Final report prepared for the California Air Resources Board
and the California Environmental Protection Agency

Determination of the Elemental Carbon, Organic Compounds, and Source Contributions to Atmospheric Particles during the Southern California Children's Health Study

Part A: Organic and Elemental Carbon Particle Concentrations During the Southern California Children's Health Study, 1994-1998

Contract Number 98-320

Lynn G. Salmon, Kimberly A. Mertz, Paul R. Mayo, and Glen R. Cass

Environmental Engineering Science Department
California Institute of Technology
Pasadena, CA 91125

May, 2001

Disclaimer

Acknowledgments

This Report was submitted in partial fulfillment of ARB contract number 98-320 and project title, "Determination of the Elemental Carbon, Organic Compounds, and Source Contributions to Atmospheric Particles during the Southern California Children's Health Study," by the California Institute of Technology under the sponsorship of the California Air Resources Board. Work was completed as of December, 2000.

Table of Contents

Acknowledgments ii

Table of Contents iii

List of Figures iv

Abstract 1

Executive Summary 1

0.1 Background 1

0.2 Methods 1

0.3 Results 2

0.4 Conclusions 2

1 Introduction 2

2 Experimental Procedures 5

3 Results and Discussion 8

3.1 Particle size cut determination 8

3.2 OC/EC concentration data during 1994-1998 8

3.3 Mass balance 12

4 References 26

Appendix 28

List of Figures

Figure 1 – Southern California Children's Health Study ambient air quality monitoring sites.

Figure 2 – Time series of 2-week average elemental carbon concentrations found in Southern California.

Figure 3 – Time series of 2-week average elemental carbon concentrations found in Southern California.

Figure 4 – Time series of 2-week average organic carbon concentrations found in Southern California.

Figure 5 – Time series of 2-week average organic carbon concentrations found in Southern California.

Figure 6 – Material balance on the chemical composition of 1994 annual airborne fine particle concentrations.

Figure 7 – Material balance on the chemical composition of 1995 annual airborne fine particle concentrations.

Figure 8 – Material balance on the chemical composition of 1996 annual airborne fine particle concentrations.

Figure 9 – Material balance on the chemical composition of 1997 annual airborne fine particle concentrations.

Figure 10 – Material balance on the chemical composition of 1998 annual airborne fine particle concentrations.

Figure 11 – Annual average fine particle chemical compositions at all sites during 1994-1998.

Abstract

A network of air monitoring sites have been operating as part of the Southern California Children's Health Study since 1994. Concentrations of fine particle mass and ions, as well as gas-phase acids, have been measured continuously since 1994. This report presents the particulate organic carbon (OC) and elemental carbon (EC) concentrations measured during the first five years of this monitoring program. The OC/EC data show seasonal and annual trends as well as spatial trends in carbon particle concentrations across the southern half of California. These data will assist the Children's Health Study investigations in the interpretation of their health effects data.

Executive Summary

0.1 Background

Particulate organic carbon (OC) and elemental carbon (EC) concentrations are measured at thirteen air monitoring sites in the southern half of the state of California over the 5-year period 1994-1998. These air monitoring sites are part of the network that supports the Southern California Children's Health Study, a large epidemiological investigation of the effects of air pollutant exposure on respiratory disease within a population of more than 3600 California school children. Other pollutants measured are ozone, nitrogen dioxide, PM_{10} mass, $PM_{2.5}$ mass and ions (chloride, nitrate, sulfate, ammonium) and gas-phase acids (hydrochloric, nitric, formic, acetic). The communities studied range from mountainous (Alpine, Lake Arrowhead) to desert (Lancaster) to rural near-coastal areas (Lompoc, Santa Maria) to sites such as Long Beach, Glendora and San Dimas within the Los Angeles County urban area plus Mira Loma and Riverside in the urban plume downwind of the Los Angeles-Long Beach area.

0.2 Methods

Organic and elemental carbon particle samples were collected on quartz fiber filters through which ambient air was drawn for two weeks. After each two week interval, new quartz fiber filters were installed at each sampling location in the Children's Health Study sampling network. The quartz fiber filters were analyzed for OC and EC content by thermal evolution and combustion. Because the carbon particle sampler did not have a defined size cut, a separate side-by-side sampling experiment was conducted to determine the effective size cut of the Two-Week Sampler using reference samplers having known size cuts. This experiment generated correction factors that were used to estimate the fine particle $PM_{2.5}$ concentrations of the Two-Week Sampler data.

0.3 Results

Annual average PM_{10}-equivalent elemental (black) carbon particle concentrations range from 0.05 - 1.74 $\mu g\ m^{-3}$ over the communities and years studied while annual average organic carbon concentrations are in the range 1.50 - 15.67 $\mu g\ m^{-3}$. The coastal sites generally show winter season EC and OC concentration peaks while the mountainous and some inland sites show summer seasonal peaks; both conditions are consistent with seasonal changes in wind direction and mixing depth. Carbonaceous aerosols account for 32 to 60 percent of fine particle concentrations between the sites studied. The overall fine particle concentrations show a coherent spatial pattern with very low mass concentrations (circa 5-8 $\mu g\ m^{-3}$) and aerosol carbon concentrations at the northern and southern-most monitoring sites, reaching the highest annual average concentration of 35.8 $\mu g\ m^{-3}$ $PM_{2.5}$ mass including 14.7 $\mu g\ m^{-3}$ organic compound mass in 1995 at Mira Loma downwind of the Los Angeles-Long Beach urban complex. Over the period 1994-1998 there is a pronounced downward trend in annual average fine particle mass and carbonaceous aerosol concentrations at the urban sites. The relative chemical composition of the aerosol did not change appreciably over that same period of time. Since all aerosol components are affected about equally the cause of the downward concentration trend could be due in part to greater atmospheric dilution in the more recent years. Some of the decline in aerosol components between 1994-1998 could possibly be due to the introduction of cleaner-burning gasoline and continued improvements in vehicle emissions.

0.4 Conclusions

The organic and elemental carbon particle data show seasonal and annual trends as well as spatial trends in carbon particle concentrations across the southern half of California. These data will assist the Children's Health Study investigations in the interpretation of their health effects data.

1 Introduction

Organic and elemental carbon particles constitute a large fraction of the fine particulate mass in the atmosphere. (Gray et al., 1986; Solomon et al., 1988; Hannigan et al., 1996, Kaplan and Gordon, 1994). Epidemiological studies have found an association between human health effects and fine particle concentrations (Dockery et al., 1993; Pope et al., 1995ab). Particular organic compounds likewise have been identified as a possible health hazard; for example, PAHs have been shown to be carcinogenic in animals (Seinfeld and Pandis, 1998). Airborne carbon particles also lead to reduced visibility via the process of light scattering and absorption (Larson et al., 1989).

Fine particle elemental carbon (EC), also referred to as black carbon, is only produced in combustion processes. Particulate organic carbon (OC) is emitted directly from combustion processes, from industrial processes, and from fugitive area-wide sources; OC also can be formed by atmospheric chemical reactions (secondary formation). Atmospheric carbon particle sources include gasoline and diesel powered vehicle exhaust, meat cooking, fireplaces, paved road dust, forest fires, spray painting, cigarette smoke, and a host of other sources. Although most air pollutant concentrations (including EC) in the Los Angeles area atmosphere have decreased in recent years, OC concentrations have not declined and in some locations OC concentrations have even increased in studies done in 1982-1993 (Christoforou et al., 2000). This difficulty in reducing OC concentrations can be attributed to the increase in population in the region and the corresponding increase in the emissions from residential and commercial area-wide sources, as well as the increase in the number of vehicle miles traveled.

Past studies of fine particle composition and concentration in Southern California have largely focused on the Los Angeles Basin and have not included sites further north and south. The inclusion of such sites would provide a broader picture of the spatial and temporal trends in various pollutant concentrations, including OC and EC.

Beginning in 1994, filter samples were collected for fine particle mass, ions, and elemental and organic carbon analysis as part of the Southern California Children's Health Study (Peters et al., 1999). The Children's Health Study is a 10-year study of the long-term effects of exposure to air pollution in children, organized by researchers at the University of Southern California (USC) under the support of the California Air Resources Board. The concentrations of major pollutants are monitored and the respiratory health of more than 3,600 children is followed. Ongoing research by personnel at USC involves analysis of data on PM_{10} and fine particle mass, nitrate, sulfate, ammonium, and chloride ion concentrations, as well as gas-phase ozone, nitrogen dioxide, formic acid, acetic acid, and nitric acid. Samples are collected in 13 cities throughout Southern California (Alpine, Atascadero, Glendora (beginning mid-1995), Lake Arrowhead, Lake Elsinore, Lancaster, Lompoc, Long Beach, Mira Loma, Riverside, San Dimas (ending 1996), Santa Maria, and Upland), as shown in Figure 1. These sites were selected to represent exposure extremes for one or more pollutants. Among the sites are mountain (Alpine, Lake Arrowhead), desert (Lancaster), and other rural locations (Lompoc, Santa Maria, Atascadero) at which there has previously been no extensive measurement of airborne particle chemical composition. In addition, this study covers a large enough geographical area and a long enough time period to document spatial and temporal trends.

The purposes of this paper are to add the analysis of particulate organic and elemental carbon to the data collected during the Children's Health Study, to present OC/EC concentration data over the first five years of the sampling campaign (1994-1998), to discuss particle size cut issues involving the Two-Week Sampler used for particle collection in that study, and to detail spatial and temporal trends in OC and EC concentrations throughout Southern California in relationship to fine particle mass and other aerosol chemical components.

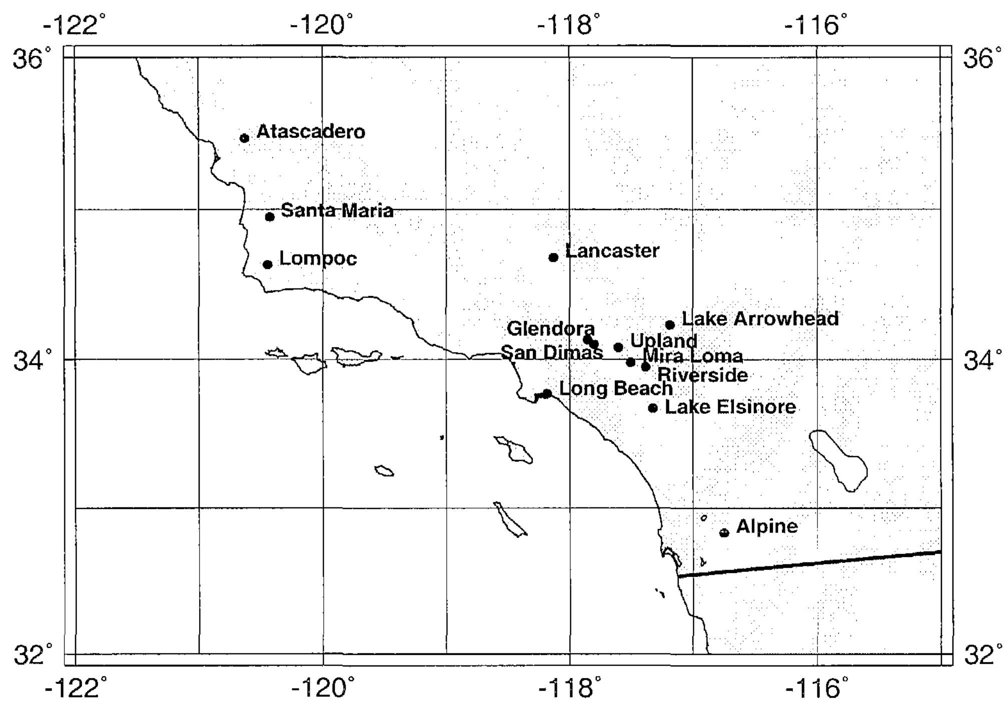


Figure 1: Southern California Children's Health Study ambient air quality monitoring sites.

