as tractors, balers, harvesters, and other types of agricultural equipment, which have common function and use characteristics. Emission factors, on the other hand, are generally best developed for different types of *engines*, such as diesel, gasoline, 4-stroke, and 2-stroke, used within an equipment type. Consequently, EPA estimated activity levels by *equipment* type, while applying emission factors appropriate to corresponding *engine* types.

EPA developed the ten equipment categories listed in Table 2-02. The primary purpose of equipment categories is to simplify the distribution of equipment populations and annual usage to the local nonattainment area level. Over 80 different types of equipment were considered in this analysis, many of which are highly specialized and have low sales

[‡‡‡‡]Note that EPA used grams/hour emission factors for most recreational equipment and grams/gallon of fuel for recreational and commercial marine equipment.

volumes. EPA recognizes that many of the 80 equipment types, such as chain saws, generator sets, forklifts, and crawler tractors, are used in more than one industry or application (e.g., farming, construction, general industry or recreation) and that, consequently, the ten equipment categories are not mutually exclusive with respect to equipment type. Nevertheless, the definition of the ten categories is consistent with the methodology used to distribute equipment populations geographically and to estimate activity levels, and so it is considered to be valid for that purpose. Equipment types used for similar purposes were grouped into categories and a methodology was developed for distributing state or national population data to the local level for each equipment category. While these categories were used for distributing population data, activity levels were developed for each equipment type. Grouping equipment types into categories also provides a convenient means of reporting the results in a format which is more readily understood.[§§§§§] A detailed list of equipment types included in each equipment category is found in Appendix H.

Table 2-02. Nonroad Mobile Source Equipment Categories.

Equipment Category	Examples of Included Types of Equipment
Lawn and Garden	lawnmowers, snowblowers, trimmers, tillers, chain saws < 4 hp
Airport Service	aircraft and baggage towing tractors, airport service vehicles
Recreational	ATVs, off-road motorcycles, golf carts, snowmobiles
Recreational Marine	inboard and outboard recreational boats
Light Commercial	air and gas compressors, welders, generator sets, pumps
Industrial	aerial lifts, forklifts, self-propelled elevating platforms, sweepers
Construction	asphalt pavers, rollers, scrapers, rubber-tired dozers
Agricultural	agricultural tractors, combines, balers, harvesters
Logging	chain saws > 4 hp, delimbers, log skidders
Commercial Marine	harbor vessels, fishing vessels, ocean-going commercial vessels

§§§§§ These categories are neither definitions of "farm equipment" or "construction equipment" (terms that will be defined by EPA in a future rulemaking) nor necessarily appropriate for the classification of new nonroad engines and new nonroad vehicles for which regulations may be promulgated under section 213(a)(3) or 213(a)(4) of the CAA.

For the categories in Table 2-02, EPA developed separate emission factors for equipment types using diesel, gasoline 4-stroke, and 2-stroke and LPG engines where appropriate. A detailed discussion of the development of emission factors is contained in Appendix I.

2.3. Development of Emission Factors

A key element necessary to determine emission inventories for nonroad sources is the emission factor. An emission factor is the average emission rate when a vehicle or unit of equipment is operated in an average manner. Emission factors are commonly mass-based and expressed in units of mass per unit of work (e.g., grams per horsepower hour), mass per unit of fuel consumed, or, in the case of on-highway vehicles, mass per mile traveled.

For this study, Inventories A and B were calculated with a common set of emission factors, except for diesel particulate emission factors, which are different for the two inventories. A list of the emission factors selected by EPA is presented in "2.7. Comparison of Data Used in Inventories A and B." Emission factors for Inventory C required special aggregation to be compatible with SIP guidance.

EPA used data available from past studies and testing, as well as new information supplied by the engine manufacturers, to develop emission factors for tailpipe exhaust, refueling, evaporative, and crankcase emissions.[fffff] Appendix I describes the various methodologies used to determine and select the most appropriate emission factors for each type of equipment. The emission factors developed for this study were reviewed by the technical review group.

The test data on which the emission factors are based consist almost exclusively of tests on new engines. While more testing needs to be completed before in-use emissions can be fully characterized, EPA believes that inventories incorporating emission factors based

[fffff] EPA contracted with Southwest Research Institute (SwRI) to perform a study to recommend categorization of nonroad sources and the best available exhaust emission factors for nonroad sources. SwRI completed this task in two parts. The first part focused on emission factors for VOC, CO, and NO_X, while the second part focused on particulate matter and air toxic emission factors. The final reports, "Non-Road Emission Factors Interim Report" and "Non-Road Emission Factors of Air Toxics" can be found in the public docket (#A-91-24). Appendix I provides detail on emission factors and how they were used. EPA received emission factor information from a number of industry sources. Appendix J indicates the sources of additional data.

solely on new engine data would grossly understate the contribution of nonroad engines to air pollution. Therefore, to estimate the magnitude of the effect of in-use emissions, which includes engine malfunctions, improper maintenance, and engine wear, EPA also developed a second set of emission factors that takes into account these effects.

Two sources of data were used to estimate in-use adjustment factors. One source was recent testing of in-use small utility engines performed by Southwest Research Institute (SwRI) under contract by EPA. The limited testing that has been done thus far suggests that in-use emissions could be 2 times higher, for some engines, than the emission factors based on new engines. The second source of data was a joint Engine Manufacturers Association (EMA)/EPA program conducted in 1983 which developed in-use emission factors for heavy-duty diesel and heavy-duty gasoline engines. The data obtained from this program suggests that, while in-use impacts are minimal for pre-controlled diesel engine emissions (i.e., diesel engine emissions do not increase with mileage/hours of operation), heavy-duty gasoline engine emissions increase with in-use operation. A detailed discussion of the in-use adjustments to emission factors is contained in Appendix I. Inventories A and B were calculated using both the new engine emission factors and the in-use emission factors. The results are presented so that the reader can clearly distinguish the estimated in-use portion of each inventory.

Another issue which is necessary to consider in the assessment of the magnitude of emission rates for nonroad equipment is whether the test cycle is representative of in-use operation. There is an ongoing debate regarding the appropriateness of using a steady state or a transient test cycle for testing the emissions of nonroad engines. This is an important issue, since measured emissions of most pollutants, especially particulate matter (PM), are sensitive to the test cycle. For instance, a steady state cycle used on a piece of equipment that experiences transient operation in-use may misrepresent the level of in-use emissions. EPA adjusted the PM, CO, and VOC emission factors which were developed using steady state procedures to account for in-use transient operation for those equipment types expected to encounter such operation. The equipment types that were adjusted are indicated by Footnote "a" in Table 2-07a. The adjustments were only made to diesel engines since the only data available was on diesel engines. A more detailed discussion of these adjustments for transient operation is contained in Appendix I.

2.4. Development of Activity Levels for Inventory A

Due to limitations in the existing guidance for developing emission inventories for nonroad mobile sources, EPA contracted to develop improved methodologies for all nonroad sources. The equipment populations, annual hours of use, average horsepower ratings, and load factors used in Inventory A are primarily based on a market research data base commercially available though Power Systems Research (PSR). This data base is continually updated through surveys of equipment manufacturers and end users. For the study, population data were disaggregated to individual nonattainment areas using commonly available economic indicators and census data.[******] The emissions analysis for commercial marine vessels was handled separately from other categories of equipment,[††††††] as discussed in Section 2.8.

The development of emission inventories for recreational boats relied on local registrations of pleasure craft. Because boats are often used outside areas where they are registered, adjustments to registration data were made based on a survey of boat owners in eight nonattainment areas conducted by Irwin Broh and Associates, Inc. for the National Marine Manufacturers Association (NMMA).[6] Annual fuel consumption from the same survey was also used in calculating recreational boat emissions.

While relying primarily on contractor input, EPA also used other data and information in calculating Inventory A. Documentation of adjustments to the contractor data are contained in Appendix K. Documentation of adjustments to the data to reflect variations in usage patterns by region of the country and season of the year is contained in Appendix L. Summaries of the data used to develop Inventory A are presented in "2.7. Comparison of Data Used in Inventories A and B," with more detailed information presented in Appendix M.

****** The methodology is documented in the Energy and Environmental Analysis final report entitled "Methodology to Estimate Nonroad Equipment Populations by Nonattainment Areas," available for review in Docket #A-91-24.

†††††† This is due to the fact that the types of commercial marine vessels are not as diverse as other nonroad categories, and to the fact that records of specific levels and types of vessel activities are more readily available

2.5. Development of Activity Levels for Inventory B

In developing emission inventories for Inventory B, EPA incorporated data submitted by the following manufacturers and associations:

- Outdoor Power Equipment Institute - nonhandheld lawn and garden equipment
- Portable Power Equipment Manufacturers Association - handheld lawn and garden equipment
- Industrial Truck Association - forklifts
- Equipment Manufacturers Institute - agricultural and construction equipment
- National Marine Manufacturers Association - recreational marine equipment
- International Snowmobile Industry Association - snowmobiles
- Motorcycle Industry Council - ATVs, off-road motorcycles

Some of the equipment populations used in Inventory B were based on confidential sales data that are not commercially available. Where gaps existed, EPA used data from Inventory A; however, for most high volume categories the data used in Inventory B were submitted by manufacturers.

In some cases, it was necessary to adjust the data provided by manufacturers for use in constructing Inventory B. The use of and adjustment to manufacturer data is documented in Appendix N. EPA made seasonal adjustments to data in Inventory B similar to those made for Inventory A, as documented in Appendix L. In cases where manufacturers only supplied annual hours of use at the national level, these hours of use were used for all areas without regional adjustments. Summaries of the data used to develop Inventory B are presented in "2.7. Comparison of Data Used in Inventories A and B." More detailed information is presented in Appendix O.

2.6. Comparison of Results from October Draft and Final Study

EPA made some adjustments to the data used to construct Inventories A and B for this final report in response to public comments on the October draft study report. The most significant adjustments to Inventory B data impacting inventory results included revisions to the recreational marine inventory methodology, revisions to annual hours of use for lawnmowers, revisions to the methodology for distributing handheld equipment (trimmers, blowers, and chain saws) to the local level, revisions to population estimates for agricultural tractors and combines, and emission factors for outboard motors and crankcase emission from lawn and garden equipment. Some of these adjustment were also made to Inventory A, but with less impact on overall inventory results. A summary of the comments received to the October draft is in Appendix Q.

Charts 2-01 and 2-02 depict the results from Inventory A and Inventory B before and after adjustments were made to the draft results. Each chart shows the median local nonroad contributions to total VOC, NO_x, and CO inventories.

Chart 2-01. Median Contributions -- Draft Inventory A and B

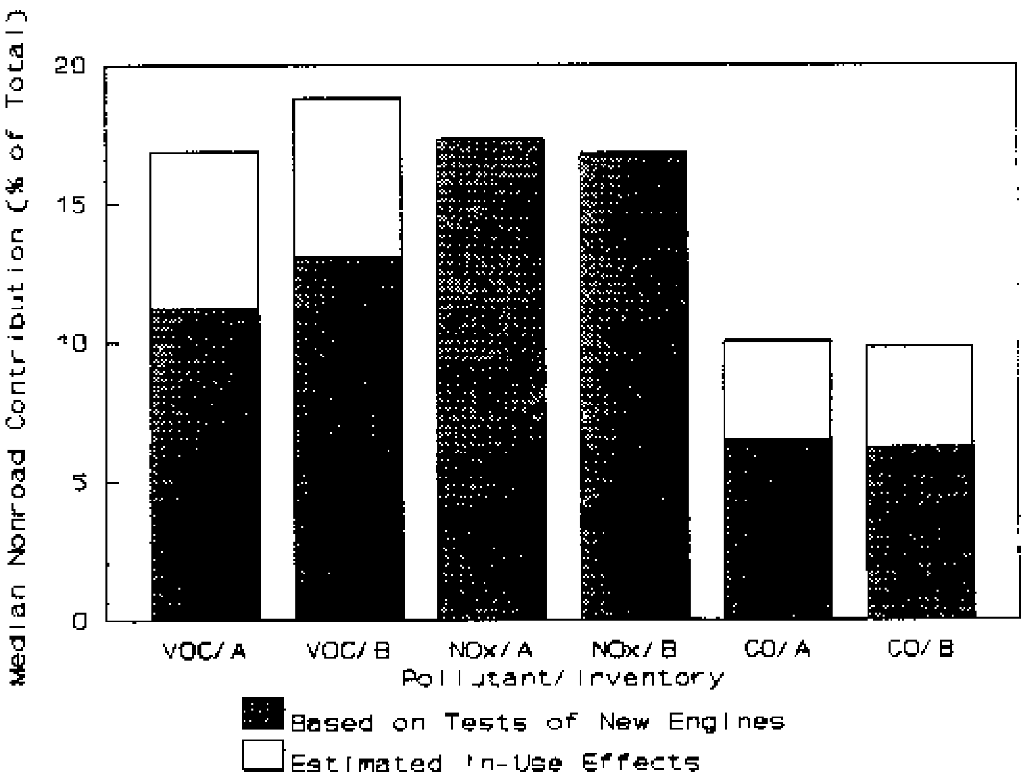
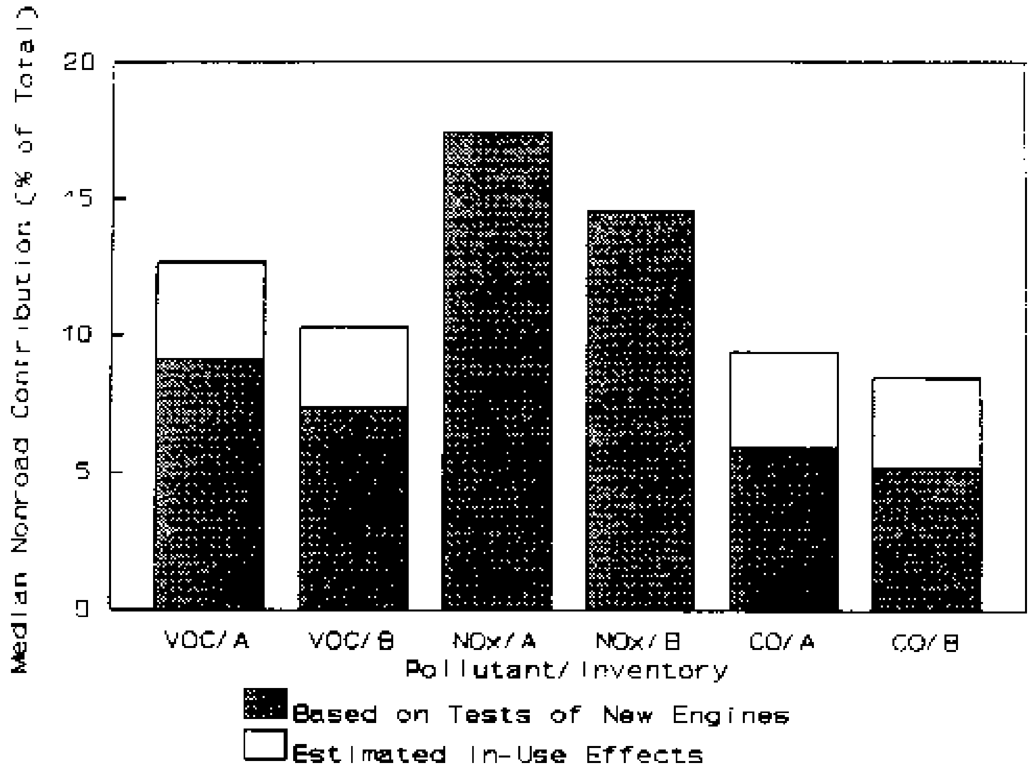


Chart 2-02. Median Contributions -- Final Inventory A and B



2.7. Comparison of Data Used in Inventories A and B

The national equipment population estimates used in constructing Inventories A and B are compared in Table 2-03. As discussed above, Inventory A incorporated population estimates developed by EPA contractors, while Inventory B incorporated, to the extent possible, data from manufacturer associations. Local population estimates used in developing Inventories A and B are included in *EPA Technical Memorandum - Nonroad Inventory Tables: Inventory A and B*, November 15, 1991. The equipment populations are presented by equipment and fuel type, including diesel, LPG/CNG, 4-stroke gasoline, and 2-stroke gasoline.

Comparisons of equipment horsepower and load factor estimates used in Inventory A and Inventory B are presented in Tables 2-04 and 2-05, respectively. Reported ranges of annual hours of use estimates, which vary by region, are compared in Table 2-06. Emission factors for diesel engines and gasoline 2- and 4-stroke engines, which were used in both Inventories A and B, are presented in Table 2-07. Seasonal adjustments, which were used in both Inventories A and B, are presented in Table 2-08, expressed in terms of the percentage of yearly activity occurring during summer and winter.

Table 2-03. Inventory A and B National Population Estimates

Class	National Population Equipment Type	Diesel Inv. A	Diesel Inv. B	LPG/CNG Inv. A	LPG/CNG Inv. B	4-cycle gas Inv. A	4-cycle gas Inv. B	2-cycle gas Inv. A	2-cycle gas Inv. B	Total Inv. A	Total Inv. B
1	Trimmers/Edgers/Brush Cutters	0	0	0	0	21,921	21,921	18,150,361	13,561,414	18,172,282	[illegible]
1	Lawn Mowers	0	0	0	0	32,149,997	28,784,172	3,594,099	3,215,828	35,744,096	32,000,000
1	Leaf Blowers/Vacuums	0	0	0	0	228	228	2,025,558	2,370,936	2,025,786	2,371,164
1	Rear Engine Riding Mowers	8,713	9,460	0	0	1,575,407	1,710,540	0	0	1,584,120	1,720,000
1	Front Mowers	0	0	0	0	257,880	280,000	0	0	257,880	280,000
1	Chain Saws < 4 hp	0	0	0	0	0	0	16,124,970	7,395,302	16,124,970	7,395,302
1	Shredders < 5 hp	0	0	0	0	87,107	87,107	20,215	20,215	107,322	107,322
1	Tillers < 5 hp	0	0	0	0	3,794,457	2,724,966	17,543	12,598	3,812,000	2,737,564
1	Lawn and Garden Tractors	211,651	184,567	0	0	5,903,349	5,148,433	0	0	6,115,000	5,333,000
1	Wood Splitters	79	79	0	0	502,181	502,181	0	0	502,260	502,260
1	Snowblowers	0	0	0	0	3,537,376	3,537,376	1,244,624	1,244,624	4,782,000	4,782,000
1	Chippers/Stump Grinders	17,087	17,087	0	0	16,791	16,791	0	0	33,878	33,878
1	Commercial Turf Equipment	0	0	0	0	568,732	568,732	0	0	568,732	568,732
1	Other Lawn and Garden Equipment	180	180	0	0	285,889	285,889	110,565	110,565	396,634	396,634
2	Aircraft Support Equipment	9,529	9,529	0	0	2,767	2,767	0	0	12,296	12,296
2	Terminal Tractors	64,998	64,998	130	130	6,386	6,386	0	0	71,514	71,514
3	All Terrain Vehicles (ATVs)	0	0	0	0	1,180,001	1,180,001	132,980	132,980	1,312,981	1,312,981
3	Minibikes	0	0	0	0	48,990	48,990	0	0	48,990	48,990
3	Off-Road Motorcycles	0	0	0	0	63,348	63,348	137,777	137,777	201,125	201,125
3	Golf Carts	0	0	0	0	93,850	93,850	28,820	28,820	122,670	122,670
3	Snowmobiles	0	0	0	0	0	0	778,559	1,200,000	778,559	1,200,000
3	Specialty Vehicles Carts	3,344	3,344	0	0	91,026	91,026	175,070	175,070	269,440	269,440
4	Vessels w/Inboard Engines	73,945	73,945	0	0	436,018	436,018	0	0	509,963	509,963
4	Vessels w/Outboard Engines	0	0	0	0	41,228	41,228	8,304,304	8,304,304	8,345,533	8,345,533
4	Vessels w/Sterndrive Engines	0	0	0	0	2,713,420	2,713,420	0	0	2,713,420	2,713,420
4	Sailboat Auxiliary Inboard Engines	443,056	443,056	0	0	110,764	110,764	0	0	553,820	553,820
4	Sailboat Auxiliary Outboard Engines	0	0	0	0	3,738	3,738	141,152	141,152	144,890	144,890
5	Generator Sets < 50 hp	198,391	198,391	0		2,921,263	2,921,263	22,023	22,023	3,141,677	3,141,677
5	Pumps < 50 hp	41,810	41,810	91,236	91,236	580,451	580,451	0	0	713,498	[illegible]
5	Air Compressors < 50 hp	15,713	15,713	0	0	176,124	176,124	0	0	191,837	[illegible]
5	Gas Compressors < 50 hp	0	0	436	43	0	0	0	0	436	[illegible]
5	Welders < 50 hp	100,490	100,490	0	0	350,545	350,545	0	0	451,035	[illegible]
5	Pressure Washers < 50 hp	3,943	3,943	0	0	290,959	290,959	0	0	[illegible]	[illegible]
6	Aerial Lifts	12,310	12,310	3,407	3,407	24,981	24,981	0	0	40,698	[illegible]
6	Forklifts	140,583	47,048	42,117	191,327	100,365	120,557	0	0	[illegible]	[illegible]
6	Sweepers/Scrubbers	36,977	36,977	9,062	9,062	16,830	16,830	0	0	62,869	[illegible]
6	Other General Industrial Equipment	18,366	18,366	0	0	21,753	21,753	1,971	1,971	42,090	[illegible]
6	Other Material Handling Equipment	5,258	5,258	0	0	2,036	2,036	0	0	7,294	[illegible]
7	Asphalt Pavers	13,594	12,000	0	0	3,022			0	[illegible]	[illegible]

Table 2-03 (Continued)

Class	National Populations Equipment Type	Diesel Inv. A	Diesel Inv. B	LPG/CNG Inv. A	LPG/CNG Inv. B	4-cycle gas Inv. A	4-cycle gas Inv. B	2-cycle gas Inv. A	2-cycle gas Inv. B	Total Inv. A	Total Inv. B
7	Tampers/Rammers	0	0	0	0	1,045	1,045	22,566	22,566	23,611	23,611
7	Plate Compactors	2,322	2,322	0	0	117,50	117,507	27,726	27,726	147,555	147,555
7	Concrete Pavers	5,511	8,400	0	0	0	0		0	5,511	8,400
7	Rollers	36,300	42,300	0	0	21,999		0	0	58,299	42,300
7	Scrapers	26,700	16,400	0	0	0	0		0	26,700	16,400
7	Paving Equipment	43,615	43,615	0	0	218,942	218,942	11,868	11,868	274,425	274,425
7	Surfacing Equipment	0	0	0	0	30,833	30,833	0	0	30,833	30,833
7	Signal Boards	20,384	20,384	0	0	1,559	1,559	0	0	21,943	21,943
7	Trenchers	50,510	53,390	0	0	27,170	27,170	0	0	77,680	80,560
7	Bore/Drill Rigs	7,761	7,761	0	0	8,395	8,395	10	106	16,262	16,262
7	Excavators	61,336	52,295	0	0	18		0	0	61,354	52,295
7	Concrete/Industrial Saws	135	61,334	0	0	36,900	36,900	0	0	37,035	98,234
7	Cement and Mortar Mixers	4,016	4,016	0	0	232,152	232,152	0	0	236,168	236,168
7	Cranes	98,357	98,357	0	0	2,541	2,541		0	100,898	100,898
7	Graders	70,045	64,000	0	0	0	0	0	0	70,045	64,000
7	Off-Highway Trucks	16,529	19,400	0	0	0		0	0	16,529	19,400
7	Crushing/Proc. Equipment	7,207	7,207	0	0	1,007	1,007	0	0	8,214	8,214
7	Rough Terrain Forklifts	53,853	25,132	0	0	2,217	2,217	0	0	56,070	27,349
7	Rubber Tired Loaders	209,454	130,000	0	0	3,433	0	0	0	212,887	130,000
7	Rubber Tired Dozers	7,737	7,737	0	0	0	0		0	7,737	7,737
7	Tractors/Loaders/Backhoes	298,265	189,000	0	0	1,365	0	0	0	300,630	189,000
7	Crawler Tractors	285,923	159,050	0	0	0	0	0	0	285,923	159,050
7	Skid Steer Loaders	150,084	140,000	0	0	27,805	0	0	0	177,859	140,000
7	Off-Highway Tractors	38,921	38,921	0	0	0	0	0	0	38,921	38,921
7	Dumpers/Tenders	194	194	0	0	24,301	24,301	0	0	24,495	24,495
7	Other Construction Equipment	11,867	11,867	0	0	1,103	1,103		0	12,970	12,970
8	2-Wheel Tractors	0	0	0	0	13,802	13,802	0	0	13,802	13,802
8	Agricultural Tractors	2,519,295	2,519,295	0	0	5,808	5,808	0	0	2,525,103	2,525,103
8	Combines	284,854	286,854	0	0	1,835	1,835	0	0	288,689	288,689
8	Sprayers	9,692	9,692	0	0	72,721	72,721	0	0	82,413	82,413
8	Balers	4,260	4,260	0	0	0	0	0	0	4,260	4,260
8	Tillers > 5 hp	78	29	0	0	785,102	562,407	0	0	785,180	562,436
8	Swathers	50,032	50,032	0	0	32,857	32,857	0	0	82,889	82,889
8	Hydro Power Units	2,366	2,366	0	0	15,042	15,042	0	0	17,408	17,408
8	Other Agricultural Equipment	18,042	18,042	0	0	6,405	6,405	0	0	24,447	24,447
9	Chain Saws > 4 hp	0	0	0	0	0	0	51,775	25,351	51,775	25,351
9	Shredders > 5 hp	0	0	0	0	100,271	100,271	0	0	100,271	100,271
9	Skidders	30,911	30,911	0	0	0	0	0	0	30,911	30,911
9	Fellers/Bunchers	15,581	15,581	0	0	0	0	0	0	15,581	15,581

Key:

1 = Lawn and Garden
2 = Airport Service
3 = Recreational Equipment
4 = Recreational Marine
5 = Light Commercial
6 = Industrial
7 = Construction
8 = Agricultural
9 = Logging

Table 2-04. Inventory A and B Average Rated Horsepower Estimates

Class	Horsepower Equipment Type	Diesel Inv. A	Diesel Inv. B	LPG/CNG Inv. A	LPG/CNG Inv. B	4-cycle gas Inv. A	4-cycle gas Inv. B	2-cycle gas Inv. A	2-cycle gas Inv. B
1	Trimmers/Edgers/Brush Cutters	NA	NA	NA	NA	1.0	1.3	1.0	1.3
1	Lawnmowers	NA	NA	NA	NA	4.0	3.8	4.0	3.8
1	Leaf Blowers/Vacuums	NA	NA	NA	NA	2.0	2.0	2.0	2.0
1	Rear Engine Riding Mowers	17.0	10.2	NA	NA	9.0	10.2	NA	NA
1	Front Mowers	NA	NA	NA	NA	12.0	13.3	NA	NA
1	Chain Saws < 4 hp	NA	NA	NA	NA	NA	NA	2.0	[illegible]
1	Shredders < 5 hp	NA	NA	NA	NA	4.0	4.0	4.0	4.9
1	Tillers < 5 hp	NA	NA	NA	NA	4.0	4.3	4.0	4.3
1	Lawn and Garden Tractors	16.0	13.3	NA	NA	12.0	13.3	NA	NA
1	Wood Splitters	58.0	58.0	NA	NA	5.0	5.0	NA	NA
1	Snowblowers	NA	NA	NA	NA	6.0	5.1	6.0	[illegible]
1	Chippers/Stump Grinders	99.0	99.0	NA	NA	62.0	62.0	NA	NA
1	Commercial Turf Equipment	NA	NA	NA	NA	13.0	11.4	NA	NA
1	Other Lawn and Garden Equipment	18.0	18.0	NA	NA	3.0	3.0	3.0	3.0
2	Aircraft Support Equipment	137.0	137.0	NA	NA	48.0	48.0	NA	NA
2	Terminal Tractors	96.0	96.0	82.0	82.0	82.0	82.0	NA	NA
3	All Terrain Vehicles (ATVs)	NA	NA	NA	NA	NA	NA	NA	NA
3	Minibikes	NA	NA	NA	NA	NA	NA	NA	NA
3	Off-Road Motorcycles	NA	NA	NA	NA	NA	NA	NA	NA
3	Golf Carts	NA	NA	NA	NA	NA	NA	NA	NA
3	Snowmobiles	NA	NA	NA	NA	NA	NA	26.0	26.0
3	Specialty Vehicles Carts	NA	NA	NA	NA	NA	NA	NA	NA
4	Vessels w/Inboard Engines	NA	NA	NA	NA	NA	NA	NA	NA
4	Vessels w/Outboard Engines	NA	NA	NA	NA	NA	NA	NA	NA
4	Vessels w/Sterndrive Engines	NA	NA	NA	NA	NA	NA	NA	NA
4	Sailboat Auxiliary Inboard Engines	NA	NA	NA	NA	NA	NA	NA	NA
4	Sailboat Auxiliary Outboard Engines	NA	NA	NA	NA	NA	0.0	NA	0.0
5	Generator Sets < 50 hp	22.0	22.0	NA	NA	11.0	11.0	11.0	[illegible]
5	Pumps < 50 hp	23.0	23.0	7.0	7.0	7.0	7.0	NA	NA
5	Air Compressors < 50 hp	37.0	37.0	NA	NA	9.0	9.0	NA	NA
5	Gas Compressors < 50 hp	NA	NA	30.0	30.0	NA	NA	NA	NA
5	Welders < 50 hp	35.0	35.0	NA	NA	19.0	19.0	NA	NA
5	Pressure Washers < 50 hp	21.0	21.0	NA	NA	7.0	7.0	NA	NA
6	Aerial Lifts	43.0	35.0	36.0	36.0	36.0	36.0	NA	NA
6	Forklifts	83.0	83.0	62.0	62.0	62.0	62.0	NA	NA
6	Sweepers/Scrubbers	97.0	97.0	39.0	39.0	39.0	39.0	NA	NA
6	Other General Industrial Equipment	107.0	107.0	NA	NA	19.0	19.0	19.0	19.0
6	Other Material Handling Equipment	111.0	111.0	NA	NA	51.0	51.0	NA	NA
7	Asphalt Pavers	91.0	77.0	NA	NA	31.0	NA	NA	NA
7	Tampers/Rammers	NA	NA	NA	NA	4.0	4.0	4.0	[illegible]
7	Plate Compactors	8.0	8.0	NA	NA	5.0	5.0	5.0	[illegible]
7	Concrete Pavers	130.0	77.0	NA	NA	NA	NA	NA	NA
7	Rollers	99.0	99.0	NA	NA	17.0	NA	NA	NA
7	Scrapers	311.0	290.0	NA	NA	NA	NA	NA	NA
7	Paving Equipment	99.0	99.0	NA	NA	7.0	7.0	7.0	[illegible]
7	Surfacing Equipment	NA	NA	NA	NA	8.0	8.0	NA	NA

Table 2-04 (Continued)

Class	Horsepower Equipment Type	Diesel Inv. A	Diesel Inv. B	LPG/CNG Inv. A	LPG/CNG Inv. B	4-cycle gas Inv. A	4-cycle gas Inv. B	2-cycle gas Inv. A	2-cycle gas Inv. B
7	Signal Boards	6.0	6.0	NA	NA	8.0	8.0	NA	NA
7	Trenchers	60.0	27.0	NA	NA	27.0	27.0	NA	NA
7	Bore/Drill Rigs	209.0	209.0	NA	NA	54.0	54.0	54.0	54.0
7	Excavators	183.0	143.0	NA	NA	80.0	NA	NA	NA
7	Concrete/Industrial Saws	56.0	56.0	NA	NA	13.0	13.0	NA	NA
7	Cement and Mortar Mixers	11.0	11.0	NA	NA	7.0	7.0	NA	NA
7	Cranes	194.0	194.0	NA	NA	55.0	55.0	NA	NA
7	Graders	172.0	147.0	NA	NA	NA	NA	NA	NA
7	Off-Highway Trucks	489.0	638.0	NA	NA	NA	NA	NA	NA
7	Crushing/Proc. Equipment	127.0	127.0	NA	NA	60.0	60.0	NA	NA
7	Rough Terrain Forklifts	93.0	84.0	NA	NA	88.0	68.0	NA	NA
7	Rubber Tired Loaders	158.0	175.0	NA	NA	67.0	NA	NA	NA
7	Rubber Tired Dozers	356.0	356.0	NA	NA	NA	NA	NA	NA
7	Tractors/Loaders/Backhoes	77.0	71.0	NA	NA	63.0	NA	NA	NA
7	Crawler Tractors	157.0	134.0	NA	NA	NA	NA	NA	NA
7	Skid Steer Loaders	42.0	44.0	NA	NA	33.0	NA	NA	NA
7	Off-Highway Tractors	214.0	214.0	NA	NA	NA	NA	NA	NA
7	Dumpers/Tenders	23.0	23.0	NA	NA	9.0	9.0	NA	NA
7	Other Construction Equipment	161.0	161.0	NA	NA	150.0	150.0	NA	NA
8	2-Wheel Tractors	NA	NA	NA	NA	7.0	7.0	NA	NA
8	Agricultural Tractors	98.0	98.0	NA	NA	87.0	87.0	NA	NA
8	Agricultural Mowers	NA	NA	NA	NA	11.0	11.0	NA	NA
8	Combines	152.0	152.0	NA	NA	131.0	131.0	NA	NA
8	Sprayers	92.0	92.0	NA	NA	24.0	24.0	NA	NA
8	Balers	74.0	98.0	NA	NA	NA	NA	NA	NA
8	Tillers > 5 hp	7.0	7.0	NA	NA	7.0	5.6	NA	NA
8	Swathers	79.0	82.0	NA	NA	106.0	106.0	NA	NA
8	Hydro Power Units	35.0	35.0	NA	NA	14.0	14.0	NA	NA
8	Other Agricultural Equipment	57.0	57.0	NA	NA	55.0	55.0	NA	NA
9	Chain Saws > 4 hp	NA	NA	NA	NA	NA	NA	6.0	6.4
9	Shredders > 5 hp	NA	NA	NA	NA	8.0	8.0	NA	NA
9	Skidders	130.0	131.0	NA	NA	NA	NA	NA	NA
9	Fellers/Bunchers	183.0	183.0	NA	NA	NA	NA	NA	NA

NA = Not applicable

Key:

1 = Lawn and Garden
2 = Airport Service
3 = Recreational Equipment
4 = Recreational Marine
5 = Light Commercial
6 = Industrial
7 = Construction
8 = Agricultural
9 = Logging

NA = Not applicable

Table 2-05. Inventory A and B Typical Operating Load Factor Estimates

Class	Load Factors Equipment Type	Diesel Inv. A	Diesel Inv. B	LPG/CNG Inv. A	LPG/CNG Inv. B	4-cycle gas Inv. A	4-cycle gas Inv. B	2-cycle gas Inv. A	2-cycle gas Inv. B
1	Trimmers/Edgers/Brush Cutters	NA	NA	NA	NA	36%	36%	50%	50%
1	Lawnmowers	NA	NA	NA	NA	36%	30%	36%	10%
1	Leaf Blowers/Vacuums	NA	NA	NA	NA	36%	36%	50%	50%
1	Rear Engine Riding Mowers	38%	38%	NA	NA	38%	38%	NA	NA
1	Front Mowers	NA	NA	NA	NA	50%	38%	NA	NA
1	Chain Saws < 4 hp	NA	NA	NA	NA	NA	NA	50%	50%
1	Shredders < 5 hp	NA	NA	NA	NA	36%	36%	36%	36%
1	Tillers < 5 hp	NA	NA	NA	NA	40%	40%	40%	40%
1	Lawn and Garden Tractors	50%	38%	NA	NA	50%	38%	NA	NA
1	Wood Splitters	50%	50%	NA	NA	50%	50%	NA	NA
1	Snowblowers	NA	NA	NA	NA	35%	35%	35%	35%
1	Chippers/Stump Grinders	37%	37%	NA	NA	39%	39%	NA	NA
1	Commercial Turf Equipment	NA	NA	NA	NA	50%	50%	NA	NA
1	Other Lawn and Garden Equipment	50%	50%	NA	NA	50%	50%	50%	50%
2	Aircraft Support Equipment	51%	51%	NA	NA	56%	56%	NA	NA
2	Terminal Tractors	82%	82%	78%	78%	78%	78%	NA	NA
3	All Terrain Vehicles (ATVs)	NA	NA	NA	NA	NA	NA	NA	NA
3	Minibikes	NA	NA	NA	NA	NA	NA	NA	NA
3	Off-Road Motorcycles	NA	NA	NA	NA	NA	NA	NA	NA
3	Golf Carts	NA	NA	NA	NA	NA	NA	NA	NA
3	Snowmobiles	NA	NA	NA	NA	NA	NA	81%	81%
3	Specialty Vehicles Carts	NA	NA	NA	NA	NA	NA	NA	NA
4	Vessels w/Inboard Engines	NA	NA	NA	NA	NA	NA	NA	NA
4	Vessels w/Outboard Engines	NA	NA	NA	NA	NA	NA	NA	NA
4	Vessels w/Sterndrive Engines	NA	NA	NA	NA	NA	NA	NA	NA
4	Sailboat Auxiliary Inboard Engines	NA	NA	NA	NA	NA	NA	NA	NA
4	Sailboat Auxiliary Outboard Engines	NA	NA	NA	NA	NA	NA	NA	NA
5	Generator Sets < 50 hp	74%	74%	NA	NA	68%	68%	68%	68%
5	Pumps < 50 hp	74%	74%	69%	69%	69%	69%	NA	NA
5	Air Compressors < 50 hp	48%	48%	NA	NA	56%	56%	NA	NA
5	Gas Compressors < 50 hp	NA	NA	60%	60%	NA	NA	NA	NA
5	Welders < 50 hp	45%	45%	NA	NA	51%	51%	NA	NA
5	Pressure Washers < 50 hp	30%	30%	NA	NA	85%	85%	NA	NA
6	Aerial Lifts	46%	55%	46%	46%	46%	46%	NA	NA
6	Forklifts	30%	30%	30%	30%	30%	30%	NA	NA
6	Sweepers/Scrubbers	68%	68%	71%	71%	71%	71%	NA	NA
6	Other General Industrial Equipment	51%	51%	NA	NA	54%	54%	54%	54%
6	Other Material Handling Equipment	59%	59%	NA	NA	53%	53%	NA	NA
7	Asphalt Pavers	62%	56%	NA	NA	66%	NA	NA	NA
7	Tampers/Rammers	NA	NA	NA	NA	55%	55%	55%	55%
7	Plate Compactors	43%	43%	NA	NA	55%	55%	55%	55%
7	Concrete Pavers	68%	56%	NA	NA	NA	NA	NA	NA
7	Rollers	56%	59%	NA	NA	62%	NA	NA	NA
7	Scrapers	72%	60%	NA	NA	NA	NA	NA	NA
7	Paving Equipment	53%	53%	NA	NA	59%	59%	59%	59%
7	Surfacing Equipment	NA	NA	NA	NA	49%	49%	NA	NA

Table 2-05 (Continued)

Class	Load Factors Equipment Type	Diesel Inv. A	Diesel Inv. B	LPG/CNG Inv. A	LPG/CNG Inv. B	4-cycle gas Inv. A	4-cycle gas Inv. B	2-cycle gas Inv. A	2-cycle gas Inv. B
7	Signal Boards	82%	82%	NA	NA	76%	76%	NA	NA
7	Trenchers	75%	64%	NA	NA	66%	0%	NA	NA
7	Bore/Drill Rigs	75%	75%	NA	NA	79%	79%	79%	79%
7	Excavators	57%	59%	NA	NA	53%	NA	NA	NA
7	Concrete/Industrial Saws	73%	73%	NA	NA	78%	78%	NA	NA
7	Cement and Mortar Mixers	56%	56%	NA	NA	59%	59%	NA	NA
7	Cranes	43%	43%	NA	NA	47%	47%	NA	NA
7	Graders	61%	54%	NA	NA	NA	NA	NA	NA
7	Off-Highway Trucks	57%	25%	NA	NA	NA	NA	NA	NA
7	Crushing/Proc. Equipment	78%	78%	NA	NA	85%	85%	NA	NA
7	Rough Terrain Forklifts	60%	35%	NA	NA	63%	63%	NA	NA
7	Rubber Tired Loaders	54%	54%	NA	NA	54%	NA	NA	NA
7	Rubber Tired Dozers	59%	59%	NA	NA	NA	NA	NA	NA
7	Tractors/Loaders/Backhoes	55%	38%	NA	NA	48%	NA	NA	NA
7	Crawler Tractors	58%	57%	NA	NA	NA	NA	NA	NA
7	Skid Steer Loaders	55%	48%	NA	NA	58%	NA	NA	NA
7	Off-Highway Tractors	65%	65%	NA	NA	NA	NA	NA	NA
7	Dumpers/Tenders	38%	38%	NA	NA	41%	41%	NA	NA
7	Other Construction Equipment	62%	62%	NA	NA	48%	48%	NA	NA
8	2-Wheel Tractors	NA	NA	NA	NA	62%	62%	NA	NA
8	Agricultural Tractors	70%	70%	NA	NA	62%	62%	NA	NA
8	Agricultural Mowers	NA	NA	NA	NA	43%	48%	NA	NA
8	Combines	70%	70%	NA	NA	74%	74%	NA	NA
8	Sprayers	50%	50%	NA	NA	50%	50%	NA	NA
8	Balers	58%	58%	NA	NA	NA	NA	NA	NA
8	Tillers > 5 hp	78%	40%	NA	NA	71%	40%	NA	NA
8	Swathers	55%	62%	NA	NA	52%	52%	NA	NA
8	Hydro Power Units	48%	48%	NA	NA	56%	56%	NA	NA
8	Other Agricultural Equipment	51%	51%	NA	NA	55%	55%	NA	NA
9	Chain Saws > 4 hp	NA	NA	NA	NA	NA	NA	92%	50%
9	Shredders > 5 hp	NA	NA	NA	NA	80%	36%	NA	NA
9	Skidders	74%	49%	NA	NA	NA	NA	NA	NA
9	Fellers/Bunchers	71%	71%	NA	NA	NA	NA	NA	NA

NA = Not applicable

Key:

1 = Lawn and Garden
2 = Airport Service
3 = Recreational Equipment
4 = Recreational Marine
5 = Light Commercial
6 = Industrial
7 = Construction
8 = Agricultural
9 = Logging

NA = Not applicable

Table 2-06. Inventory A and B Annual Use Estimates

Class	Hours/Year (* = Gallons/Year) Equipment Type	Diesel Inv. A	Diesel Inv. B	LPG/CNG Inv. A	LPG/CNG Inv. B	4-cycle gas Inv. A	4-cycle gas Inv. B	2-cycle gas Inv. A	2-cycle gas Inv. B
1	Trimmers/Edgers/Brush Cutters	NA	NA	NA	NA	8-21	19-19	8-21	19-19
1	Lawnmowers	NA	NA	NA	NA	27-73	33-49	33-91	41-61
1	Leaf Blowers/Vacuums	NA	NA	NA	NA	7-20	25-25	7-20	25-25
1	Rear Engine Riding Mowers	22-50	28-45	NA	NA	22-50	28-43	NA	NA
1	Front Mowers	NA	NA	NA	NA	25-46	28-45	NA	NA
1	Chain Saws < 4 hp	NA	NA	NA	NA	NA	NA	13-21	23-23
1	Shredders < 5 hp	NA	NA	NA	NA	3-5	75-75	3-5	3-5
1	Tillers < 5 hp	NA	NA	NA	NA	16-25	27-31	16-25	27-31
1	Lawn and Garden Tractors	173-340	37-340	NA	NA	33-65	35-65	NA	NA
1	Wood Splitters	64-95	64-95	NA	NA	18-27	18-27	NA	NA
1	Snowblowers	NA	NA	NA	NA	8-18	8-18	8-18	8-18
1	Chippers/Stump Grinders	367-523	367-523	NA	NA	386-551	386-551	NA	NA
1	Commercial Turf Equipment	NA	NA	NA	NA	410-931	410-931	NA	NA
1	Other Lawn and Garden Equipment	101-197	101-197	NA	NA	14-28	14-28	14-28	14-28
2	Aircraft Support Equipment	651-856	651-856	NA	NA	606-797	606-797	NA	NA
2	Terminal Tractors	1081-1433	1081-1433	711-943	711-943	711-943	711-943	NA	NA
3	All Terrain Vehicles (ATVs)	NA	NA	NA	NA	88-142	9-15	88-142	9-15
3	Minibikes	NA	NA	NA	NA	25-67	9-15	NA	NA
3	Off-Road Motorcycles	NA	NA	NA	NA	62-139	9-15	62-139	9-15
3	Golf Carts	NA	NA	NA	NA	637-1231	637-1231	637-1231	637-1231
3	Snowmobiles	NA	NA	NA	NA	NA	NA	77-189	90-99
3	Specialty Vehicles Carts	370-496	370-496	NA	NA	55-74	55-74	55-74	55-74
4	Vessels w/Inboard Engines < 250 hp*	343-959	100-1183	NA	NA	187-524	93-637	NA	NA
4	Vessels w/Outboard Engines*	NA	NA	NA	NA	99-134	63-213	110-214	63-213
4	Vessels w/Sterndrive Engines*	NA	NA	NA	NA	206-576	168-416	NA	NA
4	Sailboat Auxiliary Inboard Engines*	17-50	12-102	NA	NA	9-28	19-55	NA	NA
4	Sailboat Auxiliary Outboard Engines*	NA	NA	NA	NA	4-8	2-54	7-14	2-54
5	Generator Sets < 50 hp	345-483	345-483	NA	NA	117-164	117-164	117-164	117-164
5	Pumps < 50 hp	318-488	318-488	175-267	175-267	175-267	175-267	NA	NA
5	Air Compressors < 50 hp	595-954	595-954	NA	NA	353-566	353-566	NA	NA
5	Gas Compressors < 50 hp	NA	NA	8500-8500	8500-8500	NA	NA	NA	NA
5	Welders < 50 hp	418-759	418-759	NA	NA	135-245	135-245	NA	NA
5	Pressure Washers < 50 hp	93-183	93-183	NA	NA	74-145	74-145	NA	NA
6	Aerial Lifts	265-407	2053-2587	249-383	2053-2587	249-383	2053-2587	NA	NA
6	Forklifts	1513-1751	850-850	1602-1854	850-850	1602-1854	850-850	NA	NA
6	Sweepers/Scrubbers	1183-1318	1183-1318	501-557	501-557	501-557	501-557	NA	NA
6	Other General Industrial Equipment	571-1089	571-1089	NA	NA	463-884	463-884	463-884	463-884
6	Other Material Handling Equipment	366-463	366-463	NA	NA	336-425	336-425	NA	NA
7	Asphalt Pavers	534-846	594-1016	NA	NA	255-404	NA	NA	NA
7	Tampers/Rammers	NA	NA	NA	NA	110-186	110-186	110-186	110-186
7	Plate Compactors	286-610	286-610	NA	NA	98-209	98-209	98-209	98-209
7	Concrete Pavers	534-854	594-1016	NA	NA	NA	NA	NA	NA
7	Rollers	434-775	647-1016	NA	NA	379-646	NA	NA	NA

Table 2-06 (Continued)

Class	Hours/Year (* = Gallons/Year) Equipment Type	Diesel Inv. A	Diesel Inv. B	LPG/CNG Inv. A	LPG/CNG Inv. B	4-cycle gas Inv. A	4-cycle gas Inv. B	2-cycle gas Inv. A	2-cycle gas Inv. B
7	Scrapers	667-1024	667-1647	NA	NA	NA	NA	NA	NA
7	Paving Equipment	348-722	348-722	NA	NA	98-203	98-203	98-203	98-203
7	Surfacing Equipment	NA	NA	NA	NA	278-512	278-512	NA	NA
7	Signal Boards	448-978	448-978	NA	NA	133-289	133-289	NA	NA
7	Trenchers	409-692	267-593	NA	NA	277-442	0-402	NA	NA
7	Bore/Drill Rigs	261-550	261-550	NA	NA	60-126	60-126	60-126	60-126
7	Excavators	593-911	1051-1358	NA	NA	261-401	NA	NA	NA
7	Concrete/Industrial Saws	400-603	400-603	NA	NA	421-634	421-634	NA	NA
7	Cement and Mortar Mixers	157-305	157-305	NA	NA	48-93	48-93	NA	NA
7	Cranes	629-814	629-814	NA	NA	324-419	324-419	NA	NA
7	Graders	591-837	811-1110	NA	NA	NA	NA	NA	NA
7	Off-Highway Trucks	1149-1871	1149-3951	NA	NA	NA	NA	NA	NA
7	Crushing/Proc. Equipment	592-1165	592-1165	NA	NA	149-294	149-294	NA	NA
7	Rough Terrain Forklifts	410-775	662-1024	NA	NA	256-483	NA	NA	NA
7	Rubber Tired Loaders	624-890	1151-1587	NA	NA	420-599	NA	NA	NA
7	Rubber Tired Dozers	647-1034	647-1034	NA	NA	NA	NA	NA	NA
7	Tractors/Loaders/Backhoes	772-1203	653-797	NA	NA	592-922	NA	NA	NA
7	Crawler Tractors	655-1067	871-1422	NA	NA	NA	NA	NA	NA
7	Skid Steer Loaders	524-859	615-730	NA	NA	198-326	NA	NA	NA
7	Off-Highway Tractors	778-992	778-992	NA	NA	NA	NA	NA	NA
7	Dumpers/Tenders	266-685	266-685	NA	NA	60-154	60-154	NA	NA
7	Other Construction Equipment	388-624	388-624	NA	NA	237-382	237-382	NA	NA
8	2-Wheel Tractors	NA	NA	NA	NA	177-346	177-346	NA	NA
8	Agricultural Tractors	309-542	309-542	NA	NA	358-627	358-627	NA	NA
8	Agricultural Mowers	NA	NA	NA	NA	82-230	82-230	NA	NA
8	Combines	74-186	74-186	NA	NA	61-155	61-155	NA	NA
8	Sprayers	53-121	53-121	NA	NA	47-107	47-107	NA	NA
8	Balers	52-142	308-308	NA	NA	NA	NA	NA	NA
8	Tillers > 5 hp	188-289	61-68	NA	NA	47-72	27-31	NA	NA
8	Swathers	52-139	100-539	NA	NA	45-120	0-100	NA	NA
8	Hydro Power Units	600-830	600-830	NA	NA	342-473	342-473	NA	NA
8	Other Agricultural Equipment	236-453	236-446	NA	NA	77-148	77-148	NA	NA
9	Chain Saws > 4 hp	NA	NA	NA	NA	NA	NA	142-228	405-405
9	Shredders > 5 hp	NA	NA	NA	NA	158-252	75-75	NA	NA
9	Skidders	994-1413	994-1434	NA	NA	NA	NA	NA	NA
9	Fellers/Bunchers	880-1467	880-1467	NA	NA	NA	NA	NA	NA

NA = Not applicable
* = Values reported are gallons/year - not hours/year

Key:

1 = Lawn and Garden
2 = Airport Service
3 = Recreational Equipment
4 = Recreational Marine
5 = Light Commercial
6 = Industrial
7 = Construction
8 = Agricultural
9 = Logging

NA = Not applicable

Table 2-07. Emission Factors for Inventories A and B

a. DIESEL EQUIPMENT (grams/hp-hr)

Class	Equipment Types		HC				CO	NO_x	PM	Aldehydes	SO_x
			Exhaust	Crank	Evap*	Refueling					
1	Trimmers/Edgers/Brush Cutters		NA	NA	NA	NA	NA	NA	NA	NA	NA
1	Lawnmowers		NA	NA	NA	NA	NA	NA	NA	NA	NA
1	Leaf Blowers/Vacuums		NA	NA	NA	NA	NA	NA	NA	NA	NA
1	Rear Engine Riding Mowers		1.20	0.02	NA	0.005	5.00	8.00	1.00	0.06	0.93
1	Front Mowers		NA	NA	NA	NA	NA	NA	NA	NA	NA
1	Chain Saws < 4 hp		NA	NA	NA	NA	NA	NA	NA	NA	NA
1	Shredders < 5 hp		NA	NA	NA	NA	NA	NA	NA	NA	NA
1	Tillers < 5 hp		NA	NA	NA	NA	NA	NA	NA	NA	NA
1	Lawn and Garden Tractors		1.20	0.02	NA	0.005	5.00	8.00	1.00	0.06	0.93
1	Wood Splitters		1.20	0.02	NA	0.005	5.00	8.00	1.00	0.06	0.93
1	Snowblowers		NA	NA	NA	NA	NA	NA	NA	NA	NA
1	Chippers/Stump Grinders		1.20	0.02	NA	0.003	5.00	8.00	1.00	0.06	0.93
1	Commercial Turf Equipment		NA	NA	NA	NA	NA	NA	NA	NA	NA
1	Other Lawn and Garden Equipment		1.20	0.02	NA	0.005	5.00	8.00	1.00	0.06	0.93
2	Aircraft Support Equipment	*	1.57	0.03	NA	0.003	6.06	14.00	1.60	0.06	0.93
2	Terminal Tractors	*	1.57	0.03	NA	0.003	6.06	14.00	1.60	0.06	0.93
3	All Terrain Vehicles (ATVs)	*	NA	NA	NA	NA	NA	NA	NA	NA	NA
3	Minibikes	*	NA	NA	NA	NA	NA	NA	NA	NA	NA
3	Off-Road Motorcycles	*	NA	NA	NA	NA	NA	NA	NA	NA	NA
3	Golf Carts	*	NA	NA	NA	NA	NA	NA	NA	NA	NA
3	Snowmobiles		NA	NA	NA	NA	NA	NA	NA	NA	NA
3	Specialty Vehicles Carts	*	1.20	0.02	NA	0.330	5.00	8.00	1.00	0.06	0.93
4	Vessels w/Inboard Engines	**	24.39	NA	NA	0.040	37.01	172.49	10.89	0.92	12.20
4	Vessels w/Outboard Engines	**	24.39	0.49	NA	0.000	37.01	172.49	10.89	0.92	12.20
4	Vessels w/Sterndrive Engines	**	24.39	NA	NA	0.000	37.01	172.49	10.89	0.92	12.20
4	Sailboat Auxiliary Inboard Engines	**	122.45	NA	NA	0.040	217.72	163.29	10.89	0.92	12.20
4	Sailboat Auxiliary Outboard Engines	**	122.45	2.45	NA	0.040	217.72	163.29	10.89	0.92	12.20
5	Generator Sets < 50 hp		1.20	0.02	NA	0.003	5.00	8.00	1.00	0.06	0.93
5	Pumps < 50 hp		1.20	0.02	NA	0.003	5.00	8.00	1.00	0.06	0.93
5	Air Compressors < 50 hp		1.20	0.02	NA	0.005	5.00	8.00	1.00	0.06	0.93
5	Gas Compressors < 50 hp		NA	NA	NA	NA	NA	NA	NA	NA	NA
5	Welders < 50 hp		1.20	0.02	NA	0.003	5.00	8.00	1.00	0.06	0.93
5	Pressure Washers < 50 hp		1.20	0.02	NA	0.003	5.00	8.00	1.00	0.06	0.93
6	Aerial Lifts	*	1.57	0.03	NA	0.005	6.06	14.00	1.60	0.21	0.93
6	Forklifts	*	1.57	0.03	NA	0.003	6.06	14.00	1.60	0.21	0.93
6	Sweepers/Scrubbers	*	1.57	0.03	NA	0.003	6.06	14.00	1.60	0.21	0.93
6	Other General Industrial Equipment	*	1.57	0.03	NA	0.003	6.06	14.00	1.60	0.21	[illegible]
6	Other Material Handling Equipment	*	1.57	0.03	NA	0.003	6.06	14.00	1.60	0.21	[illegible]
7	Asphalt Pavers		0.60	0.01	NA	0.003	3.20	10.30	0.90	0.20	[illegible]
7	Tampers/Rammers		0.00	0.00	NA	NA	0.00	0.00	0.00	0.00	[illegible]
7	Plate Compactors		0.80	0.02	NA	0.007	3.10	9.30	0.90	0.20	[illegible]
7	Concrete Pavers		1.10	0.02	NA	0.005	4.57	10.02	0.90	0.20	[illegible]

Table 2-07a. (Continued)

