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of Transportation
Federal Highway
Administration

An Overview of PM-10 Base Year Emissions Inventories

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SEEING CLEARLY...A Series of Reports on Transportation and Air Quality

Prepared for

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Office of Environment and Planning
Federal Highway Administration
U.S. Department of Transportation

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The Clean Air Act Amendments (CAAA) of 1990 required areas designated as being in violation of the National Ambient Air Quality Standards for particle matter measuring less than or equal to 10 micrometers in aerodynamic mass median diameter (PM-10) to submit State Implementation Plans (SIPs) beginning with Base Year inventories. In recent years, PM-10 has been a subject of debate over the relative health danger posed by particulate matter. According to the U.S. Environmental Protection Agency (EPA), as of January 1996 there were approximately 82 PM-10 nonattainment areas nationwide which encompass a population of approximately 68 million people.

In an effort to support the successful implementation of the CAAA and to provide support and information to the transportation community and state planning agencies, the Federal Highway Administration (FHWA) is seeking to provide an overview of PM-10 requirements and SIP contents. This document reviews U.S. EPA's PM-10 guidance documentation and the contents of 1990 Base Year PM-10 SIPs from various regions throughout the country including: Denver, CO; Boise, ID; Spokane, WA; Phoenix, AZ; and Presque Isle, ME. The report discusses the contents of PM-10 emissions estimation methodologies, PM-10 modeling techniques, and PM-10 control measures.

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PREFACE

Research for this report was conducted by Philip vanderWilden of the Volpe National Transportation Systems Center (Volpe Center). The author is indebted to Dick Schoeneberg and Kevin Black, both of the Federal Highway Administration, and Don Pickrell and Beth Deysher, both of the Volpe National Transportation Systems Center, for their careful review and insightful comments on earlier versions of the report.

This report is one in a series of publications produced or distributed by the Federal Highway Administration of the U.S. Department of Transportation to address important issues in transportation and air quality planning for metropolitan areas. Copies of this and other reports in this series can be ordered by calling 202-366-2069.

METRIC/ENGLISH CONVERSION FACTORS

ENGLISH TO METRIC

LENGTH (APPROXIMATE)

1 inch (in) = 2.5 centimeters (cm)
1 foot (ft) = 30 centimeters (cm)
1 yard (yd) = 0.9 meter (m)
1 mile (mi) = 1.6 kilometers (km)

AREA (APPROXIMATE)

1 square inch (sq in, in^2) = 6.5 square centimeters (cm^2)
1 square foot (sq ft, ft^2) = 0.09 square meter (m^2)
1 square yard (sq yd, yd^2) = 0.8 square meter (m^2)
1 square mile (sq mi, mi^2) = 2.6 square kilometers (km^2)
1 acre = 0.4 hectare (ha) = 4,000 square meters (m^2)

MASS - WEIGHT (APPROXIMATE)

1 ounce (oz) = 28 grams (gm)
1 pound (lb) = .45 kilogram (kg)
1 short ton = 2,000 pounds (lb) = 0.9 tonne (t)

VOLUME (APPROXIMATE)

1 teaspoon (tsp) = 5 milliliters (ml)
1 tablespoon (tbsp) = 15 milliliters (ml)
1 fluid ounce (fl oz) = 30 milliliters (ml)
1 cup (c) = 0.24 liter (l)
1 pint (pt) = 0.47 liter (l)
1 quart (qt) = 0.96 liter (l)
1 gallon (gal) = 3.8 liters (l)
1 cubic foot (cu ft, ft^3) = 0.03 cubic meter (m^3)
1 cubic yard (cu yd, yd^3) = 0.76 cubic meter (m^3)

TEMPERATURE (EXACT)

°C=5/9(°F - 32)

METRIC TO ENGLISH

LENGTH (APPROXIMATE)

1 millimeter (mm) = 0.04 inch (in)
1 centimeter (cm) = 0.4 inch (in)
1 meter (m) = 3.3 feet (ft)
1 meter (m) = 1.1 yards (yd)
1 kilometer (km) = 0.6 mile (mi)

AREA (APPROXIMATE)

1 square centimeter (cm^2) = 0.16 square inch (sq in, in^2)
1 square meter (m^2) = 1.2 square yards (sq yd, yd^2)
1 square kilometer (km^2) = 0.4 square mile (sq mi, mi^2)
10,000 square meters (m^2) = 1 hectare (ha) = 2.5 acres

MASS - WEIGHT (APPROXIMATE)

1 gram (gm) = 0.036 ounce (oz)
1 kilogram (kg) = 2.2 pounds (lb)
1 tonne (t) = 1,000 kilograms (kg) = 1.1 short tons

VOLUME (APPROXIMATE)

1 milliliter (ml) = 0.03 fluid ounce (fl oz)
1 liter (l) = 2.1 pints (pt)
1 liter (l) = 1.06 quarts (qt)
1 liter (l) = 0.26 gallon (gal)
1 cubic meter (m^3) = 36 cubic feet (cu ft, ft^3)
1 cubic meter (m^3) = 1.3 cubic yards (cu yd, yd^3)

TEMPERATURE (EXACT)

°F=9/5(°C) + 32

QUICK INCH-CENTIMETER LENGTH CONVERSION

INCHES	0	1	2	3	4	5

CENTIMETERS	0	1	2	3	4	5	6	7	8	9	10	11	12	13

QUICK FAHRENHEIT-CELSIUS TEMPERATURE CONVERSION

°F	-40°	-22°	-4°	14°	32°	50°	68°	86°	104°	122°	140°	158°	176°	194°	212°
°C	-40°	-30°	-20°	-10°	0°	10°	20°	30°	40°	50°	60°	70°	80°	90°	100°

For more exact and or other conversion factors, see NIST Miscellaneous Publication 286, Units of Weights and Measures. Price $2.50. SD Catalog No. C13 10286.

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LIST OF ABBREVIATIONS

AEL	attainment emissions level
CAAA	Clean Air Act Amendments
CDH	Colorado Department of Health
CMB	chemical mass balance
DRCOG	Denver Regional Council of Governments
FHWA	Federal Highway Administration
FTA	failure to attain
FTD	failure to demonstrate
GVW	gross vehicle weight
IAQB	Idaho Air Quality Bureau
IPP	inventory preparation plan
ISC	industrial source complex
NAAQS	National Ambient Air Quality Standards
RACM	reasonably available control measure
RFP	reasonable further progress
RAM	Gaussian-Plume Multiple Source Air Quality Algorithm
RM	receptor modeling
SIP	state implementation plan
TIP	transportation improvement program
TSP	total suspended particles
U.S. DOT	United States Department of Transportation
U.S. EPA	United States Environmental Protection Agency
Volpe Center	John A. Volpe National Transportation Systems Center
VOC	volatile organic compounds

1. INTRODUCTION

The Clean Air Act Amendments (CAAA) of 1990 required areas designated as being in violation of the National Ambient Air Quality Standards (NAAQS) for PM-10 to submit a state implementation plan (SIP) by November 15, 1991. In recent years, PM-10 has been the subject of increasing debate over the relative health danger posed by particulate matter and particularly with regard to respiratory ailments. According to the United States Environmental Protection Agency (U.S. EPA), as of January 1996 there were approximately 82 PM-10 nonattainment areas nationwide (see appendix A) which encompass a population of approximately 68 million people.

In an effort to support the successful implementation of the CAAA and to provide support and information to the transportation community and state planning agencies, the Federal Highway Administration's (FHWA) Noise and Air Quality Branch of the United States Department of Transportation (U.S. DOT) requested the U.S. DOT Volpe National Transportation System Center's (Volpe Center's) assistance in developing an overview of PM-10 requirements and SIP contents. For the purposes of this study, U.S. EPA PM-10 guidance documentation and a sample of 1990 Base Year PM-10 SIPs from various regions throughout the country were collected by the Volpe Center for review. The study was limited to review of the five most complete PM-10 SIPs available for review in-house which included the following areas: Denver, Colorado; Boise, Idaho; Spokane, Washington; Phoenix, Arizona; and Presque Isle, Maine.