2 Experimental Procedures

Organic and elemental carbon particle samples were collected on 47 mm diameter, pre-baked quartz fiber filters (Pallflex 2500 QAO) through which ambient air was drawn at a flow rate of 1.3 lpm using the Two-Week sampler designed by Hering (Lurmann et al., 1994). The quartz fiber filters were placed in "Leg C" of the Two-Week Sampler in Savilex Teflon filter holders mounted 2 m above ground level and placed facing downward beneath Teflon hoods to shield them from rain and sun. The samplers were run continuously and filters were collected and replaced at two-week intervals. Following collection, filter samples were placed in annealed foil-lined petri dishes, sealed with Teflon tape, and stored in a freezer prior to analysis. In addition to "Leg C" used for the OC/EC samples, the Two-Week Sampler has two other independent sampling legs including "Leg A" which employs Teflon filters from which fine aerosol mass and ionic species measurements are made. Each Teflon filter is preceded by an oiled impactor in order to deliberately obtain a particle size cut at 2.5 μm particle diameter and thus collect fine particle samples ($PM_{2.5}$) for mass, sulfates, nitrates, chlorides, and ammonium ion. "Leg A" also contains a glass honeycomb denuder coated with sodium carbonate that is analyzed directly by ion chromatography for nitric and hydrochloric acid. "Leg B" of the Two-Week sampler contains a filter pack for the collection of formic and acetic acids.

In order to avoid organics contamination from the anti-bounce coating used in the impactors, the inlet to "Leg C" of the sampler containing the quartz fiber filter for carbon particle analysis consisted solely of a cylindrical tube 6 mm in diameter and 2.5 cm long. To determine the effective size cut of the carbon particle leg of the Two-Week Sampler, side-by-side sampling was conducted for 10 weeks that encompass five 2-week sampling cycles using reference samplers having known size cuts, specifically an open-face filter holder for total suspended particulate matter (TSP) collection, a Sierra-Anderson low volume PM10 sampling head with filters downstream (Solomon et al., 1989), and an AIHL cyclone separator (John and Reischl, 1980) operated to achieve a 2.5 μm diameter particle size cut. Bypass air flows were used to maintain the total air flow through the PM_{10} and cyclone samplers at the correct level. The samplers were placed on the roof of a two-story building located in Pasadena, CA. OC/EC samples were collected on 47 mm diameter pre-baked quartz fiber filters. The $PM_{2.5}$ particle samples were collected with flow rates of 1, 2, and 10 lpm; PM10 particle samples were collected at 1.5 and 10 lpm; and open-face TSP samples were collected at 1 and 2.5 lpm. The $PM_{2.5}$ and PM_{10} samples run at 10 lpm were initially collected and replaced daily in order to provide a comparison between the Two-Week Sampler and a conventional 24-hour average fine particle sampling protocol. Subsequently, the 10 lpm samples were collected weekly for the last 4 weeks of the side-by-side comparison study. All other quartz fiber filters, including those in the Two-Week Sampler, were replaced biweekly.

Quartz fiber filters were analyzed for OC and EC content by the thermal evolution and combustion technique of Birch and Cary (1996). In the thermal-optical organic and elemental carbon concentration measurement method, 1.5 cm^2 rectangular filter punches are first placed in a temperature and atmosphere-controlled oven. The analysis process occurs in two stages. In the first stage, the temperature is raised progressively to approximately 850°C in a pure helium atmosphere in order to volatilize organic carbon from the sample. The volatilized carbon is oxidized catalytically to CO_2, which is then reduced to CH_4. The CH_4 is then quantified using a flame ionization detector (FID). During this process, the filter may darken somewhat due to production of artifact EC by pyrolysis. Elemental carbon measurement and correction for any artifact EC formed by pyrolysis during OC analysis are accomplished during stage two. At the beginning of this second stage of analysis, the oven temperature is initially reduced, a 4% oxygen, 96% helium mixture is introduced, and the temperature is then raised progressively to approximately 900°C. As the black elemental carbon is oxidized and CO_2 is evolved, there is an increase in filter transmittance. In order to correct for any contribution to the elemental carbon present due to OC pyrolysis during stage 1 of the analysis, the amount of EC oxidation necessary to return the filter to its initial transmittance is first measured. The point at which the filter transmittance equals its initial value is taken to be the point at which the actual EC begins to evolve from the sample. Any EC oxidized prior to that point is assumed to be due to OC pyrolysis earlier in the analysis and thus is added to the OC concentration measured in the first step of this analysis.

This analysis method is known as the NIOSH (National Institute of Occupational Safety and Health) protocol and has been employed by our group for nearly 20 years. A second protocol, the IMPROVE (Interagency Monitoring of Protected Visual Environments) protocol is also used for carbon measurements. The analysis method in the IMPROVE protocol is the same as that described above, however, the EC fraction is calculated by allocating part of the OC evolving at 850°C to EC rather than OC. This results in EC values approximately twice as large when the IMPROVE protocol is used. The protocols are equivalent for total carbon, however. For a detailed comparison of the two protocols see Chow et al., (2001).

The effect of long freezer storage time on OC/EC results has been investigated by our laboratory. Samples originally analyzed in 1997 have been stored frozen and new punches were analyzed in 2001 for signs of sample degradation (See Table 1). There is no statistical evidence that results for OC/EC analysis have been affected by freezer storage to date.

Table 1. Effect of freezer storage on OC/EC results of archived samples

Sample Name	Date Analyzed	Organic Carbon (ug cm^{-2})	Elemental Carbon (ug cm^{-2})	Total Carbon (ug cm^{-2})
OG-C-970428	8-01-1997	3.47 ± 0.37	0.29 ± 0.21	3.76 ± 0.49
OG-C-970428	4-16-2001	3.17 ± 0.36	0.21 ± 0.21	3.37 ± 0.47
OG-C-970416	8-01-1997	5.89 ± 0.49	1.18 ± 0.29	7.07 ± 0.65
OG-C-970416	4-20-2001	5.53 ± 0.48	1.14 ± 0.26	6.66 ± 0.63
OG-C-970410	8-01-1997	5.52 ± 0.48	1.49 ± 0.27	7.00 ± 0.65
OG-C-970410	4-16-2001	5.04 ± 0.45	1.13 ± 0.26	6.18 ± 0.61
OG-C-970422	8-01-1997	6.02 ± 0.50	1.73 ± 0.29	7.75 ± 0.69
OG-C-970422	4-16-2001	5.32 ± 0.47	1.48 ± 0.27	6.81 ± 0.64
OG-C-970814	9-30-1997	5.51 ± 0.48	1.11 ± 0.25	6.62 ± 0.63
OG-C-970814	4-16-2001	5.19 ± 0.46	0.62 ± 0.23	5.81 ± 0.59
OG-C-971212	12-30-1997	13.00 ± 0.85	1.21 ± 0.26	14.21 ± 1.01
OG-C-971212	4-16-2001	13.04 ± 0.85	1.27 ± 0.26	14.31 ± 1.02
OG-C-971118	12-29-1997	12.19 ± 0.81	3.80 ± 0.39	15.99 ± 1.10
OG-C-971118	4-16-2001	12.49 ± 0.82	3.50 ± 0.38	15.99 ± 1.10
OCy-C-970430	12-30-1997	5.61 ± 0.48	1.81 ± 0.29	7.42 ± 0.67
OCy-C-970430	4-20-2001	5.30 ± 0.47	1.31 ± 0.27	6.61 ± 0.63
OCy-C-970709	12-31-1997	5.78 ± 0.49	0.38 ± 0.22	6.16 ± 0.61
OCy-C-970709	4-20-2001	5.43 ± 0.47	0.20 ± 0.21	5.63 ± 0.58
ICy-C-970727	12-30-1997	4.63 ± 0.43	0.31 ± 0.22	4.93 ± 0.55
ICy-C-970727	4-20-2001	4.15 ± 0.41	0.25 ± 0.21	4.41 ± 0.52

3 Results and Discussion

3.1 Particle size cut determination

The results of the side-by-side comparison of samplers are presented in Table 2. The PM_{10} sampler run continuously for 2 weeks at 1.5 lpm closely approximated the EC and OC concentrations measured using the Two-Week Sampler. Both the $PM_{2.5}$ and PM_{10} samplers yielded larger OC and EC concentrations when the flow rates were increased to 10 lpm and filters were changed daily. This result can be explained by two factors: (1) increased quartz filter surface area exposed to the air stream when filters are changed daily increasing the potential for positive artifacts in the 24-hour samples, and (2) increased residence time on the sampler leading to increased opportunity for sample evaporation in the case of those samples run continuously for two weeks. This is further illustrated during Periods 4 and 5 when samplers operated at 10 lpm were changed weekly instead of daily resulting in a decrease in OC values compared to what had been observed during Periods 1-3. From these experiments, we conclude that the Two-Week Sampler quartz fiber filter samples are effectively the same as PM_{10} samples taken at low flow rates over long time periods. All size cuts also show decreased OC concentrations when flow rates are increased while sampling duration is maintained at 2-weeks.

3.2 OC/EC concentration data during 1994-1998

Annual average elemental carbon particle concentrations for the years 1994-1998 across the Children's Health Study monitoring network ranged from 0.05 $\mu g\ m^{-3}$ to 1.74 $\mu g\ m^{-3}$, as shown in Table 3. The lowest average EC concentrations for each year were found at the rural, coastal Lompoc site. Initially, in 1994 and 1995 the highest EC concentrations were found at Long Beach, which is close to the heavy industry and traffic in the Los Angeles/Long Beach harbor area. During subsequent years, the highest annual average EC concentrations were found inland at the Mira Loma site. General trends indicate a decline in EC concentrations from 1994 to 1998 consistent with newer diesel engines and improved diesel fuels being introduced into the vehicle fleet.

