CHAPTER 6

FUTURE RESEARCH

6.1 Introduction

Improvement of urban air quality by deliberate control of emission sources requires a thorough understanding of the phenomena associated with air pollution. It has been the objective of this work to further this knowledge, specifically for atmospheric fine aerosol carbon, by characterizing the existing pollution levels, and by developing methods that can be used by engineers to design aerosol carbon abatement programs. In the course of this work, a number of questions requiring further study have been identified. In this chapter, suggestions for future research into the behavior of atmospheric carbon particle air pollution are outlined.

6.2 Air Quality Observations

In Chapter 2, it was concluded that primary emissions are responsible for the majority of long-term average carbon particle concentrations in the Los Angeles area during 1982. The formation of secondary aerosol carbon in the atmosphere is expected to occur, and the reasons for not finding an obvious enrichment in organic aerosol relative to elemental carbon during summer months needs to be investigated further. The ambient aerosol monitoring program executed as part of this study involved collection of 24-hour average filter samples. Further insight into the importance of secondary formation of particulate carbon may be gained by contrasting these long-term average results with the conditions present during summer months in the middle of the day, when photochemical reactions are expected to be at their peak. Examination of the ratio of fine total carbon to fine elemental carbon for a number of summer mid-day events would help one to determine the extent to which secondary formation is occurring under photochemical smog episode conditions.

A more complete identification of the organic compounds present in atmospheric aerosols would aid in the understanding of pathways of secondary particulate matter formation. The extent to which secondary aerosol formation is occurring in the atmosphere could be better quantified, and information regarding the nature of toxic materials in the atmosphere would be enhanced, if aerosol samples representing a full annual cycle were analyzed for the details of the individual organic compound present. During the course of the air quality monitoring program described in Chapter 2, a quartz fiber filter was included in the sampling protocol that was intended to be reserved for organic compound identification. Detailed speciation of the organic material present on these filters may be achieved using high-resolution gas chromatography (GC) and high-resolution gas chromatography/mass spectrometry (GCMS) techniques. This work is in progress at present (Mazurek, 1985).

6.3 Air Quality Model Application

The air quality model described in Chapter 3 was used to predict long-term average fine primary carbon particle concentrations in the Los Angeles area during 1982. The computation of horizontal advective transport was based on a uniform wind field generated from data of a single wind monitoring location. The accuracy of the model predictions of fine primary carbon particle concentrations may be improved by employing a more sophisticated two-dimensional wind field. A considerable effort would then be required to gather more wind data and to generate continuous wind fields for every hour of the modeling period. In addition, the computer time required for computation will be greatly increased.

Further improvements of the air quality model application include reducing the size of the receptor grid cells which would provide a greater spatial resolution of model predictions. It would then be necessary to compile a more detailed spatially-resolved emissions inventory which matches the new receptor grid.

The model was designed to simulate the emission and transport of primary carbonaceous aerosol. A topic for future study would involve incorporating into the model an explicit secondary aerosol formation calculation. This would require a comprehensive knowledge of the physical and chemical kinetic mechanisms for organic aerosol formation. Also more detailed hydrocarbon emissions information would need to be compiled.

The modeling technique developed during this study has been shown to accurately simulate the long-term behavior of the transport of fine primary carbonaceous aerosol in the Los Angeles area. It would not be difficult to employ this model to simulate the transport of primary pollutants in other cities as well. The specific meteorological conditions in other urban air basins would have to be assessed to determine whether the assumptions built into the model are consistent with the nature of transport in that air basin. The model accounts for different physical processes independently of each other, so that it is possible to modify the computation of a single process without destroying the integrity of the model.

6.4 Emission Control Strategies

In Chapter 5, strategies for atmospheric carbon particle control were evaluated. Many of the control measures have implications regarding the control of other aerosol pollutant species as well. Local control agencies are faced with the problem of controlling a variety of pollutants. It would be desirable to incorporate source to receptor information for many aerosol species to design a control strategy for simultaneously reducing concentrations of sulfates, nitrates, carbonaceous species, and other toxic species which are present in urban atmospheres. A difficulty encountered in a multi-attribute control program is in assigning a weight to each species present regarding its detriment to the environment. Assumptions about the trade-offs between toxicity, overall mass burden, and visibility degradation must be made to determine the effectiveness of a proposed control strategy.

Results from an air quality model which accounts for secondary aerosol formation could be used to evaluate control strategies for the abatement ot secondary carbonaceous aerosol concentrations in the atmosphere. However, then a non-linear programming approach would be required. A further improvement to the control strategy optimization technique would involve the use of an integer program which would inhibit the selection of fractions of control measures when such a choice is infeasible.

Application of the linear programming technique presented in Chapter 5 demonstrates the usefulness of the air quality model for designing aerosol carbon pollution abatement strategies. More detailed information on the costs and emission reduction capabilities of control technologies is needed. In the future, when more complete information concerning control technologies is available, the air quality model results from this study may be directly applied to the optimization of a strategy for control of a number of primary pollutants, including fine primary carbon particles, in the Los Angeles area.

6.5 Conclusions

In this chapter, avenues for future research have been discussed. Scientific investigations into the phenomena of atmospheric processes will improve the capabilities of the air quality model. Application of the model to evaluation of emission control programs promises to contribute toward the improvement of urban air quality.

6.6 References for Chapter 6

Mazurek, M. A. 1985. Geochemical investigations of organic matter contained in ambient aerosols and rainwater particulates. Ph.D. thesis. University of California at Los Angeles.

APPENDIX A

1982 EMISSIONS ESTIMATES IN THE 50X50-MILE MODELING GRID

Table A.1

Emissions Estimates for Mobile Sources in 50X50-mile grid

	Estimated 1982 Fuel Use (10^9 Btu/day)	Thous. VMT/day	Total Particulate Emission Factor ($kg/10^9$ Btu)	Total Particulate Emission Factor (gm/mile)	Total Particulate Emissions (kg/day)	Mass Fraction < 2.1 µm	Fine Total Particulate (kg/day)	%Total Carbon in < 2.1 µm Fraction	Fine Total Carbon (kg/day)	Partition of Carbon: Volatile Carbon % OC	Partition of Carbon: Non-volatile Carbon % EC	Fine Organic Carbon (kg/day)	Fine Elemental Carbon (kg/day)
MOBILE SOURCES													
Highway Vehicles													
Catalyst Autos	515.2(a)	86996(a)		0.016(k)	1391.9	86% (v)	1197.1	39% (ff)	466.9	55%	45% (ff)	256.8	210.1
Non-catalyst Autos	305.6(a)	33385(a)		0.32 (l)	10683.2	36.4% (w)	3888.7	76.4% (w)	2971.0	78.7%	21.3% (w)	2338.1	632.8
Diesel Autos	14.0(a)	2494(a)		0.48 (m)	1197.1	93% (x)	1113.3	83.7%(gg)	931.9	23.4%	76.6%(gg)	218.1	713.8
Catalyst Light Trucks	96.0(a)	11882(a)		0.022(n)	261.4	86% (y)	224.8	39% (hh)	87.7	55%	45% (hh)	48.2	39.5
Non-catalyst Light Trucks	57.0(a)	4560(a)		0.44 (o)	2006.4	36.4% (z)	730.3	76.4% (z)	558.0	78.7%	21.3% (z)	439.1	118.8
Diesel Light Trucks	2.6(a)	341(a)		0.48 (m)	163.7	93% (aa)	152.2	83.7%(ii)	127.4	23.4%	76.6%(ii)	29.8	97.6
Catalyst Medium Trucks	58.9(a)	4993(a)		0.033(p)	164.8	86% (y)	141.7	39% (hh)	55.3	55%	45% (hh)	30.4	24.9
Non-catalyst Medium Trucks	40.1(a)	3399(a)		0.41 (q)	1393.6	36.4% (z)	507.3	76.4% (z)	387.6	78.7%	21.3% (z)	305.0	82.5
Gasoline Heavy Trucks	66.9(a)	3050(a)		0.77 (r)	2348.5	36.4% (z)	854.9	76.4% (z)	653.1	78.7%	21.3% (z)	514.0	139.1
Diesel Heavy Trucks	147.4(a)	5857(a)		1.39 (s)	8141.2	93% (aa)	7571.3	83.7%(ii)	6337.2	23.4%	76.6%(ii)	1482.9	4854.3
Motorcycles	3.8(a)	1503(a)		0.15 (t)	225.5	36.4% (z)	82.1	76.4% (z)	62.7	78.7%	21.3% (z)	49.3	13.4
LPG use for Carburetion	7.7(b)			(u)	1.6(u)								
Civil Aviation													
Jet Aircraft	47.0(c)		(c)		410.5(c)	~100% (bb)	410.5	96% (bb)	394.1	23.4%	76.6%(jj)	92.2	301.9
Aviation Gas	1.9(c)		(c)		43.8(c)	36.4%(cc)	15.9	76.4%(cc)	12.2	78.7%	21.3%(cc)	9.6	2.6
Commercial Shipping													
Residual Oil-fired Ships	11.9(d)		85.50(h)		1017.5	72% (dd)	732.6	11.3%(dd)	82.8	80%	20% (kk)	66.2	16.6
Diesel Ships	4.7(d)		49.17(i)		231.1	93% (ee)	214.9	83.7%(ii)	179.9	23.4%	76.6%(ii)	42.1	137.8
Railroad													
Diesel Oil	14.1(e)		81.95(j)		1155.5	93% (ee)	1074.6	83.7%(ii)	899.4	23.4%	76.6%(ii)	210.5	689.0
Miscellaneous													
Off Highway Diesel Vehicles	25.7(f)		78.67(f)		2024.1(f)	93% (ee)	1882.4	83.7%(ii)	1575.6	23.4%	76.6%(ii)	368.7	1206.9
Off Highway Gasoline Vehicles	(g)				295.3(g)	36.4%(cc)	107.5	76.4%(cc)	82.1	78.7%	21.3%(cc)	64.6	17.5
TOTAL MOBILE SOURCES									15864.9			6565.6	9299.1

Notes for Table A.1

(a) See Table A.6. Vehicle miles travelled (VMT) are computed for each vehicle type from traffic count data. Fuel use is then computed from mileage for each vehicle type, employing fuel economies from Table A.5.

(b) Based on fuel sales data for California from the Energy Information Administration (1983); see Appendix B, Table B.6.

(c) Average daily fuel use and particulate emissions at commercial airports were obtained from Federal Aviation Administration (1981) air traffic data plus U.S. Environmental Protection Agency (1982, section 3.2.1) calculation procedure.

(d) Based on procedure by Cass (1977).

(e) Consumption of fuel oil sold to railroads is assumed to be proportional to track mileage. Railroad track mileage in the 50X50-mile grid was measured on United States Geological Survey 7½ minute topographic maps and was estimated to be 1047.9 miles. Track mileage in the state of California of 8446 miles was obtained from the Federal Railway Administration as reported by Cass (1977, p. 628). Fuel sales data from the Energy Information Administration (1983) indicate that 7138 thousand barrels of distillate fuel oil were used by railroads in the state of California in 1982; see Appendix B, Table B.6. The grid contains 12.4% of the track mileage in the state; therefore, the fuel use in the grid is estimated to be 7138 X 12.4% = 885.6 (1000 bbls/yr) or 14.1×10^9 Btu/day.

(f) Total particulate emissions from off-highway diesels is 2024.1 kg/day in the 50X50-mile grid from the California Air Resources Board 1982 inventory of area source emissions (Ranzieri 1983). Using the particulate emissions factor of 24 lb/10^3 gal or 78.67 kg/10^9 Btu, the fuel use is estimated to be 25.7×10^9 Btu/day.

(g) Total particulate emissions from off-highway gasoline consumption in the 50X50-mile grid from the California Air Resources Board 1982 inventory of area source emissions (Ranzieri 1983). No information is available on the fuel use.

(h) Industrial boiler emission factor of 21.64 kg/10^9 Btu at 0.4% sulfur in fuel was scaled up to 85.50 kg/10^9 Btu at 1.58% sulfur in bunker fuel based on evidence of Taback et al. (1979) that shows that the particulate emissions rate from residual oil-fired boilers is roughly proportional to the fuel oil sulfur content.

(i) U.S. Environmental Protection Agency (1982, Table 3.2.3-2) gives 15 lb/10^3 gal or 49.17 kg/10^9 Btu.

(j) U.S. Environmental Protection Agency (1982, Table 3.2.2-1) gives 25 lb/10^3 gal or 81.95 kg/10^9 Btu.

(k) Laresgoiti and Springer (1977), at 0.3% sulfur in unleaded gasoline, obtained 0.016 g/mile for oxidation catalyst car; Muhlbaier and Williams (1982) reported a similar emissions factor (0.014 g/mile); and Schuetzle (1983, Table 8) reported a weighted average of many published data for particulate emissions from catalyst automobiles (0.017 g/mile).

(l) 0.32 g/mile from Habibi (1973, Table VIII) (leaded fuel cars) adjusted downward to 0.0402 g/mile lead emitted. Total particulate emissions is computed only to complete the table; fine carbon emissions are calculated independently. See note (w), below.

(m) Pierson (1979) cites numerous researchers on the particulate emission rate from a light-duty diesel and reports a value of about 300 mg/km (or 0.48 g/mile). Many other researchers (Schuetzle 1983; Hyde et al. 1983; Gabele et al. 1982; Gibbs, Hyde, and Byer 1980; Williams and Chock 1980) have found similar emission rates ranging from 0.36 to 0.89 g/mile for light-duty diesel automobiles.

(n) Assuming the same particulate emission rate per gallon of fuel burned as light-duty catalyst automobiles. The weighted average fuel economy is 0.0474 gal/mile for catalyst autos and 0.0647 gal/mile for light trucks; see Table A.6. Scaling upward from the emission rate of 0.016 g/mile for catalyst autos (see note [k], above), this gives 0.022 g/mile (0.016 g/mile / 0.0474 gal/mile = 0.338 g/gal;
0.338 g/gal X 0.0647 gal/mile = 0.022 g/mile).

(o) Assuming the same particulate emission rate per gallon of fuel burned as light-duty non-catalyst automobiles. The weighted average fuel economy is 0.0733 gal/mile for non-catalyst autos and 0.1000 gal/mile for non-catalyst light trucks; see Table A.6. Scaling upward from the emission rate of 0.032 g/mile for non-catalyst autos (see note [1], above), this gives 0.44 g/mile (0.32 g/mile / 0.0733 gal/mile = 4.37 g/gal;
4.37 g/gal X 0.1000 gal/mile = 0.44 g/mile).

(p) Assuming the same particulate emission rate per gallon of fuel burned as light-duty catalyst automobiles and trucks (0.338 g/gal); see note (n), above. The weighted average fuel per mileage for catalyst medium trucks is 0.0943 gal/mile; see Table A.6. This gives 0.032 g/mile (0.338 g/gal X 0.0943 gal/mile).

(q) Assuming the same particulate emission rate per gallon of fuel burned as light-duty non-catalyst automobiles and trucks (4.37 g/gal); see note (o), above. The weighted average fuel per mileage for non-catalyst medium trucks is 0.0943 gal/mile; see Table A.6. This gives 0.41 g/mile (4.37 g/gal X 0.0943 gal/mile).

(r) Assuming the same particulate emission rate per gallon of fuel burned as other leaded gasoline (non-catalyst) autos and trucks (4.37 g/gal); see note (o), above. The weighted average fuel per mileage for gasoline (non-catalyst) heavy trucks is 0.1754 gal/mile; see Table A.6. This gives 0.77 g/mile (4.37 g/gal X 0.1754 gal/mile). Tests done by Dietzman, as reported in Lang et al. (1982), give a range of 0.58-0.89 g/mile. U.S. Environmental Protection Agency (1982, Table 3.1.4-13) gives a value of 0.91 g/mile.

(s) Pierson and Brachaczek (1983, Table 2) give 865 ± 161 mg/km (or 1.39 ± 0.26 g/mile). U.S. Environmental Protection Agency (1982, Table 3.1.5-1) gives 1.3 g/mile; and Baines, Somers, and Harvey (1979) report a Los Angeles diesel usage emission factor of 0.83 g/km (or 1.34 g/mile).

(t) U.S. Environmental Protection Agency (1982, pp. 3.1.7-1 and 3.1.7-2) report that 38% of the motorcycles in use have two-stroke engines emitting 0.33 g/mile and 62% have four-stroke engines which emit 0.046 g/mile. The weighted average is 0.15 g/mile.

(u) Total particulate emissions from LPG use for carburetion is 1.6 kg/day from the California Air Resources Board 1982 inventory of area source emissions (Ranzieri 1983). This source is very small and is hereafter neglected.

(v) Watson (1979, p. 100).

(w) The fine particle emission factor from leaded fuel auto fleet was assembled as follows: average lead content in 1982 was 0.82 g/gal (Shelton 1982-1983; 1/4 winter 1981-1982, 1/2 summer 1982, 1/4 winter 1982-1983). At 13.7 miles/gal (see Table A.5), lead consumption is 0.06 g/mile. From Huntzicker, Friedlander, and Davidson (1975), 70.5% of lead consumed in gasoline in Los Angeles is emitted as aerosol and 19% of aerosol lead emitted is in sizes less than 1 μm, giving 8.0 mg/mile fine aerosol lead or 13.5 mg/mile fine lead salts as $2PbBrCl \cdot NH_4Cl$. The emissions rate of particulate carbon for pre-catalyst autos burning leaded gasoline at low altitude is 89.0 mg/mile, from Gorse (1984). (Inference from Pierson and Brachaczek [1983, Table 2], gives 94.6 mg/mile, consistent with the emission rate from Gorse [1984].) Aerosol carbon is assumed to be concentrated in the fine particle fraction of the auto exhaust. Fine elemental carbon emissions are estimated to be 19.0 mg/mile by applying an elemental/total carbon factor of 21.3%, which is an average of results from four researchers: Johnson et al. (1981) (8%), Muhlbaier and Williams (1982) (26.5%), Gorse (1984) (<37%--known to be overestimated by as much as a factor of 2), and Watson (1979) (13.8%). Organic carbon remaining is (89.0 mg/mile - 19.0 mg/mile) = 70.0 mg/mile which becomes about 84.0 mg/mile as organic material. Total auto fine particle emissions become 116.5 mg/mile (13.5 mg/mile lead salts, 19.0 mg/mile elemental carbon, 84.0 mg/mile organic material). This fine aerosol is about 36.4% of the total aerosol emission factor (i.e., 0.1165/0.32 = 0.364). The fraction of the fine aerosol which is carbon is therefore 76.4% (i.e., 89.0/116.5).

(x) Taback et al. (1979, table p. A-5).

(y) Assumed size distribution similar to catalyst autos (unleaded gasoline); see note (v).

(z) Other non-catalyst (leaded gasoline) vehicles assumed to have the same size distribution and chemical composition as leaded auto exhaust; see note (w).

(aa) Assumed size distribution similar to diesel autos; see note (x).

(bb) Heywood, Fay, and Linden (1971).

(cc) Assumed similar to leaded auto exhaust; see note (w).

(dd) Assumed similar to industrial boilers burning residual oil (Taback et al. 1979, table p. A-3).

(ee) Assumed size distribution similar to heavy-duty diesel highway vehicles; see notes (aa) and (x).

(ff) Muhlbaier and Williams (1982) report that catalyst equipped cars at low elevation emit aerosol with the following properties: total mass 14 mg/mile, organic carbon 3.0 mg/mile, elemental carbon 2.5 mg/mile.