Class	Equipment Types		HC Exhaust	HC Crank	HC Evap*	HC Refueling	CO	NO_x	PM	Aldehydes	SO_x
7	Rollers		0.80	0.02	NA	0.003	3.10	9.30	0.78	0.20	1.00
7	Scrapers	a	0.70	0.01	NA	0.003	5.00	8.70	1.26	0.28	0.99
7	Paving Equipment		1.01	0.02	NA	0.003	4.60	11.01	0.90	0.20	0.93
7	Surfacing Equipment		0.00	0.00	NA	NA	0.00	0.00	0.00	0.00	0.00
7	Signal Boards		1.20	0.02	NA	0.007	5.00	8.00	1.00	0.20	0.93
7	Trenchers	a	1.54	0.03	NA	0.003	9.14	10.02	1.44	0.20	0.93
7	Bore/Drill Rigs	a	1.41	0.03	NA	0.003	9.20	11.01	1.44	0.20	0.93
7	Excavators	a	0.70	0.01	NA	0.003	5.20	10.75	1.44	0.20	0.93
7	Concrete/Industrial Saws	a	1.41	0.03	NA	0.003	9.20	11.01	1.44	0.20	0.93
7	Cement and Mortar Mixers		1.01	0.02	NA	0.003	4.60	11.01	0.90	0.20	0.93
7	Cranes	a	1.26	0.03	NA	0.003	4.20	10.30	1.44	0.20	0.93
7	Graders	a	1.54	0.03	NA	0.003	3.80	9.60	1.00	0.12	0.87
7	Off-Highway Trucks	a	0.84	0.02	NA	0.003	2.80	9.60	0.90	0.22	0.89
7	Crushing/Proc. Equipment	a	1.41	0.03	NA	0.003	9.20	11.01	1.44	0.20	0.93
7	Rough Terrain Forklifts	a	1.68	0.03	NA	0.003	10.00	8.00	1.60	0.20	0.93
7	Rubber Tired Loaders	a	0.84	0.02	NA	0.003	4.80	10.30	1.29	0.20	0.86
7	Rubber Tired Dozers	a	0.84	0.02	NA	0.003	2.80	9.60	0.66	0.16	0.93
7	Tractors/Loaders/Backhoes	a	1.40	0.03	NA	0.003	6.80	10.10	1.05	0.10	0.85
7	Crawler Tractors	a	1.26	0.03	NA	0.003	4.80	10.30	1.11	0.17	0.85
7	Skid Steer Loaders	a	2.10	0.04	NA	0.003	9.00	9.80	1.44	0.20	0.93
7	Off-Highway Tractors	a	2.46	0.05	NA	0.003	14.68	11.91	2.03	0.28	0.93
7	Dumpers/Tenders	a	0.84	0.02	NA	0.003	2.80	9.60	1.44	0.20	0.89
7	Other Construction Equipment	a	1.41	0.03	NA	0.003	9.20	11.01	1.44	0.20	0.93
8	2-Wheel Tractors		NA	NA	NA	NA	NA	NA	NA	NA	NA
8	Agricultural Tractors	a	2.23	0.04	NA	0.003	8.94	11.21	2.05	0.34	0.87
8	Agricultural Mowers		NA	NA	NA	NA	NA	NA	NA	NA	NA
8	Combines	a	1.26	0.03	NA	0.003	4.20	11.50	2.42	0.30	0.92
8	Sprayers		2.23	0.04	NA	0.003	3.78	7.78	1.51	0.30	0.92
8	Balers		2.23	0.04	NA	0.003	3.78	7.78	1.51	0.30	0.92
8	Tillers > 5 hp		1.20	0.02	NA	0.007	5.00	8.00	1.00	0.06	0.92
8	Swathers		0.90	0.02	NA	0.003	2.10	11.50	1.51	0.30	0.92
8	Hydro Power Units		2.23	0.04	NA	0.003	3.78	7.78	1.51	0.30	0.92
8	Other Agricultural Equipment		1.82	0.04	NA	0.003	4.37	11.12	1.31	0.30	0.92
9	Chain Saws > 4 hp		NA	NA	NA	NA	NA	NA	NA	NA	NA
9	Shredders > 5 hp		NA	NA	NA	NA	NA	NA	NA	NA	NA
9	Skidders	a	0.84	0.02	NA	0.003	5.20	11.30	1.44	0.20	0.93
9	Fellers/Bunchers	a	0.84	0.02	NA	0.003	5.20	11.30	1.44	0.20	0.93

Evap* = g/day
* g/hr
** g/gallon
a = Exhaust HC, CO, and PM adjusted for transient speed and/or transient load operation
NA = Not applicable

Table 2-07. (Continued)

b. GASOLINE 4-STROKE EQUIPMENT (grams/hp-hr) Not Adjusted for In-Use Effects

Class	Equipment Types		HC				CO	NO_x	PM	Aldehydes	SO_x
			Exhaust	Crank	Evap*	Refueling					
1	Trimmers/Edgers/Brush Cutters		24.18	7.98	0.54	21.98	393.34	2.02	0.41	0.53	0.37
1	Lawnmowers		37.70	12.44	1.16	8.60	430.00	2.02	0.74	0.53	0.37
1	Leaf Blowers/Vacuums		19.40	6.40	0.61	6.61	380.30	2.03	0.29	0.53	0.37
1	Rear Engine Riding Mowers		9.30	3.07	3.30	3.21	353.00	2.03	0.05	0.24	0.37
1	Front Mowers		9.30	3.07	18.80	1.30	353.00	2.03	0.05	0.24	0.37
1	Chain Saws < 4 hp		NA	NA	NA	NA	NA	NA	NA	NA	NA
1	Shredders < 5 hp		37.70	12.44	1.75	7.68	430.00	2.02	0.74	0.53	0.37
1	Tillers < 5 hp		37.70	12.44	1.38	9.39	430.00	2.02	0.74	0.53	0.37
1	Lawn and Garden Tractors		9.40	3.10	7.13	1.84	354.00	2.11	0.10	0.24	0.37
1	Wood Splitters		37.70	12.44	1.16	8.60	430.00	2.02	0.74	0.53	0.37
1	Snowblowers		37.70	12.44	2.50	5.82	430.00	2.02	0.74	0.53	0.37
1	Chippers/Stump Grinders		37.70	12.44	94.86	0.42	430.00	2.02	0.05	0.53	0.37
1	Commercial Turf Equipment		9.40	3.10	15.50	1.38	354.00	2.11	0.10	0.24	0.37
1	Other Lawn and Garden Equipment		37.70	12.44	1.16	8.60	430.00	2.02	0.05	0.53	0.37
2	Aircraft Support Equipment		6.68	2.20	73.44	0.48	199.00	5.16	0.06	0.22	0.27
2	Terminal Tractors		6.68	2.20	17.13	0.32	199.00	5.16	0.06	0.22	0.27
3	All Terrain Vehicles (ATVs)	*	100.00	33.00	6.00	31.15	975.00	9.00	1.15	1.18	0.55
3	Minibikes	*	100.00	33.00	1.50	21.68	975.00	9.00	1.15	1.18	0.55
3	Off-Road Motorcycles	*	100.00	33.00	6.00	30.92	975.00	9.00	1.15	1.18	0.55
3	Golf Carts	*	100.00	33.00	18.00	5.44	975.00	9.00	1.15	1.18	0.55
3	Snowmobiles		NA	NA	NA	NA	NA	NA	NA	NA	NA
3	Specialty Vehicles Carts	*	100.00	33.00	18.00	7.04	975.00	9.00	1.15	1.18	0.55
4	Vessels w/Inboard Engines	**	72.46	NA	260.10	5.13	1214.03	45.79	0.74	3.07	2.90
4	Vessels w/Outboard Engines	**	87.71	28.94	NA	8.75	1421.95	66.58	0.74	3.07	2.90
4	Vessels w/Sterndrive Engines	**	72.46	NA	63.00	5.26	1214.03	45.79	0.74	3.07	2.90
4	Sailboat Auxiliary Inboard Engines	**	72.46	NA	18.00	8.75	1214.03	45.79	0.74	3.07	2.90
4	Sailboat Auxiliary Outboard Engines	**	87.71	28.94	NA	8.75	1421.95	66.58	0.74	3.07	2.90
5	Generator Sets < 50 hp		9.50	3.14	5.06	3.45	353.00	2.03	0.06	0.22	0.27
5	Pumps < 50 hp		9.50	3.14	2.25	6.33	353.00	2.03	0.06	0.22	0.27
5	Air Compressors < 50 hp		9.50	3.14	3.38	3.20	353.00	2.03	0.06	0.22	0.27
5	Gas Compressors < 50 hp		NA	NA	NA	NA	NA	NA	NA	NA	NA
5	Welders < 50 hp		9.50	3.14	9.75	1.72	353.00	2.03	0.06	0.22	0.27
5	Pressure Washers < 50 hp		9.50	3.14	2.25	6.33	353.00	2.03	0.06	0.22	0.27
6	Aerial Lifts		6.68	2.20	55.08	0.49	199.00	5.16	0.06	0.22	0.27
6	Forklifts		6.68	2.20	54.00	0.49	199.00	5.16	0.06	0.22	0.27
6	Sweepers/Scrubbers		6.68	2.20	59.67	0.48	199.00	5.16	0.06	0.22	0.27
6	Other General Industrial Equipment		6.68	2.20	29.07	0.93	199.00	5.16	0.06	0.22	0.27
6	Other Material Handling Equipment		6.68	2.20	78.03	0.48	199.00	5.16	0.06	0.22	0.27
7	Asphalt Pavers		6.49	2.14	47.43	0.43	198.00	4.79	0.06	0.22	0.25
7	Tampers/Rammers		6.49	2.14	2.81	5.34	198.00	4.79	0.06	0.22	0.25
7	Plate Compactors		6.49	2.14	2.81	5.34	198.00	4.79	0.06	0.22	0.25
7	Concrete Pavers		NA	NA	NA	NA	NA	NA	NA	NA	NA
7	Rollers		9.25	3.05	9.00	1.61	202.00	5.28	0.06	0.26	0.27

Table 2-07b. (Continued)

Class	Equipment Types		HC Exhaust	HC Crank	HC Evap*	HC Refueling	CO	NO_x	PM	Aldehydes	SO_x
7	Scrapers		NA	NA	NA	NA	NA	NA	NA	NA	NA
7	Paving Equipment		6.49	2.14	3.00	5.02	198.00	4.79	0.06	0.22	0.25
7	Surfacing Equipment		6.49	2.14	3.00	4.84	198.00	4.79	0.06	0.22	0.25
7	Signal Boards		6.49	2.14	3.06	4.94	198.00	4.79	0.06	0.22	0.25
7	Trenchers		6.49	2.14	7.69	0.94	198.00	4.79	0.06	0.22	0.25
7	Bore/Drill Rigs		6.49	2.14	82.62	0.42	198.00	4.79	0.06	0.22	0.25
7	Excavators		6.49	2.14	122.40	0.42	198.00	4.79	0.06	0.22	0.25
7	Concrete/Industrial Saws		6.49	2.14	4.13	2.74	198.00	4.79	0.06	0.22	0.25
7	Cement and Mortar Mixers		6.49	2.14	3.75	4.09	198.00	4.79	0.06	0.22	0.25
7	Cranes		6.49	2.14	84.15	0.42	198.00	4.79	0.06	0.22	0.25
7	Graders		NA	NA	NA	NA	NA	NA	NA	NA	NA
7	Off-Highway Trucks		NA	NA	NA	NA	NA	NA	NA	NA	NA
7	Crushing/Proc. Equipment		6.49	2.14	91.80	0.42	198.00	4.79	0.06	0.22	0.25
7	Rough Terrain Forklifts		6.49	2.14	134.64	0.42	198.00	4.79	0.06	0.22	0.25
7	Rubber Tired Loaders		5.56	1.83	102.51	0.42	163.00	5.42	0.06	0.22	0.24
7	Rubber Tired Dozers		NA	NA	NA	NA	NA	NA	NA	NA	NA
7	Tractors/Loaders/Backhoes		6.49	2.14	96.39	0.42	198.00	4.79	0.06	0.22	0.25
7	Crawler Tractors		NA	NA	NA	NA	NA	NA	NA	NA	NA
7	Skid Steer Loaders		6.49	2.14	25.01	0.44	198.00	4.79	0.06	0.22	0.25
7	Off-Highway Tractors		NA	NA	NA	NA	NA	NA	NA	NA	NA
7	Dumpers/Tenders		6.49	2.14	9.00	1.74	198.00	4.79	0.06	0.22	0.25
7	Other Construction Equipment		6.49	2.14	229.50	0.41	198.00	4.79	0.06	0.22	0.25
8	2-Wheel Tractors		5.49	1.81	7.13	2.09	143.00	6.62	0.06	0.30	0.23
8	Agricultural Tractors		5.49	1.81	133.11	0.42	143.00	6.62	0.06	0.30	0.23
8	Agricultural Mowers		7.18	2.37	8.01	1.84	218.00	5.24	0.06	0.22	0.28
8	Combines		7.18	2.37	200.43	0.41	218.00	5.24	0.06	0.22	0.28
8	Sprayers		7.18	2.37	4.50	1.39	218.00	5.24	0.06	0.22	0.28
8	Balers		NA	NA	NA	NA	NA	NA	NA	NA	NA
8	Tillers	> 5 hp	37.70	12.44	3.63	4.38	430.00	2.02	0.74	0.22	0.37
8	Swathers		7.18	2.37	162.18	0.42	218.00	5.24	0.06	0.22	0.28
8	Hydro Power Units		7.18	2.37	15.00	1.40	218.00	5.24	0.06	0.22	0.28
8	Other Agricultural Equipment		7.18	2.37	84.15	0.42	218.00	5.24	0.06	0.22	0.28
9	Chain Saws	> 4 hp	NA	NA	NA	NA	NA	NA	NA	NA	NA
9	Shredders	> 5 hp	9.30	3.07	3.00	5.02	353.00	2.02	0.03	0.24	0.37
9	Skidders		NA	NA	NA	NA	NA	NA	NA	NA	NA
9	Fellers/Bunchers		NA	NA	NA	NA	NA	NA	NA	NA	NA

Evap* = g/day
* g/hr
** g/gallon
NA = Not applicable

Table 2-07. (Continued)

c. GASOLINE 4-STROKE EQUIPMENT - (grams/hp-hr) Adjusted for In-Use Effects

Class	Equipment Types		HC				CO	NO_x	PM	Aldehydes	SO_x
			Exhaust	Crank	Evap*	Refueling					
1	Trimmers/Edgers/Brush Cutters	b	50.78	7.98	0.54	21.98	747.35	0.81	1.48	0.53	0.37
1	Lawnmowers	b	79.17	12.44	1.16	8.60	817.00	0.81	2.66	0.53	0.37
1	Leaf Blowers/Vacuums	b	40.74	6.40	0.61	6.61	722.37	0.81	1.04	0.53	0.37
1	Rear Engine Riding Mowers	b	19.53	3.07	3.30	3.21	670.70	0.81	0.18	0.24	0.37
1	Front Mowers	b	19.53	3.07	18.60	1.30	670.70	0.81	0.18	0.24	0.37
1	Chain Saws < 4 hp		NA	NA	NA	NA	NA	NA	NA	NA	NA
1	Shredders < 5 hp	b	79.17	12.44	1.75	7.68	817.00	0.81	2.66	0.53	0.37
1	Tillers < 5 hp	b	79.17	12.44	1.38	9.39	817.00	0.81	2.66	0.53	0.37
1	Lawn and Garden Tractors	b	19.74	3.10	7.13	1.84	672.60	0.84	0.36	0.24	0.37
1	Wood Splitters	b	79.17	12.44	1.16	8.60	817.00	0.81	2.66	0.53	0.37
1	Snowblowers	b	79.17	12.44	2.50	5.82	817.00	0.81	2.66	0.53	0.37
1	Chippers/Stump Grinders	c	56.55	12.44	94.86	0.42	559.00	2.02	0.05	0.53	0.37
1	Commercial Turf Equipment	b	19.74	3.10	15.50	1.38	672.60	0.84	0.36	0.24	0.37
1	Other Lawn and Garden Equipment	b	79.17	12.44	1.16	8.60	817.00	0.81	0.18	0.53	0.37
2	Aircraft Support Equipment	c	10.02	2.20	73.44	0.48	258.70	5.16	0.06	0.22	0.27
2	Terminal Tractors	c	10.02	2.20	17.13	0.52	258.70	5.16	0.06	0.22	0.27
3	All Terrain Vehicles (ATVs)	*, b	210.00	33.00	6.00	31.15	1852.50	3.60	4.14	1.18	0.55
3	Minibikes	*, b	210.00	33.00	1.50	21.68	1852.50	3.60	4.14	1.18	0.55
3	Off-Road Motorcycles	*, c	150.00	33.00	6.00	30.92	1267.50	9.00	1.15	1.19	0.55
3	Golf Carts	*, b	210.00	33.00	18.00	5.44	1852.50	3.60	4.14	1.18	0.55
3	Snowmobiles		NA	NA	NA	NA	NA	NA	NA	NA	NA
3	Specialty Vehicles Carts	*, b	210.00	33.00	18.00	7.04	1852.50	3.60	4.14	1.18	0.55
4	Vessels w/Inboard Engines	**, c	108.69	NA	260.10	5.13	1578.24	45.79	0.74	3.07	2.90
4	Vessels w/Outboard Engines	**, c	131.57	28.94	NA	8.75	1848.54	66.58	0.74	3.07	2.99
4	Vessels w/Sterndrive Engines	**, c	108.69	NA	63.00	5.26	1578.24	45.79	0.74	3.07	2.90
4	Sailboat Auxiliary Inboard Engines	**, c	108.69	NA	18.00	8.75	1578.24	45.79	0.74	3.07	2.99
4	Sailboat Auxiliary Outboard Engines	**, c	131.57	28.94	NA	8.75	1848.54	66.58	0.74	3.07	2.90
5	Generator Sets < 50 hp	b	19.95	3.14	3.06	3.43	670.70	0.81	0.22	0.22	0.27
5	Pumps < 50 hp	b	19.95	3.14	2.25	6.33	670.70	0.81	0.22	0.22	0.27
5	Air Compressors < 50 hp	b	19.95	3.14	3.38	3.20	670.70	0.81	0.22	0.22	0.27
5	Gas Compressors < 50 hp	c	NA	NA	NA	NA	NA	NA	NA	NA	NA
5	Welders < 50 hp	b	19.95	3.14	9.75	1.72	670.70	0.81	0.22	0.22	0.27
5	Pressure Washers < 50 hp	b	19.95	3.14	2.25	6.33	670.70	0.81	0.22	0.22	0.27
6	Aerial Lifts	c	10.02	2.20	55.08	0.49	258.70	5.16	0.06	0.22	0.27
6	Forklifts	c	10.02	2.20	54.00	0.49	258.70	5.16	0.06	0.22	0.27
6	Sweepers/Scrubbers	c	10.02	2.20	59.67	0.48	258.70	5.16	0.06	0.22	0.27
6	Other General Industrial Equipment	c	10.02	2.20	29.67	0.93	258.70	5.16	0.06	0.22	0.27
6	Other Material Handling Equipment	c	10.02	2.20	78.03	0.48	258.70	5.16	0.06	0.22	[illegible]
7	Asphalt Pavers	c	9.74	2.14	47.43	0.45	257.40	4.79	0.06	0.22	[illegible]
7	Tampers/Rammers	b	13.63	2.14	2.81	5.34	376.20	1.92	0.22	0.22	[illegible]
7	Plate Compactors	b	13.63	2.14	2.81	5.34	376.20	1.92	0.22	0.22	[illegible]
7	Concrete Pavers		NA	NA	NA	NA	NA	NA	NA	NA	NA
7	Rollers	b	19.43	3.05	9.00	1.61	383.80	2.11	0.22	0.26	[illegible]

Table 2-07c. (Continued)

Class	Equipment Types		HC Exhaust	HC Crank	HC Evap*	HC Refueling	CO	NO_x	PM	Aldehydes	SO_x
7	Scrapers		NA	NA	NA	NA	NA	NA	NA	NA	NA
7	Paving Equipment	b	13.63	2.14	3.00	5.02	376.20	1.92	0.22	0.22	0.25
7	Surfacing Equipment	b	13.63	2.14	3.00	4.84	376.20	1.92	0.22	0.22	0.25
7	Signal Boards	b	13.63	2.14	3.00	4.94	376.20	1.92	0.22	0.22	0.25
7	Trenchers	c	9.74	2.14	7.69	0.94	257.40	4.79	0.06	0.22	0.25
7	Bore/Drill Rigs	c	9.74	2.14	82.62	0.42	257.40	4.79	0.06	0.22	0.25
7	Excavators	c	9.74	2.14	122.40	0.42	257.40	4.79	0.06	0.22	0.25
7	Concrete/Industrial Saws	b	13.63	2.14	4.13	2.74	376.20	1.92	0.22	0.22	0.25
7	Cement and Mortar Mixers	b	13.63	2.14	3.75	4.09	376.20	1.92	0.22	0.22	0.25
7	Cranes	c	9.74	2.14	84.15	0.42	257.40	4.79	0.06	0.22	0.25
7	Graders		NA	NA	NA	NA	NA	NA	NA	NA	NA
7	Off-Highway Trucks		NA	NA	NA	NA	NA	NA	NA	NA	NA
7	Crushing/Proc. Equipment	c	9.74	2.14	91.80	0.42	257.40	4.79	0.06	0.22	0.25
7	Rough Terrain Forklifts	c	9.74	2.14	134.64	0.42	257.40	4.79	0.06	0.22	0.25
7	Rubber Tired Loaders	c	8.34	1.83	102.51	0.42	211.90	5.42	0.06	0.22	0.24
7	Rubber Tired Dozers		NA	NA	NA	NA	NA	NA	NA	NA	NA
7	Tractors/Loaders/Backhoes	c	9.74	2.14	96.39	0.42	257.40	4.79	0.06	0.22	0.25
7	Crawler Tractors		NA	NA	NA	NA	NA	NA	NA	NA	NA
7	Skid Steer Loaders	c	9.74	2.14	25.01	0.44	257.40	4.79	0.06	0.22	0.25
7	Off-Highway Tractors		NA	NA	NA	NA	NA	NA	NA	NA	NA
7	Dumpers/Tenders	b	13.63	2.14	9.00	1.74	376.20	1.92	0.22	0.22	[illegible]
7	Other Construction Equipment	c	9.74	2.14	229.50	0.41	257.40	4.79	0.06	0.22	[illegible]
8	2-Wheel Tractors	b	11.53	1.81	7.13	2.69	271.70	2.65	0.22	0.30	0.23
8	Agricultural Tractors	c	8.24	1.81	133.11	0.42	185.90	6.62	0.06	0.30	0.23
8	Agricultural Mowers	b	15.08	2.37	8.01	1.84	414.20	2.10	0.22	0.22	0.28
8	Combines	c	10.77	2.37	200.43	0.41	283.40	5.24	0.06	0.22	0.28
8	Sprayers	c	10.77	2.37	4.50	1.39	283.40	5.24	0.06	0.22	0.29
8	Balers		NA	NA	NA	NA	NA	NA	NA	NA	NA
8	Tillers > 5 hp	b	79.17	12.44	3.63	4.38	817.00	0.81	2.66	0.22	0.17
8	Swathers	c	10.77	2.37	162.18	0.42	283.40	5.24	0.06	0.22	0.28
8	Hydro Power Units	b	13.08	2.37	15.00	1.40	414.20	2.10	0.22	0.22	0.28
8	Other Agricultural Equipment	c	10.77	2.37	84.15	0.42	283.40	5.24	0.06	0.22	0.28
9	Chain Saws > 4 hp		NA	NA	NA	NA	NA	NA	NA	NA	NA
9	Shredders > 5 hp	b	19.53	3.07	3.00	5.02	670.70	0.81	0.18	0.24	0.17
9	Skidders		NA	NA	NA	NA	NA	NA	NA	NA	NA
9	Fellers/Bunchers		NA	NA	NA	NA	NA	NA	NA	NA	NA

Evap* = g/day
* g/hr
** g/gallon
b = adjusted for in-use effects using small utility engine data
c = adjusted for in-use effects using heavy duty engine data
NA = Not applicable

Table 2-07. (Continued)

d. GASOLINE 2-STROKE EQUIPMENT (grams/hp-hr) Not Adjusted for In-Use Effects

Class	Equipment Types			HC				CO	NO_x	PM	Aldehydes	SO_x
				Exhaust	Crank	Evap*	Refueling					
1	Trimmers/Edgers/Brush Cutters			224.56	NA	0.54	21.98	728.22	0.91	3.89	2.04	0.54
1	Lawnmowers			208.00	NA	1.16	8.60	486.00	0.29	7.70	2.04	0.54
1	Leaf Blowers/Vacuums			215.29	NA	0.61	6.61	716.81	0.96	3.60	2.04	0.54
1	Rear Engine Riding Mowers			NA	NA	NA	NA	NA	NA	NA	NA	NA
1	Front Mowers			NA	NA	NA	NA	NA	NA	NA	NA	NA
1	Chain Saws	< 4 hp		298.00	NA	0.32	35.93	699.00	0.96	3.60	1.60	0.54
1	Shredders	< 5 hp		208.00	NA	1.75	7.68	486.00	0.29	7.70	2.04	0.54
1	Tillers	< 5 hp		208.00	NA	1.38	9.39	486.00	0.29	7.70	2.04	0.54
1	Lawn and Garden Tractors			NA	NA	NA	NA	NA	NA	NA	NA	NA
1	Wood Splitters			NA	NA	NA	NA	NA	NA	NA	NA	NA
1	Snowblowers			208.00	NA	2.50	5.82	486.00	0.29	7.70	2.04	0.54
1	Chippers/Stump Grinders			NA	NA	NA	NA	NA	NA	NA	NA	NA
1	Commercial Turf Equipment			208.00	NA	15.50	1.38	486.00	0.29	7.70	2.04	0.54
1	Other Lawn and Garden Equipment			208.00	NA	1.16	8.60	486.00	0.29	7.70	2.04	0.54
2	Aircraft Support Equipment			NA	NA	NA	NA	NA	NA	NA	NA	NA
2	Terminal Tractors		**	3.00	0.99	17.13	0.52	63.70	17.90	0.05	0.22	0.00
3	All Terrain Vehicles (ATVs)		*	600.00	NA	6.00	31.15	800.00	1.50	8.20	2.75	0.95
3	Minibikes		*	NA	NA	NA	21.68	NA	NA	NA	NA	NA
3	Off-Road Motorcycles		*	600.00	NA	6.00	30.92	800.00	1.50	8.20	2.75	0.95
3	Golf Carts		*	600.00	NA	18.00	5.44	800.00	1.50	8.20	2.75	0.95
3	Snowmobiles			109.00	NA	24.24	0.67	169.00	1.70	4.80	0.40	0.15
3	Specialty Vehicles Carts		*	600.00	NA	18.00	7.04	800.00	1.50	8.20	2.75	0.95
4	Vessels w/Inboard Engines		***	728.06	NA	280.10	5.13	1357.34	8.77	48.10	3.07	2.90
4	Vessels w/Outboard Engines		***	728.06	NA	NA	8.75	1357.34	8.77	48.10	3.07	2.90
4	Vessels w/Sterndrive Engines		***	728.06	NA	63.00	5.26	1357.34	8.77	48.10	3.07	2.90
4	Sailboat Auxiliary Inboard Engines		***	NA	NA	NA	NA	NA	NA	NA	NA	NA
4	Sailboat Auxiliary Outboard Engines		***	728.06	NA	NA	8.75	1357.34	8.77	48.10	3.07	2.90
5	Generator Sets	< 50 hp		208.00	NA	3.06	3.43	486.00	0.29	7.70	2.04	0.27
5	Pumps	< 50 hp	**	4.28	1.41	2.25	6.33	113.00	7.04	0.05	0.22	0.00
5	Air Compressors	< 50 hp		NA	NA	NA	NA	NA	NA	NA	NA	NA
5	Gas Compressors	< 50 hp	**	4.28	1.41	NA	NA	113.00	7.04	0.05	0.22	0.00
5	Welders	< 50 hp		NA	NA	NA	NA	NA	NA	NA	NA	NA
5	Pressure Washers	< 50 hp		NA	NA	NA	NA	NA	NA	NA	NA	NA
6	Aerial Lifts		**	3.00	0.99	55.08	0.49	63.70	17.90	0.05	0.22	0.00
6	Forklifts		**	3.00	0.99	54.00	0.49	63.70	17.90	0.05	0.22	0.00
6	Sweepers/Scrubbers		**	3.00	0.99	59.67	0.48	63.70	17.90	0.05	0.22	0.00
6	Other General Industrial Equipment			208.00	NA	29.07	0.93	486.00	0.29	7.70	2.04	0.27
6	Other Material Handling Equipment			NA	NA	NA	NA	NA	NA	NA	NA	NA
7	Asphalt Pavers			NA	NA	NA	NA	NA	NA	NA	NA	NA
7	Tampers/Rammers			208.00	NA	2.81	5.34	486.00	0.29	7.70	2.04	0.25
7	Plate Compactors			208.00	NA	2.81	5.34	486.00	0.29	7.70	2.04	0.25
7	Concrete Pavers			NA	NA	NA	NA	NA	NA	NA	NA	NA
7	Rollers			NA	NA	NA	NA	NA	NA	NA	NA	NA

Table 2-07d. (Continued)

Class	Equipment Types		HC Exhaust	HC Crank	HC Evap*	HC Refueling	CO	NO_x	PM	Aldehydes	SO_x
7	Scrapers		NA	NA	NA	NA	NA	NA	NA	NA	NA
7	Paving Equipment		208.00	NA	3.00	5.02	486.00	0.29	7.70	2.04	0.25
7	Surfacing Equipment		NA	NA	NA	NA	NA	NA	NA	NA	NA
7	Signal Boards		NA	NA	NA	NA	NA	NA	NA	NA	NA
7	Trenchers		NA	NA	NA	NA	NA	NA	NA	NA	NA
7	Bore/Drill Rigs		208.00	NA	82.62	0.42	486.00	0.29	7.70	2.04	0.25
7	Excavators		NA	NA	NA	NA	NA	NA	NA	NA	NA
7	Concrete/Industrial Saws		NA	NA	NA	NA	NA	NA	NA	NA	NA
7	Cement and Mortar Mixers		NA	NA	NA	NA	NA	NA	NA	NA	NA
7	Cranes		NA	NA	NA	NA	NA	NA	NA	NA	NA
7	Graders		NA	NA	NA	NA	NA	NA	NA	NA	NA
7	Off-Highway Trucks		NA	NA	NA	NA	NA	NA	NA	NA	NA
7	Crushing/Proc. Equipment		NA	NA	NA	NA	NA	NA	NA	NA	NA
7	Rough Terrain Forklifts		NA	NA	NA	NA	NA	NA	NA	NA	NA
7	Rubber Tired Loaders		NA	NA	NA	NA	NA	NA	NA	NA	NA
7	Rubber Tired Dozers		NA	NA	NA	NA	NA	NA	NA	NA	NA
7	Tractors/Loaders/Backhoes		NA	NA	NA	NA	NA	NA	NA	NA	NA
7	Crawler Tractors		NA	NA	NA	NA	NA	NA	NA	NA	NA
7	Skid Steer Loaders		NA	NA	NA	NA	NA	NA	NA	NA	NA
7	Off-Highway Tractors		NA	NA	NA	NA	NA	NA	NA	NA	NA
7	Dumpers/Tenders		NA	NA	NA	NA	NA	NA	NA	NA	NA
7	Other Construction Equipment		NA	NA	NA	NA	NA	NA	NA	NA	NA
8	2-Wheel Tractors		NA	NA	NA	NA	NA	NA	NA	NA	NA
8	Agricultural Tractors		NA	NA	NA	NA	NA	NA	NA	NA	NA
8	Agricultural Mowers		NA	NA	NA	NA	NA	NA	NA	NA	NA
8	Combines		NA	NA	NA	NA	NA	NA	NA	NA	NA
8	Sprayers		NA	NA	NA	NA	NA	NA	NA	NA	NA
8	Balers		NA	NA	NA	NA	NA	NA	NA	NA	NA
8	Tillers	> 5 hp	NA	NA	NA	NA	NA	NA	NA	NA	NA
8	Swathers		NA	NA	NA	NA	NA	NA	NA	NA	NA
8	Hydro Power Units		NA	NA	NA	NA	NA	NA	NA	NA	NA
8	Other Agricultural Equipment		NA	NA	NA	NA	NA	NA	NA	NA	NA
9	Chain Saws	> 4 hp	152.00	NA	0.66	18.22	513.00	0.96	3.60	1.60	0.37
9	Shredders	> 5 hp	NA	NA	NA	NA	NA	NA	NA	NA	NA
9	Skidders		NA	NA	NA	NA	NA	NA	NA	NA	NA
9	Fellers/Bunchers		NA	NA	NA	NA	NA	NA	NA	NA	NA

Evap* = g/day
* g/hr
** Emission factors for 4-stroke propane-fueled equipment
*** g/gallon
NA = Not applicable

Table 2-07. (Continued)

e. GASOLINE 2-STROKE EQUIPMENT - (grams/hp-hr) Adjusted for In-Use Effects

Class	Equipment Types		HC Exhaust	HC Crank	HC Evap*	HC Refueling	CO	NO_x	PM	Aldehydes	SO_x
1	Trimmers/Edgers/Brush Cutters	d	471.58	NA	0.54	21.98	1383.62	0.91	3.89	2.04	0.54
1	Lawnmowers	d	436.80	NA	1.16	8.60	923.40	0.29	7.70	2.04	0.54
1	Leaf Blowers/Vacuums	d	452.11	NA	0.61	6.61	1361.94	0.96	3.60	2.04	0.54
1	Rear Engine Riding Mowers		NA	NA	NA	NA	NA	NA	NA	NA	NA
1	Front Mowers		NA	NA	NA	NA	NA	NA	NA	NA	NA
1	Chain Saws < 4 hp	d	625.80	NA	0.32	35.93	1328.10	0.96	3.60	1.60	0.54
1	Shredders < 5 hp	d	436.80	NA	1.75	7.68	923.40	0.29	7.70	2.04	0.54
1	Tillers < 5 hp	d	436.80	NA	1.38	9.39	923.40	0.29	7.70	2.04	0.54
1	Lawn and Garden Tractors		NA	NA	NA	NA	NA	NA	NA	NA	NA
1	Wood Splitters		NA	NA	NA	NA	NA	NA	NA	NA	NA
1	Snowblowers	d	436.80	NA	2.50	5.82	923.40	0.29	7.70	2.04	0.54
1	Chippers/Stump Grinders		NA	NA	NA	NA	NA	NA	NA	NA	NA
1	Commercial Turf Equipment	d	436.80	NA	15.50	1.38	923.40	0.29	7.70	2.04	0.54
1	Other Lawn and Garden Equipment	d	436.80	NA	1.16	8.60	923.40	0.29	7.70	2.04	0.54
2	Aircraft Support Equipment		NA	NA	NA	NA	NA	NA	NA	NA	NA
2	Terminal Tractors	**, c	4.50	0.99	17.13	0.52	82.81	17.90	0.05	0.22	0.00
3	All Terrain Vehicles (ATVs)	*, d	1260.00	NA	6.00	31.15	1520.00	1.50	8.20	2.75	0.95
3	Minibikes		NA	NA	NA	NA	NA	NA	NA	NA	NA
3	Off-Road Motorcycles	*, d	1260.00	NA	6.00	30.92	1520.00	1.50	8.20	2.75	0.95
3	Golf Carts	*, d	1260.00	NA	18.00	5.44	1520.00	1.50	8.20	2.75	0.95
3	Snowmobiles	d	228.90	NA	24.24	0.67	321.10	1.70	4.80	0.40	0.15
3	Specialty Vehicles Carts	*, d	1260.00	NA	18.00	7.04	1520.00	1.50	8.20	2.75	0.95
4	Vessels w/Inboard Engines	***, e	873.67	NA	260.10	5.13	1628.81	8.77	48.10	3.07	2.90
4	Vessels w/Outboard Engines	***, e	873.67	NA	NA	8.75	1628.81	8.77	48.10	3.07	2.90
4	Vessels w/Sterndrive Engines	***, e	873.67	NA	63.00	5.26	1628.81	8.77	48.10	3.07	2.90
4	Sailboat Auxiliary Inboard Engines		NA	NA	NA	NA	NA	NA	NA	NA	NA
4	Sailboat Auxiliary Outboard Engines	***, e	873.67	NA	NA	8.75	1628.81	8.77	48.10	3.07	2.90
5	Generator Sets < 50 hp	d	436.80	NA	3.06	3.43	923.40	0.29	7.70	2.04	0.27
5	Pumps < 50 hp	**, b	8.99	1.41	2.25	6.33	214.70	2.82	0.18	0.22	0.00
5	Air Compressors < 50 hp		NA	NA	NA	NA	NA	NA	NA	NA	NA
5	Gas Compressors < 50 hp	**, c	6.42	1.41	NA	NA	146.90	7.04	0.05	0.22	0.00
5	Welders < 50 hp		NA	NA	NA	NA	NA	NA	NA	NA	NA
5	Pressure Washers < 50 hp		NA	NA	NA	NA	NA	NA	NA	NA	NA
6	Aerial Lifts	**, c	4.50	1.49	55.08	0.49	82.81	17.90	0.05	0.22	0.00
6	Forklifts	**, c	4.50	1.49	54.00	0.49	82.81	17.90	0.05	0.22	0.00
6	Sweepers/Scrubbers	**, c	4.50	1.49	59.67	0.48	82.81	17.90	0.05	0.22	0.00
6	Other General Industrial Equipment	c	312.00	NA	29.07	0.93	631.80	0.29	7.70	2.04	0.27
6	Other Material Handling Equipment		NA	NA	NA	NA	NA	NA	NA	NA	NA
7	Asphalt Pavers		NA	NA	NA	NA	NA	NA	NA	NA	NA
7	Tampers/Rammers	d	436.80	NA	2.81	5.34	923.40	0.29	7.70	2.04	0.25
7	Plate Compactors	d	436.80	NA	2.81	5.34	923.40	0.29	7.70	2.04	0.25
7	Concrete Pavers		NA	NA	NA	NA	NA	NA	NA	NA	NA
7	Rollers		NA	NA	NA	NA	NA	NA	NA	NA	NA

Table 2-07e. (Continued)

Class	Equipment Types			HC Exhaust	HC Crank	HC Evap*	HC Refueling	CO	NO_x	PM	Aldehydes	SO_x
7	Scrapers			NA	NA	NA	NA	NA	NA	NA	NA	NA
7	Paving Equipment		d	436.80	NA	3.00	5.02	923.40	0.29	7.70	2.04	0.25
7	Surfacing Equipment			NA	NA	NA	NA	NA	NA	NA	NA	NA
7	Signal Boards			NA	NA	NA	NA	NA	NA	NA	NA	NA
7	Trenchers			NA	NA	NA	NA	NA	NA	NA	NA	NA
7	Bore/Drill Rigs		d	436.80	NA	82.62	0.42	923.40	0.29	7.70	2.04	0.25
7	Excavators			NA	NA	NA	NA	NA	NA	NA	NA	NA
7	Concrete/Industrial Saws			NA	NA	NA	NA	NA	NA	NA	NA	NA
7	Cement and Mortar Mixers			NA	NA	NA	NA	NA	NA	NA	NA	NA
7	Cranes			NA	NA	NA	NA	NA	NA	NA	NA	NA
7	Graders			NA	NA	NA	NA	NA	NA	NA	NA	NA
7	Off-Highway Trucks			NA	NA	NA	NA	NA	NA	NA	NA	NA
7	Crushing/Proc. Equipment			NA	NA	NA	NA	NA	NA	NA	NA	NA
7	Rough Terrain Forklifts			NA	NA	NA	NA	NA	NA	NA	NA	NA
7	Rubber Tired Loaders			NA	NA	NA	NA	NA	NA	NA	NA	NA
7	Rubber Tired Dozers			NA	NA	NA	NA	NA	NA	NA	NA	NA
7	Tractors/Loaders/Backhoes			NA	NA	NA	NA	NA	NA	NA	NA	NA
7	Crawler Tractors			NA	NA	NA	NA	NA	NA	NA	NA	NA
7	Skid Steer Loaders			NA	NA	NA	NA	NA	NA	NA	NA	NA
7	Off-Highway Tractors			NA	NA	NA	NA	NA	NA	NA	NA	NA
7	Dumpers/Tenders			NA	NA	NA	NA	NA	NA	NA	NA	NA
7	Other Construction Equipment			NA	NA	NA	NA	NA	NA	NA	NA	NA
8	2-Wheel Tractors			NA	NA	NA	NA	NA	NA	NA	NA	NA
8	Agricultural Tractors			NA	NA	NA	NA	NA	NA	NA	NA	NA
8	Agricultural Mowers			NA	NA	NA	NA	NA	NA	NA	NA	NA
8	Combines			NA	NA	NA	NA	NA	NA	NA	NA	NA
8	Sprayers			NA	NA	NA	NA	NA	NA	NA	NA	NA
8	Balers			NA	NA	NA	NA	NA	NA	NA	NA	NA
8	Tillers	> 5 hp		NA	NA	NA	NA	NA	NA	NA	NA	NA
8	Swathers			NA	NA	NA	NA	NA	NA	NA	NA	NA
8	Hydro Power Units			NA	NA	NA	NA	NA	NA	NA	NA	NA
8	Other Agricultural Equipment			NA	NA	NA	NA	NA	NA	NA	NA	NA
9	Chain Saws	> 4 hp	d	319.20	NA	0.66	18.22	974.70	0.96	12.96	1.60	0.37
9	Shredders	> 5 hp		NA	NA	NA	NA	NA	NA	NA	NA	NA
9	Skidders			NA	NA	NA	NA	NA	NA	NA	NA	NA
9	Fellers/Bunchers			NA	NA	NA	NA	NA	NA	NA	NA	NA

Evap* = g/day
* g/hr
** Emission factors for 4-stroke propane-fueled equipment
*** g/gallon
b = adjusted for in-use effects using small utility engine data
c = adjusted for in-use effects using heavy duty engine data
d = adjusted for in-use effects using small utility engine data except no NO_x or PM adjustment
e = adjusted for in-use effects by a factor of 1.2 for HC and CO
NA = Not Applicable

Key:

1 = Lawn and Garden
2 = Airport Service
3 = Recreational Equipment
4 = Recreational Marine
5 = Light Commercial
6 = Industrial
7 = Construction
8 = Agricultural
9 = Logging

Table 2-08a. Summer and Winter Percentages of Yearly Activity.

Equipment Class	Cold/Northern		Medium/Central		Warm/Southern	
	Summer (%)	Winter (%)	Summer (%)	Winter (%)	Summer (%)	Winter (%)
Agricultural	50	6	40	6	34	6
Construction	43	10	38	15	33	20
Industrial	30	20	25	25	25	25
Lawn and Garden (excl. chain saws)	50	6	40	6	34	6
Snowblowers/Snowmobiles	0	100	0	100	0	100
Commercial Marine	25	25	25	25	25	25
Airport Service	25	25	25	25	25	25
Logging (including chain saws)	25	25	25	25	25	25
Light Commercial	25	25	25	25	25	25

Table 2-08b. Summer and Winter Percentages of Yearly Activity for Recreational Marine Equipment

Region	% During Summer	% During Winter
Northeast	68	1
Southeast	48	7
Mid-Atlantic Coast	57	2
Great Lakes	70	0
Southwest	48	7
Rocky Mountains	69	0
Northwest	57	5
West Coast	48	7

Table 2-08c. Summer and Winter Percentages of Yearly Activity for Recreational Equipment.‡‡‡‡‡‡

Region	% During Summer	% During Winter
East	42%	12%
Midwest	46%	8%
South	36%	15%
West	44%	11%
New England	44%	14%
Mid-Atlantic Coast	41%	12%
East Central	48%	9%
West Central	44%	8%
Southeast	35%	17%
Southwest	37%	12%
Rocky Mountains	44%	8%
Pacific	43%	13%
National Average	42%	12%

‡‡‡‡‡‡Excluding snowmobiles.

2.8. Emissions from Commercial Marine Vessels

A detailed analysis of commercial marine vessel activity and emissions was developed for the following nonattainment areas:[§§§§§§]

1. Baltimore, MD MSA
2. Baton Rouge, LA MSA
3. Houston-Galveston-Brazoria, TX CMSA
4. New York-Northern New Jersey-Long Island, NY-NJ-CT CMSA/NECMA
5. Philadelphia-Wilmington-Trenton, PA-NJ-DE-MD CMSA
6. Seattle-Tacoma, WA CMSA

For other nonattainment areas, estimates of emissions from commercial vessels were based on information obtained from different sources, including SIP emission inventories and the 1985 National Emission Report.[7]

When the latter was used, marine vessel activity was assumed to be uniform during the year. Emissions from commercial marine vessels are shown in Table 2-09.

§§§§§§ This analysis is documented in the Booz•Allen & Hamilton final report entitled "Commercial Marine Vessel Contributions to Emission Inventories," which may also be found in the public docket.

Table 2-09. Emissions from Commercial Marine Vessels

Commercial Vessel Emissions

Geographical Area	tpy VOC	tpy NOx	tpy CO	tpy PM	tpy Aldehydes	tpy SOx	tpsd VOC	tpsd NOx	tpsd CO	Data Sources VOC	Data Sources NOx	Data Sources CO	Data Sources PM/SOx
Baltimore CMSA	1,623	5,970	30,332	302	ND	1,718.54	4.45	16.34	63.10	5	5	5	5
Chicago CMSA	ND	808	ND	300	ND	ND	1.16	26.47	ND	1	1		1
Denver CMSA	ND	ND	0	ND	ND	ND	ND	ND	0.00			1	
Houston CMSA	688	12,462	1,716	741	ND	5,152.10	1.88	34.14	4.71	5	5	5	5
Milwaukee CMSA	457	386	ND	ND	ND	ND	1.25	1.09	ND	3	3		
Boston NECMA	ND	ND	ND	173	ND	ND	0.25	4.96	0.61	1	1	1	1
Hartford NECMA	11	280	29	ND	ND	ND	0.03	0.71	0.08	1	1	1	
New York CMSA/NECMA	789	12,881	2,488	820	ND	4,239.50	2.16	36.58	8.73	5	5	5	5
Philadel. CMSA	494	9,181	1,377	553	ND	4,344.20	1.35	25.15	3.77	5	5	5	5
Seat.-Tac. CMSA	2,194	17,263	31,840	1,017	ND	7,578.74	6.01	47.27	87.51	5	5	5	5
Atlanta CMSA	0	0	ND	ND	ND	ND	0.00	0.00	ND	1	1		
Baton Rouge CMSA	108	1,848	394	109	ND	739.40	0.30	5.07	1.08	5	5	5	5
Cleveland CMSA	1,003	109	3,767	ND	ND	ND	2.75	0.30	ND	3	3		
El Paso CMSA	0	0	0	0	0	0	0.00	0.00	0.00	3	3	3	3
San Jq. Val. AB	ND	ND	ND	62	ND	401.50	0.22	2.64	0.35	1	1	1	1
South Coast AB	ND	ND	ND	1,515	ND	12,796.99	7.39	68.38	10.48	1	1	1	1
Miami CMSA	943	1,310	ND	ND	ND	ND	2.58	3.59	ND	3	3		
Min.-St.Paul CMSA	ND	ND	28	3	ND	ND	ND	ND	0.08			1	1
Provo-Orem CMSA	ND	ND	315	ND	ND	ND	ND	ND	0.86			3	
San Diego AB	ND	ND	ND	684	ND	6,978.80	2.50	41.11	4.75	1	1	1	1
Spokane CMSA	ND	ND	245	ND	ND	ND	ND	ND	0.67			3	
St. Louis CMSA	2,488	1,826	ND	184	ND	ND	6.82	4.99	ND	3	3		
Washington DC CMSA	808	227	2,820	ND	ND	ND	2.21	0.62	7.73	3	3	3	
Springfield NECMA	0	0	0	0	0	0	0.00	0.00	ND	1	1		
Nation	543,464	216,798	1,822,827	18,204	ND	24,403.71	1,488.94	580.45	4,903.22	6	6	6	6

ND - No Data

1. State Implementation Plan / CARB Contractor Study
2. Phase II Volatility Control Support Runs
3. 1985 National Emission Report
4. Cold Carbon Monoxide Support Runs
5. Booz Allen, Hamilton Study for EPA
6. 1989 National Air Pollutant Emission Estimates

2.9. Emissions from Other Sources

EPA compared its estimates of emissions from nonroad engines and vehicles to emissions from highway and other area and point sources. At the national level, 1989 emissions were obtained from the *National Air Pollutant Emission Estimates: 1940-1989.*[8] For all but five nonattainment areas,[££££££] emissions from highway and other sources were available from the following sources:

VOC: *Phase II Volatility Control Support Runs*, April 5, 1990 - VOC emissions were reported in tons per summer day for 1990.

CO: Support computer runs for Cold CO Rulemaking documentation, Jan. 18, 1991 - CO emissions were reported in tpy for 1987. To estimate tons per winter day, highway vehicle CO emissions were divided by 365 and corrected for decreased driving during the winter. Emissions from other area and point sources were simply divided by 365.

NO_X: *1985 National Emission Report*[9] - NO_X emissions were reported in tons per year for 1985. To estimate tons per summer day, highway vehicle NO_X emissions were divided by 365 and corrected for increased summer driving. Emissions from other area and part sources were simply divided by 365.

PM: *1985 National Emission Report* - PM emissions were reported in tons per year for 1985.

SO_X: *1985 National Emission Report* - SO_X emissions were reported in tons per year for 1985.

[££££££]For five areas (Boston NECMA, Springfield NECMA, Hartford NECMA, South Coast Air Basin, and San Joaquin Valley Air Basin), the geographical definition of the nonattainment areas differed slightly from that used in the analyses discussed above. In these cases, EPA relied on estimates of emissions from highway and other sources that were developed in the most recent State Implementation Plans.

For both VOC and CO, the original estimates of nonroad mobile source emissions from the Phase II and Cold CO emission inventories could not be readily distinguished from other area sources. To avoid counting nonroad sources among other area and point sources, EPA computed the ratio of nonroad to the sum of nonroad and other area and point sources for both VOC and CO emissions in each nonattainment area using data from the 1985 *National Emission Report*. These ratios were applied to the VOC and CO emissions from all nonhighway sources reported in the Phase II and Cold CO emission inventories. It was thus possible to estimate emissions from all other area and point sources without including nonroad engines and vehicles.

Emissions from highway vehicles and other area and point sources are shown in Tables 2-10 and 2-11, respectively. The data sources are also indicated by area in these tables.

These total inventories do not include emissions of VOCs from vegetation (biogenic VOCs). Although recent studies have shown that, in some cities, emissions of VOCs from plants may be more important in ozone formation than previously thought, EPA has only recently completed a computer model for estimating biogenic emissions in urban areas and has determined that reliable biogenic inventories do not exist for most areas. While the biogenic inventories to be included in future State Implementation Plans will affect the fine-tuning of nonattainment areas' pollution control strategies, the magnitude of VOC inventories from biogenic sources will not alter the need to reduce anthropogenic VOCs substantially to bring many urban areas into attainment of the ozone standard.

Table 2-10. Emissions from Highway Vehicles

Highway Vehicle Emissions

Geographical Area	tpy VOC	tpy NOx	tpy CO	tpy PM	tpy Aldehydes	tpy SOx	tpsd VOC	tpsd NOx	tpwd CO	Data Sources VOC	Data Sources NOx	Data Sources CO	Data Sources PM/SOx
Baltimore CMSA	ND	64,317	ND	ND	ND	ND	200.00	163.70	1,327.60	2	3	4	
Chicago CMSA	ND	153,215	ND	113,526	ND	ND	587.70	461.74	ND	2	3		
Denver CMSA	ND	ND	417,408	32,716	ND	ND	ND	ND	2,371.20			4	3
Houston CMSA	ND	100,865	ND	ND	ND	ND	442.40	303.96	ND	2	3		
Milwaukee CMSA	ND	33,493	ND	ND	ND	ND	105.70	100.94	ND	2	3		
Boston NECMA	ND	ND	ND	ND	ND	ND	414.90	206.93	1,470.00	1	1	1	
Hartford NECMA	ND	29,311	108,380	ND	ND	ND	188.50	88.33	590.00	1	3	1	
New York CMSA/NECMA	ND	317,257	3,129,400	232,798	ND	ND	1,114.16	966.12	7,373.40	2	3	4	3
Philadel. CMSA	ND	123,720	[illegible]	ND	ND	ND	431.50	372.65	ND	2	3		
Seat.-Tac. CMSA	ND	ND	287,670	30,151	ND	ND	ND	ND	1,514.60			4	3
Atlanta CMSA	ND	49,146	ND	ND	ND	ND	318.80	208.39	ND	2	3		
Baton Rouge CMSA	ND	14,585	ND	ND	ND	ND	44.00	43.86	ND	2	3		
Cleveland CMSA	ND	64,808	412,340	46,728	ND	ND	241.80	196.91	2,359.90	2	3	4	3
El Paso CMSA	ND	11,154	320,700	7,278	ND	ND	36.30	33.62	755.80	2	3	4	3
San Jq. Val. AB	ND	ND	ND	13,506	ND	9,125.00	150.00	240.00	1,180.00	1	1	1	1
South Coast AB	ND	ND	ND	34,676	ND	11,680.00	960.00	680.00	9,732.00	1	1	4	1
Miami CMSA	ND	63,264	ND	ND	ND	ND	308.80	190.66	ND	2	3		
Min.-St.Paul CMSA	ND	ND	419,140	42,282	ND	ND	ND	ND	2,421.70			4	3
Provo-Orem CMSA	ND	ND	73,864	3,688	ND	ND	ND	ND	440.40			4	3
San Diego AB	ND	47,134	570,190	6,935	ND	2,409.00	129.70	142.08	1,343.20	2	3	4	1
Spokane CMSA	ND	ND	9,029	3,881	ND	ND	ND	ND	251.20			4	3
St. Louis CMSA	ND	92,039	ND	38,099	ND	ND	207.70	186.87	1,709.60	2	3	4	3
Washington DC CMSA	ND	93,068	[illegible]	ND	ND	ND	346.08	260.34	2,160.60	2	3	4	
Springfield NECMA	ND	ND	ND	ND	ND	ND	62.47	30.30	ND	1	1		
Nation	5,639,464	6,647,783	36,034,743	1,397,738	ND	662,572.00	16,996.61	19,732.96	84,903.78	5	5	5	5

ND - No Data

1. State Implementation Plan
2. Phase II Volatility Control Support Runs
3. 1985 National Emission Report
4. Cold Carbon Monoxide Support Runs
5. 1989 National Air Pollutant Emission Estimates

Table 2-11. Emissions from Other Area and Point Sources

Other Area and Point Source Emissions

Geographical Area	tpy VOC	tpy NOx	tpy CO	tpy PM	tpy Aldehydes	tpy SOx	tpsd VOC	tpsd NOx	tpsd CO	Data Sources VOC	Data Sources NOx	Data Sources CO	Data Sources PM/SOx
Baltimore CMSA	ND	59,979	34,462	ND	ND	ND	226.00	164.32	225.86	2	3	4	
Chicago CMSA	ND	302,107	ND	181,246	ND	ND	1,029.00	603.01	ND	2	3		
Denver CMSA	ND	ND	88,876	146,877	ND	ND	ND	ND	167.58			4	
Houston CMSA	ND	440,825	ND	ND	ND	ND	1,391.00	859.40	ND	2	3		
Milwaukee CMSA	ND	39,621	ND	ND	ND	ND	195.00	108.55	ND	2	3		
Boston NECMA	ND	ND	ND	ND	ND	ND	304.49	168.62	698.54	1	1	1	
Hartford NECMA	ND	11,859	51,997	ND	ND	ND	76.66	16.08	210.00	1	1	1	
New York CMSA/NECMA	ND	232,882	546,800	119,873	ND	ND	1,578.00	638.03	993.96	2	3	4	
Philadel. CMSA	ND	137,579	178,772	ND	ND	ND	911.00	376.93	ND	2	3		
Seat.-Tac. CMSA	ND	ND	199,979	37,679	ND	ND	ND	ND	564.87			4	
Atlanta CMSA	ND	92,553	ND	ND	ND	ND	287.00	248.24	ND	2	3		
Baton Rouge CMSA	ND	82,744	ND	ND	ND	ND	270.00	226.70	ND	2	3		
Cleveland CMSA	ND	42,301	88,401	64,267	ND	ND	389.00	170.49	251.62	2	3	4	
El Paso CMSA	ND	20,382	18,000	129,939	ND	ND	50.00	24.87	24.31	2	3	4	
San Jq. Val. AB	ND	ND	ND	731,789	ND	16,790.00	1,022.10	248.70	483.20	1	1	1	1
South Coast AB	ND	ND	ND	766,500	ND	18,213.50	1,400.00	333.80	265.00	1	1	1	1
Miami CMSA	ND	36,464	ND	ND	ND	ND	235.00	97.16	ND	2	3		
Min.-St.Paul CMSA	ND	63,307	125,911	214,398	ND	ND	ND	173.44	356.71			4	
Provo-Orem CMSA	ND	ND	36,273	45,615	ND	ND	ND	ND	36.38			4	
San Diego AB	ND	ND	94,000	179,215	ND	3,723.00	271.00	34.16	153.83	2	1	4	1
Spokane CMSA	ND	ND	77,748	9,837	ND	ND	ND	ND	223.79			4	
St. Louis CMSA	ND	158,510	ND	69,636	ND	ND	360.00	434.27	441.10	2	3	4	
Washington DC CMSA	ND	88,338	59,924	ND	ND	ND	202.00	242.02	166.74	2	3	4	
Springfield NECMA	ND	ND	ND	ND	ND	ND	49.64	29.99	ND	1	1		
Nation	13,684,163	13,865,333	24,480,414	6,384,620	ND	22,311,998.00	37,400.86	38,233.79	87,206.61	5	5	5	5

ND - No Data

1. State Implementation Plan
2. Phase II Volatility Control Support Runs
3. 1985 National Emission Report
4. Cold Carbon Monoxide Support Runs
5. 1989 National Air Pollutant Emission Estimates

Chapter 3. Results

As described in Chapter 2, EPA developed two new sets of inventories for nonroad engines and vehicles. Inventory A was developed from data supplied by EPA contractors, and Inventory B incorporated information supplied by manufacturers.