Annual average organic carbon particle concentrations ranged from 1.50 to 15.67 $\mu g\ m^{-3}$ between stations. The lowest annual average OC concentrations were consistently found at Lompoc, while the highest annual average concentrations were found at Mira Loma. In general, both OC and EC concentrations were highest at the Los Angeles Basin sites and lowest at the sites in the outlying areas (San Luis Obispo, Santa Barbara, and San Diego Counties), the mountain site at Lake Arrowhead, and the desert site at Lancaster. There is also a general trend of decreasing elemental carbon to total carbon (TC = EC + OC) ratios moving from west to east across the Los Angeles Basin. This can be attributed to the fact that as an airmass moves across the basin the organic fraction can be enhanced by the formation of secondary organic aerosol as a result of condensation from the gas phase; elemental carbon, conversely, is introduced to the atmosphere solely via the direct or primary emission of particles. There is also a trend toward lower OC annual average concentrations with time over the 1994 through 1998 period.

Table 2. Side-by-side comparison of carbonaceous aerosol concentration measurements as a function of particle size, duration, and air flow rate[a]

Sampler	Flow rate	Period 1	Period 2	Period 3	Period 4	Period 5
Organic Carbon:						
Two-Week	1.6 lpm	5.79 ± 0.43	5.66 ± 0.43	9.67 ± 0.68	8.99 ± 0.64	11.03 ± 0.77
PM2.5	1 lpm	4.91 ± 0.43	4.22 ± 0.38	8.96 ± 0.68	8.57 ± 0.65	9.45 ± 0.71
PM2.5	2 lpm	–[b]	–[b]	–[b]	6.91 ± 0.49	6.18 ± 0.44
PM2.5	10 lpm	6.04 ± 0.55[c]	6.20 ± 0.57[c]	10.80 ± 0.85[c]	5.01 ± 0.34[d]	5.89 ± 0.40[d]
PM10	1.5 lpm	5.74 ± 0.45	5.31 ± 0.42	9.87 ± 0.70	8.89 ± 0.64	9.54 ± 0.68
PM10	10 lpm	6.69 ± 0.59[c]	7.29 ± 0.63[c]	11.73 ± 0.90[c]	6.36 ± 0.43[d]	7.37 ± 0.50[d]
TSP	1 lpm	9.58± 0.71	9.24 ± 0.70	14.47 ± 1.02	15.14 ± 1.06	15.57 ± 1.09
TSP	2.5 lpm	7.22 ± 0.50	6.10 ± 0.43	11.24 ± 0.76	13.29 ± 0.65	11.52 ± 0.78
Elemental Carbon:						
Two-Week	1.6 lpm	0.72 ± 0.12	0.56 ± 0.11	0.68 ± 0.11	0.78 ± 0.12	1.15 ± 0.13
PM2.5	1 lpm	0.62 ± 0.16	0.43 ± 0.15	0.56 ± 0.16	0.76 ± 0.17	1.21 ± 0.20
PM2.5	2 lpm	–[b]	–[b]	–[b]	0.81 ± 0.10	0.98 ± 0.11
PM2.5	10 lpm	0.70 ± 0.22[c]	0.58 ± 0.22[c]	0.86 ± 0.23[c]	0.70 ± 0.07[d]	0.86 ± 0.08[d]
PM10	1.5 lpm	0.62 ± 0.13	0.48 ± 0.12	0.66 ± 0.13	0.78 ± 0.12	1.01 ± 0.13
PM10	10 lpm	0.69 ± 0.22[c]	0.60 ± 0.21[c]	0.88 ± 0.22[c]	0.80 ± 0.07[d]	1.11 ± 0.09[d]
TSP	1 lpm	0.62 ± 0.15	0.64 ± 0.17	0.72 ± 0.16	0.89 ± 0.17	1.15 ± 0.18
TSP	2.5 lpm	0.77 ± 0.09	1.19 ± 0.12	0.74 ± 0.09	0.87 ± 0.14	1.38 ± 0.13
Total Carbon:						
Two-Week	1.6 lpm	6.51 ± 0.51	6.22 ± 0.49	10.34 ± 0.75	9.77 ± 0.71	12.17 ± 0.86
PM2.5	1 lpm	5.53 ± 0.52	4.65 ± 0.46	9.52 ± 0.76	9.34 ± 0.75	10.66 ± 0.84
PM2.5	2 lpm	–[b]	–[b]	–[b]	7.72 ± 0.56	7.16 ± 0.53
PM2.5	10 lpm	6.74 ± 0.67[c]	6.78 ± 0.68[c]	11.67 ± 0.97[c]	5.71 ± 0.40[d]	6.74 ± 0.47[d]
PM10	1.5 lpm	6.36 ± 0.52	5.79 ± 0.48	10.53 ± 0.78	9.67 ± 0.71	10.55 ± 0.77
PM10	10 lpm	7.37 ± 0.70[c]	7.89 ± 0.74[c]	12.61 ± 1.02[c]	7.16 ± 0.49[d]	8.47 ± 0.57[d]
TSP	1 lpm	10.21± 0.79	9.88 ± 0.79	15.19 ± 1.11	16.03 ± 1.16	16.72 ± 1.20
TSP	2.5 lpm	7.99 ± 0.57	11.98 ± 0.83	14.86 ± 1.07	14.15 ± 0.72	12.90 ± 0.88

a. Sample duration is 14 days for all samplers except those at 10lpm which were run for 14 1-day periods during periods 1-3 and for 2 7-day periods during periods 4 and 5.
b. No data for this period.
c. Average of filters changed daily.
d. Average of two 1-week samples.

Table 3. Statistical Description of Annual Average Carbon Concentrations measured using Two-Week Samplers

Year	No. of Carbon Samples	— Organic Carbon — OC sample population mean ± SD	Max OC	Min OC	— Elemental Carbon — EC sample population mean ± SD	Max EC	Min EC
Alpine:							
1994	22	3.56 ± 1.00	6.16	1.83	0.38 ± 0.11	0.62	0.17
1995	23	4.41 ± 1.95	10.10	1.52	0.51 ± 0.19	0.85	0.24
1996	26	3.12 ± 1.10	5.67	1.44	0.42 ± 0.21	1.05	0.16
1997	24	3.19 ± 1.01	5.41	1.70	0.39 ± 0.13	0.62	0.15
1998	26	2.84 ± 1.19	5.33	1.17	0.28 ± 0.10	0.46	0.14
Atascadero:							
1994	26	5.27 ± 2.77	10.78	0.85	0.44 ± 0.24	0.87	0.03
1995	24	5.18 ± 1.87	9.06	2.72	0.51 ± 0.24	1.08	0.21
1996	23	3.89 ± 1.14	6.05	2.20	0.36 ± 0.15	0.73	0.11
1997	26	3.96 ± 1.31	7.06	2.28	0.41 ± 0.14	0.66	0.17
1998	26	3.68 ± 1.79	8.55	1.48	0.26 ± 0.17	0.70	0.02
Glendora:							
1996	25	7.15 ± 2.27	11.89	4.21	0.90 ± 0.26	1.43	0.43
1997	23	5.90 ± 1.30	8.60	4.03	0.82 ± 0.25	1.29	0.52
1998	25	5.25 ± 1.85	8.96	2.97	0.64 ± 0.26	1.14	0.29
Lake Arrowhead:							
1994	19	3.96 ± 1.76	7.13	1.69	0.33 ± 0.15	0.60	0.12
1995	14	2.95 ± 1.21	5.05	1.14	0.42 ± 0.20	0.80	0.10
1996	21	3.24 ± 2.19	9.23	0.68	0.45 ± 0.33	1.63	0.07
1997	25	2.75 ± 1.70	6.91	0.34	0.31 ± 0.18	0.80	0.08
1998	19	2.73 ± 1.77	6.58	0.63	0.27 ± 0.15	0.60	0.07
Lake Elsinore:							
1994	23	5.33 ± 1.95	11.74	2.57	0.67 ± 0.16	1.09	0.40
1995	24	6.09 ± 2.35	10.66	2.01	0.82 ± 0.31	1.56	0.29
1996	24	4.43 ± 1.09	6.69	2.41	0.64 ± 0.22	0.98	0.18
1997	25	4.55 ± 1.05	6.07	2.90	0.64 ± 0.20	1.08	0.27
1998	26	4.13 ± 1.57	6.91	1.82	0.49 ± 0.18	0.82	0.19
Lancaster:							
1994	25	6.57 ± 2.59	14.72	3.01	0.66 ± 0.33	1.56	0.22
1995	24	7.17 ± 2.62	15.02	3.29	0.79 ± 0.32	1.49	0.39
1996	25	5.67 ± 1.45	8.55	3.14	0.57 ± 0.19	0.98	0.18
1997	24	4.95 ± 1.19	7.43	2.78	0.54 ± 0.14	0.77	0.25
1998	26	4.92 ± 1.68	7.75	2.34	0.48 ± 0.15	0.85	0.28
Lompoc:							
1994	25	2.05 ± 1.35	4.69	0.52	0.14 ± 0.12	0.44	0.00
1995	23	2.10 ± 1.07	4.09	0.21	0.15 ± 0.12	0.33	0.00
1996	26	1.82 ± 0.73	3.59	0.73	0.13 ± 0.10	0.34	0.00
1997	24	1.87 ± 0.96	4.60	0.69	0.15 ± 0.09	0.35	0.03
1998	26	1.50 ± 0.82	3.46	0.53	0.05 ± 0.07	0.26	0.00

Table 3. (continued)