(gg) Average of nine source tests performed on light-duty diesels by Japar et al. (1984, Table I) (FTP runs only; carbon determination by thermal-optical method of Johnson et al. [1981], with pyrolysis correction). The value of 83.7% carbon is in excellent agreement with the results of Pierson and Brachaczek (1983) for the 1977 Tuscarora Tunnel experiment which yielded 83.8% carbon for heavy-duty diesel trucks. The organic/elemental carbon ratio (23.4/76.6) is also in good agreement with both Pierson and Brachaczek (1983) (29./71.) and Johnson et al. (1981) (27./73.).

(hh) Assumed chemical composition similar to catalyst autos (unleaded gasoline); see note (ff).

(ii) Assumed chemical composition similar to diesel autos; see note (gg).

(jj) Jet aircraft emissions measured in this manner are all "soot" (Heywood, Fay, and Linden 1971); assume chemical composition looks like diesel soot (Flagan 1980).

(kk) Johnson et al. (1981).

Table A.2

Emissions Estimates for Stationary Combustion Sources in 50X50-mile grid

	Estimated 1982 Fuel Use (10^9 Btu/day)	Total Particulate Emissions Factor (kg/10^9 Btu)	Total Particulate Emissions (kg/day)	Mass Fraction < 2.1 μm	Fine Total Particulate (kg/day)	%Total Carbon in < 2.1 μm Fraction	Fine Total Carbon (kg/day)	Partition of Carbon: Volatile Carbon % OC	Partition of Carbon: Non-volatile Carbon % EC	Fine Organic Carbon (kg/day)	Fine Elemental Carbon (kg/day)
	(a)										
STATIONARY SOURCES											
Fuel Combustion											
Electric Utilities											
Natural Gas (boilers)	572.3	1.08(b)	618.1	92% (s)	568.6	7% (dd)	39.8	100%	small(rr)	39.8	0
Natural Gas (turbines)	38.3	5.99(c)	229.4	92% (s)	211.1	7% (dd)	14.8	100%	small(rr)	14.8	0
Residual Oil	112.1	9.09(d)	1019.0	95% (t)	968.0	20% (ee)	193.6	80%	20%(ss)	154.9	38.7
Distillate Oil (turbines)	0.40	16.35(e)	6.5	96.4% (u)	6.3	15% (ff)	0.9	42%	58%(tt)	0.4	0.5
Digester Gas	0.57	1.08(f)	0.6	92% (s)	0.6	7% (dd)	0.04	100%	small(rr)	0.04	0
Refinery Fuel											
Natural Gas	99.0	9.07(g)	897.9	92% (v)	826.1	7% (gg)	57.8	100%	small(uu)	57.8	0
Refinery Gas	333.6	9.07(g)	3025.8	92% (s)	2783.7	7% (hh)	194.9	100%	small(rr)	194.9	0
Residual Oil	5.25	21.64(h)	113.6	72% (w)	81.8	11.3%(ii)	9.2	80%	20%(ss)	7.4	1.8
Non-refinery Industrial/Low Priority Commercial Fuel											
Natural Gas	307.2	7.56(i)	2322.4	92% (s)	2136.6	7% (hh)	149.6	100%	small(rr)	149.6	0
LPG	4.10	7.56(i)	31.0	92% (s)	28.5	7% (hh)	2.0	100%	small(rr)	2.0	0
Residual Oil	7.27	21.64(h)	157.3	72% (x)	113.3	11.3%(ii)	12.8	80%	20%(ss)	10.2	2.6
Distillate Oil	26.5	23.55(j)	624.1	96.4% (y)	601.6	15% (kk)	90.2	42%	58%(tt)	37.9	52.3
Digester Gas (IC engines)	5.70	20.41(k)	116.3	99% (z)	115.2	21% (ll)	24.2	77%	23%(ll)	18.6	5.6
Coke Oven Gas	0	7.56(l)	0	92% (s)	-	7% (hh)	-	100%	small(rr)	-	-
Gasoline (IC engines)	4.54(m)	23.49(m)	106.6(m)	99% (aa)	105.5	20% (mm)	21.1	90%	10%(mm)	19.0	2.1
Distillate Oil (IC engines)	5.43(n)	109.81(n)	596.0(n)	93% (bb)	554.3	4% (nn)	22.2	small	100%(vv)	0	22.2
Residential/High Priority Commercial Fuel											
Natural Gas	721.6	8.06(o)	5816.1	92% (s)	5350.8	12% (oo)	642.1	67%	33%(ww)	430.2	211.9
LPG	13.0	8.06(p)	104.8	92% (s)	96.4	12% (pp)	11.6	67%	33%(ww)	7.8	3.8
Residual Oil	23.4	21.64(q)	506.4	72% (w)	364.6	11.3%(ii)	41.2	80%	20%(ss)	33.0	8.2
Distillate Oil	17.1	21.64(q)	370.0	96.4% (u)	356.7	15% (ff)	53.5	42%	58%(tt)	22.5	31.0
Coal	0.43	378.0 (r)	162.5	62% (oo)	100.8	96% (qq)	96.7	78%	22%(xx)	75.5	21.3
TOTAL FUEL COMBUSTION							1678.2			1276.3	402.0

Notes for Table A.2

(a) See Appendix B, except for stationary gasoline and distillate internal combustion engines; see notes (m) and (n).

(b) Danielson and Graves (1976, p. 77); 0.015 lb/equivalent bbl (1.08 kg/10^9 Btu) from Los Angeles tests.

(c) U.S. Environmental Protection Agency (1982, Table 3.3.1-2) gives 14 lb/10^6 ft^3 or 5.99 kg/10^9 Btu.

(d) Taback et al. (1979, pp. 2-9); 3 lb/1000 gal (9.09 kg/10^9 Btu) used for 0.25% sulfur oil.

(e) U.S. Environmental Protection Agency (1982, Table 3.3.1-2) gives 5 lb/10^3 gal or 16.35 kg/10^9 Btu.

(f) Electric utility boiler natural gas combustion emission factor used; see note (b).

(g) Danielson and Graves (1976, p. 77); 0.126 lb/equivalent bbl (9.07 kg/10^9 Btu).

(h) Danielson and Graves (1976, p. 77); 0.30 lb/equivalent bbl (21.64 kg/10^9 Btu) for combustion of industrial residual fuel oil.

(i) Danielson and Graves (1976, p. 77); 0.105 lb/equivalent bbl (7.56 kg/10^9 Btu). LPG combustion is assumed to emit at the same rate as industrial natural gas combustion on an equivalent heat input basis. This is the same assumption as made by the U.S. Environmental Protection Agency (1982, Table 1.5-1) except that the natural gas emission factor of Danielson and Graves (n.d.) is lower.

(j) Taback et al. (1979, Table 2-1), KVB data, 7.2 lb/10^3 gal (23.55 kg/10^9 Btu).

(k) Average of two tests by Taback et al. (1979, p. 4-100) performed on digester gas-fired IC engine; 0.045 lb/10^6 Btu (20.41 kg/10^9 Btu).

(l) Assumed similar to industrial natural gas combustion on an equivalent heat input basis.

(m) Fuel use is derived from total particulate emissions (106.6 kg/day) which is from the Air Resources Board of California inventory of industrial point and area source emissions (Ranzieri 1983). U.S. Environmental Protection Agency (1982, Table 3.3.3-1) gives 6.47 lb/10^3 gal or 23.49 kg/10^9 Btu.

(n) Fuel use is derived from total particulate emissions (596.0 kg/day) which is from the Air Resources Board of California inventory of industrial point and area source emissions (Ranzieri 1983). U.S. Environmental Protection Agency (1982, Table 3.3.3-1) gives 33.5 $lb/10^3$ gal or 109.81 $kg/10^9$ Btu.

(o) Danielson and Graves (1976, p. 77); 0.112 lb/equivalent bbl (8.06 $kg/10^9$ Btu).

(p) Assumed same as residential natural gas on an equivalent heat input basis. This is the same assumption as made by the U.S. Environmental Protection Agency (1982, Table 1.5-1) except that the natural gas emission factor of Danielson and Graves (n.d.) is lower.

(q) Assumed same as industrial boiler burning residual fuel oil; see note (h).

(r) U.S. Environmental Protection Agency (1982, Table 1.1-2), assuming hand-fired stove use, 20 lb/ton coal (378.0 $kg/10^9$ Btu).

(s) Assumed similar to size distribution from large refinery heaters burning natural gas; see note (v).

(t) Taback et al. (1979, table p. A-8).

(u) Assumed similar to size distribution from industrial boiler burning distillate oil; see note (y).

(v) Taback et al. (1979, table p. A-29).

(w) Assumed similar to size distribution from industrial boiler burning residual fuel oil; see note (x).

(x) Taback et al. (1979, table p. A-3).

(y) Taback et al. (1979, table p. A-4).

(z) Taback et al. (1979, table p. 4-99).

(aa) Taback et al. (1979, table p. A-6).

(bb) Taback et al. (1979, table p. A-5).

(cc) Assumed similar to fireplace wood combustion profile from Watson (1979). Possibly a poor assumption, but data on fireplace coal combustion are lacking.

(dd) Assumed based on refinery heater test by Taback et al. (1979); see note (gg). Electric utility source test by Manfredi and Mansour (1975) showed that particulate matter emitted from LADWP Scattergood Unit 3 when burning natural gas consisted mostly of Fe, Na, Si, and Ca compounds. Mansour (n.d.) confirms that power plant samples when burning gas during that test were not dark in color.

(ee) Taback et al. (1979, table p. A-8).

(ff) Assumed similar to industrial boiler burning distillate oil; see note (kk).

(gg) Taback et al. (1979, table p. A-29).

(hh) Assumed similar to refinery heaters burning natural gas; see note (gg).

(ii) Assumed similar to industrial boiler burning residual fuel oil; see note (jj).

(jj) Taback et al. (1979, table p. A-3).

(kk) Taback et al. (1979, table p. A-4).

(ll) Taback et al. (1979, table 4-36, p. 4-101); average of impinger catches.

(mm) Taback et al. (1979, table p. A-6).

(nn) Taback et al. (1979, table p. A-5).

(oo) Muhlbaier and Williams (1982) report that 12% of aerosol mass is carbon from ten samples taken downstream of a small furnace. Note that the overall emission factor for carbonaceous aerosol from domestic natural gas combustion becomes (8.06 kg/10^9 Btu X 0.12) = 0.97 kg C/10^9 Btu = 0.97 μg C/Btu. Source tests by Hansen, Benner, and Novakov (1978) show that domestic natural gas combustion sources emit carbon at a rate of between 0.2 to 2.5 μg C/Btu, in good agreement with the emission rate used in this study.

(pp) Assumed similar to residential natural gas combustion; see note (oo).

(qq) No data are available on carbon mass as a fraction of fine particle mass emissions from coal combustion in fireplaces; therefore, an extreme upper limit has been used.

(rr) Assumed similar to large refinery heaters burning natural gas; see note (uu).

(ss) Johnson et al. (1981) for residual fuel oil combustion with pyrolysis correction.

(tt) Johnson et al. (1981) for distillate fuel oil combustion with pyrolysis correction.

(uu) Taback et al. (1979, table p. A-29). All carbon collected during source test was volatile.

(vv) Taback et al. (1979, table p. A-5). Volatile carbon collected during source test was less than 0.1% of total carbon.

(ww) Muhlbaier and Williams (1982) report that two-thirds of the carbon found on ten samples taken downstream of a small furnace was present as organics.

(xx) Chemical composition of carbon present is based on volatile organic to non-volatile carbon ratio for fine particles from fireplace combustion of wood given by Watson (1979). Assumptions made for this source class are poor, but the source class is very small.

Table A.3

Emissions Estimates for Industrial Processes in 50X50-mile grid

	Total Particulate Emissions (kg/day)	Mass Fraction < 2.1 µm	Fine Suspended Particulate < 2.1 µm (kg/day)	% Total Carbon in < 2.1 µm Fraction	Fine Total Carbon (kg/day)	Partition of Carbon: Volatile Carbon % OC	Partition of Carbon: Non-volatile Carbon % EC	Fine Organic Carbon (kg/day)	Fine Elemental Carbon (kg/day)
	(a)								
STATIONARY SOURCES									
Industrial Process Point Sources									
Petroleum Industry									
Refining (FCCU)	1591.2	54% (b)	859.2	3.8%(b)	32.7	75%	25% (b)	24.5	8.2
Other	335.2	100% (c)	335.2	≤83% (q)	278.2	100%	0% (q)	278.2	0
Organic Solvent Use									
Surface Coating	2847.2	91.5%(d)	2605.2	55% (d)	1432.9	100%	0% (d)	1432.9	0
Printing	25.6	91.5%(d)	23.4	55% (d)	12.9	100%	0% (d)	12.9	0
Degreasing	6.2	100% (c)	6.2	≤83% (q)	5.1	100%	0% (q)	5.1	0
Other	128.0	100% (c)	128.0	≤83% (q)	106.2	100%	0% (q)	106.2	0
Chemical									
Organic	2360.6	94.5%(e)	2230.8	33% (e)	736.2	94%	6% (e)	692.0	44.2
Inorganic	151.2	94.5%(f)	142.9	0%	0	-	-	-	-
Metallurgical									
Primary	392.8	98.2%(g)	385.7	59.2%(g)	228.4	100%	0% (g)	228.4	0
Secondary	1449.8	88.5%(h)	1283.1	13% (h)	166.8	100%	0% (h)	166.8	0
Fabrication	547.1	77% (i)	421.3	0% (i)	0	-	-	-	-
Mineral	3772.6	55.1%(j)	2078.7	10.2%(j)	212.0	74.4%	25.6%(j)	157.7	54.3
Waste Burning	264.9	84.5%(k)	223.8	30% (k)	67.2	30%	70% (k)	20.1	47.0
Wood Processing	370.8	56% (l)	207.6	41.2%(l)	85.6	87%	13% (l)	74.4	11.1
Food and Agriculture	1653.7	1% (m)	16.5	30% (m)	5.0	100%	0% (m)	5.0	0
Asphalt Roofing	377.1	93% (n)	350.7	24% (n)	84.2	96%	4% (n)	80.8	3.4
Textile	218.6	1% (o)	2.2	≤83% (q)	1.8	100%	0% (q)	1.8	0
Rubber and Plastics	43.0	100% (c)	43.0	≤83% (q)	35.7	100%	0% (q)	35.7	0
Coke Calciner	266.4	100% (c)	266.4	89.8%(r)	239.2	0%	100% (r)	0	239.2
Miscellaneous Industrial	1865.3	69.5%(p)	1296.4	32.7%(p)	423.9	92.8%	7.2%(p)	393.4	30.5
TOTAL PROCESS POINT SOURCES					4154.0			3715.9	437.9

Notes for Table A.3

(a) Total particulate emissions data are from the Air Resources Board of California inventory of industrial point and area source emissions (Ranzieri 1983).

(b) Based on FCC unit CO boiler profile from Taback et al. (1979, table p. A-30).

(c) Assumed to be all fine, < 2.1 µm.

(d) Based on paint spray booth profile (oil-based paint) from Taback et al. (1979, table p. A-24).

(e) Based on urea manufacturing profile as a typical organic chemical product; Taback et al. (1979, table p. A-26).

(f) Assumed similar to size distribution for organic chemical manufacturing; see note (e).

(g) The total particulate matter from primary metallurgical production is from many sources. Size distribution and chemical profile data are available from Taback et al. (1979, tables pp. A-14, A-15, and A-33) for steel sinter operations, open hearth furnace, and basic oxygen furnace. Additionally, coke oven volatiles are assumed to be < 2.1 µm organics. These four sources account for 43% of the total particulate emissions from primary metals production. Data used in this table represent a composite of these four profiles, in proportion to the contribution of each source to the total particulate emissions in the SCAB (32.0% sinter plant profile, 3.6% open hearth furnace profile, 12.8% basic oxygen furnace profile, and 51.6% coke oven volatiles).

(h) Based on aluminum foundry profile from Taback et al. (1979, table p. A-13).

(i) Based on steel abrasive blasting profile from Taback et al. (1979, table p. A-12). Total carbon collected during source test was reported to be less than 0.1% of fine particulate matter.

(j) Profiles are available from Taback et al. (1979) for eight processes which account for 30.5% of the total particulate emissions from mineral processes; calcination of gypsum (p. A-16), brick grinding and screening (p. A-17), cement production (p. A-18), glass melting furnace (p. A-19), rock crushers (p. A-35), rock screening (p. A-36), asphaltic concrete batch plant (p. A-22), and fiberglass forming line (p. A-20). Data used in this table represent a composite of these eight profiles, in proportion to the contribution of each source to the total particulate emissions in the SCAB (2.7% gypsum, 18.3% brick grinding, 36.8% cement, 17.5% glass, 7.9% rock crushers, 0.4% rock screening, 10.6% asphalt batch plant, and 5.8% fiberglass).

(k) Based on wood waste boiler profile from Taback et al. (1979, table p. A-7). These emissions are probably from special purpose permitted incinerators for which local source test data on chemical composition are lacking.

(l) Based on an average of wood resawing and wood sanding operations from Taback et al. (1979, tables pp. A-26 and A-28).

(m) Based on feed and grain operations profile from Taback et al. (1979, table p. A-31). Source category actually includes emissions from wool and cotton fabrications, meat packing, rendering, cooking, etc. All carbon present is assumed to be organic carbon.

(n) Taback et al. (1979, table p. A-21).

(o) Size distribution data are not available for particulate emissions from fabric production. It is assumed that almost all particles emitted are larger than 2.1 μm.

(p) No data; value assumed to be the average of all other industrial process point sources listed above (in the SCAB; see Appendix C, Table C.3).

(q) Assumed to be a typical organic liquid: organic mass $\simeq$ 1.2 times carbon present (Wolff et al. 1982, Countess et al. 1980, Groblicki 1981).

(r) Petroleum coke is 89.2% carbon and 10.4% volatile material, based on proprietary information from a Long Beach area coke supplier. Similar results may be found in Kerr McGee Corporation (1982). The volatile (organic material) is removed during the calcining process, leaving the remaining 89.6% of the mass to be emitted to the atmosphere as fine particulate matter. The 10.4% of petroleum coke, which is organic material, becomes about 8.7% as carbon; therefore, the elemental carbon fraction of the coke is 89.2 - 8.7 = 80.5%. The carbon fraction of the emissions is then 80.5/89.6 = 89.8% (all elemental carbon).