1.1 WHAT IS PM-10?

PM-10 is defined as particulate matter that measures less than or equal to 10 micrometers in aerodynamic mass median diameter. On July 1, 1987 the U.S. EPA published final rulemaking for a new PM-10 particulate standard which focuses on inhalable particulates rather than on total suspended particles (TSP) which was formerly the case. PM-10 may be directly emitted into the atmosphere from a source or it may be formed in the atmosphere as a result of condensation or chemical reactions of other pollutants.

1.1.1 Types of PM-10

PM-10 emissions are classified as one of three types as follows:

Primary PM-10: Made up of particles that enter the atmosphere as a direct emission from a stack or an open source. U.S. EPA guidance states that Primary PM-10 emissions should be the focus of emission inventories for PM-10 nonattainment areas.

Condensible PM-10: Condensible particulate matter can be broadly defined as material that is not particulate matter at stack conditions but which condenses and/or reacts (upon cooling and dilution in the ambient air) to form particulate matter immediately after discharge from the stack. Condensible particle matter forms in a few seconds in the stack exhaust due primarily to immediate cooling and air dilution. Condensible particulate matter is of potential importance because it usually is quite fine and thus falls primarily within the PM-10 size definition. U.S.

EPA guidance recommends that condensible particulate matter should always be included in the emission inventory.

Secondary PM-10 (PM-10 Precursors): Secondary particulate matter can be broadly defined as particles that form through chemical reactions in the ambient air well after dilution and condensation have occurred (usually at some distance downwind from the emission point). Generally, secondary particulate matter can be distinguished from condensible particulate matter by the time and/or distance downwind from the stack required for formation. Precursor emissions contributing to secondary particulate matter should not be included in the PM-10 inventory except where U.S. EPA and the state determine that the sources of PM-10 precursors contribute significantly to PM-10 levels.

1.1.2 PM-10 Standards

The primary and secondary NAAQS for PM-10, as promulgated in 1987, are for 24-hour and annual concentrations. The standards are:

- ***24-hour***–The ambient air quality standard for fine particulate matter is 150 μg/m3 for a 24-hour average concentration. The standards are attained when the expected number of days per calendar year with a 24-hour average concentration above 150 μg/m3 is equal to or less than one.

- ***Annual***–The ambient air quality standard for fine particulate matter is 50 μg/m3 for an annual arithmetic mean. The standards are attained when the expected annual arithmetic mean concentration is less than or equal to 50 μg/m3.

1.2 SUMMARY OF REGULATORY REQUIREMENTS

1.2.1 Clean Air Act Amendment Requirements

Under section 189(a)(2) of the Clean Air Act Amendments of 1990 (CAAA), states were required to submit a SIP containing a draft base year inventory for moderate PM-10 areas by November 15, 1991. By May 15, 1992 states were required to develop and submit a SIP for every area designated as a nonattainment area and classified as moderate for PM-10 under the CAAA that would demonstrate attainment of the PM-10 NAAQS by December 31, 1994 and demonstrate maintenance of the standard for three years after attainment.

Classification. Section 188 of the CAAA outlines the process for classification of an area and establishes the area's required attainment date. In accordance with section 188(a), at the time of designation, all PM-10 nonattainment areas are classified as moderate by operation of law. Due dates for submittals and U.S. EPA actions for PM-10 moderate areas are shown in table 1.

Table 1. PM-10 moderate nonattainment area due dates.

Event	Months Following Designation	Approx. Date
Designation as nonattainment	0	11/15/90
Classification (moderate by operation of law)	0	11/15/90
Inventory Preparation Plan (IPP)	3	2/15/91
Draft Inventory	12	11/15/91
SIP due containing: a) New Source Review permit program b) attainment demonstration that includes 1) air quality modeling 2) base year actual emissions inventory 3) modeling inventory (projected allowables at attainment [i.e., at 72 months]) 4) inventory showing projected allowables at 48 months when RACM/RACT is implemented c) RACM/RACT implementation program d) Quantitative milestones (RFP) e) PM-10 precursors assessment	18	5/15/92
Decision by EPA whether to reclassify area as serious for FTD attainment (18 months from submission)	36	11/15/93
Implementation of control strategies, including RACM/RACT	48	11/15/94
RFP Milestone due date	54	5/15/95
Determination by EPA that State's RFP milestone is met	57	8/15/95
SIP revision due for failure to report RFP milestone or determination by EPA that milestone was not met	63	2/15/96
Attainment (as expeditiously as possible but no later than)	72	11/15/96
Redesignation to serious if in violation of NAAQS after attainment date	72-78	11/15/96

Reclassification. A moderate nonattainment area can be reclassified as serious if the EPA determines that the area cannot "practicably" attain the PM-10 NAAQS by the applicable attainment date (i.e., fails to demonstrate [FTD]), or the area has failed to attain (FTA) the PM-10 NAAQS by the applicable attainment date. Due dates for submittals and U.S. EPA actions for PM-10 serious areas are shown in table 2.

Demonstration of Attainment. Section 189(a)(1)(B) of the CAAA provides that states with moderate PM-10 nonattainment areas must submit a demonstration (including air quality modeling) showing either attainment by the applicable attainment date or that attainment by the applicable date is impracticable. The attainment demonstration projects must show how the area will come into attainment (or will fail to attain) with the NAAQS, based on air quality modeling with forecasted emissions. The SIP must contain the emissions forecasts used in the air quality modeling attainment demonstration.

1.2.2 Summary of SIP Inventory Types

U.S. EPA required states to prepare a brief Inventory Preparation Plan (IPP) specifying how they intended to develop, document, and submit their inventories. The IPP was to include a discussion of the methodologies applied to develop the Point, Area, and Mobile source elements of the inventories. For PM-10 nonattainment areas, there are three basic kinds of inventories: base year inventories, modeling inventories, and periodic inventories.

Base Year Inventory. The base year inventory is the primary inventory from which all other inventories are derived. The base year inventory must include emissions from all point, area, and mobile sources. States are required to model short-term (daily) and long-term (annual) air quality for PM-10 in their inventories, even if air quality measurements show exceedances for only one time period. If a moderate nonattainment area is reclassified as serious, they are required to submit a serious area base year emission inventory which is due 18 months following reclassification. Should an area classified as serious "fail to attain" (FTA), then those areas must reinventory the actual emissions at the time they should have attained. Such an inventory would be due 18 months after determining that the area "failed to attain."

Modeling Inventories. Since there are no specific levels of reduction required under the CAAA for PM-10 as there are for volatile organic compounds (VOC), the level of reductions required will be determined by the reasonably available control measure (RACM) requirements and what is necessary to demonstrate attainment of the PM-10 NAAQS by the appropriate attainment date. A modeled attainment demonstration is achieved when the sixth highest values at each receptor on a modeling grid are at or below the 24-hour average standard of 150 μg/m3. The sixth highest value is the determining value because the model is typically run with five years of meteorological data and an area is allowed an average of one exceedance each year before officially violating the standard. One of the primary purposes of the modeling inventories will be to demonstrate attainment. For control measure evaluations and the attainment demonstration, the modeling emission inventory consists of allowable emissions for the base

Table 2. PM-10 serious nonattainment area due dates.

Event	Months Following Reclassification
Reclassification	0
Inventory Preparation Plan (IPP)	3
Draft Inventory (the base year for FTA will be the actual emissions for the year the area should have attained; for FTD areas the base year inventory will become the modeling emission inventory projected to the attainment year)	12
RFP Milestone due date	*
Determination by EPA that state's RFP demonstration is adequate	**
BACM SIP due containing: a) BACM/BACT implementation program (schedule for implementation) b) PM-10 precursors assessment c) base year inventory	18
SIP revision due for failure to report RFP milestone or determination by EPA that milestone was not met	***
Full SIP containing BACM SIP information and: a) attainment demonstration with air quality modeling b) additional BACM/BACT requirements	48
Implementation of BACM/BACT	48
RFP Milestone is due	†
Determination by EPA that state's RFP milestone is met	††
SIP revision due for failure to report RFP milestone or determination by EPA that milestone was not met	†††
RFP Milestone is due	†
Determination by EPA that state's RFP milestone is met	††
SIP revision due for failure to report RFP milestone or determination by EPA that milestone was not met	†††
Attainment (as expeditiously as possible but no later than)	120

* 54 months after designation as a moderate nonattainment area for areas that FTD; 90 months after designation as a moderate nonattainment area for areas that FTA

** 3 months following *

*** 6 months following **

† 3 years following previous RFP milestone due date

†† 3 months following †

††† 6 months following ††

year and projected allowable emissions for the attainment year. Modeling inventories should be based on the actual daily emissions for model performance validation.