Year	No. of Carbon Samples	Organic Carbon OC sample population mean ± SD	Max OC	Min OC	Elemental Carbon EC sample population mean ± SD	Max EC	Min EC
Long Beach:							
1994	26	7.98 ± 4.46	20.92	2.94	1.40 ± 0.61	3.10	0.75
1995	24	7.41 ± 3.11	16.15	3.19	1.74 ± 0.55	3.12	0.83
1996	13	5.21 ± 2.69	13.42	2.81	1.01 ± 0.54	2.48	0.41
1997	25	6.20 ± 2.95	14.22	2.90	1.24 ± 0.53	2.16	0.35
1998	25	5.98 ± 3.38	15.22	2.53	0.93 ± 0.45	2.03	0.33
Mira Loma:							
1994	24	14.48 ± 5.77	27.88	5.67	1.23 ± 0.39	2.34	0.54
1995	22	15.67 ± 7.87	28.24	6.19	1.51 ± 0.76	3.49	0.64
1996	25	15.35 ± 6.43	31.49	6.09	1.30 ± 0.41	2.31	0.57
1997	26	14.52 ± 5.23	22.47	7.41	1.32 ± 0.37	2.34	0.46
1998	24	13.77 ± 7.38	28.18	4.16	1.08 ± 0.45	1.96	0.32
Riverside:							
1994	25	7.34 ± 2.05	11.54	4.09	0.96 ± 0.27	1.59	0.56
1995	23	8.79 ± 3.67	16.54	3.50	1.19 ± 0.44	2.41	0.67
1996	26	6.83 ± 2.08	11.91	3.89	0.98 ± 0.29	1.62	0.47
1997	26	6.47 ± 1.91	10.82	3.65	0.97 ± 0.27	1.78	0.59
1998	26	5.66 ± 2.15	9.54	2.47	0.74 ± 0.24	1.05	0.21
San Dimas:							
1994	26	8.22 ± 2.10	12.17	4.33	1.18 ± 0.29	1.76	0.70
1995	23	9.12 ± 2.88	15.44	4.17	1.51 ± 0.50	3.00	0.88
1996	23	6.90 ± 1.93	11.40	4.05	1.11 ± 0.35	1.96	0.51
Santa Maria:							
1994	26	3.45 ± 1.25	6.37	1.90	0.33 ± 0.14	0.59	0.09
1995	24	3.82 ± 1.09	6.46	2.04	0.43 ± 0.10	0.62	0.24
1996	24	3.08 ± 0.90	4.83	1.69	0.35 ± 0.17	0.76	0.04
1997	26	3.13 ± 0.85	4.72	1.83	0.35 ± 0.12	0.62	0.18
1998	26	2.95 ± 0.92	5.17	1.85	0.18 ± 0.10	0.37	0.00
Upland:							
1994	26	8.90 ± 2.39	13.18	4.35	1.18 ± 0.30	1.69	0.64
1995	23	10.63 ± 3.99	18.13	4.00	1.51 ± 0.51	2.61	0.71
1996	25	8.11 ± 2.19	12.99	4.33	1.23 ± 0.40	2.14	0.62
1997	25	7.88 ± 1.92	13.07	5.42	1.14 ± 0.31	1.88	0.42
1998	25	6.71 ± 2.24	10.60	3.58	0.89 ± 0.32	1.48	0.39

Figures 2 and 3 show the time series of bi-weekly measurements of elemental carbon over the period 1994-1998. Each data point on these plots represents a two-week sampling period. Gaps in the data indicate sampling periods during which OC/EC samples were labeled as invalid by the station operators; in many cases this designation signified that the duration of sampling was insufficient (due to a power failure for example).

Elemental carbon concentrations typically show a strong seasonal variation with high concentrations in the winter and decreased concentrations in the spring and summer, especially at Long Beach, Lancaster and the coastal sites in San Luis Obispo and Santa Barbara counties. That seasonal variation is not as pronounced at Riverside and other locations farther inland. At Lake Arrowhead and Alpine the situation is reversed with higher EC concentrations found during the summer than during the winter months. EC typifies direct particle emissions from primary sources and is strongly influenced by diesel engine exhaust in Southern California (Cass and Gray, 1995; Schauer et al., 1996, Gray and Cass, 1998).

Fine particle organic species in Los Angeles have been shown to be mostly due to emissions from primary sources (Gray and Cass, 1998; Hildemann et al., 1993; Schauer et al., 1996). Therefore, it is not surprising that particulate organic compound concentrations follow a seasonal trend that is similar to EC as shown in the bi-weekly time series measurements in Figures 4 and 5. Again, during the stagnant winter months, high OC concentrations are observed at many of the coastal and rural sites with lower concentrations observed during the spring and summer months. Notable exceptions occur in the mountain sites which experience summer maxima. This seasonal difference between coastal and inland sites in the Los Angeles area has been explained previously by Gray et al. (1986). In the winter, the net air mass motion is toward the offshore direction thereby placing sites like Long Beach downwind of the city at a time when wind speeds are slow and early morning surface temperature inversions are common. In the summer, the prevailing wind direction is reversed and strong on-shore flow transports aerosol from the Los Angeles Basin deep into the mountains. Other inland sites such as Mira Loma have high OC concentrations during the summer months as well.

3.3 Mass balance

The fine particle mass concentration, chloride, nitrate, sulfate, and ammonium ion concentration measurements available from the Children's Health Study database were acquired downstream of impactors having a 2.5 micron size cut. Therefore, to construct a material balance on the chemical composition of the particulate matter collected at the Children's Health Study sampling sites, the measured PM_{10}-equivalent OC and EC concentrations were adjusted to the extent possible to emulate results obtained at a $PM_{2.5}$ size cut as determined during the rooftop comparison testing described previously.

To adjust the Two-Week Sampler EC and OC measurements to $PM_{2.5}$ values, correction factors were introduced. These correction factors were calculated using data from Periods 4 and 5 of the rooftop comparison test due to missing data from the $PM_{2.5}$ sampler during Periods 1-3 (See Table 2). Measurements made over these two, 2-week

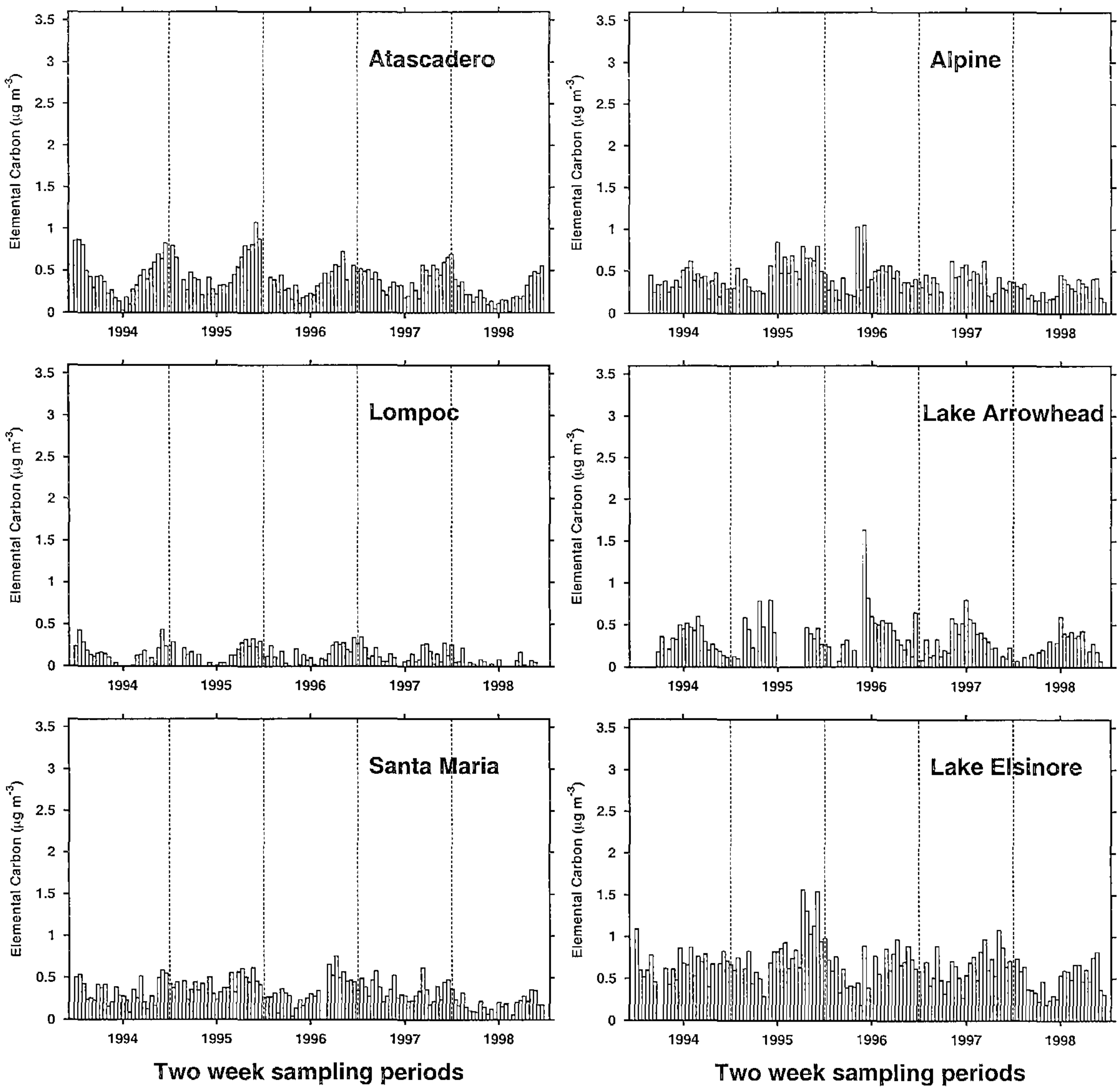


Figure 2: Time series of 2-week average elemental carbon concentrations found in Southern California.