Table A.4

Emissions Estimates for Fugitive Sources
in 50X50-mile grid

	Total Particulate Emissions (kg/day)	Mass Fraction < 2.1 µm	Fine Total Particulate (kg/day)	% Total Carbon in < 2.1 µm Fraction	Fine Total Carbon (kg/day)	Partition of Carbon: Volatile Carbon % OC	Partition of Carbon: Non-volatile Carbon % EC	Fine Organic Carbon (kg/day)	Fine Elemental Carbon (kg/day)
FUGITIVE SOURCES									
Road and Building Construction	66906.2(a)	32% (g)	21410.0	0% (g)	0	-	-	-	-
Agricultural Tilling	2727.7(a)	30.5%(h)	831.9	0% (h)	0	-	-	-	-
Livestock Feedlots	1886.1(a)	54% (i)	1018.5	2% (i)	20.4	100%	0% (i)	20.4	0
Unpaved Road Dust	4039.6(a)	24% (j)	969.5	0% (j)	0	-	-	-	-
Paved Road Dust	129705.0(a)	27% (k)	35020.4	15.1% (v)	5288.1	96.7%	3.3% (v)	5113.6	174.5
Tire Attrition	4604.1(b)	25% (l)	1151.0	87% (w)	1001.4	67%	33% (w)	670.9	330.5
Brake Lining Attrition	6445.7(c)	100% (m)	6445.7	28% (x)	1804.8	82%	18% (x)	1479.9	324.9
Forest Fires (seasonal)	1722.2(a)	86% (n)	1481.1	63% (y)	933.1	94%	6% (y)	877.1	56.0
Structural Fires	357.5(a)	86.5%(o)	309.2	30% (o)	92.8	68%	32% (cc)	63.1	29.7
Fireplaces	6556.1(d)	42% (p)	2753.6	(z)	1612.6	(z)	(z)	1269.6	343.0
Cigarettes	1669.0(e)	100% (q)	1669.0	82.5% (q)	1376.9	97%	3% (q)	1335.6	41.3
Charcoal Broilers	5414.4(r)	100% (r)	5414.4	82.3% (r)	4456.1	98.5%	1.5% (r)	4389.2	66.8
Agricultural Burning	5.8(a)	94% (s)	5.5	52% (aa)	2.8	91%	9% (aa)	2.6	0.3
Sea Salt	30131.3(f)	8% (t)	2410.5	0% (bb)	0	-	-	-	-
Roofing Tar Pots	921.9(a)	100% (u)	921.9	81.7% (u)	753.2	99.9%	0.1% (u)	752.4	0.8
TOTAL FUGITIVE SOURCES					17342.2			15974.4	1367.8

Notes for Table A.4

(a) Total particulate emissions data are from the Air Resources Board of California spatially resolved inventory of point and area source emissions (Ranzieri 1983).

(b) See Table A.7.

(c) See Table A.8.

(d) See Table A.9.

(e) Taback et al. (1979, pp. 2-70, 2-71), estimate that each year an average of 0.1538 lb of particulate matter is emitted per person from cigarette smoke. There are 8,734,856 people in the 50X50-mile grid (see Appendix B, Table B.1) yielding 1.34×10^6 lb/yr or 1669.0 kg/day.

(f) Taback et al. (1979, pp. 2-85 to 2-92), estimate 20,000 tons/year of sea salt emissions (particles < 10 µm). The size distribution data indicate that 76% of particles are < 10 µm, yielding 26,316 tons/year or 65,406.9 kg/day of total particulate emissions in the SCAB. It is assumed that 46.1% of the SCAB emissions are in the 50X50-mile grid (shipping lane distance fraction from bunker fuel emissions calculation; see note [d], Table A.1) giving 30,131.3 kg/day in the grid. This estimate is not very precise, but the source class contributes no particulate carbon; see note (cc).

(g) Taback et al. (1979, table p. A-46).

(h) Taback et al. (1979, table p. A-50).

(i) Taback et al. (1979, table p. A-44); assumed to be organic carbon.

(j) Taback et al. (1979, table p. A-45).

(k) Taback et al. (1979, figure p. 2-58).

(l) Average of data from Pierson and Brachaczek (1974, pp. 1295 and 1296).

(m) Assumed to be all fine, < 2.1 µm.

(n) Taback et al. (1979, table p. A-48).

(o) Taback et al. (1979, table p. A-37).

(p) Taback et al. (1979, table p. A-39).

(q) Taback et al. (1979, table p. A-41), give 100% in the fine fraction. Source tests on cigarettes (Gray, Cass, and Turpin 1985) yield 82.5% total carbon, and 97% of the carbon was found to be organic. Taback et al. (1979, table p. A-41) found similar results for the total carbon in the fine fraction (85%).

(r) The Air Resources Board of California uses an estimate of 3000 lb/year for the total particulate emissions rate from a typical charcoal broiler facility to compute annual emissions for this source class (Grisinger 1982). This value is checked against the results of a study by Bornstein (1978) which indicates an emission rate of 1360 kg (or 2998 lb) per facility per year (all in particle sizes less than 2.1 μm). Since these results are in agreement, the total particulate emissions inventory from the ARB is used. Source tests on charcoal broilers indicate that all material emitted is in the fine fraction. Of the 82.3% found to be carbon, 98.5% was organics (Gray, Cass, and Turpin 1985).

(s) Taback et al. (1979, table p. A-47).

(t) Taback et al. (1979, figure p. 2-92).

(u) Source tests on roofing tar pots indicate that all material emitted is in the fine fraction. Of the 81.7% found to be carbon, 99.9% was organics (Gray, Cass, and Turpin 1985).

(v) Source tests of paved road dust give 15.1% total carbon, and 96.7% of the carbon was found to be organics (Gray, Cass, and Turpin 1985). The carbon content of roadside soil was found to be 7.3% by Pierson and Brachaczek (1983, table p. 18); and fine particle analysis on street dust by Watson (1979, table p. 94), gives 92% organics.

(w) 87% carbon computed from formula for oil extended synthetic tire rubber given by Morton (1973); 29% of tire tread batch is ISAF carbon black. Carbon present is thus found as about 67% organics, 33% elemental carbon.

(x) Based on automobile brake lining chemical composition given by Lynch (1968), plus the assumption that resins and polymers are 83% carbon by weight, and assuming that carbon present is emitted as aerosol without combustion or pyrolysis.

(y) Based on slash burning fine particulate matter analysis from Watson (1979, table p. 107).

(z) See Table A.9.

(aa) Based on simulated field burning fine particulate matter analysis from Watson (1979, table p. 109).

(bb) Taback et al. (1979, table p. A-42).

(cc) Based on carbon emission rates from soft wood from Muhlbaier and Williams (1982, Table 2, p. 190).

Table A.5

Fuel Economy Calculation for 1982 Automobile Fleet

Age (years)	Model Year	% Vehicles in Use	% Diesels per Year	(α) % Gasoline Vehicles in Use	(β) %Diesel Vehicles in Use	(γ) Annual Avg. Mileage	(α)(γ)	(β)(γ)	(α)(γ)/sum Fraction VMT Gasoline	(β)(γ)/sum Fraction VMT Diesel	Fuel Economy Gasoline (mpg)	Inverse Fuel Economy Gasoline (gal/mi)	Weighted Avg. Inverse Fuel Econ Gasoline (gal/mi)	Fuel Economy Diesel (mpg)	Inverse Fuel Economy Diesel (gal/mi)	
		(a)	(b)			(c)					(d)			(e)		
1	1982	7.77	4.6	7.41	0.36	15900	1178.60	56.83	0.111	0.0054	26.2	0.038		27.0	0.0370	
2	1981	7.77	5.9	7.31	0.46	15000	1096.74	68.76	0.104	0.0065	25.1	0.040		25.9	0.0386	
3	1980	8.76	4.6	8.36	0.40	14000	1169.99	56.41	0.111	0.0053	23.5	0.043		24.2	0.0413	
4	1979	9.20	2.2	9.00	0.20	13100	1178.69	26.51	0.111	0.0025	20.3	0.049	0.0474 (21.10 mpg)	20.9	0.0478	
5	1978	8.50	0.4	8.47	0.03	12200	1032.85	4.15	0.098	0.0004	19.9	0.050		20.5	0.0488	0.0405 (24.69 mpg)
6	1977	6.73	0.1	6.72	0.01	11300	759.73	0.76	0.072	0.00007	18.3	0.055		18.9	0.0529	
7	1976	5.51	0.1	5.50	0.01	10300	566.96	0.57	0.054	0.00005	17.5	0.057		18.0	0.0556	
8	1975	5.37	0.1	5.36	0.01	9400	504.28	0.50	0.048	0.00005	15.8	0.063		16.3	0.0613	
9	1974	6.45	0.1	6.44	0.01	8500	547.70	0.55	0.052	0.00005	14.2	0.070		14.6	0.0685	
10	1973	5.78	-	5.78	-	7600	439.28	-	0.042		13.6	0.074				
11	1972	4.90	-	4.90	-	6700	328.30	-	0.031		13.6	0.074	0.0733 (13.65 mpg)			
12	1971	3.88	-	3.88	-	6700	259.96	-	0.025		13.6	0.074				
≥13	1970(-)	19.38	-	19.38	-	6700	1298.46	-	0.123		13.6	0.074				
				sum = (α)(γ) + (β)(γ)			= 10576.58		average annual mileage/vehicle							

	Fraction VMT	Weighted Average (gal/mi)	Weighted Average Mi/Gal (mpg)
Light-duty gasoline catalyst (unleaded)	0.7080	0.0474	21.66
Light-duty gasoline non-catalyst (leaded)	0.2717	0.0733	13.71
Light-duty diesel automobiles	0.0203	0.0405	24.93

Notes for Table A.5

(a) Percent distribution of fee-paid registrations by age of vehicle, 1982, from California Department of Finance (1982, Table J-5).

(b) Values for 1980 and previous years are from Diesel Impacts Study Committee (1982, pp. 1 and 90). Values for 1981 and 1982 are from Automotive News, as cited by Holman and Lauderdale (1983, p. 7).

(c) U.S. Environmental Protection Agency (1982, Table 3.1.2-5).

(d) Motor Vehicle Manufacturers' Association (1983, p. 74).

(e) Fuel economy for 1982 diesel automobiles is 27.0 mpg from Cadle (1983). It is assumed that the fuel economy improvements for newer diesel automobiles are proportional to that observed for newer gasoline automobiles.

Table A.6

Vehicle Miles Travelled and Fuel Usage for Each Vehicle Type in 1982

Vehicle Class	Vehicle Type	Fraction of Daily VMT Within Class	Class Fraction	Fraction of Daily Total VMT	Weighted Avg. (gal/mi)	50X50-mile grid: Thous. VMT/day	50X50-mile grid: Fuel Use (10^9 Btu/day)	4-County SCAB: Thous. VMT/day	4-County SCAB: Fuel Use (10^9 Btu/day)
			(b)				(i)		(i)
Autos			0.7754						
	Catalyst	0.7080 (a)		0.5490	0.0474 (c)	86996	515.2	101641	601.9
	Non-catalyst	0.2717		0.2107	0.0733 (c)	33385	305.6	39005	357.1
	Diesel	0.0203		0.0157	0.0405 (c)	2494	14.0	2914	16.3
Light Trucks			0.1059						
	Catalyst	0.7080 (a)		0.0750	0.0647 (d)	11882	96.0	13882	112.2
	Non-catalyst	0.2717		0.0288	0.1000 (e)	4560	57.0	5328	66.6
	Diesel	0.0203		0.0021	0.0553 (d)	341	2.6	398	3.0
Medium Trucks			0.0530						
	Catalyst	0.5951 (b)		0.0315	0.0943 (f)	4994	58.9	5835	68.8
	Non-catalyst	0.4049		0.0214	0.0943 (f)	3398	40.1	3970	46.8
	Diesel	—		—	—	—	—	—	—
Heavy Trucks									
	Gas (Leaded)		0.0193	0.0193	0.1754 (f)	3050	66.9	3564	78.1
	Diesel		0.0370	0.0370	0.1818 (f)	5857	147.4	6843	172.2
Motorcycles									
	Gas (Leaded)		0.0095	0.0095	0.0200 (g)	1503	3.8	1756	4.4
ALL CLASSES TOTAL						158460 (h)	1307.5	185136 (j)	1527.4
	Catalyst Total			0.6555		103872	670.1	121358	782.9
	Non-catalyst Total			0.2897		45896	473.4	53623	553.0
	Diesel Total			0.0548		8692	164.0	10155	191.5

Notes for Table A.6

(a) See Table A.5.

(b) Air Resources Board of California (1983) data from EMFAC 1982 vehicle emissions model for the South Coast Air Basin.

(c) Light duty fuel economy calculation; see Table A.5.

(d) Assuming improvement in newer light truck fuel economy proportional to that observed for newer automobiles.

(e) U.S. Environmental Protection Agency (1982, Table 3.1.4-7).

(f) Medium and heavy-duty truck fuel economy from EPA test data as reported by the Air Resources Board of California (1980, Table II-10).

(g) Motorcycle fuel economy from Motor Vehicles Facts and Figures '76 as reported by Air Resources Board of California (1980, Table II-10).

(h) Freeway traffic data from Caltrans (California Department of Transportation 1983) give 67,661.6 thousand vehicle miles travelled per day on the 50X50-mile grid. This is added to the surface traffic total of 90,800.0 thousand vehicle miles per day from Cass, Hahn, and Noll (1982) (updated to 1982) to give 158,461.6 thousand vehicle miles travelled per day in 1982.

(i) The heating value of gasoline is 5248×10^3 Btu/bbl (or 124,952 Btu/gal). The heating value of diesel is 5812×10^3 Btu/bbl (or 138,381 Btu/gal) from Cass (1977, p. 598).

(j) Total vehicle miles travelled by all vehicles in the South Coast Air Basin (four counties) is 185,136 thousand VMT/day from Air Resources Board of California (1983) EMFAC.

Table A.7

Tire Attrition 1982

	1976 Estimated Annual Mileage/ Vehicle	No. of Tires	Vehicles SCAB	1976 SCAB 10^6 Tire Miles/ Year	10^6 Counted Vehicles Miles/Yr.	Weighted Avg. No. Tires/ Counted Vehicle	50X50-mile grid: 1982 VMT (Thous. VMT/day)	50X50-mile grid: Tire Attrition (kg/day)	SCAB: 1982 VMT (Thous. VMT/day)	SCAB: Tire Attrition (kg/day)
	(a)	(a)	(a)	(b)	(c)			(d)		(d)
Counted Vehicles										
Light Duty Vehicles										
Autos	9634	4	4641484	178864	44716					
Comm'l 2-axle <5000# curb wt	9634	4	750176	28909	7227					
TOTAL				207773	51943	4.000	141161	3557.3	164924	4156.1
Medium Duty Vehicles										
Comm'l 2-axle 5000-10,000# curb wt	8822	4	79683	2812	703					
Comm'l 3-axle 5000-10,000# curb wt	49125	10	413	203	20					
TOTAL				3015	723	4.168	8392	220.4	9805	257.5
Heavy Duty Vehicles										
Comm'l 2-axle >10,000# curb wt	8822	6	20883	1105	184					
Comm'l 3-axle >10,000# curb wt	49125	10	22475	11041	1104					
Comm'l 4-axle >10,000# curb wt	8822	14	313	39	3					
TOTAL				12185	1291	9.438	8907	529.6	10407	618.8
COUNTED VEHICLE TOTAL					53957		158460 (e)	4307.3	185136 (e)	5032.4
Trailers										
1-axle <5000# curb wt	3854	2	161367	1244						
2-axle <5000# curb wt	3854	4	30096	464						
3-axle <5000# curb wt	3854	6	610	14						
1-axle 5000-10,000# curb wt	3528	2	24303	17						
2-axle 5000-10,000# curb wt	44213	8	23372	8267						
3-axle 5000-10,000# curb wt	44213	6	257	68						
4-axle 5000-10,000# curb wt	3528	8	29	1						
1-axle >10,000# curb wt	7940	4	1484	47						
2-axle >10,000# curb wt	44213	8	16253	5749						
3-axle >10,000# curb wt	7940	12	156	15						
4-axle >10,000# curb wt	7940	16	29	4						
TRAILER TOTAL				16044				296.8 (g)	55050 (f)	346.8
ALL VEHICLE TOTAL								4604.1		5379.2

Notes for Table A.7

(a) Data for 1976 from Halberg (1980).

(b) Tire miles are computed by multiplying annual mileage per vehicle, number of tires and vehicles in the South Coast Air Basin (SCAB). This calculation is performed using 1976 data to get the average number of tires per counted vehicle and the relative number of trailer tire miles to counted vehicle tire miles.

(c) One vehicle count is made for each vehicle (not including trailers) in the SCAB by multiplying annual mileage and number of vehicle.

(d) Suspended aerosol emission rate of 0.0063 gm/tire/mile based on average of results by Pierson and Brachaczek (1974, pp. 1295 and 1296).

(e) See Table A.6 for 1982 grid and SCAB total vehicle miles travelled (VMT).

(f) Vehicle tire miles for trailers was scaled by 1.252 to reflect the increase from 1976 AQMD counted VMT to 1982 VMT (i.e., 53,957 $\times 10^6$ VMT/yr or 147,827 $\times 10^3$ VMT/day $\times$ 1.252 = 185,1136 $\times 10^3$ VMT/day, and 16,044 $\times 10^6$ tire miles/yr or 43,956 $\times 10^3$ tire miles/day $\times$ 1.252 = 55,050 $\times 10^3$ tire miles/day). This value represents thousand tire miles per day.

(g) It is assumed that tire miles for trailers in the 50$\times$50-mile grid are of the same proportion to the SCAB as vehicle miles (85.6%); see Table A.6.

Table A.8

Brake Lining Attrition 1982

	1976 Estimated Annual Mileage	Adjusted 1982 Annual Mileage Per Vehicle	Vehicles in SCAB	% VMT Using Front Disc Brakes	Particulate Emission Factors ($lbs/10^6$ VMT) (d): With Disc	Particulate Emission Factors ($lbs/10^6$ VMT) (d): Without Disc	1982 Particulate Emissions SCAB: With Front Disc (kg/day)	1982 Particulate Emissions SCAB: Without Disc (kg/day)	Total (kg/day)
	(a)	(b)	(a)	(c)					
Light Duty Vehicles									
Autos	9634	12065	4641484	80%	14.6 + 43.4	43.4 X 2	3229.1	1208.1	4437.2
Comm'l 2-axle <5000# curb wt	9634	12065	750176	80%	14.6 + 43.4	43.4 X 2	521.9	195.3	717.2
Medium Duty Vehicles									
Comm'l 2-axle 5000-10,000# curb wt	8822	11048	79683			125 X 2			273.5
Comm'l 3-axle 5000-10,000# curb wt	49125	61523	413			125 X 3			11.8
Heavy Duty Vehicles									
Comm'l 2-axle >10,000# curb wt	8822	11048	20883	100%		233 X 2	133.6		133.6
Comm'l 3-axle >10,000# curb wt	49125	61523	22475	100%		83 + 233 X 2	943.4		943.4
Comm'l 4-axle >10,000# curb wt	8822	11048	313	100%		83 + 233 X 3	3.4		3.4
Trailers									
1-axle <5000# curb wt	3854	4827	161367			43.4			42.0
2-axle <5000# curb wt	3854	4827	30096			43.4 X 2			15.7
3-axle <5000# curb wt	3854	4827	610			43.4 X 3			0.5
1-axle 5000-10,000# curb wt	3528	4418	24303			125 X 1			16.7
2-axle 5000-10,000# curb wt	44213	55371	23372			125 X 2			402.1
3-axle 5000-10,000# curb wt	44213	55371	257			125 X 3			6.6
4-axle 5000-10,000# curb wt	3528	4418	29			125 X 4			0.1
1-axle >10,000# curb wt	7940	9944	1484	100%		233 X 1	4.3		4.3
2-axle >10,000# curb wt	44213	55371	16253	100%		233 X 2	521.2		521.2
3-axle >10,000# curb wt	7940	9944	156	100%		233 X 3	1.3		1.3
4-axle >10,000# curb wt	7940	9944	29	100%		233 X 4	0.3		0.3
							SCAB TOTAL		7530.8
							GRID TOTAL (e)		6445.7

Notes for Table A.8

(a) Data for 1976 from Halberg (1980).

(b) 1976 AQMD data multiplied by 1.252 to coincide with 1982 VMT data (not including trailers) in the South Coast Air Basin; see Table A.7, note (f).

(c) Taback et al. (1979, p. 2-88). All past-1970 GM passenger cars equipped with front disc brakes.

