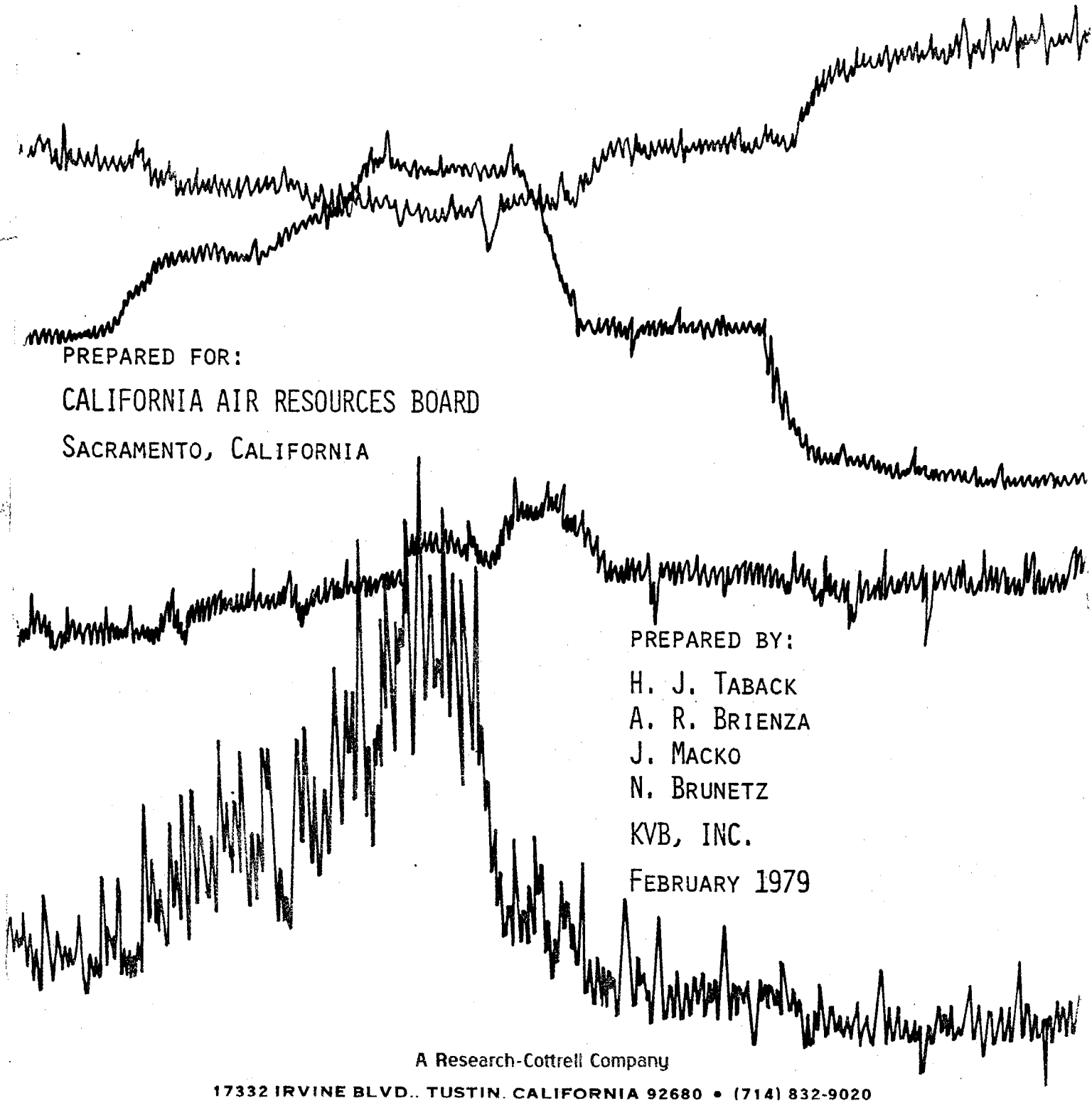
FINE PARTICLE EMISSIONS FROM STATIONARY AND MISCELLANEOUS SOURCES IN THE SOUTH COAST AIR BASIN