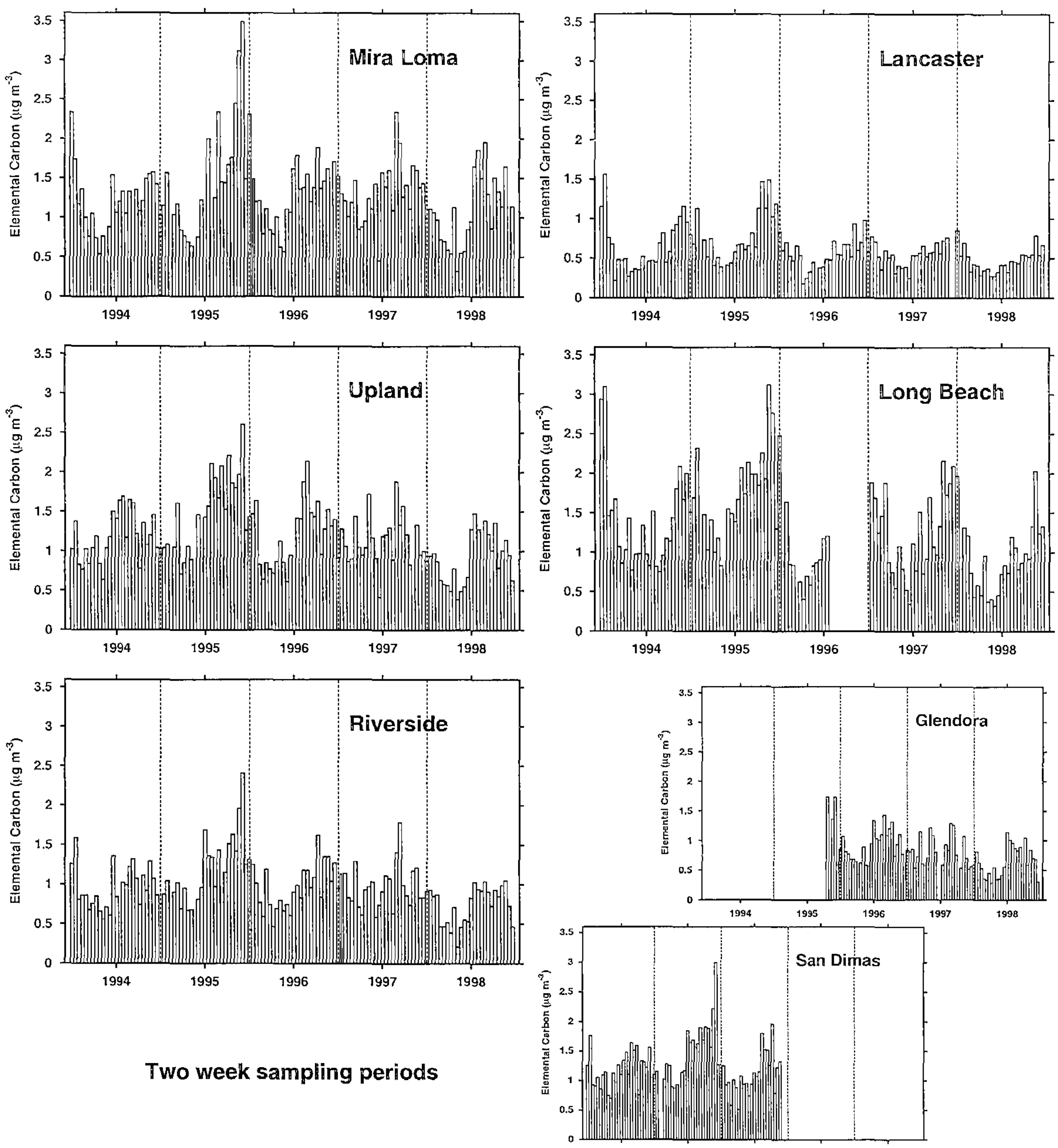


Figure 3: Time series of 2-week average elemental carbon concentrations found in Southern California.

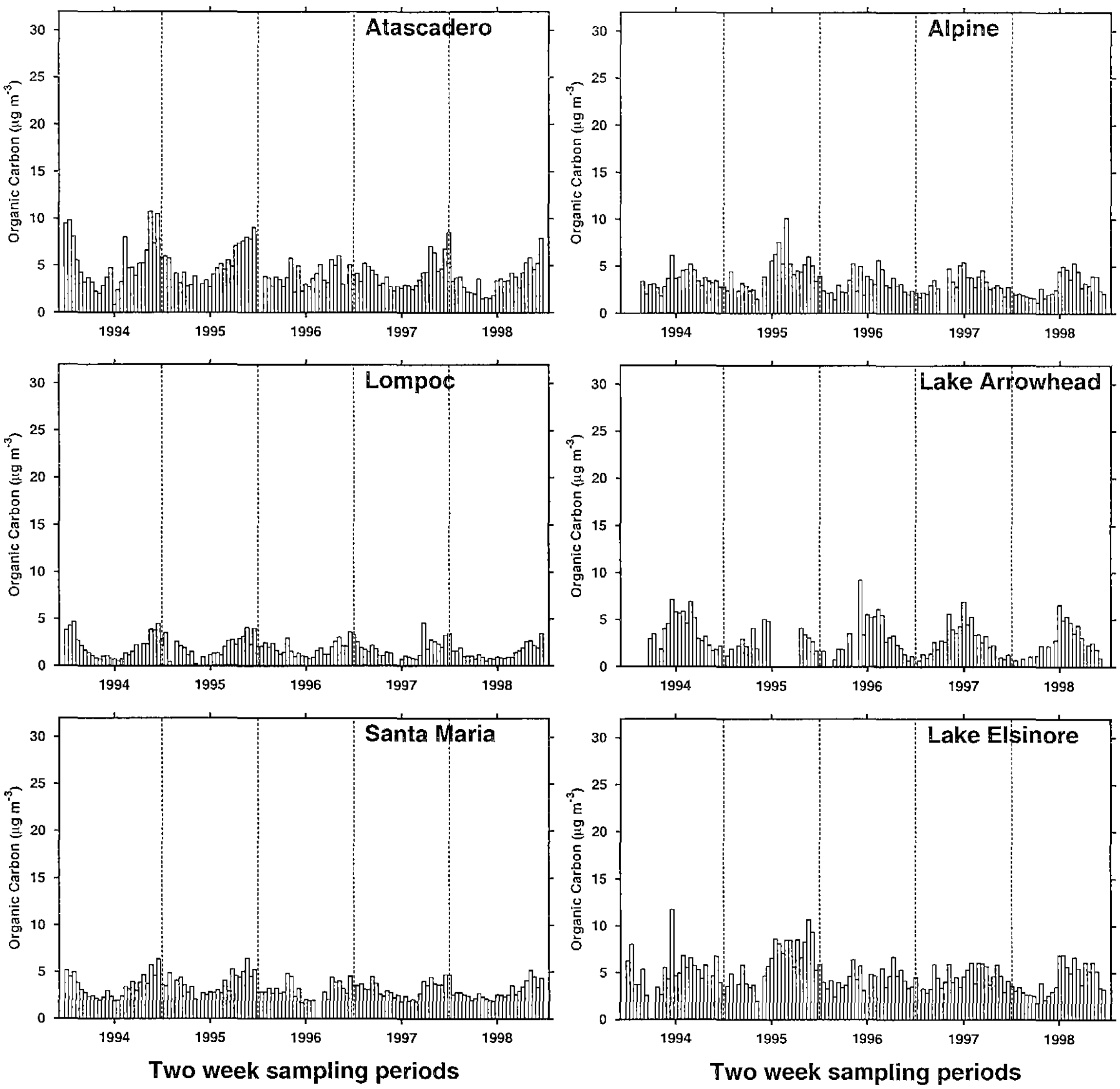


Figure 4: Time series of 2-week average organic carbon concentrations found in Southern California.

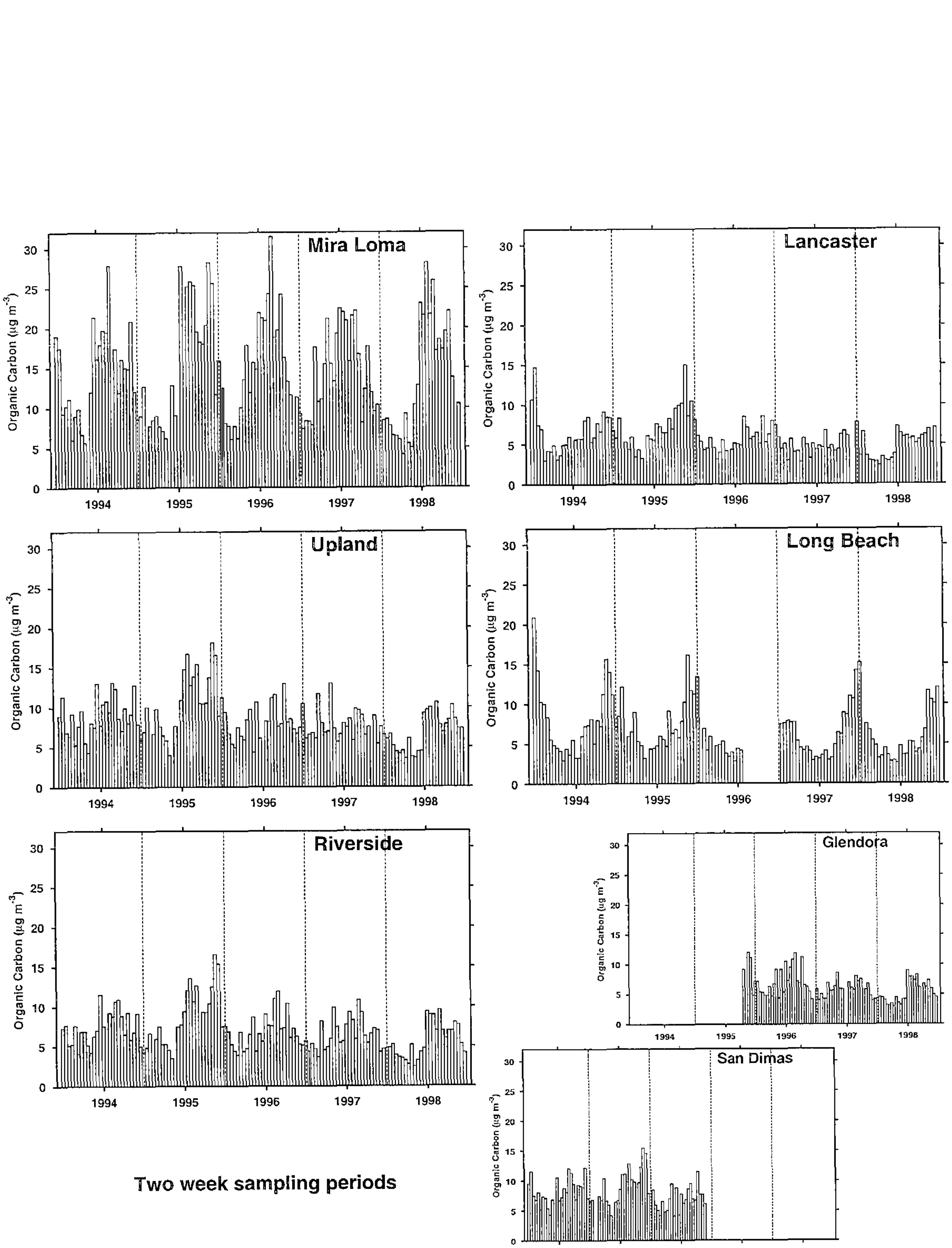


Figure 5: Time series of 2-week average organic carbon concentrations found in Southern California.

periods using the $PM_{2.5}$ sampler operated at 1 and 2 lpm were first averaged, and then the ratio of those values to the data collected side-by-side with the Two-Week Sampler operated at 1.6 lpm were calculated for both OC and EC. The scale factors that best translate Two-Week Sampler measurements into $PM_{2.5}$ estimates for OC and EC, respectively, are 0.78 and 0.98. These results agree with previous findings that more than 90 percent of airborne EC mass is found in sub-micrometer particles (Seinfeld and Pandis, 1998). As a result, very little adjustment of EC measurements is required, as expected. A greater amount of OC is present in the 2.5 μm to 10 μm size range due in part to the presence of humic material and plant fragments in soil dust and road dust. The measured OC and EC concentrations from the Children's Health Study were multiplied by the appropriate correction factor to yield estimated $PM_{2.5}$ OC and EC concentrations. In order to account for oxygen and hydrogen associated with organic material, the OC concentrations were next multiplied by 1.2 to estimate the organic matter concentrations. Factors used to convert organic carbon into organic mass in material balance studies range from 1.2 to 1.4 (Gray et al., 1986). The lower value was chosen for this study since a higher conversion factor would have resulted in a greater incidence of over-balanced mass. The estimated annual average fine particle ($PM_{2.5}$) organic compound and elemental carbon concentrations are given alongside fine particle mass and ionic species concentrations determined by the California Air Resources Board from samples taken on the other legs of the Two-Week samplers in Table 4. Chloride ion concentrations were not provided due to the very low concentrations (and low precision) of the chloride measurements.