Both inventories were developed by multiplying the activity levels by the appropriate emission factors. Where possible, the resulting data were compared to emission inventories for highway mobile sources and other area and point sources.

The results of Inventories A and B are summarized in this chapter. Detailed presentations of both inventories can be found in Appendixes M (Inventory A) and O (Inventory B). This chapter also contains a summary of the results from EPA's analysis of SIP and CARB inventories.

3.1. VOC, NO_x, CO, and Particulate Nonroad Inventories

Table 3-01 presents nonroad emissions of VOC, NO_x, CO, and particulates as percentages of the total emission inventory for each of the 24 nonattainment areas studied. For each entry, a range is provided. The lower end of each range was calculated using new engine emission factors, while the upper end utilized in-use emission factors.

Due to the seasonal nature of ozone and CO nonattainment in many areas, EPA made adjustments to the emission inventories developed for VOC, NO_x, and CO. The results are reported as percentage tons per summer day for VOC and NO_x and percentage tons per winter day for CO. Table 3-01 also provides a comparison of results from Inventory A and Inventory B.

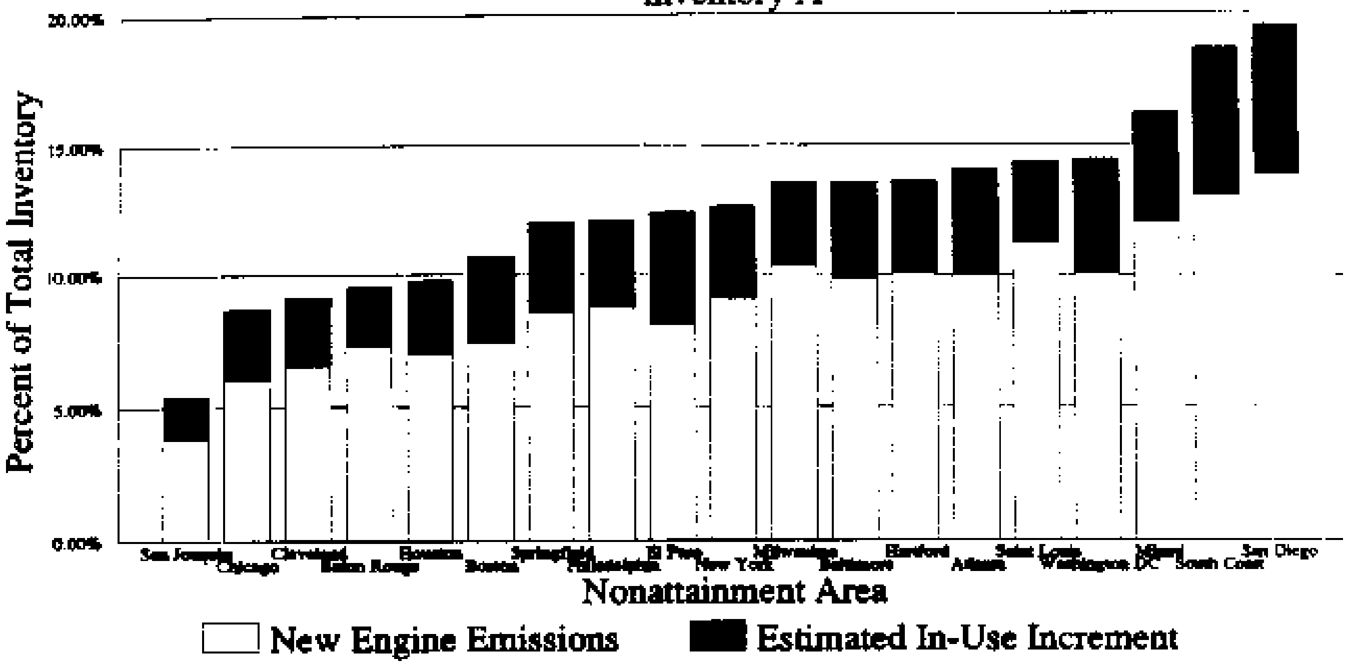
To help visualize the nonroad contribution to total local emission inventories, stacked bar charts are used to display the distribution of the results from Table 3-01 in eight charts following the table. Calculations using both new engine and in-use emission factors are presented in each chart to illustrate the range of potential nonroad emission contributions. Of the 24 nonattainment areas included in the inventories, 19 were studied for NO_x and VOC, 16 were studied for CO, and 13 were studied for particulates.

Table 3-01. Total Nonroad Emissions by Nonattainment Area and Pollutant (%)

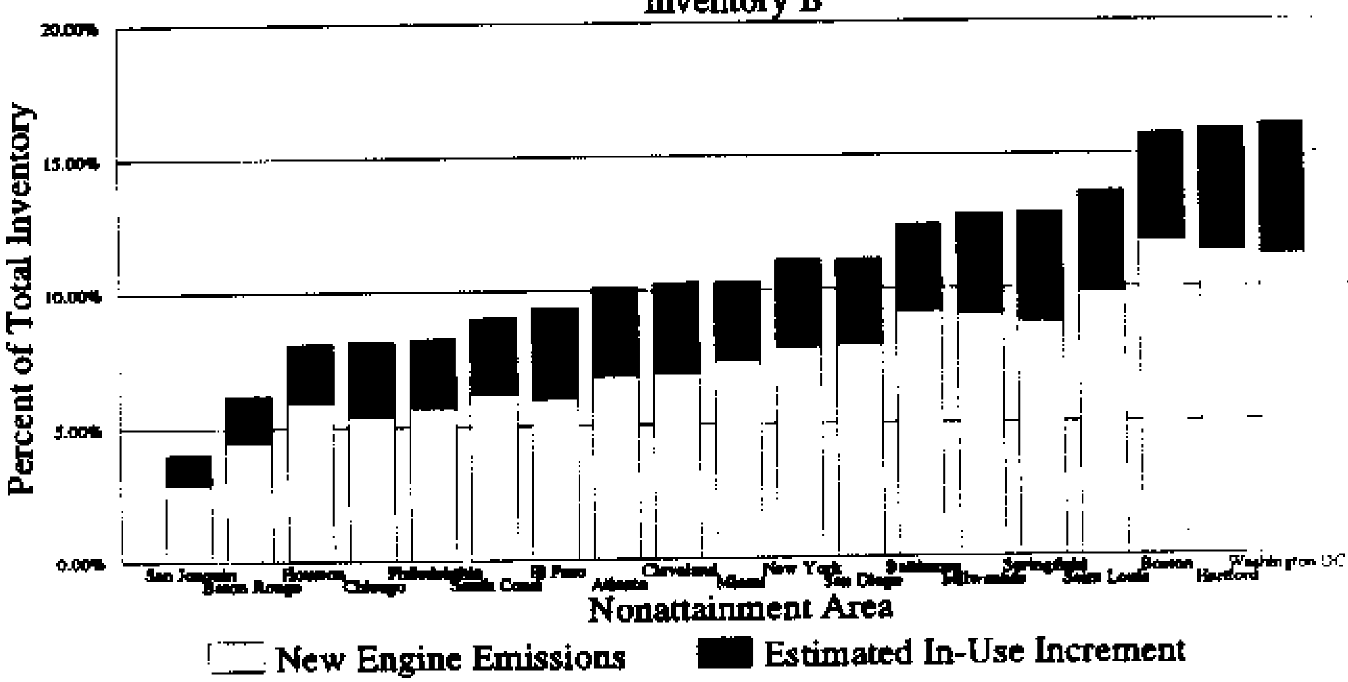
Nonattainment Area	Inventory A				Inventory B			
	VOC tpsd (%)	NO_x tpsd (%)	CO tpwd (%)	PM tpy (%)	VOC tpsd (%)	NO_x tpsd (%)	CO tpwd (%)	PM tpy (%)
Atlanta	10-14*	13			7-10	13		
Baltimore	10-14	19	11-14		9-12	18	11-14	
Baton Rouge	7-10	13			4-6	8		
Boston	7-11	19	9-15		12-16	25	8-13	
Chicago	6-9	16		2	5-8	12		1
Cleveland	7-9	15	5-8	2	7-10	12	4-7	1
Denver			6-9	1			5-8	0.5
El Paso	8-12	22	5-8	0.4	6-9	15	4-7	0.2
Hartford	10-14	25	9-13		11-16	31	4-11	
Houston	7-10	15			6-8	10		
Miami	12-16	18			7-10	16		
Milwaukee	10-14	16			9-13	13		
Minneapolis			4-7	1			3-6	0.7
New York	9-13	20	9-14	3	8-11	14	8-13	2
Philadelphia	9-12	17			6-8	14		
Provo-Orem			3-4	0.4			2-4	0.3
San Diego	14-20	39	9-14	2	8-11	31	7-11	1
Seattle			9-12	5			9-11	3
South Coast, CA	13-19	29	8-13	2	6-9	20	6-9	0.7
San Joaquin Valley	4-5	19	6-10	0.6	3-4	17	5-8	0.4
Springfield, MA	9-12	15			9-13	15		
Spokane			2-4	2			2-4	1
St. Louis	11-14	12	5-8	2	10-14	10	4-7	1
Washington, DC	10-14	17	5-8		11-16	13	6-9	

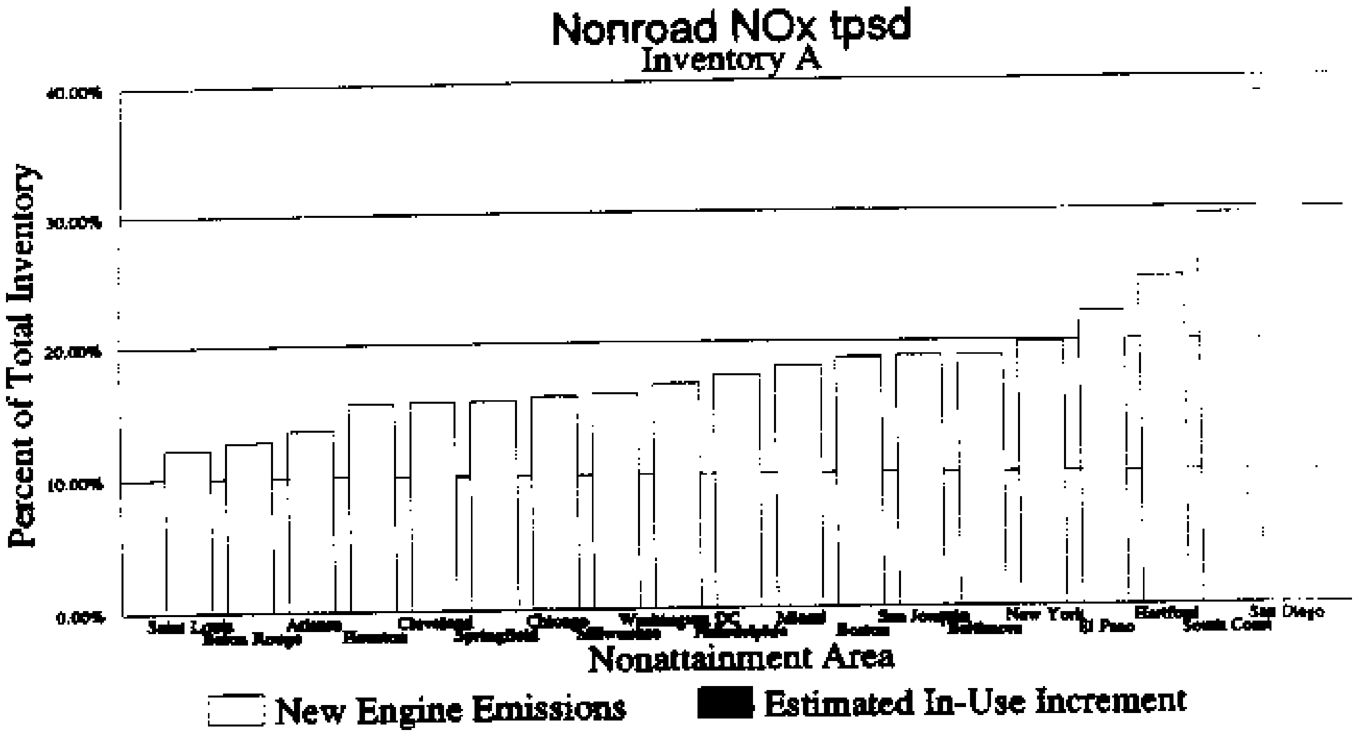
*The range presented is based on calculation of emissions from new and in-use emission factors.

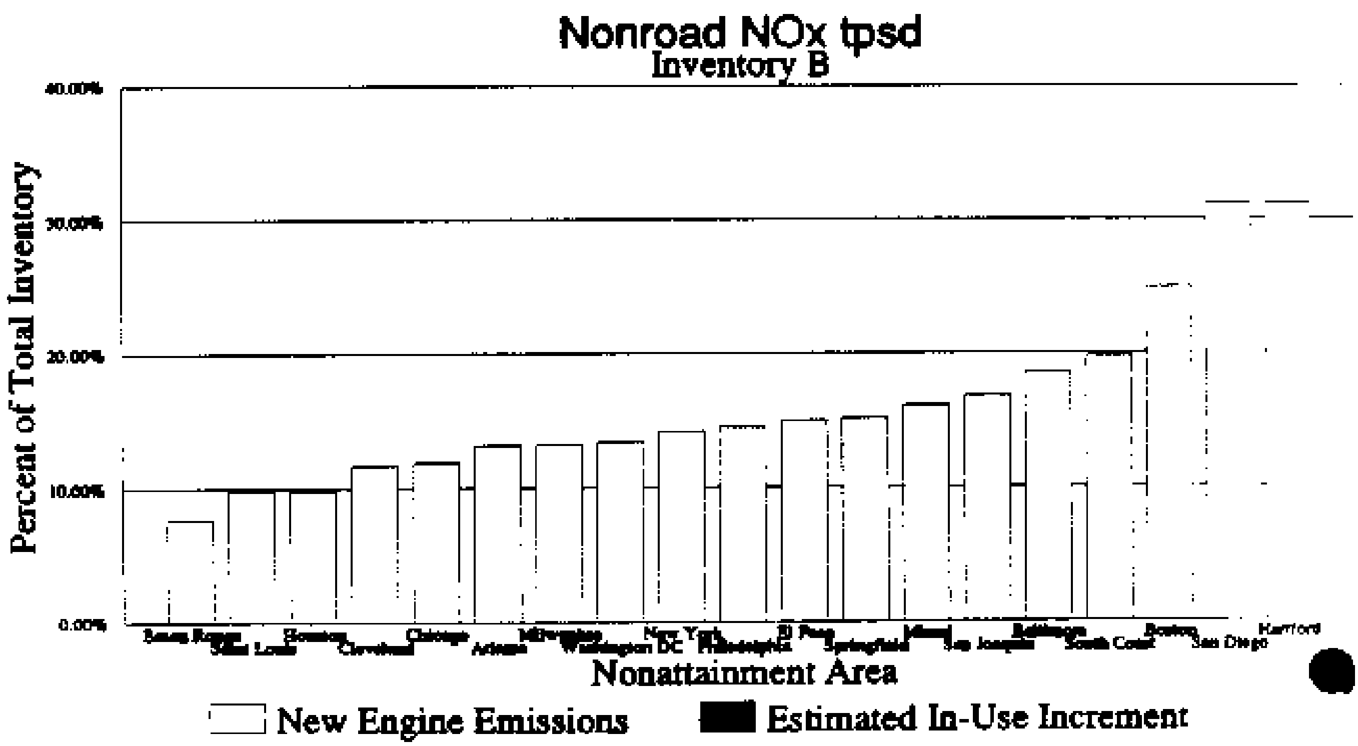
Nonroad VOC tpsd
Inventory A



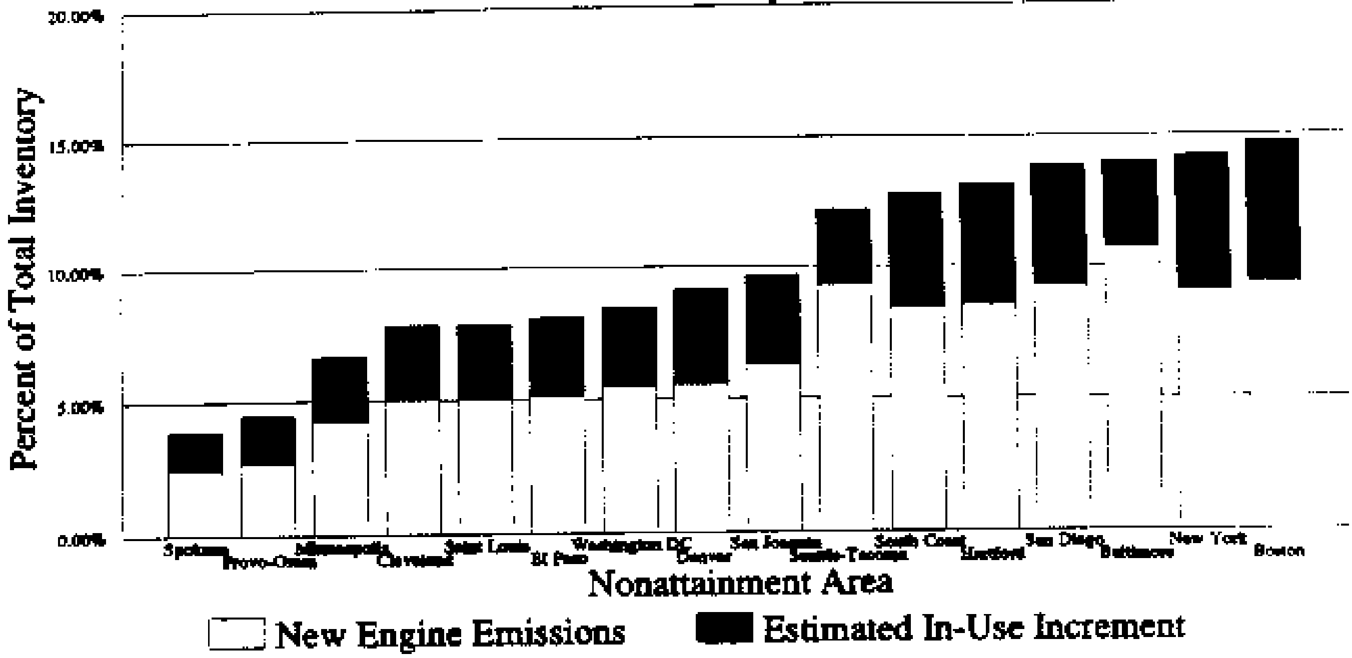
Nonroad VOC tpsd
Inventory B



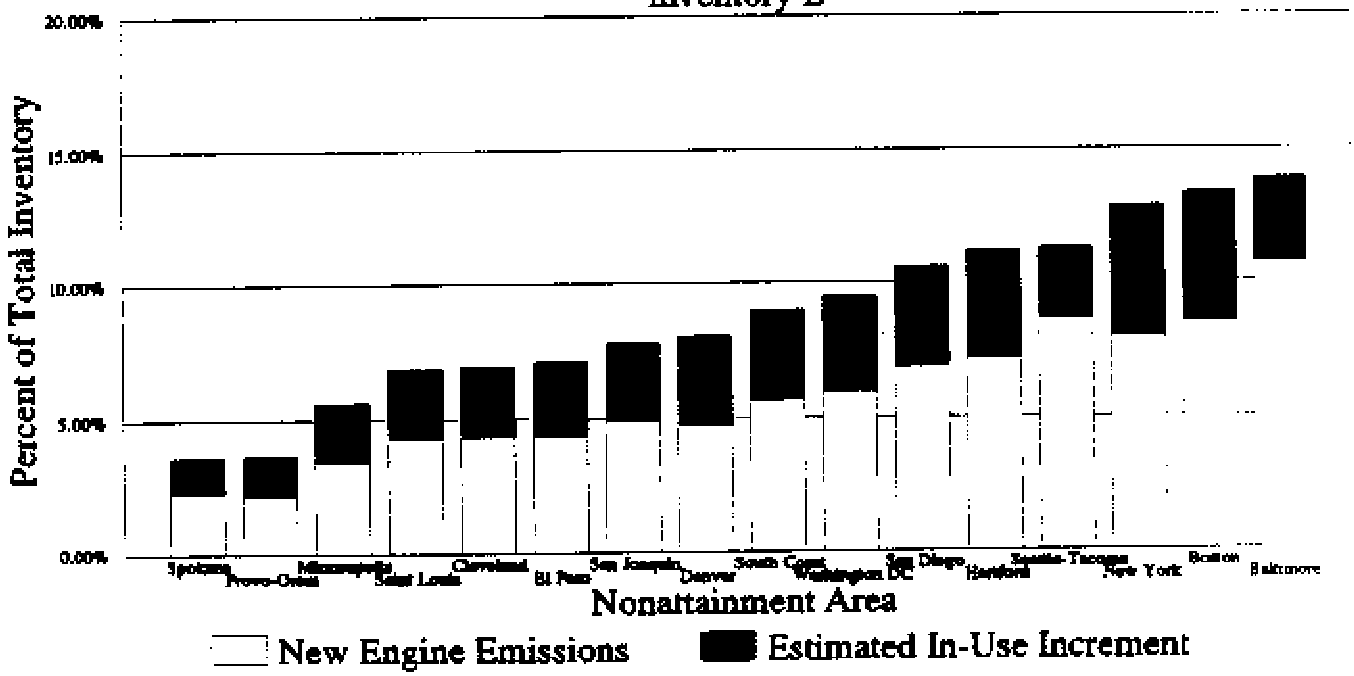

Nonroad NOx tpsd
Inventory A
40.00%
30.00%
20.00%
10.00%
0.00%
Percent of Total Inventory
Saint Louis
Baton Rouge
Atlanta
Houston
Cleveland
Springfield
Chicago
Milwaukee
Washington DC
Philadelphia
Miami
Boston
San Joaquin
Baltimore
New York
El Paso
Hartford
South Coast
San Diego
Nonattainment Area
New Engine Emissions
Estimated In-Use Increment

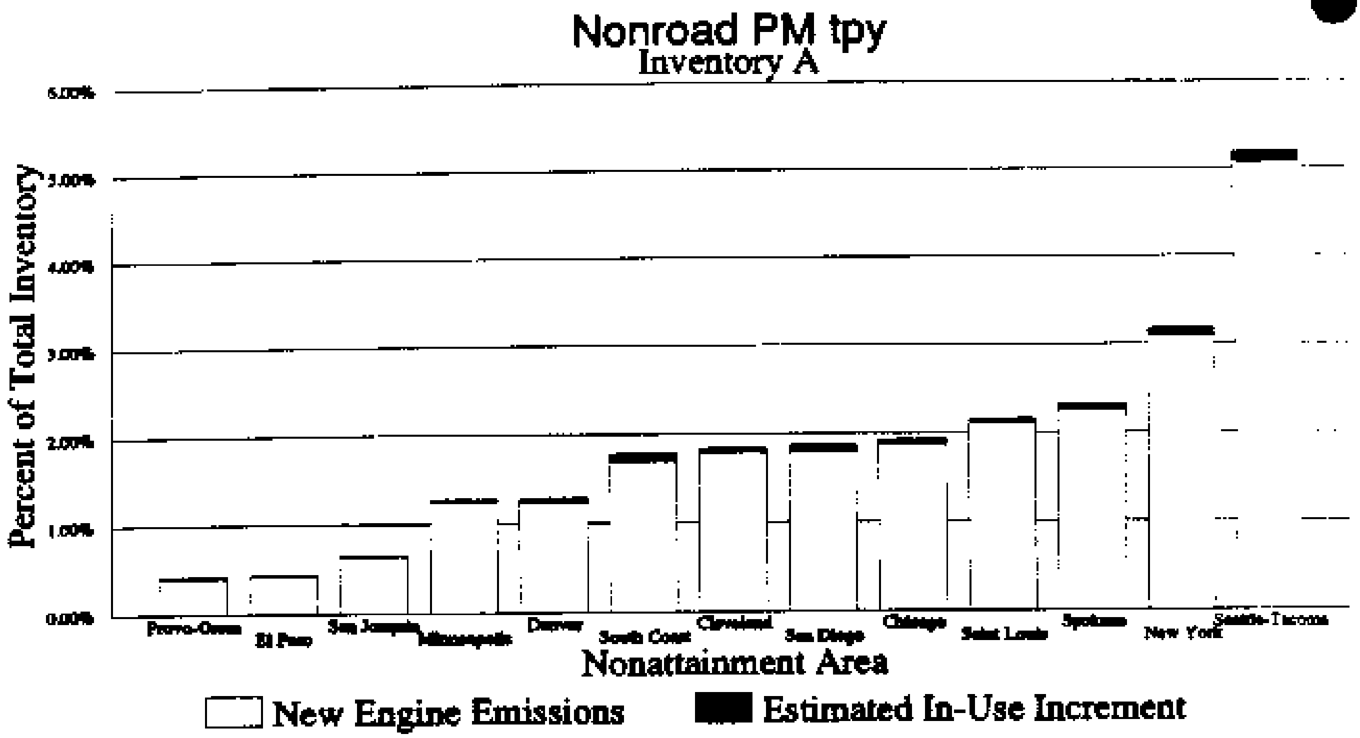

Nonroad NOx tpsd
Inventory B
40.00%
30.00%
20.00%
10.00%
0.00%
Percent of Total Inventory
Baton Rouge
Saint Louis
Houston
Cleveland
Chicago
Atlanta
Milwaukee
Washington DC
New York
Philadelphia
El Paso
Springfield
Miami
San Joaquin
Baltimore
South Coast
Boston
San Diego
Hartford
Nonattainment Area
New Engine Emissions
Estimated In-Use Increment

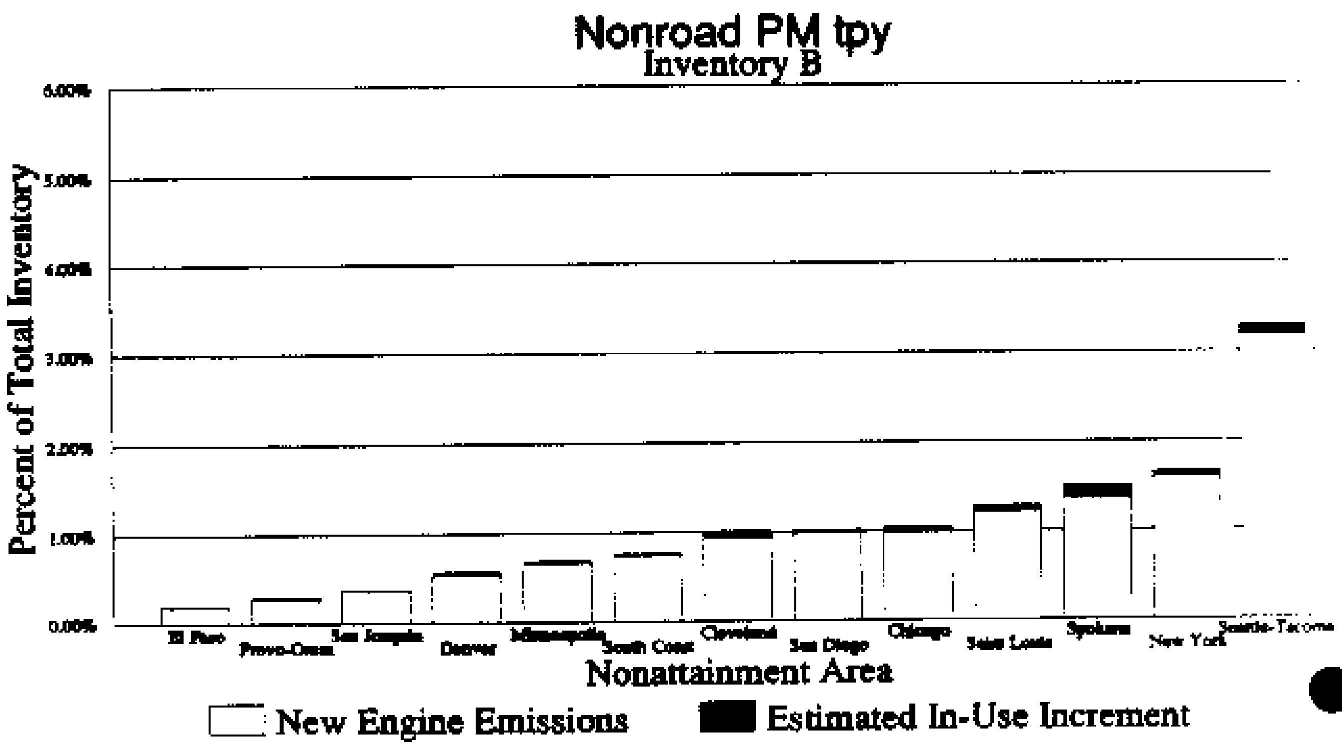
Nonroad CO tpwd
Inventory A



Nonroad CO tpwd
Inventory B

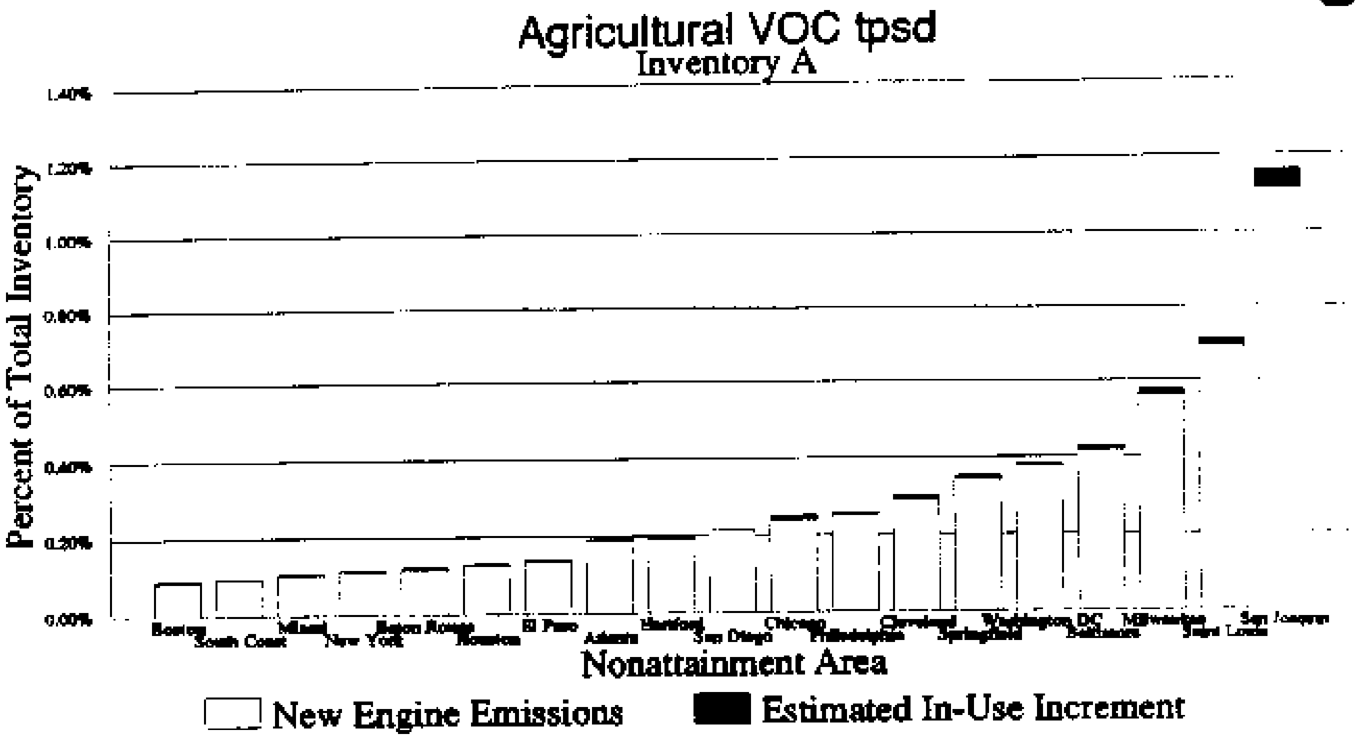


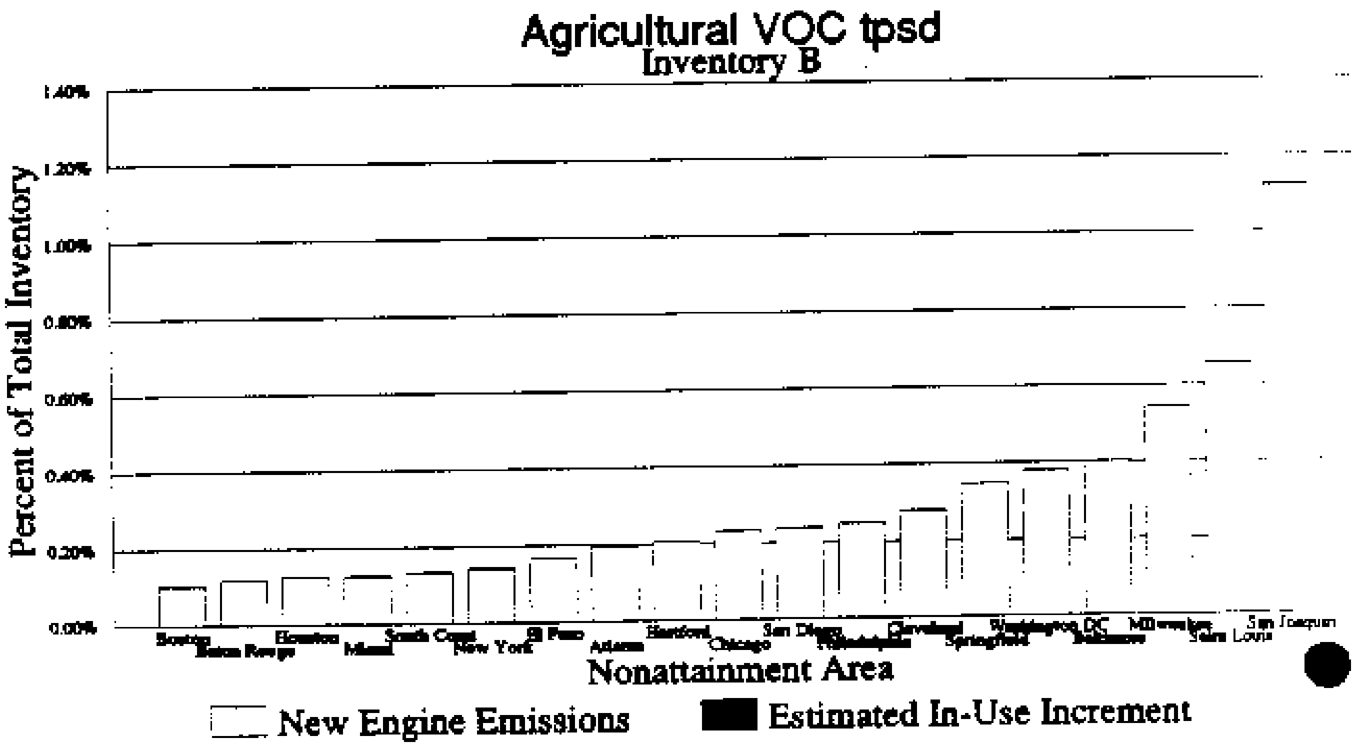

Nonroad PM tpy
Inventory A
6.00%
5.00%
4.00%
3.00%
2.00%
1.00%
0.00%
Percent of Total Inventory
Provo-Orem
El Paso
San Joaquin
Minneapolis
Denver
South Coast
Cleveland
San Diego
Chicago
Saint Louis
Spokane
New York
Seattle-Tacoma
Nonattainment Area
New Engine Emissions
Estimated In-Use Increment

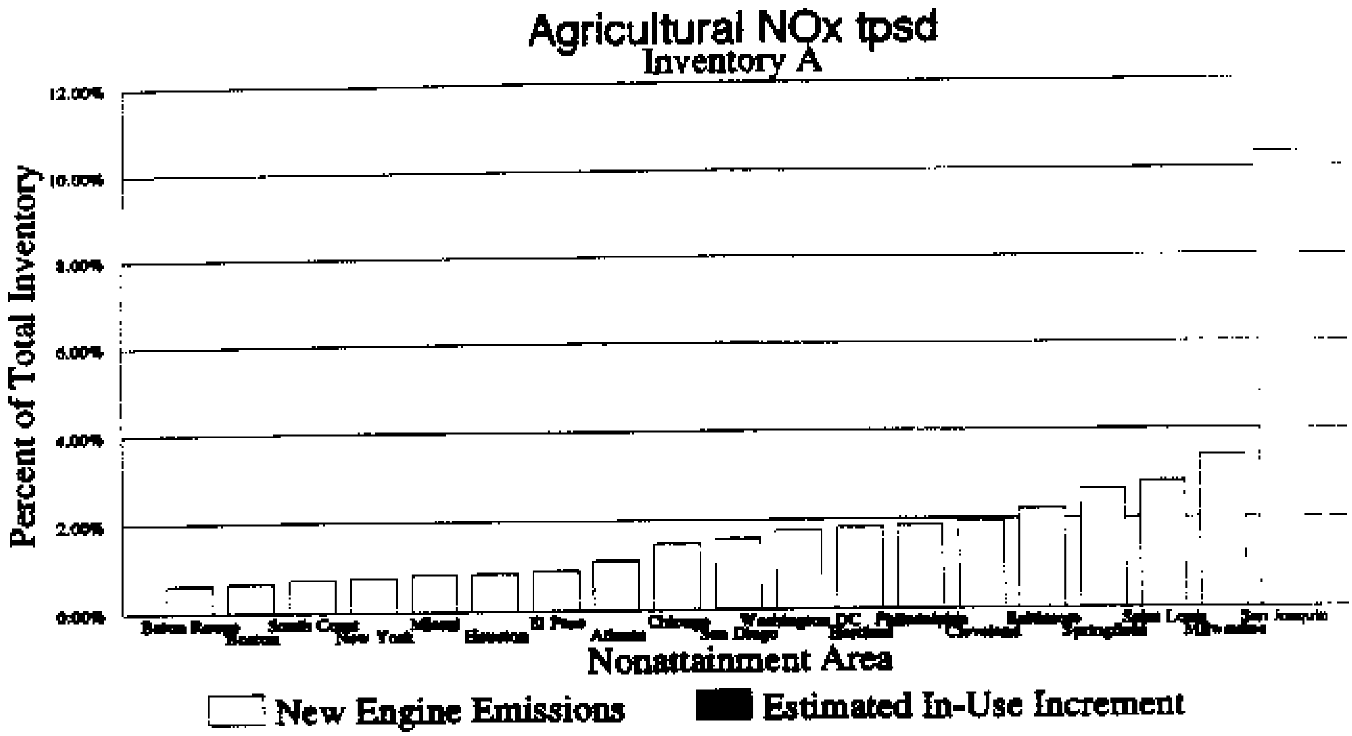

Nonroad PM tpy
Inventory B
6.00%
5.00%
4.00%
3.00%
2.00%
1.00%
0.00%
Percent of Total Inventory
El Paso
Provo-Orem
San Joaquin
Denver
Minneapolis
South Coast
Cleveland
San Diego
Chicago
Saint Louis
Spokane
New York
Seattle-Tacoma
Nonattainment Area
New Engine Emissions
Estimated In-Use Increment

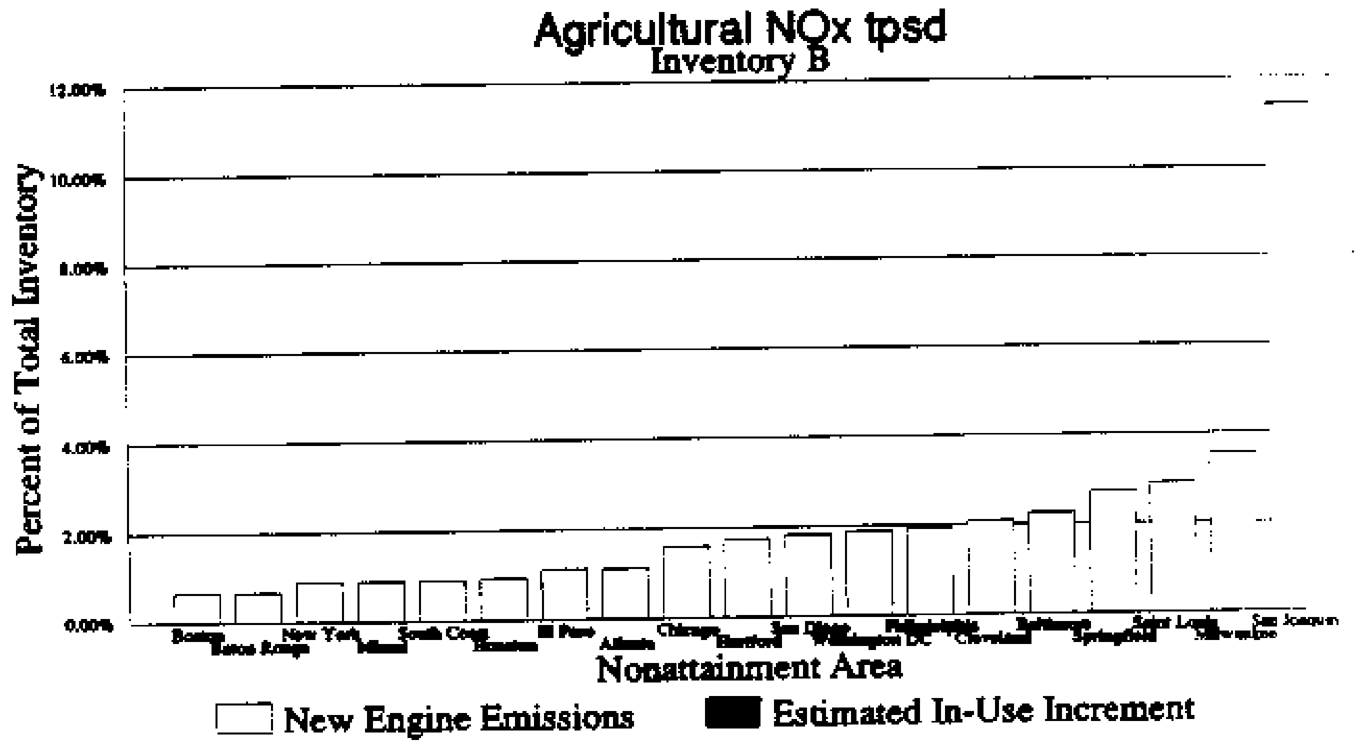
3.2. VOC, NO_X, CO, and Particulate Nonroad Inventories by Categories

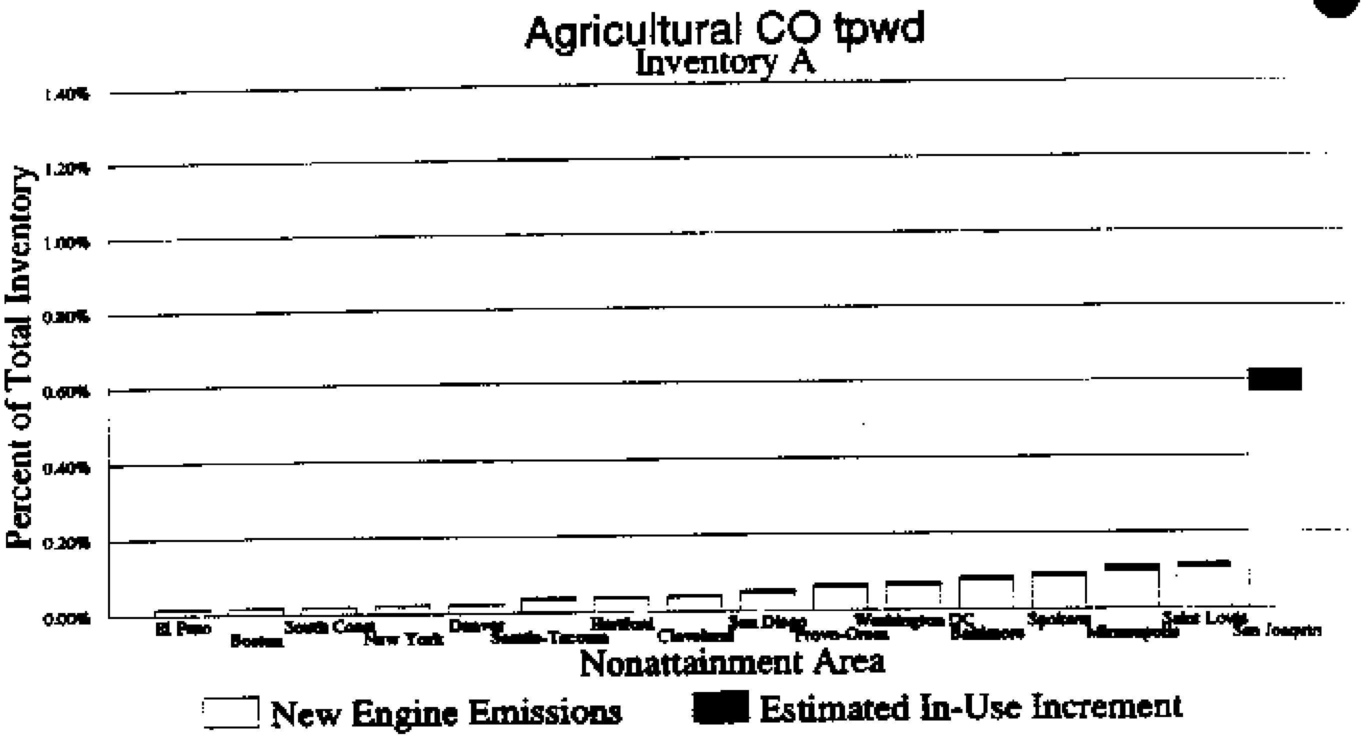
The following charts summarize the contribution of each category of nonroad equipment to total emission inventories. Each chart presents the VOC, NO_X, CO, and particulate contribution determined by each of the two inventory methods for one equipment category.

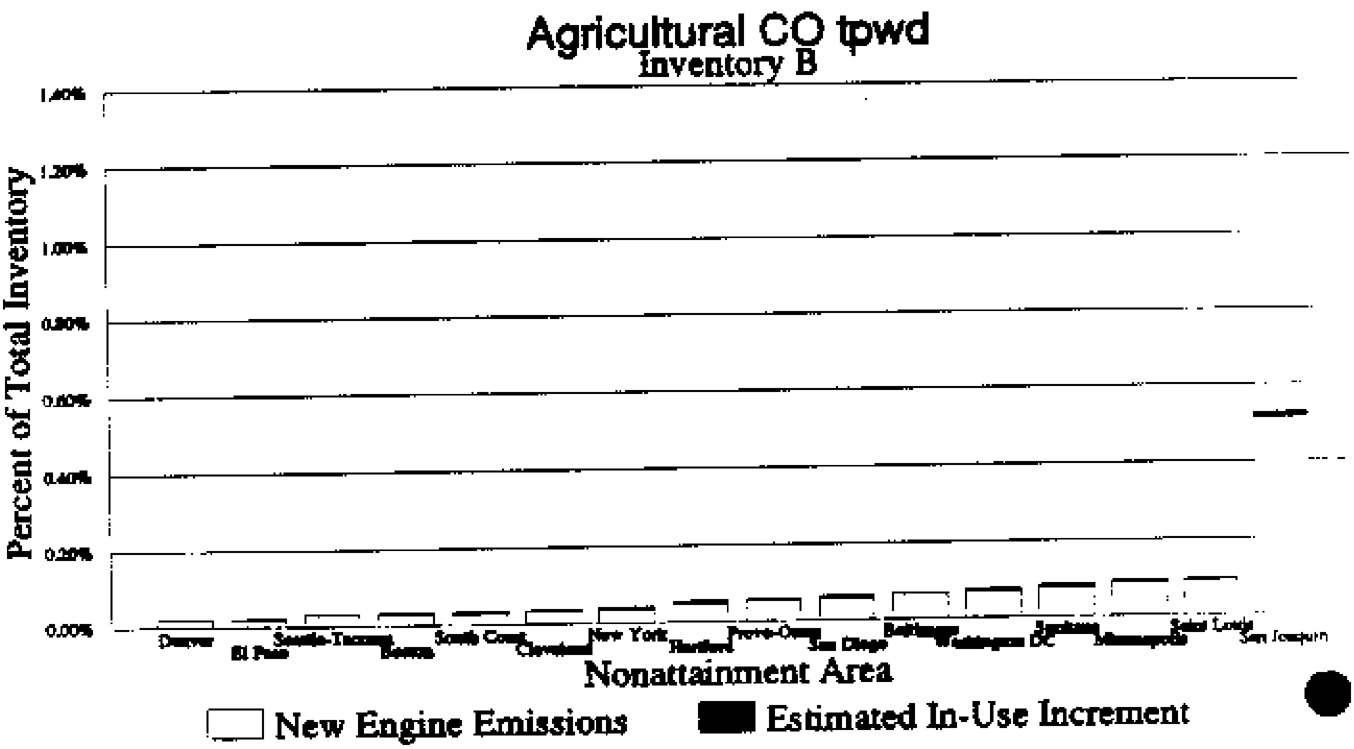

Agricultural VOC tpsd
Inventory A
1.40%
1.20%
1.00%
0.80%
0.60%
0.40%
0.20%
0.00%
Percent of Total Inventory
Boston
South Coast
Miami
New York
Baton Rouge
Houston
El Paso
Atlanta
Hartford
San Diego
Chicago
Philadelphia
Cleveland
Springfield
Washington DC
Baltimore
Milwaukee
Saint Louis
San Joaquin
Nonattainment Area
New Engine Emissions
Estimated In-Use Increment

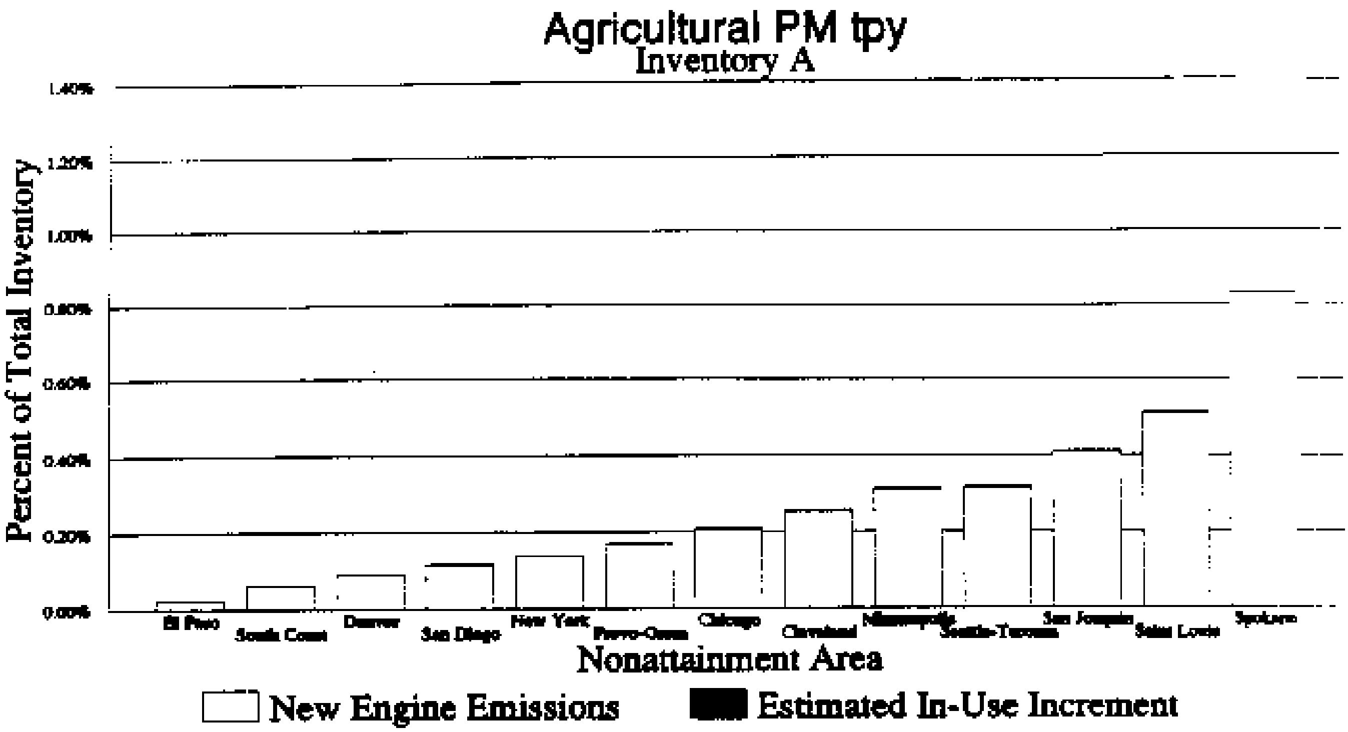

Agricultural VOC tpsd
Inventory B
1.40%
1.20%
1.00%
0.80%
0.60%
0.40%
0.20%
0.00%
Percent of Total Inventory
Boston
Baton Rouge
Houston
Miami
South Coast
New York
El Paso
Atlanta
Hartford
Chicago
San Diego
Philadelphia
Cleveland
Springfield
Washington DC
Baltimore
Milwaukee
Saint Louis
San Joaquin
Nonattainment Area
New Engine Emissions
Estimated In-Use Increment

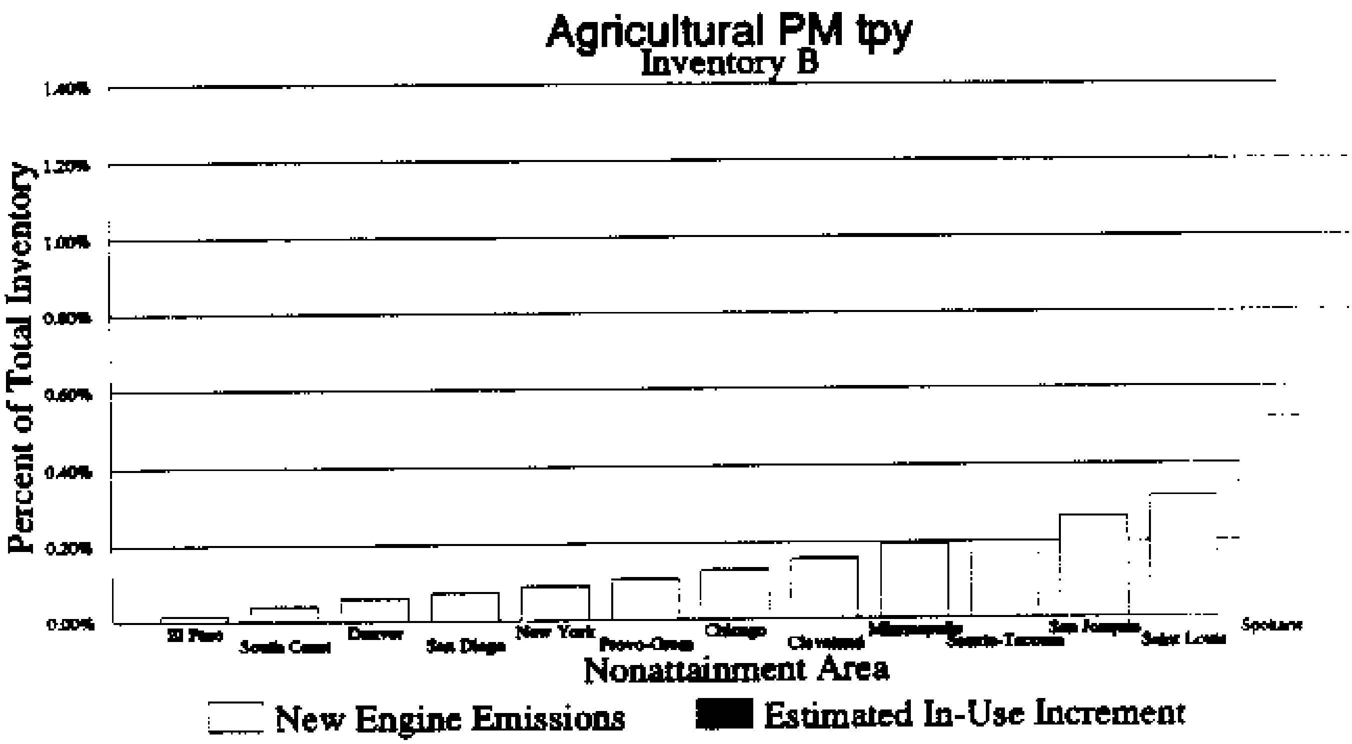

Agricultural NOx tpsd
Inventory A
12.00%
10.00%
8.00%
6.00%
4.00%
2.00%
0.00%
Percent of Total Inventory
Nonattainment Area
New Engine Emissions
Estimated In-Use Increment