(d) Taback et al. (1979, pp. 283-288).

(e) The emissions in the 50X50-mile grid are proportional to the SCAB emissions in the same ratio as vehicle miles travelled; see Table A.6.

Table A.9.1

Fireplace Emissions 1982

	Residences	% Residences Burning Wood	Residences Burning Wood	Avg. Cords/ Residence-Yr. (Wood Burners)	Fraction of Wood Type	Cords/ Residence-Yr. (Wood Burners)	Cords Burned/ Year	kg Mass/ Cord	10^6 kg Wood Burned/ Year	Total Particulate Emission Factor (g/kg wood)	Total Particulate Emissions (kg/day)
	(a)	(b)		(b)	(b)			(c)		(d)	
Los Angeles County	2808130										
Orange County	716791										
TOTAL	3524921	20.3%	715559	0.286							
Softwood					0.664	0.190	135888	1469.7	199.7	6.20	3392.4
Hardwood					0.336	0.096	68762	1796.2	123.5	9.99	3380.5
Total											6772.9
50X50-mile grid (f)	3412124										6556.1
San Bernardino County	299174										
Riverside County	224844										
TOTAL	524018	50.0%	262009	1.083							
Softwood					0.373	0.404	105841	1469.7	155.6	6.20	2642.3
Hardwood					0.627	0.679	177915	1796.2	319.6	9.99	8746.6
Total											11388.9
Total 4-County SCAB	4048939										18161.8

Table A.9.2

Fireplace Emissions 1982

	Total Particulate Emissions (kg/day)	Mass Fraction < 2.1 µm	Fine Total Particulate < 2.1 µm	% Total Carbon in < 2.1 µm Fraction	Total Fine Carbon (kg/day)	Partition of Carbon: Volatile Carbon % OC	Partition of Carbon: Non-volatile Carbon % EC	Fine Organic Carbon (kg/day)	Fine Elemental Carbon (kg/day)
		(e)		(d)		(d)	(d)		
Los Angeles and Orange Counties									
Softwood	3392.4	42%	1424.8	66.1%	941.8	68.3%	31.7%	643.3	298.6
Hardwood	3380.5	42%	1419.8	51.0%	724.1	92.3%	7.7%	668.3	55.8
Total	6772.9		2844.6		1665.9			1311.6	354.3
50X50-mile grid (f)	6556.1		2753.6		1612.6			1269.6	343.0
San Bernardino and Riverside Counties									
Softwood	2642.3	42%	1109.8	66.1%	733.6	68.3%	31.7%	501.0	232.5
Hardwood	8746.6	42%	3673.6	51.0%	1873.5	92.3%	7.7%	1729.3	144.3
Total	11388.9		4783.3		2607.1			2230.3	376.8
Total 4-County SCAB	18161.8		7627.9		4273.0			3541.9	731.1

Notes for Table A.9

(a) Total dwellings by county in South Coast Air Basin, 1980, from Southern California Association of Governments (1982, p. 70) using population statistics and data on persons per dwelling unit.

(b) As part of this study, a survey was conducted throughout the South Coast Air Basin to determine the average level of wood-burning in residential fireplaces. The results of this survey produced data on the fraction of residences in each county burning wood, how much wood, what type of wood, and seasonal variation of usage. These data are presented in this table (seasonal variation: 70.8% winter, 10.1% spring, 2.3% summer, 16.8% autumn; 83 responses).

(c) Based on cord weights of red oak (hardwood) and yellow pine (softwood) from Baumeister, Avallone, and Baumeister (1978, pp. 6-124 and 7-13).

(d) Muhlbaier and Williams (1982, Table 2, p. 190).

(e) Taback et al. (1979, table p. A-39).

(f) Emissions in the 50X50-mile grid are assumed to be in proportion to the on-grid fraction of the Los Angeles and Orange Counties population. The fraction of the two-counties population residing in the grid is 0.968 (Southern California Association of Governments 1982).

Table A.10
Correspondence between source types used in this study and California Air Resources Board category of emission source (CES, SCC) numbers

	source type used in emission inventory (a)	California Air Resources Board category of emmission source (CES, SCC) numbers (b)
19	Off Highway Diesel	AAA47480,AAA54379,AAA54437,AAA54452, AAA54478,AAA54494,AAA54536,AAA54593
20	Off Highway Gasoline	AAA47449,AAA47464,AAA54387,AAA54411
35	Industrial IC Gasoline	AAA66746,20200301
36	Industrial IC Distillate	AAA54353,20200102,20200902
42	Petrochemical FCCU	30600201
43	Petrochemical Other	30600401,30600501,30600805,30600999, 30601301,30699998,30699999,40300199, 40399999
44	Organic Solvent Coating	AAA18697,AAA19034,AAA19109,AAA19315, AAA20107,AAA24794,AAA24877,AAA24935, AAA25056,AAA25213,AAA27920,AAA27920, AAA27995,AAA28464,AAA31583,AAA31963, AAA37861,AAA42358,AAA42416,40200101, 40200110,40200199,40200210,40200301, 40200399,40200401,40200410,40200499, 40200501,40200599,40200601,40200603, 40200701,40200799,40200801,40200803, 40201001,40201002,40288801,40299999
45	Organic Solvent Printing	40500101,40500201,40500301,40500401
46	Organic Solvent Degreasing	40100103,40100299
47	Organic Solvent Other	49099999

(a) Emissions for these source types have been compiled in Tables A.1 through A.4. The number corresponds to the source type number in Table D.38 (second column).

(b) The Califonia Air Resources Board uses CES numbers for area sources (first three digits: AAA) and SCC numbers for point sources (Ranzieri 1983).

Table A.10 (continued)

	source type used in emission inventory	California Air Resources Board category of emmission source (CES, SCC) numbers
48	Chemical Organic	30100199,30100901,30100902,30100999, 30101501,30101599,30101801,30101802, 30101899,30101903,30102699,30103204, 30199999
49	Metal Primary	30300199,30300302,30300303,30300304, 30300399,30300801,30300819,30300821, 30300901,30300913,30300914,30300999, 30301003,30303005,30388801,30400301, 30400350,30400699,30400701,30400702, 30400704,30400705,30400706,30400799
50	Metal Secondary	30400101,30400102,30400103,30400109, 30400199,30400203,30400205,30400208, 30400209,30400212,30400217,30400219, 30400221,30400223,30400224,30400402, 30400403,30400407,30400408,30400499, 30400501,30400599,30400801,30400803, 30400808,30400828,30400899,30488801, 30499999
51	Mineral	30500201,30500205,30500299,30500302, 30500311,30500605,30500606,30500609, 30500610,30500613,30500616,30500617, 30500619,30500699,30500799,30500801, 30500803,30500899,30501101,30501199, 30501201,30501204,30501205,30501299, 30501401,30501402,30501404,30501406, 30501410,30501411,30501503,30501599, 30501701,30501703,30502006,30502501, 30502599,30503203,30503299,30588801, 30588802,30599999
52	Waste Burning	10201201,50200505,50300101,50300102, 50300108
53	Wood and Paper Products	30700401,30700402,30799999
54	Asphalt Roofing	30500104,30500105,30500199
55	Rubber and Plastics	30800699
56	Coke Calciner	30601401

Table A.10 (continued)

	source type used in emission inventory	California Air Resources Board category of emmission source (CES, SCC) numbers
57	Food and Agriculture	30200901,30200999,30201301,30203299, 30299998,30299999
58	Textile	33000199,33000399
59	Miscellaneous Industrial	AAA10108,39999999
60	Livestock Dust	AAA47340
61	Paved Road Dust	AAA47456
64	Structural Fires	AAA47324
67	Agricultural Burning	AAA47258
68	Charcoal Broilers	AAA60418
69	Roofing Tar Pots	AAA66738
70	Chemical Inorganic	30101701,30102308,30103601,30103701, 30113003
71	Metal Fabrication	30903099,30999999
72	Road/Building Construction	AAA47357,AAA47365,AAA47373,AAA47381, AAA54551,AAA60400
73	Agricultural Tilling	AAA47332
74	Unpaved Road Dust	AAA47399,AAA47407,AAA47415,AAA47431
-	Wild Fires (c)	AAA47308,AAA47316
-	Tire Burning (c)	AAA57307
-	LPG for Carburetion (c)	AAA58727

(c) Source class is not input to the air quality model.

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APPENDIX B

1982 FUEL USE DATA

Table B.1

1980 Population by Region

	1980 Population	Fraction of California	Fraction of 6-County	Fraction of 4-County SCAB
	(a)			
50X50-mile grid (b)	8,734,856	36.9%	77.5%	83.1%
4-County SCAB (c)	10,508,922	44.4%	93.3%	100%
6-County Basin (d)	11,266,521	47.6%	100%	
California State Total	23,667,902	100%		

Notes for Table B.1

(a) From the Southern California Association of Governments (1982).

(b) For definition of the grid; see Figure 4.1.

(c) Contains Los Angeles, Orange, Riverside, and San Bernardino Counties.

(d) Contains Los Angeles, Orange, Riverside, San Bernardino, Ventura, and Santa Barbara Counties.

Table B.2

Electric Generating Stations 1982 Fuel Use

Power Plant	County	Grid Location Coordinates I	Grid Location Coordinates J	Natural Gas: Boilers (Equivalent bbls/yr) (a)	Natural Gas: Turbines (Equivalent bbls/yr) (a)		Residual Fuel Oil (Equivalent bbls/yr) (a)	Distillate (Equivalent bbls/yr) (a)	Digester Gas (Equivalent bbls/yr) (a)
SCE El Segundo	LA	7	12	5,373,103.50	0		190,911.0	0	0
DWP LA Scattergood	LA	7	13	1,028,281.19	0		348,730.0	0	18,254.30
SCE Redondo	LA	8	10	5,641,818.50	0		11,682.0	0	0
DWP LA Valley	LA	8	24	116,017.51	0		45,675.0	0	14,529.00
Burbank Magnolia	LA	10	22	631,502.06	59,292.0		7340.0	0	0
Glendale Airway	LA	11	21	283,391.50	216,602.0		715.0	77.0	0
SCE Northridge	LA	3	25	0	169,072.0		0	0	0
DWP LA Harbor	LA	11	7	137,130.41	11,491.0		21,026.0	1439.0	0
LB Gas Dept. (1)	LA	14	8	0	801.0		0	0	0
SCE Long Beach	LA	12	7	12,894.50	1,687,470.0		0	15,080.0	0
LB Gas Dept. (2)	LA	16	9	0	960.0		0	0	0
Pasadena Glenarm	LA	15	20	599,898.81	7,835.0		0	0	0
SCE Mt. Vernon	LA	25	18	0	44,781.0		0	0	0
SCE Alamitos	LA	16	7	10,852,545.00	13,072.0		2,333,868.0	5,721.0	0
DWP Haynes	LA	16	7	3,212,852.00	0		3,064,680.0	0	0
SCE H. Beach	Orange	19	3	5,269,042.00	7,161.0		468,774.0	542.0	0
SCE Etiwanda	SBdo	off grid		4,054,134.75	4,515.0		173,554.0	1988.0	0
SCE Highgrove	SBdo	off grid		78,694.70	0		18,986.0	0	0
SCE San Bernardino	SBdo	off grid		573,207.56	0		200,654.0	0	0
Ormond Beach	Ventura	off grid		28,166,950.00 (MCF/yr)	0		545,468.0	0	0
Mandalay	Ventura	off grid		9,782,188.00 (MCF/yr)	0		304,818.0	5571.0	0
				(10^9 Btu/day)	(10^9 Btu/day)	Total Natural Gas (10^9 Btu/day)	(10^9 Btu/day)	(10^9 Btu/day)	(10^9 Btu/day)
TOTAL GRID (b)		16 utilities		572.32	38.29	610.61	112.08	0.395	0.566
TOTAL 4-CO. SCAB (c)		19 utilities		653.55	38.37	691.92	118.86	0.429	0.566
TOTAL 6-CO. BASIN (d)		21 utilities		763.76	38.37	802.13	133.54	0.525	0.566

Notes for Table B.2

(a) Data from South Coast Air Quality Management District (1983) electric utility fuel use reports for 1982. Ventura County data from the Air Pollution Control District (1983).

(b) Each equivalent barrel of fuel has a heating value of 6.3×10^6 Btu/equiv.bbl (or 1.06×10^6 Btu/MCF).

(c) Includes Los Angeles, Orange, Riverside, and San Bernardino Counties.

(d) Includes Los Angeles, Orange, Riverside, San Bernardino, Ventura, and Santa Barbara Counties.

Table B.3

Refineries Fuel Use 1982

Refinery	County	Grid Location Coordinates I	Grid Location Coordinates J	Residual Fuel Oil (Equivalent bbls/yr)	Natural Gas (Equivalent bbls/yr)	Refinery Gas (Equivalent bbls/yr)
				(a)	(a)	(a)
Newhall Refining	LA	off grid		5,251.0	93,113.061	28,455.829
Standard Oil of California	LA	7	12	231,189.0	1,444,488.990	4,141,342.457
Mobile Oil	LA	9	10	0.0	196,274.673	3,410,700.430
Union Oil	LA	11	8	0.0	778,004.489	2,015,775.272
Fletcher Oil & Refining	LA	11	9	0.0	37,290.828	347,632.531
Golden Eagle Refinery	LA	11	10	0.0	48,574.657	47,864.169
Shell Oil, Wilmington	LA	12	10	0.0	314,923.842	1,138,756.653
Shell Oil, Dominguez	LA	12	10	0.0	574,024.331	880,800.292
Champlin Petroleum	LA	12	8	0.0	12,498.178	957,762.669
Texaco Inc.	LA	12	8	0.0	307,701.665	1,824,471.343
Atlantic Richfield	LA	12	9	43,515.0	856,525.160	3,019,616.466
Macmillan Ring-free Oil	LA	14	8	0.0	51,849.670	663.955
Marlex Oil & Refining I	LA	14	9	0.0	53,075.009	1,999.441
Edgington Oil	LA	14	11	1894.0	224,006.833	16,220.333
Douglas Oil	LA	15	12	5940.0	139,437.336	233,262.134
Powerline Oil	LA	17	13	21,350.0	305,240.180	668,341.003
Gulf Oil	LA	18	12	118.0	390,836.013	623,792.801
				(10^9 Btu/day)	(10^9 Btu/day)	(10^9 Btu/day)
TOTAL GRID (b)	16 refineries			5.25	98.98	333.62
TOTAL (c)	17 refineries			5.34	100.59	334.12

Notes for Table B.3

(a) Data from South Coast Air Quality Management District (1983) electric utility fuel use reports for 1982.

(b) Each equivalent barrel of fuel has a heating value of 6.3×10^6 Btu/equiv.bbl.

(c) Newhall Refining is in Los Angeles County but outside of the 50X50-mile grid.

Table B.4

Residential and High Priority Commercial
Natural Gas Sales, 1982

	COUNTY									
		Los Angeles							TOTAL 4-CO	TOTAL 6-CO
	Orange	So. Cal. Gas Co.	Long Beach Gas Co.	San Bernardino	Riverside	Santa Barbara	Ventura	TOTAL GRID (10^9 Btu/day)	SCAB (10^9 Btu/day)	BASIN (10^9 Btu/day)
	(a)	(a)	(b)	(a)	(a)	(a)	(a)	(f)	(g)	(h)
Residential Natural Gas Use (MCF/yr) (c)	45,823,497.4	160,440,064.5	8,002,238.0 (b)	19,303,560.5	7,502,997.8	5.322,729.0	12,075,307.6		700.10	750.63
High Priority Commercial Natural Gas Use (MCF/yr) (c)	9,504,176.3	36,489,017.8	1,819,956.0 (b)	3,605,984.3	1,837,433.2	1,862,494.7	2,531,487.1		154.66	167.42
Total Residential/ High Priority Commercial Natural Gas Use (MCF/yr)	55,327,673.7	196,929,082.3	9,822,194.0 (b)	22,909,544.8	9,340,431.0	7,185,223.7	14,606,794.7		854.76	918.05
Gridded Residential Natural Gas Use (MCF/yr) (d)	42,661676,.1	149,369,700.0	7,450,083.6					579.32		
Weighted Average Monthly Total Grid Residential								585.9		
Gridded High Priority Commercial Natural Gas Use (MCF/yr) (e)	9,200,043.7	35,321,369.2	1,761,717.4					134.41		
Weighted Average Monthly Total Grid High Priority Commercial								135.7		
Total Gridded Residential/ High Priority Commercial Natural Gas Use (MCF/yr)	51,861,718.7	184,691,069.2	9,211,801.0					713.73		
Weighted Average Monthly Total Grid Residential/ Commercial								721.6		

Notes for Table B.4

(a) Data from Southern California Gas Company (1983) reports of natural gas sales by county and FPC priority number for 1982. Los Angeles County is supplied by the Southern California Gas Company and also by the City of Long Beach Gas Department.

(b) Data from the City of Long Beach Gas Department monthly natural gas deliveries for 1982 (Kortz 1983). This represents 92.1% of the priority P1 natural gas delivered in Long Beach, which is the same fraction of P1 sold to residential/high-priority commercial users in Los Angeles County during 1982 as reported by the Southern California Gas Company (1983). The remaining 7.9% is assumed to be industrial P1. This 9,322,194 MCF is assumed to be divided into residential and high priority commercial using the proportions found in Los Angeles for P1 fuel sales by the Southern California Gas Company.

(c) FPC priority number P1 only. (Residential users are all classified P1.)

(d) The 50X50-mile grid comprises 93.1% of the population in Los Angeles and Orange Counties (Cass 1977). It is assumed that residential natural gas use is distributed spatially proportional to population distribution.

(e) The 50X50-mile grid comprises 96.8% of the employment in Los Angeles and Orange Counties (Cass 1977). It is assumed that commercial natural gas use is distributed spatially proportional to employment distribution.

(f) The natural gas sales for the calendar year 1982 reported by the Southern California Gas Company do not agree with the total of the monthly gas sales for the same period presented in the same report. Both the annual total and the sum of the monthly values are presented here.

(g) Includes Los Angeles, Orange, Riverside, and San Bernardino Counties.

(h) Includes Los Angeles, Orange, Riverside, San Bernardino, Ventura, and Santa Barbara Counties.

Table B.5

Industrial and Low Priority Commercial
Natural Gas Sales, 1982

County	Industrial Natural Gas Use (MCF/yr)	Low Priority Commercial Natural Gas Use (MCF/yr)	Total Industrial Low Priority Commercial Natural Gas Use (MCF/yr)
	(c)	(d)	
Orange (a)	36,338,823.3	3,270,117.3	39,608,940.6
Los Angeles			
So. Cal. Gas Co. (a)	249,619,080.6	39,064,738.3	288,683,818.9
Long Beach Gas Co. (b)	18,106,099.4 (b)	2,833,557.6 (b)	20,939,657.0 (b)
San Bernardino (a)	24,505,501.7	2,220,592.8	26,726,094.5
Riverside (a)	2,262,233.1	889,539.9	3,1511,773.0
Santa Barbara (a)	1,907,290.6	717,569.6	2,624,860.2
Ventura (a)	39,816,393.3	995,194.5	40,81,587.8

	(10^9 Btu/day)	(10^9 Btu/day)	(10^9 Btu/day)	Weighted Average Monthly Total Grid Industrial/ Commercial (10^9 Btu/day)
Total Industrial/Low Priority Commercial (e)				
2-County (f)	883.04	131.17	1014.21	
4-County (g)	960.77	140.21	1100.98	
6-County (h)	1081.94	145.18	1227.12	
Utilities (i)				
2-County			610.61	
4-County			691.92	
6-County			802.13	
Refineries (j)				
2-County			100.59	
4-County			100.59	
6-County			100.59	
Total Non-refinery Non-utility Industrial/Low Priority Commercial (k)				
2-County			303.01	
50X50-mile grid (l)			293.31 (m)	307.2 (m)
4-County SCAB			308.47	
6-County Basin			324.40	

Notes for Table B.5

(a) Data from Southern California Gas Company (1983) reports of natural gas sales by county and FPC priority number for 1982. Los Angeles County is supplied by the Southern California Gas Company and also by the City of Long Beach Gas Department.