The modeling inventories will also serve as a tool for projection of future years' emission levels, evaluation of the impact of rulemaking, evaluation of control measures and technology, receptor modeling reconciliation, and determination of design concentrations. Rule effectiveness, which refers to the actual ability of a proposed regulatory program to reduce emissions, is currently not required by U.S. EPA but may be at a later date. Finally, modeling inventories will be used for showing maintenance. The maintenance demonstration does not need to be done with a complete dispersion model run, but rather can be shown through a roll forward analysis of modeled emissions using demographic and VMT data as the basis for the analysis. The concentration for each source category predicted in an attainment model run is increased in proportion to the growth in one or more of these categories to determine the total concentrations through the end of the maintenance requirement years.

Periodic Inventories. The CAAA states that the emission inventories may be periodically updated as deemed necessary by the Administrator. A periodic inventory may be the consequence of reasonable further progress (RFP) requirements, a maintenance plan for an attainment area, or for other reasons deemed necessary by U.S. EPA. The PM-10 program will not arbitrarily require inventories every three years. It will rely on "event"-oriented periodic emission inventories and, therefore, will be decided on a case-by-case basis.

1.2.3 Requirements for Future Growth, Development, and Conformity

New source review for both primary and secondary PM-10 requires full offset for any new source or modification to existing sources. On January 11, 1993, EPA issued its proposed rule on criteria and procedures for determining conformity. With respect to PM-10, the proposed rule requires analyses of PM-10 hot spots as well as regional analyses of PM-10 and PM-10 precursors if the applicable implementation plan identifies transportation-related precursor emissions within the area as a significant contributor to the PM-10 nonattainment problem. Transportation projects would also be required to be designed and funded to comply with transportation-related PM-10 control measures in the applicable PM-10 SIP. The long range transportation plan and the transportation improvement program (TIP) are required to be consistent with the motor source emissions budget in the applicable SIP. This is satisfied if the total emissions of PM-10 and its precursors expected to result from implementation of the projects and activities contained in the long-range plan and TIP are demonstrated to be less than or equal to the mobile source emissions budget established in the applicable SIP. The emissions budget is envisioned to be based on the emissions inventory contained in the SIP's demonstration of attainment and maintenance.

2. COMPOSITION OF PM-10 EMISSIONS

U.S. EPA guidance specifies the categories of pollutants that are required to be inventoried in PM-10 nonattainment areas as well as the recommended methodologies for use in calculating the amount of those pollutants. The required categories and methodologies are similar to U.S. EPA requirements for ozone and carbon monoxide nonattainment areas, and, in fact, much of the data gathered for one nonattainment classification SIP can be readily applied to the development of the PM-10 SIP and vice versa.

2.1 PM-10 SOURCE CATEGORIES

Emission inventories are required to include all types of stationary point, area, and mobile sources:

2.1.1 Point Sources

Point sources are physical emission points or processes usually within a plant that result in pollutant emissions. PM-10 point sources generally refer to specific facilities or stacks for which individual records are collected and maintained. All stationary sources or groups of stationary sources located within a contiguous area and under common control which emit directly, or have the potential to emit (i.e., allowable emissions) in the following volumes must be included in the inventory:

- Moderate Areas - 100 tons per year or more
- Serious Areas - 70 tons per year or more.

2.1.2 Area and Mobile Sources

Area sources are generally defined as an aggregation of all sources not defined as point sources in a specific geographic area. Area sources include fugitive dust sources, mobile sources, and stationary sources that are too small, difficult, or numerous to account for individually as point sources. Area sources also include residential wood combustion sources, and prescribed, silvicultural, and agricultural burning sources. In some instances, mobile sources will be reported separately from area sources. Process fugitive emissions, such as from materials handling and transport within a point source facility, should be included in the point source inventory.

While mobile sources often refer only to the particulate air pollution impact of in-use vehicles resulting from exhaust, brake wear, and tire wear, re-entrained dust is often included as a mobile source as well. Re-entrained dust typically refers to particulate matter (dust, dirt, and road sand) suspended in the air by mechanical disturbance, while fugitive dust refers to particle matter suspended by wind action blowing across the surface. Mechanical disturbance includes resuspension of particles from vehicles traveling over roadways, parking lots, and other open areas. Street sanding can be a significant source of re-entrained or fugitive dust (depending on how the area chooses to classify) which occurs after streets have been sanded due to snow or ice storms.

2.2 EMISSIONS ESTIMATION METHODOLOGIES

The estimation of each source type of PM-10 pollutant is clearly laid out in U.S. EPA guidance documentation. For the purposes of this report, a brief overview of the estimation methodologies is provided below.

2.2.1 Point Sources Estimation Methodologies

Emissions are typically calculated using calculation spreedsheets or emissions models specifically designed for measuring point source outputs such as the Industrial Source Complex (ISC) model. Data is typically submitted voluntarily by each facility or solicited via questionairre. The data gathered and used to estimate emissions include: location, emission rate, physical stack height, stack gas exit velocity, stack inside diameter, stack gas temperature, and particle size distribution with corresponding settling velocities.

2.2.2 Area Sources–Non-Mobile Estimation Methodologies

The calculation of emissions from area sources such as burning (residential wood, agricultural, etc.), heating oil and natural gas, construction and other miscellaneous categories were typically calculated using emissions factors and calculation formulas for that activity which are provided by U.S. EPA's AP-42 emissions guidance. Emissions are then based on the emissions factor per unit of activity such as emissions per acres burned or per gallons of heating oil used times the level of that activity. Input factors for various activities might include: population involved in a particular activity (i.e., open yard burning); estimated number of piles or number of fireplaces or woodstoves; amount burned (i.e., cords of wood) per population or burning device; or, amount of construction equipment in the local area. None of the areas reviewed estimated fugitive dust resulting from wind erosion.

2.2.3 Area Sources–Mobile Estimation Methodologies

Re-entrained dust and street sand emissions are related to both the amount of particulate loading on the roadway and the amount of travel on the roadway. Paved and unpaved road emission sources are typically calculated using the equation from U.S. EPA's AP-42. Input variables include: 1) miles per year traveled on road; 2) silt content indicating the percentage of silt on the road; 3) average speed of travel; 4) number of days of precipitation for the year; and, 5) average vehicle weight. For wintertime emissions, it is estimated that particulate emissions will be reduced because of more damp conditions. Mobile source emissions are tied directly to the type of roadway and the amount of travel. Thus, the highest mobile source PM-10 emissions levels occur where the amount of travel is the greatest and most concentrated.

In-use vehicle emissions are typically derived using U.S. EPA's PART5 model for estimating PM-10 emissions from mobile sources. The model can be used to estimate total particulate matter emissions as well as particulate matter fractions ranging from 1.0 to 10 micrometers. For gasoline engines, total exhaust particulate matter includes direct sulfate (exhausted as sulfuric acid) and lead emissions. For diesel engines, total exhaust particulate matter also includes emissions for the soluble organic fraction and the remaining carbon portion. Each of these emission components can also be estimated individually. The PART5 model can also be used to estimate the following: particulate matter from brake and tire wear; gaseous sulfur dioxide exhaust emissions; indirect sulfate emissions formed later in the atmosphere associated with sulfur dioxide exhaust emissions; idle-speed exhaust emissions; and, fugitive dust emissions from paved and unpaved roads (if not provided separately).