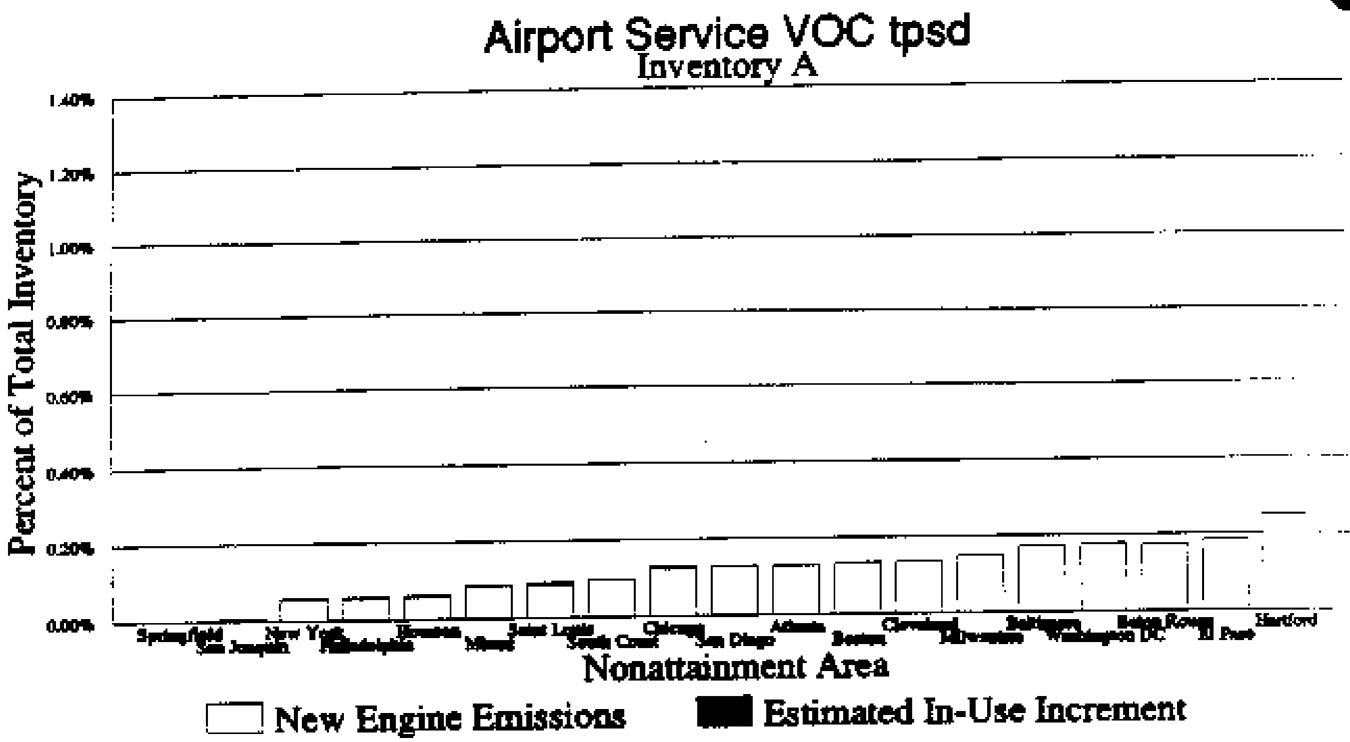

Agricultural NOx tpsd
Inventory B
12.00%
10.00%
8.00%
6.00%
4.00%
2.00%
0.00%
Percent of Total Inventory
Nonattainment Area
New Engine Emissions
Estimated In-Use Increment

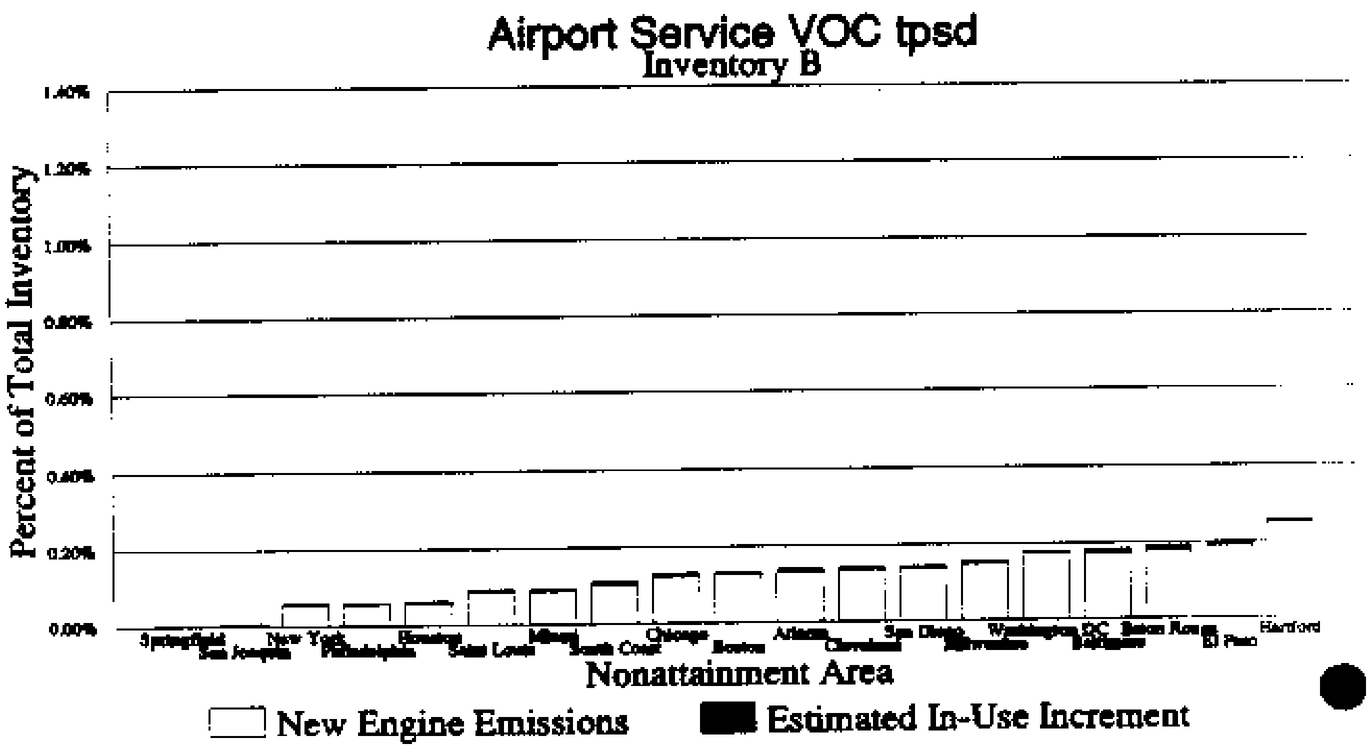

Agricultural CO tpwd
Inventory A
1.40%
1.20%
1.00%
0.80%
0.60%
0.40%
0.20%
0.00%
Percent of Total Inventory
El Paso
Boston
South Coast
New York
Denver
Seattle-Tacoma
Hartford
Cleveland
San Diego
Provo-Orem
Washington DC
Baltimore
Spokane
Minneapolis
Saint Louis
San Joaquin
Nonattainment Area
New Engine Emissions
Estimated In-Use Increment

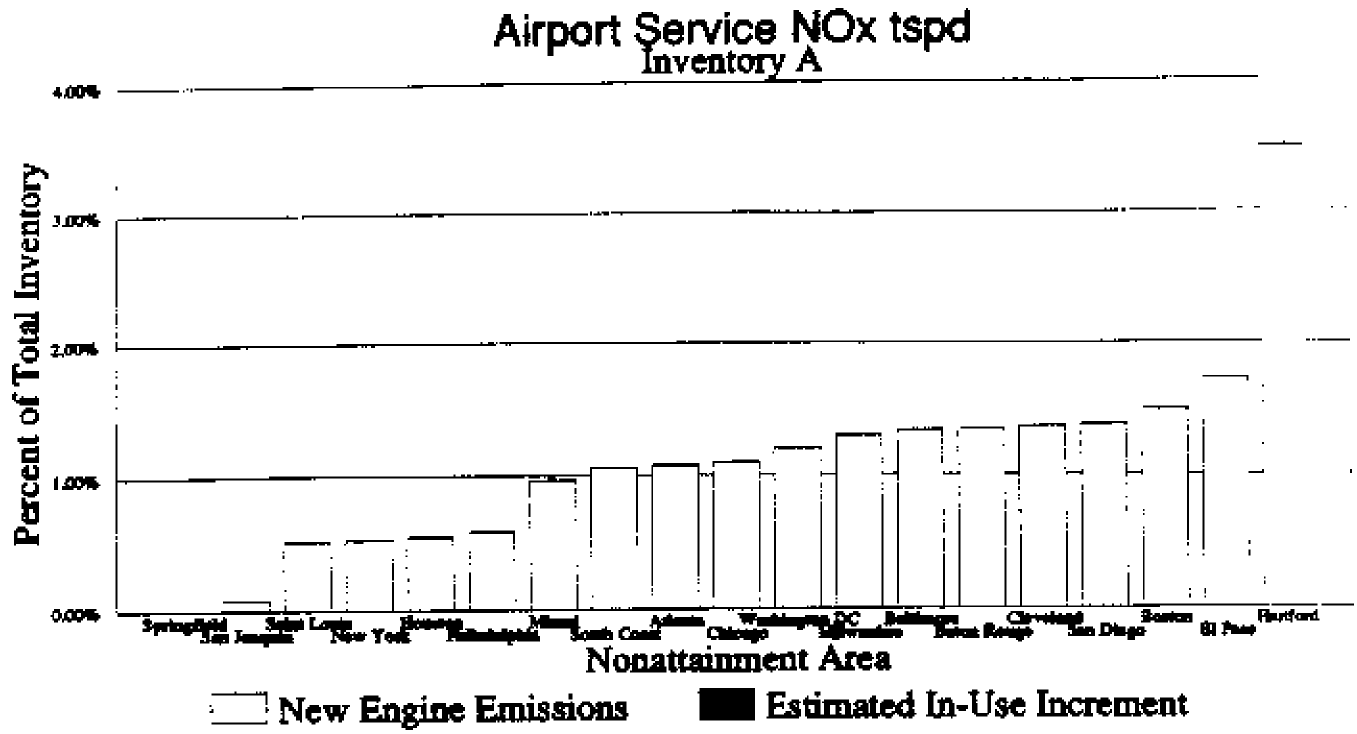

Agricultural CO tpwd
Inventory B
1.40%
1.20%
1.00%
0.80%
0.60%
0.40%
0.20%
0.00%
Percent of Total Inventory
Denver
El Paso
Seattle-Tacoma
Boston
South Coast
Cleveland
New York
Hartford
Provo-Orem
San Diego
Baltimore
Washington DC
Spokane
Minneapolis
Saint Louis
San Joaquin
Nonattainment Area
New Engine Emissions
Estimated In-Use Increment

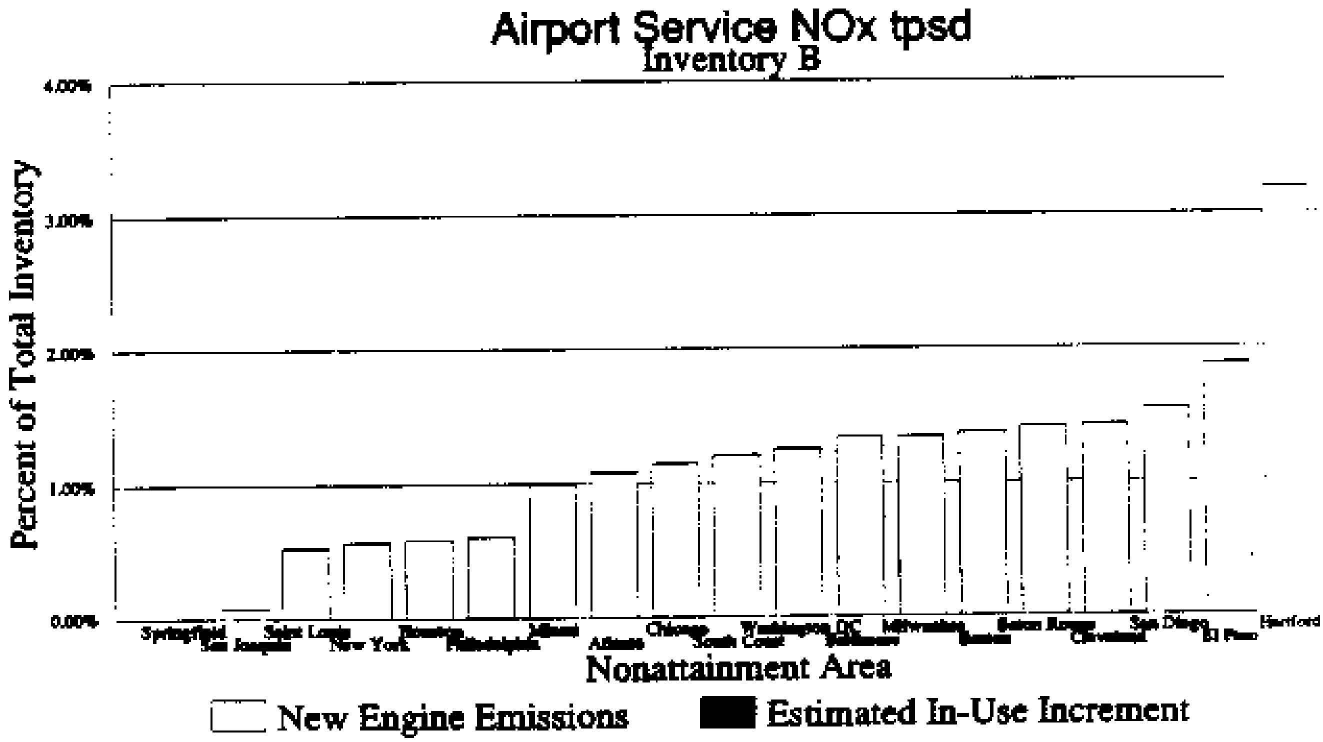

Agricultural PM tpy
Inventory A
Percent of Total Inventory
1.40%
1.20%
1.00%
0.80%
0.60%
0.40%
0.20%
0.00%
El Paso
South Coast
Denver
San Diego
New York
Provo-Orem
Chicago
Cleveland
Minneapolis
Seattle-Tacoma
San Joaquin
Saint Louis
Spokane
Nonattainment Area
New Engine Emissions
Estimated In-Use Increment

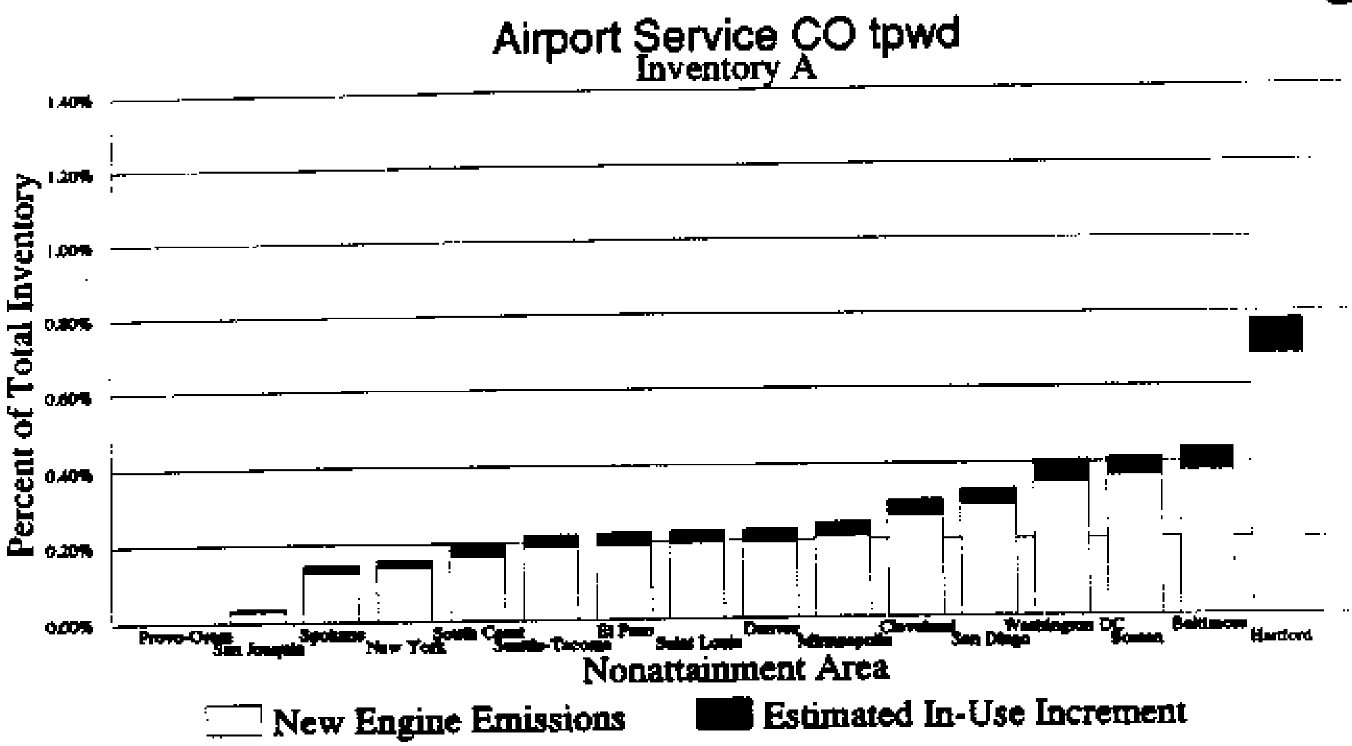

Agricultural PM tpy
Inventory B
Percent of Total Inventory
1.40%
1.20%
1.00%
0.80%
0.60%
0.40%
0.20%
0.00%
El Paso
South Coast
Denver
San Diego
New York
Provo-Orem
Chicago
Cleveland
Minneapolis
Seattle-Tacoma
San Joaquin
Saint Louis
Spokane
Nonattainment Area
New Engine Emissions
Estimated In-Use Increment

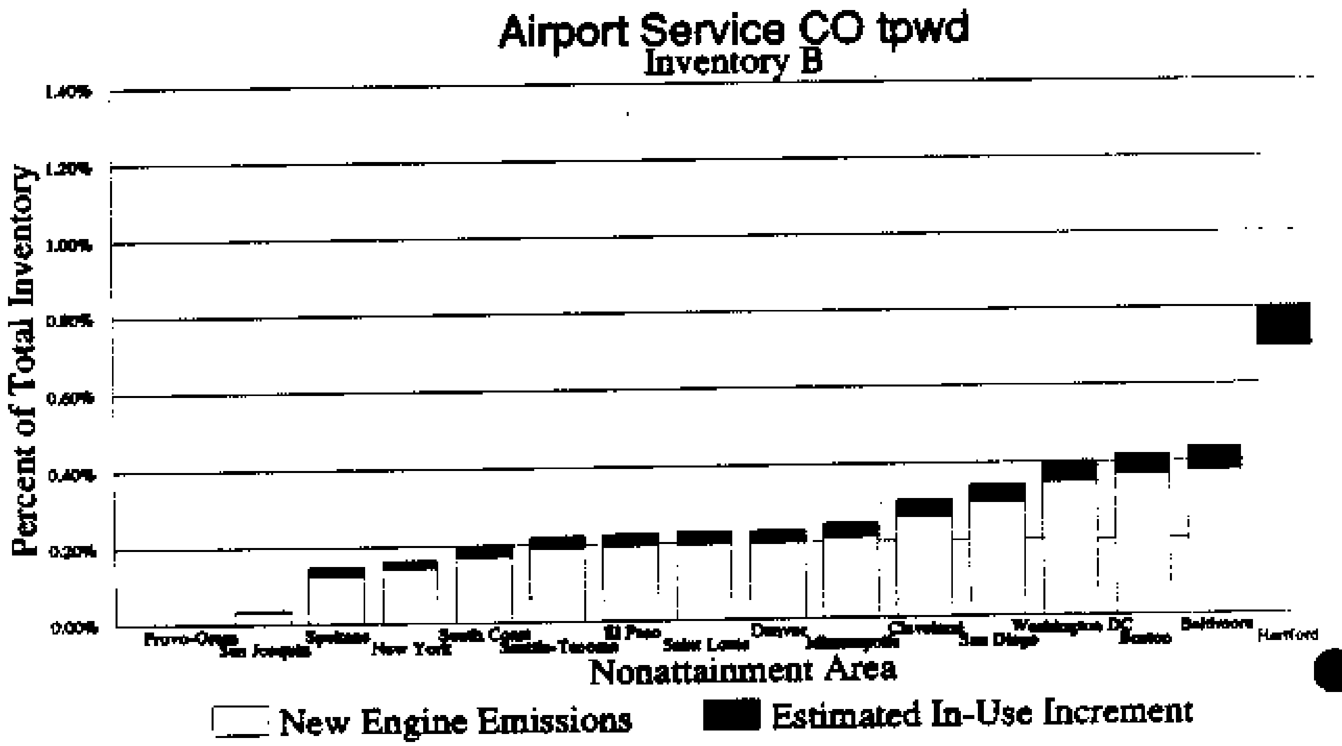

Airport Service VOC tpsd
Inventory A
1.40%
1.20%
1.00%
0.80%
0.60%
0.40%
0.20%
0.00%
Percent of Total Inventory
Springfield
San Joaquin
New York
Philadelphia
Houston
Miami
Saint Louis
South Coast
Chicago
San Diego
Atlanta
Boston
Cleveland
Milwaukee
Baltimore
Washington DC
Baton Rouge
El Paso
Hartford
Nonattainment Area
New Engine Emissions
Estimated In-Use Increment

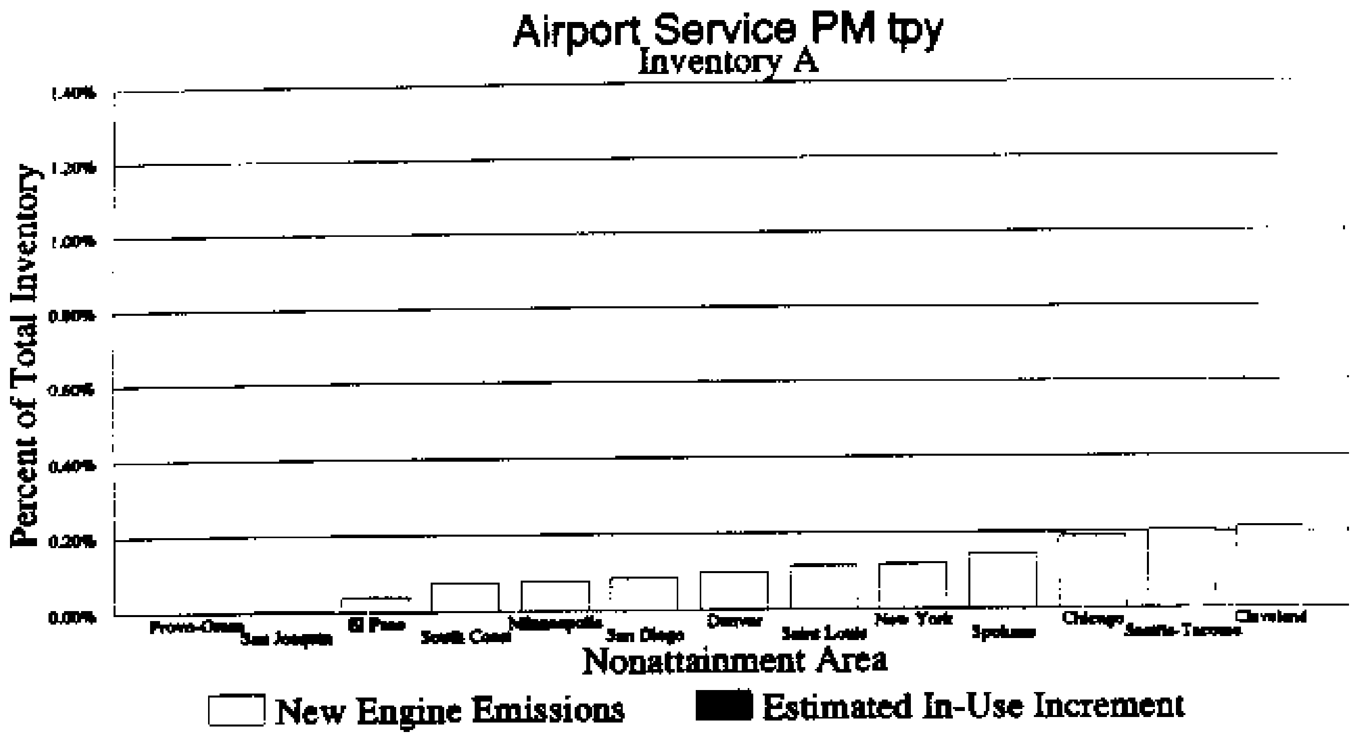

Airport Service VOC tpsd
Inventory B
1.40%
1.20%
1.00%
0.80%
0.60%
0.40%
0.20%
0.00%
Percent of Total Inventory
Springfield
San Joaquin
New York
Philadelphia
Houston
Saint Louis
Miami
South Coast
Chicago
Boston
Atlanta
Cleveland
San Diego
Milwaukee
Washington DC
Baltimore
Baton Rouge
El Paso
Hartford
Nonattainment Area
New Engine Emissions
Estimated In-Use Increment

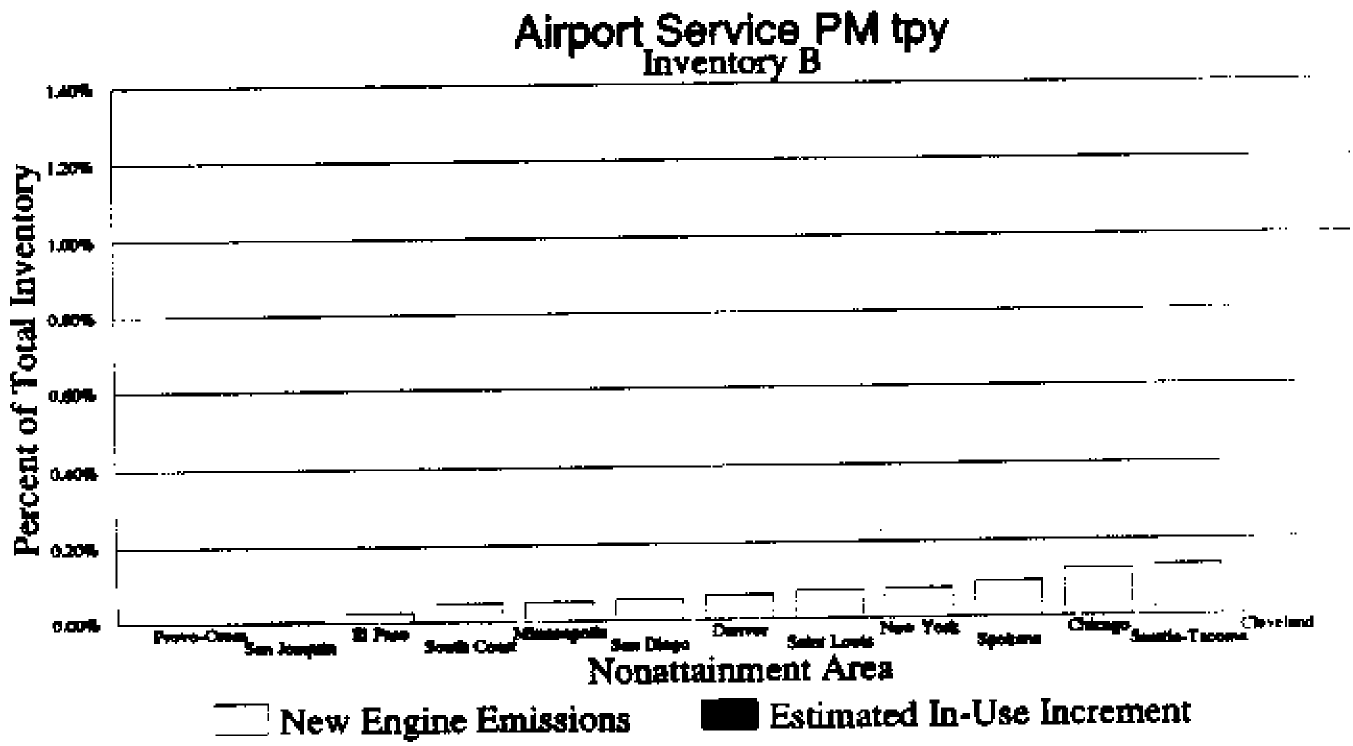

Airport Service NOx tspd
Inventory A
4.00%
3.00%
2.00%
1.00%
0.00%
Percent of Total Inventory
Springfield
San Joaquin
Saint Louis
New York
Houston
Philadelphia
Miami
South Coast
Atlanta
Chicago
Washington DC
Milwaukee
Baltimore
Baton Rouge
Cleveland
San Diego
Boston
El Paso
Hartford
Nonattainment Area
New Engine Emissions
Estimated In-Use Increment

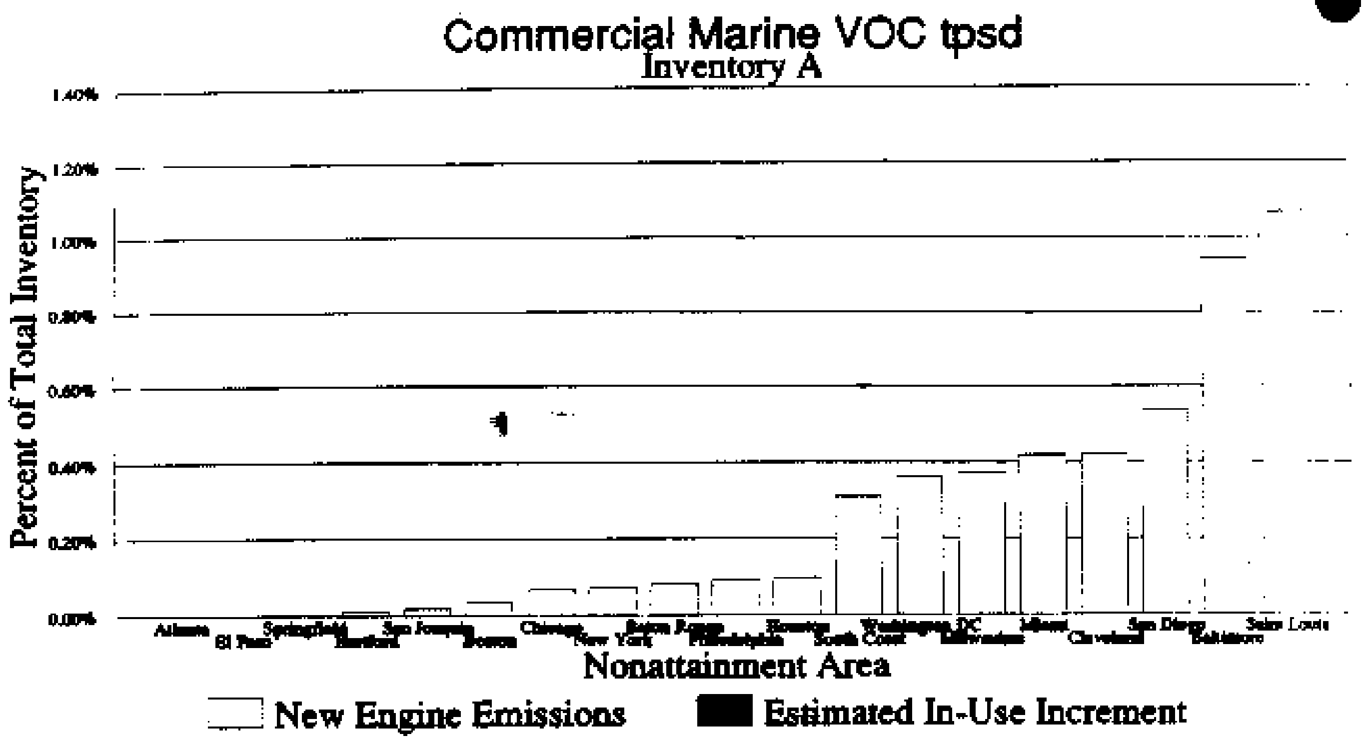

Airport Service NOx tpsd
Inventory B
4.00%
3.00%
2.00%
1.00%
0.00%
Percent of Total Inventory
Springfield
San Joaquin
Saint Louis
New York
Houston
Philadelphia
Miami
Atlanta
Chicago
South Coast
Washington DC
Baltimore
Milwaukee
Boston
Baton Rouge
Cleveland
San Diego
El Paso
Hartford
Nonattainment Area
New Engine Emissions
Estimated In-Use Increment

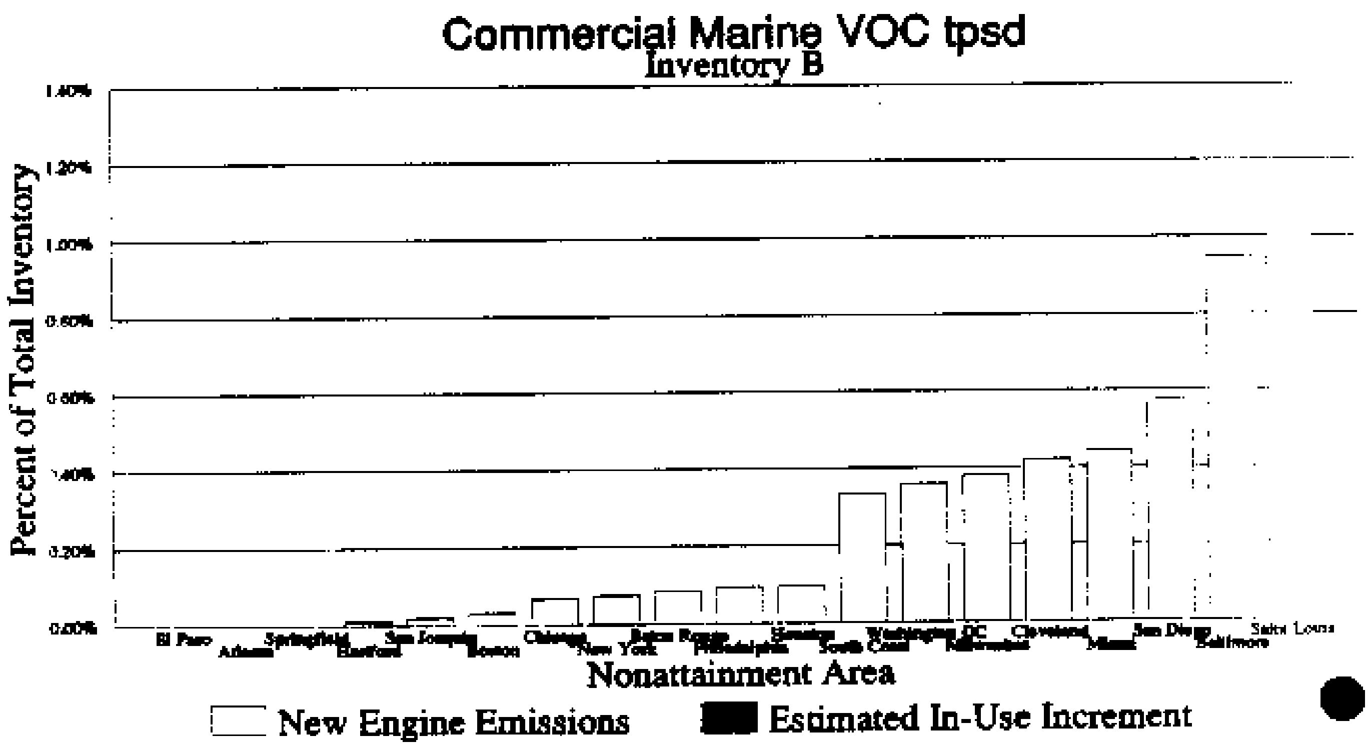

Airport Service CO tpwd
Inventory A
1.40%
1.20%
1.00%
0.80%
0.60%
0.40%
0.20%
0.00%
Percent of Total Inventory
Provo-Orem
San Joaquin
Spokane
New York
South Coast
Seattle-Tacoma
El Paso
Saint Louis
Denver
Minneapolis
Cleveland
San Diego
Washington DC
Boston
Baltimore
Hartford
Nonattainment Area
New Engine Emissions
Estimated In-Use Increment

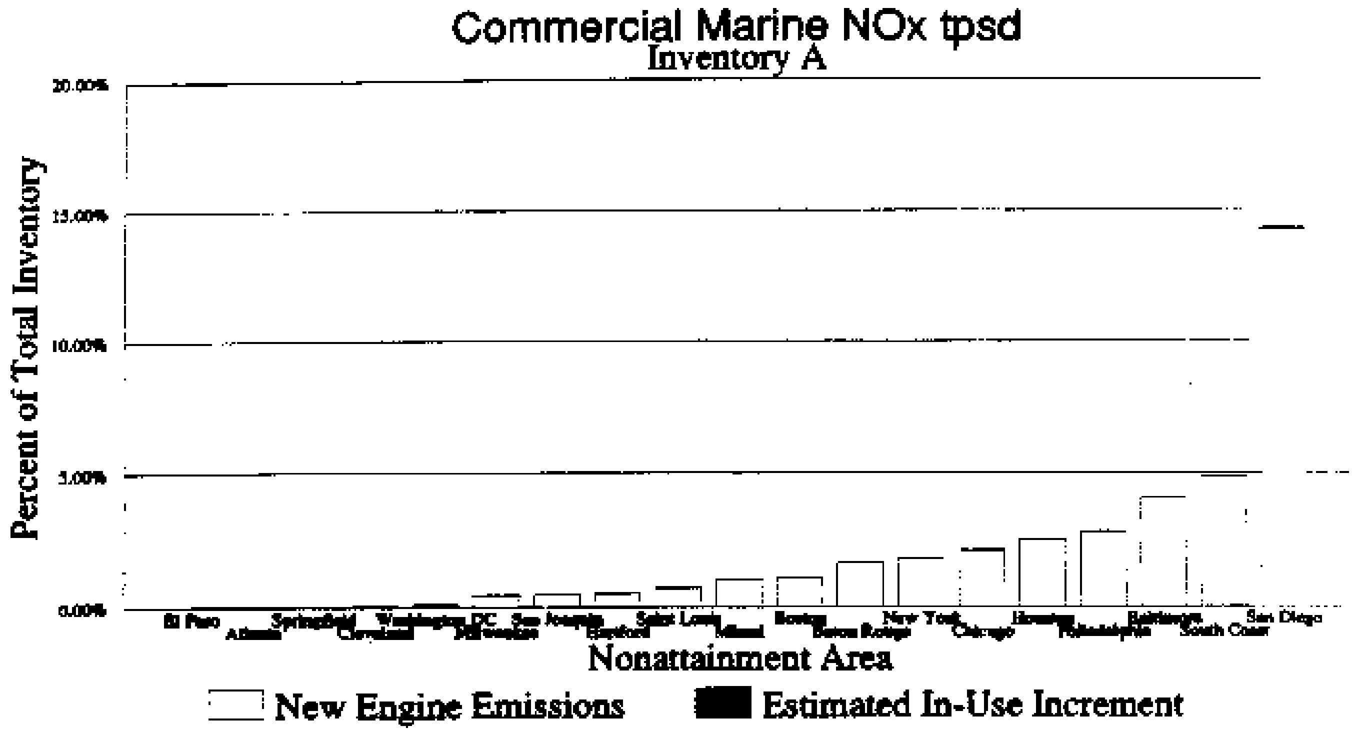

Airport Service CO tpwd
Inventory B
1.40%
1.20%
1.00%
0.80%
0.60%
0.40%
0.20%
0.00%
Percent of Total Inventory
Provo-Orem
San Joaquin
Spokane
New York
South Coast
Seattle-Tacoma
El Paso
Saint Louis
Denver
Minneapolis
Cleveland
San Diego
Washington DC
Boston
Baltimore
Hartford
Nonattainment Area
New Engine Emissions
Estimated In-Use Increment

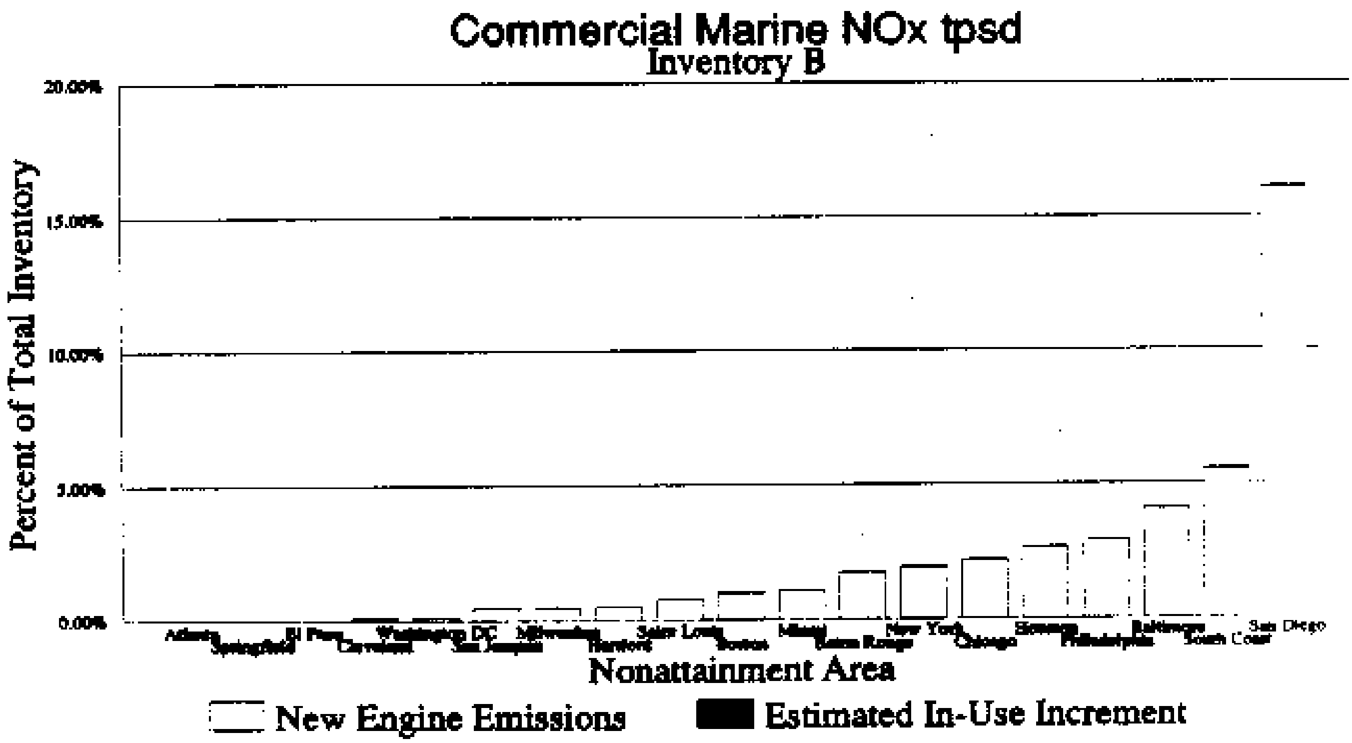

Airport Service PM tpy
Inventory A
Percent of Total Inventory
1.40%
1.20%
1.00%
0.80%
0.60%
0.40%
0.20%
0.00%
Provo-Orem
San Joaquin
El Paso
South Coast
Minneapolis
San Diego
Denver
Saint Louis
New York
Spokane
Chicago
Seattle-Tacoma
Cleveland
Nonattainment Area
New Engine Emissions
Estimated In-Use Increment

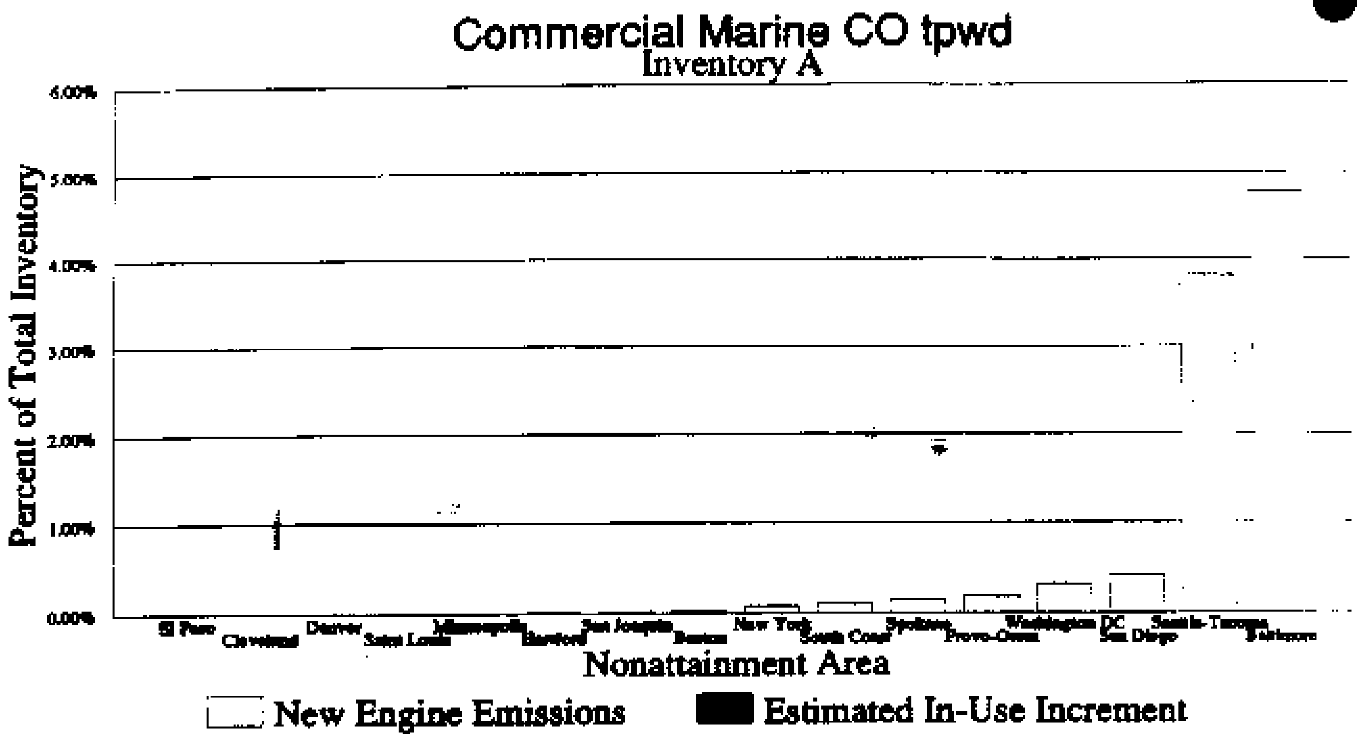

Airport Service PM tpy
Inventory B
Percent of Total Inventory
1.40%
1.20%
1.00%
0.80%
0.60%
0.40%
0.20%
0.00%
Provo-Orem
San Joaquin
El Paso
South Coast
Minneapolis
San Diego
Denver
Saint Louis
New York
Spokane
Chicago
Seattle-Tacoma
Cleveland
Nonattainment Area
New Engine Emissions
Estimated In-Use Increment

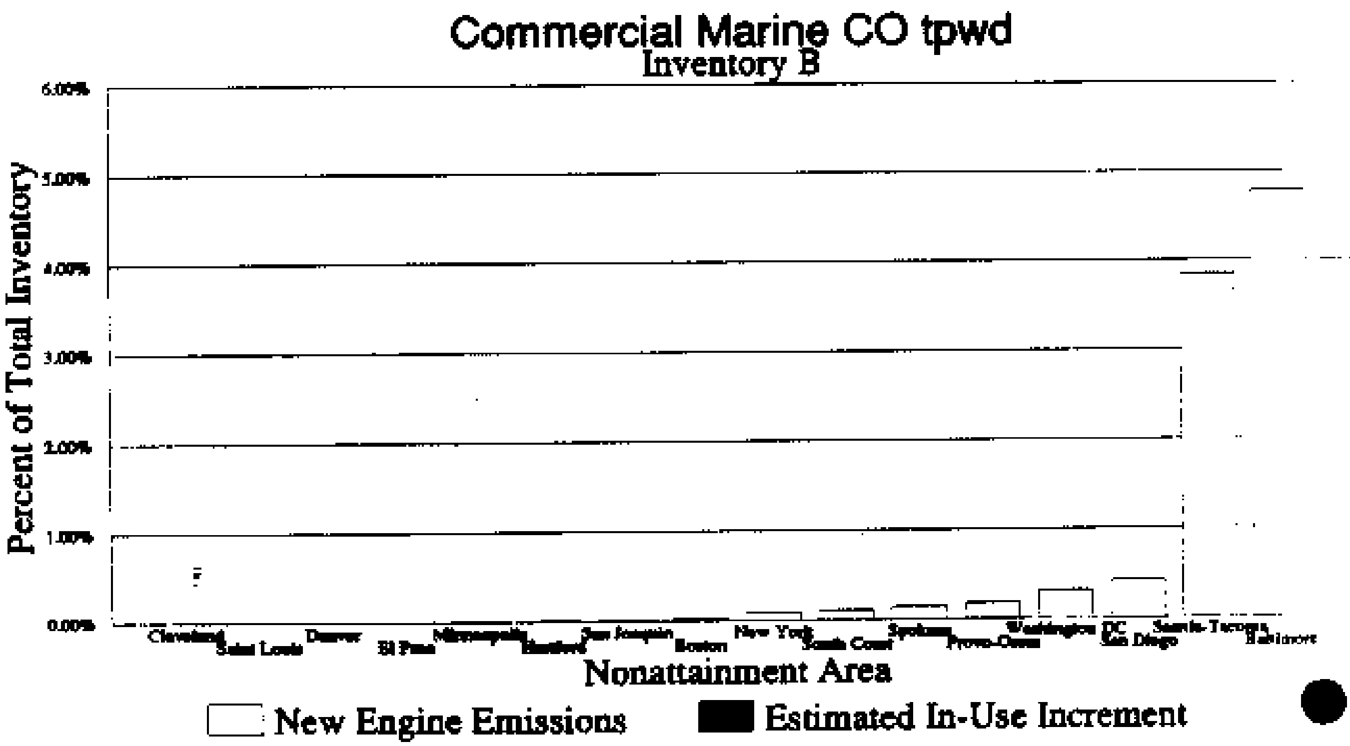

Commercial Marine VOC tpsd
Inventory A
Percent of Total Inventory
1.40%
1.20%
1.00%
0.80%
0.60%
0.40%
0.20%
0.00%
Nonattainment Area
New Engine Emissions
Estimated In-Use Increment
Saint Louis

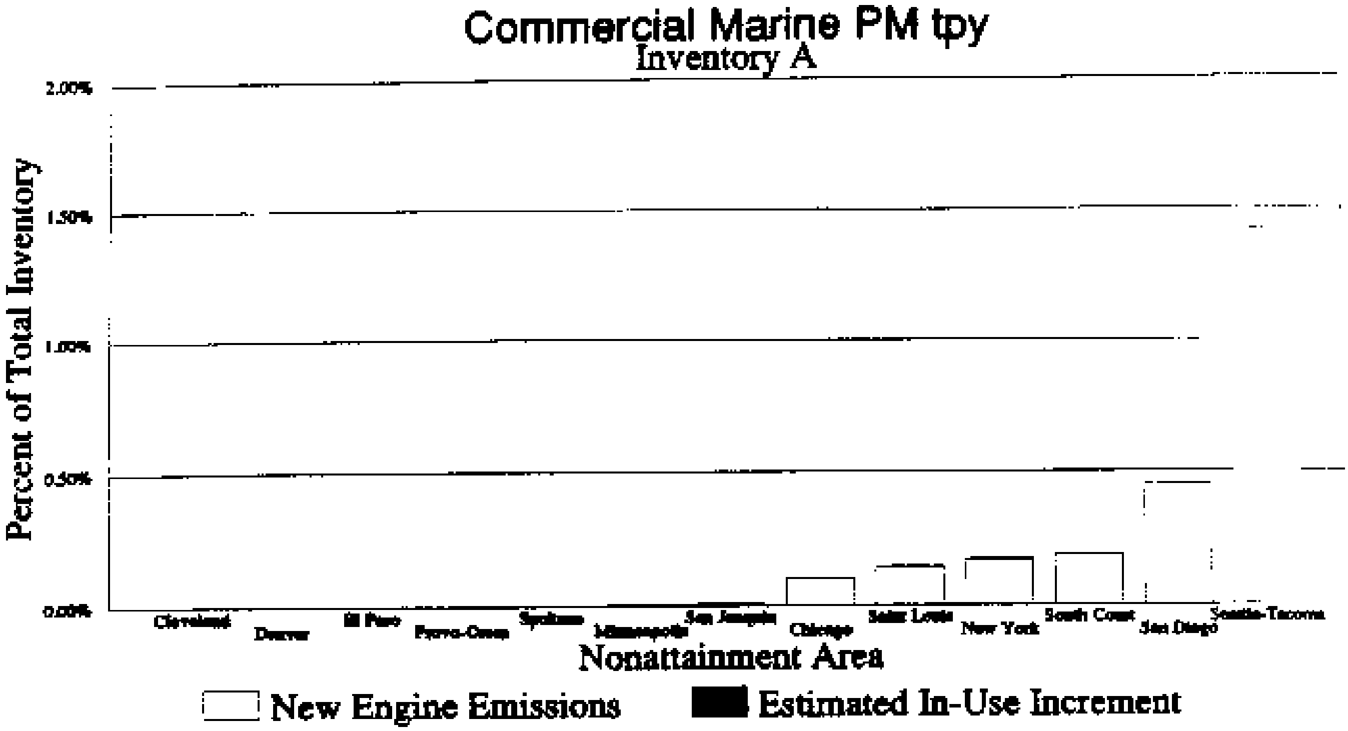

Commercial Marine VOC tpsd
Inventory B
Percent of Total Inventory
1.40%
1.20%
1.00%
0.00%
Nonattainment Area
New Engine Emissions
Estimated In-Use Increment
Saint Louis

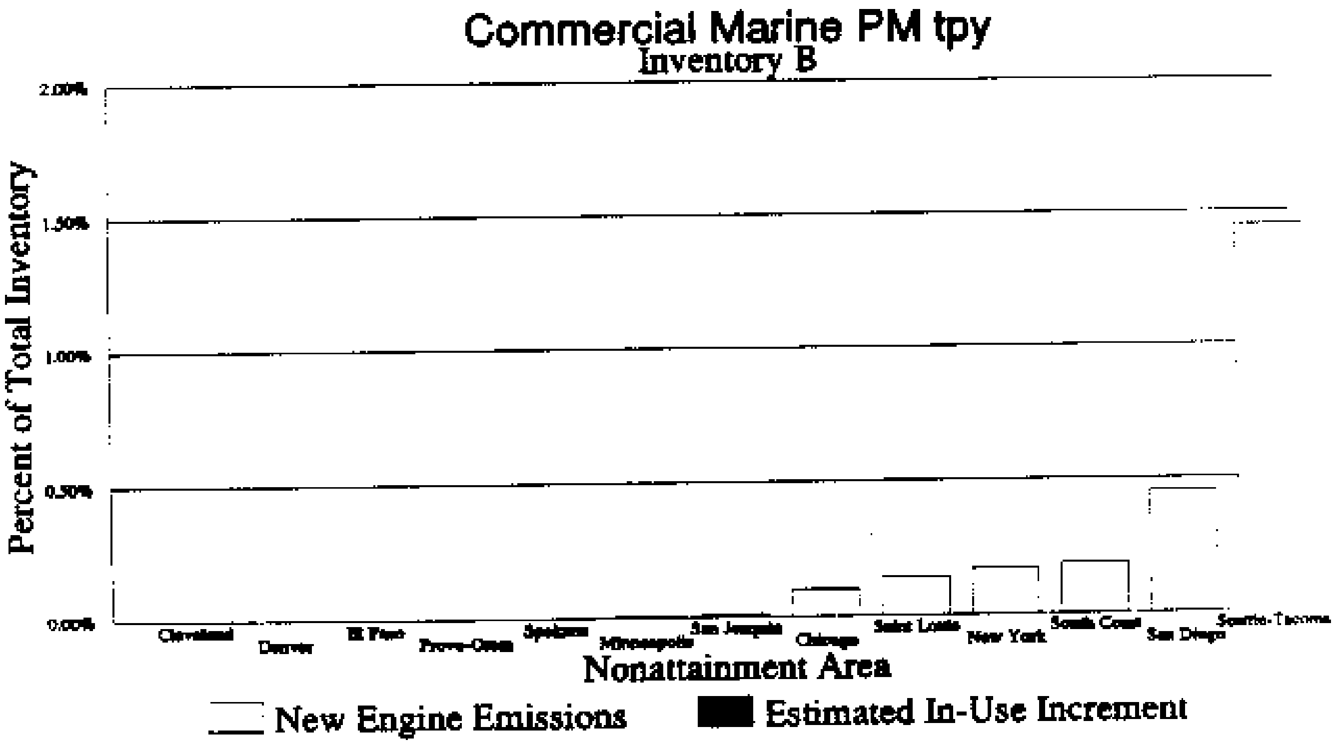

Commercial Marine NOx tpsd
Inventory A
20.00%
15.00%
10.00%
5.00%
0.00%
Percent of Total Inventory
Nonattainment Area
New Engine Emissions
Estimated In-Use Increment