(b) Data from the City of Long Beach Gas Department monthly natural gas deliveries for 1982 (Kortz 1983). This represents 7.9% of the priority P1 natural gas and all of the lower priority natural gas delivered; see note (b), Table B.4. The 20,939,657 MCF is assumed to be divided into industrial and low priority commercial using the proportions found in Los Angeles County for fuel sales by the Southern California Gas Company.

(c) All FPC priorities. This includes gas supplied to utilities and refineries which is subtracted below.

(d) All FPC priorities lower than P1.

(e) Includes gas supplied to utilities and refineries.

(f) Includes Orange and Los Angeles Counties.

(g) Includes Los Angeles, Orange, Riverside, and San Bernardino Counties.

(h) Includes Los Angeles, Orange, Riverside, San Bernardino, Ventura, and Santa Barbara Counties.

(i) From Table B.2.

(j) From Table B.3. All 17 refineries are in Los Angeles County.

(k) Non-refinery, non-utility industrial and low priority commercial natural gas usage is obtained by subtracting the natural gas used by utilities and refineries from the total industrial and low priority commercial natural gas use.

(l) The natural gas use by non-refinery, non-utility industrial and low priority commercial establishments in the 50X50-mile grid is assumed to be 96.8% of the natural gas use in Los Angeles and Orange Counties (2-county). This is the fraction of the 2-county employment in the grid (Cass 1977).

(m) The natural gas sales for the calendar year 1982 reported by the Southern California Gas Company do not agree with the total of the monthly gas sales for the same period presented in the same report. Both the annual total and the sum of the monthly values are presented here.

Table B.6

Deliveries of Fuels in 1982

	California (1000 bbls/yr)	6-County Basin (1000 bbls/yr)	6-County Basin (10^9 Btu/day)	4-County SCAB (10^9 Btu/day)	50X50-mile Grid (10^9 Btu/day)
	(a)				
Distillate Fuel Oil					
Residential/Commercial	4482	1380.5 (c)	22.03 (k)	20.55 (o)	17.08 (o)
Industrial (b)	4794	2301.1 (d)	36.72 (k)	27.92 (p)	26.54 (p)
Railroad	7138	1557.0 (e)	24.85 (k)	22.42 (e)	14.13 (e)
Residual Fuel Oil					
Residential/Commercial	5697	1754.7 (f)	30.22 (l)	28.19 (o)	23.43 (o)
Industrial (b)	973	467.0 (g)	8.04 (l)	7.65 (q)	7.27 (q)
Liquefied Petroleum Gas (LPG)					
Internal Combustion Engines	1697.5	814.8 (h)	8.48 (m)	8.07 (q)	7.67 (q)
Residential/Commercial	5220.0	1607.8 (i)	16.74 (m)	15.61 (n)	12.98 (n)
Industrial (b)	907.5	435.6 (j)	4.54 (m)	4.31 (q)	4.10 (q)
Digester Gas--Industrial			6.30 (n)	5.99 (q)	5.70 (q)
Coke Oven Gas--Industrial			37.53 (n)	37.53 (r)	0 (r)
Coal--Residential/Commercial			0.55 (n)	0.51 (n)	0.43 (n)

Notes for Table B.6

(a) Deliveries of fuels in 1982 for the state of California from the Energy Information Administration (1983). Liquefied petroleum gas (LPG) was reported by the state of California in 10^3 gal/yr, so those values are divided by 42 (gal/bbl).

(b) Non-refinery, non-utility industrial fuel.

(c) Southern California portion of residential and commercial oil use in California is 0.4 from Stanford Research Institute (1973). The 6-county basin fuel use is assumed to be a fraction of the Southern California fuel use based on population density. From the 1980 census of population in California counties (U.S. Bureau of the Census 1982), 77% of Southern California population is in the six counties; therefore, $4482 \times 0.4 \times 0.77 = 4482 \times 0.308 = 1380.5 \times 10^3$ bbls/yr.

(d) 64% of the state of California's industrial oil use is in Southern California from Stanford Research Institute (1973), and 75% of the non-refinery industrial heating demand in Southern California is in the 6-county basin from Cass (1977); therefore, $4794 \times 0.64 \times 0.75 = 4794 \times 0.48 = 2301.1 \times 10^3$ bbls/yr. This contains some fuel used for internal combustion engines; see note (o), below.

(e) Railroad fuel is assumed to be used geographically in proportion to track mileage. The track mileage in railroad yards was counted for each track to account for the heavy traffic in those areas. From Cass (1977, p. 628), track miles were summed for the 6-county basin and were found to be 1842.3 miles, which is 21.8% of the 8446.6 miles of railroad track in California. The 4-county SCAB track mileage was obtained by subtracting the 180.0 miles in the counties of Santa Barbara and Ventura, leaving 1662.3 miles in the 4-county SCAB (19.7% of the state). The track miles existing on the 50X50-mile grid totalled 1047.9 miles (12.4% of the state).

(f) 30.8% of the California residential and commerical oil is consumed in the 6-county basin (see note [c], above); therefore, $5697 \times 0.308 = 1754.7 \times 10^3$ bbls/yr.

(g) 48% of the California industrial oil use is in the 6-county basin (see note [d], above); therefore $973 \times 0.48 = 467.0 \times 10^3$ bbls/yr.

(h) The Energy Information Administration (1983) gives $71{,}294 \times 10^3$ gal/yr for LPG use by internal combustion engines in California during 1982. Assuming usage is proportional to population, this gives 71,294 $\times 10^3$ gal ÷ 42 gal/bbl (= 1697.5 bbls/yr) $\times$ 48% = 814.8 $\times 10^3$ bbls/yr; see note (d).

(i) The Energy Information Administration (1983) gives 219,239 $\times 10^3$ gal/yr for LPG use by residential and commercial customers in California for 1982. The fraction of LPG used by customers in the 6-county basin is estimated to be 30.8% (see note [c], above); therefore, 219,239 $\times 10^3$ gal/yr ÷ 42 gal/bbl (= 5220.0 bbls/yr) $\times$ 30.8% = 1607.8 bbls/yr.

(j) LPG use in the state of California for chemical and industrial uses totalled 214,216 $\times 10^3$ gal in 1982 from the Energy Information Administration (1983). Also, 17.8% of chemical/industrial LPG use was for industrial customers (including a small amount of refinery fuel) in the United States during 1982. Assuming this proportion holds for California LPG use, then 214,216 $\times 10^3$ gal/yr $\times$ 17.8% ÷ 42 gal/bbl = 907.5 bbls/yr $\times 10^3$ bbls/yr. It is assumed that 48% of the California LPG use is in the 6-county basin (see note [d], above); therefore, 907.5 $\times$ 48% = 435.6 $\times 10^3$ bbls/yr.

(k) Assumed distillate fuel oil heating value of 5825 $\times 10^3$ Btu/bbl from Cass (1977, p. 598).

(l) Assumed residual oil heating value of 6287 $\times 10^3$ Btu/bbl from Cass (1977, p. 598).

(m) Assumed LPG heating value of 3800 $\times 10^3$ Btu/bbl from Cass (1977, p. 598).

(n) No recent information available. Assumed 1973 value from Cass, Boone, and Macias (1981) as an estimate for 1982.

(o) Assuming the fuel use in the 6-county basin is distributed geographically in proportion to population, then 93.3% of the 6-county basin fuel use is in the 4-county SCAB and 77.5% of the 6-county basin fuel use is in the 50X50-mile grid.

(p) The fraction of fuel used in the 4-county SCAB is assumed to be equal to the ratio of industrial natural gas usage in the four counties to industrial usage in the six counties, which is 95.1% from Table B.5. This gives 34.92 $\times 10^9$ Btu/yr for the 4-county industrial distillate oil used. This includes distillate oil used by internal combustion engines, which is estimated to be 7.00 $\times 10^9$ Btu/day in the 4-county SCAB and 5.43 $\times 10^9$ Btu/day in the 50X50-mile grid, from the Air Resources Board of California 1982 inventory of area and point source emissions (Ranzieri 1983); see note (n), Table A.2. Therefore, the total for industrial distillate not including IC fuel in the 4-county SCAB is 34.92 − 7.00 = 27.92 $\times 10^9$ Btu/day. It is further assumed that the fraction of the 4-county SCAB distillate oil used within the 50X50-mile grid is equal to the ratio of industrial natural gas usage in the grid versus the four counties, which is 95.1%; see Table B.5. Therefore, the grid total is 27.92 X 95.1% = 26.54 X 10^9 Btu/day.

(q) Assuming the fuel use for industrial customers is proportional to the natural gas used in the 6-county, 4-county, and 50X50-mile grid gives 95.1% of the 6-county basin industrial fuel is in the 4-county SCAB and 90.4% of the 6-county basin industrial fuel is in the 50X50-mile grid.

(r) All the coke oven gas use is in the 4-county SCAB but outside the 50X50-mile grid.

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APPENDIX C

1982 EMISSIONS ESTIMATES IN THE 4 COUNTY SOUTH COAST AIR BASIN

The following tables contain estimates of particle emissions in the 4 county South Coast Air Basin during 1982. The methodology used to construct Tables C.1 through C.4 is the same as that used in Tables A.1 through A.4, respectively. Therefore explanatory notes are omitted from tables in Appendix C. The interested reader will find explanations of the calculations in the notes following the corresponding table in Appendix A.

Table C.1

Emissions Estimates for Mobile Sources in 4 County South Coast Air Basin (a)

	Estimated 1982 Fuel Use (10^9 Btu/day)	Thous. VMT/day	Total Particulate Emission Factor ($kg/10^9$ Btu)	Total Particulate Emission Factor (gm/mile)	Total Particulate Emissions (kg/day)	Mass Fraction < 2.1 µm	Fine Total Particulate (kg/day)	%Total Carbon in < 2.1 µm Fraction	Fine Total Carbon (kg/day)	Partition of Carbon: Volatile Carbon % OC	Partition of Carbon: Non-volatile Carbon % EC	Fine Organic Carbon (kg/day)	Fine Elemental Carbon (kg/day)
MOBILE SOURCES													
Highway Vehicles													
Catalyst Autos	601.9	101641		0.016	1626.3	86%	1398.6	39%	545.4	55%	45%	300.0	245.5
Non-catalyst Autos	357.1	39005		0.32	12481.6	36.4%	4543.3	76.4%	3471.1	78.7%	21.3%	2731.7	739.3
Diesel Autos	16.3	2914		0.48	1398.7	93%	1300.8	83.7%	1088.8	23.4%	76.6%	254.8	834.0
Catalyst Light Trucks	112.2	13882		0.022	305.4	86%	262.6	39%	102.4	55%	45%	56.3	46.1
Non-catalyst Light Trucks	66.6	5328		0.44	2344.3	36.4%	853.3	76.4%	651.9	78.7%	21.3%	513.1	138.9
Diesel Light Trucks	3.0	398		0.48	191.0	93%	177.7	83.7%	148.7	23.4%	76.6%	34.8	113.9
Catalyst Medium Trucks	68.8	5835		0.033	192.6	86%	165.6	39%	64.6	55%	45%	35.5	29.1
Non-catalyst Medium Trucks	46.8	3970		0.41	1627.7	36.4%	592.5	76.4%	452.7	78.7%	21.3%	356.2	96.4
Gasoline Heavy Trucks	78.1	3564		0.77	2744.3	36.4%	998.9	76.4%	763.2	78.7%	21.3%	600.6	162.6
Diesel Heavy Trucks	172.2	6843		1.39	9511.8	93%	8845.9	83.7%	7404.1	23.4%	76.6%	1732.5	5671.5
Motorcycles	4.4	1756		0.15	263.4	36.4%	95.9	76.4%	73.3	78.7%	21.3%	57.6	15.6
LPG use for Carburetion	8.1				1.6								
Civil Aviation													
Jet Aircraft	49.3				434.5	~100%	434.5	96%	417.1	23.4%	76.6%	97.6	319.5
Aviation Gas	2.4				54.6	36.4%	19.9	76.4%	15.2	78.7%	21.3%	11.9	3.2
Commercial Shipping													
Residual Oil-fired Ships	14.8		85.50		1265.5	72%	911.2	11.3%	103.0	80%	20%	82.4	20.6
Diesel Ships	6.3		49.17		309.8	93%	288.1	83.7%	241.1	23.4%	76.6%	56.4	184.7
Railroad													
Diesel Oil	22.4		81.95		1835.7	93%	1707.2	83.7%	1428.9	23.4%	76.6%	334.5	1094.5
Miscellaneous													
Off Highway Diesel Vehicles	39.0		78.67		3064.5	93%	2850.0	83.7%	2385.4	23.4%	76.6%	558.2	1827.2
Off Highway Gasoline Vehicles	--				429.9	36.4%	156.5	76.4%	119.6	78.7%	21.3%	94.1	25.5
TOTAL MOBILE SOURCES									19476.5			7908.1	11568.1

(a) See Table A.1 for calculation procedure.

Table C.2

Emissions Estimates for Stationary Combustion Sources in 4 County South Coast Air Basin (a)

	Estimated 1982 Fuel Use (10^9 Btu/day)	Total Particulate Emissions Factor (kg/10^9 Btu)	Total Particulate Emissions (kg/day)	Mass Fraction < 2.1 µm	Fine Total Particulate (kg/day)	%Total Carbon in < 2.1 µm Fraction	Fine Total Carbon (kg/day)	Partition of Carbon: Volatile Carbon % OC	Partition of Carbon: Non-volatile Carbon % EC	Fine Organic Carbon (kg/day)	Fine Elemental Carbon (kg/day)
STATIONARY SOURCES											
Fuel Combustion											
Electric Utilities											
Natural Gas (boilers)	653.6	1.08	705.9	92%	649.4	7%	45.5	100%	small	45.5	0
Natural Gas (turbines)	38.4	5.99	230.0	92%	211.6	7%	14.8	100%	small	14.8	0
Residual Oil	118.9	9.09	1080.8	95%	1026.8	20%	205.4	80%	20%	164.3	41.1
Distillate Oil (turbines)	0.43	16.35	7.0	96.4%	6.8	15%	1.0	42%	58%	0.4	0.6
Digester Gas	0.57	1.08	0.6	92%	0.6	7%	0.04	100%	small	0.04	0
Refinery Fuel											
Natural Gas	100.6	9.07	912.4	92%	839.4	7%	58.8	100%	small	58.8	0
Refinery Gas	334.1	9.07	3030.3	92%	2787.9	7%	195.2	100%	small	195.2	0
Residual Oil	5.34	21.64	115.6	72%	83.2	11.3%	9.4	80%	20%	7.5	1.9
Non-refinery Industrial/Low Priority Commercial Fuel											
Natural Gas	308.5	7.56	2332.3	92%	2145.7	7%	150.2	100%	small	150.2	0
LPG	4.31	7.56	32.6	92%	30.0	7%	2.1	100%	small	2.1	0
Residual Oil	7.65	21.64	165.5	72%	119.2	11.3%	13.5	80%	20%	10.8	2.7
Distillate Oil	27.9	23.55	657.0	96.4%	633.4	15%	95.0	42%	58%	39.9	55.1
Digester Gas (IC engines)	5.99	20.41	122.3	99%	121.0	21%	25.4	77%	23%	19.6	5.8
Coke Oven Gas	37.5	7.56	283.5	92%	260.8	7%	18.3	100%	small	18.3	0
Gasoline (IC engines)	5.16	23.49	121.2	99%	120.0	20%	24.0	90%	10%	21.6	2.4
Distillate Oil (IC engines)	7.00	109.81	768.7	93%	714.9	4%	28.6	small	100%	0	28.6
Residential/High Priority Commercial Fuel											
Natural Gas	854.8	8.06	6889.7	92%	6338.5	12%	760.6	67%	33%	509.6	251.0
LPG	15.6	8.06	125.7	92%	115.7	12%	13.9	67%	33%	9.3	4.6
Residual Oil	28.2	21.64	610.2	72%	439.4	11.3%	49.6	80%	20%	39.7	9.9
Distillate Oil	20.6	21.64	445.8	96.4%	429.7	15%	64.5	42%	58%	27.1	37.4
Coal	0.51	378.0	192.8	62%	119.5	96%	114.7	78%	22%	89.5	25.2
TOTAL FUEL COMBUSTION							1890.5			1424.2	466.3

(a) See Table A.2 for calculation procedure.

Table C.3

Emissions Estimates for Industrial Processes in 4 County South Coast Air Basin (a)

	Total Particulate Emissions (kg/day)	Mass Fraction < 2.1 µm	Fine Suspended Particulate < 2.1 µm (kg/day)	% Total Carbon in < 2.1 µm Fraction	Fine Total Carbon (kg/day)	Partition of Carbon: Volatile Carbon % OC	Partition of Carbon: Non-volatile Carbon % EC	Fine Organic Carbon (kg/day)	Fine Elemental Carbon (kg/day)
STATIONARY SOURCES									
<u>Industrial Process Point Sources</u>									
Petroleum Industry									
Refining (FCCU)	1591.2	54%	859.2	3.8%	32.7	75%	25%	24.5	8.2
Other	342.4	100%	342.4	≤83%	284.2	100%	0%	284.2	0
Organic Solvent Use									
Surface Coating	3131.6	91.5%	2865.4	55%	1576.0	100%	0%	1576.0	0
Printing	32.0	91.5%	29.3	55%	16.1	100%	0%	16.1	0
Degreasing	29.6	100%	29.6	≤83%	24.6	100%	0%	24.6	0
Other	154.1	100%	154.1	≤83%	127.9	100%	0%	127.9	0
Chemical									
Organic	2435.3	94.5%	2301.4	33%	759.4	94%	6%	713.9	45.6
Inorganic	151.2	94.5%	142.9	0%	0	–	–	–	–
Metallurgical									
Primary	6211.1	98.2%	6099.3	59.2%	3610.8	100%	0%	3610.8	0
Secondary	1906.8	88.5%	1687.5	13%	219.4	100%	0%	219.4	0
Fabrication	556.4	77%	428.4	0%	0	–	–	–	–
Mineral	14257.1	55.1%	7855.7	10.2%	801.3	74.4%	25.6%	596.2	205.1
Waste Burning	297.9	84.5%	251.7	30%	75.5	30%	70%	22.7	52.9
Wood Processing	372.4	56%	208.5	41.2%	85.9	87%	13%	74.8	11.2
Food and Agriculture	2442.3	1%	24.4	30%	7.3	100%	0%	7.3	0
Asphalt Roofing	377.1	93%	350.7	24%	84.2	96%	4%	80.8	3.4
Textile	237.8	1%	2.4	≤83%	2.0	100%	0%	2.0	0
Rubber and Plastics	77.2	100%	77.2	≤83%	64.1	100%	0%	64.1	0
Coke Calciner	266.4	100%	266.4	89.8%	239.2	0%	100%	0	239.2
Miscellaneous Industrial	2098.7	69.5%	1458.6	32.7%	477.0	92.8%	7.2%	442.6	34.3
TOTAL PROCESS POINT SOURCES					8487.6			7887.9	599.9

(a) See Table A.3 for calculation procedure.