Executive Summary

KVB 5806-783



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ABSTRACT

An investigation of fine particulate emissions from stationary and miscellaneous sources in the greater Los Angeles area was conducted. The objectives were to help provide information on the origin of the ambient aerosol (haze) and to develop a basis from which to plan control strategy. The program results included extensive field test data, an inventory of total suspended particulate (TSP) emissions, a comprehensive profile on these emissions (i.e., by size distribution and chemical composition) and recommendations of alternative methods of emission control. The particulate inventory was delivered to the ARB in the form of computer print-outs and magnetic tapes. The emission profiles developed on the program were presented as an appendix to the final report. These profiles divide the TSP emissions by weight percent into four categories, >10μm, 3-10μm, 1-3μm, and <1μm. Within each category, the chemical composition is tabulated in weight percent. These data include: elemental composition (by X-ray fluorescence); sulfate and nitrate composition (by wet chemistry); and carbon content (by carbon analyzer) in the forms of volatile, carbonate, and total carbon.

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OVERVIEW

INTRODUCTION

In order to characterize air quality in the California South Coast Air Basin (SCAB) and to provide information on which to base control strategy decisions, the ARB has sponsored a series of programs to inventory emissions from stationary sources and investigate the systems in place for their control. The NOx, SOx and VOC* programs have already been completed and the present program documents the work performed to provide the same information for fine particulates.

Air-suspended matter having particle diameters of less than 10μm is defined as fine particulates. Emitted from stationary sources, fine particulates contribute to the ambient aerosol, causing haze or reduced visibility, and constitute a human health hazard. Because of their visibility, some of the earliest efforts to control air pollution were directed at particulate emissions. As a result, the mass flow of particle emissions has been reduced by 95% or more from what prevailed under previously uncontrolled conditions. Because of the classifying nature of the control processes applied, however, the remaining particulate emissions are in the fine particle range. This material tends to remain suspended in the ambient air and, compared with coarser particle ranges, constitutes the greatest health hazard.

Fennelly (Ref. 1-1) indicates that for very fine (<1μm) particles that enter the pulmonary system, more than 30% will remain there. In considering a fine particulate standard recently, the U.S. EPA decided that particles <15μm are in the respirable range. In combustion sources, KVB (Ref. 1-2) and others (Ref. 1-3) have found that the smaller particles often have higher concentrations of toxic metals than do larger particles. This effect is due

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*Volatile Organic Compounds

to selective condensation in the cooling gas. Friedlander (Ref. 1-4) identified fuel-oil fly ash as a significant constituent in the ambient aerosol of the Basin.

Particles having diameters of 0.3 to 1.0μm are considered to be most effective in light scattering and, therefore, haze production. This is because this size range corresponds to the wavelength range of visible light. Thus, while emissions of (coarser) particulates in the Basin have been greatly reduced as a result of applied controls, fine particle that are still emitted by stationary sources contribute significantly to reduced visibility and increased health hazards. In view of these considerations, a study of the persistent fine fraction of particulate emissions was considered justified. A contract was accordingly awarded by the ARB, resulting in the work described here.

The objectives of this program were to:

a. Characterize the emissions of fine particulates from stationary sources in the South Coast Air Basin and Ventura County in terms of:
   - identification and location of point and area sources
   - individual source annual emission rates
   - seasonal and temporal operational variations
   - particle size distributions
   - predominant chemical compositions

b. Report the above data (excluding chemical compositions) in the EPA's Emission Sub-system format on IBM-compatible magnetic tape.

c. Generate the following computer print-outs or typed reports:
   - Application Category Report
   - Geographic Location Listing (10 km grid)
   - Emission profile listing by SCC Code

d. Provide particle size distribution and chemical composition data in the form of emission profiles

e. Assess the cost effectiveness of potential methods of reducing the emissions identified.

SUMMARY AND CONCLUSIONS

In order to accomplish the above objectives, the first steps undertaken were: to prepare a preliminary inventory of total suspended particulates (TSP) without consideration of particle size or composition; to identify the major emission sources; and to determine the distribution of emissions among the various source types.