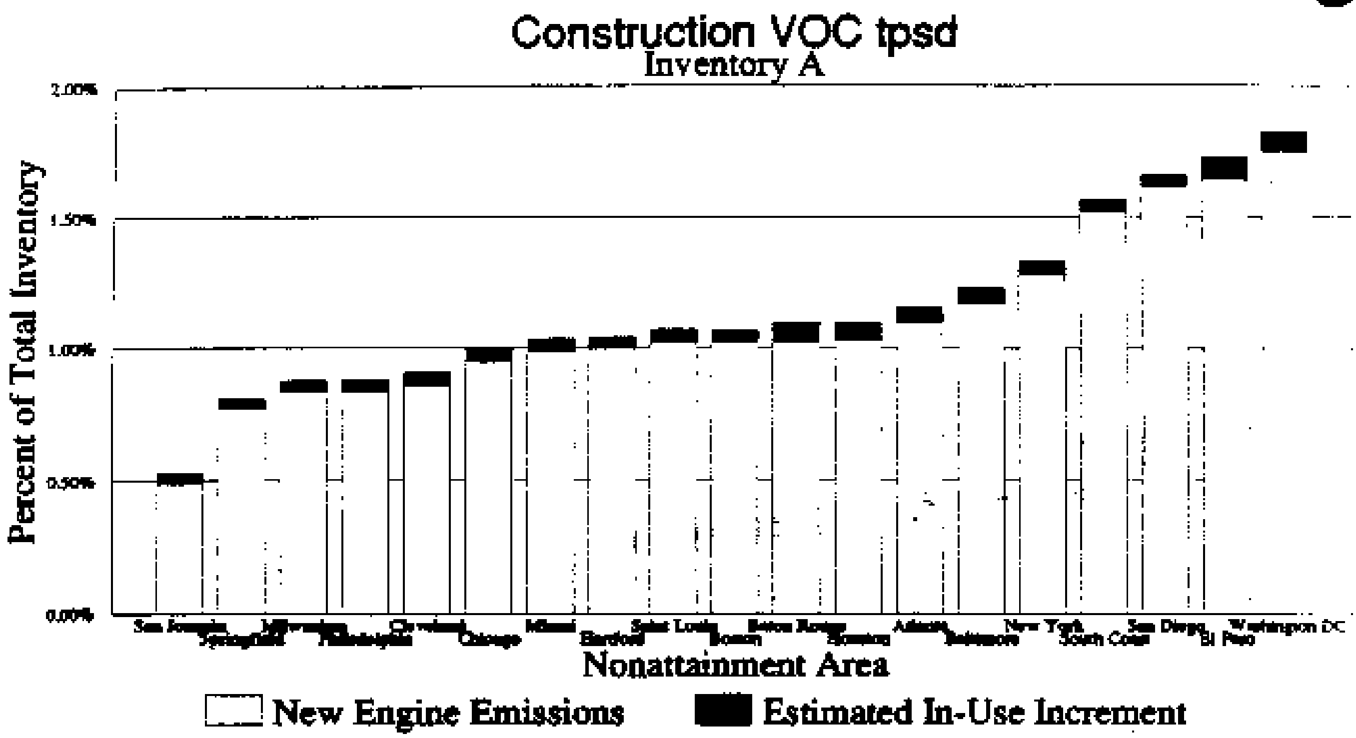

Commercial Marine NOx tpsd
Inventory B
20.00%
15.00%
10.00%
5.00%
0.00%
Percent of Total Inventory
Nonattainment Area
New Engine Emissions
Estimated In-Use Increment

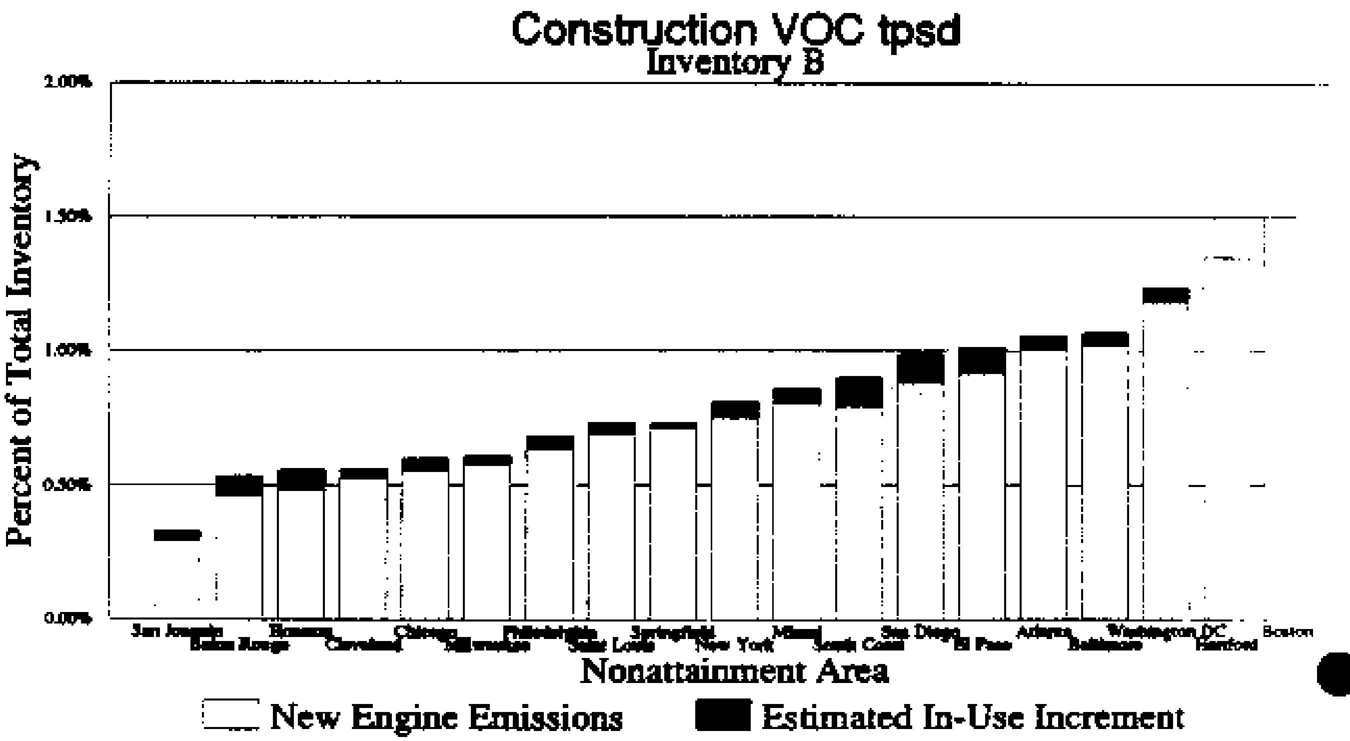

Commercial Marine CO tpwd
Inventory A
Percent of Total Inventory
6.00%
5.00%
4.00%
3.00%
2.00%
1.00%
0.00%
El Paso
Cleveland
Denver
Saint Louis
Minneapolis
Hartford
San Joaquin
Boston
New York
South Coast
Spokane
Provo-Orem
Washington DC
San Diego
Seattle-Tacoma
Baltimore
Nonattainment Area
New Engine Emissions
Estimated In-Use Increment


Commercial Marine CO tpwd
Inventory B
Percent of Total Inventory
6.00%
5.00%
4.00%
3.00%
2.00%
1.00%
0.00%
Cleveland
Saint Louis
Denver
El Paso
Minneapolis
Hartford
San Joaquin
Boston
New York
South Coast
Spokane
Provo-Orem
Washington DC
San Diego
Seattle-Tacoma
Baltimore
Nonattainment Area
New Engine Emissions
Estimated In-Use Increment

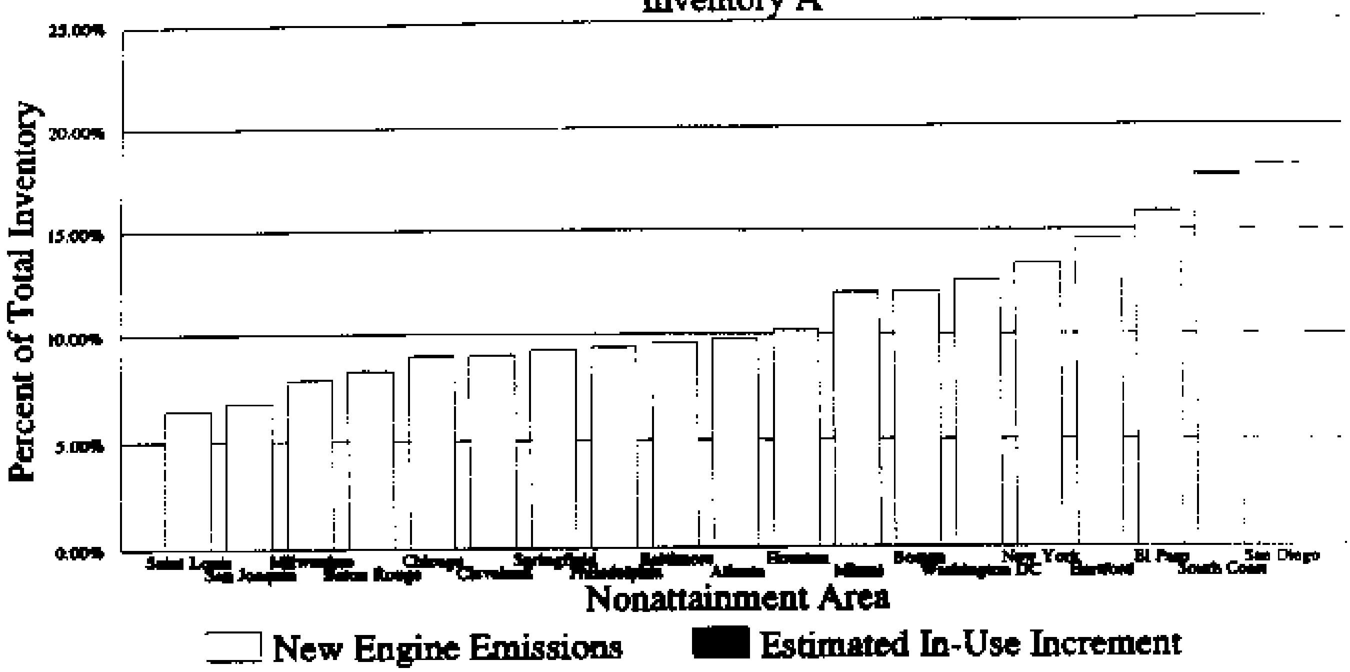

Commercial Marine PM tpy
Inventory A
2.00%
1.50%
1.00%
0.50%
0.00%
Percent of Total Inventory
Cleveland
Denver
El Paso
Provo-Orem
Spokane
Minneapolis
San Joaquin
Chicago
Saint Louis
New York
South Coast
San Diego
Seattle-Tacoma
Nonattainment Area
New Engine Emissions
Estimated In-Use Increment


Commercial Marine PM tpy
Inventory B
2.00%
1.50%
1.00%
0.50%
0.00%
Percent of Total Inventory
Cleveland
Denver
El Paso
Provo-Orem
Spokane
Minneapolis
San Joaquin
Chicago
Saint Louis
New York
South Coast
San Diego
Seattle-Tacoma
Nonattainment Area
New Engine Emissions
Estimated In-Use Increment

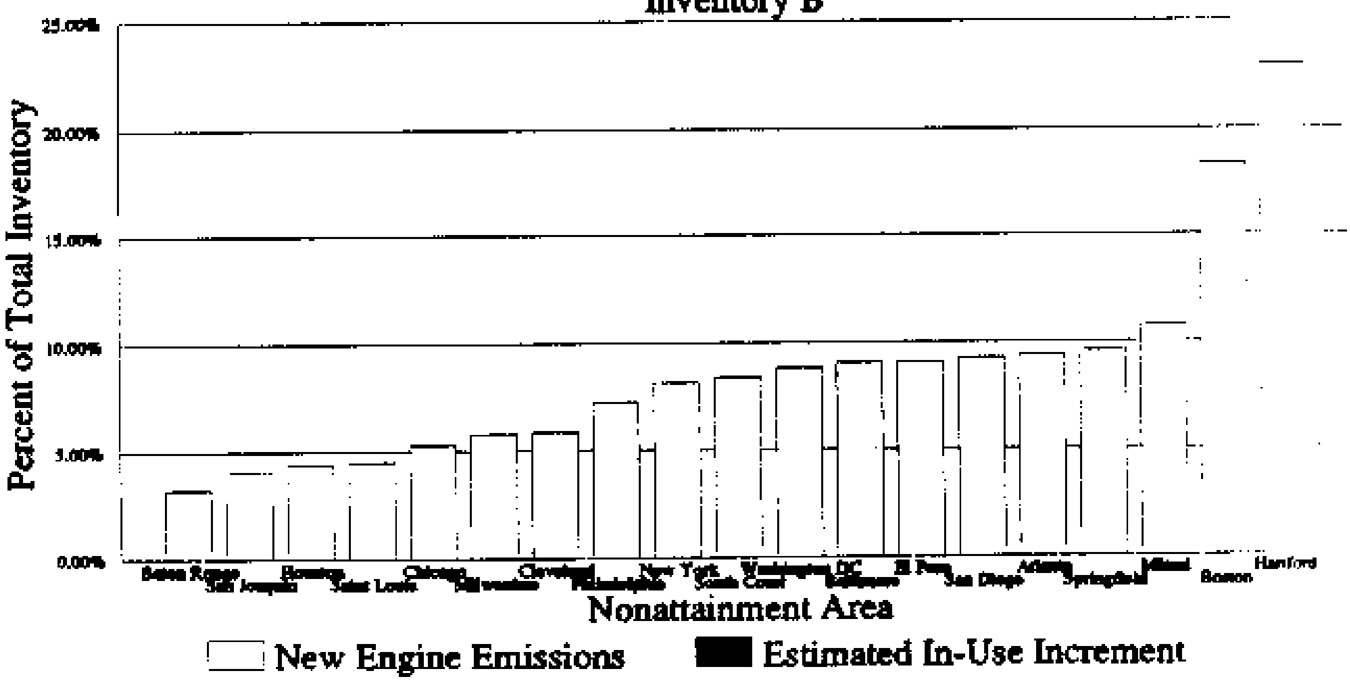

Construction VOC tpsd
Inventory A
2.00%
1.50%
1.00%
0.50%
0.00%
Percent of Total Inventory
Nonattainment Area
New York
South Coast
El Paso
Washington DC
New Engine Emissions
Estimated In-Use Increment


Construction VOC tpsd
Inventory B
2.00%
1.50%
1.00%
0.50%
0.00%
Percent of Total Inventory
Nonattainment Area
New York
Boston
New Engine Emissions
Estimated In-Use Increment

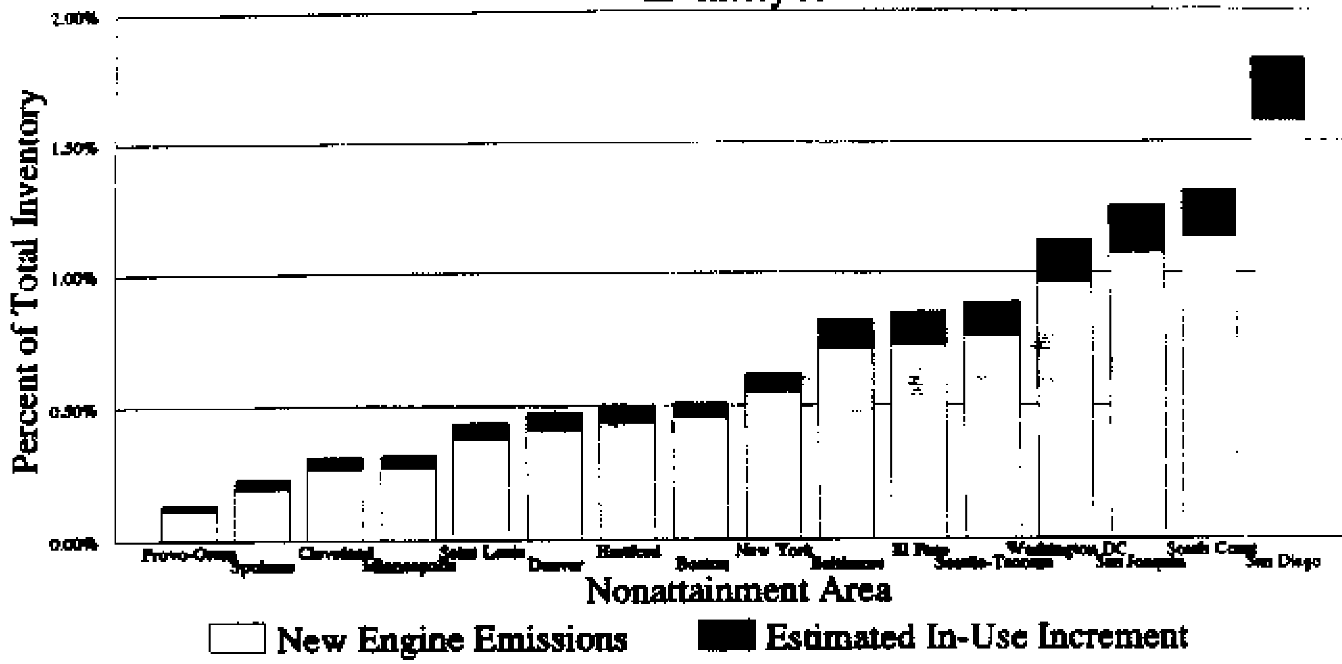
Construction NOx tpsd
Inventory A



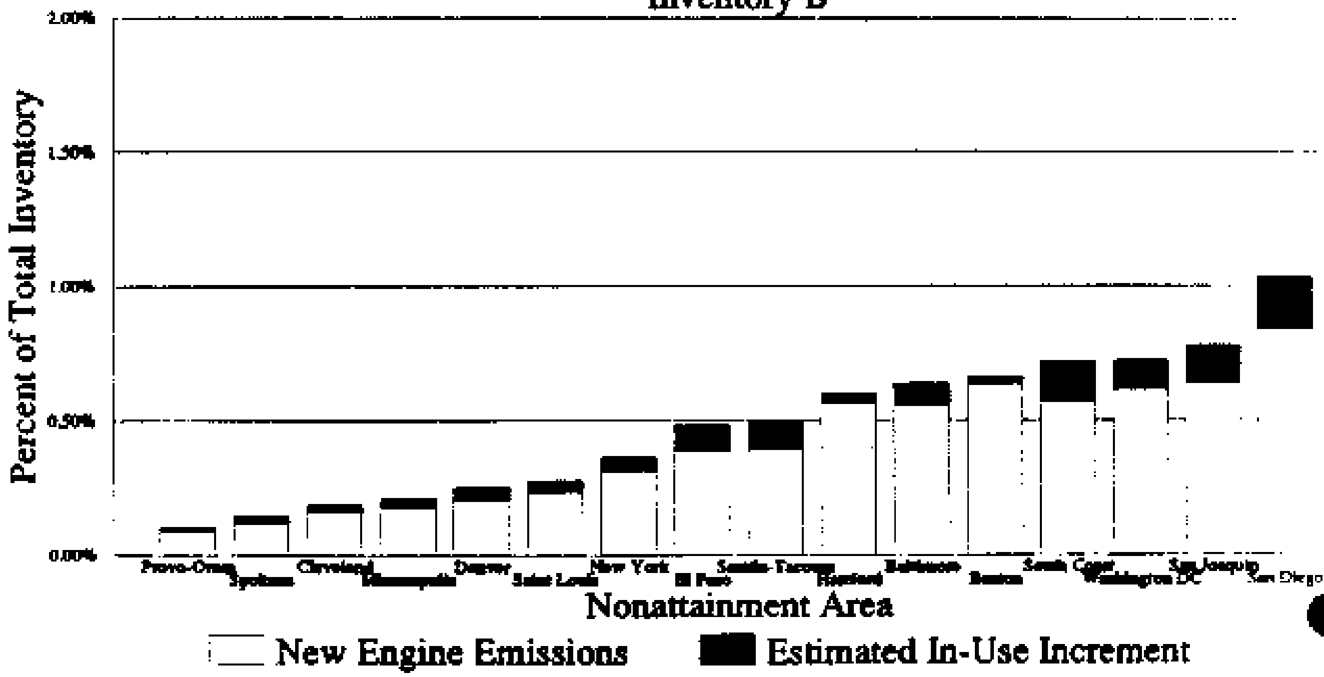
Construction NOx tpsd
Inventory B



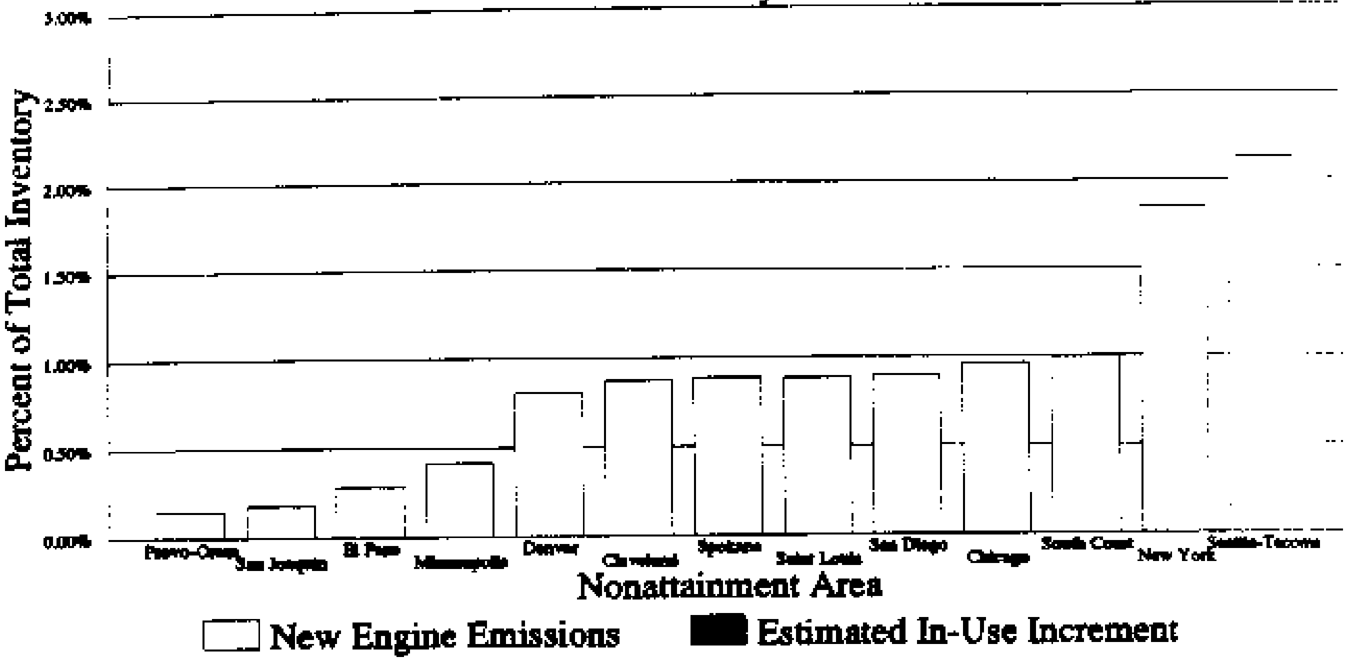
Construction CO tpwd
Inventory A



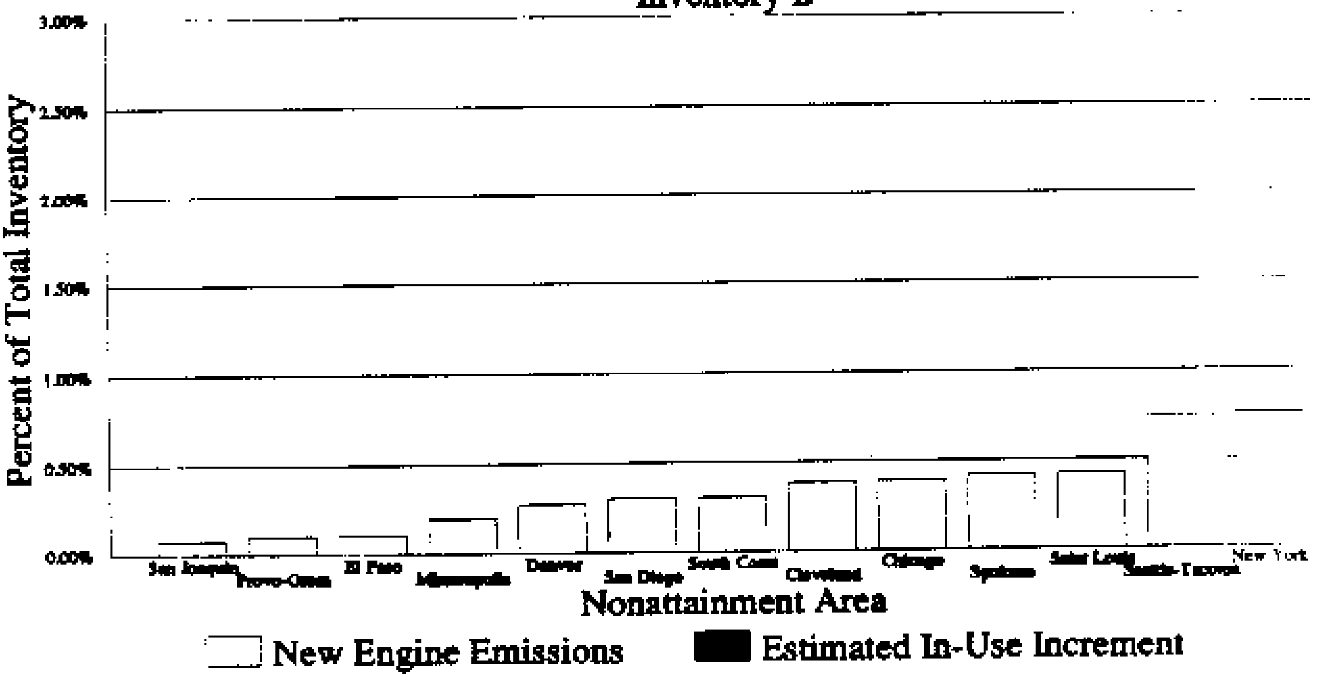
Construction CO tpwd
Inventory B

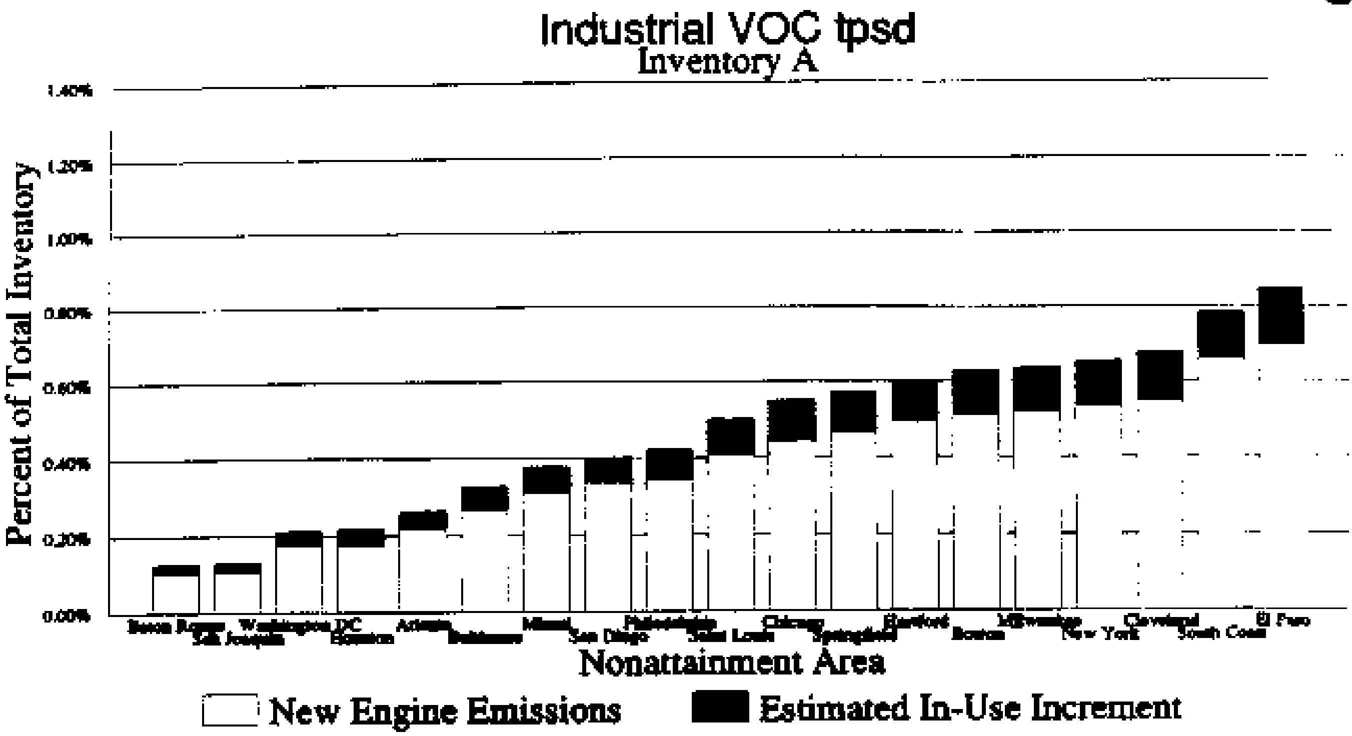


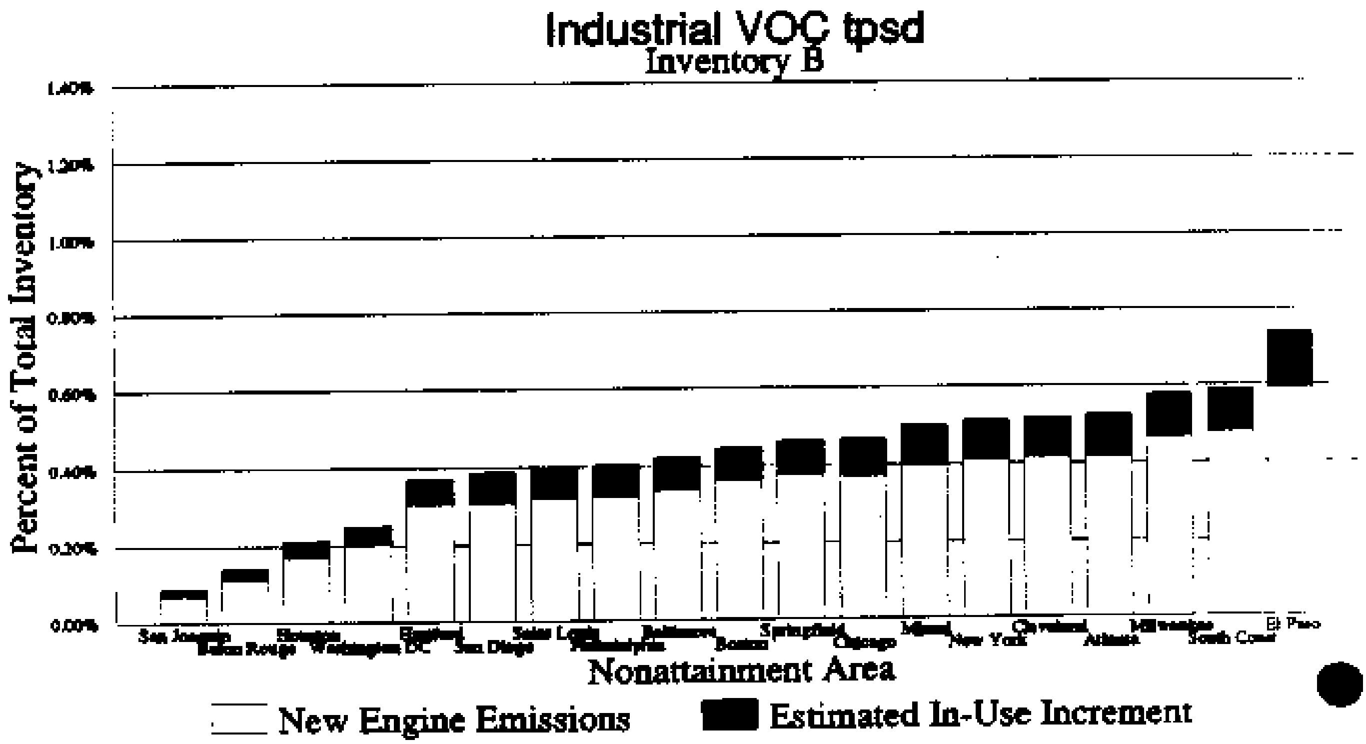
Construction PM tpy
Inventory A



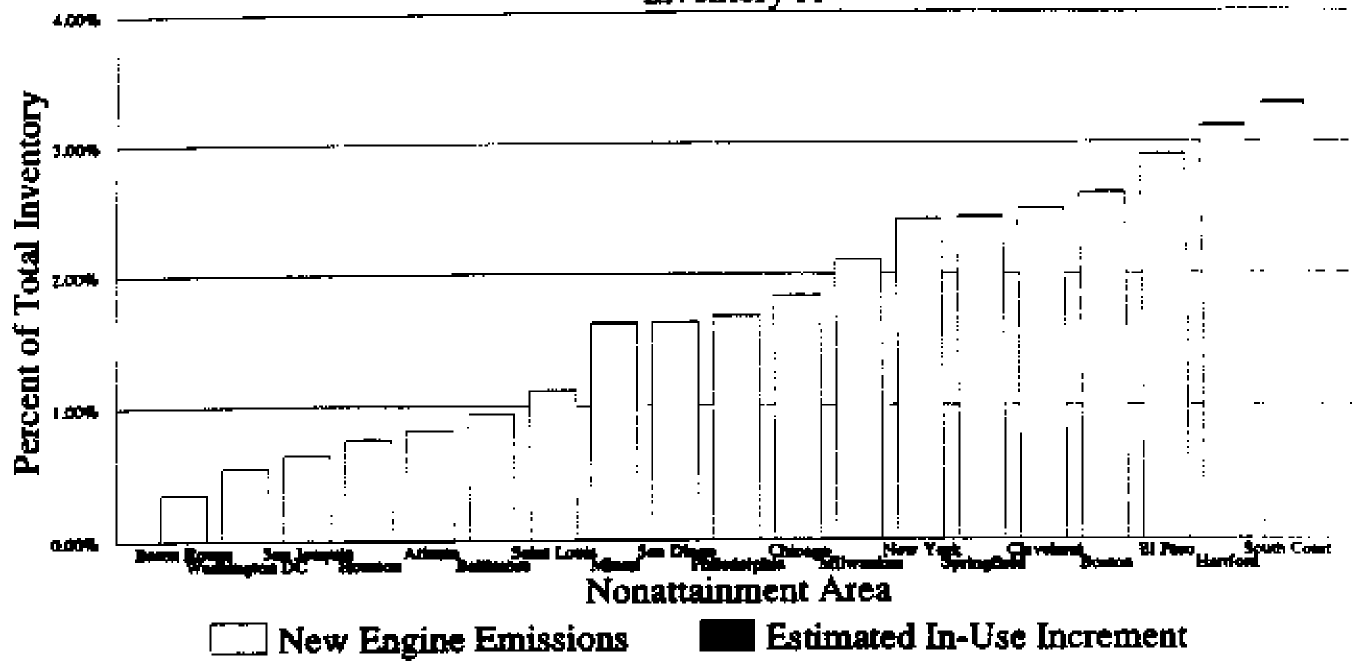
Construction PM tpy
Inventory B



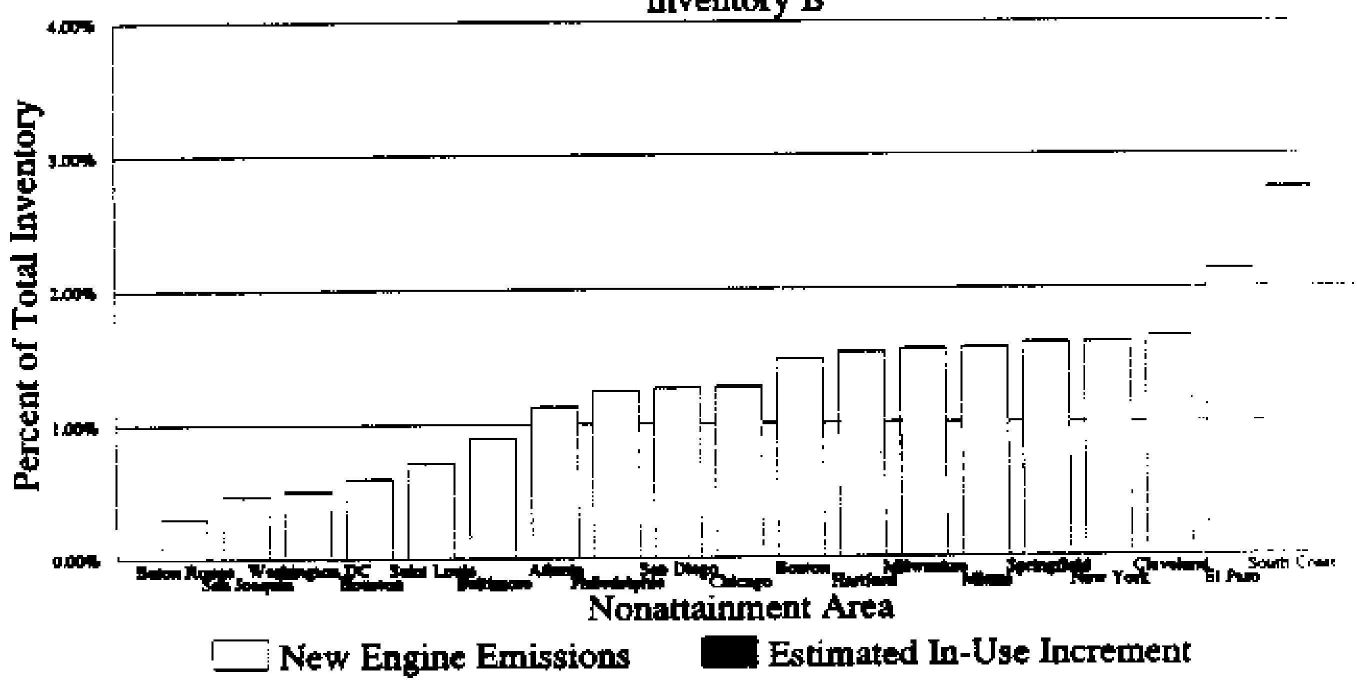

Industrial VOC tpsd
Inventory A
1.40%
1.20%
1.00%
0.80%
0.60%
0.40%
0.20%
0.00%
Percent of Total Inventory
Baton Rouge
San Joaquin
Washington DC
Houston
Atlanta
Baltimore
Miami
San Diego
Philadelphia
Saint Louis
Chicago
Springfield
Hartford
Boston
Milwaukee
New York
Cleveland
South Coast
El Paso
Nonattainment Area
New Engine Emissions
Estimated In-Use Increment

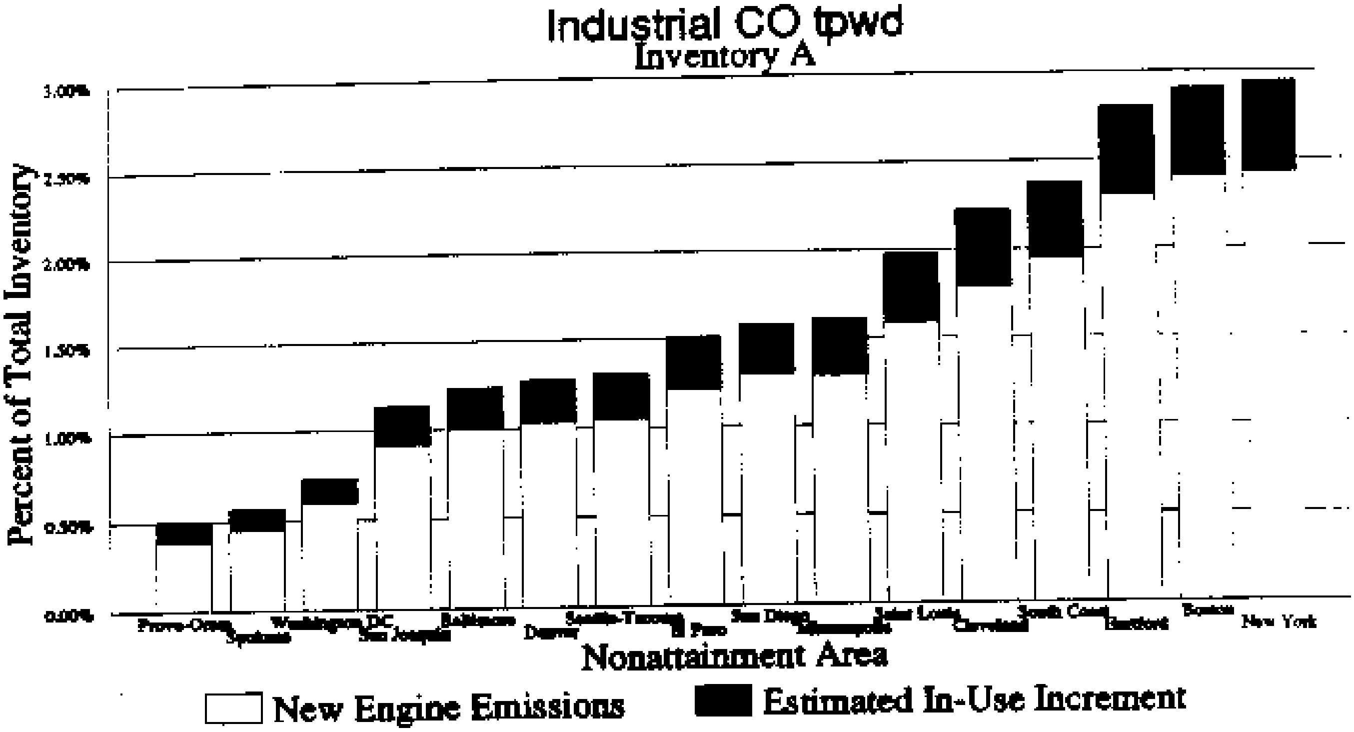

Industrial VOC tpsd
Inventory B
1.40%
1.20%
1.00%
0.80%
0.60%
0.40%
0.20%
0.00%
Percent of Total Inventory
San Joaquin
Baton Rouge
Houston
Washington DC
Hartford
San Diego
Saint Louis
Philadelphia
Baltimore
Boston
Springfield
Chicago
Miami
New York
Cleveland
Atlanta
Milwaukee
South Coast
El Paso
Nonattainment Area
New Engine Emissions
Estimated In-Use Increment

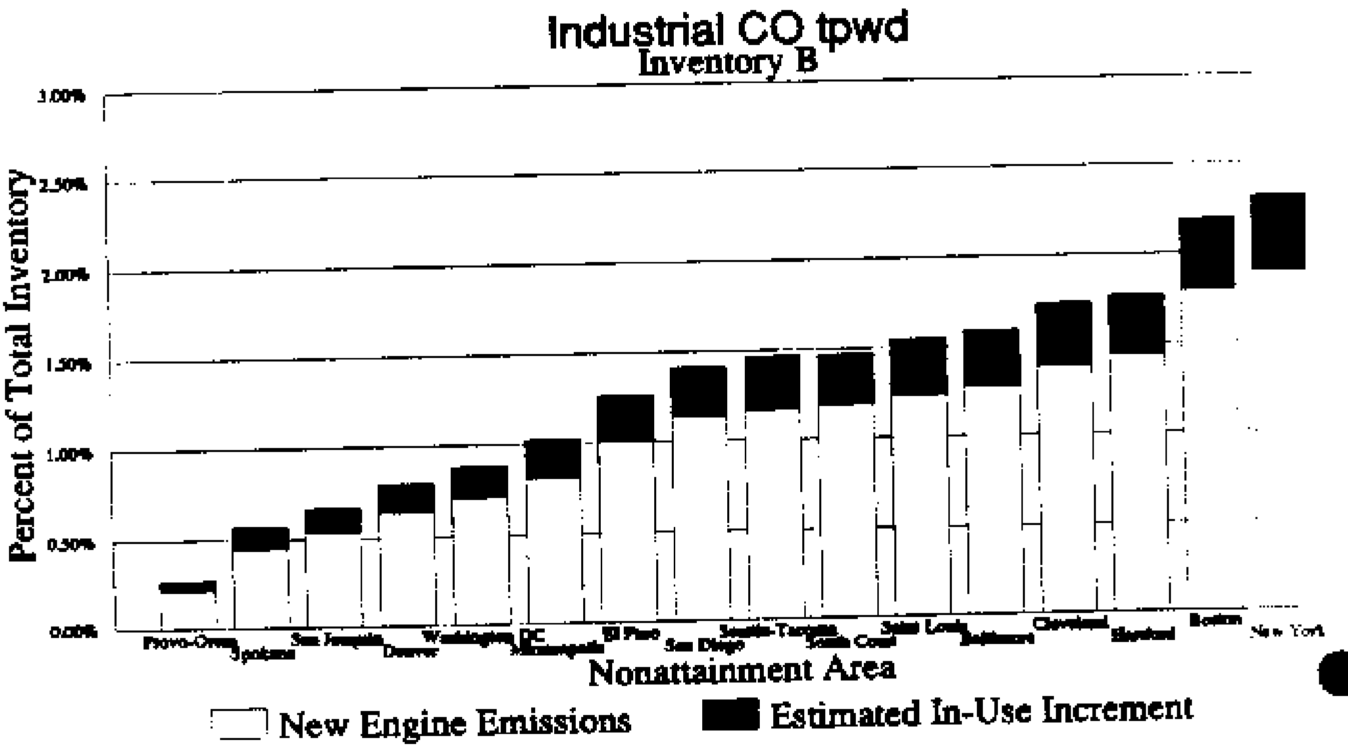
Industrial NOx tpsd
Inventory A



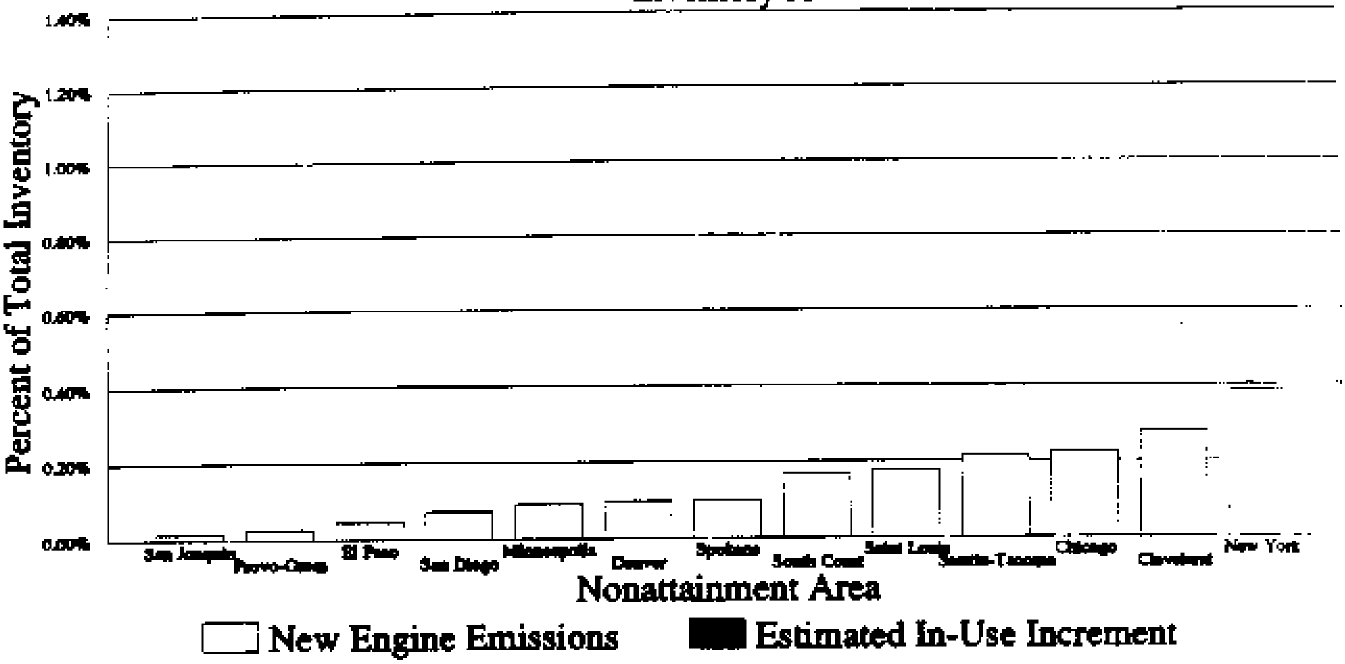
Industrial NOx tpsd
Inventory B



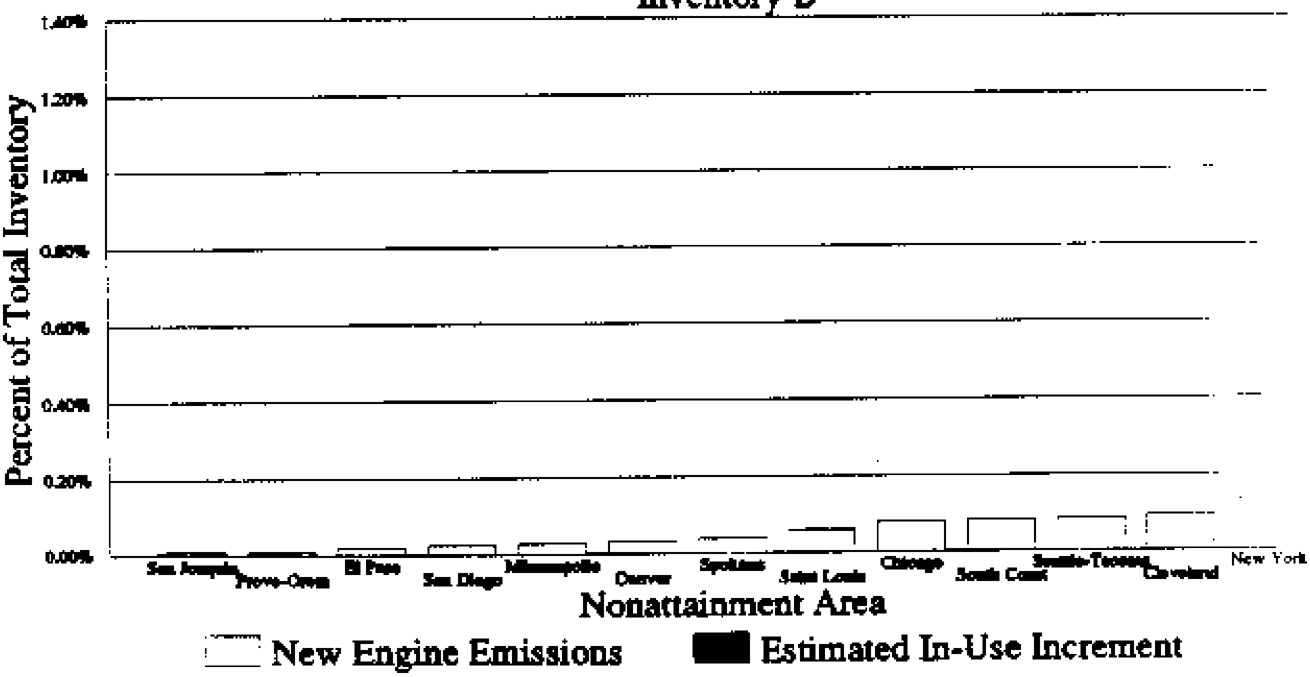

Industrial CO tpwd
Inventory A
Percent of Total Inventory
3.00%
2.50%
2.00%
1.50%
1.00%
0.50%
0.00%
Provo-Orem
Spokane
Washington DC
San Joaquin
Baltimore
Denver
Seattle-Tacoma
El Paso
San Diego
Minneapolis
Saint Louis
Cleveland
South Coast
Hartford
Boston
New York
Nonattainment Area
New Engine Emissions
Estimated In-Use Increment

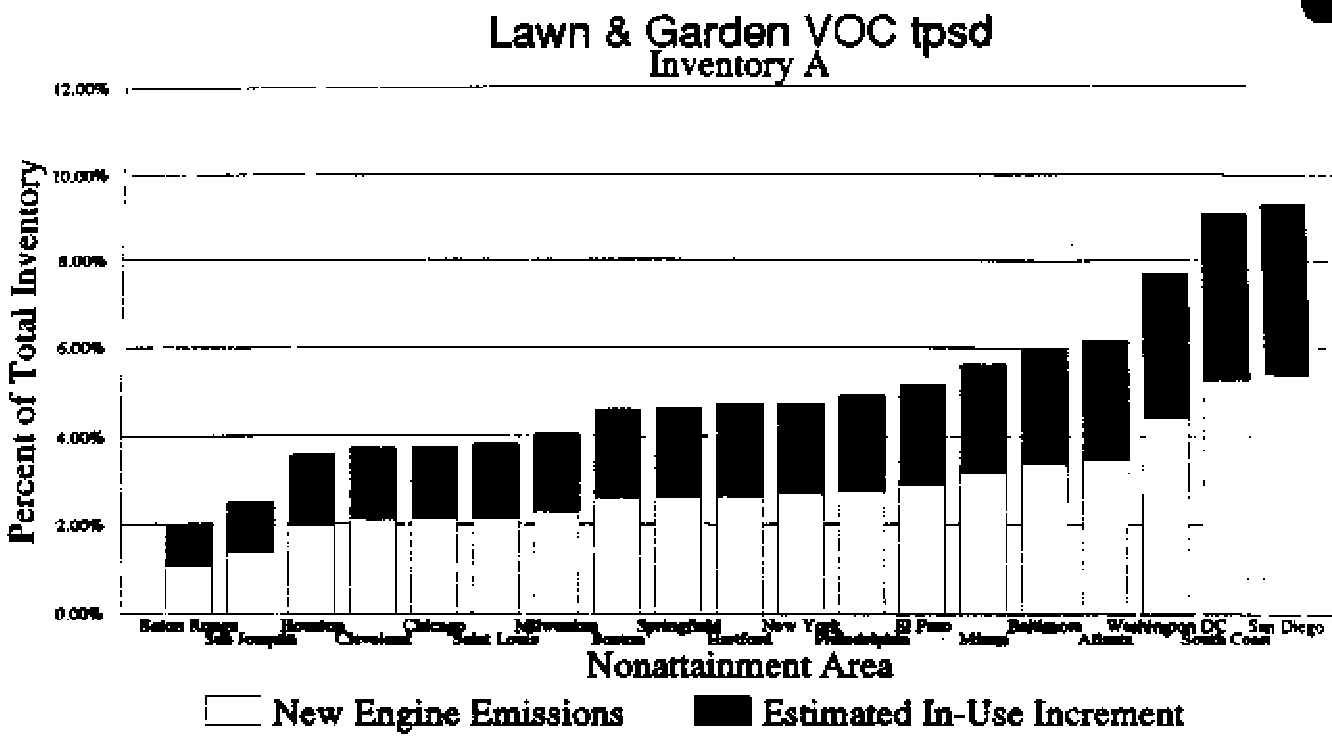

Industrial CO tpwd
Inventory B
Percent of Total Inventory
3.00%
2.50%
2.00%
1.50%
1.00%
0.50%
0.00%
Provo-Orem
Spokane
San Joaquin
Denver
Washington DC
Minneapolis
El Paso
San Diego
Seattle-Tacoma
South Coast
Saint Louis
Baltimore
Cleveland
Hartford
Boston
New York
Nonattainment Area
New Engine Emissions
Estimated In-Use Increment