Table C.4

Emissions Estimates for Fugitive Sources
in 4 County South Coast Air Basin
(a)

	Total Particulate Emissions (kg/day)	Mass Fraction < 2.1 μm	Fine Total Particulate (kg/day)	% Total Carbon in < 2.1 μm Fraction	Fine Total Carbon (kg/day)	Partition of Carbon: Volatile Carbon % OC	Partition of Carbon: Non-volatile Carbon % EC	Fine Organic Carbon (kg/day)	Fine Elemental Carbon (kg/day)
FUGITIVE SOURCES									
Road and Building Construction	90341.0	32%	28909.1	0%	0	-	-	-	-
Agricultural Tilling	68200.9	30.5%	20801.3	0%	0	-	-	-	-
Livestock Feedlots	38073.6	54%	20559.7	2%	411.2	100%	0%	411.2	0
Unpaved Road Dust	33009.3	24%	7922.2	0%	0	-	-	-	-
Paved Road Dust	158306.6	27%	42742.8	15.1%	6454.2	96.7%	3.3%	6241.2	213.0
Tire Attrition	5379.2	25%	1344.8	87%	1170.0	67%	33%	783.9	386.1
Brake Lining Attrition	7530.8	100%	7530.8	28%	2108.6	82%	18%	1729.1	379.6
Forest Fires (seasonal)	13564.8	86%	11665.7	63%	7349.4	94%	6%	6908.4	441.0
Structural Fires	396.0	86.5%	342.5	30%	102.8	68%	32%	69.9	32.9
Fireplaces	18161.8	42%	7627.9		4273.0			3541.9	731.1
Cigarettes	2008.6	100%	2008.6	82.5%	1657.1	97%	3%	1607.4	49.7
Charcoal Broilers	6342.0	100%	6342.0	82.3%	5219.5	98.5%	1.5%	5141.2	78.3
Agricultural Burning	28.8	94%	27.1	52%	14.1	91%	9%	12.8	1.3
Sea Salt	65406.9	8%	5232.6	0%	0	-	-	-	-
Roofing Tar Pots	1028.7	100%	1028.7	81.7%	840.4	99.9%	0.1%	839.6	0.8
TOTAL FUGITIVE SOURCES					29600.3			27286.6	2313.8

(a) See Table A.4 for calculation procedure.

APPENDIX D

ESTIMATES OF THE COSTS AND EMISSION REDUCTIONS OF FINE PARTICLE CONTROL MEASURES

The costs and fine carbon particle emission reductions for the control measures used in this study are summarized in Chapter 5, Table 5.1. The source types affected by each control measure are identified by numbers which appear below the titles of the control measures. These numbers correspond to the source type identification numbers listed in the right-hand column of Table D.38.

Cost Calculation D.1

Unleaded Gasoline Use by Non-catalyst Autos and Light Trucks

Sources Affected: 3,4

Cost: 82.924×10^6 \$/yr

1. Difference in retail price between unleaded and leaded gas, national average 1982: 6.7¢/gal or \$536.20/10^9 Btu from Energy Information Administration (1982).
2. SCAB 1982 fuel use: 423.7×10^9 Btu/day (from Table C.1).

$$\text{Total Cost} = (\$536.20/10^9 \text{ Btu})\ (423.7 \times 10^9 \text{ Btu/day}) \times (365 \text{ days/yr}) = 82.924 \times 10^6 \$/\text{yr}$$

Purpose:

This is not a control measure for aerosol carbon emission reduction. The cost of unleaded fuel is needed in order to evaluate Control Measure D.2 which involves replacement of non-catalyst autos and light trucks by catalyst equipped vehicles.

Control Measure D.2

Catalysts on Non-catalyst Autos and Light Trucks

Sources Affected: 3,4

Cost: 236.352×10^6 $/yr

1. Unleaded fuel must be used. Cost: 82.926×10^6 $/yr (see Cost Calculation D.1).
2. Catalyst cost: $155 per system for 1978 Federal System (this system would be adequate to achieve carbon particle emission reduction cited) from Cross (1982). Convert to 1982 dollars by multiplying by 0.512/0.344 (Dept. of Labor 1985), which gives a cost of $230.70/system.
3. Assume 5 year payback period at 10% interest which yields a capital recovery factor of 0.26380. This gives an annual cost of $60.86/vehicle-yr for the catalyst system.
4. Number of light-duty autos and trucks in SCAB, 1982, is esimated to be 6,243,184 from the California Air Resources Board (1983a). From Table A.5, 40.38% of the automobile fleet was non-catalyst in 1982 giving approximately 2,521,000 light-duty non-catalyst vehicles.

Total Cost = ($60.86/vehicle-yr) (2,521,000 vehicles)
+ 82.924×10^6 $/yr = 236.352×10^6 $/yr

Fine TC Reduction: 3.7387 T/day

1. Fine total carbon emission factors:
Noncat: 9.72 kg/10^9 Btu (see Table C.1).
Catalyst: 0.91 kg/10^9 Btu (see Table C.1).
2. Fine total carbon emissions from sources: 4.1230 T/day (SCAB, Table C.1).

Reduction = (4.1230 T/day) (1 - 0.91/9.72) = 3.7387 T/day

TC fraction reduction = 0.9068
EC fraction reduction = 1 - (0.45) (1 - 0.9068)/(0.213) = 0.8031
(see Table A.1 for EC/TC ratios)

Control Measure D.3

#1 Diesel Fuel Use by Light-duty Diesel Vehicles

Sources Affected: 6,7

Cost: 4.317×10^6 \$/yr

1. Diesel price difference: 8.5¢/gal (Difference of arithmetic averages for #1 and #2 diesel fuel from 1982 Lundberg Survey from Turner 1985). $(\$0.085/\text{gal}) \left(\frac{42 \text{ gal}}{\text{bbl}}\right) \left(\frac{1 \text{ bbl}}{5825 \times 10^3 \text{ Btu}}\right) = \$612.88/10^9 \text{ Btu}$.
2. SCAB 1982 fuel use: 19.3×10^9 Btu/day (from Table C.1).

$$\text{Total Cost} = (\$612.88/10^9 \text{ Btu})\ (19.3 \times 10^9 \text{ Btu/day})\ (365 \text{ days/yr}) = 4.317 \times 10^6 \text{ \$/yr}$$

Fine TC Reduction: 0.2475 T/day

1. Particulate emissions are reduced 20% by switching from #2 diesel to #1 diesel (from Burley and Rosebrock 1979, SAE 790923, fig. 6).
2. Fine total carbon emissions from sources: 1.2375 T/day (SCAB, Table C.1).

Reduction = (0.20) (1.2375) = 0.2475 T/day

TC fraction reduction = 0.20
EC fraction reduction = 0.20

Conflicts: D.4, D.5

Control Measure D.4

Particle Traps on Light-duty Diesel Vehicles

Sources Affected: 6,7

Cost: 8.148×10^6 \$/yr

1. California Air Resources Board (1983b) cites a number of sources including manufacturers and independent consultants concerning estimates of the consumer cost of a fuel additive ceramic monolith trap-oxidizer system for light-duty diesel vehicles. Estimates of the initial cost ranged from \$140 to \$450, although the CARB believes the lower end of the range to be most realistic. Their findings are supported by cost estimates of Weaver et al. (1983), who estimated an initial cost of \$180 to \$342. Assume an initial cost of \$280/vehicle (approximate middle of both ranges stated).
2. Assume 5 year payback period at 10% interest which results in a capital recovery factor of 0.26380. This gives an equivalent annual charge for the capital cost of \$73.86/vehicle-yr.
3. Number of light-duty diesel vehicles in SCAB, 1982 estimated as 92,400 from California Air Resources Board (1983a; 6,243,184 light-duty vehicles) and Table A.5 (diesels make up 1.48% of light-duty fleet).
4. Weaver et al. (1983) estimated the loss in fuel economy due to the trap to be about 2%. Total fuel use by light-duty diesels in 1982 was 19.3×10^9 Btu/day (SCAB, Table C.1) or 50.91×10^6 gal/yr . Dividing by 92,400 vehicles gives 550.9 gal/vehicle-yr. At \$1.30/gal, this gives additional cost of \$14.32/vehicle-yr. The total cost is then \$88.18/vehicle-yr.

$$\text{Total Cost} = \left(\frac{\$88.18}{\text{vehicle-year}}\right)(92{,}400 \text{ vehicles})$$
$$= 8.148 \times 10^6 \ \$/\text{yr}$$

Control Measure D.4 (continued)

Fine TC Reduction: 0.9900 T/day

1. Collection efficiencies ranging from 50% to greater than 90% have been reported for the cellular ceramic filters (CARB 1982; Weaver 1983; Urban et al. 1983; Ludecke and Dimick 1983; Miller et al. 1983; Montierth 1984; Ullman et al. 1984; Howitt and Montieth 1981; Wade et al. 1983; Wiedemann et al. 1983, 1984; Ludecke and Bly 1984; General Motors 1983). A mean value of 80% would probably be attained for large scale use.
2. Fine total carbon emissions from sources: 1.2375 T/day (SCAB, Table C.1).

Reduction = (0.80) (1.2375) = 0.9900 T/day

TC fraction reduction = 0.80
EC fraction reduction = 0.80

Conflicts: D.3, D.5

Control Measure D.5

Particle Traps & #1 Diesel Fuel Use for Lt-duty Diesel Vehicles

Sources Affected: 6,7

Cost: 12.465 X 10^6\$/yr

1. Cost of #1 diesel fuel: 4.317 X 10^6\$/yr (see Control D.3).
2. Particle trap system cost: 8.148 X 10^6\$/yr (see Control D.4).

Total Cost = 4.317 + 8.148 = 12.465 X 10^6\$/yr

Fine TC Reduction: 1.0395 T/day

1. 20% reduction due to #1 diesel fuel use (see Control D.3).
2. Additionally, 80% of the remaining 80% is removed by trap (see Control D.4).
3. Fine total carbon emissions from sources: 1.2375 T/day (SCAB, Table C.1).

Reduction = (1.2375 T/day) [0.20 + 0.80 (0.80)] = 1.0395 T/day

TC fraction reduction = 0.84
EC fraction reduction = 0.84

Conflicts: D.3, D.4

Cost Calculation D.6

Unleaded Gasoline Use by Non-catalyst Medium & Heavy Vehicles

Sources Affected: 9,10

Cost: 24.445×10^6 \$/yr

1. Difference in retail price between unleaded and leaded gas: \$536.20/10^9 Btu (see Control D.1).
2. SCAB 1982 fuel use: 124.9×10^9 Btu/day (from Table C.1).

$$\text{Total Cost} = (\$536.20/10^9 \text{ Btu})(124.9 \times 10^9 \text{ Btu/day})(365 \text{ day/yr}) = 24.445 \times 10^6 \$/\text{yr}$$

Purpose:

This is not a control measure for aerosol carbon emission reduction. The cost of unleaded fuel is needed in order to evaluate Control Measure D.7 which involves replacement of non-catalyst medium and heavy vehicles by catalyst equipped vehicles.

Control Measure D.7

Catalysts on Non-Catalyst Medium & Heavy Gas Vehicles

Sources Affected: 9,10

Cost: 66.453×10^6\$/yr

1. Unleaded fuel must be used. Cost: 24.445×10^6\$/yr (see Cost Calculation D.6).
2. Catalyst cost: \$353/system (average of estimates by EPA, GM, and Chrysler for 1979 system) from Cross (1982). Convert to 1982 dollars by multiplying by 0.461/0.344 (Dept. of Labor 1985) which gives a cost of \$473.06/system.
3. Assume 5 year payback period at 10% interest which results in a capital recovery factor of 0.26380. Then the annual cost is \$124.79/vehicle-yr for the catalyst system.
4. Number of medium and heavy non-catalyst vehicles in SCAB, 1982 is 336,631 from California Air Resources Board (1983a).

Total Cost = (\$124.79/vehicle-yr) (336,631 vehicles) + 24.445×10^6\$/yr = 66.453×10^6\$/yr

Fine TC Reduction: 1.1026 T/day

1. Fine total carbon emission factors:
   Noncat: 9.72 kg/10^9 Btu (see Table C.1).
   Catalyst: 0.91 kg/10^9 Btu (see Table C.1).
   (Note: Small differences between these emission factors and those found by dividing TC emissions by fuel use in Table C.1 are due to roundoff. These emission factors per unit fuel burned are assumed to be the same as for light-duty vehicles; see Control D.2.)
2. Fine total carbon emissions from sources: 1.2159 T/day (SCAB, Table C.1).

Reduction = (1.2159 T/day) (1 - 0.91/9.72) = 1.1026 T/day

TC fraction reduction = 0.9068
EC fraction reduction = 0.8031 (see Control D.2)

Control Measure D.8

#1 Diesel Fuel Use by Heavy-duty Diesel Vehicles

Sources Affected: 11

Cost: 38.523 X 10^6\$/yr

1. Diesel price difference: \$612.9/10^9 Btu (see Control D.3).
2. SCAB 1982 fuel use: 172.2 X 10^9 Btu/day (from Table C.1).

Total Cost = (\$612.9/10^9 Btu) (172.2 X 10^9 Btu/day) (365 day/yr)
= 38.523 X 10^6\$/yr

Fine TC Reduction: 1.4808 T/day

1. 20% reduction (see Control D.3).
2. Fine total carbon emissions from sources: 7.4041 T/day (SCAB, Table C.1).

Reduction = (0.20) (7.4041 T/day) = 1.4808 T/day

TC fraction reduction = 0.20
EC fraction reduction = 0.20

Conflicts: D.9, D.10

Control Measure D.9

Particle Traps on Heavy-duty Diesel Vehicles

Sources Affected: 11

Cost: 36.240×10^6 \$/yr

1. Weaver et al. (1984) estimates a lifecycle cost (assuming average vehicle life of 8 years) for a Monolith/Additive particle trap system of \$2471.58/vehicle if the trap is cleaned periodically (including the cost of periodic cleaning) or \$3906.74/vehicle if the trap must be replaced instead of cleaned (including replacement costs). These costs include estimates for maintenance and loss in fuel consumption. Using the average of these two costs gives a lifecycle cost of \$3189.16/vehicle.
2. Amortizing this cost over 8 years at 10% interest results in a capital recovery factor of 0.18744, which gives an annual cost of \$597.78/vehicle-yr.
3. Number of heavy-duty diesels in SCAB, 1982 is 60,624 from California Air Resources Board (1983a).

Total Cost = (\$597.78/vehicle-yr) (60,624 vehicles)
= 36.240×10^6 \$/yr

Fine TC Reduction: 6.6637 T/day

1. This trap system can be designed to be over 90% effective from Weaver et al. (1984).
2. Fine total carbon emissions from sources = 7.4041 T/day (SCAB, Table C.1).

Reduction = (0.90) (7.4041 T/day) = 6.6637 T/day

TC fraction reduction = 0.90
EC fraction reduction = 0.90

Conflicts: D.8, D.10

Control Measure D.10

Particle Traps & #1 Diesel Fuel for Heavy-duty Diesel Vehicles

Sources Affected: 11

Cost: 74.763×10^6 $/yr

1. Cost of #1 diesel fuel: 38.523×10^6 $/yr (see Control D.8).
2. Particle trap system cost: 36.240×10^6 $/yr (see Control D.9).

Total Cost = $38.523 + 36.240 = 74.763 \times 10^6$ $/yr

Fine TC Reduction: 6.8118 T/day

1. 20% reduction due to #1 diesel fuel use (see Control D.3).
2. Additionally, 90% of the remaining 80% is removed by trap (see Control D.9).
3. Fine total carbon emissions from sources: 7.4041 T/day (SCAB, Table C.1).

Reduction = (7.4041 T/day) [0.20 + 0.90 (0.80)] = 6.8118 T/day

TC fraction reduction = 0.92
EC fraction reduction = 0.92

Conflicts: D.8, D.9

Control Measure D.11

Air Taxi Modification (Towing)

Sources Affected: 12

Cost: $0 (overall savings expected)

This control measure is proposed as part of the 1982 Air Quality Management Plan for the South Coast Air Basin. The South Coast Air Quality Management District (1982) has determined that the fuel savings involved should exceed the cost of the change in operations.

Fine TC Reduction: 0.1354 T/day

1. Of the 417.1 kg/day TC emitted from jet aircraft in the SCAB (see Table C.1), emissions at the surface account for 227.8 kg/day (idle and takeoff cycles -- using USEPA calculation procedure, see Table A.1; note [c]; TC (kg/day) from idle: 193.32; takeoff: 34.44; climbout: 87.49; approach: 101.84). Idle operations, therefore, account for 84.9% of emissions from surface operations.
2. Most of the particulate emissions during idle can be avoided by towing the aircraft into and out of the terminal (even considering tow truck fuel use). A conservative estimate is a 70% reduction. See South Coast Air Quality Management District (1982) for a desription of this control measure.

Reduction = (0.849) (0.70) (0.2278 T/day) = 0.1354 T/day

TC fraction reduction = 0.5943
EC fraction reduction = 0.5943

Control Measure D.12

0.5%S Residual Oil for Shipping — Berthing Operations

Sources Affected: 16

Cost: 2.253×10^6 \$/yr

1. Low sulfur fuel oil (0.5%S) is to be used for berthing operations only. Fuel costs will increase approximately \$2 per barrel (from Nazemi et al. 1981) or \$318.12/10^9 Btu.
2. Of the 14.8×10^9 Btu/day residual oil use in the SCAB for shipping operations in 1982 (see Table C.1), 9.5×10^9 Btu/day was used during berthing operations (see Table A.1; note [d]).
3. Additionally, Nazemi et al. (1981) estimate an extra labor cost required for fueling operations of 1.15×10^6 \$/yr.

$$\text{Total Cost} = (9.5 \times 10^9 \text{ Btu/day}) (\$318.12/10^9 \text{ Btu}) (365 \text{ days/yr}) + 1.15 \times 10^6 \$/\text{yr} = 2.253 \times 10^6 \$/\text{yr}$$

Fine TC Reduction: 0.0442 T/day

1. Assume particulate emissions are reduced by 67% for switching from 1.5%S to 0.5%S fuel oil (based on observations by Taback et al. [1979]—particle emissions are proportional to sulfur content).
2. Only 64% of the emissions from residual oil combustion (9.5/14.8; see above) are operated on with this control measure (berthing operations only).
2. Fine total carbon emissions from sources: 0.1030 T/day (SCAB, Table C.1).

$$\text{Reduction} = (0.67)\ (0.64)\ (0.1030 \text{ T/day}) = 0.0442 \text{ T/day}$$

TC fraction reduction = 0.4288
EC fraction reduction = 0.4288

Control Measure D.13

#1 Diesel Fuel Use by Railroads

Sources Affected: 18

Cost: 5.011×10^6 \$/yr

1. Diesel price difference: \$612.9/10^9 Btu (see Control D.3).
2. SCAB 1982 fuel use: 22.4×10^9 Btu/day (from Table C.1).