2.3 A DETAILED LOOK AT U.S. EPA'S PART 5–THE PM-10 MOBILE MODEL

The PART5 PM-10 Mobile model was developed by US EPA's Office of Mobile Sources and released in February 1995. PART5 is a Fortran program for use in the analysis of the particulate air pollution impact of in-use gasoline-fueled and diesel-fueled motor vehicles. It calculates particle emission factors in grams per mile (g/mi) from on-road automobiles, trucks, and motorcycles, for particle sizes 1-10 microns. The particulate matter emissions factors include exhaust particulate, exhaust particulate components, brake wear, tire wear, and re-entrained road dust, all of which are required for PM-10 inventories and analysis. The model can be used for comparative analyses, such as comparing the potential impact of one traffic control measure versus another.

PART5 differs from the previous particulate model (released in 1985) in the following ways: it reflects the low sulfur diesel fuel regulation of October 1993; lower particulate standards; and, heavy-duty cars and trucks are differentiated by gasoline and diesel usage. Additions to the new model include an option to print gaseous SO_2, the calculation of re-entrained dust for paved and unpaved roads based on algorithms developed by the US EPA's Office of Air Quality Planning and Standards, and an option to calculate idle emissions developed from manufacturer's data. The mileage accumulation rates, vehicle counts, diesel sales fractions, registration distributions, and catalyst fractions also were updated to be consistent with the MOBILE5 model used for ozone and carbon monoxide inventories.

PART5 differs from MOBILE by differentiating between twelve (versus eight) vehicle classifications as shown in the table on the following page with their corresponding FHWA class and gross vehicle weights (GVW). See table 3.

Table 3. PART5 vehicle classifications.

Vehicle Class	FHWA Class	Gross Vehicle Weight (lbs)
LDGV (Light-Duty Gasoline Vehicle)		
LDGT1 (Light-Duty Gasoline Truck, I)	1	<6,000
LDGT2 (Light-Duty Gasoline Truck, II)	2A	6,001-8,500
HDGV (Heavy-Duty Gasoline Truck)	2B-8B	>8,500
MC (Motorcycle)		
LDDV (Light-Duty Diesel Vehicle)	1	<6,000
LDDT (Light-Duty Diesel Truck)	2A	6,001-8,500
2BHDDV (Class 2B Heavy-Duty Diesel Vehicle)	2B	8,501-10,000
LHDDV (Light Heavy-Duty Diesel Vehicle)	3,4,5	10,001-19,500
MHDDV (Medium Heavy-Duty Diesel Vehicle)	6,7,8a	19,501-33,000
HHDDV (Heavy Heavy-Duty Diesel Vehicle)	8B	33,000+
BUSES (buses)		

PART5 contains default values for most data required for the calculation of all the emission factors, but it also allows for user-supplied data in many cases. Similar to the MOBILE model, PART5 contains control flags that allow local data to be entered by users as follows:

- VMFLAG specifies whether default or user-supplied VMT mixes are used. The VMT mix in PART5 is based on national averages and changes over time. Three main shifts have impacted the VMT mix: (1) shift of sales from light duty passenger cars to light duty trucks; (2) light duty diesel trucks increasing in sales over time as compared to light duty gasoline trucks; and, (3) heavy duty diesel trucks replacing heavy duty gasoline trucks. The only place where PART5 uses the VMT mix is to weight all the emissions factors for each individual vehicle class together into an "all vehicles" emission factor shown in the output.

- MYMRFG is the second control flag and specifies whether default or user-supplied mileage accumulation rates and registration distributions will be used. The mileage accumulation rate is the expected number of miles a vehicle will travel in one year, divided by 100,000. The rates are assumed to vary by vehicle class and the age of the vehicle. Rates are required for vehicles from 1 to 25+ years of age. The registration distribution contains the fractions of the total number of vehicles in a particular class that are of ages 1 through 25+.

- IMFLAG specifies whether or not an inspection and maintenance program is assumed.

- RFGFLG specifies whether reformulated gasoline effects are required which, in the case of particulate matter, is based on the sulfur content of the gasoline used.

- IDLFLG specifies whether or not to print the idle emissions factors which are calculated for heavy-duty diesel vehicles.

- BUSFLG determines which alternative bus cycle emission factors to use.

The resulting outputs available from PART5 are classified into different pollutant categories (in grams per mile) as follows:

Lead	=	exhausted lead
SOF	=	soluble organic fraction
RCP	=	remaining carbon portion
Direct SO4	=	direct sulfate emissions, exhausted as sulfuric acid (H_2SO_4)
Exhaust PM	=	lead + SOF + RCP + Direct SO_4
Indirect SO4	=	estimated indirect sulfate material [(NH_4) $2SO_4$]
Sulfate PM	=	indirect sulfate + direct sulfate
Brake	=	brake wear emissions
Tire	=	tire wear emissions
Total PM	=	Exhaust PM + brake + tire + indirect SO_4
Unpaved dust	=	road dust from unpaved roads
Paved dust	=	road dust from paved roads

Details regarding the methodologies used to calculate particulate emissions factors from motor vehicles in PART5 are provided in the appendix of the U.S. EPA's draft "User's Guide to PART5: A Program for Calculating Particle Emissions from Motor Vehicles."

3. INVENTORIES

For the purpose of this overview, the Volpe Center reviewed five PM-10 base year inventories for structure, content, and methodology. The study was limited to a review of the five most complete PM-10 SIPs available for review in-house which included the following areas: Denver, Colorado; Boise, Idaho; Spokane, Washington; Phoenix, Arizona; and Presque Isle, Maine. This section presents a synthesis of the materials contained in the five SIPs including the content and structure, area overviews, area base year emissions inventories, a review of the control measures applied, and a brief description of various modeling processes employed.

3.1 STRUCTURE AND CONTENT OF PM-10 SIPS

U.S. EPA guidance did not specify how a PM-10 SIP must be structured, but did identify the minimum components required. Among these requirements are identification of the agency responsible for developing and submitting the SIP, descriptions of the monitoring network, a base year inventory of source emissions including the methodologies used to develop the inventory, a demonstration of how attainment would be achieved (or fail to be achieved), and a discussion of contol measures that will be employed to address the PM-10 problem. Toward that end, most PM-10 SIPs are similarly structured and contain detailed information in similar formats.

The five PM-10 SIPs reviewed for this study followed basic formats such as the one illustrated below which is a composite of the five SIPs:

I. *Introduction* – reviews the organizations involved in preparing the SIP, the contents of the SIP, and the SIP adoption process and procedure.
II. *Background* – reviews the PM-10 NAAQS standard, the health effects of PM-10, implementation responsibilities, requirements of the CAAA, possible sanctions that might apply, and defines the boundary of the nonattainment area and local demographics.
III. *Problem Definition* – presents PM-10 standards history in the local area, a description of the monitoring network and sites, results obtained from the monitoring network and data history, the history of exceedances of the standard and the corresponding design values.
IV. *Emissions Inventory* – presents a breakdown of existing pollutant sources for the base and target years.
V. *Overview of Control Measures* – presents the proposed package of control strategies to be applied to meet attainment by the deadline and details of the implementation of the applicable control measures.
VI. *Attainment and Maintenance Demonstration* – contains the modeling results showing attainment and maintenance of the PM10 standard with control measures applied.
VII. *List of Appendices* – presents background data on emissions, emissions calculation methodologies, modeling, public involvement, etc.

3.2 AREA SUMMARIES

Each of the five emissions inventories reviewed for this study contained details consistent with the SIP content outline discussed above. Depending upon the area's history of daily or annual violations, the SIPs contained inventories consistent with the problem. In cases where the area had experienced both 24-hour and annual violations, both 24-hour and annual inventories were provided as well as attainment demonstrations for both standards.

While all of the areas used similar techniques for estimating emissions contributions, the most notable differences in the inventories were regarding the classification of vehicle activity derived sources within either the area or mobile source classification. As shown in table 4 below, while most areas classified re-entrained road dust from paved and unpaved roads within the mobile source category, there were exceptions such as Spokane and Phoenix. The classification of a specific pollutant source within a given category can be significant in the approach an area will take to the appropriate control measures.