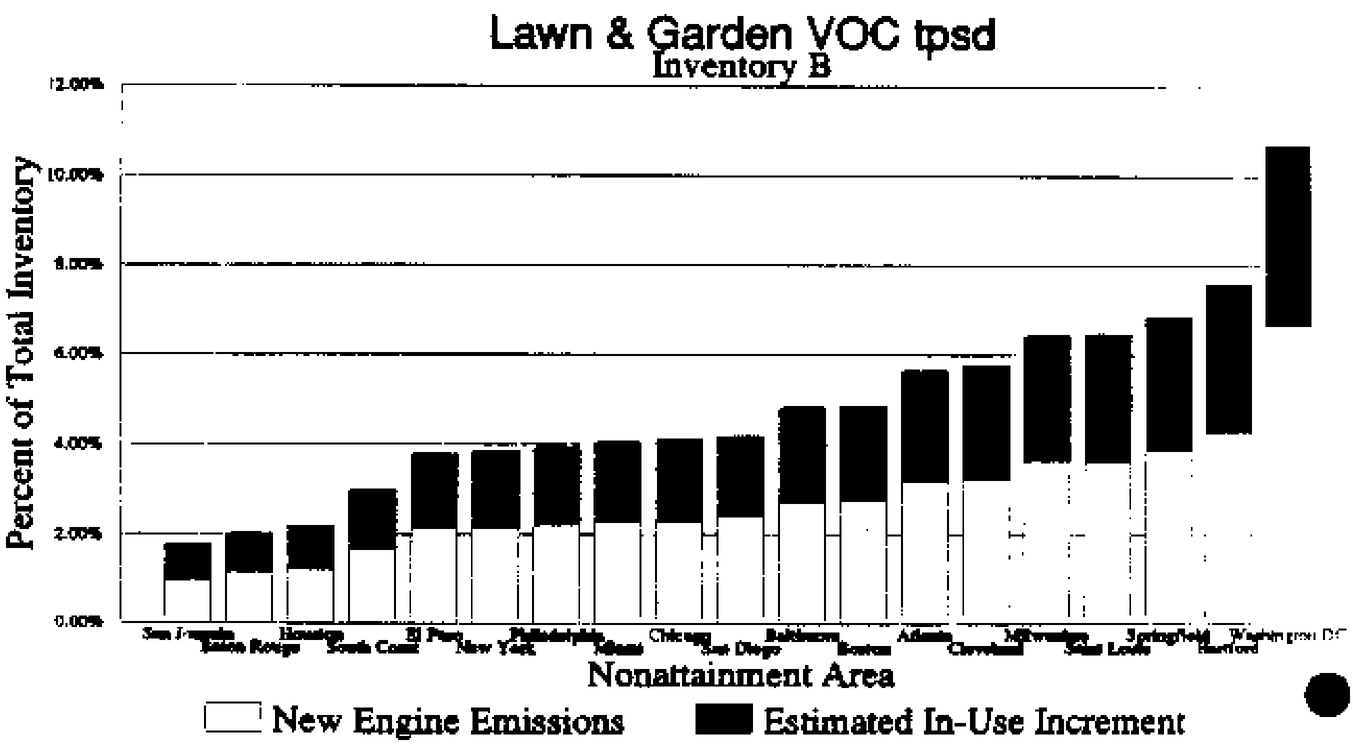
Industrial PM tpy
Inventory A



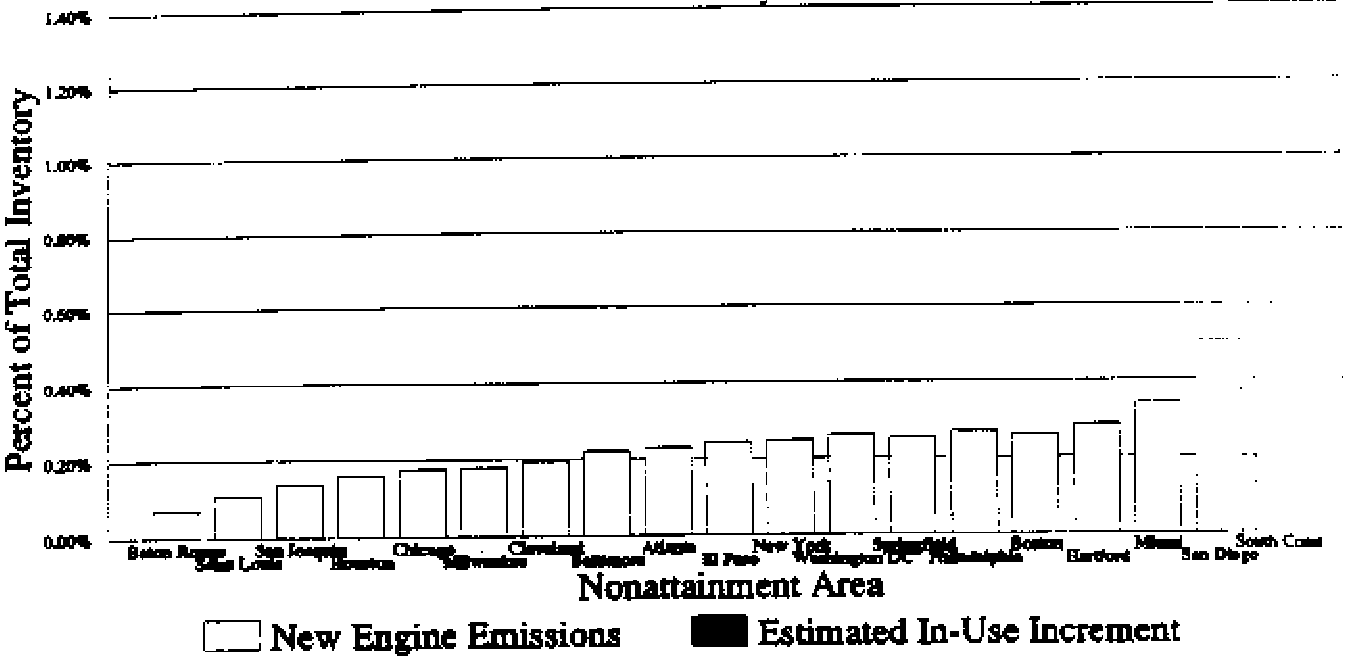
Industrial PM tpy
Inventory B



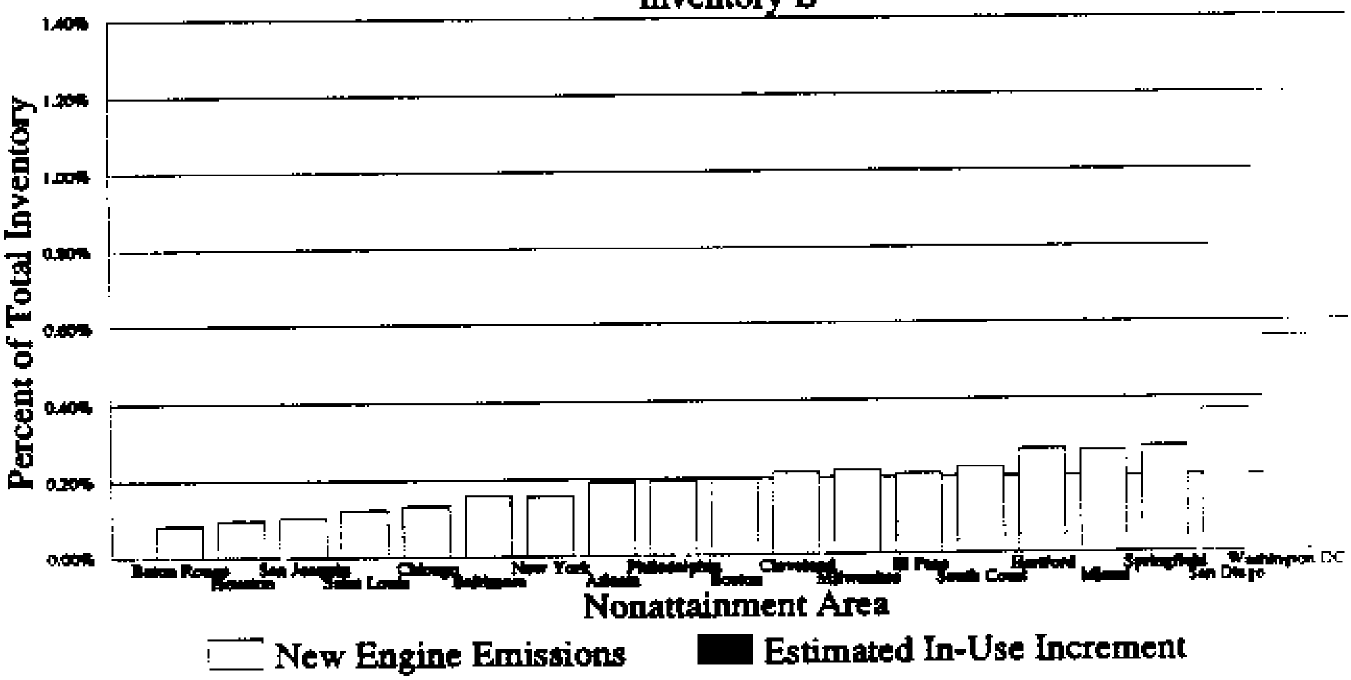

Lawn & Garden VOC tpsd
Inventory A
Percent of Total Inventory
12.00%
10.00%
8.00%
6.00%
4.00%
2.00%
0.00%
Baton Rouge
San Joaquin
Houston
Cleveland
Chicago
Saint Louis
Milwaukee
Boston
Springfield
Hartford
New York
Philadelphia
El Paso
Miami
Baltimore
Atlanta
Washington DC
South Coast
San Diego
Nonattainment Area
New Engine Emissions
Estimated In-Use Increment

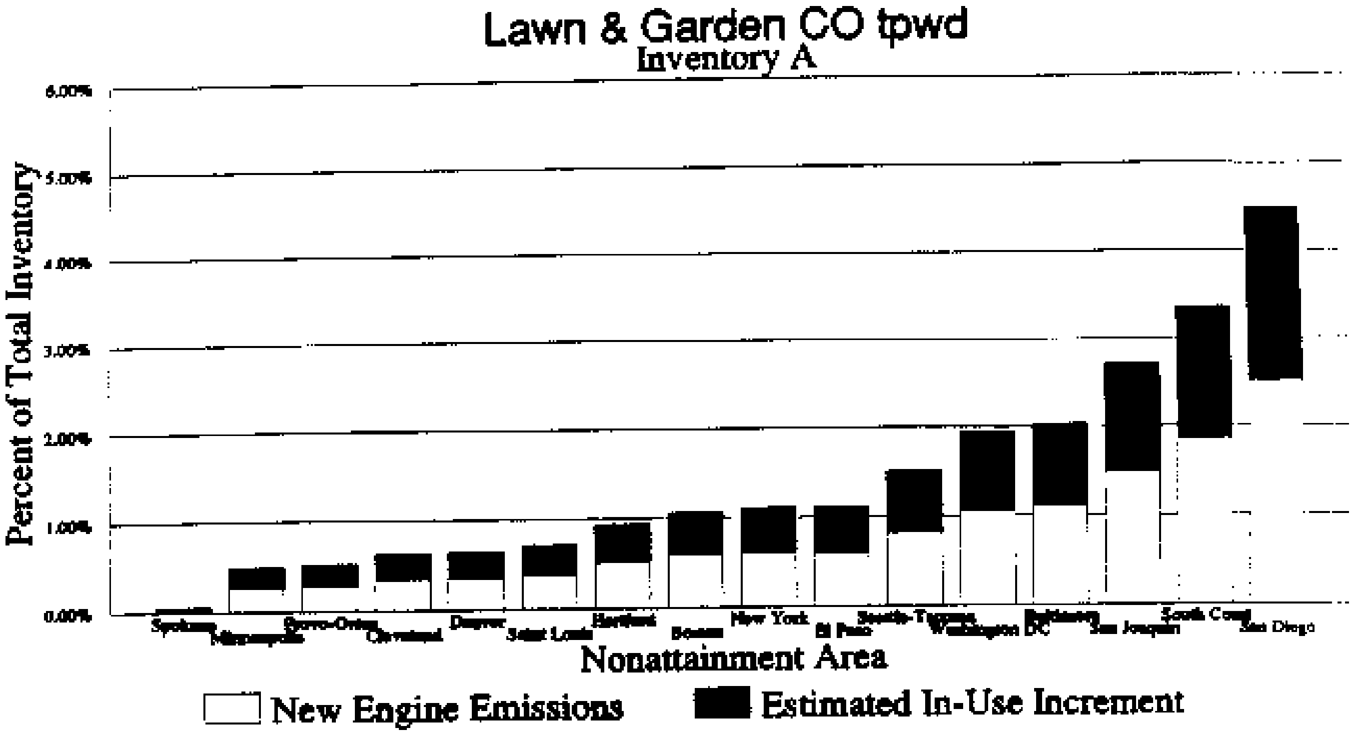

Lawn & Garden VOC tpsd
Inventory B
Percent of Total Inventory
12.00%
10.00%
8.00%
6.00%
4.00%
2.00%
0.00%
San Joaquin
Baton Rouge
Houston
South Coast
El Paso
New York
Philadelphia
Miami
Chicago
San Diego
Baltimore
Boston
Atlanta
Cleveland
Milwaukee
Saint Louis
Springfield
Hartford
Washington DC
Nonattainment Area
New Engine Emissions
Estimated In-Use Increment

Lawn & Garden NOx tpsd
Inventory A

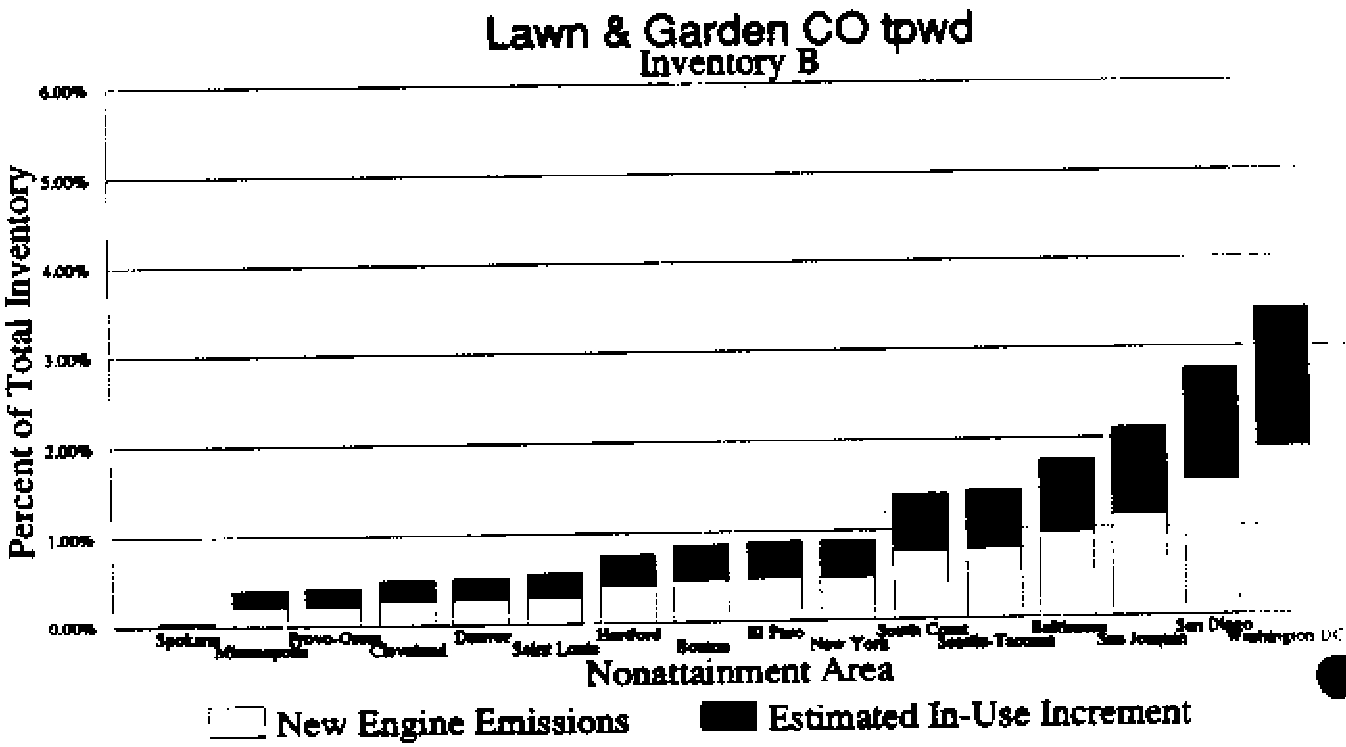


Lawn & Garden NOx tpsd
Inventory B

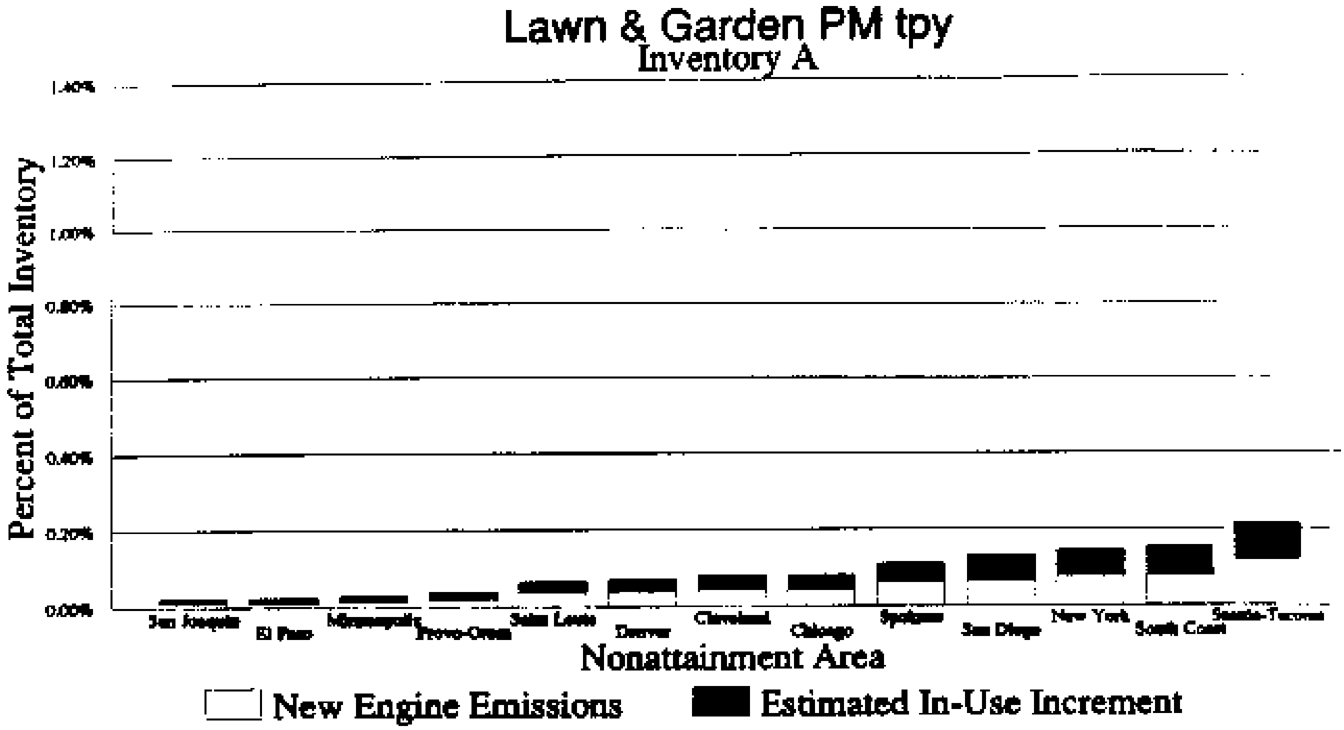


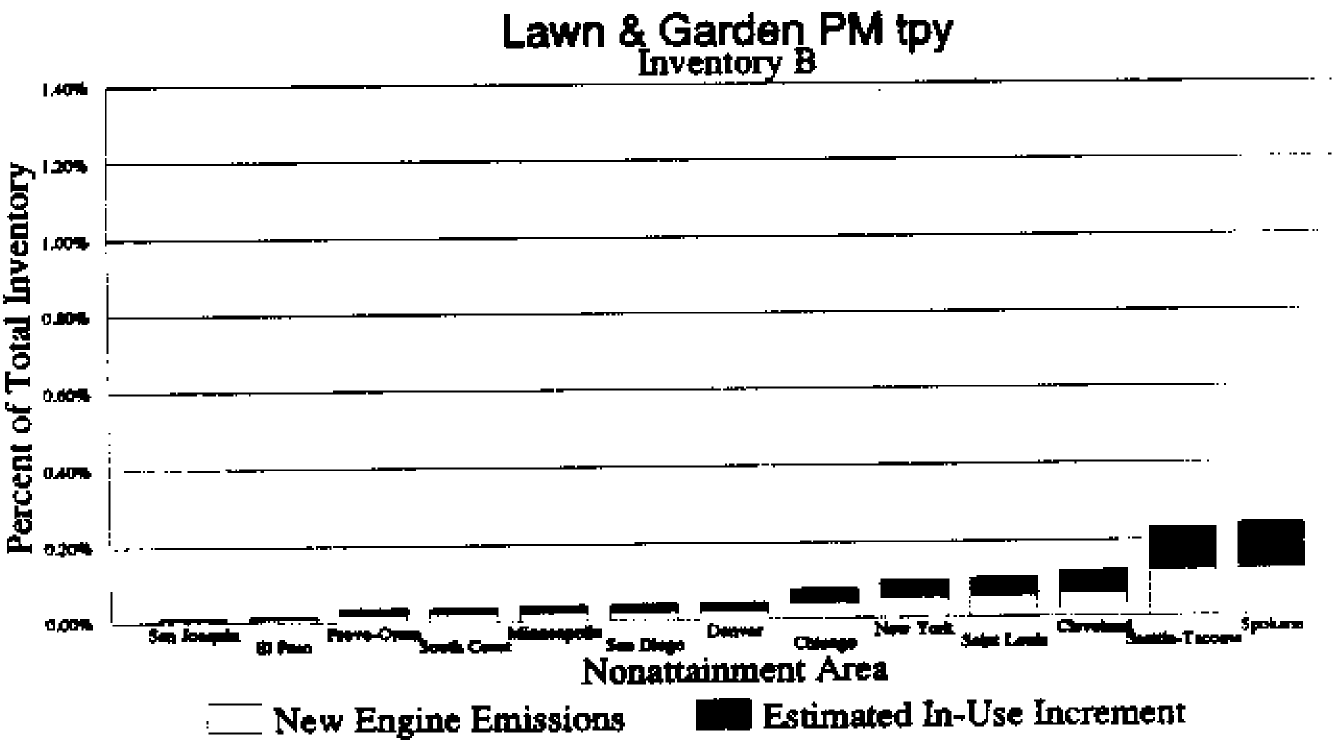


Lawn & Garden CO tpwd
Inventory A
Percent of Total Inventory
6.00%
5.00%
4.00%
3.00%
2.00%
1.00%
0.00%
Spokane
Minneapolis
Provo-Orem
Cleveland
Denver
Saint Louis
Hartford
Boston
New York
El Paso
Seattle-Tacoma
Washington DC
Baltimore
San Joaquin
South Coast
San Diego
Nonattainment Area
New Engine Emissions
Estimated In-Use Increment

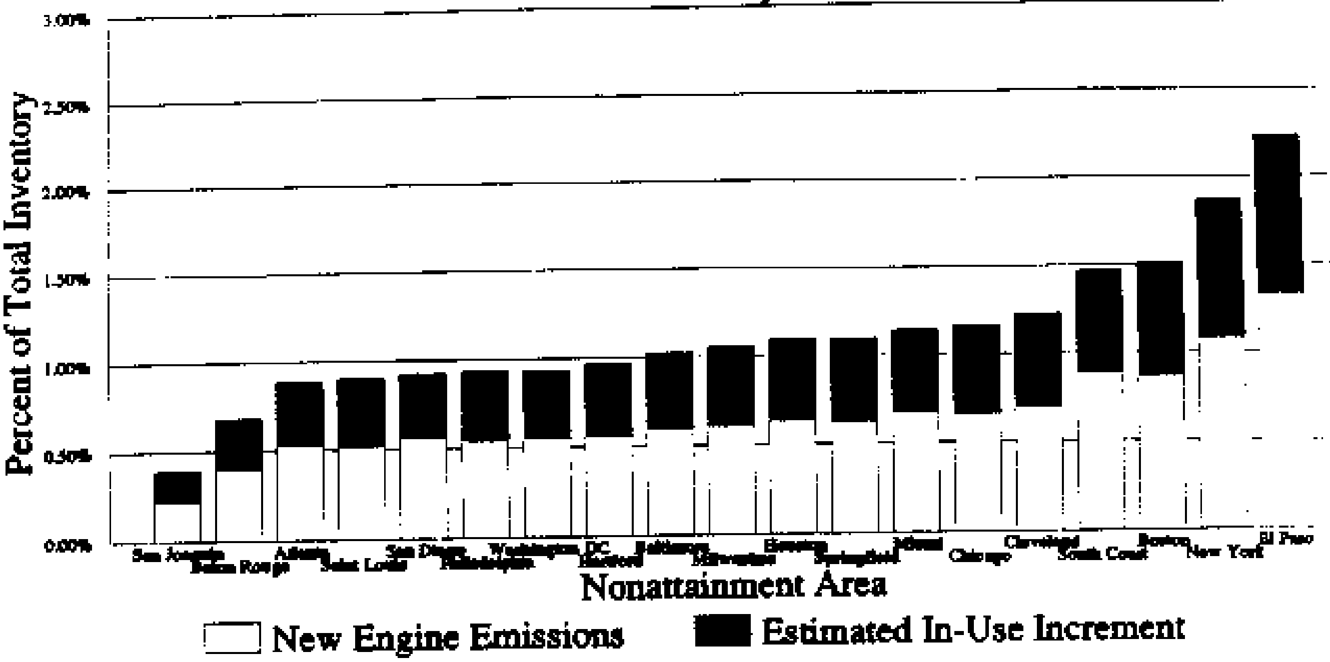


Lawn & Garden CO tpwd
Inventory B
Percent of Total Inventory
6.00%
5.00%
4.00%
3.00%
2.00%
1.00%
0.00%
Spokane
Minneapolis
Provo-Orem
Cleveland
Denver
Saint Louis
Hartford
Boston
El Paso
New York
South Coast
Seattle-Tacoma
Baltimore
San Joaquin
San Diego
Washington DC
Nonattainment Area
New Engine Emissions
Estimated In-Use Increment

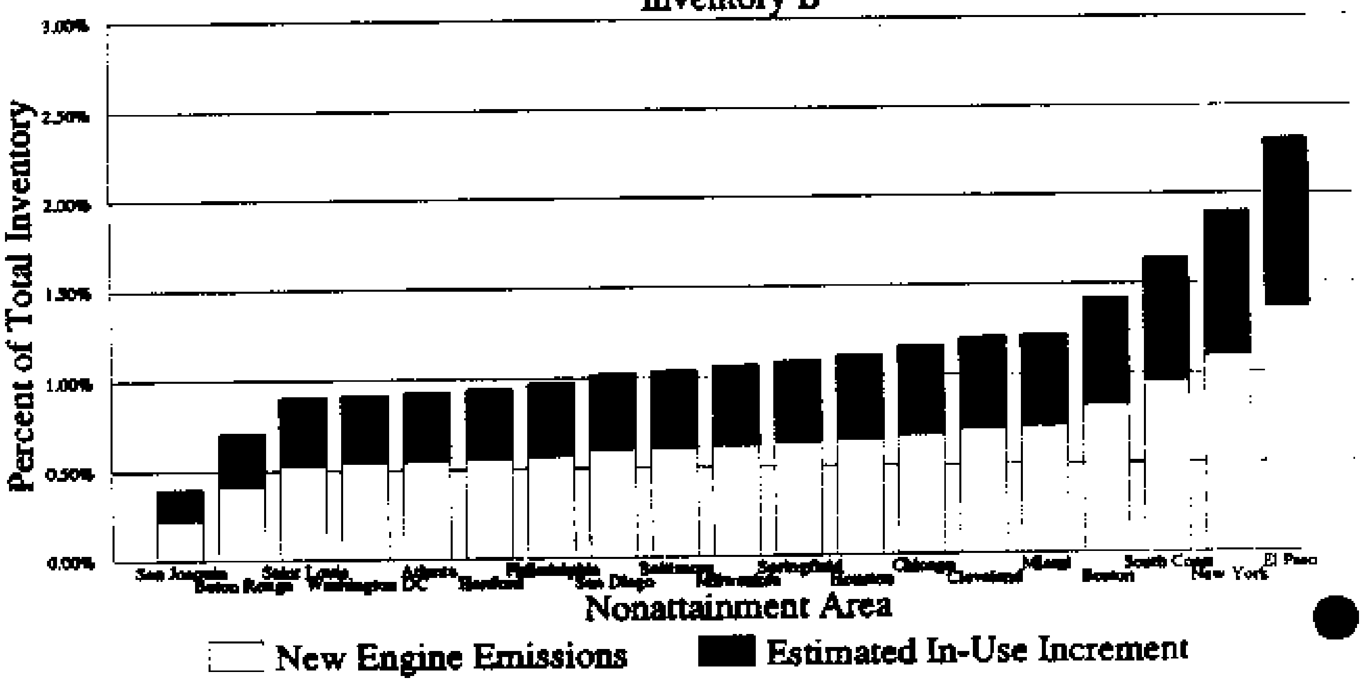

Lawn & Garden PM tpy
Inventory A
1.40%
1.20%
1.00%
0.80%
0.60%
0.40%
0.20%
0.00%
Percent of Total Inventory
San Joaquin
El Paso
Minneapolis
Provo-Orem
Saint Louis
Denver
Cleveland
Chicago
Spokane
San Diego
New York
South Coast
Seattle-Tacoma
Nonattainment Area
New Engine Emissions
Estimated In-Use Increment

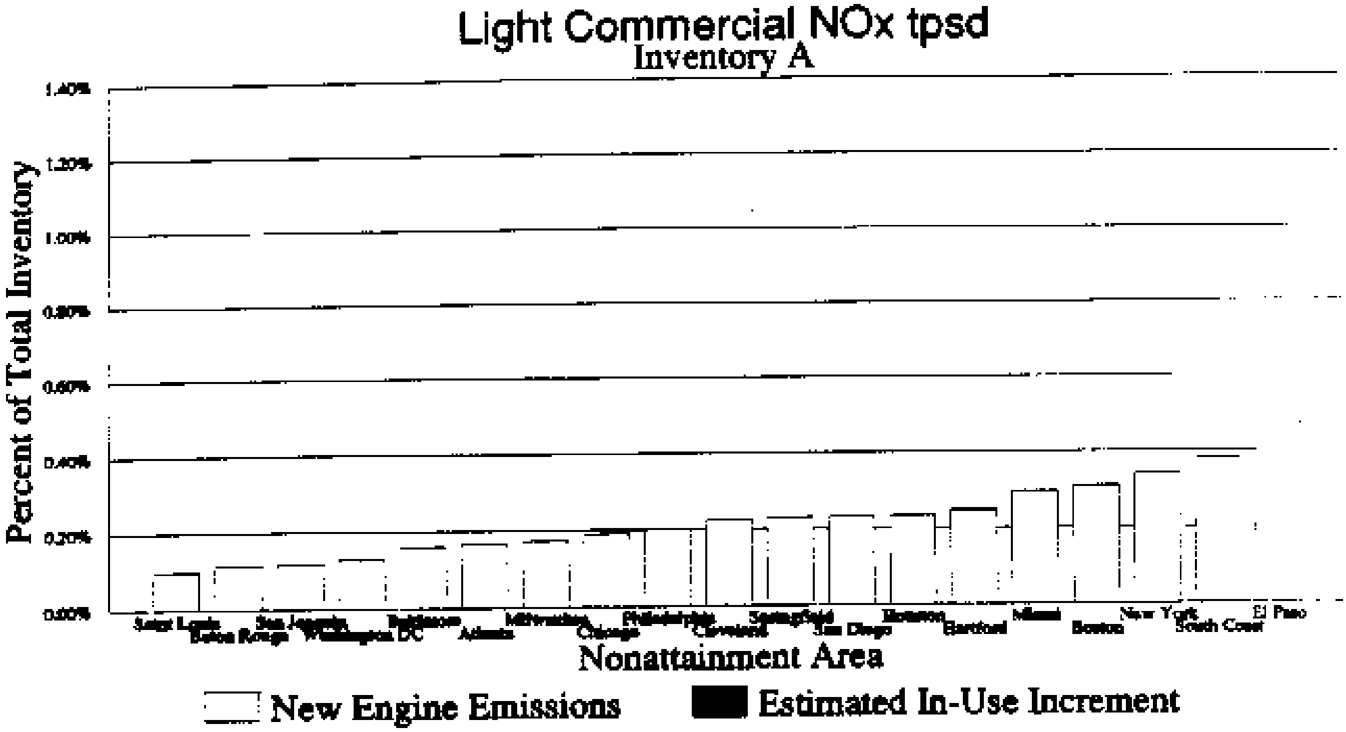

Lawn & Garden PM tpy
Inventory B
1.40%
1.20%
1.00%
0.80%
0.60%
0.40%
0.20%
0.00%
Percent of Total Inventory
San Joaquin
El Paso
Provo-Orem
South Coast
Minneapolis
San Diego
Denver
Chicago
New York
Saint Louis
Cleveland
Seattle-Tacoma
Spokane
Nonattainment Area
New Engine Emissions
Estimated In-Use Increment

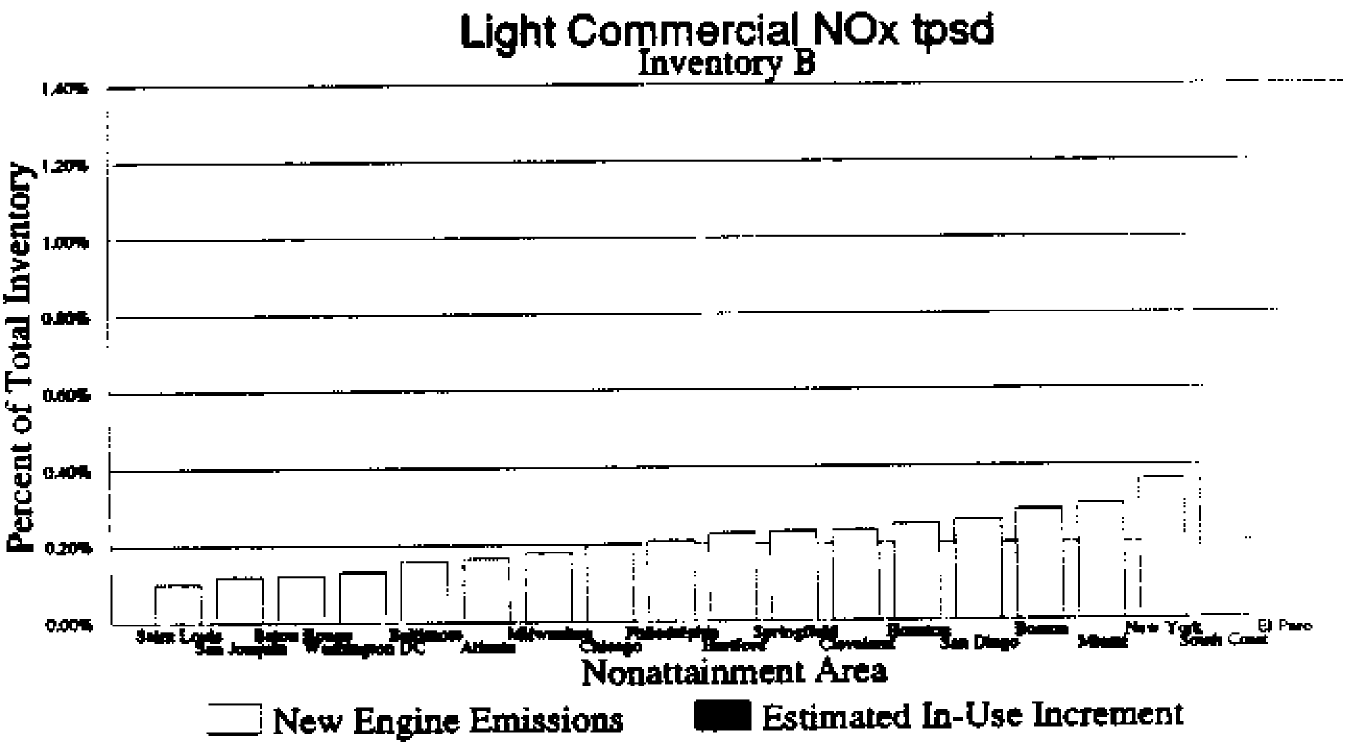
Light Commercial VOC tpsd
Inventory A

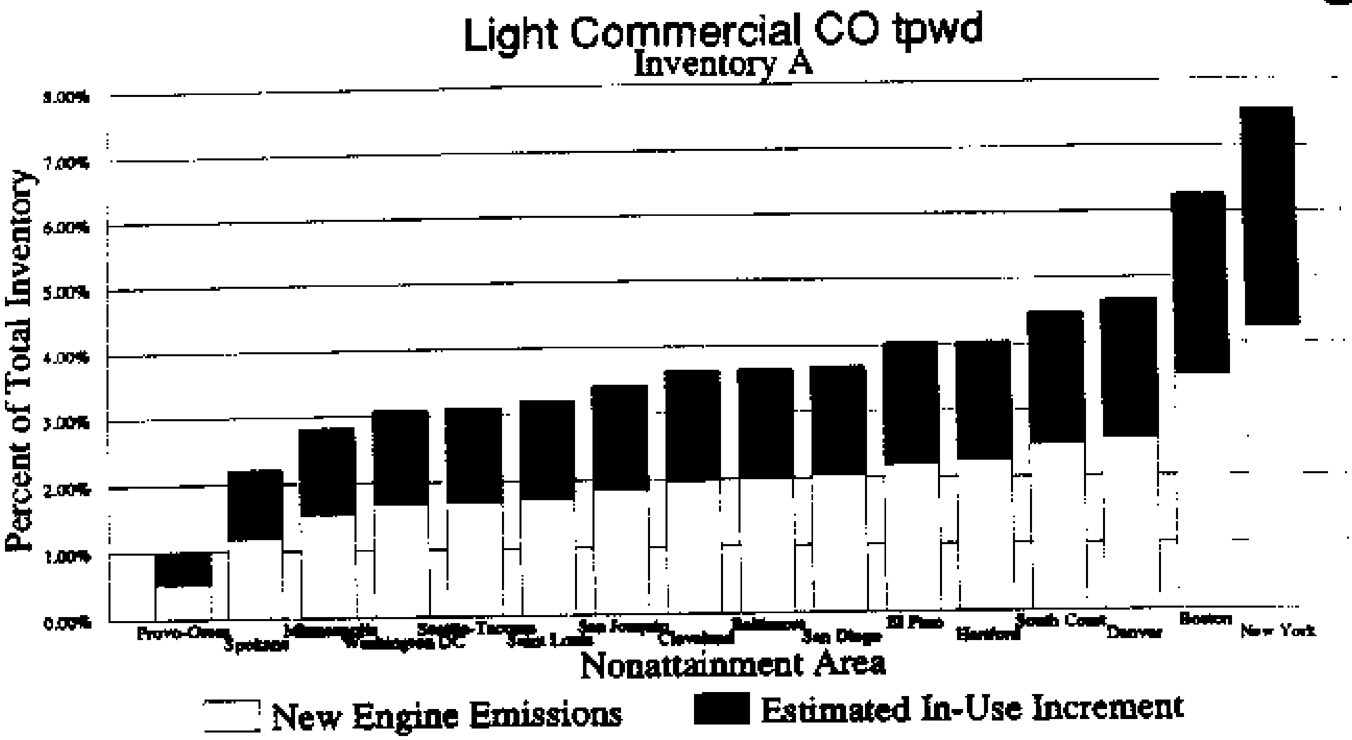


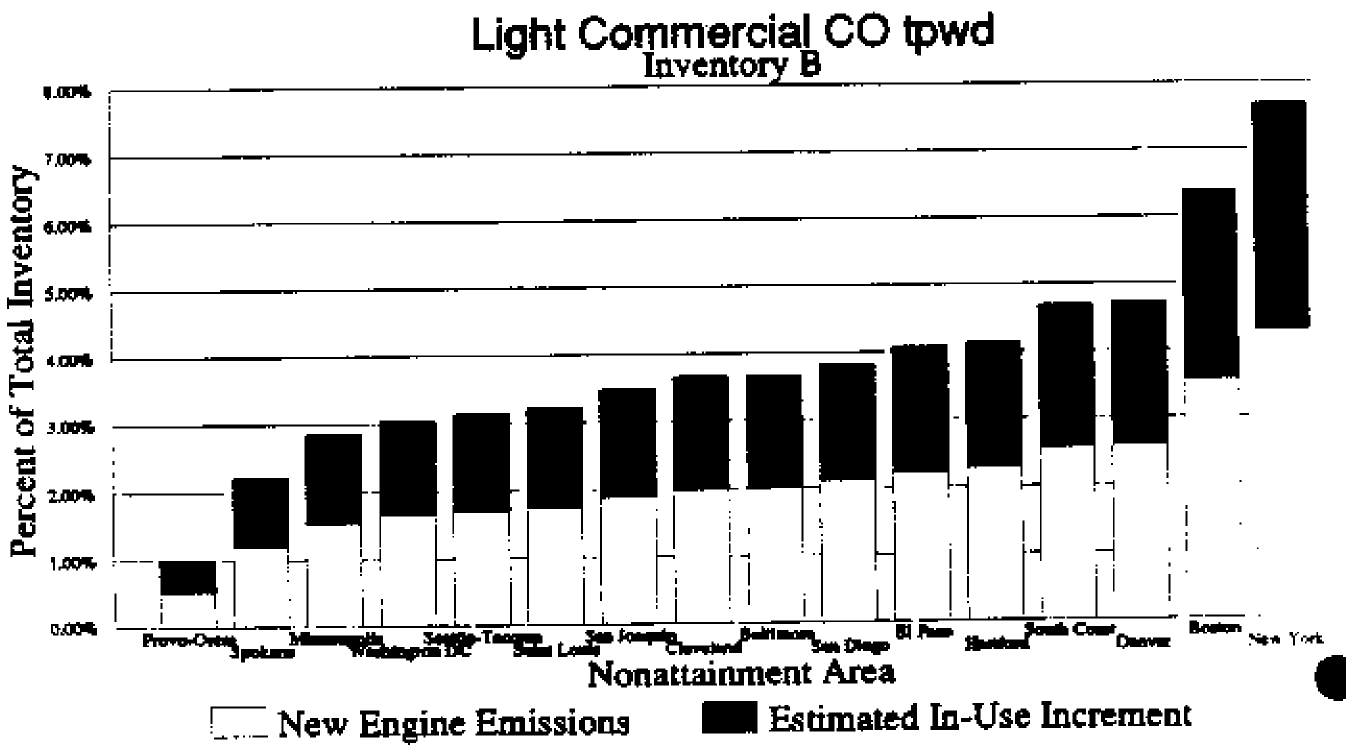
Light Commercial VOC tpsd
Inventory B

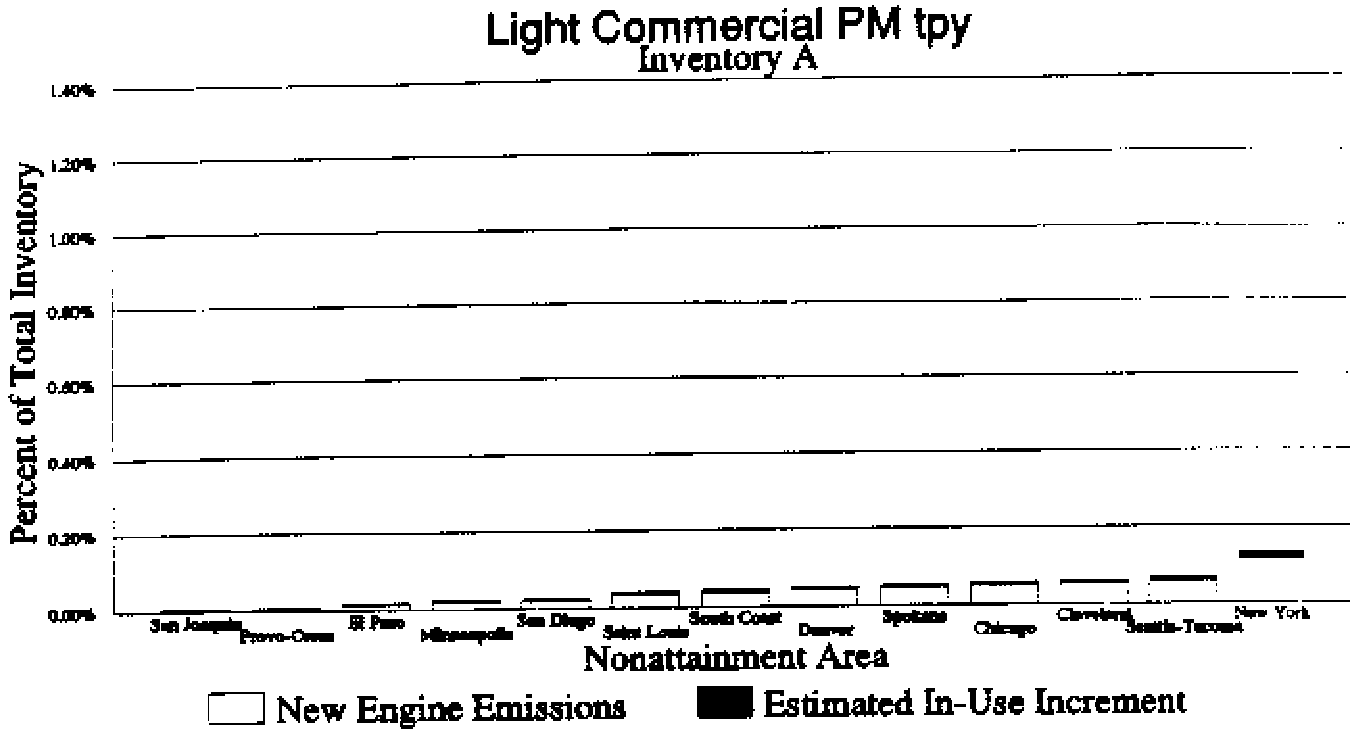



Light Commercial NOx tpsd
Inventory A
Percent of Total Inventory
1.40%
1.20%
1.00%
0.80%
0.60%
0.40%
0.20%
0.00%
Saint Louis
Baton Rouge
San Joaquin
Washington DC
Baltimore
Atlanta
Milwaukee
Chicago
Philadelphia
Cleveland
Springfield
San Diego
Hartford
Miami
Boston
New York
South Coast
El Paso
Nonattainment Area
New Engine Emissions
Estimated In-Use Increment

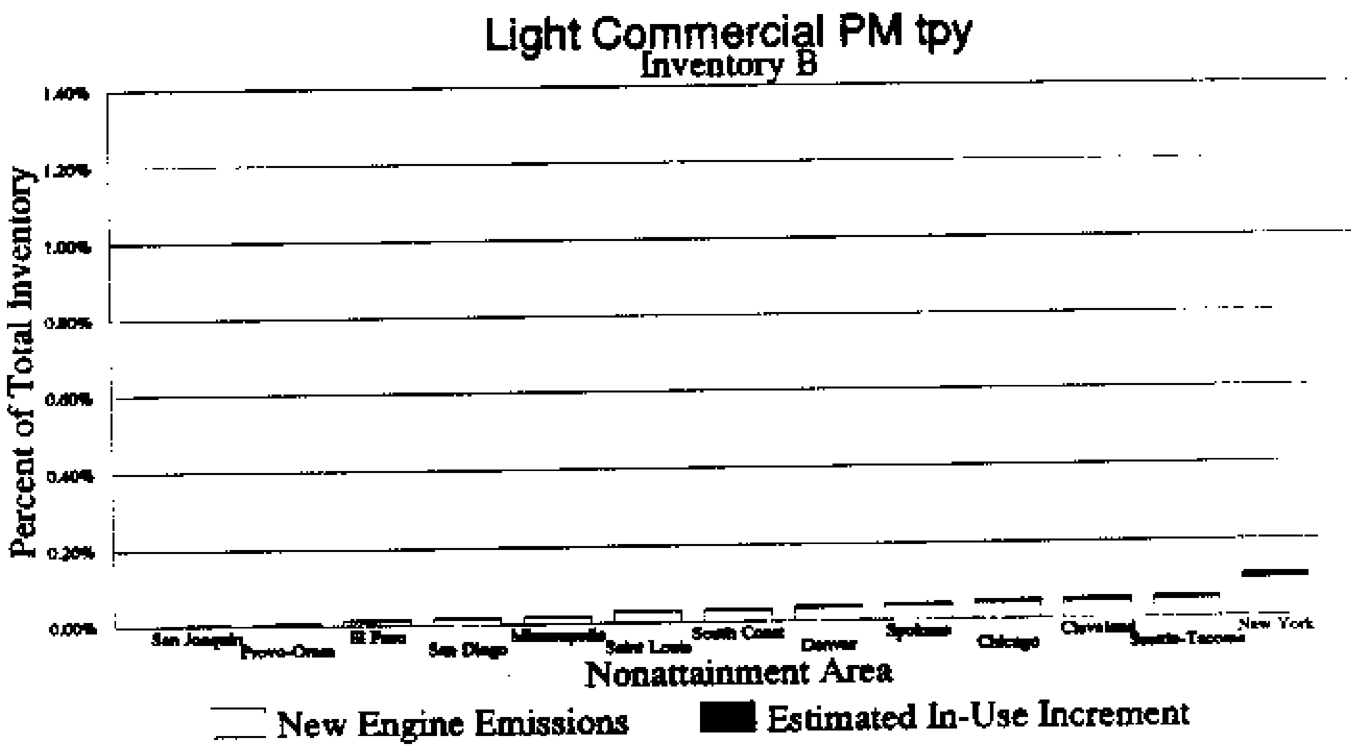

Light Commercial NOx tpsd
Inventory B
Percent of Total Inventory
1.40%
1.20%
1.00%
0.80%
0.60%
0.40%
0.20%
0.00%
Saint Louis
San Joaquin
Baton Rouge
Washington DC
Baltimore
Atlanta
Milwaukee
Chicago
Philadelphia
Hartford
Springfield
Cleveland
San Diego
Boston
Miami
New York
South Coast
El Paso
Nonattainment Area
New Engine Emissions
Estimated In-Use Increment


Light Commercial CO tpwd
Inventory A
8.00%
7.00%
6.00%
5.00%
4.00%
3.00%
2.00%
1.00%
0.00%
Percent of Total Inventory
Provo-Orem
Spokane
Minneapolis
Washington DC
Seattle-Tacoma
Saint Louis
San Joaquin
Cleveland
Baltimore
San Diego
El Paso
Hartford
South Coast
Denver
Boston
New York
Nonattainment Area
New Engine Emissions
Estimated In-Use Increment

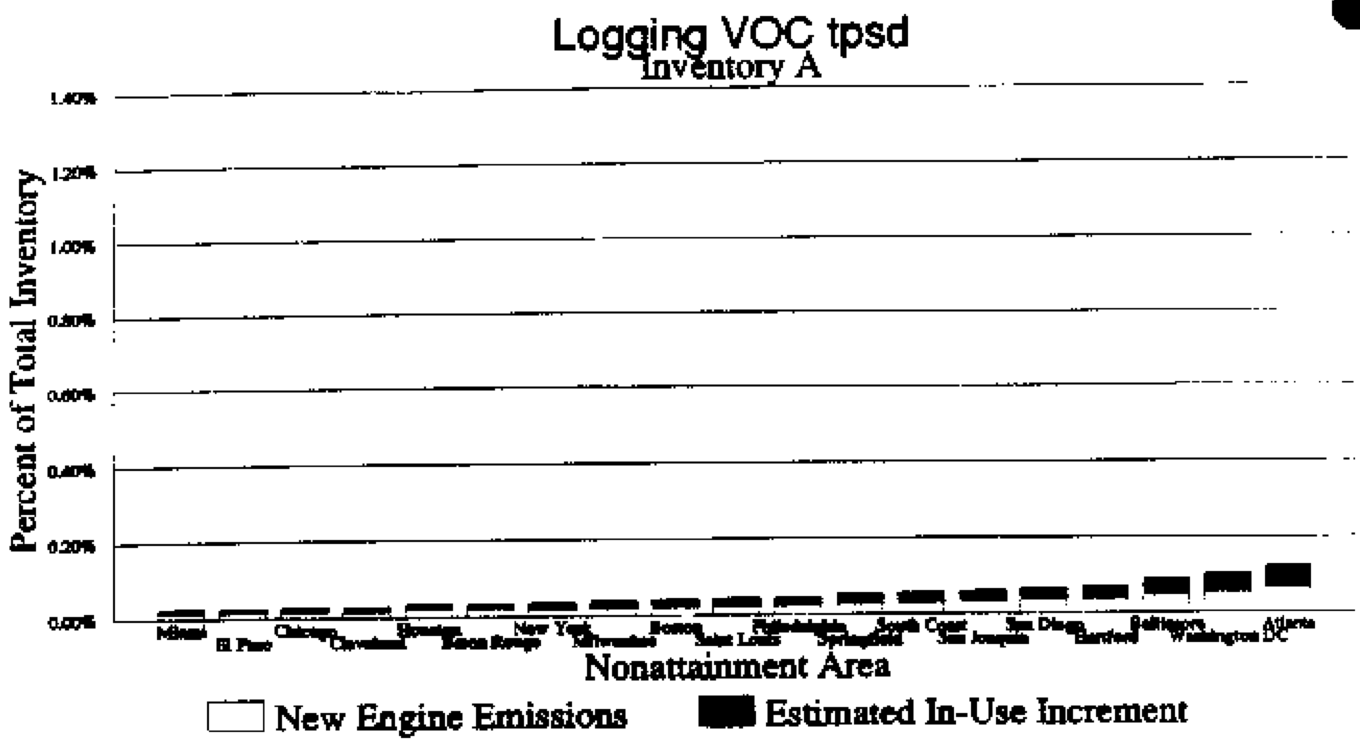

Light Commercial CO tpwd
Inventory B
8.00%
7.00%
6.00%
5.00%
4.00%
3.00%
2.00%
1.00%
0.00%
Percent of Total Inventory
Provo-Orem
Spokane
Minneapolis
Washington DC
Seattle-Tacoma
Saint Louis
San Joaquin
Cleveland
Baltimore
San Diego
El Paso
Hartford
South Coast
Denver
Boston
New York
Nonattainment Area
New Engine Emissions
Estimated In-Use Increment

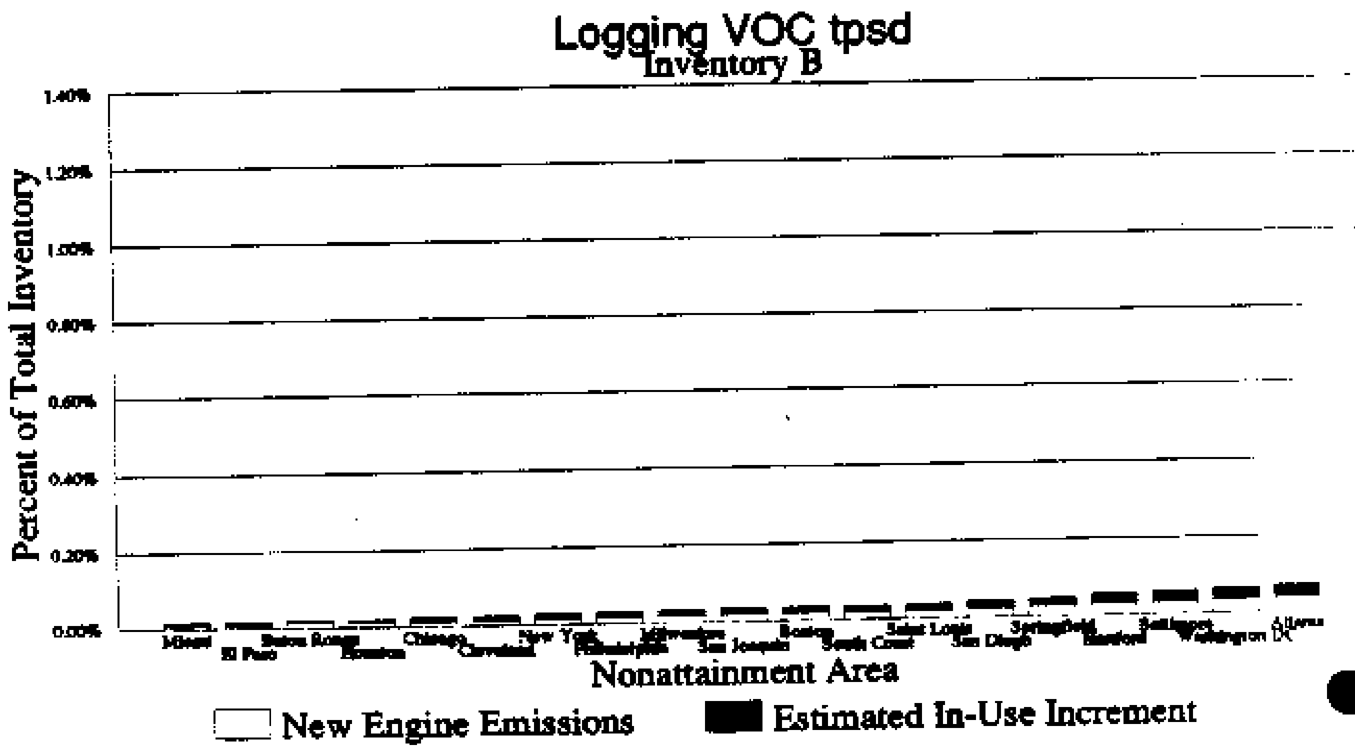


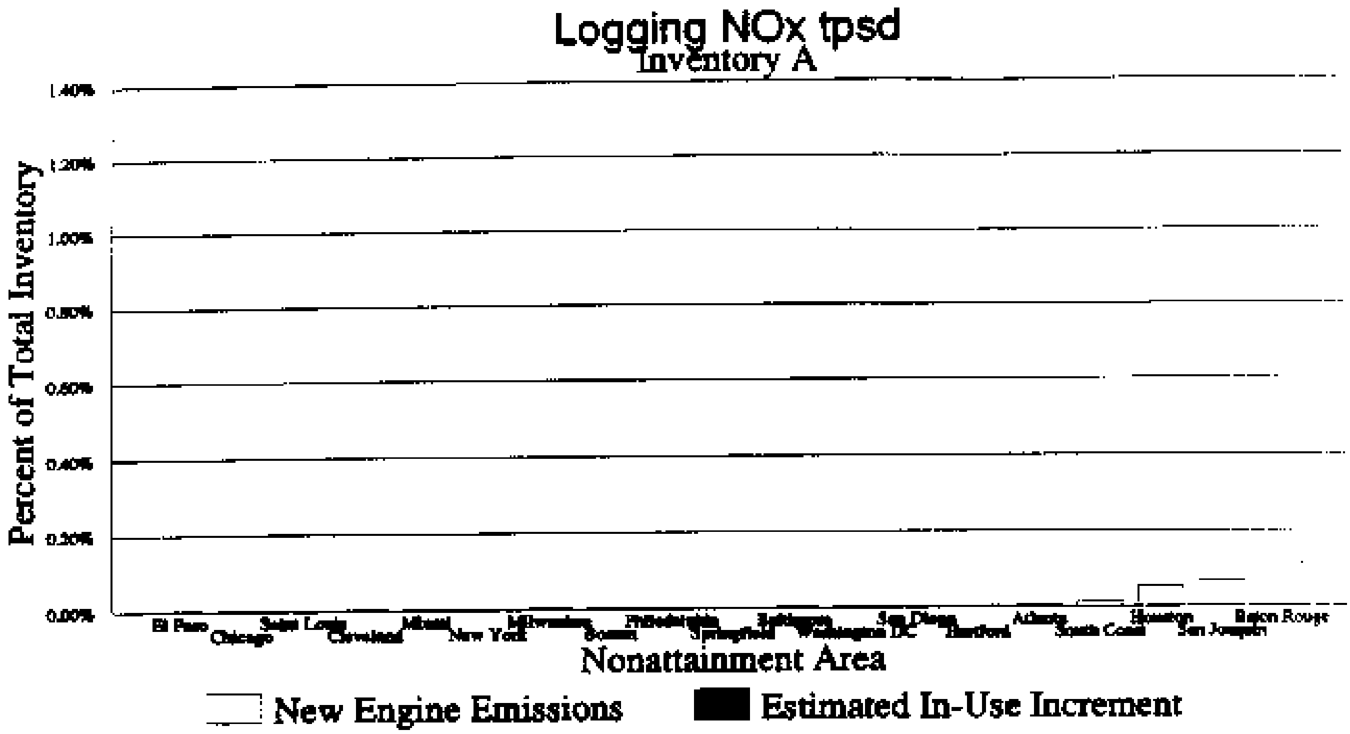
Light Commercial PM tpy
Inventory A
1.40%
1.20%
1.00%
0.80%
0.60%
0.40%
0.20%
0.00%
Percent of Total Inventory
San Joaquin
Provo-Orem
El Paso
Minneapolis
San Diego
Saint Louis
South Coast
Denver
Spokane
Chicago
Cleveland
Seattle-Tacoma
New York
Nonattainment Area
New Engine Emissions
Estimated In-Use Increment