Total Cost = (\$612.9/10^9 Btu) (22.4×10^9 Btu/day) (365 day/yr)
= 5.011×10^6 \$/yr

Fine TC Reduction: 0.2858 T/day

1. Assumed 20% reduction (see Control D.3).
2. Fine total carbon emissions from sources: 1.4289 T/day (SCAB, Table C.1).

Reduction = (0.20) (1.4289 T/day) = 0.2858 T/day

TC fraction reduction = 0.20
EC fraction reduction = 0.20

Control Measure D.14

#1 Diesel Fuel Use in Off-road Diesel Engines

Sources Affected: 19

Cost: 8.725×10^6 \$/yr

1. Diesel price difference: \$612.9/10^9 Btu (see Control D.3).
2. SCAB 1982 fuel use: 39.0×10^9 Btu/day (from Table C.1).

$$\text{Total Cost} = (\$612.9/10^9\ \text{Btu})\ (39.0 \times 10^9\ \text{Btu/day})\ (365\ \text{day/yr}) = 8.725 \times 10^6\ \$/\text{yr}$$

Fine TC Reduction: 0.4771 T/day

1. Assumed 20% reduction (see Control D.3).
2. Fine total carbon emissions from sources: 2.3854 T/day (SCAB, Table C.1).

Reduction = (0.20) (2.3854 T/day) = 0.4771 T/day

TC fraction reduction = 0.20
EC fraction reduction = 0.20

Conflicts: D.15, D.16

Control Measure D.15

Particle Traps on Off-road Diesel Engines

Sources Affected: 19

Cost: 19.535×10^6\$/yr

1. Number of off-road diesel vehicles in SCAB, 1982, estimated to be 75,194, of which 44,827 are light-duty and 30,367 are heavy-duty vehicles, from California Air Resources Board (1984) and data of Ranzieri (1983).
2. Light-duty engine particle trap system cost: $73.86/vehicle-yr (see Control D.4; not including additional fuel cost due to loss in fuel economy).
3. Heavy-duty engine particle trap system cost: Capital cost (data from Weaver et al. 1984): $1121.04; using 5 year payback period at 10% interest gives capital recovery factor of 0.26380, so annual capital cost is $295.73/yr; Maintenance cost: $5/yr (approximation based on ratio of fuel usage for individual off-road engines and heavy diesel trucks and maintenance cost for heavy diesel trucks from Weaver et al. [1984]); Replacement cost (one per 5 year lifetime): $776 (from Weaver et al. 1984); amortized over 5 years gives $145.46/yr. Total cost (not including additional fuel cost due to reduction in fuel economy): $446.19/vehicle-yr.
4. Total fuel use by off-road diesel engines in 1982 was 39.0×10^9 Btu/day (SCAB, Table C.1) or 102.9×10^6 gal/yr. Assuming a loss in fuel economy of 2% and $1.30/gal, this gives additional fuel cost of 2.675×10^6\$/yr.

$$\text{Total Cost} = (\$73.86/\text{vehicle-yr})\,(44{,}827\ \text{vehicles}) + (\$446.19/\text{vehicle-yr})\,(30{,}367\ \text{vehicles}) + 2.675 \times 10^6\,\$/\text{yr} = 19.535 \times 10^6\,\$/\text{yr}$$

Control Measure D.15 (continued)

Fine TC Reduction: 2.0827 T/day

1. From Ranzieri (1983), light-duty off-road vehicles (CARB categories AAA54536 and AAA54379; see Table A.10; source type 19) accounted for 26.9% of the emissions in this source class.
2. Particulate fraction reductions: 80% (light-duty; see Control D.4) and 90% (heavy-duty; see Control D.9).
3. Fine total carbon emissions from sources: 2.3854 T/day (SCAB, Table C.1).

Reduction = [(0.269)(0.80) + (0.731)(0.90)] (2.3854 T/day)
= 2.0827 T/day

TC fraction reduction = 0.8731
EC fraction reduction = 0.8731

Conflicts: D.14, D.16

Control Measure D.16

Particle Traps & #1 Diesel Fuel Use for Off-road Diesel Engines

Sources Affected: 19

Cost: 28.260×10^6\$/yr

1. Cost of #1 diesel fuel: 8.725×10^6\$/yr (see Control D.14).
2. Particle trap system cost: 19.535×10^6\$/yr (see Control D.15).

Total Cost = 8.725 + 19.535 = 28.260×10^6\$/yr

Fine TC Reduction: 2.1432 T/day

1. Light-duty vehicles are 26.9% of this source class (by emissions; see Control D.15).
2. Particulate fraction reductions: 84% (light-duty; see Control D.5) and 92% (heavy-duty; see Control D.10).
3. Fine total carbon emissions from sources: 2.3854 T/day (SCAB, Table C.1).

Reduction = [(0.269)(0.84) + (0.731)(0.92)] (2.3854 T/day)
= 2.1432 T/day

TC fraction reduction = 0.8985
EC fraction reduction = 0.8985

Conflicts: D.15, D.16

Cost Calculation D.17

Unleaded Gasoline Use by Off-road Gasoline Engines

Sources Affected: 20

Cost: 1.840×10^6 \$/yr

1. Difference in retail price between unleaded and leaded gas: \$536.20/10^9 Btu (see Control D.1).
2. SCAB 1982 fuel use estimated as 12.3×10^9 Btu/day (from Table C.1, using approximate particulate emission factor of 35.0 kg/10^9 Btu from light-duty non-catalyst vehicles).
3. This measure is operable on off-road recreational vehicles and forklifts (source categories AAA47464, AAA54387, and AAA54411; see Table A.10; source 20) but not on residential utility equipment (category AAA47449). The fraction of this source class falling into categories AAA47464, AAA54387, and AAA54411 is 76.6% (by emissions, from Ranzieri [1983]), so controllable fuel use is assumed to be (0.766) (12.3×10^9 Btu/day) = 9.4×10^9 Btu/day.

Total Cost = (\$536.20/10^9 Btu) (9.4×10^9 Btu/day) (365 day/yr)
= 1.840×10^6 \$/yr

Purpose:

This is not a control measure for aerosol carbon emission reduction. The cost of unleaded fuel is needed in order to evaluate Control Measure D.18 which involves replacement of non-catalyst off-road vehicles by catalyst equipped vehicles.

Control Measure D.18

Catalysts on Off-road Gasoline Engines

Sources Affected: 20

Cost: 15.615 X 10^6\$/yr

1. Unleaded fuel must be used. Cost: 1.840 X 10^6\$/yr (see Cost Calculation D.17).
2. Assume catalysts used are similar to those used for light-duty vehicles. Annual cost is \$60.86/vehicle-yr (see Control D.2).
3. Number of vehicles in source categories AAA47464, AAA54387, and AAA54411 (see Cost Calculation D.17) is estimated to be 226,346 from California Air Resources Board (1984) data.
4. Catalyst cost: (\$60.86/vehicle-yr) (226,346 vehicles) = 13.775 X 10^6\$/yr.

Total Cost = 1.840 + 13.775 = 15.615 X 10^6\$/yr

Fine TC Reduction: 0.0831 T/day

1. Assume similar emissions reduction as light-duty catalyst use: 90.68% (see Control D.2).
2. Fine total carbon emissions from sources: 0.1196 T/day (SCAB, Table C.1).
3. Controllable sources account for 76.6% of this source class (see Cost Calculation D.17).

Reduction = (0.9068) (0.766) (0.1196 T/day) = 0.0831 T/day

TC fraction reduction = (0.9068) (0.766) = 0.6946
EC fraction reduction = (0.8031) (0.766) = 0.6152 (see Control D.2)

Control Measure D.19

Use of 0.10%S Residual Oil by Utilities

Sources Affected: 23

Cost: 30.442×10^6\$/yr

1. Difference in price between 0.25%S and 0.10%S residual oil is estimated to be \$4.41/bbl or \$701.45/10^9 Btu from Energy Information Administration (Monthly Petroleum Price Report, Dec. 1982 and Annual Energy Review, 1982) and data from Robert Elrod (1985) of Southern California Edison Co.
2. SCAB 1982 fuel use: 118.9×10^9 Btu/day (from Table C.2).

Total Cost = (\$701.45/10^9 Btu) (118.9×10^9 Btu/day) (365 day/yr)
= 30.442×10^6\$/yr

Fine TC Reduction: 0.1232 T/day

1. Assume particulate emissions are in proportion to sulfur content, based on observations by Taback et al. (1979). This gives a reduction of 60%.
2. Fine total carbon emissions from sources: 0.2054 T/day (SCAB, Table C.2).

Reduction = (0.60) (0.2054 T/day) = 0.1232 T/day

TC fraction reduction = 0.60
EC fraction reduction = 0.60

Conflicts: D.34

Control Measure D.20

Use of 0.10%S Residual Oil by Refineries

Sources Affected: 28

Cost: 1.367×10^6 \$/yr

1. Difference in price between 0.25%S and 0.10%S residual oil is estimated to be \$701.45/10^9 Btu (see Control D.19).
2. SCAB 1982 fuel use: 5.34×10^9 Btu/day (from Table C.2).

Total Cost = (\$701.45/10^9 Btu) (5.34×10^9 Btu/day) (365 day/yr)
= 1.367×10^6 \$/yr

Fine TC Reduction: 0.0056 T/day

1. Assume particulate emissions are in proportion to sulfur content, based on observations by Taback et al. (1979). This gives a reduction of 60%.
2. Fine total carbon emissions from sources: 0.0094 T/day (SCAB, Table C.2).

Reduction = (0.60) (0.0094 T/day) = 0.0056 T/day

TC fraction reduction = 0.60
EC fraction reduction = 0.60

Conflicts: D.35

Control Measure D.21

Use of 0.25%S Residual Oil in Industrial Boilers

Sources Affected: 31

Cost: 0.445×10^6 \$/yr

1. Difference in price between 0.50%S and 0.25%S residual oil is estimated to be \$1.89/bbl or \$300.62/10^9 Btu from Energy Information Administration (Monthly Petroleum Price Report, Dec. 1982 and Annual Energy Review, 1982) and data from Robert Elrod (1985) of Soutern California Edison Co. Assume that this price difference is representative of the price difference between fuel oil in the range [0.25%S to 0.50%S] vs. oil meeting [$\leq$ 0.25%S] specifications.
2. Approximately 53% of residual oil used in industrial boilers is in the range 0.25% $\leq$ %S $\leq$ 0.50%, from industrial fuel use survey (South Coast Air Quality Management District 1983).
3. SCAB 1982 fuel use: 7.65×10^9 Btu/day (from Table C.2).

$$\text{Total Cost} = (0.53)\ (\$300.62/10^9\ \text{Btu})\ (7.65 \times 10^9\ \text{Btu/day}) \times (365\ \text{day/yr}) = 0.445 \times 10^6\ \$/\text{yr}$$

Fine TC Reduction: 0.0047 T/day

1. Assume particulate emissions are in proportion to sulfur content, based on observations by Taback et al. (1979). This gives a reduction of 50% in emissions for 50% reduction in fuel sulfur content.
2. Control is only operative on 53% of residual oil use (see note [2], above).
3. Fine total carbon emissions from sources: 0.0135 T/day (SCAB, Table C.2). Controllable carbon emissions:

$$(0.0135\ \text{T/day}) \left(\frac{0.53/0.5}{0.47 + 0.53/0.5}\right) = 0.0094\ \text{T/day}.$$

$$\text{Reduction} = (0.50)\ (0.0094\ \text{T/day}) = 0.0047\ \text{T/day}$$

TC fraction reduction = 0.3464
EC fraction reduction = 0.3464

Conflicts: D.22, D.36

Control Measure D.22

Use of 0.10%S Residual Oil in Industrial Boilers

Sources Affected: 31

Cost: 2.404×10^6\$/yr

1. Cost for getting all industries down to 0.25%S: 0.445×10^6\$/yr (see Control D.21).
2. Difference in price between 0.25%S and 0.10%S residual oil is \$701.45/10^9 Btu (see Control D.19) (assumed to represent price increase for reducing maximum allowable sulfur content from 0.25%S to 0.10%S).
3. SCAB 1982 fuel use: 7.65×10^9 Btu/day (from Table C.2).

Total Cost = (\$701.45/10^9 Btu) (7.65×10^9 Btu/day) (365 day/yr) + 0.445×10^6\$/yr = 2.404×10^6\$/yr

Fine TC Reduction: 0.0100 T/day

1. Assume particulate emissions are in proportion to sulfur content, based on observations by Taback et al. (1979). This gives an emissions reduction of 60% (for sulfur content reduction from 0.25%S to 0.10%S).
2. Reduction achieved from getting all industries down to 0.25%S: 0.0047 T/day (see Control D.21).
3. Fine total carbon emissions from sources: 0.0135 T/day (SCAB, Table C.2).

Reduction = 0.0047 T/day + (0.60) [(0.0135 - 0.0047) T/day]
= 0.0100 T/day

TC fraction reduction = 0.7386
EC fraction reduction = 0.7386

Conflicts: D.21, D.36

Cost Calculation D.23

Unleaded Gasoline Use in Large Industrial IC Engines

Sources Affected: 35

Cost: 0.060×10^6 \$/yr

1. Difference in retail price between unleaded and leaded gas: \$536.20/10^9 Btu (see Control D.1).
2. SCAB 1982 fuel use: 5.16×10^9 Btu/day (from Table C.2).
3. This measure is operable on industrial IC engines (pt. source category 20200301; see Table A.10; source 35). The industrial IC engine source class in emission inventory of Table C.2 includes many types of small gasoline engines that are too small to merit consideration. Large engines which might be considered for control account for only 5.94% of the emissions stated in Table C.2 (from Ranzieri 1983). The fuel use that could be controlled is assumed to be (0.0594) (5.16×10^9 Btu/day) = 0.307×10^9 Btu/day.

Total Cost = (\$536.20/10^9 Btu) (0.307×10^9 Btu/day) (365 day/yr)
= 0.060×10^6 \$/yr

Purpose:

This is not a control measure for aerosol carbon emission reduction. The cost of unleaded fuel is needed in order to evaluate Control Measure D.24 which involves replacement of non-catalyst industrial IC engines by catalyst equipped engines.

Control Measure D.24

Catalysts on Gasoline Large Industrial IC Engines

Sources Affected: 35

Cost: 0.113 $\times$ 10^6\$/yr

1. Unleaded fuel must be used. Cost: 0.060 $\times$ 10^6\$/yr (see Cost Calculation D.23).
2. The number of industrial gasoline IC engines is not known exactly. Assume same average heat input per engine as diesel industrial IC engines. From Control D.26, there were 9671 diesel units in the SCAB, 1982, consuming fuel at a rate of 7.00 $\times$ 10^9 Btu/day, so number of gasoline industrial IC engines in pt. source category 20200301 (see Cost Calculation D.23) is estimated to be (0.307/7.00) (9671 units) = 424 units.
3. Assuming catalysts used are similar to those used for medium/heavy vehicles. Annual cost of catalyst is \$124.79/unit-yr (see Control D.7).

Total Cost = (\$124.79/unit-yr) (424 units) + 0.060 $\times$ 10^6\$/yr
= 0.113 $\times$ 10^6\$/yr

Fine TC Reduction: 0.0013 T/day

1. Assume similar emissions reduction as medium/heavy-duty catalyst use: 90.68% (see Control D.7).
2. Fine total carbon emissions from sources: 0.0240 T/day (SCAB, Table C.2).
3. Controllable sources account for 5.94% of this source class (see Cost Calculation D.23).

Reduction = (0.9068) (0.0594) (0.0240 T/day) = 0.0013 T/day

TC fraction reduction = (0.9068) (0.0594) = 0.0539
EC fraction reduction = (0.8031) (0.0594) = 0.0477 (see Control D.2)
(Reduction is relative to entire source category of industrial gasoline IC engines shown in Table C.2.)

Control Measure D.25

#1 Diesel Fuel Use in Diesel Industrial IC Engines

Sources Affected: 36

Cost: 1.566×10^6 \$/yr

1. Diesel price difference: \$612.9/10^9 Btu (see Control D.3).
2. SCAB 1982 fuel use: 7.00×10^9 Btu/day (from Table C.2).

Total Cost = (\$612.9/10^9 Btu) (7.00×10^9 Btu/day) (365 day/yr)
= 1.566×10^6 \$/yr

Fine TC Reduction: 0.0057 T/day

1. Assumed 20% reduction (see Control D.3).
2. Fine total carbon emissions from sources: 0.0286 T/day (SCAB, Table C.2).

Reduction = (0.20) (0.0286 T/day) = 0.0057 T/day

TC fraction reduction = 0.20
EC fraction reduction = 0.20

Conflicts: D.26, D.27

Control Measure D.26

Particle Traps on Diesel Industrial IC Engines

Sources Affected: 36

Cost: 4.796×10^6 \$/yr

1. Number of diesel IC engines in this source category in the SCAB, 1982, estimated to be 9671 units (data on number of units in 1979 from California Air Resources Board [1984], emission factors from Grisinger [1982], and 1982 emissions inventory from Ranzieri [1983]).
2. Assume traps used are similar to those used for heavy-duty diesel engines. From Control D.15, the annual cost (including capital cost, maintenance, and replacement costs) is estimated to be \$446.19/unit-yr.
3. SCAB 1982 fuel use for industrial IC engines: 7.00×10^9 Btu/day (from Table C.2) or 18.5×10^6 gal/yr. Assuming a loss in fuel economy due to the particle trap of 2%, and \$1.30/gal, this gives additional fuel cost of 0.481×10^6 \$/yr.

Total Cost = (\$446.19/unit-yr) (9671 units) + 0.481×10^6 \$/yr
= 4.796×10^6 \$/yr

Fine TC Reduction: 0.0257 T/day

1. Assume 90% efficient control (similar to heavy-duty trucks--see Control D.9).
2. Fine total carbon emissions from sources: 0.0286 T/day (SCAB, Table C.2).

Reduction = (0.90) (0.0286 T/day) = 0.0257 T/day

TC fraction reduction = 0.90
EC fraction reduction = 0.90

Conflicts: D.25, D.27

Control Measure D.27

Particle Traps & #1 Fuel in Diesel Industrial IC Engines

Sources Affected: 36

Cost: 6.362×10^6 \$/yr

1. Cost of #1 diesel fuel: 1.566×10^6 \$/yr (see Control D.25).
2. Particle trap system cost: 4.796×10^6 \$/yr (see Control D.26).

Total Cost = $1.566 + 4.796 = 6.362 \times 10^6$ \$/yr

Fine TC Reduction: 0.0263 T/day

1. 20% reduction due to #1 diesel fuel use (see Control D.3).
2. Additionally, 90% of the remaining 80% is removed by trap (see Control D.9).
3. Fine total carbon emissions from sources: 0.0286 T/day (SCAB, Table C.2).

Reduction = (0.0286 T/day) [0.20 + 0.90 (0.80)] = 0.0263 T/day

TC fraction reduction = 0.92
EC fraction reduction = 0.92

Conflicts: D.25, D.26

Control Measure D.28

Use of 0.25%S Residual Oil by Residential/Commercial

Sources Affected: 39

Cost: 3.094×10^6 \$/yr

1. Difference in price between 0.50%S and 0.25%S residual oil is \$300.62/10^9 Btu (see Control D.21).
2. SCAB 1982 fuel use: 28.2×10^9 Btu/day (from Table C.2).

Total Cost = (\$300.62/10^9 Btu) (28.2×10^9 Btu/day) (365 day/yr)
= 3.094×10^6 \$/yr

Fine TC Reduction: 0.0248 T/day

1. Assume particulate emissions are in proportion to sulfur content, based on observations by Taback et al. (1979). This gives a reduction of 50%.
2. Fine total carbon emissions from sources: 0.0496 T/day (SCAB, Table C.2).