Figures 6-11 show the relative quantity of the $PM_{2.5}$ mass contributed by each of the major chemical species measured at each site during each year, 1994-1998. In cases where the mass of species identified chemically exceeds by a small amount the mass measured gravimetrically, the species contributions are presented as a percentage of the total mass of identified species. "Other" in the pie charts represents the remainder of the measured mass after all of the identified components have been subtracted. Other components that are not accounted for in this study include mineral dust and other trace metals as well as sodium ion, which could be present from sea salt aerosol at coastal sites. The combined mass of EC plus organic matter averaged at each site over all five years accounts for 33 to 60 percent of $PM_{2.5}$ mass at the various sites. Riverside (33%) and Lompoc (33%) lie at the low end of this range; at the high end of the range are Lancaster (60% organics plus EC) and Atascadero (57% organics plus EC). With the exception of Riverside, the concentrations of organic compounds plus EC at Los Angeles Basin sites lie between 38 and 45 percent of $PM_{2.5}$ mass. Previous findings have placed the average of organics plus EC for the Los Angeles Basin at approximately 40 percent of fine particle mass (Gray et al., 1986), consistent with the present findings. The apparent lower relative carbon content at Riverside can be explained by the higher $PM_{2.5}$ ammonium nitrate concentration at the site. Higher carbon content percentages are found at mountain and desert sites, as well as sites further north and south. These higher percentages of carbonaceous aerosol at the outlying sites are accompanied by lower absolute carbon particle concentrations as well as lower absolute concentrations of fine particle mass, chloride, sulfate, nitrate, and ammonium ions.

Table 4. Annual Average Fine Particle ($PM_{2.5}$) Mass Concentrations ($\mu g\ m^{-3}$)

Year	Fine Mass	Fine Organic Material[a,b]	Fine Elemental Carbon[b]	Nitrate	Sulfate	Ammonium
Alpine:						
1994	9.04	3.33	0.37	2.03	2.06	1.23
1995	8.54	4.12	0.49	1.84	1.84	1.10
1996	9.03	2.92	0.41	1.56	1.74	0.87
1997	7.78	2.98	0.38	1.67	1.57	0.88
1998	7.51	2.66	0.27	1.48	1.29	0.76
Atascadero:						
1994	7.94	4.93	0.43	1.99	0.77	0.80
1995	7.35	4.84	0.50	1.41	0.99	0.70
1996	7.07	3.65	0.35	1.23	0.83	0.58
1997	7.41	3.71	0.39	1.43	0.69	0.55
1998	7.12	3.45	0.25	1.34	0.68	0.54
Glendora:						
1996	19.46	6.70	0.88	5.74	2.92	2.43
1997	15.11	5.53	0.80	5.37	2.04	1.85
1998	14.06	4.91	0.63	4.97	1.87	1.72
Lake Arrowhead:						
1994	10.55	3.70	0.32	3.30	1.23	1.46
1995	7.53	2.76	0.41	2.54	0.77	1.01
1996	8.27	3.03	0.43	2.17	1.17	0.95
1997	8.38	2.57	0.30	2.24	1.14	0.97
1998	7.79	2.55	0.26	1.99	0.92	0.87
Lake Elsinore:						
1994	13.94	4.99	0.65	3.94	2.02	1.76
1995	14.95	5.70	0.80	4.82	2.44	2.15
1996	12.85	4.14	0.62	3.21	1.97	1.41
1997	12.36	4.26	0.62	3.01	1.99	1.38
1998	10.76	3.87	0.47	2.83	1.49	1.24
Lancaster:						
1994	9.26	6.15	0.64	2.71	0.95	1.14
1995	8.57	6.72	0.76	2.26	1.10	1.00
1996	8.29	5.31	0.55	1.75	0.90	0.73
1997	7.80	4.64	0.53	1.92	0.91	0.83
1998	7.59	4.61	0.46	1.88	0.92	0.84
Lompoc:						
1994	5.93	1.92	0.16	0.81	1.04	0.43
1995	6.01	1.96	0.18	0.83	1.34	0.50
1996	6.71	1.70	0.14	0.79	1.10	0.42
1997	5.26	1.75	0.14	0.74	0.99	0.34
1998	4.77	1.40	0.08	0.67	0.85	0.32

Table 4. (continued)

Year	Fine Mass	Fine Organic Material[a,b]	Fine Elemental Carbon[b]	Nitrate	Sulfate	Ammonium
Long Beach:						
1994	16.68	7.47	1.35	5.93	2.77	2.58
1995	22.16	6.93	1.69	7.19	3.87	3.17
1996	14.08	4.88	0.98	3.82	2.81	1.73
1997	17.18	5.80	1.21	4.60	2.85	1.91
1998	15.19	5.60	0.90	4.09	2.04	1.62
Mira Loma:						
1994	31.64	13.55	1.19	13.61	2.91	4.89
1995	35.78	14.67	1.47	16.10	3.07	5.76
1996	30.23	14.37	1.26	11.33	2.88	4.10
1997	25.62	13.59	1.28	9.68	2.36	3.35
1998	24.63	12.89	1.05	9.44	2.09	3.35
Riverside:						
1994	25.80	6.88	0.93	10.98	2.52	4.13
1995	26.47	8.22	1.16	11.70	2.66	4.27
1996	22.41	6.39	0.95	8.67	2.43	3.14
1997	19.71	6.06	0.94	7.41	2.14	2.77
1998	19.30	5.30	0.72	7.19	1.90	2.67
San Dimas:						
1994	22.53	7.70	1.15	8.26	2.84	3.40
1995	24.22	8.53	1.46	9.32	3.26	3.70
1996	19.93	6.46	1.08	6.48	2.74	2.56
Santa Maria:						
1994	6.93	3.23	0.32	1.43	1.28	0.68
1995	8.40	3.58	0.41	1.68	1.71	0.92
1996	6.95	2.88	0.34	1.21	1.39	0.54
1997	6.72	2.93	0.34	1.22	1.39	0.54
1998	6.58	2.76	0.19	1.15	1.18	0.53
Upland:						
1994	24.13	8.33	1.14	9.16	2.55	3.72
1995	27.12	9.95	1.47	10.68	3.01	4.04
1996	22.40	7.59	1.19	7.85	2.59	2.97
1997	19.51	7.37	1.10	6.47	2.31	2.45
1998	18.16	6.28	0.87	6.26	1.75	2.29

a. Organic carbon measured by the thermal/optical technique multiplied by 1.2 to compensate for O and H associated with organic matter.
b. Organic material and elemental carbon fine particle concentrations estimated using correction factors based on collocated sampling with $PM_{2.5}$ monitors.

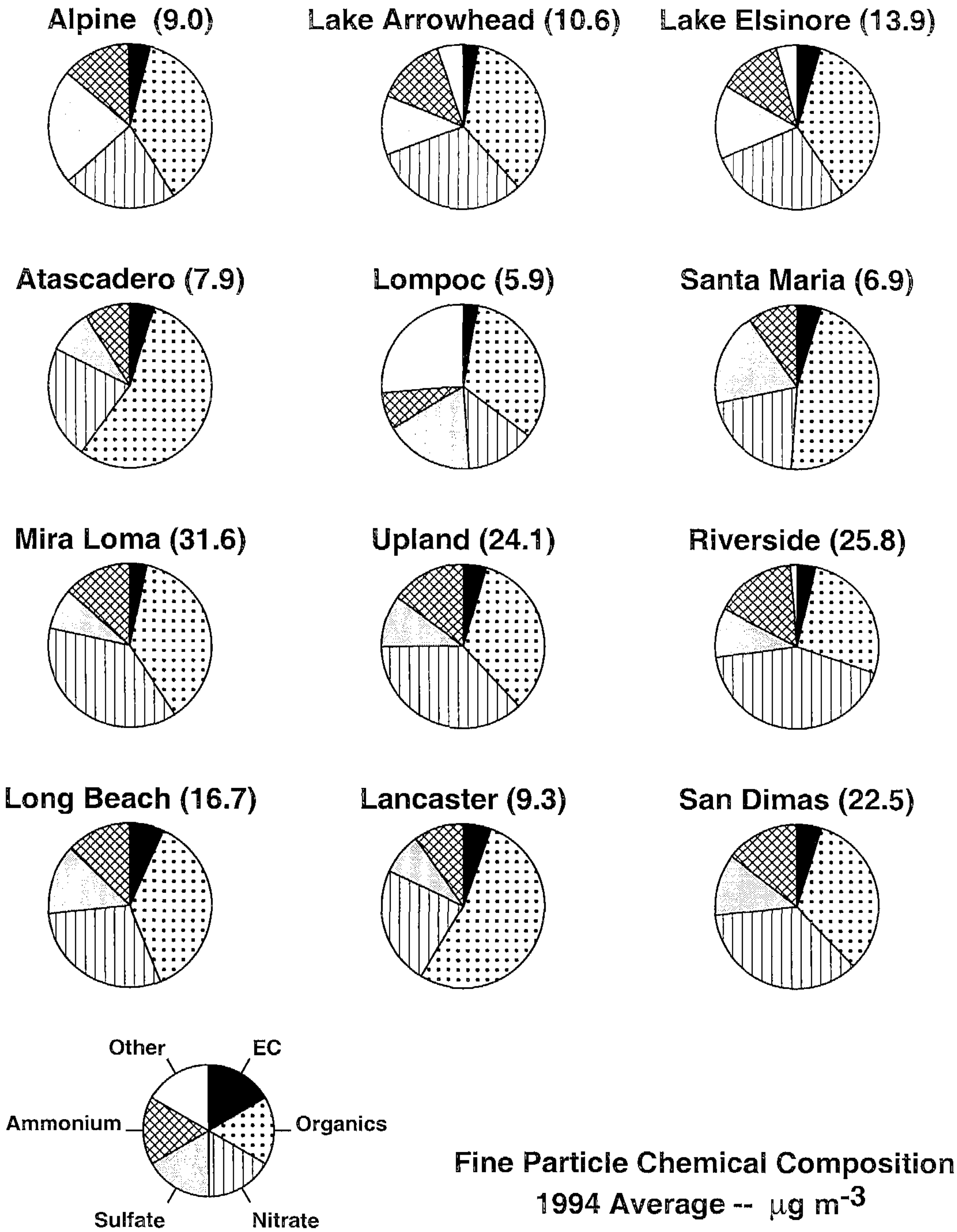


Figure 6: Material balance on the chemical composition of 1994 annual airborne fine particle concentrations.