On the basis of this preliminary inventory, a field test program was next conducted to characterize emissions from the sources selected, emphasizing those source types producing the greater amounts of emissions. Seventy-eight particulate sampling runs were then made, 40 using the EPA Source Assessment Sampling System (SASS) and 37 employing a modified EPA Method 5 train. In each run particles were collected in three cyclones with particle size cuts of 10, 3 and 1 μm followed by a backup filter and water impinger. Whenever catches in excess of 100 milligrams were acquired, they were analyzed for chemical composition. A summary of the sources tested is as follows:

Source Type	No. of Runs
Utility Boiler	18
Industrial Boiler	10
IC Engine	3
Hog Fuel (Woodchip) Boiler	1
Gypsum Plant	1
Brick Plant	2
Cement Plant	2
Glass Furnace	6
Fiberglass Plant	2
Asphalt Roofing Plant	2
Asphalt Paving Plant	2
Rice Dryer	2
Carob Plant	2
Heat Treating Process	2
Sand Blasting Process	2

Open Hearth Plant	2
Spray Booth	4
Boric Acid Plant	2
Fertilizer Plant	2
Wood Processing	5
Process Heater	1
Fluidized Bed Catalytic Cracking (FCC Unit)	1

In preparing for the field test program a commercial SASS unit without the standard organic module was acquired along with a commercial Method 5 unit. With the assistance of the Southern Research Institute a set of three cyclones having the same cut sizes as the SASS train were designed and fabricated for the Method 5 train. Subsequently, both the SASS and the Method 5 cyclone sets were calibrated at 400 °F using sperical aluminum powder. At flow rates of 4 and 1 SCFM, respectively, the results were as follows:

Nominal Cut Size, μm	SASS D_{50}*, μm	Method 5 D_{50}*, μm
10	9.2	8.3 (9.1)†
3	3.8	1.9 (4.1)†
1	1.3	0.6 (1.2)§

*D_{50} is the aerodynamic diameter at which 50% of the particles would be retained in the cyclone and 50% would pass through.

†The numbers in parenthesis are the D_{50}'s obtained by Southern Research on identical cyclones using a vibrating orifice aerosol generator calibration technique (See Section 3.2.1 of the final report).

§The value of (1.2) shown was not measured directly by Southern Research but was derived from measurements at a lower temperature.

Particle size distributions were calculated for each particulate sampling run. Chemical analysis of the particulate catches consisted of X-ray fluorescence analysis for elemental composition, wet chemistry for nitrate and sulfate content, and carbon analysis for volatile, carbonate, and total carbon values.

From these data--plus data found in the literature--emission profiles were prepared for 81 of the 135 Source Classification Codes which are found in the Basin. The profiles divide the TSP emissions by weight percent into

four categories: >10μm, 3-10μm, 1-3μm and <1μm. The XRF analysis, sulfates, nitrate and carbon composition are listed in weight percent for each size category.

The next step in the program was to generate a final inventory. The ARB provided Emission Information Subsystem (EIS) data files for the South Coast Air Quality Management District (SCAQMD), which includes Los Angeles, Orange, Riverside, and San Bernardino Counties, and the Ventura Air Pollution Control District (VAPCD), along with a breakdown of human population data for the Basin on a 1 Km grid map. The EIS data were the basis for the KVB final inventory. The emission factors in the EIS files were reviewed by KVB and adjusted where necessary by applying correction factors determined from data obtained in tests of specific sources or from data for a group of sources identified with a certain Source Classification Code (SCC) number. The emission profiles were keyed to the specific sources. Additionally, source types not contained in the EIS files, primarily area sources, were added to the data base.

The final inventory was delivered to the ARB under separate cover as computer print-outs and magnetic tape files. The primary elements delivered are as follows:

- a total suspended particulates report with 10 km-grid mapping
- a total suspended particulates report by ARB application category
- a plant index
- an emission profile listing (Appendix A of final report)
- an SCC report
- a point source emission file in EIS format (tape)
- an area source file (tape)
- an SCC report file (tape)

The inventory, which has the time frame of 1975-1976, shows total suspended particulate emissions of 510 tons/day. Of this, 385 tons/day derived from miscellaneous area sources, such as fugitive dust (290 tons/day) sea salt (55 tons/day), automotive tires and brakes (30 tons/day), and various forms of open burning (12 tons/day). Of the 125 tons/day emitted by point

sources, 28 percent came from mineral sources, notably one sand and gravel and one brick manufacturing plant (both in Ventura County). Utility boilers accounted for 27% of the point source emission, while the entire category of "Combustion of Fuel" accounted for 30% of the point source emissions.