Table 4. Categorization of pollutants by area or mobile sources.

Pollutant Category	Denver, CO	Boise, ID	Spokane,WA	Phoenix, AZ	Presque Isle, ME
Vehicle Exhaust	Mobile	Mobile	Mobile	Mobile	Mobile
Brake/Tire Wear	Mobile	Mobile	Mobile	Mobile	Mobile
Re-entrained Dust-Paved Roads	Mobile	Mobile	Area	Mobile	Mobile
Re-entrained Dust-Unpaved Roads	Mobile	Mobile	Area	Area	Mobile
Fugitive Dust-Parking Lot	NA	NA	Area	NA	NA
Street Sanding	Mobile	NA	NA	NA	Part of Re-ent. Dust
Construction Equipment	Area	Area	Mobile	Area	Area
Industrial Equipment	Area	Area	Mobile	Area	Area

The brief area summaries provide a description of the primary sources of the PM-10 problem in each area. The summaries also include discussions of conditions particular to that area, a description of the monitoring network, sources of data for developing emissions inventories, and any future trends that were identified and their impact on achieving attainment.

3.2.1 Denver, Colorado

The PM-10 inventory for the Denver area identifies re-entrained dust from paved roads (43.9 percent), residential wood combustion (18.1 percent), and re-entrained dust from unpaved roads (12.6 percent) as the primary sources of the local PM-10 problem. Of the five SIPs revewied, only Denver identified secondary particle matter as a PM-10 problem which can make up to 20 percent or 30 percent of elevated levels of PM-10 in the area. The Colorado Department of

Health (CDH) operates a network of thirteen PM-10 monitoring sites. Estimates of emissions were prepared for each source category by using pertinent activity levels for each source along with emissions factors approved by the U.S. EPA. The Denver Regional Council of Governments (DRCOG) provides data on the percentage change in population, employment, households, and daily VMT for the base year and attainment year. Emission factors for re-entrained dust and street sand, two significant contributors of emissions from mobile sources, were derived from an analysis of data from two street sanding studies conducted in the Denver area. The 1995 inventory was prepared based on projected growth and any changes in per unit emission factors reflecting cleaner technology. For the attainment demonstration, another 1995 inventory was prepared reflecting emission reduction credits for the control measures contained in the SIP.

3.2.2 Boise, Idaho

The PM-10 inventory for the Boise area identifies residential wood combustion (70.5 percent) and re-entrained dust from paved roads (14.5 percent) as the primary sources of the local PM-10 problem in the winter months, while on an annual basis re-entrained dust from paved roads (51.2 percent) is the primary emission source. The Idaho Air Quality Bureau (IAQB) operates a four PM-10 monitoring sites in Boise. Source activity information is obtained by a wide variety of methods such as public surveys, process log books, census data, traffic counts, and questionnaires. Intermountain Demographics supplied household and employment data for the Boise area. Ada Planning Association supplied VMT data. Woodstove use data was provided by Boise State University. Fuel use data was supplied by Idaho Power Co. Emissions were calculated based on emission factors and emission control efficiency from U.S. EPA's AP-42, material throughput rates, and VMT. It is estimated that woodburning will remain the largest single source of PM-10 through the year 2000, contributing approximately 50 percent of the emissions for each modeled year while re-entrained road dust is predicted to be the largest increasing source.

3.2.3 Spokane, Washington

The PM10 inventory for Spokane identifies residential wood combustion (35.8 percent), re-entrained dust from paved roads (23.1 percent) and re-entrained dust from unpaved roads (18.6 percent) as the dominant category of emissions in the area. These percentages remain relatively constant regardless of whether emissions are measured on a daily or annual basis. In 1985, a PM-10 monitoring network was established in the Spokane area consisting of five monitoring stations located throughout the urban area. Growth factors provided by the Spokane Regional Council project area and mobile sources emissions to increase by an annual rate of 0.5 percent which is equivalent to the rate of population growth projected. Point sources were not increased since it is not expected that the industry will increase over the time period considered. Mobile sources and area sources derived from vehicle activity are projected to continue to account for the same percentage of the overall inventories in both 1994 and 1997.

3.2.4 Phoenix, Arizona

Within the Maricopa County area, particulate pollution is a significant air pollution problem throughout the year. Based upon the receptor modeling inventory, the PM-10 inventory for the Phoenix area identifies re-entrained dust from paved roads (46.1 percent) and vehicular exhaust (37.1 percent) as the largest source contributors to the PM-10 problem. The monitoring network for PM10 particulates is composed of nine permanent sites and one mobile unit. A 23.1 percent goal for attainment was calculated, but selected control measures were projected to reduce emissions by only 4.7 percent by 1994 which demonstrates that attainment by the target date is impracticle. On a regional basis, the total daily VMT is projected to be 48.6 million in 1991 which will increase to 56.1 million by 1995 and 69.7 million by 2001 which constitutes a 43.4 percent increase over the ten year period. Therefore, it is likely that vehicular mobile sources will continue to be the dominate source pollutant in the future.

3.2.5 Presque Isle, Maine

The PM-10 inventory for the Presque Isle area identifies re-entrained dust from paved roads (87.5 percent) and residential wood combustion (5.4 percent) as the primary sources of the local PM-10 problem. Re-entrained dust is primarily due to sand and road salt used during the winter months. It is the sanding operation build-up over the winter that causes the exceedances. Exceedances were recorded prior to 1987 and the estimated exceedances are less than one per year. The Presque Isle PM-10 network consists of four monitoring sites. The State of Maine ambient standard PM-10 is 150 μg/m3 for a 24-hour average and 40 μg/m3 for an annual average (versus the 50 μg/m3 NAAQS). No exceedances of the annual standards have been recorded and since 1987, only one exceedance of the 24-hour standard has been monitored.

3.3 COMPARISON OF BASE YEAR PM-10 EMISSIONS INVENTORIES

A comparison of the five PM-10 inventories reveals that on-road mobile sources is the primary contributor to the PM-10 problem in most areas. The only exception to this was Boise, Idaho where residential wood combustion was the largest source (70.5 percent) on a daily basis during the winter months; however, on an annual basis re-entrained dust was again the largest contributor for the Boise area. In order to compare relative contributions of sources between each nonattainment area, pollutant sources were re-categorized between area and mobile sources, and then further between on-road and non-road mobile sources. The rationale employed to group specific sources under on-road mobile sources, such as re-entrained road dust and street sanding, was to isolate PM-10 pollutant sources generated by normal vehicle activities. In the case of street sanding in Denver, the contribution to overall emissions is a result not of the sanding itself, but of that sand being re-entrained by vehicle traffic on the roads.

Figure 1 illustrates that with the exception of daily (winter) emissions in Boise, on-road mobile sources was the largest contributor with a range of 43.2 percent to 87.7 percent of total emissions. Within the on-road mobile source category, it is clear that the PM-10 problem is