Reduction = (0.50) (0.0496 T/day) = 0.0248 T/day

TC fraction reduction = 0.50
EC fraction reduction = 0.50

Conflicts: D.37

Control Measure D.29

Paved Road Flushing

Sources Affected: 61

Cost: 430.689×10^6 \$/yr

1. 1983 flusher truck cost: \$84.47/street mile from Yamanishi (1983).
2. Equivalent street mileage in 4-county SCAB: 42,276 miles (road mileage data from Higgins [1982] and Black [1982]; It was assumed that freeways have as many lanes as 5 surface streets, thus freeway mileage was multiplied by 5 before being added to surface streets to arrive at this total).
3. Assume streets are flushed every third day.
4. Deflate 1983 price by 0.341/0.344 to get 1982 dollars from Consumer Price Index (Department of Labor 1985).

$$\text{Total Cost} = (\$84.47/\text{mile})\ (42{,}276\ \text{miles})\ \left(\frac{1}{3\ \text{days}}\right)\ (365\ \text{day/yr})$$
$$\times\ (\ 0.341/0.344\ ) = 430.689 \times 10^6\ \$/\text{yr}$$

Fine TC Reduction: Not computed

1. 68.1% control efficiency for fine particulate emissions from Cuscino et al. (1982).
2. Road dust contribution to ambient air quality was determined by receptor modeling approach (see Chapter 4, Section 4.2.1). Fraction reduction for control is applied directly to ambient road dust concentration contribution estimate at each monitoring site to determine effect of control measure. (Applying this control measure to the original estimate of road dust emissions from Ranzieri [1983] gives a fine TC reduction of (0.681) (6.4542 T/day) = 4.3953 T/day; see Table C.4.)

TC fraction reduction = 0.681
EC fraction reduction = 0.681
(Fraction is applied directly to air quality contribution.)

Conflicts: D.30

Control Measure D.30

Paved Road Flushing and Broom Sweep

Sources Affected: 61

Cost: 556.628×10^6 \$/yr

1. 1983 flusher truck cost: \$84.47/street mile from Yamanishi (1983).
2. 1983 broomsweeping cost: \$12.35 per curb-mile or \$24.70/street mile from Yamanishi (1983).
3 Equivalent street mileage in 4-county SCAB: 42,276 miles (see Control D.29)
4. Assume streets are flushed and broomswept every three days.
5. Deflate 1983 price by 0.341/0.344 to get 1982 dollars from Consumer Price Index (Department of Labor 1985).

$$\text{Total Cost} = [(\$84.47 + \$24.70)/\text{mile}]\ (42{,}276 \text{ miles})\ \left(\frac{1}{3 \text{ days}}\right)$$
$$\times\ (365 \text{ day/yr})\ (\ 0.341/0.344\ ) = 556.628 \times 10^6 \$/\text{yr}$$

Fine TC Reduction: Not computed

1. 71.8% control efficiency for fine particulate emissions from Cuscino et al. (1982).
2. Road dust contribution to ambient air quality was determined by receptor modeling approach (see Chapter 4, Section 4.2.1). Fraction reduction for control is applied directly to ambient road dust concentration contribution estimate at each monitoring site to determine effect of control measure. (Applying this control measure to the original estimate of road dust emissions from Ranzieri [1983] gives a fine TC reduction of (0.718) (6.4542 T/day) = 4.6341 T/day; see Table C.4.)

TC fraction reduction = 0.718
EC fraction reduction = 0.718
(Fraction is applied directly to air quality contribution.)

Conflicts: D.29

Control Measure D.31

Radial Tire Use on Light-duty Vehicles

Sources Affected: 62

Cost: $0

Radial tires have higher cost but wear proportionately longer than bias-ply tires.

Fine TC Reduction: 0.1167 T/day

1. Approximately 70% of tires on road in 1982 were radials (domestic passenger cars) from Standard & Poor's Corporation (1981).
2. 50% longer life from Firestone Study in Standard & Poor's Corporation (1981) implies 1/3 reduction in emissions rate.
3. Tire attrition from light-duty vehicles accounts for 77.26% of the tire wear in the SCAB (see TableA.7).
4. Fine total carbon emissions from sources: 1.170 T/day (SCAB, Table C.4).
5. Current bias-ply total fine carbon emissions from light-duty vehicles:

$$(0.7726)\ (1.170\ \text{T/day})\ \left(\frac{0.30 \times 1.5}{(0.30 \times 1.5) + 0.70}\right) = 0.3537\ \text{T/day}.$$

Reduction = (0.33) (0.3537 T/day) = 0.1167 T/day

TC fraction reduction = 0.0998
EC fraction reduction = 0.0998

Control Measure D.32

Use of Gas Logs in Fireplaces

Sources Affected: 65

Cost: 23.897×10^6 \$/yr

1. Approximate cost of new gas log unit: \$200 (typical middle range price of gas log set, with installation; quoted at Floyd S. Lee, Pasadena, 1985). Assume ten-year payback period at 10% interest, giving a capital recovery factor of 0.16275.
2. Number of residences burning wood in SCAB is 977,568 (see Table A.9).

Gas log fireplace cost = (0.16275/yr) (977,568 residences) $\times$ (\$200/residence) = 31.820×10^6 \$/yr

3. Assume natural gas use replaces logs at same energy level, i.e., same number of Btu/year.
   Hardwood: 246,677 cords/yr (see Table A.9) $\times$ 30.4×10^6 Btu/cord (Baumeister et al. 1978, p. 7-19) = 7499.0×10^9 Btu/yr.
   Softwood: 241,729 cords/yr (see Table A.9) $\times$ 26.0×10^6 Btu/cord (Baumeister et al. 1978, p. 7-19) = 6285.0×10^9 Btu/yr.

Natural gas cost = $13,783.93 \times 10^9$ Btu/yr $\times$ \$3500/10^9 Btu = 48.244×10^6 \$/yr

(Natural gas price estimated from author's home utility bill.)

4. Assume half the wood burned is purchased as firewood. Approximate 1985 cost of cord of firewood is \$230/cord (quote from Glatts Lumber, Pasadena, August 1985).

Firewood cost savings = (488,406 cords/yr) (0.50) (\$230/cord) = 56.167×10^6 \$/yr

Total Cost = 31.820 + (48.244 - 56.167) = 23.897×10^6 \$/yr

Control Measure D.32 (continued)

Fine TC Reduction: 4.2394 T/day

1. Fine total carbon emissions factors:
   Residential natural gas: 0.8898 kg/10^9 Btu (see Table A.2).
   Fireplace: 113.15 kg/10^9 Btu (see Table A.4).
2. Fine total carbon emissions from sources: 4.2730 T/day (SCAB, Table C.4).

Reduction = (4.2730 T/day) (1 - 0.8898/113.15) = 4.2394 T/day

TC fraction reduction = 0.9921
EC fraction reduction = 1 - (0.33) (1 - 0.9921)/(0.1711) = 0.9847

Control Measure D.33

Charcoal Broiler Control

Sources Affected: 68

Cost: 4.370×10^6 $/yr

1. Approximate cost of mist eliminator system for typical charbroiler facility (i.e., "The Conqueror" manufactured by Hardee's Food Systems) is between $4500 and $5500 (includes installation) from Stahl (1985). Assume $5000 per facility. Assume five-year payback period at 10% interest which gives a capital recovery factor of 0.26380. Then annual capital cost is $1319.00/yr.
2. Maintenance cost is approximately $1000–1500/year from Stahl (ibid.). Assume $1250/year.
3. The number of charcoal broilers in the South Coast Air Basin, 1982, is calculated to be 1701 from California Air Resources Board data (Ranzieri 1983) on total particulate emissions of 6342.0 kg/day (see Table C.4) divided by the CARB emission factor of 3000 lb/facility (Grisinger 1982).

Total Cost = (1701 facilities) ($1319/yr + $1250/yr)/facility
= 4.370×10^6 $/yr

Fine TC Reduction: 4.8541 T/day

1. Mist eliminator (i.e., "The Conqueror" manufactured by Hardee's Food Systems) removes 93% of particulate by weight (from Bornstein 1978 and Stahl 1985).
2. Fine total carbon emissions from sources: 5.2195 T/day (SCAB, Table C.4).

Reduction = (0.93) (5.2195) = 4.8541 T/day

TC fraction reduction = 0.93
EC fraction reduction = 0.93

Control Measure D.34

Substitute Natural Gas for Residual Oil in Utility Boilers

Sources Affected: 23

Cost: $0 (savings to utilities if natural gas is available)

1. Natural gas price is approximately $\$5000/10^9$ Btu from Robert Elrod (1985) of Southern California Edison Co.
2. Residual oil price (0.25%S) is estimated to be $33.39/bbl = $\$5310.96/10^9$ Btu from Energy Information Administration (1982) data and data from Robert Elrod (1985).
3. SCAB 1982 residual fuel oil use: 118.9×10^9 Btu/day (from Table C.2).

$$\text{Savings} = [(5310.96 - 5000.00)\$/10^9 \text{ Btu}]\ (118.9 \times 10^9 \text{ Btu/day}) \times (365 \text{ day/yr}) = 13.495 \times 10^6 \$/\text{yr}$$

Fine TC Reduction: 0.1971 T/day

1. Fine total carbon emission factors for utility boiler fuels:
   Natural gas: 0.0696 $kg/10^9$ Btu (see Table A.2).
   Residual oil: 1.7271 $kg/10^9$ Btu (see Table A.2).
2. Fine total carbon emissions from sources: 0.2054 T/day (SCAB, Table C.2).

$$\text{Reduction} = (0.2054 \text{ T/day})\ (1 - 0.0696/1.7271) = 0.1971 \text{ T/day}$$

TC fraction reduction = 0.9597
EC fraction reduction = 1.0000 (see Table A.2, note [rr])

Conflicts: D.19

Natural gas resource: 118.9×10^9 Btu/day

Control Measure D.35

Substitute Natural Gas for Residual Oil in Refineries

Sources Affected: 28

Cost: $0 small savings (see Control D.34)

Fine TC Reduction: 0.0063 T/day

1. Fine total carbon emission factors for refinery boiler fuels:
   Natural gas: 0.5841 kg/10^9 Btu (see Table A.2).
   Residual oil: 1.7606 kg/10^9 Btu (see Table A.2).
2. Fine total carbon emissions from sources: 0.0094 T/day (SCAB, Table C.2).

Reduction = (0.0094 T/day) (1 - 0.5841/1.7606) = 0.0063 T/day

TC fraction reduction = 0.6682
EC fraction reduction = 1.0000 (see Table A.2, note [uu])

Conflicts: D.20

Natural gas resource: 5.34 X 10^9 Btu/day

Control Measure D.36

Substitute Natural Gas for Residual Oil in Industrial Boilers

Sources Affected: 31

Cost: $0 small savings (see Control D.34)

Fine TC Reduction: 0.0098 T/day

1. Fine total carbon emission factors for industrial boiler fuels:
   Natural gas: 0.4869 kg/10^9 Btu (see Table A.2).
   Residual oil: 1.7606 kg/10^9 Btu (see Table A.2).
2. Fine total carbon emissions from sources: 0.0135 T/day (SCAB, Table C.2).

Reduction = (0.0135 T/day) (1 - 0.4869/1.7606) = 0.0098 T/day

TC fraction reduction = 0.7235
EC fraction reduction = 1.0000 (see Table A.2, note [rr])

Conflicts: D.21, D.22

Natural gas resource: 7.65 $\times$ 10^9 Btu/day

Control Measure D.37

Substitute Natural Gas for Residual Oil in Residential/Commercial

Sources Affected: 39

Cost: $0 small savings (see Control D.34)

Fine TC Reduction: 0.0245 T/day

1. Fine total carbon emission factors for residential/commercial boiler fuels:
   Natural gas: 0.8898 kg/10^9 Btu (see Table A.2).
   Residual oil: 1.7606 kg/10^9 Btu (see Table A.2).
2. Fine total carbon emissions from sources: 0.0496 T/day (SCAB, Table C.2).

Reduction = (0.0496 T/day) (1 - 0.8898/1.7606) = 0.0245 T/day

TC fraction reduction = 0.4946
EC fraction reduction = 1 - (0.33) (1 - 0.4946)/(0.20) = 0.1577
(see Table A.2 for EC/TC ratios)

Conflicts: D.28

Natural gas resource: 28.2 X 10^9 Btu/day

Table D.38
Source class list correspondence

source classes input to the air quaility model (a)	source types used in emission and control inventories (b)
Mobile Sources	
1 CAT AUTO/LT TRUCKS	1 CATALYST AUTOS 2 CATALYST LT TRUCKS
2 NON-CAT AUTO/LT TRUCK	3 NON-CAT AUTOS 4 NON-CAT LIGHT TRUCKS 5 MOTORCYCLES
3 DIESEL AUTO/LT TRUCK	6 DIESEL AUTOS 7 DIESEL LIGHT TRUCKS
4 MED/HEAVY GAS TRUCKS	8 CATALYST MED TRUCKS 9 NON-CAT MED TRUCKS 10 GAS HEAVY TRUCKS
5 HEAVY DIESEL TRUCKS	11 HEAVY DIESEL TRUCKS
6 AIRCRAFT SURFACE	12 AIRCRAFT SURFACE 13 AVIATION GAS
7 AIRCRAFT MIDDLE ALT	14 AIRCRAFT MIDDLE ALT
8 AIRCRAFT HIGH ALT	15 AIRCRAFT HIGH ALT
9 SHIPPING RESID OIL	16 SHIPPING RESID OIL
10 SHIPPING DIST OIL	17 SHIPPING DIST OIL
11 RAILROAD DIESEL	18 RAILROAD DIESEL
12 OFF-ROAD DIESEL	19 OFF-ROAD DIESEL
13 OFF-ROAD GASOLINE	20 OFF-ROAD GASOLINE

(a) These are the 47 source classes input to the air quality model (see Chapter 4). Source types within each source class have similar emission characteristics.

(b) These are the 74 source types identified in the emission inventory (Tables A.1 through A.4) and the control strategy inventory (Tables D.1 through D.37).

Table D.38 (continued)

source classes input to the air quaility model	source types used in emission and control inventories
Stationary Combustion Sources	
14 UTILITIES ALL FUELS	21 UTILITIES BOILER NG
	22 UTILITIES TURBINE NG
	23 UTILITIES RESID OIL
	24 UTILITIES DISTILLATE
	25 UTILITIES DIGAS
15 REFINERIES ALL FUELS	26 REFINERIES NAT GAS
	27 REFINERIES REF GAS
	28 REFINERIES RESID OIL
16 INDUSTRIAL BOILERS	29 INDUS BOILERS NG
	30 INDUS BOILERS LPG
	31 INDUS BOILERS RESID
	32 INDUS BOILERS DIST
	33 INDUS BOILERS COG
17 INDUSTRIAL IC ENGINE	34 INDUS IC DIGAS
	35 INDUS IC GASOLINE
	36 INDUS IC DISTILLATE
18 RES/COMM ALL FUELS	37 RES/COMM NAT GAS
	38 RES/COMM LPG
	39 RES/COMM RESID OIL
	40 RES/COMM DISTILLATE
	41 RES/COMM COAL

Table D.38 (continued)

source classes input to the air quaility model	source types used in emission and control inventories
Stationary Industrial Process Sources (c)	
19 PETRO FCCU	42 PETRO FCCU
20 PETRO OTHER	43 PETRO OTHER
21 ORG SOLV COAT/PRINT	44 ORGANIC SOLVENT COAT 45 ORGANIC SOLVENT PRNT
22 ORG SOLV OTHER	46 ORG SOLV DEGREASING 47 ORGANIC SOLV OTHER
23 CHEMICAL	48 CHEMICAL ORGANIC
24 PRIMARY METALS	49 PRIMARY METALS
25 SECONDARY METALS	50 SECONDARY METALS
26 MINERAL	51 MINERAL
27 WASTE BURNING	52 WASTE BURNING
28 WOOD PROCESSING	53 WOOD PROCESSING
29 ASPHALT ROOFING	54 ASPHALT ROOFING
30 RUBBER/PLASTICS	55 RUBBER/PLASTICS
31 COKE CALCINER	56 COKE CALCINER
32 MISC INDUSTRIAL	57 MISC:FOOD AND AGRI 58 MISC:TEXTILE 59 MISC:INDUSTRIAL

(c) For the correspondence between source types used in this study and California Air Resources Board category of emission source (CES, SCC) numbers, see Table A.10.

Table D.38 (continued)

source classes input to the air quaility model	source types used in emission and control inventories
Fugitive Sources (c)	
33 LIVESTOCK DUST	60 LIVESTOCK DUST
34 PAVED ROAD DUST	61 PAVED ROAD DUST
35 TIRE ATTRITION	62 TIRE ATTRITION
36 BRAKE LIN ATTRITION	63 BRAKE LIN ATTRITION
37 STRUCTURAL FIRES	64 STRUCTURAL FIRES
38 FIREPLACES	65 FIREPLACES
39 CIGARETTES	66 CIGARETTES
40 AGRI BURNING	67 AGRI BURNING
41 CHARCOAL BROILERS	68 CHARCOAL BROILERS
42 ROOFING TAR POTS	69 ROOFING TAR POTS
43 CHEMICAL INORGANIC	70 CHEMICAL INORGANIC
44 METAL FABRICATION	71 METAL FABRICATION
44 ROAD/BLDNG CONST	72 ROAD/BLDNG CONST
46 AGRI TILLING	73 AGRI TILLING
47 UNPAVED ROAD	74 UNPAVED ROAD

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APPENDIX E

FINE PARTICLE CONCENTRATIONS AT ELEVEN LOCATIONS IN THE SOUTH COAST AIR BASIN DURING 1982

Appendix E contains the results of the air quality monitoring program conducted in the Los Angeles area during 1982 (see Chapter 2). The locations monitored were Azusa, Burbank, Long Beach, Lennox, Pasadena, West Los Angeles, Los Angeles (central), Upland, Rubidoux, Anaheim, and San Nicolas Island. A 24-hour sample was collected at each location on every sixth day in conjunction with the NASN sampling schedule. Tabulated in this appendix are the daily average concentrations (and error bounds) for the following fine (d_p < 2.1 μm) aerosol species: Total mass, organic carbon, elemental carbon, NO_3^-, $SO_4^=$, NH_4^+, Al, Si, P, S, Cl, K, Ca, Ti, V, Cr, Mn, Fe, Ni, Cu, Zn, Ga, As, Se, Br, Rb, Sr, Y, Zr, Mo, Pd, Ag, Cd, In, Sn, Sb, Ba, La, Hg, and Pb. Also included are the daily fine particle fractions of total mass, $SO_4^=$, NO_3^-, and Pb which were obtained by dividing the fine aerosol concentrations by the corresponding species concentration found in the total suspended particulate matter data reported by the South Coast Air Quality Management District, El Monte, California (all locations except Burbank, Upland, and San Nicolas Island). Monthly and annual averages of these values are also tabulated. Throughout this appendix, missing data are indicated by the value -10.0 or -9.9.

Appendix E and Appendix F are contained in a separate volume. The data are available by contacting the Environmental Quality Laboratory, Caltech, Pasadena, California 91125.

APPENDIX F

SOURCE CLASS CONTRIBUTIONS TO 1982 ANNUAL AVERAGE CARBON PARTICLE AIR QUALITY

Appendix F contains the contributions to fine total carbon and fine elemental carbon concentrations at seven receptor sites from each of 74 source classes, as computed by the air quality model (see Chapter 4). Estimates of emissions are also presented for each source class (see Appendix A and Appendix C).

Appendix E and Appendix F are contained in a separate volume. The data are available by contacting the Environmental Quality Laboratory, Caltech, Pasadena, California 91125.