Over 90% of the total emissions (point and area source) have a particle size of less than ten μm. This assessment was based on an analysis of available emission profiles for the various application categories. It should be pointed out, however, that the major category, "Miscellaneous Area Sources," here includes only particulate contributions of 10μm and smaller. A summary of the overall TSP and fine particulate emissions for the period covered is as follows:

Application Category	TSP Tons/Day	Fine Particle (<10μm) Tons/Day
Petroleum	2.1	1.2
Solvent use	3.2	2.1
Chemical	1.5	1.4
Metallurgical	11.5	10.4
Mineral	35	6.8
Combustion of fuel	38	35
Food and agriculture	30	24
Wood processing	0.4	0.2
Waste burning	1.6	1.1
Misc. industrial	1.2	0.5
Misc. area sources	385	385
Total	510	468

From these totals, it can be seen that 66% of the particulates emitted from point sources in the Basin were in the fine (<10μm) particle size range.

Table 1-1 summarizes the TSP particulate emissions of both point and area sources by application category. As given, area sources account for 80% of the TSP. In this connection, it should be pointed out that the Table 1-1 data and that tabulated just above do not reflect fugitive dust emissions attributable to "paved road travel." This major classification comprises materials released from roadbeds, including deposited dusts but not automotive exhaust particulates or matter released from tires or brakes. Paved road travel emissions and the rationale for their omission in these totals are explained in Section 2.3.3 of the final report.

TABLE 1-1. EIS/KVB TSP PARTICULATE EMISSION INVENTORIES
Tons/Year

Application Category	No. Point Sources	1975-76 EIS/KVB File		
		Point Sources	Area Sources	Total
Petroleum		750		750
Production	34	50	0	50
Refining	25	600	0	600
Marketing	8	100	0	100
Organic Solvent Use		1160		1160
Surface coating	546	1150	5	1150
Degreasing	5	10	0	10
Other	4	5	0	5
Chemical	157	540	0	540
Metallurgical	547	4200	0	4200
Mineral	480	12600	0	12600
Waste Burning	48	75	500	600
Combustion of Fuel		13900		13900
Utility boilers	187	9100	0	9100
Industrial devices	1084	2700	0	2700
Commercial/institut'l	199	600	0	600
Petroleum	316	1500	0	1500
Wood Processing	25	130	0	130
Food and Agriculture	163	460	11000	11000
Miscell. Industrial	72	440	10	450
Unclassified (Misc. Area)	0	0	140,500	140,500
Fugitive dust			105,000	105,000
Forest & structural fires			4,500	4,500
Tires and brakes			11,000	11,000
Sea salt			20,000	20,000
	3900 Sources			
Total, Tons/Year,		34000	152,000	185,830
(Total), Tons/Day		(93)	(416)	(510)

Table 1-2 is a detailed breakdown, with estimated accuracies, of the miscellaneous area sources by county in the SCAB. These estimates involve an overall uncertainty of +65,000 tons/year (180 tons/day) and -36,000 tons/year (-99 tons/day). Unlike the previous two tables, paved road travel emissions are included in Table 1-2.

Figure 1-1 furnishes a spatial distribution of point and area TSP sources based on a 10-km grid map of the SCAB. Each grid element shows the daily emission rate, while Table 1-3 itemizes those grid elements with TSP emission rates greater than 5 tons/day.

Finally, an investigation of control techniques was made. Control techniques reviewed in the report include:

- Mechanical collectors (cyclones, settling chambers, etc.)
- Wet scrubbers
- Electrostatic precipitators
- Fabric filters (baghouses)

Cost data for control systems were obtained from Research-Cottrell and are presented. These data present installed cost as a function of: mean particle size; volumetric flow rate; and particulate loading.