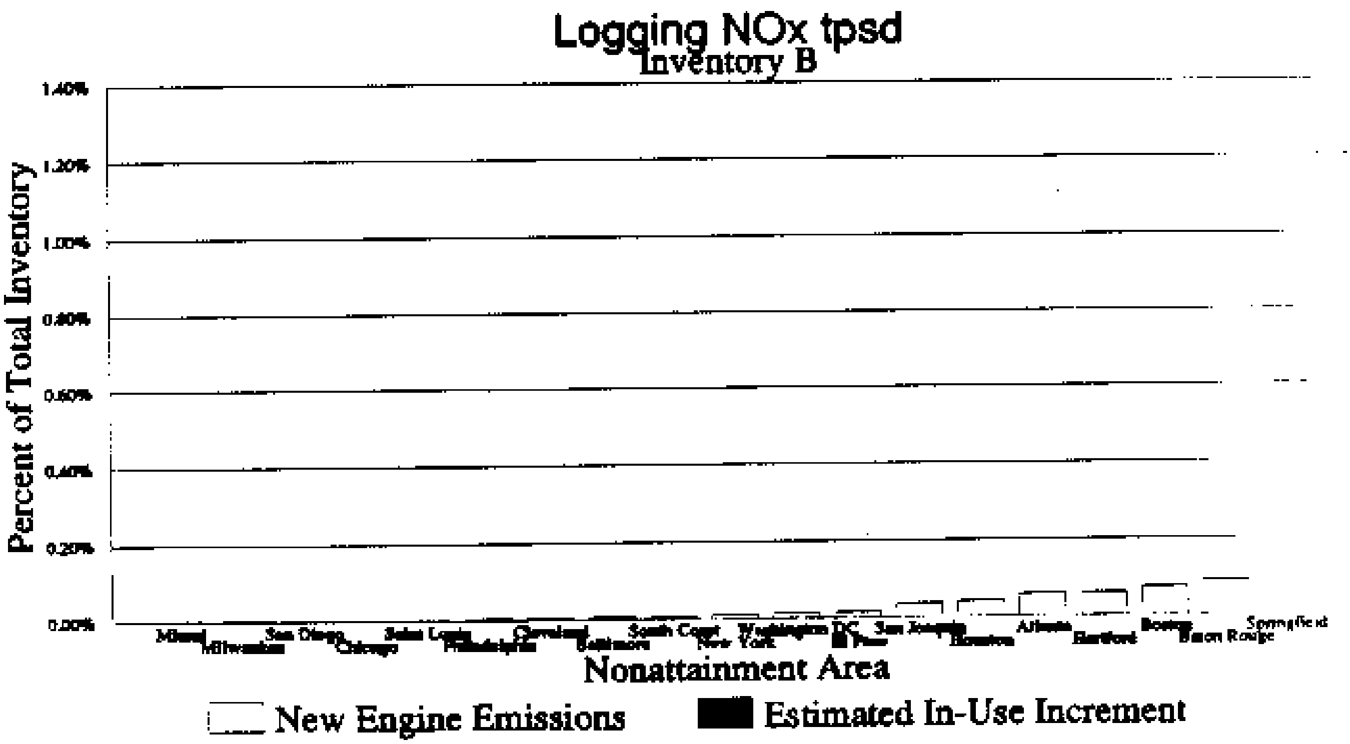


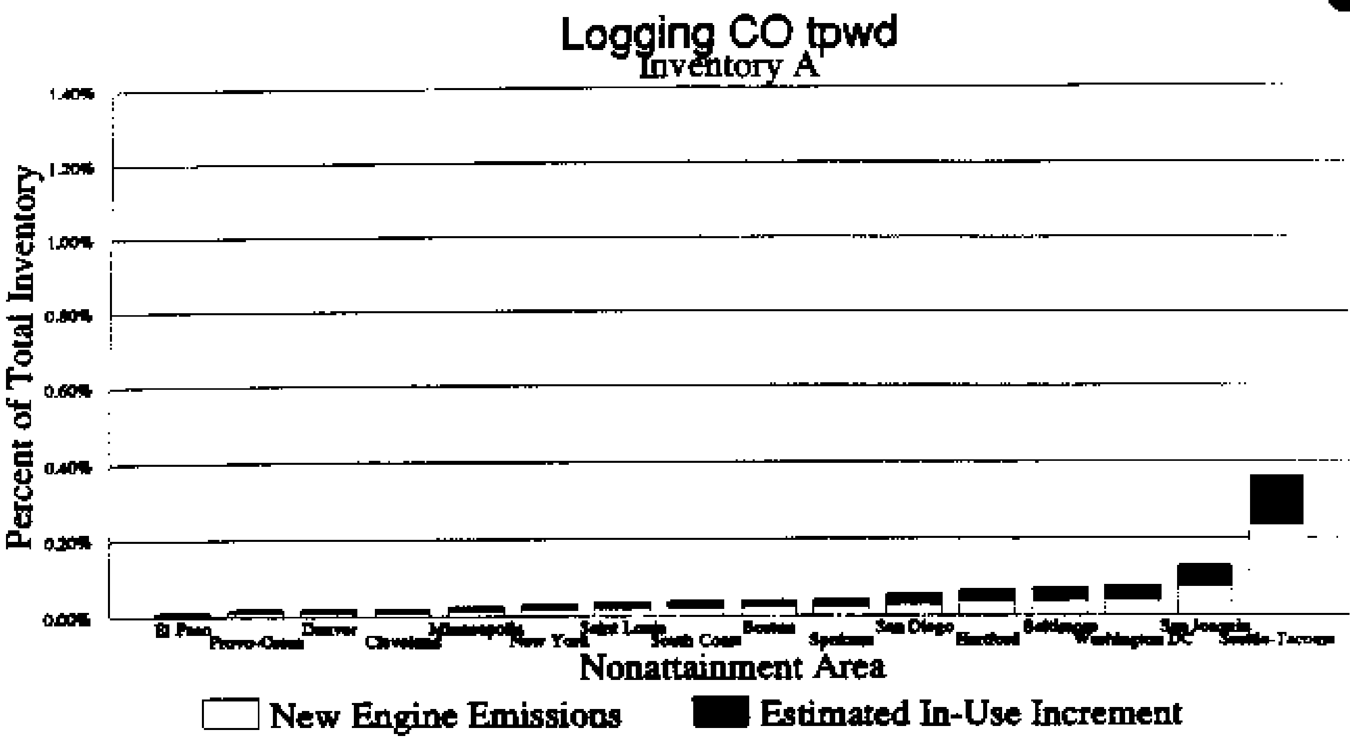
Light Commercial PM tpy
Inventory B
1.40%
1.20%
1.00%
0.80%
0.60%
0.40%
0.20%
0.00%
Percent of Total Inventory
San Joaquin
Provo-Orem
El Paso
San Diego
Minneapolis
Saint Louis
South Coast
Denver
Spokane
Chicago
Cleveland
Seattle-Tacoma
New York
Nonattainment Area
New Engine Emissions
Estimated In-Use Increment

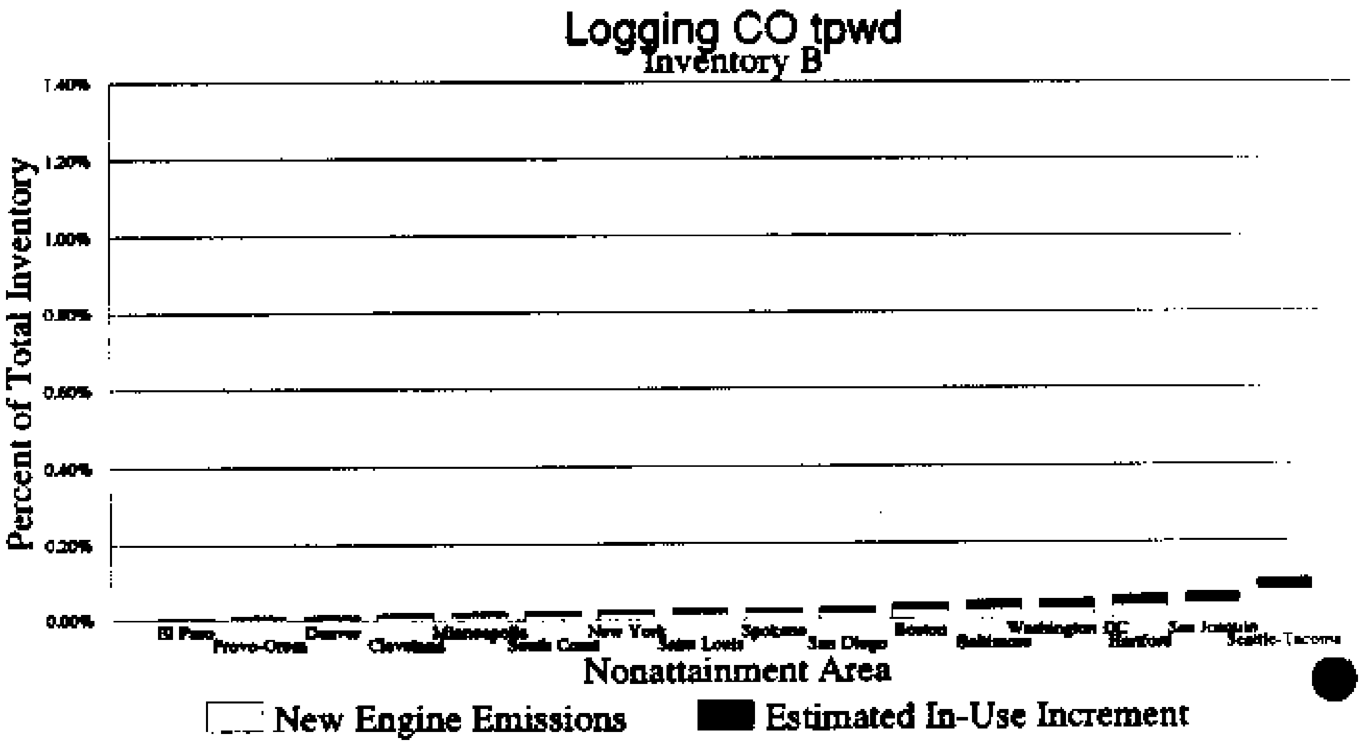

Logging VOC tpsd
Inventory A
1.40%
1.20%
1.00%
0.80%
0.60%
0.40%
0.20%
0.00%
Percent of Total Inventory
Miami
El Paso
Chicago
Cleveland
Houston
Baton Rouge
New York
Milwaukee
Boston
Saint Louis
Philadelphia
Springfield
South Coast
San Joaquin
San Diego
Hartford
Baltimore
Washington DC
Atlanta
Nonattainment Area
New Engine Emissions
Estimated In-Use Increment

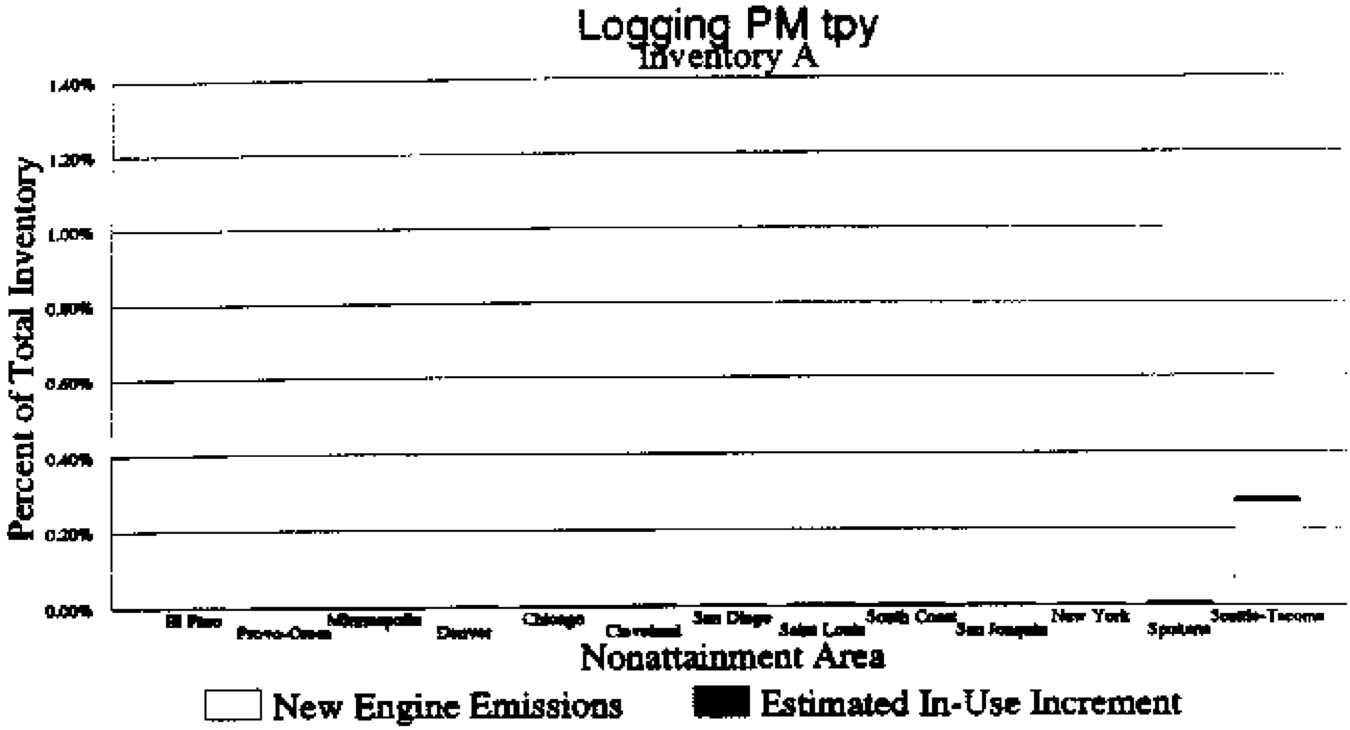

Logging VOC tpsd
Inventory B
1.40%
1.20%
1.00%
0.80%
0.60%
0.40%
0.20%
0.00%
Percent of Total Inventory
Miami
El Paso
Baton Rouge
Houston
Chicago
Cleveland
New York
Philadelphia
Milwaukee
San Joaquin
Boston
South Coast
Saint Louis
San Diego
Springfield
Hartford
Baltimore
Washington DC
Atlanta
Nonattainment Area
New Engine Emissions
Estimated In-Use Increment

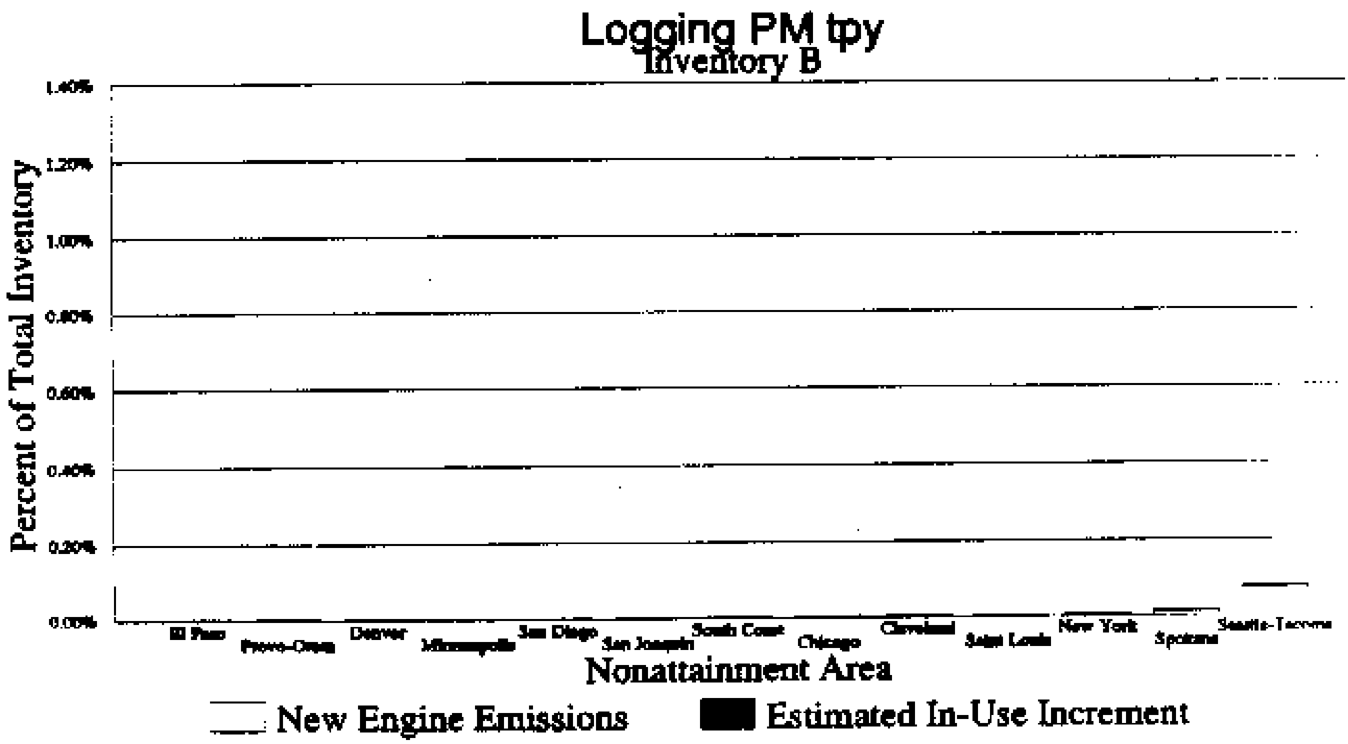

Logging NOx tpsd
Inventory A
1.40%
1.20%
1.00%
0.80%
0.60%
0.40%
0.20%
0.00%
Percent of Total Inventory
El Paso
Chicago
Saint Louis
Cleveland
Miami
New York
Milwaukee
Boston
Philadelphia
Springfield
Baltimore
Washington DC
San Diego
Hartford
Atlanta
South Coast
Houston
San Joaquin
Baton Rouge
Nonattainment Area
New Engine Emissions
Estimated In-Use Increment

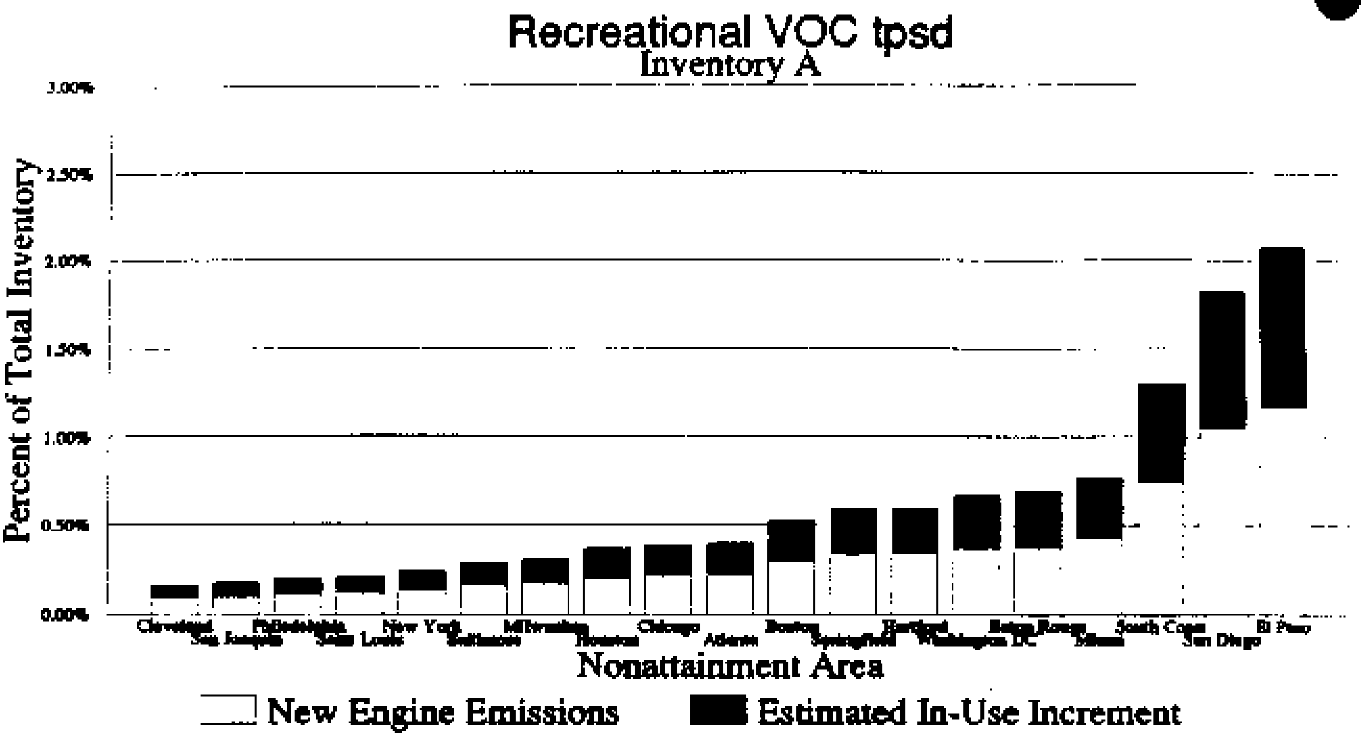

Logging NOx tpsd
Inventory B
1.40%
1.20%
1.00%
0.80%
0.60%
0.40%
0.20%
0.00%
Percent of Total Inventory
Miami
Milwaukee
San Diego
Chicago
Saint Louis
Philadelphia
Cleveland
Baltimore
South Coast
New York
Washington DC
El Paso
San Joaquin
Houston
Atlanta
Hartford
Boston
Baton Rouge
Springfield
Nonattainment Area
New Engine Emissions
Estimated In-Use Increment

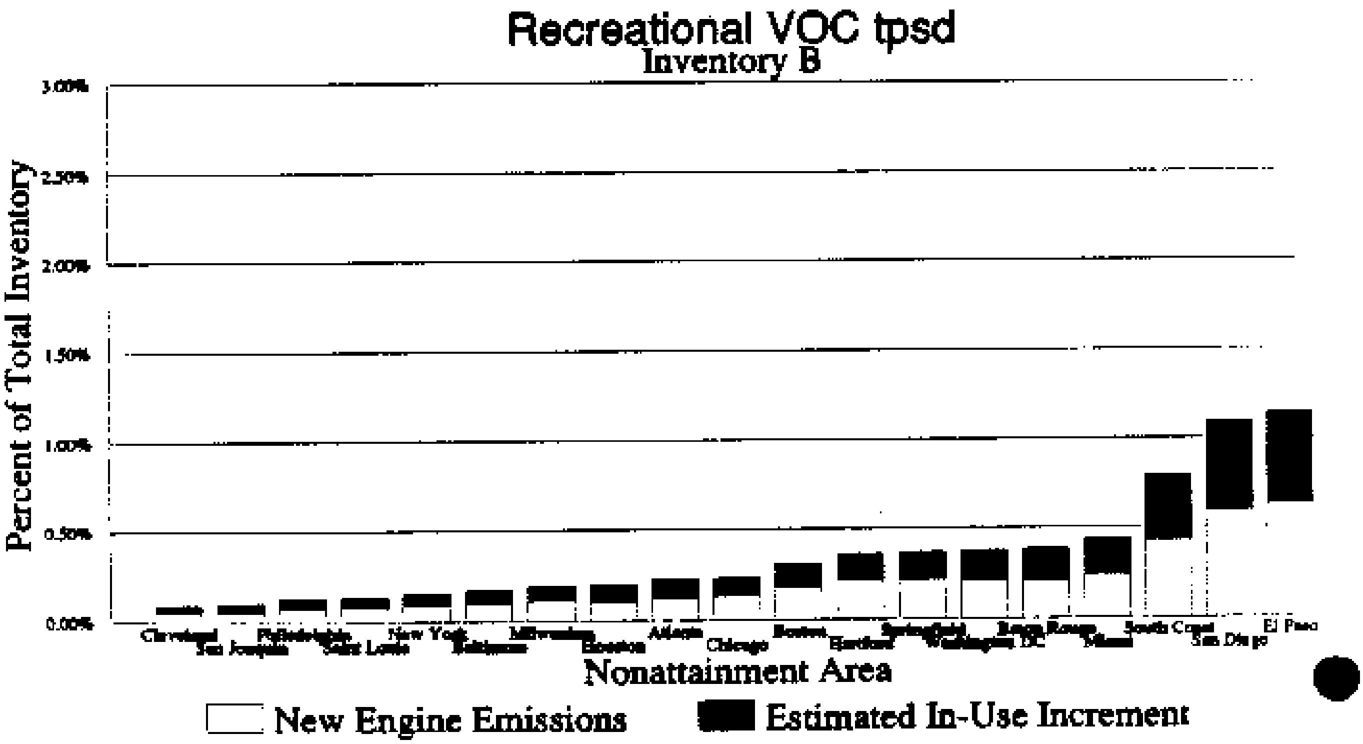

Logging CO tpwd
Inventory A
Percent of Total Inventory
1.40%
1.20%
1.00%
0.80%
0.60%
0.40%
0.20%
0.00%
El Paso
Provo-Orem
Denver
Cleveland
Minneapolis
New York
Saint Louis
South Coast
Boston
Spokane
San Diego
Hartford
Baltimore
Washington DC
San Joaquin
Seattle-Tacoma
Nonattainment Area
New Engine Emissions
Estimated In-Use Increment


Logging CO tpwd
Inventory B
Percent of Total Inventory
1.40%
1.20%
1.00%
0.80%
0.60%
0.40%
0.20%
0.00%
El Paso
Provo-Orem
Denver
Cleveland
Minneapolis
South Coast
New York
Saint Louis
Spokane
San Diego
Boston
Baltimore
Washington DC
Hartford
San Joaquin
Seattle-Tacoma
Nonattainment Area
New Engine Emissions
Estimated In-Use Increment


Logging PM tpy
Inventory A
1.40%
1.20%
1.00%
0.80%
0.60%
0.40%
0.20%
0.00%
Percent of Total Inventory
El Paso
Provo-Orem
Minneapolis
Denver
Chicago
Cleveland
San Diego
Saint Louis
South Coast
San Joaquin
New York
Spokane
Seattle-Tacoma
Nonattainment Area
New Engine Emissions
Estimated In-Use Increment


Logging PM tpy
Inventory B
1.40%
1.20%
1.00%
0.80%
0.60%
0.40%
0.20%
0.00%
Percent of Total Inventory
El Paso
Provo-Orem
Denver
Minneapolis
San Diego
San Joaquin
South Coast
Chicago
Cleveland
Saint Louis
New York
Spokane
Seattle-Tacoma
Nonattainment Area
New Engine Emissions
Estimated In-Use Increment


Recreational VOC tpsd
Inventory A
Percent of Total Inventory
0.00%
0.50%
1.00%
1.50%
2.00%
2.50%
3.00%
Nonattainment Area
New Engine Emissions
Estimated In-Use Increment


Recreational VOC tpsd
Inventory B
Percent of Total Inventory
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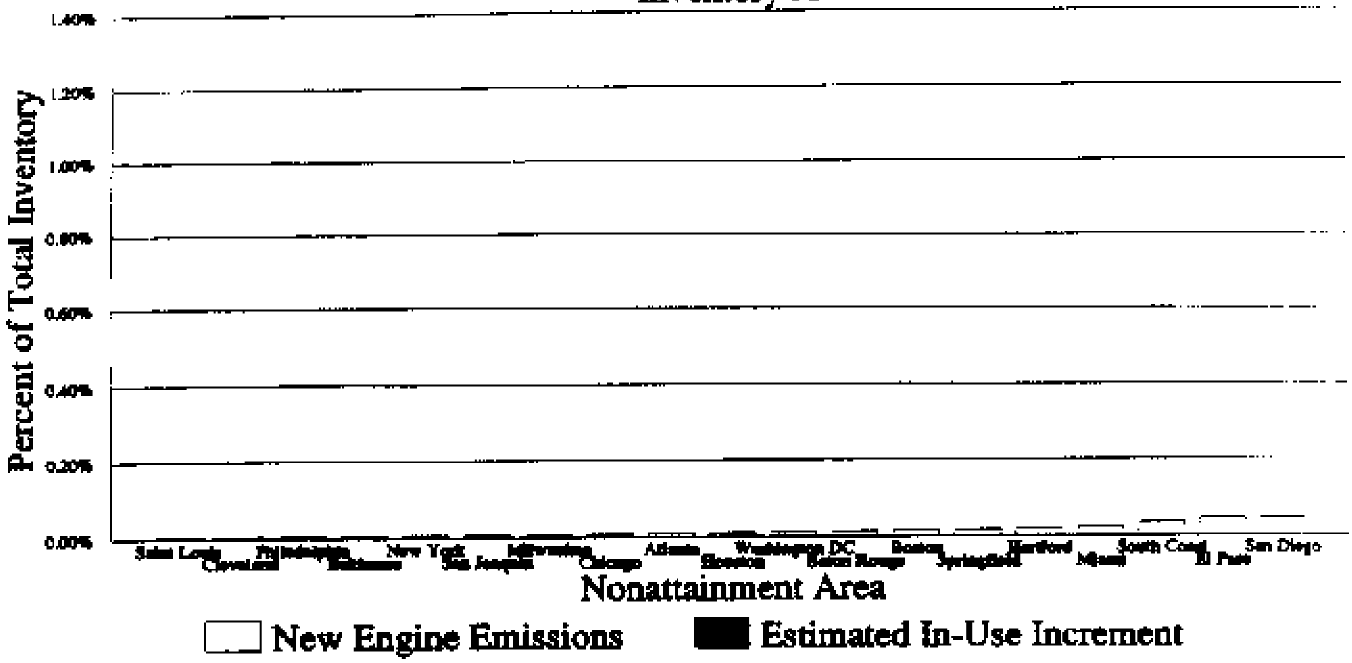
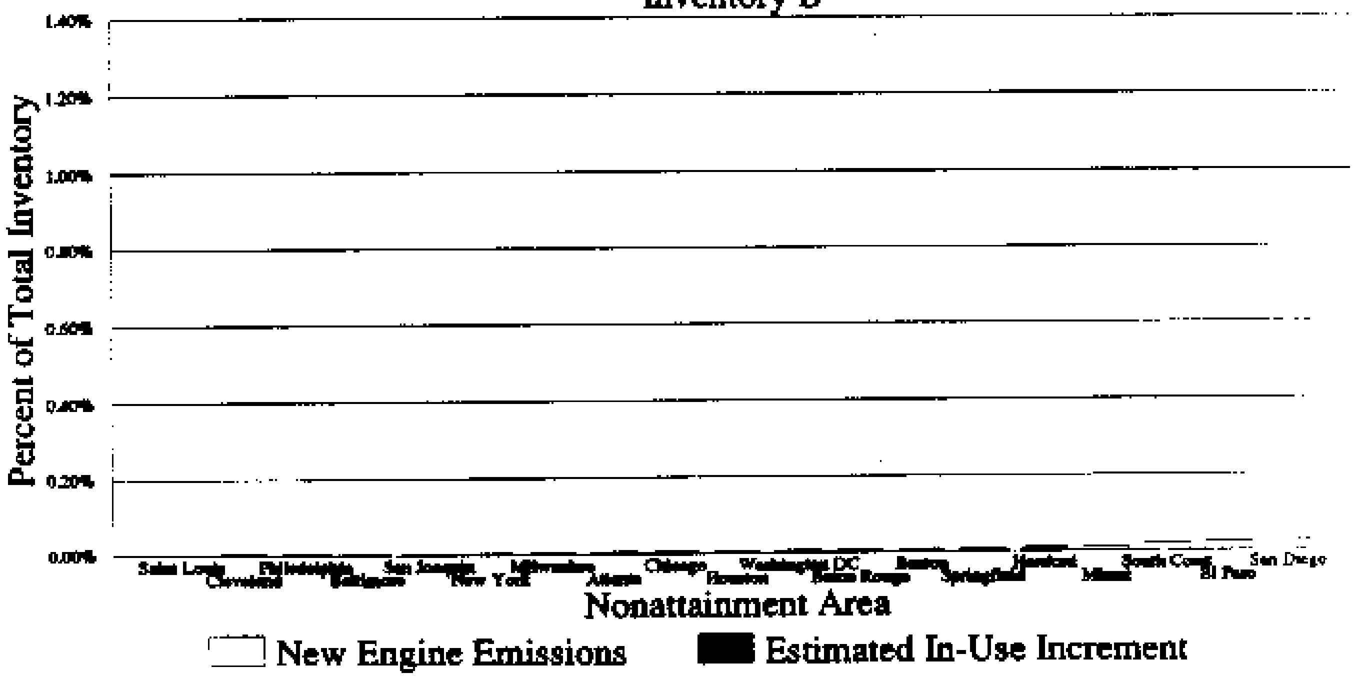
0.50%
1.00%
1.50%
2.00%
2.50%
3.00%
Nonattainment Area
New Engine Emissions
Estimated In-Use Increment

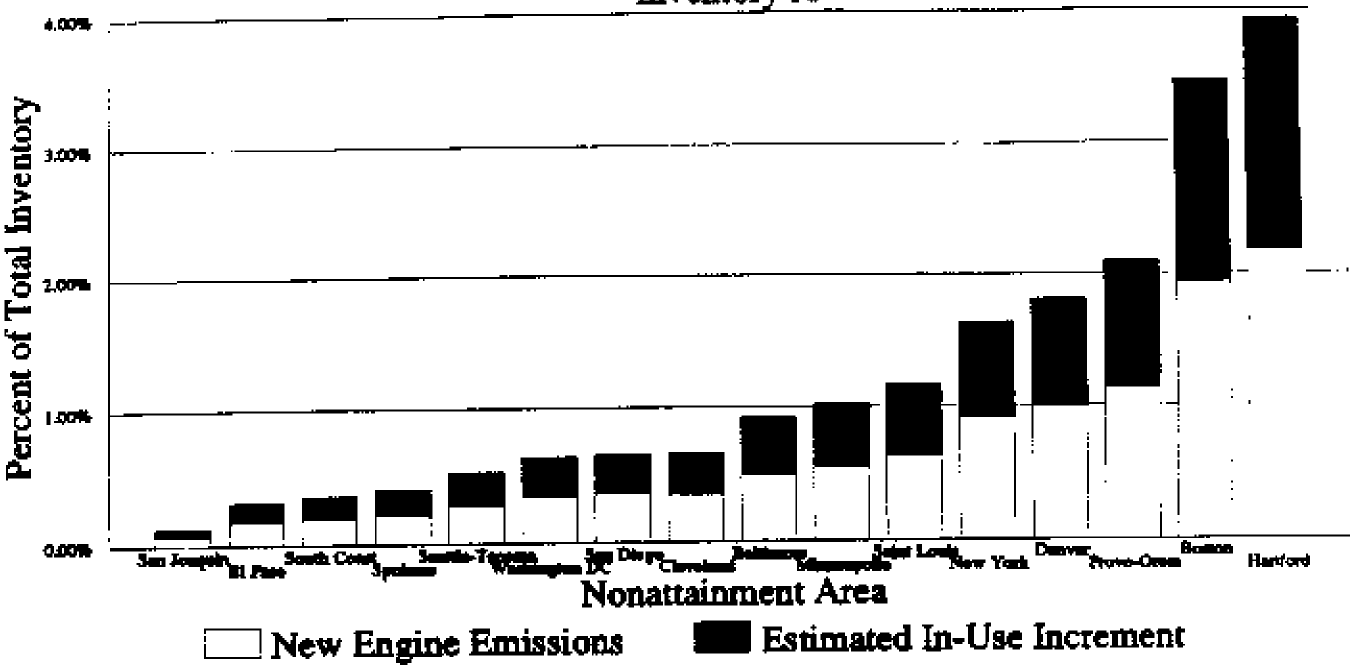
Recreational NOx tpsd
Inventory A



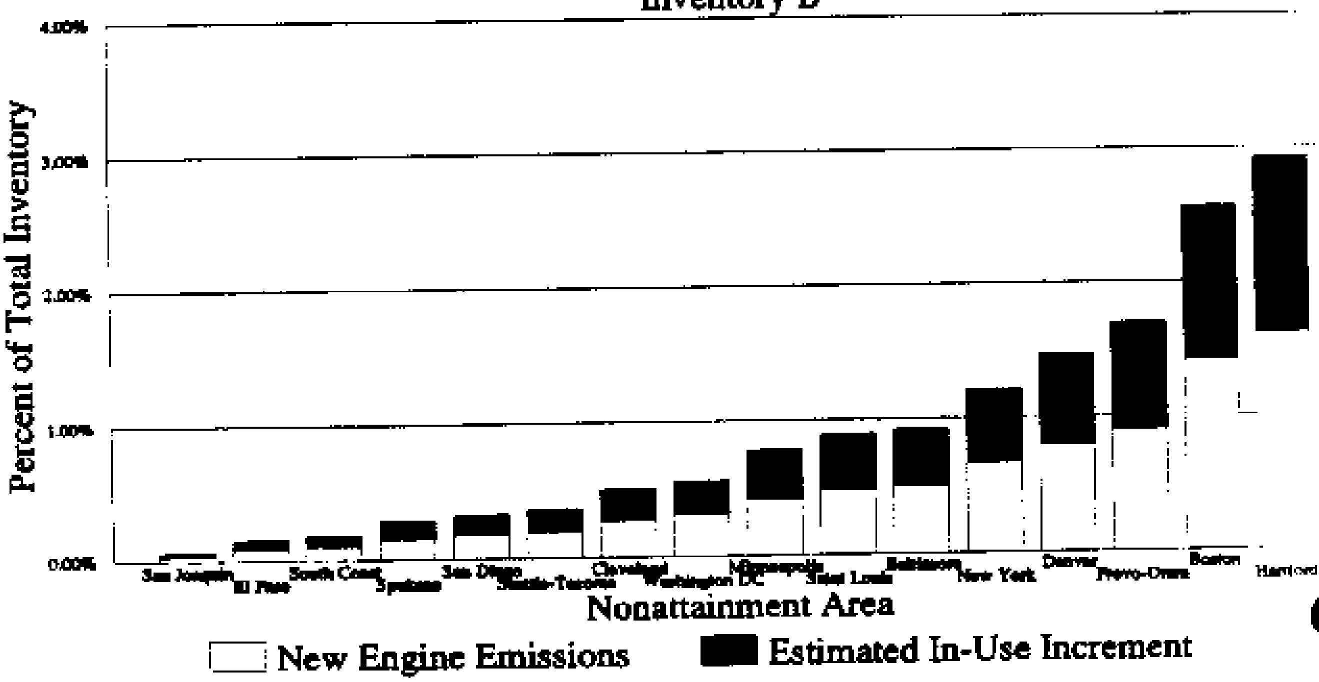
Recreational NOx tpsd
Inventory B

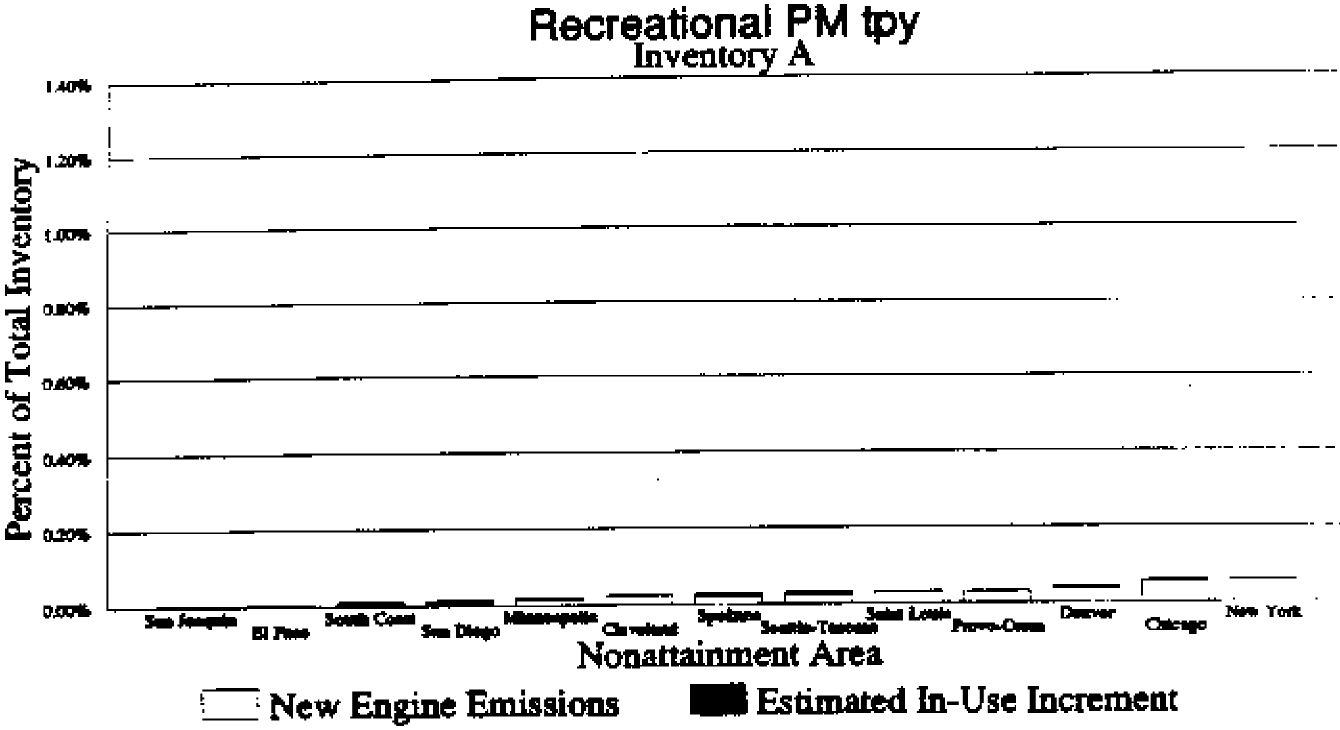


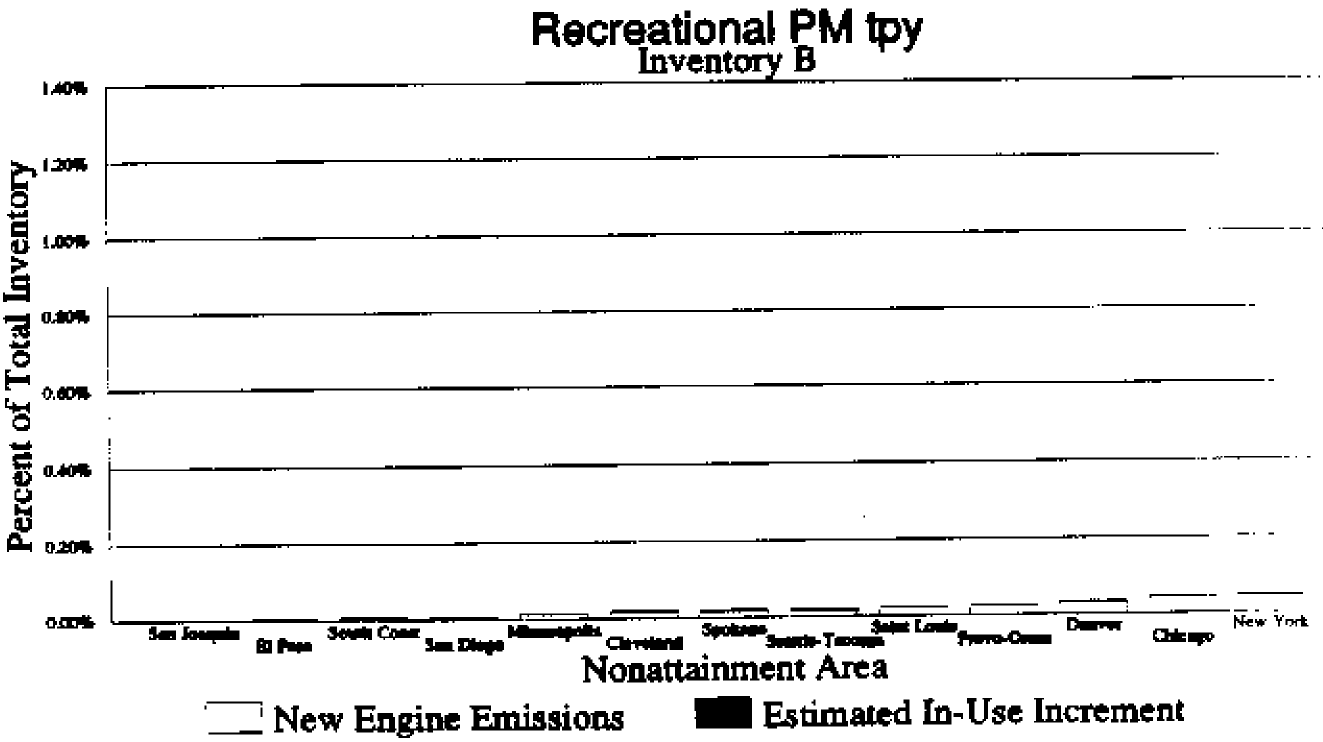
Recreational CO tpwd
Inventory A



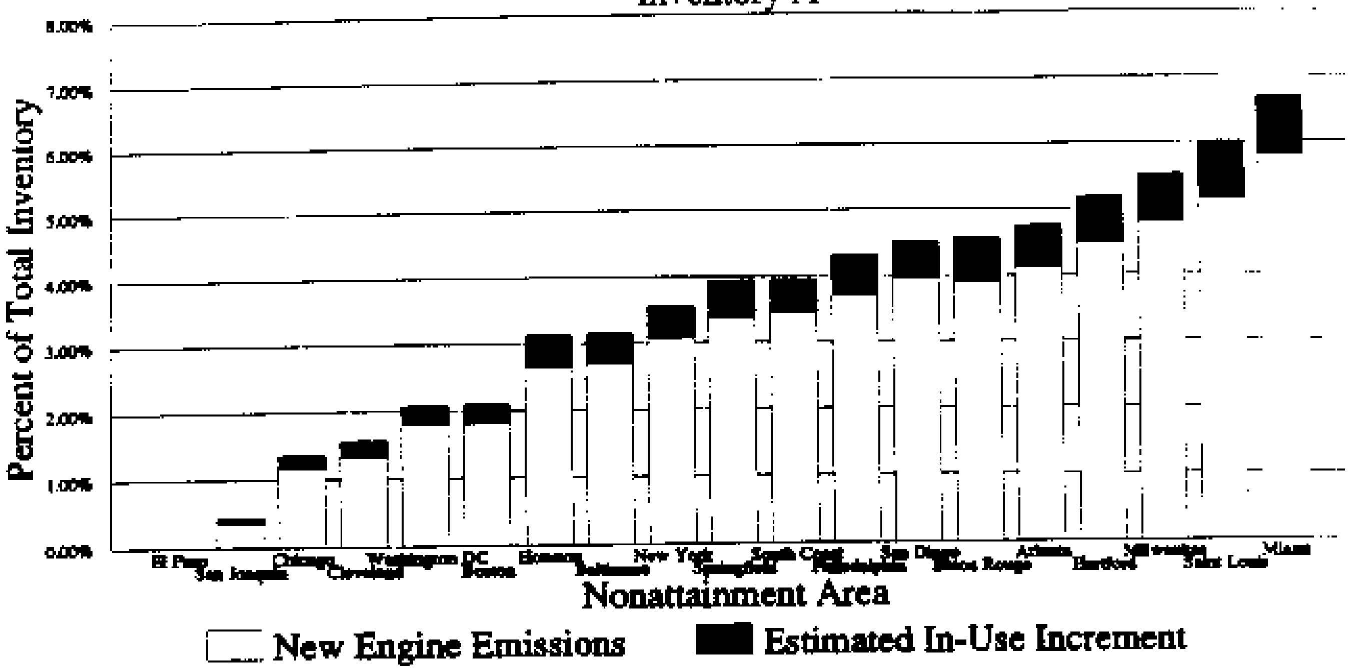
Recreational CO tpwd
Inventory B



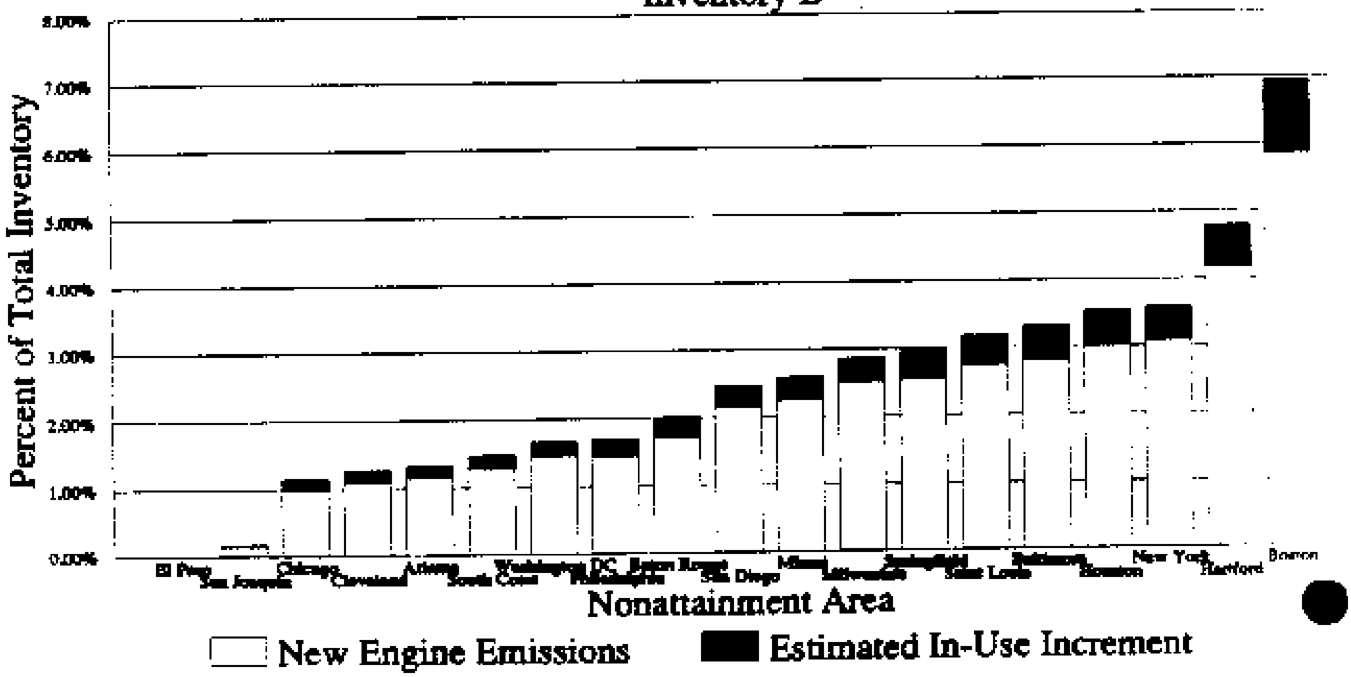

Recreational PM tpy
Inventory A
Percent of Total Inventory
Nonattainment Area
New Engine Emissions
Estimated In-Use Increment

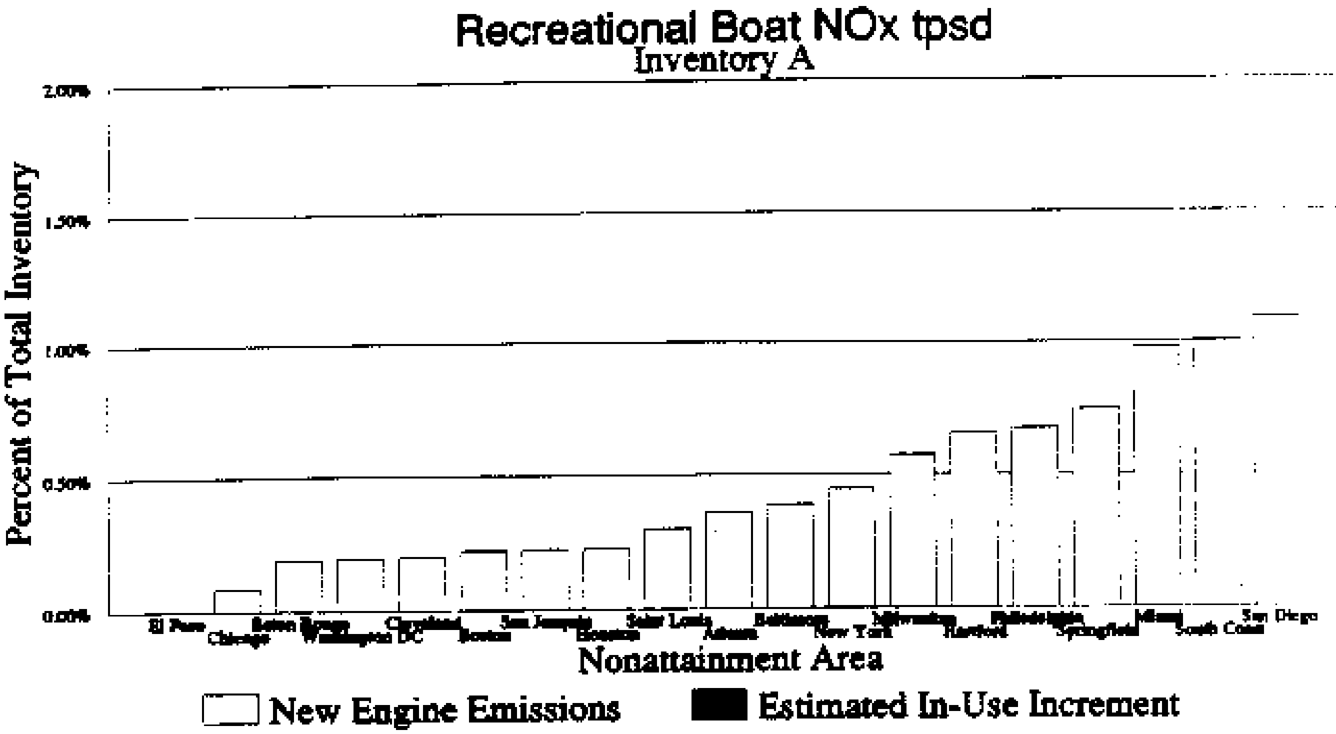

Recreational PM tpy
Inventory B
Percent of Total Inventory
Nonattainment Area
New Engine Emissions
Estimated In-Use Increment