Category	SPOKANE, WA PM-10 Annual (Tons)	SPOKANE, WA % of PM-10 Annual	SPOKANE, WA PM-10 Daily (lbs/day)	SPOKANE, WA % of PM-10 Daily	DENVER, CO PM-10 Daily (Tons)	DENVER, CO % of PM-10 Daily	BOISE, ID PM-10 Annual (Tons)	BOISE, ID % of PM-10 Annual	BOISE, ID PM-10 Daily (lbs/day)	BOISE, ID % of PM-10 Daily	PHOENIX, AZ PM-10 Annual (Tons)	PHOENIX, AZ % of PM-10 Annual	PRESQUE ISLE, ME PM-10 Annual (Tons)	PRESQUE ISLE, ME % of PM-10 Annual
Point Sources	924.0	13.7%	7,386.0	10.4%	2.5	3.9%	323.0	5.5%	3,360.0	7.0%	-	0.0%	171.0	5.0%
Area Sources	2,771.3	41.1%	30,515.0	43.1%	14.5	22.8%	2,167.2	37.0%	35,852.0	74.3%	4,977.0	12.5%	251.0	7.3%
Agricultural Burning	3.4	0.1%	35.0	0.0%	-	0.0%	31.0	0.5%	500.0	1.0%	-	0.0%	-	0.0%
Residential Burning	13.8	0.2%	560.0	0.8%	-	0.0%	-	0.0%		0.0%	142.0	0.4%	-	0.0%
Comm/Ind. Incineration	3.1	0.0%	17.0	0.0%	-	0.0%	-	0.0%		0.0%	-	0.0%	67.0	1.9%
Wildfires/ Structural Fires	237.0	3.5%	2,576.0	3.6%	-	0.0%	-	0.0%		0.0%	42.0	0.1%	-	0.0%
Residential Wood Combustion	2,414.0	35.8%	26,240.0	37.1%	11.5	18.1%	1,370.0	23.4%	34,000.0	70.5%	2,049.0	5.2%	184.0	5.4%
Other Heating/ Heating Oil	100.0	1.5%	1,087.0	1.5%		0.0%	2.0	0.0%	72.0	0.1%	-	0.0%	-	0.0%
Natural Gas/ Coal Combustion	-	0.0%	-	0.0%	1.0	1.6%	13.2	0.2%	410.0	0.8%	555.0	1.4%	-	0.0%
Construction	-	0.0%	-	0.0%	1.0	1.6%	751.0	12.8%	870.0	1.8%	302.0	0.8%	-	0.0%
Charbroilers	-	0.0%	-	0.0%	1.0	1.6%	-	0.0%	-	0.0%	221.0	0.6%	-	0.0%
Misc. Processing and Production	-	0.0%	-	0.0%	-	0.0%	-	0.0%	-	0.0%	1,666.0	4.2%	-	0.0%
Mobile Sources	3,042.0	45.2%	32,879.0	46.5%	46.6	73.3%	3,370.0	57.5%	9,030.0	18.7%	34,768.0	87.5%	3,014.3	87.7%
On-Road Mobile Sources- Subtotal	2,909.0	43.2%	31,616.0	44.7%	45.5	71.5%	3,170.0	54.1%	7,930.0	16.4%	33,723.0	84.8%	3,014.3	87.7%
Vehicular Exhaust		0.0%		0.0%	4.2	6.6%	150.0	2.6%	823.0	1.7%	14,751.0	37.1%	7.3	0.2%
Hwy. Vehicle Brake/ Tire Wear	41.0	0.6%	446.0	0.6%		0.0%	20.0	0.3%	107.0	0.2%	-	0.0%	-	0.0%
Re-Entrained Dust -Paved Roads	1,555.0	23.1%	16,900.0	23.9%	27.9	43.9%	3,000.0	51.2%	7,000.0	14.5%	18,337.0	46.1%	3,007.0	87.5%
Re-Entrained Dust -Unpaved Roads	1,250.0	18.6%	13,585.0	19.2%	8.0	12.6%	-	0.0%		0.0%	635.0	1.6%	-	0.0%
Fugitive Dust -Unpaved Parking Lots	63.0	0.9%	685.0	1.0%		0.0%	-	0.0%		0.0%	-	0.0%	-	0.0%
Street Sanding	-	0.0%	-	0.0%	5.4	8.5%	-	0.0%	-	0.0%	-	0.0%	-	0.0%
Non-Road Mobile Sources- Subtotal	133.0	2.0%	1,263.0	1.8%	1.1	1.7%	200.0	3.4%	1,100.0	2.3%	1,045.0	2.6%	-	0.0%
Aircraft	23.0	0.3%	125.0	0.2%	0.5	0.8%	200.0	3.4%	1,100.0	2.3%	256.0	0.6%	-	0.0%
Construction Equipment	86.0	1.3%	935.0	1.3%	0.4	0.6%	-	0.0%		0.0%	428.0	1.1%	-	0.0%
Industrial Equipment	13.0	0.2%	141.0	0.2%	0.1	0.2%	-	0.0%		0.0%	-	0.0%	-	0.0%
Agricultural Equipement	-	0.0%	-	0.0%	-	0.0%	-	0.0%	-	0.0%	47.0	0.1%	-	0.0%
Off-Road Vehicles	-	0.0%	-	0.0%	-	0.0%	-	0.0%	-	0.0%	3.0	0.0%	-	0.0%
Railroad Locomotives	11.0	0.2%	62.0	0.1%	0.1	0.2%	-	0.0%		0.0%	311.0	0.8%	-	0.0%
TOTALS	6,737.3		70,780.0		63.6		5,860.2		48,242.0		39,745.0		3,436.3	

Figure 1. PM-10 base year inventories by pollutant source.

related to vehicle activity rather than exhaust emissions. With the exception of Phoenix, where vehicular exhaust accounted for 37.1 percent of the total inventory, vehicular exhaust accounted for no more than 6.6 percent (Denver) of total emissions. In contrast, re-entrained dust from paved and unpaved roads taken together account for a minimum of 41.7 percent in each area (again with the exception of Boise daily emissions). Even in Phoenix, where vehicular exhaust is significant, re-entrained dust from paved roads is still the single largest contributor to total emissions.

Overall, point sources appear to be of lesser significance to PM-10 pollution levels, contributing a high of 13.7 percent of the total in Spokane (annual) and 0.0 percent in Phoenix. While area sources as a group are significant, the majority of area source contributions are derived from a single source, residential wood combustion. In all cases, residential wood combustion is typically a winter problem.

3.4 CONTROL MEASURES

Most control measures can be described as either reducing the severity or content of emissions through such things as cleaner burning fuels or as decreasing the activity which generates the emissions such as reductions in VMT. Of the areas reviewed in this study, each area applied control measures most appropriate to controlling the source of emissions. In some cases, only one or two measures were necessary, whereas in other cases such as Phoenix, a variety of measures were still insufficient to reach attainment of the PM-10 standard. While mobile sources, as grouped in figure 1 earlier, were the largest source of PM-10 emissions, area source control measures for such things as wood burning appear to be the most effective approach to addressing local problems rather than mobile source control measures.

For general discussion purposes, the control measures that were applied are grouped by either point, area, or mobile source measures. The estimated impact of the control measures in the areas in which they were applied is also discussed where information was provided. Each control measures section of the PM-10 SIPs reviewed included discussions of the process used to select control measures, projected effect of applying the measures, and contingency measures available for further reductions. Details on implementation, surveillance, and enforcement of measures were also provided in detail in each of the SIPs, and in some cases total costs and savings from each measure was provided.

3.4.1 Stationary Source Control Measures

Of the five SIPs reviewed, only Denver included a discussion of stationary source control measures. With reasonably available control measures (RACM) already in place, PM-10 is well controlled from sources such as manufacturing plants and refineries. Denver will place restrictions on oil use at some of those facilities as a moderate control measure. Denver also included an analysis of precursor emissions of NO_X and SO_2 where stationary sources are determined to contribute above or below the *de minimus* level of $1\mu g/m3$ to predicted PM-10 concentrations. Then, depending on that determination, the maximum potential emissions or anticipated actual emissions are modeled respectively. Limits on large plants for emissions of secondary precursors are then put in place as necessary, such as low NO_X burners which are already in place in some locations.

3.4.2 Wood Burning Control Measures

Wood burning control measures were significant elements toward achieving emissions reductions in Denver, Boise, and Spokane. Some areas provided details including objective targets for converting fireplaces and stoves with cleaner burning units while other areas focused on certification of standards. The programs proposed in these areas combined a number of the following elements:

- Wood burning appliance certification and permit requirements for all new wood stoves and fireplace insert installations;
- Mandatory wood burning restrictions legislation for high pollution days such as banning the use of noncertified wood stoves during times of impaired air quality;
- Financial incentive programs for accelerated conversion to certified stoves;
- Air Quality Index Program establishing constant monitoring and a hotline to call for voluntary and mandatory wood burning restrictions based on stagnation probability forecasts;
- Lowered alert level stages to enact no burning restrictions earlier during a probable episode; and,
- Legislation to curtail future emissions by employing cleaner burning technology.