The final report consists of five sections, the present discussion comprising Section 1.0. Section 2.0 deals with the emission inventory; it describes the data sources and presents the detailed data used in the inventory compilations. Various summary tables and plots are also presented. Section 3.0 presents the sampling and analysis methodology as well as an assessment of the data quality. Section 4.0 is a detailed discussion of results obtained from each of the tests conducted. Finally, Section 5.0 is a treatment of control techniques and their associated costs of application.

RECOMMENDATIONS FOR FURTHER RESEARCH

On this program, a maximum effort has been made to perform as many tests as possible within budgetary constraints. There are many additional sources that could not be tested due to lack of time or the availability of

TABLE 1-2. ESTIMATED 1976 AREA SOURCE FINE PARTICLE EMISSIONS SUMMARY[a]

	South Coast Air Basin Counties[b]						(c)	Percent	
	Orange	Los Angeles	River-side	San Bernardino	Ventura	Santa Barbara	Emissions Tons/yr	of Grand Total	Estimated Percent Accuracy
Road & Building Construction	21,000	24,000	7,100	11,000	6,400	1,000	71,000	20.9	+50,-20
Agricultural Tilling	1,300	1,200	3,100	800	3,100	40	9,500	2.8	±25
Refuse Disposal Sites	60	200	20	20	20	6	300	<0.1	±25,-20
Livestock Feedlots	150	3	150	950	5	5	1,300	0.4	±50
Unpaved Road Travel	2,000	14,000	2,000	1,800	2,600	230	23,000	6.8	±40
Paved Road Travel (d)	33,000	140,000	7,600	12,000	8,800	3,100	200,000(d)	58.8	±50
Fugitive Dust--Subtotal							305,000	89.7	
Forest Fires	120	700	600	430	530	50	2,400	0.7	+50,-20
Structural Fires (e)	40	160	10	15	10	5	200	<0.1	+100,-20
Fireplaces	70	280	30	60	20	10	500	0.1	+100,-10
Residential Natural Gas	20	90	5	10	10	5	100	<0.1	±25
Cigarettes	130	520	30	50	30	10	800	0.2	+20,-50
Agricultural Burning	20	50	30	--	400	10	500	0.1	±25
Combustion--Subtotal							4,500	1.3	
Tire Attrition	1,400	5,700	320	490	370	130	8,400	2.5	±20
Brake Lining Attrition	530	2,100	120	180	140	50	3,100	0.9	±20
Automotive--Subtotal							11,000	3.2	
Sea Salt--	4,000	6,700	---	---	3,500	5,800	20,000	5.9	+50,-20
Grand Total							340,000	100%	

a) Emission estimates are based on particles ≤ 10 μm

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b) Includes only that portion of County within SCAB

c) Rounded to three significant figures

d) A large (but unknown) percentage of the 200,000 tons/year is assignable to other area source categories only some of which were studied on this program. For this reason (see Section 2.3.3 A-6) it was not included in the final inventory count as indicated in Table 2-18 of the final report.

e) Includes property, contents and vehicle loss.