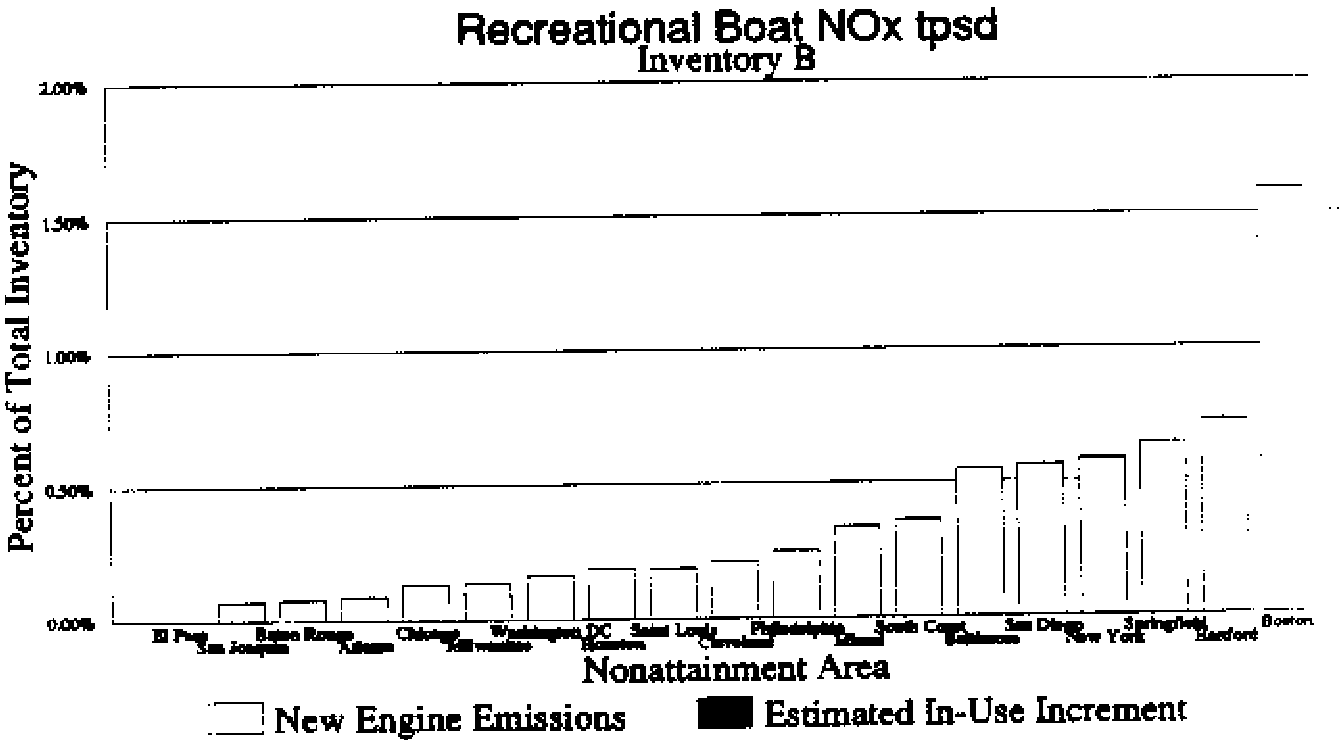
Recreational Boat VOC tpsd
Inventory A

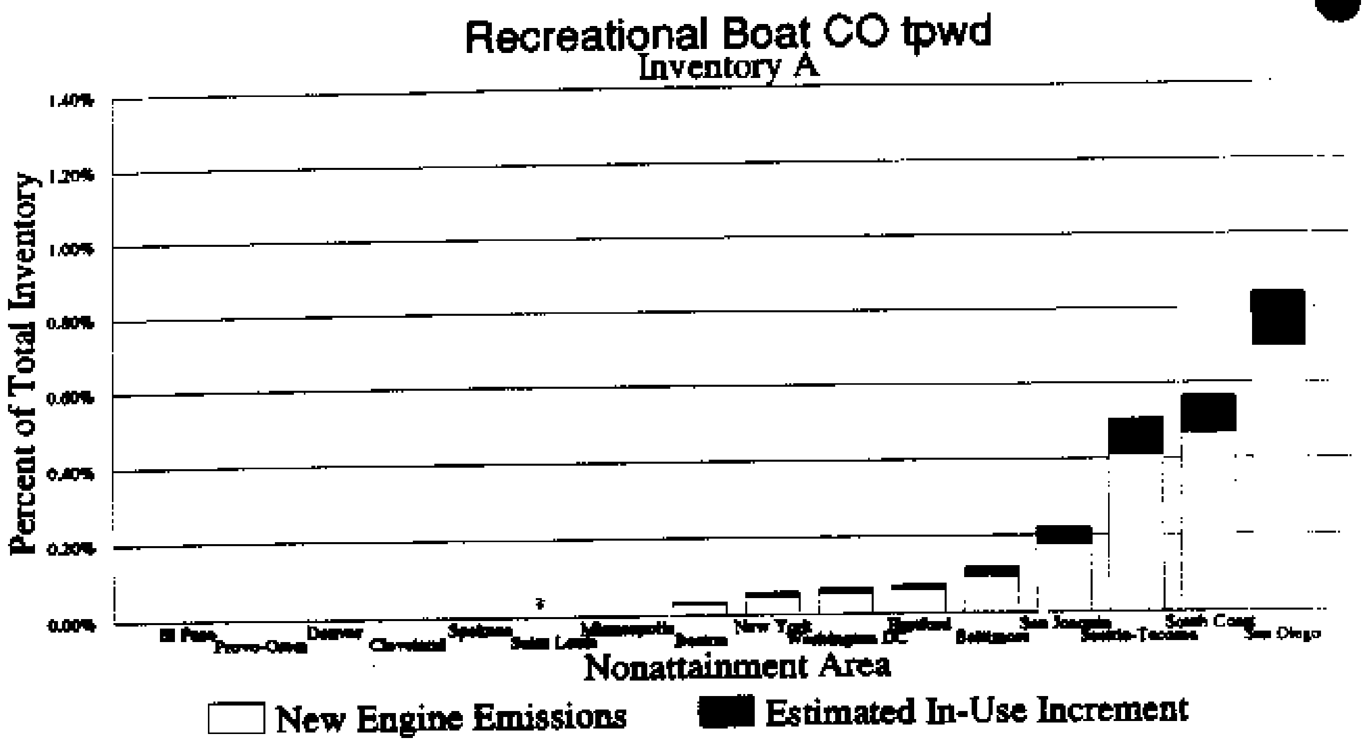


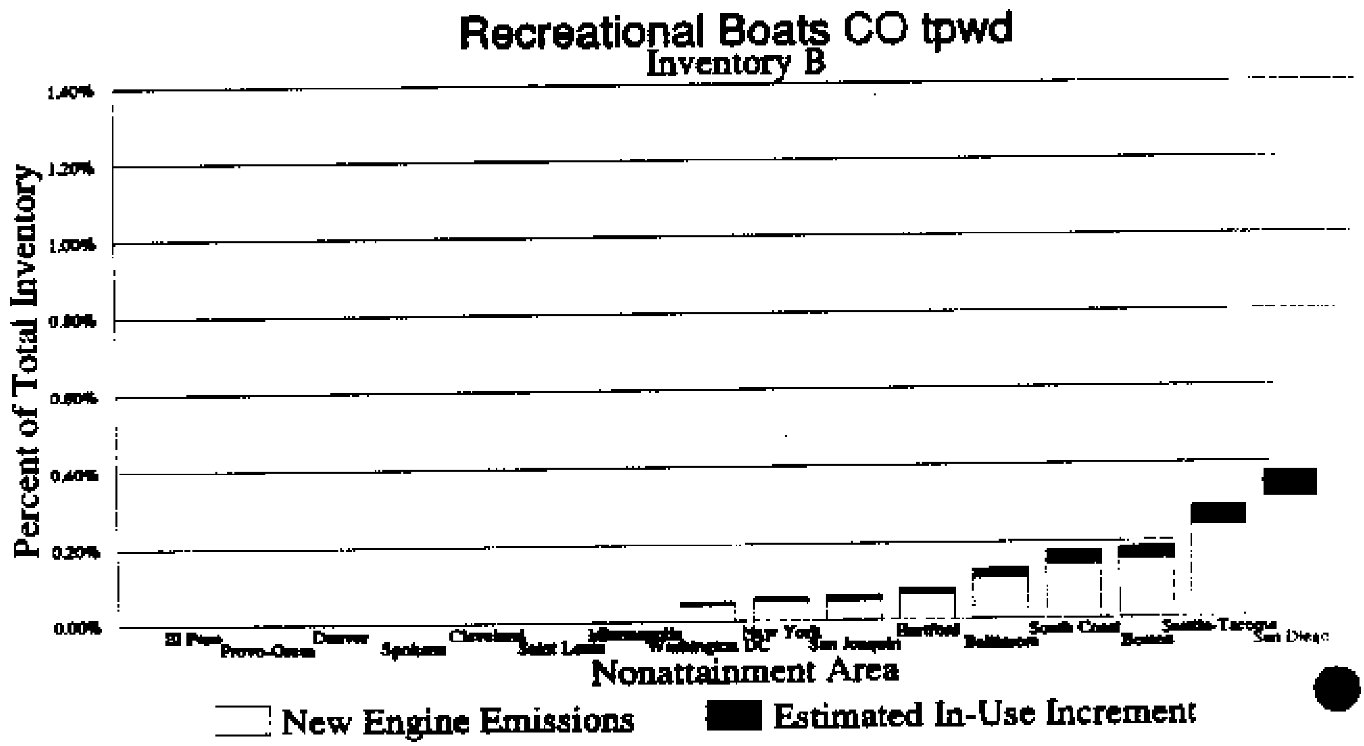
Recreational Boat VOC tpsd
Inventory B

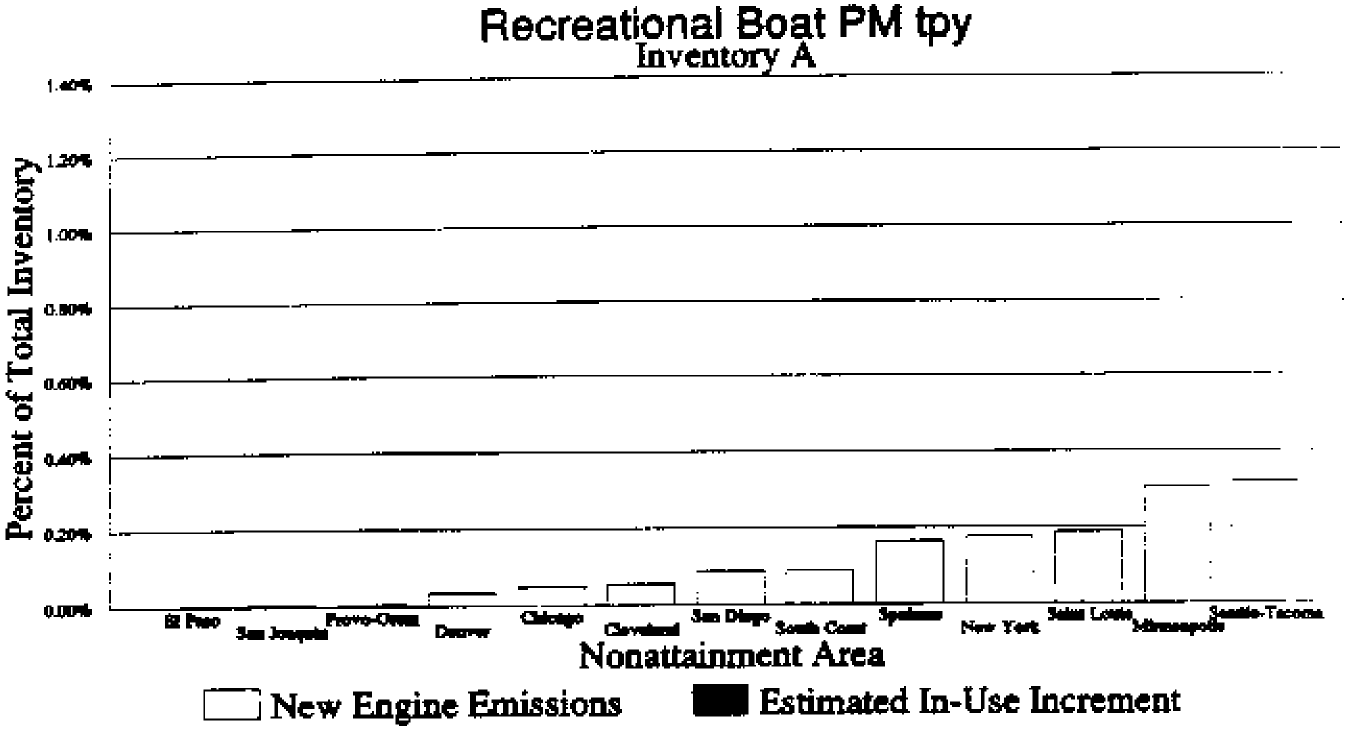


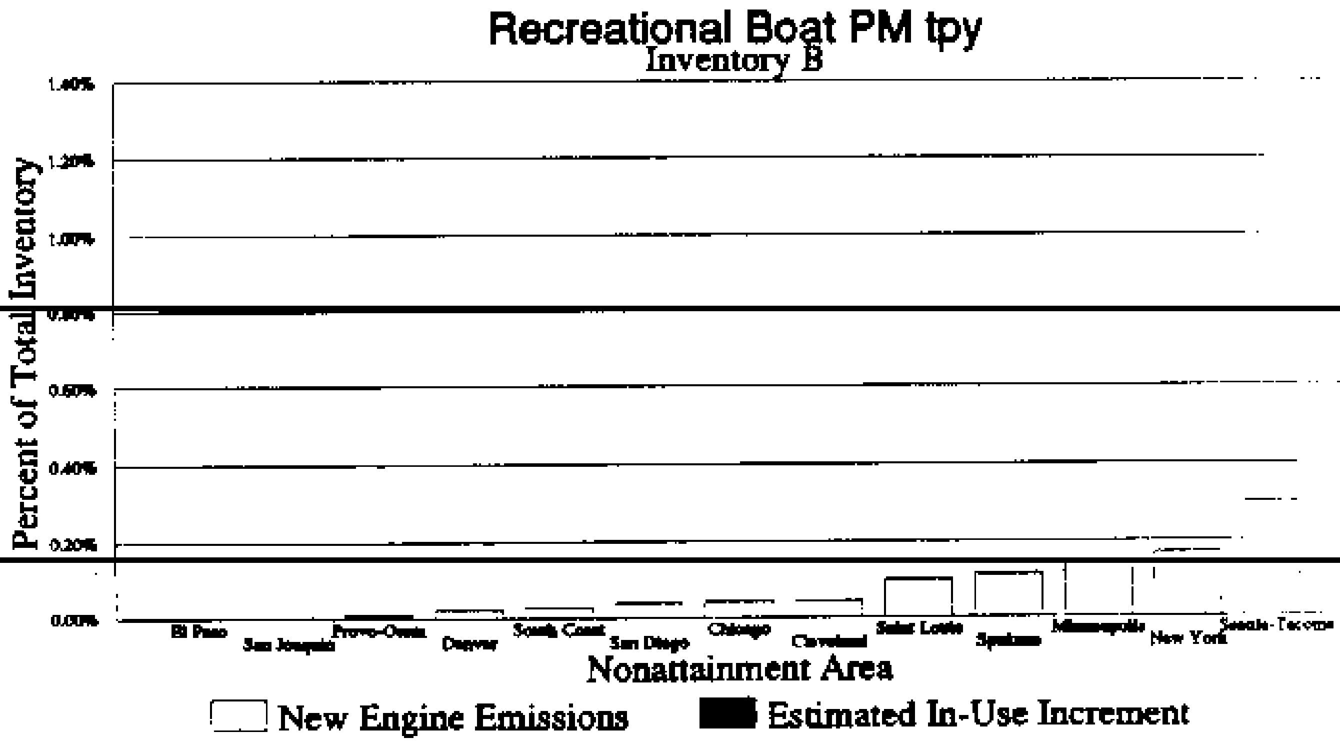

Recreational Boat NOx tpsd
Inventory A
2.00%
1.50%
1.00%
0.50%
0.00%
Percent of Total Inventory
El Paso
Chicago
Baton Rouge
Washington DC
Cleveland
Boston
San Joaquin
Houston
Saint Louis
Atlanta
Baltimore
New York
Milwaukee
Hartford
Philadelphia
Springfield
Miami
South Coast
San Diego
Nonattainment Area
New Engine Emissions
Estimated In-Use Increment


Recreational Boat NOx tpsd
Inventory B
2.00%
1.50%
1.00%
0.50%
0.00%
Percent of Total Inventory
El Paso
San Joaquin
Baton Rouge
Atlanta
Chicago
Milwaukee
Washington DC
Houston
Saint Louis
Cleveland
Philadelphia
Miami
South Coast
Baltimore
San Diego
New York
Springfield
Hartford
Boston
Nonattainment Area
New Engine Emissions
Estimated In-Use Increment


Recreational Boat CO tpwd
Inventory A
Percent of Total Inventory
1.40%
1.20%
1.00%
0.80%
0.60%
0.40%
0.20%
0.00%
Nonattainment Area
New York
San Diego
New Engine Emissions
Estimated In-Use Increment


Recreational Boats CO tpwd
Inventory B
Percent of Total Inventory
1.40%
1.20%
1.00%
0.80%
0.60%
0.40%
0.20%
0.00%
Nonattainment Area
San Diego
New Engine Emissions
Estimated In-Use Increment


Recreational Boat PM tpy
Inventory A
1.40%
1.20%
1.00%
0.80%
0.60%
0.40%
0.20%
0.00%
Percent of Total Inventory
El Paso
San Joaquin
Provo-Orem
Denver
Chicago
Cleveland
San Diego
South Coast
Spokane
New York
Saint Louis
Minneapolis
Seattle-Tacoma
Nonattainment Area
New Engine Emissions
Estimated In-Use Increment


Recreational Boat PM tpy
Inventory B
1.40%
1.20%
1.00%
0.60%
0.40%
0.20%
0.00%
Percent of Total Inventory
El Paso
San Joaquin
Provo-Orem
Denver
South Coast
San Diego
Chicago
Cleveland
Saint Louis
Spokane
Minneapolis
New York
Seattle-Tacoma
Nonattainment Area
New Engine Emissions
Estimated In-Use Increment

3.3. National PM, SO_X, and Air Toxics Inventories

Table 3-02 summarizes national emission inventories for particulate matter, formaldehyde, benzene, 1,3-butadiene, gasoline vapors, and oxides of sulfur for all nonroad sources. Inventories from highway vehicles and other area and point sources are presented where available and the contribution of nonroad sources to total inventory is calculated. Due to the extremely limited availability of data for toxic inventories for highway and other area and point sources, the data in the table are from the most recent year for which data was available. Therefore, the data can only be used for approximate comparisons of the contributions from the various sources of air toxic emissions. The nonroad inventories for air toxics in Table 3-02 are the in-use adjusted Inventory A numbers. The formaldehyde and benzene inventories for highway and other area and point sources were taken from an EPA technical report by P. Carey.[10] The PM and SO_X inventories were derived from EPA's 1989 emission trends report.[11] The highway vehicle value for 1,3-butadiene was based on assuming that this toxic accounted for 0.35% of the total exhaust hydrocarbons emitted from highway vehicles.[12] The aldehyde emission factors used in this study for nonroad sources are in terms of total aldehydes. To compare formaldehyde inventories from nonroad to other sources, EPA assumed that 60% of the total nonroad aldehyde emissions were formaldehyde.[*******]

[*******] The 60% estimate was typical for engines which had separate formaldehyde, as well as total aldehyde, emission measurements reported in *Nonroad Emission Factors of Air Toxics* by Melvin N. Ingalls, Southwest Research Institute, SwRI 08-3426-005.

Table 3-02. Air Toxics Emission Inventories

Toxic	Nonroad Sources		Highway Sources		Other Area And Point Sources		Total tpy
	tpy	% of Total	tpy	% of Total	tpy	% of Total	
particulate*	457,396	5.55	1,397,738	16.96	6,384,620	77.49	8,239,754
formaldehyde	41,663	13.05	74,961	23.48	202,670	63.47	319,294
benzene	109,783	25.37	275,579	63.68	47,400	10.95	432,762
1,3-butadiene	47,816		9,869				
gasoline vapors	237,048**		2,819,727				
SO_x	230,495	0.99	652,572	2.81	22,311,998	96.19	23,195,065

* Does not include fugitive dust from unpaved roads and airstrips which accounts for about 77% of total suspended particles.

** Does not include running losses or hot soak evaporative emissions.

3.4. SIP and CARB Inventory Analysis

As discussed in Chapter 2, inventories were prepared using data from SIPs and CARB analyses. The following tables summarize the results from the SIP- and CARB-based inventories. It should be noted that the emission factors used to develop SIP- and CARB-based inventories do not include in-use or transient operation adjustments. A discussion of the emission factors used to develop these inventories can be found in Appendix I. A discussion of the methodology used to create these inventories and a more detailed report of the results can be found in Appendix G.

Table 3-03. SIP-Based Inventory Summary

CMSA/NECMA	VOC		NO_x		CO	
	tpy (%)	tpsd (%)	tpy (%)	tpsd (%)	tpy (%)	tpwd (%)
Atlanta, GA	3	4	7	8		
Beaumont-Port Arthur, TX		1		18		
Boston, MA		6		9		6
Chicago, Il		5		7.6		
Connecticut		10		21		4
Dallas, TX		4		14		
Denver, CO						3
Duluth, MN					6	
El Paso, TX		3		18		
Fort Collins, CO						4
Hartford, CT		7		25		4
Houston, TX		4		6		
Louisville, KY		12		44		
Minneapolis, MN					16	
New Jersey	6		13		16	
Seattle, WA					9	
Springfield, MA		12		9		
State of Mass.		8		8	6	

Table 3-04. CARB-Based Inventory Summary

Air Basin	VOC tpsd (%)	NO_x tpsd (%)	CO tpwd (%)
Mountain Counties	5	31	6
Sacramento Valley	4	19	10
San Diego	3	29	10
San Francisco Bay Area	2	21	11
San Joaquin	2	13	13
South Central Coast	2	13	12
South Coast	3	17	11

Chapter 4. Discussion and Analysis of Results

Chapter 3 presented a summary of the inventories calculated from the data collected for this study. This chapter contains EPA's analysis of these inventories and its interpretation of the results. Specifically, the first section contains an analysis of nonroad contributions to total emissions by pollutant and equipment categories. A discussion of the methodologies used to calculate the inventories and their potential impact on the results is presented in the second section. Last, the contribution of nonroad emissions is compared to other categories that are currently regulated.

4.1. Discussion of Inventory Results

Following are discussions of the results for emissions of VOC, NO_X, CO, and other pollutants, and the relative contribution of equipment categories. The overall nonroad emission contributions are summarized by pollutant.

4.1.1. Volatile Organic Compounds (VOC) Inventories

Both Inventory A and Inventory B estimate that substantial summertime VOC emissions derive from nonroad sources. Inventory A estimates that 18 of the 19 ozone nonattainment areas examined have nonroad contributions over 6-9% (lower limit represents new engine and upper limit represents in-use emission factors) of total summertime VOC inventories, with a median contribution of 9.1-12.6%. The estimates in Inventory B are about 15-20% lower than those in Inventory A. However, Inventory B still estimates that 14 of the 19 areas have nonroad contributions over 6-9%, with a median contribution of 7.4-10.3%.

The largest contributors to nonroad VOC emissions are the lawn and garden and recreational marine categories. In Inventory A, the median contribution of lawn and garden equipment to total summertime VOC inventories is 2.7-4.7%, with the lowest reported contribution being 1.1-1.9%. Inventory B is slightly lower, on average, with estimates of the median lawn and garden contribution at 2.4-4.2%, and 18 areas above 1.1-1.9%.

Contributions of recreational marine equipment to nonroad VOC emissions are similar to lawn and garden contributions. Inventory A estimates the median contribution of recreation marine equipment to be 3.4-4.0%, with 15 of the 19 areas above 2%. Inventory B estimates are about a third lower, overall, but still estimates a median contribution of 2.2-2.5%, with 10 of the 19 areas above 2%.

The light commercial and construction categories each contribute at least 0.5% of total summertime inventories in 17 of the 19 nonattainment areas. Table 4-01 shows the number of nonattainment areas in which the equipment category listed contributes at least 1% of the VOC inventory.

Table 4-01. Equipment Categories Contributing at least 1% of Total Summertime VOC Inventory

Equipment Category	Number of Areas	
	Inventory A	Inventory B
Lawn and Garden	19	18-19
Recreational Equipment	2-3	0-2
Recreational Marine	17	17
Light Commercial	2-11	2-12
Construction	11-14	5-6
Agricultural	1	1
Commercial Marine	1	1

It should be noted that exhaust emissions account for less than three-quarters of the total VOC emissions from the lawn and garden category. The remaining VOC emissions from this category are due to crankcase, evaporative, and refueling spillage emissions. Spillage during refueling of the equipment is estimated to contribute 7.5% of the total lawn and garden VOC inventories and 8.9% of the lawnmower VOC inventories.

4.1.2. Nitrogen Oxide (NO_x) Inventories

Total summertime NO_x emissions from nonroad sources are estimated to be larger, as a percentage of total emissions, than nonroad VOC emissions. Nonroad NO_x emissions in all of the ozone nonattainment areas in Inventory A are estimated to be greater than 12% of the total summertime NO_x inventory, with a median contribution of 17.3%. Although lower, Inventory B still estimates that nonroad emissions contribute over 11% of total summertime NO_x emissions in 16 of the 19 nonattainment areas studied, with a median contribution of 14.5%.

Construction equipment is the largest contributor to nonroad NO_x emissions in 17 of the 19 nonattainment areas studied. Inventory A estimates that construction equipment contributes at least 6.4% of total summertime NO_x emissions in each area, with a median contribution of 9.7%. Inventory B is more than 15% lower, but still estimates that 15 of the 19 areas have construction equipment contributions of over 5%, with a median contribution of 8.4%.

NO_x contributions from airport service equipment, industrial equipment, and agricultural equipment are each estimated to be at least 1% in most of the nonattainment areas studied. However, only in one case (agricultural equipment in the San Joaquin Valley) does the contribution from any of these categories exceed 3.6% in any nonattainment area. The commercial marine vessel contributions are more variable, with larger contributions in a limited number of areas. The inventories estimate contributions of over 4% in three nonattainment areas for the commercial marine category. Table 4-02 shows the number of nonattainment areas in which the category listed contributes at least 1% of the NO_x inventory.

Table 4-02. Equipment Categories Contributing at least 1% of Total Summertime NO_X Inventory

Equipment Category	Number of Areas	
	Inventory A	Inventory B
Airport Service Equipment	12	12
Recreational Marine	2	1
Industrial	13	13
Construction	19	19
Agricultural	12	13
Commercial Marine	10	9

4.1.3. Carbon Monoxide (CO) Inventories

Inventory A estimates that nonroad emissions contribute at least 9-12% of total wintertime CO emissions in 7 of the 16 CO nonattainment areas studied, with a median contribution of 5.9-9.4%. Although slightly lower, with a median contribution of 5.2-8.5%, Inventory B estimates that nonroad emissions contribute at least 6.9-10.5% of total wintertime CO emissions in 6 areas.

Unlike nonroad emission contributions to VOC and NO_X, the nonroad emission contribution to CO is not dominated by any one or two equipment categories. The lawn and garden, light commercial, industrial, recreational, and commercial marine equipment categories each contribute a minimum of 1.4-2.2% of total wintertime CO emissions in at least 2 nonattainment areas. The single largest nonroad contributor to winter CO emissions is light commercial equipment. Both Inventory A and Inventory B estimate that this category contributes at least 2.0-3.6% of total emissions in 8 of the 16 nonattainment areas studied. Table 4-03 shows the number of nonattainment areas in which the category listed contributes at least 1% of the CO inventory.

Table 4-03. Equipment Categories Contributing at least 1% of Total Wintertime CO Inventory

Equipment Category	Number of Areas	
	Inventory A	Inventory B
Lawn and Garden	5-9	3-6
Recreational Equipment	3-7	2-5
Commercial Marine	2	2
Light Commercial	15	15
Industrial	12-13	10-11
Construction	3-4	0-1

4.1.4. Particulate (PM) Inventories

Inventory A estimates that nonroad emissions contribute over 3% of total PM inventories in 2 of the 13 PM nonattainment areas studied, with a median contribution of 1.8%. Inventory B is substantially lower, with a median contribution of about 1.0%, and only estimates that 1 area has nonroad contributions of over 3%.

Table 4-04 shows the number of nonattainment areas in which the category listed contributes at least 1% of the PM inventory.

Table 4-04. Equipment Categories Contributing at least 1% of Total PM Inventory

Equipment Category	Number of Areas	
	Inventory A	Inventory B
Construction	2	0
Commercial Marine	1	1

4.1.5. National Air Toxics Inventories

Section 3.3 presented estimates of toxic emissions from nonroad sources (Table 3-02). The limited availability of toxic emission data for nonroad sources made it difficult to quantify precisely the inventory from these sources. Uncertainties also exist as to the health effects (example: number of cancer incidences per year) of toxic emissions. A summary table of cancer risk estimates for air toxics is provided in Table 4-05. In this section, PM is treated as a toxic emission because of its long-term health effects (carcinogenicity) and its status as a criteria pollutant.

A rough approximation of the cancer risk from nonroad toxic emissions relative to highway toxic emissions can be determined from the ratio of nonroad inventory to highway inventory which is derived from Table 3-02. Table 4-06 shows the ratio using this method for 1986. These risk estimates are intended to be used to rank the nonroad toxic pollutants and should not be viewed as actual numbers of cancer cases per year. In addition, the model used to derive the values in Table 4-05 was developed for national highway vehicles which are more likely to be used in populated urban areas than nonroad engines and vehicles on a national level. Therefore, the accuracy of the nonroad estimates is dependent on the differences in urban/rural usage of on-highway vehicles and nonroad equipment.

Table 4.05. Summary of Risk Estimates from Motor Vehicle Air Toxics.*††††††††

Motor Vehicle Pollutant	U.S. Cancer Incidences/Year**		
	1986	1995	2005
1,3-butadiene	236-269	139-172	144-171
Diesel Particulate	178-860	106-662	104-518
Benzene	100-155	60-107	67-114
Formaldehyde	46-86	24-43	27-48
Gasoline Vapors	17-68	24-95	30-119
Asbestos	5-33	ND***	ND
Acetaldehyde	2	1	1
Gasoline Particulate	1-176	1-156	1-146
Ethylene Dibromide	1	< 1	< 1
Cadmium	< 1	< 1	< 1
Dioxins	ND	ND	ND
Vehicle Interior Emissions	ND	ND	ND

* The risk estimates are 95% upper confidence limits.

** The risk estimates for asbestos, cadmium and ethylene dibromide are for urban exposure only. Risks for the other pollutants include both urban and rural exposure.

*** ND = Not Determined.

††††††††The risk estimates are upper bound estimates; therefore, they are not intended to represent actual numbers of cancer cases but rather can be used to rank the mobile source pollutants and to guide further study. Table taken from "Air Toxics Emissions and Health Risks from Motor Vehicles," presented by J.M. Adler and P.M. Carey at the AWMA Annual Meeting, 1989.

Table 4-06. Risk Estimates for Nonroad Toxic Emissions.

Nonroad/Highway Inventory Ratio	
1,3-Butadiene	4.85
Particulates	0.33
Benzene	0.40
Formaldehyde	0.56

As Table 4-06 shows, 1,3-butadiene cancer risk estimates are extremely high for nonroad sources compared to on-highway sources. This is due primarily to two factors. The first factor relates to emission levels of 1,3-butadiene and the use of catalysts. Most on-highway vehicles use catalysts and have 1,3-butadiene emissions that are about 0.35% of total exhaust emissions. In comparison, few nonroad engines are so equipped, and as a result, have 1,3-butadiene emissions that comprise about 1.3% of total exhaust hydrocarbons. Further discussion of this difference is found in Appendix I. The second factor relates to crankcase use. While the majority of on-highway vehicles use a closed crankcase system, most nonroad engines do not and, as a result, have higher 1,3-butadiene emissions.

Many toxics such as benzene, 1,3-butadiene, aldehydes, and gasoline vapors are included in the broad category of pollutants referred to as volatile organic compounds (VOCs). Measures to control VOC emissions should reduce emissions of these air toxics. However, the magnitude of reduction will depend on whether the control technology reduces the individual toxics in the same proportion that total VOCs are reduced.

As evidenced by the 1990 Clean Air Act Amendments, Congress recognized the need to study and regulate emissions of air toxics from motor vehicles and fuels. The Amendments require that EPA complete a study of emissions that pose the greatest risk to human health or about which significant uncertainties remain by May 15, 1992. Also, EPA must promulgate vehicle or fuel standards containing reasonable requirements to control toxic emissions, applying at the minimum to benzene and formaldehyde, by May 15, 1995.

4.2. Analysis of Inventory Methodologies

As outlined in Chapter 2, many of the inputs used to generate Inventory A and Inventory B are based upon different sources of information. This section discusses the effect that these differences could have on the inventory estimates. The results of this study could also be affected by methodologies which overestimate or underestimate emission inventories, as well as factors such as photochemical modeling, nonseasonal temporal adjustments, photochemical reactivity and transport. The potential impact of these factors on emission inventories is also discussed in this section.

4.2.1. Data Differences

The results and analysis presented in Chapters 3 and 4 reveal that Inventory A generally estimates higher nonroad emissions than Inventory B. This difference in emissions is primarily due to different local amounts of boat usage and annual fuel consumption estimates for the recreational marine category, activity level estimates for lawnmowers and population estimates for the construction category. The following highlights the differences in each category.

Lawn and Garden Equipment--Both the Outdoor Power Equipment Institute (OPEI) and the Portable Power Equipment Manufacturers Association (PPEMA) submitted local and national population estimates, annual hours of use, average horsepower, and load factors for lawn and garden equipment. This data was used to estimate the emissions inventory for Inventory B. Although there are several differences between the national populations, annual hours of use, average horsepowers, and load factors for lawn and garden equipment in Inventories A and B, these tend to offset one another in most cases, resulting in similar estimates of emissions from most lawn and garden equipment. The primary exception is lawnmowers. Inventory A estimates for lawnmower populations, annual hours of use, horsepower, and load factor are higher than those for Inventory B by 10%, 20%, 5%, and 20%, respectively, leading to activity level estimates for Inventory A that are, in general, about 70% higher than for Inventory B. Overall, Inventory A estimates lawn and garden emissions that are about 10-15% higher than Inventory B.

Recreational Equipment--The Motorcycle Industry Council (MIC) submitted survey results for actual miles driven and seasonal activity for off-road motorcycles and all-terrain vehicles. The seasonal activity levels were used by EPA to make seasonal adjustments for both inventories. The International Snowmobile Industry Association (ISIA) submitted national population and annual hours of use estimates for snowmobiles. The only substantial difference between Inventories A and B, is the latter's lower annual usage estimates. While this caused Inventory B's emission estimates from recreational equipment to be significantly lower than Inventory A's, the impact on total nonroad emissions is small due to the relatively low contribution of the category.

Recreational Marine--Both inventories used local boat registration data as the basis for making population estimates. However, the methods of allocating the number of boats actually used in the nonattainment areas differ significantly. Inventory A relies on survey results submitted by the National Marine Manufacturers Association (NMMA) from eight nonattainment areas to establish the ratio of boats used to boats registered in the nonattainment area. For Inventory B, NMMA supplied a method of estimating the ratio of boats used to boats registered based on the amount of water surface area in the nonattainment are per registered boat. The methodology used for Inventory B yields estimates of boat usage in the nonattainment areas that are about 10% lower than those in Inventory A. Another factor accounting for the difference between the two inventories is the estimate of annual gallons of fuel consumed. The average fuel use calculated for Inventory A from annual hour of use, average horsepower, and load factor estimates is very similar to the fuel use survey results reported by NMMA. However, NMMA believes that the reported fuel use in the survey is overstated. Thus, for Inventory B, EPA adjusted the average amount of fuel reported in the survey by the ratio of a national average fuel use calculation for outboard motors, 91 gallons/year, to the average reported in the NMMA survey for outboard motors, 142 gallons/year, before applying the results to the unsurveyed areas. Overall, emission estimates in Inventory B are about a third lower than those in Inventory A.

Industrial--The Industrial Truck Association (ITA) submitted population, annual hours of use, load factor, and engine type estimates for forklifts. The load factor estimates were adopted by EPA for both inventories. Overall, ITA's estimates yield emission inventory estimates substantially lower than the forklift estimates in Inventory A, primarily due to much lower annual hours of use estimates. Due to the relatively small amount of emissions from forklifts compared to some other equipment types, the impact on the overall NO_X inventory was less than 3% (the impact on the VOC and CO inventories is much lower yet). No information was submitted by industry for the other equipment types in this category.

Construction--Equipment Manufacturers Institute (EMI) submitted national horsepower, national load factor, regional hours of use, and regional population estimates for most of the equipment types in this category. Overall, the horsepower, load factor, and annual hours of use estimates are similar to the estimates used in Inventory A. However, EMI's population estimates are lower than those in Inventory A.

Agricultural, Airport Service, Light Commercial, Logging, and Commercial Marine--No substantial amount of information was submitted by industry for these equipment categories.

4.2.2. Factors Causing Overestimation or Underestimation

EPA had sufficient information in several areas to know that methodologies used to quantify emission inventories could tend to overstate or understate the actual inventories. Where sufficient data was available to quantify the bias, corrections were incorporated into the data used for the inventories developed for this study. However, in some cases, which are discussed in this section, sufficient data was not available to make adjustments.

The estimates used for NO_X emissions from highway vehicles and other area and point sources are taken from the 1985 National Emission Report. While more recent NO_X data is available on the national level, no general source of local NO_X emissions is available after 1985. The level of emissions from highway vehicles in 1990 is actually somewhat lower due to the replacement of older vehicles with new vehicles having more effective emission controls.[‡‡‡‡‡‡] In this study, use of the 1985 data has the effect of overestimating NO_X emissions from other sources and, hence, underestimating the proportion of NO_X emissions from nonroad engines.

[‡‡‡‡‡‡]Based on *National Air Pollutant Emission Estimates: 1940-1989*, highway NO_X emissions dropped 16% between 1985 and 1989.

No estimates of emissions from personal watercraft (e.g., Jet Skis) are included in this study due to lack of data. PSR does not compile information on personal watercraft and the survey conducted by Irwin Broh and Associates for NMMA contained numerous cases where the respondent obviously misunderstood the category. This omission has the effect of slightly understating the inventory estimates.

The emission factors developed by EPA for this study include new and more extensive test data than previously incorporated into emission factor estimates. For the first time, the emission factors also consider evaporative and refueling emissions. In addition, in-use deterioration estimates were incorporated into a second set of emission estimates for each inventory. Nevertheless, the potential for inaccuracies still exist due to lack of data in some areas.

Factors that may cause the emission factors and, hence, the inventories to be understated are:

- Spillage factor. Application of the spillage factor for on-highway vehicles to large nonroad engines could result in underestimation of emission factors, since on-highway users are likely to be more conscious of spilling fuel on themselves and/or damaging the car's finish. Further, spillage from all equipment is likely to be underestimated due to the fact that all refuelings were assumed to be complete fill-ups.

- Evaporative emissions. The absence of data on hot soak or running loss emissions for nonroad vehicles and vapor displacement for gas can refueling may have resulted in underestimation of total evaporative emissions.

- Wintertime CO emissions. All emission factor testing has occurred at typical summertime temperatures (roughly 75°F). CO emissions, however, increase at colder temperatures due to additional fuel enrichment and longer warmup times. This effect was not accounted for in the determination of CO tpwd for nonroad engines due to lack of data. The proportion of cold start operation on nonroad engines is unknown, but is likely to be much lower than for automobiles due to the tendency for most nonroad engines to be used for extended periods of time. It should be noted that the on-highway mobile source inventories used to determine the relative contribution of nonroad emissions did include the effect of wintertime temperatures on emissions.

- Crankcase CO and NO_x emissions. Exclusion of crankcase CO and NO_x emissions could result in slight underestimation of nonroad emissions, even though their contribution is relatively small.

4.2.3. Additional Considerations

Several factors that could potentially offset the contribution of nonroad engines to air quality nonattainment were not incorporated into this study. Some were not included because it was determined that to do so would not improve the validity of the results, while for others, insufficient information was available to develop methodologies within the timeframe mandated by Congress. This section discusses these factors, the reasons why they were excluded, and the potential impact (if any) on the results.

Non-Seasonal Temporal Adjustments--As previously discussed, EPA adjusted nonroad equipment activity levels for seasonal variation in usage. The inventories in this study are expressed in average daily emissions during summer (tpsd) and winter (tpwd), which are the seasons associated most strongly with ozone and CO nonattainment, respectively. As discussed in Appendix L, ozone and CO exceedences occur during both weekdays and weekends. Consequently, variations in source activity during the week and during the day were not considered.

Photochemical Modeling--As has been noted elsewhere in this report, the formation of ozone is an extremely complex process. It is difficult to understand the exact role played by emissions from the thousands of sources inside and upwind of a particular nonattainment area without a detailed photochemical model that takes into account not only manmade emissions but also local wind and weather patterns and biogenic emissions. Only recently have reliable photochemical models come into widespread use. The Regional Oxidant Model (ROM) for large, multi-state areas and the Urban Airshed Model (UAM) for individual urban areas represent the state of the art in air quality modeling for attainment planning. Congress has mandated that the worst nonattainment areas use photochemical modeling as a tool in developing individual customized plans for attaining the ozone standard.

EPA has not included photochemical modeling in this study for two reasons. First, developing and calibrating these models for even one nonattainment area would not have been possible within the deadline and budget for completion of this study. Second, the detailed, localized information available from photochemical models of individual cities would have added little additional relevant information to the overall question of the importance of nonroad emissions to attainment problems nationwide. Photochemical models are useful in deciding such questions as "On the margin, which kind of additional control would be more effective in reducing ozone in a particular area, NO_X or VOC?" Thus photochemical modeling is important in severe nonattainment areas, where very large emission reductions are needed and each additional emission reduction strategy is likely to be costly. Detailed photochemical modeling of all nonattainment cities is not required to reach the conclusion that the ozone problem in urban areas across the United States is serious and attainment of the ozone standard will require large reductions of both VOC and NO_X emissions nationwide; that conclusion has already been reached in the establishment of the CAA itself. The photochemical modeling of alternative emission control strategies contained in the recent ROMNET report[15] offers additional support: ROMNET found that reductions in both VOC and NO_X emissions beyond the minimum requirements of the CAA and across the northeastern U.S. would be required to bring the major East Coast cities into attainment of the ozone standard. Thus, EPA is satisfied that if nonroad sources are found to be a significant contributor of either NO_X or VOCs, then they are a significant contributor to nonattainment of the ozone standard.

Photochemical Reactivity--An issue related to photochemical modeling is whether nonroad VOC emissions are, on average, more or less photochemically reactive than emissions from other sources. As is evident from the discussion of toxic emissions from nonroad engines, very little data exists on the amount of individual species of VOCs emitted by nonroad engines. For the purposes of this study, EPA has assumed that the photochemical reactivity of nonroad VOC emissions is the same, on average, as VOC emissions from other sources. This is a reasonable assumption given that most nonroad engines are related to on-highway engines and that on-highway engines are the single most important source of VOC emissions in nonattainment areas.

Transport--During the past few years, it has become more apparent that ozone is a regional and not a local air quality problem. Recent studies [14 15 16] have shown that ozone and ozone precursors can travel long distances and affect air quality in areas at least two hundred miles from the source of ozone-forming emissions under some circumstances. Obviously, ozone does not respect the political boundaries enclosed by city, county, state, or nonattainment area lines.

Ozone transport complicates the assessment of nonroad emission contribution to urban nonattainment. To keep this study to a manageable size, EPA decided to include only equipment usage within the nonattainment areas in the inventory estimates. However, EPA is aware that emissions from equipment outside the nonattainment area boundaries also will affect the ozone level within nonattainment areas. Because emissions from equipment used outside nonattainment area boundaries may affect air quality, but are not accounted for in the inventories included here, the contribution of this equipment to urban nonattainment will be underestimated in this study. Underestimation of the air quality impact of nonroad equipment will be greatest for those types of equipment that have a substantial portion of their usage outside urban areas, such as agricultural equipment and recreational equipment (including marine pleasure craft).

It is difficult to quantify the underestimation of the nonroad impact on urban nonattainment that is due to transport for several reasons. First, EPA does not have current detailed information on nonroad populations and usage rates outside the areas considered in this study. County-by-county inventories for nonroad equipment are contained in national emission data bases, such as the inventories used in the National Acid Precipitation Assessment Program (NAPAP), but these inventories are at a rather broad level of categorization (such as "nonroad-diesel"), and use some obsolete emission factors. Second, it is difficult to estimate exactly what proportion of the emissions outside nonattainment areas affect nonattainment area air quality. It would seem reasonable to assume that emissions from sources 50 miles from a nonattainment area would have a greater impact than an identical source 150 miles from the nonattainment area, but currently no accepted "distance discount factor" is available that could be applied to inventories outside nonattainment areas.

Third, the impact of transported emissions in any given area may vary considerably with meteorological conditions, particularly wind speed and direction. A study of transport in California found that, in some air basins, transport may have an "overwhelming" impact on ozone levels under one set of meteorological conditions, but an "inconsequential" impact under another set of meteorological conditions. Finally, local topography would be expected to influence the pattern and importance of transport in different areas. Transport characteristics in a nonattainment area surrounded by mountains and valleys would be different from those in nonattainment areas surrounded by flat land.

To adequately assess the impact of transport on individual areas, detailed regional oxidant models (ROMs) must be constructed. These models include thousands of parameters, such as spatially distributed emission inventories for manmade and biogenic emissions over a wide area, detailed meteorological data, and topographical characteristics. Construction of these models was beyond the scope of this study. However, EPA's Office of Air Quality Planning and Standards, in association with EPA regions and state authorities, has recently completed a five-year study of transport and ozone formation in the Northeast, the Regional Oxidant Model for Northeast Transport (ROMNET). ROMNET concluded that emissions outside the heavily urbanized northeast coastal "Corridor" contributed to nonattainment in the Corridor. The ROMNET report states: "The results suggest that without stringent upwind controls, ozone levels in parts of the Corridor may not be reduced to below the concentration specified in the NAAQS even with stringent controls along the entire length of the Corridor." (p. ES-11).

The ROMNET inventories and modeling results may be used to make an "order-of-magnitude" assessment of the potential impact of transported nonroad emissions on nonattainment. By looking at the effect of reducing upwind emission inventories on ozone levels in particular nonattainment areas and at the proportion of nonroad emissions in the upwind inventories, a rough estimate of the impact of transported nonroad emissions on these cities under one set of meteorological conditions may be obtained. According to control measure simulations in the ROMNET study, a reduction of 65% of the non-Corridor VOC inventory and 60% of the non-Corridor NO_x inventory resulted in an average peak ozone reduction of 8.6 ppb in the Corridor as a whole and 11.5 ppb average peak ozone reduction in the nonattainment areas of Washington/Baltimore and Philadelphia. This implies that 1% of the non-Corridor VOC and NO_x inventories account for 0.14 ppb of the peak ozone concentration in the Corridor cities on average and about 0.18 ppb of the peak ozone concentration in the Washington/Baltimore and Philadelphia areas. The ROMNET Study assumed that nonroad engines accounted for 2.3% of the non-Corridor VOC inventory and 4.4% of the non-Corridor NO_x inventory in 1985. Very roughly, this implies that transported pollutants from nonroad sources account for 0.5 ppb of the peak ozone concentrations in the Corridor cities as a whole and 0.6 ppb of the peak ozone concentration in the Baltimore/ Washington and Philadelphia areas under the meteorological conditions modeled. If nonroad sources are not controlled, transported pollutants from non-Corridor nonroad sources would account for roughly 0.3-0.45% of the ozone level along the East Coast during nonattainment episodes after implementation of the other measures in the 1990 CAAA. These estimates are not included in the estimates of the impact of nonroad emissions on urban nonattainment in the rest of this report, because they were available for only a few cities under specific circumstances and because the ROMNET nonroad emission estimates are likely to be greatly understated.

EPA and state and local air quality authorities are continuing their study of the impact of transported emissions on urban nonattainment. Efforts are currently underway to further characterize ozone formation and transport in the Northeast, and comprehensive ROMs covering the Midwest and Southeast are also planned. A comprehensive study of ozone transport in the Lake Michigan area has been launched by EPA's Region V and the states surrounding Lake Michigan.

A more complete description of existing transport studies is contained in Appendix P.

4.3. Analysis of Nonroad Emission Impact

A great deal of effort and money has been expended on reducing emissions from a wide variety of sources, from the automobile to area sources such as dry cleaning and bakeries. The CAAA of 1990 mandate additional controls in many areas and more stringent controls on most of the equipment currently regulated. The purpose of this section is to help put the nonroad emission contribution into context by comparing nonroad emissions to currently regulated sources.

The nonroad emission inventories developed for this study estimate that the median nonroad contribution to total VOC and NO_x emissions for the nonattainment areas studied is over 7% for VOC and over 14% for NO_x. Based on emission inventories for all sources given in *National Air Pollutant Emission Estimates: 1940-1989*, the only source categories with larger VOC contributions at the national level are on-highway mobile sources and solvent evaporation. Also at the national level, the only source categories with greater NO_x contributions are on-highway mobile sources and electrical generation. Among the source categories with lower estimated contributions are industrial combustion, industrial processes, petroleum refining, and petroleum product storage and transfer. All of these other source categories are currently subject to emission control regulations. The estimated contributions of these categories are presented in Table 4-07.

Table 4-07. Contribution to Total Inventory

Pollutant	Source Category	% contribution[‡‡‡‡‡‡]
VOC	On-highway Mobile	25
	Solvent Evaporation	24
	Nonroad	7-13
	Petroleum Refining	3
	Petroleum Product Storage and Transfer	7
NO_x	On-highway Mobile	29
	Electrical Generation	32
	Nonroad	14-17
	Industrial Combustion	14
	Industrial Processes	3

Another comparison of nonroad emissions to other sources can be made by examining the 1990 CAAA requirements for Reasonably Available Control Technology (RACT) on stationary sources. RACT controls will now be required on all stationary sources with either VOC or NO_x emission above 50 tpy in serious nonattainment areas, 25 tpy in severe areas.

[‡‡‡‡‡‡] Nonroad based on median contribution determined by this study; ranges reflect the largest and smallest local contributions calculated by Inventories A and B with new engine and in-use emission factors. All other contribution estimates are based on data from *National Air Pollution Emission Estimates: 1940-1989*, and are given at the national level for 1989.

and 10 tpy in extreme areas. This means, for example, that an area designated as an extreme ozone nonattainment area is required to install RACT control on every stationary source over 10 tpy. By comparison, Table 4-08 provides the number of new vehicles or pieces of equipment that it would take to generate 10 tpy, based on their typical yearly operation. For the nonroad sources, the chart indicates the range between data used to develop A and B national inventories.

Table 4-08. Comparison of Ozone Precursor Emissions from Various Vehicles and Equipment

Vehicles or Equipment	No. for 10 tpy
Off-highway trucks	1.6-2.1
Crawler tractors	10
On-highway heavy-duty diesel truck*	20
Agricultural tractors	24
Boats with outboard motors	74-142
Passenger Cars*	700
Chain saws	730-1,630
Lawnmowers	1,680-2,380
String trimmers	2,810-4,630
* Based on first-year emissions of a current technology vehicle.	

Because CO nonattainment is usually more localized than ozone nonattainment, comparisons of national CO emissions may be misleading. A comparison of nonroad and highway CO emissions may, however, be made at the local level. Inventories developed for this study indicate that the median nonroad contribution to local wintertime CO emissions ranged from 5.2% to 9.4%, while the median contribution from highway vehicles was 81%.

Chapter 5. Conclusions

A significant quantity of new information was generated by CARB, EPA, EPA contractors, and the industry in response to California's proposed nonroad regulations and this study. EPA used this new information and existing data to develop Inventories A and B. As a result, these inventories provide a more comprehensive picture of nonroad emission contributions to VOC, NO_x, CO and PM, than previously available. Among the findings of this study are the following:

1. Median nonroad contributions to the total emission inventory for the 24 areas are estimated to be:

	VOC (%)	NO_x (%)	CO (%)	PM (%)
Inventory A	9.1-12.6	17.3	5.9-9.4	1.8
Inventory B	7.3-10.3	14.5	5.2-8.5	1.0

2. Congress mandated that EPA study emissions from nonroad sources to determine whether such emissions cause or significantly contribute to air quality problems, and in particular whether they are contributors to ozone or CO concentrations in more than one CO or ozone nonattainment area. Of the nonattainment areas studied, the second highest contribution to total inventories from nonroad engines and vehicles for VOC, NO_x, and CO is as follows:

	VOC (%)	NO_x (%)	CO (%)
Inventory A	13.1-18.7	29.3	9.0-14.2
Inventory B	11.4-16.0	31.1	8.5-13.3

3. The results discussed throughout this report do not include the transport of ozone into the nonattainment areas. The effect of ozone transport would be to increase the emission contribution of typically nonurban equipment, such as agricultural,

recreational marine, and logging equipment. While this effect may be relatively small, it is not insignificant.

4. Only on-highway vehicles, electric generation, and solvent evaporation have NO_x and/or VOC emissions that exceed those of nonroad equipment.

Recommendations for Inventory Improvements

The study identified a number of areas where inventory estimates could be affected by the absence of data or the use of limited information. Nonroad inventory estimates could be enhanced by collection of additional data, particularly in the area of emission factors. For example, existing nonroad emission data allows an adequate assessment of tailpipe emissions from relatively new engines. More information, however, is needed to quantify other types of emissions, such as evaporative, crankcase, and toxic emissions, and the effect of in-use deterioration. Specifically, data should be obtained for the following areas:

1. In-use emissions. Additional testing needs to be conducted on in-use engines to further quantify the effects of deterioration on the different types of nonroad engines.

2. Hot soak and running loss evaporative emissions. Currently, no hot soak and running loss evaporative emission data exist for nonroad engines. Such emissions are substantial for on-highway vehicles and can vary significantly according to the type of equipment on which an engine is installed. Therefore, tests should be conducted to determine whether these emissions from nonroad equipment need to be controlled.

3. Toxic emissions. EPA used the limited data that was available on toxic emission from nonroad engines to make the assumptions regarding such emissions. Such assumptions, particularly those for 1,3-butadiene, should be verified through further testing.

4. Crankcase emissions. Further studies should be conducted to improve the measurement of crankcase emission levels from nonroad engines and to determine which engines use open and closed crankcases.

5. Cold start emissions. Currently, no data are available on the contribution of cold starts to nonroad emissions. Work should be undertaken to assess the proportion of cold start fuel enrichment operation on different types of nonroad equipment, and then to measure the impact of such operation on total emissions.

6. Emission data representativeness. Currently, nonroad emission data are uniformly applied to all similar nonroad engines. More accurate emission factors could be developed if emission testing were performed on engines representative of the population.

7. Cycle representativeness. Steady state test cycles do not adequately represent VOC, CO, and particulate emissions generated during in-use transient operation. To the extent that nonroad equipment encounters transient operation in-use, steady state cycles could significantly understate emissions, especially particulate matter. The adjustments made in this study to account for transient operation were based on very limited test data which applied only to diesel engines. More work should be done to assess the typical operating cycles of nonroad equipment. Such characterizations would facilitate the assessment of the amount and importance of transient operation on nonroad engines, as well as improve load factor estimates.

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Makeup of the Non-road Diesel Engine Industry

(over 37kW (50 Hp))

	Population	Hrs/Year	Aver Hp	Load (f)	g/Bhp-hr
Agricultural Tractors	2,519k	411	98	70%	11.2
Tractors/Loaders	189	700	71	38	10.1
Terminal Tractors	65	1,200	96	82	14.0
Concrete/Industrial Saws	61	487	56	73	11.0
Swathers	50	100	82	62	11.5
Forklifts	47	850	83	30	14.0
Paving Equipment	44	507	99	53	11.0
Rollers	43	682	99	59	9.3
Sweepers/Scrubbers	37				
Rough Terrain Forklifts	25				
Other Agric Equipment	18				
Chippers/Stump Grinders	17				
Asphalt Pavers	12	814	77	56%	10.3
Sprayers	10	88	92	50	7.8
All Others	12				
	=====				
50-100 Hp	3,149k				

	Population	Hrs/Year	Aver Hp	Load (f)	g/Bhp-hr
Combines	285k	812	107	51%	14.0
Crawlers/Tractors	159	1,021	134	57	10.3
Graders	64	924	147	54	9.6
Excavators	52	1,190	143	59	10.8
Skidders	31	1,398	131	49	11.3
Genl Industrial Equip	18	812	107	51	14.0
Other Construction Eq	12				
Aircraft Support Equip	10				
Crushing/Processes	7				
Matl Handling	5				
	====				
100-175 Hp	643k				

	Population	Hrs/Year	Aver Hp	Load (f)	g/Bhp-hr
Rubber-tired Loaders	130k	1,398	175	54%	10.3
Cranes	98	701	194	43	10.3
Off-hiway Tractors	39	859	214	65	11.9
Off-hiway Trucks	19	3,293	658	25	9.6
Scrapers	16	1,385	290	60	8.7
Fellers/Bunchers	16	1,110	183	71	11.3
Rubber-tired Dozers	8	818	356	59	9.6
Bore Drill Rigs	8	389	209	75	11.0
	====				
over 175 Hp	334k				