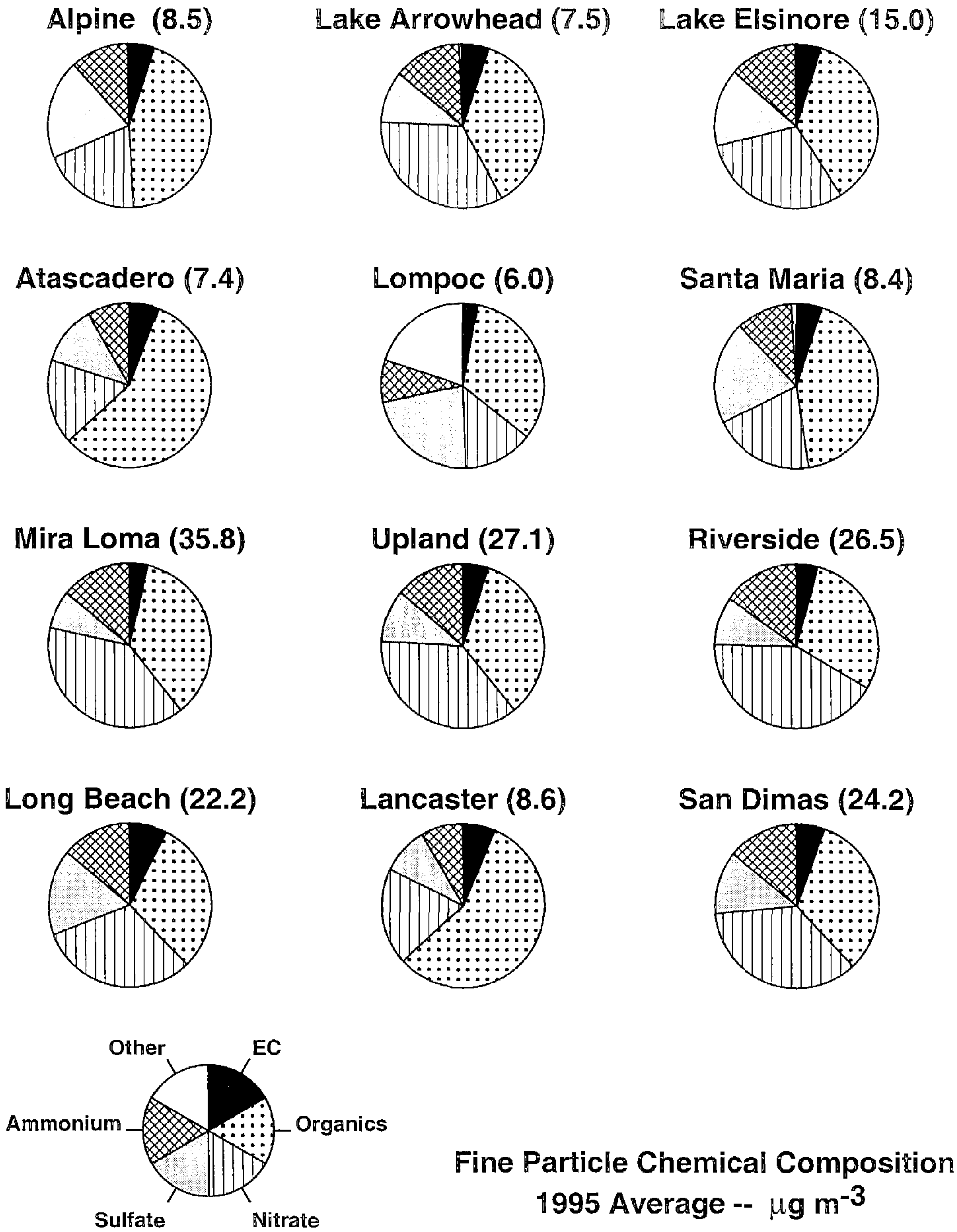


Figure 7: Material balance on the chemical composition of 1995 annual airborne fine particle concentrations.

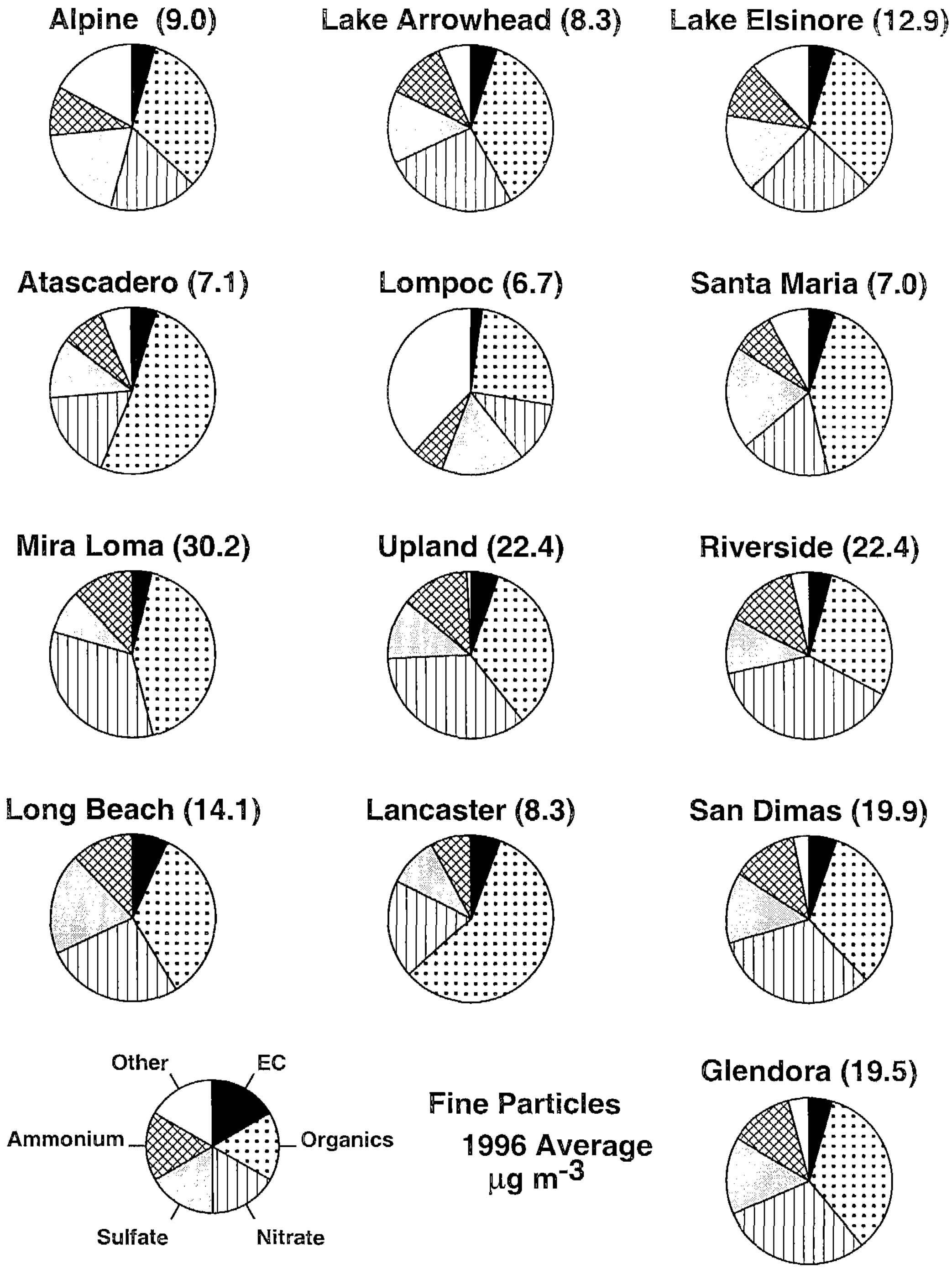


Figure 8: Material balance on the chemical composition of 1996 annual airborne fine particle concentrations.

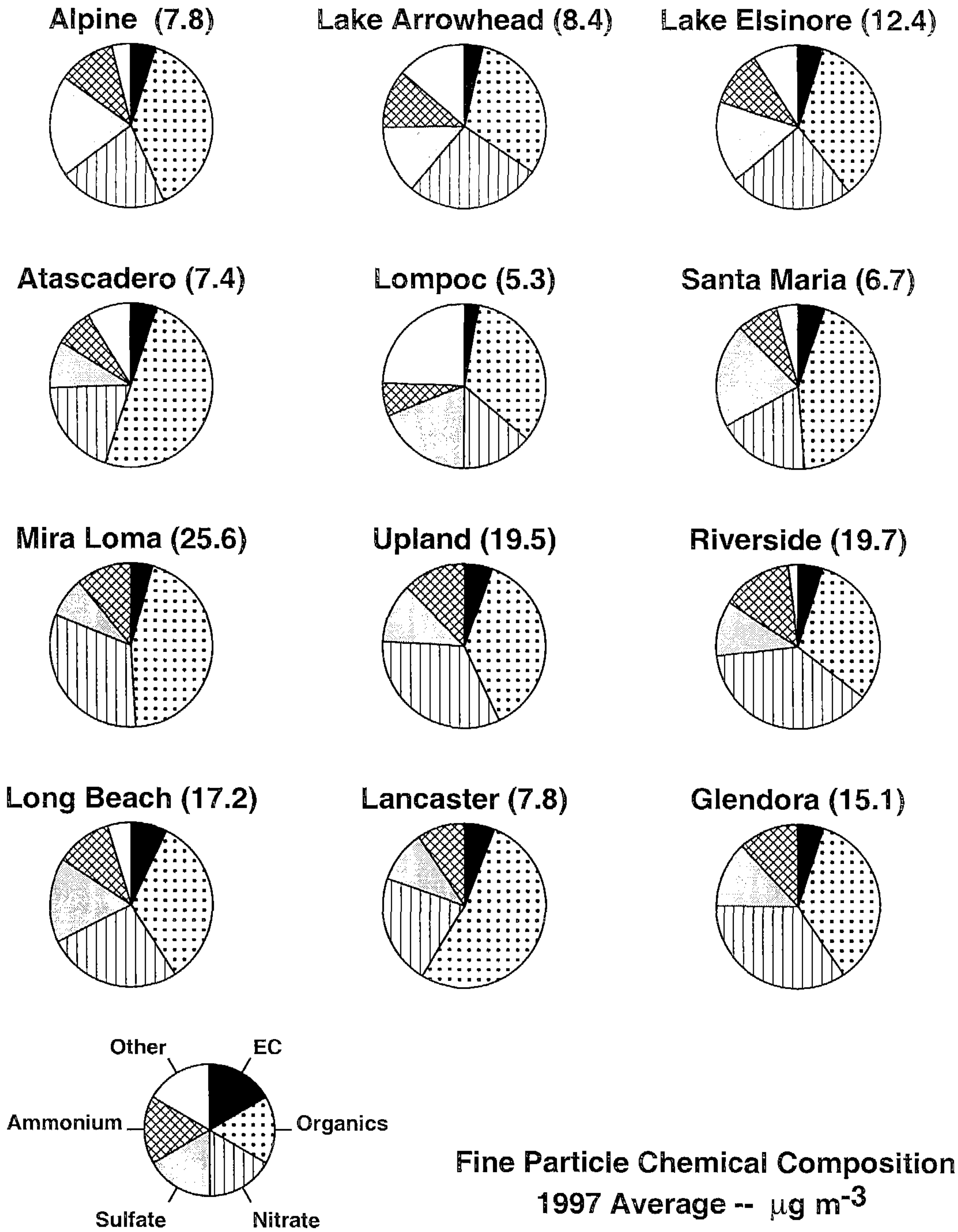


Figure 9: Material balance on the chemical composition of 1997 annual airborne fine particle concentrations.