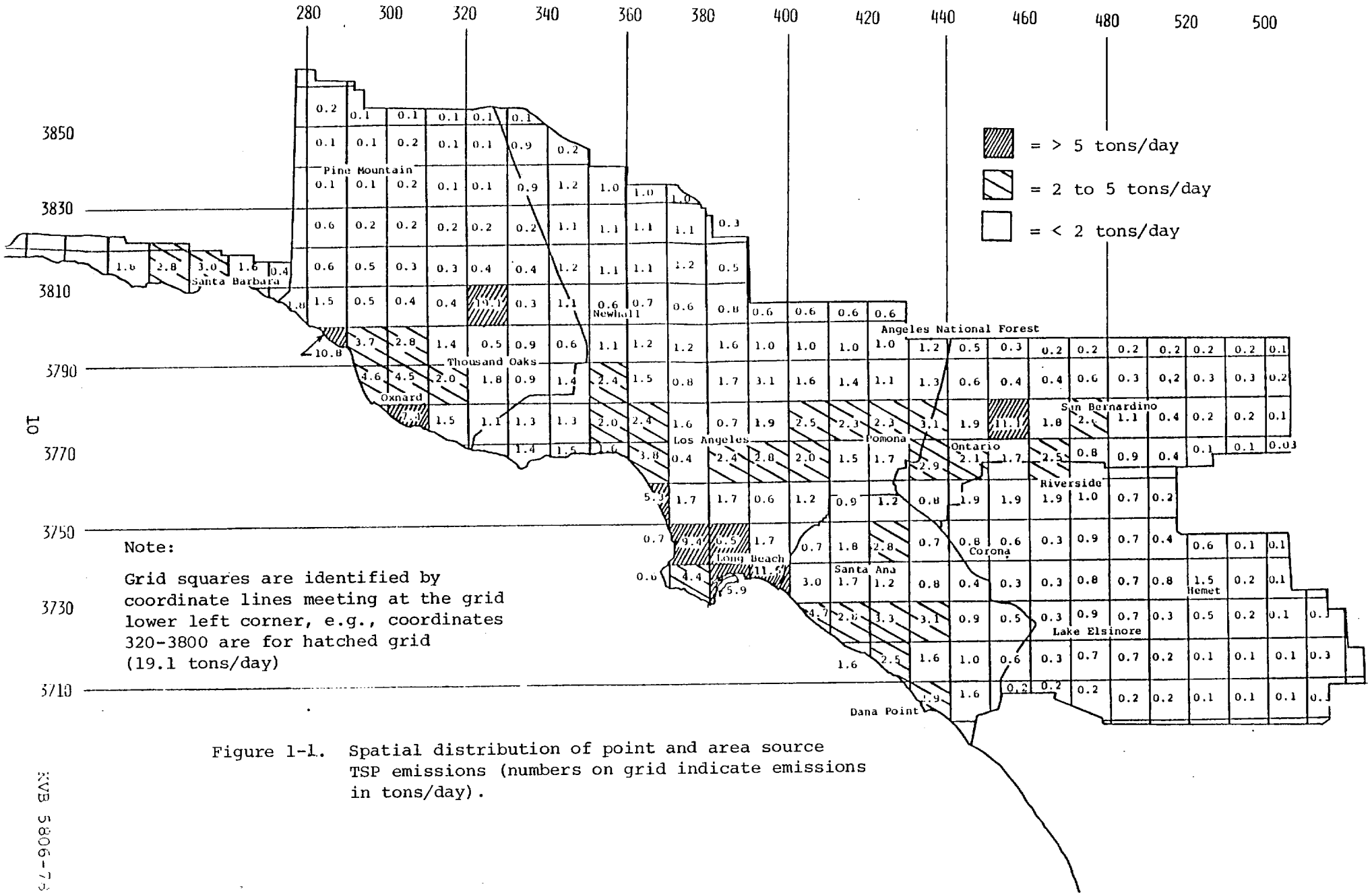

Figure 1-1. Spatial distribution of point and area source TSP emissions (numbers on grid indicate emissions in tons/day).

TABLE 1-3. GRID-ZONES HAVING ESTIMATED EMISSION RATES IN EXCESS OF 5 TONS/DAY

UTM Coor. E/W	UTM Coor. N/S	Nearest City	Emissions (Ton/Day)	Principal Source Type
280	3790	W. Ventura	10.8	Ceramic manufacturing
300	3770	Pt. Mugu	7.4	Elect. gen. & area.
320	3800	Fillmore	19.1	Sand and gravel
360	3750	LA Airport	5.3	Area
370	3740	Torrance	9.4	Elect. gen. & area
380	3740	Paramount	6.4	280 Pt. sources & area sources
380	3730	LA Harbor	5.9	250 Pt. sources & area sources
390	3730	Long Beach	11.5	Elect. gen. & area
450	3770	Fontana	11.1	Steel manufacturing

the test unit. As mentioned earlier, only 70% of the SCC's found in the Basin had emission profiles developed for them. In most cases a source type has had to be characterized by the emission from only a single plant tested.

To give a greater universality to the emission profiles developed in this program and to develop additional new profiles, it is recommended that further testing be considered. Particulate testing with the full characterizations achieved on this program is expensive, particularly if compared to any other type of pollution testing. The trains used in this program performed adequately, but it is questionable if this would have been true had more economical approaches been applied. Therefore, to insure that these presently developed data are to be meaningfully used with any future new data that are generated, it is recommended that the same general procedures used on this program be employed in any subsequent efforts.

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