Two areas provided estimates of the impact of wood burning control measures. Denver estimated a 50 percent reduction in wood burning emissions. In Spokane, their program is supported by education and aggressive enforcement and is calculated to provide an emission reduction of 27.9 percent from total PM-10 emissions.

3.4.3 Mobile Source Control Measures

Mobile source control measures were widely applied in an effort to achieve emissions reductions in Denver, Spokane, Phoenix, and Presque Isle. However, these measures were only moderately successful and most control measures were in the form of reducing the pollutant content of emissions rather than controling vehicle activity. In some areas such as Denver, estimates of regionwide VMT growth of 18 percent between 1990 and 1995 are predicted to wipe out air quality gains achieved through reduced street sanding and vehicle exhaust programs. The mobile source control measures in the SIPs could generally be categorized as either street sanding measures, paving measures, CAAA mandates and related measures, and vehicle activity reduction and transportation system improvement measures. The programs proposed in each area typically combined numerous elements from the four subgroups detailed below:

Street Sanding

- Material specifications for street sanding materials (silt loading);
- Street sanding guidelines standardizing the amount and frequencies of applications, reduced use of rock salt, etc.;
- Local management plans to enhance street sweeping capabilities (frequency);
- Purchase of a vacuum street sweeper and implementation of a street sweeping program;
- Increased snowplowing to pick up some of the sanding material;
- Special clean up efforts by bucket loader and road grader to gather excess material in the curb lane; and,
- Flushing with high powered hoses.

Emissions from street sand are estimated to be reduced by approximately 20 percent regionwide and 35 percent within the City and County of Denver and the I-25 corridor. In Presque Isle, a reduction in silt loading to $10 g/m^2$ had the reported effect of a 72.41 percent reduction in the emission factor for light duty vehicles and a 38.3 percent reduction in the emission factor for heavy duty vehicles. However, removal of materials through sweeping did not prove very effective in Presque Isle and, in fact, had a worsening effect by kicking up more dust. In Boise, since road dust presently contributes only 15 percent to area PM-10 levels during stagnation (daily) conditions, street sweeping measures will not result in major reductions.

Paving

- Road paving;
- Curbing, paving, or stabilizing of paved road shoulders;
- Parking areas were paved within the critical area; and,
- Amendments to zoning codes requiring the paving of parking lots before a Certificate of Occupancy can be issued.

The City of Spokane developed a road paving program to reduce emissions from paved and unpaved roads. This plan calls for the paving of 4.5 miles of roads within the Spokane metropolitan area and divides the city/county into prioritized cells which do not meet the standards. The paving of these streets will provide for a 90 percent reduction in emissions from those streets. In Phoenix, the curbing, paving, or stabilizing of paved road shoulders is estimated to reduce PM-10 by only 1.9 percent in urban areas and 0.7 percent in rural areas.

CAAA Mandated or Related

- Enhanced inspection and maintenance (I/M);
- Oxygenated fuels program;
- New tailpipe standards for light-duty cars and trucks;
- Urban bus standards; and,
- Conversion of buses to alternative fuels.

In Denver, the I/M program is expected to reduce particulate emissions from vehicle exhaust by about 15 percent from light duty vehicles and by about 7 percent from heavy duty vehicles. The state's oxygenated fuels program is estimated to result in 14 percent reductions from closed-loop catalyst vehicles, which comprise more than 90 percent of the light duty gasoline vehicles and more than 60 percent of the light-duty gasoline trucks.

Vehicle Activity and Transportation System Improvements

- Traffic control sequencing to control speed because PM-10 road dust emissions are a function of traffic speed;
- Enhanced transit service;
- Park-and-ride lots;
- Regional ridesharing;
- Employer/developer based transportation management;
- Express bus service to the airport;
- Commuter Check where employers subsidize employee's monthly bus passes through a voucher;
- Unlimited bus pass;
- Light rail system in the downtown area;
- Transportation Improvement Program (TIP) projects including:
  - -dedicated bus/HOV lanes on interstates
  - -carpool matching service
  - -bicycle enhancement projects
- Covering of haul trucks; and,
- Trip reduction programs (no details provided).

The Denver Regional Council of Government's 1993 TIP identified approximately $190 million in projects and programs related to air quality improvements and TCMs. Denver's SIP also discusses a light rail line through the downtown area which has the potential to eliminate 500 diesel bus trips daily. In Phoenix, speed and VMT reductions on unpaved roads was judged to reduce PM-10 by only 0.3 percent in urban areas and 9.4 percent in rural areas. Previous PM-10 control plans in Phoenix had identified a trip reduction program (0.68 percent) and the covering of haul trucks (2.99 percent) as the two measures with the largest potential impact on PM-10 emissions.

3.5 MODELING

Section 189(a)(1)(B) of the CAAA requires that all demonstrations be based on some form of air quality modeling. The *Guideline on Air Quality Models* (revised) published by the U.S. EPA is the primary guidance for air quality modeling for all nonattainment classifications including PM-10. The guideline suggests that areas should consider the use of one of the numerous models listed in Appendix A of the guideline and referred to as an Appendix A model. The air quality modeling procedures discussed in the guideline can be categorized into four generic classes as follows:

- *Gaussian* models are the most widely used techniques for estimating the impact of nonreactive pollutants;

- *Numerical* models may be more appropriate than Gaussian models for area source urban applications that involve reactive pollutants, but they require much more extensive input data bases and resources and therefore are not as widely applied;

- *Statistical or empirical* techniques are frequently employed in situations where incomplete scientific understanding of the physical and chemical processes or lack of the required data bases make the use of a Gaussian or numerical model impractical; and,

- *Physical* modeling, involves the use of wind tunnel or other fluid modeling facilities.

If an Appendix A model is not applicable to the meteorology, topography, or source characteristics of the problem, an area may consider the use of an appropriate non-guideline technique or model listed in Appendix B of the guideline, which are referred to as Appendix B models. The non-guideline model applicability must be demonstrated through an evaluation that shows the model is not biased toward under-estimation. In cases where very little data exists to demonstrate that the non-guideline model does not underestimate, U.S. EPA has required that agencies perform modeling with both a non-guideline model and a guideline model for comparison.

While it is clear from the guideline that the use of dispersion models in combination with receptor models is the preferred approach, in certain limited situations, the use of a receptor model (RM) demonstration alone may be adequate to demonstrate attainment. Receptor models sample air for the purposes of analyzing the particle content of airborne pollutants. According to U.S. EPA guidance, in order for this to be adequate an area should be relatively small, characterized by uniform areawide emissions of one or two source categories, and geographically isolated from other PM-10 source areas. Examples of circumstances where RM demonstrations may be justifiable are small air-sheds where the only significant emissions sources are residential wood combustion and/or road antiskid materials. Finally, where there is no recommended air quality model and area sources are a predominant component of PM-10, an attainment demonstration may be based on rollback of the source apportionment derived from two reconciled receptor models.

The brief area summaries below detail the modeling techniques employed by the various regions. In each case, the choice of appropriate models was based on local topographical conditions and whether the PM-10 problem was primarily from area (including mobile) or stationary sources and whether it was primarily dominated by one or two source categories.

3.5.1 Denver, Colorado

The Colorado Department of Health (CDH) developed a modeling protocol for PM-10 approved by EPA. Primary PM-10 emissions from area sources, including mobile sources, were evaluated using a Gaussian Plume Multiple Source Air Quality Algorithm (RAM), a computer-based model formulated around assumptions of steady-state Gaussian dispersion for estimating concentrations of relatively stable pollutants. Primary PM-10 emissions from major stationary sources were evaluated using the short-term version of the Industrial Source Complex (ISC) model, which is also a steady-state Gaussian plume model approved by EPA.

3.5.2 Boise, Idaho

Because of stagnation conditions that existed at the time of PM-10 exceedances, the lack of significant point sources, and the inability of the Guassian models to simulate a "plume" reimpacting upon itself which render them unable to simulate particle dispersion in Boise, a non-guideline model (WYNDvalley stagnation model, Version 2.12) was selected for the PM-10 SIP analysis. Past exceedances were simulated to verify that the model could accurately recreate the ambient concentrations that actually existed and the model was then re-run with emissions profiles and controls representing the projected attainment year using a past worst-case meteorological episode to test the effectiveness of the control strategy.

3.5.3 Spokane, Washington

The Washington Department of Ecology applied a simple Rollback Modeling methodology for the attainment demonstration as laid out in four steps as follows:

1) Emissions Reduction Target required from the base year (1990) is calculated using the roll back method to determine the percentage needed based on the following equation:

$$R = (Cd - Cs)/(Cd - Bd)$$

where:

R=Percent Reduction Required
Cd=Design Concentration
Bd= Background Concentration
Cs= Level of the Standard

Then, using the highest 24-hour design value, the percentage is calculated.

2) The Attainment Emissions Level (AEL) is calculated by reducing the base year emissions by the percentage from step 1 calculated in step 1.

3) The required reduction is then calculated by subtracting the AEL from the base year emissions to calculate the reductions needed to meet the AEL.

4) Finally, the effect of the control measures are applied to the base year, demonstration, and maintenance inventories to compare whether the measures reduce the emissions to meet the AEL.

After this demonstration, the Spokane SIP also lays out the attainment by calculating ambient concentrations for 1994 and 1997, then applying emissions control measure reductions, and finally calculating future year ambient levels.

3.5.4 Phoenix, Arizona

Chemical Mass Balance (CMB) receptor modeling was used to fingerprint the emissions data. Receptor models use the chemical and physical characteristics of gases and particulates measured at the source and the receptor to both identify sources and quantify their contribution at the receptor. The 1989 inventory was then projected forward to 1994 using per year growth factors including population (3 percent) and VMT (4 percent). Phoenix then used modified Rollback Modeling as described under Spokane, Washington above for their attainment demonstration.

3.5.5 Presque Isle, Maine

The Caline 3 dispersion model (an Appendix A guideline model) was used because the PM-10 sources involved were from the road networks. Caline 3 is a steady-state Gaussian model that can be used to estimate the concentrations of nonreactive pollutants from highway traffic to determine air pollution concentrations at receptor locations downwind of "at-grade," "fill," "bridge," and "cut section" highways located in relatively uncomplicated terrain. Use of absolute predicted values from CALINE 3 was not successful. Therefore, as a means of performing a source apportionment for PM-10 data, chemical mass balance (CMB) receptor modeling was employed. Projection year estimates were made assuming 2 percent growth in VMT.

APPENDIX A - SIMPLIFIED PM-10 NONATTAINMENT AREA LIST
(as of January 17, 1996)

	State	Area Name (b)	PM-10 Nonattainment Areas	Population (c) (1000s)	
1	AK	Anchorage	1	130	
2	AK	Juneau	1	12	
3	AZ	Ajo	1	6	
4	AZ	Bullhead City	1	5	
5	AZ	Douglas	1	13	
6	AZ	Miami-Hayden	1	3	
7	AZ	Nogales	1	19	
8	AZ	Paul Spur	1	1	
9	AZ	Payson	1	5	
10	AZ	Phoenix	1	2,092	
11	AZ	Rillito	1	1	
12	AZ	Yuma	1	55	
13	CA	Coachella Valley	1	183	
14	CA	Imperial Valley	1	92	
15	CA	Mammoth Lakes (in Mono Co.)	1	10	(Pop Mono Co.)
16	CA	Mono Basin (in Mono Co.)	1	.	(See Mono Co. above)
17	CA	Owens Valley	1	18	
18	CA	Sacramento Metro	1	1,639	
19	CA	San Joaquin Valley	1	2,742	
20	CA	Searles Valley	1	31	
21	CO	Aspen	1	5	
22	CO	Canon City	1	13	
23	CO	Denver-Boulder	1	1,836	
24	CO	Lamar	1	8	
25	CO	Pagosa Springs	1	1	
26	CO	Steamboat Springs	1	7	
27	CO	Telluride	1	1	
28	CT	Greater Connecticut	1	2,470	
29	ID	Boise	1	205	
30	ID	Bonner Co.(Sandpoint)	1	27	
31	ID	Pinehurst	1	2	
32	ID	Pocatello	1	61	
33	ID	Shoshone	1	1	
34	IL	Oglesby	1	4	
35	IN	Vermillion Co.	1	17	
36	CA	Los Angeles-South Coast Air Basin	2	13,513	

	State	Area Name (b)	PM-10 Nonattainment Areas		Population (c) (1000s)
37	IL-IN	Chicago-Gary-Lake County	3		7,886
38	ME	Presque Isle	1		11
39	MI	Detroit	1		1,028
40	MN	Minneapolis-St. Paul	1		2,310
41	MO-IL	St. Louis	1	(d)	2,390
42	MT	Butte	1		34
43	MT	Columbia Falls	1		3
44	MT	Kalispell	1		12
45	MT	Lame Deer	1		1
46	MT	Libby	1		3
47	MT	Missoula	1		43
48	MT	Polson	1		3
49	MT	Ronan	1		2
50	MT	Thompson Falls	1		1
51	MT	Whitefish	1		4
52	NM	Anthony	1		2
53	NV	Las Vegas	1		741
54	NV	Reno	1		255
55	NY-NJ-CT	New York-N. New Jersey-Long Island	1		17,654
56	OH	Cleveland-Akron-Lorain	1		2,859
57	OH	Jefferson Co.	1		80
58	OR	Grants Pass	1		25
59	OR	Klamath Falls	1		37
60	OR	Lakeview	1		4
61	OR	LaGrande	1		12
62	OR	Medford	1		116
63	OR	Oakridge	1		3
64	OR	Springfield-Eugene	1		190
65	PA	Pittsburgh-Beaver Valley	1		2,468
66	PR	Guaynabo Co.	1		85
67	TX	El Paso	1		592
68	UT	Salt Lake City	1		914
69	UT	Utah Co.	1		264
70	WA	Olympia-Tumwater-Lacey	1		64
71	WA	Spokane	1		279
72	WA	Wallula	1		2
73	WA	Yakima	1		93
74	WV	Follansbee	1		3

	State	Area Name (b)	PM-10 Nonattainment Areas	Population (c) (1000s)
75	WV	Wier.-Butler-Clay (in Hancock Co)	1	3
76	WY	Sheridan	1	14
77	WA	Seattle-Tacoma	3	2,559
	Totals		82	68,309

Notes:

(a) This is a simplified listing of Classified Nonattainment areas. Unclassified and transitional nonattainment areas are not included. In certain cases, footnotes are used to clarify the areas involved. For example, the lead nonattainment area listed within the Dallas-Fort Worth ozone nonattainment area is in Frisco, Texas, which is not in Dallas County, but is within the designated boundaries of the ozone nonattainment area. Readers interested in more detailed information should use the official Federal Register citation (40 CFR 81).

(b) Names of nonattainment areas are listed alphabetically within each state. The largest city determines which state is listed first in the case of multiple-city nonattainment areas. When a larger nonattainment area, such as ozone, contains 1 or more smaller nonattainment areas, such as PM-10 or lead, the common name for the larger nonattainment area is used.

(c) Population figures were obtained from 1990 census data. For nonattainment areas defined as only partial counties, population figures for just the nonattainment area were used when these were available. Otherwise, whole county population figures were used. When a larger nonattainment area encompasses a smaller one, double-counting the population is avoided by only counting the population of the larger nonattainment area. Note that several smaller nonattainment areas may be inside one larger nonattainment area, as is the case in figure 1, which is considered one nonattainment area. Caution must be used in these cases, as population figures will not be representative of small nonattainment areas for one pollutant inside larger nonattainment areas for another pollutant. Occasionally, two nonattainment areas may only partially overlap, as in figure 2. For the purpose of this table, these are considered two distinct nonattainment areas.

(d) PM-10 nonattainment area is Granite City, Illinois, in Madison County.

APPENDIX B - REFERENCES

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