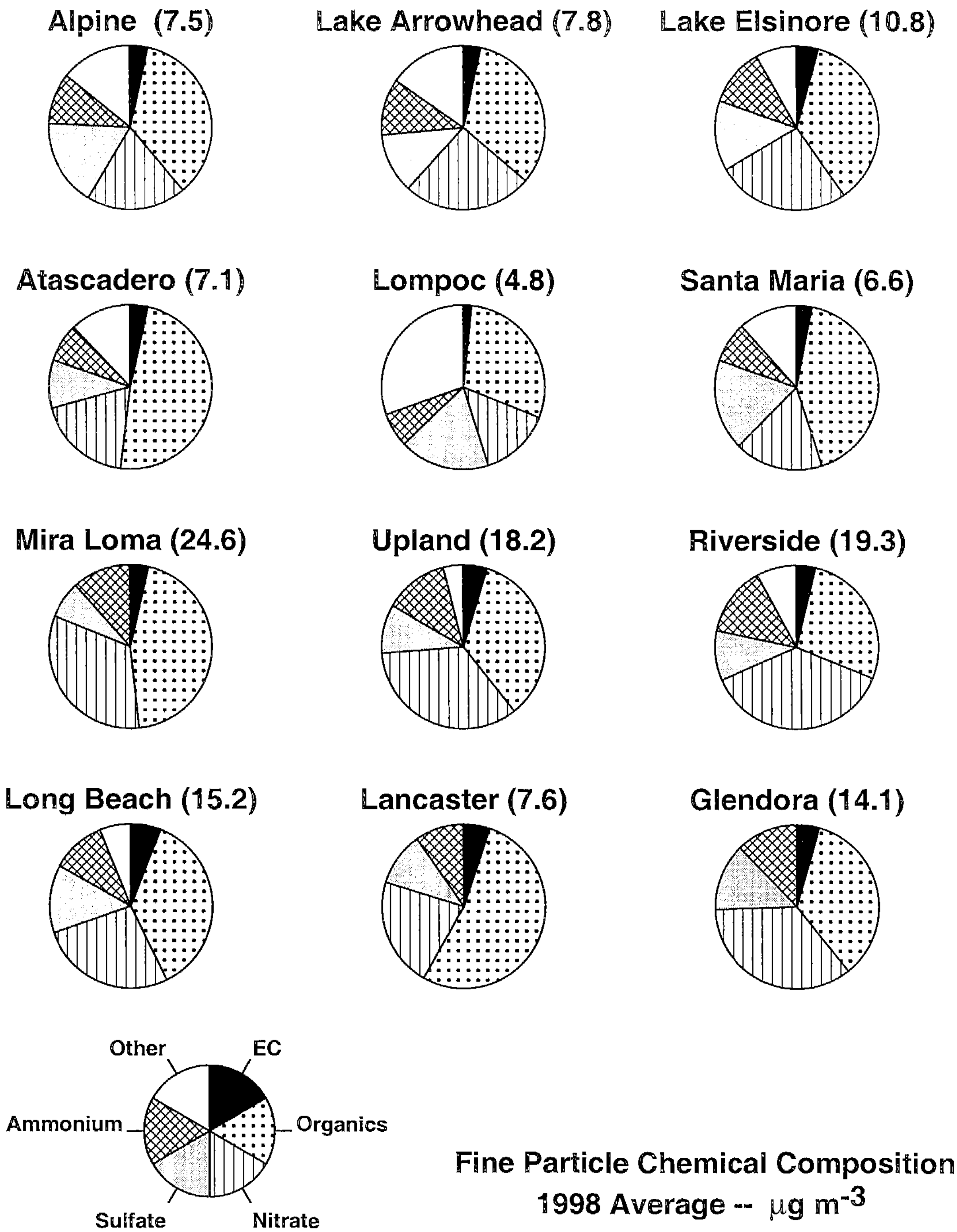


Figure 10: Material balance on the chemical composition of 1998 annual airborne fine particle concentrations.

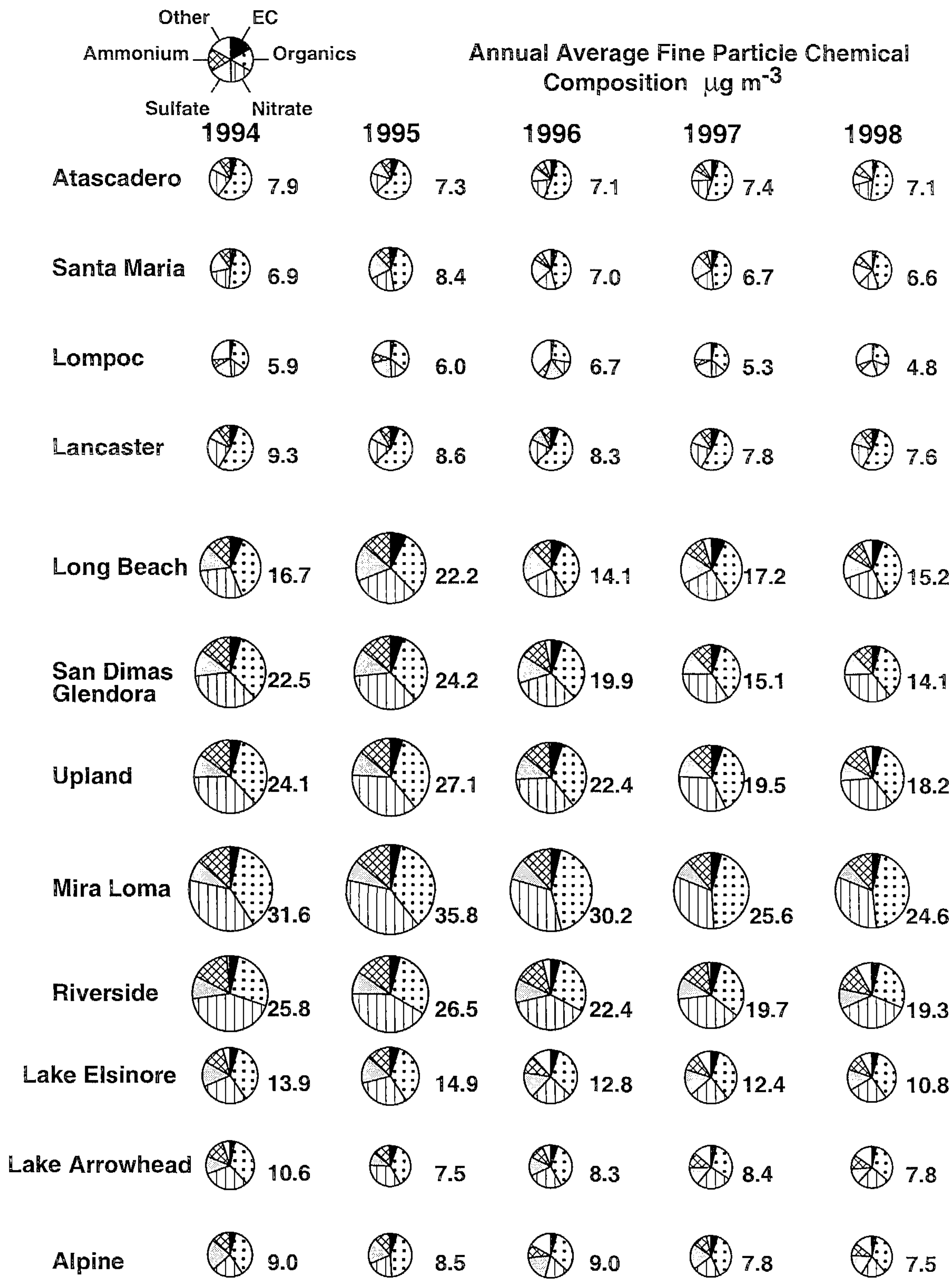


Figure 11: Annual average fine particle chemical compositions at all sites during 1994-1998. The area of the pie charts is proportional to fine particle mass concentration.

4 References

Birch, M.E.; and Cary, R.A. (1996) "Elemental carbon-based method for monitoring occupational exposures to particulate diesel exhaust," *Aerosol Science and Technology* **25** 221-241.

Cass, G.R.; and Gray, H.A. (1995) "Regional emissions and atmospheric concentrations of diesel engine particulate matter: Los Angeles as a case study," In *Diesel Exhaust: A Critical Analysis of Emissions, Exposure, and Health Effects*, Health Effects Institute, Cambridge, MA.

Chow, J.C.; Watson, J.G.; Crow, D.; Lowenthal, D.H.; and Merrifield, T. (2001) "Comparison of IMPROVE and NIOSH Carbon Measurements," *Aerosol Sci. and Technol.* **34** 23-34.

Christoforou, C.S.; Salmon, L.G; Hannigan, M.P., Solomon, P.A.; and Cass, G.R. (2000) "Trends in fine particle concentration and chemical composition in Southern California," *Journal of the Air and Waste Management Association* **50** 43-53.

Dockery, D.W.; Pope, C.A., III; Xu, X.; Spengler, J.D.; Ware, J.H.; Martha, E.F.; Ferris, B.G., Jr.; and Speizer, F.E. (1993) "An association between air pollution and mortality in six U.S. Cities," *N. Engl. J. Med.* **329** 1753-1759.

Gray, H.A.; Cass, G.R.; Huntzicker, J.J.; Heyerdahl, E.K.; and Rau, J.A. (1986) "Characteristics of atmospheric organic and elemental carbon particle concentrations in Los Angeles," *Environ. Sci. Technol.* **20** 580-589.

Gray, H.A. and Cass, G.R. (1998) "Source contributions to atmospheric fine carbon particle concentrations," *Atmos. Environ.* **32**, pp. 3805-3825.

Hannigan, M.P.; Salmon, L.G.; Christoforou, C.S.; Gharib, S.S.; Butcher, C.H.; Cass, G.R.; Chow, J.C.; and Frazier, C.A. (1996) "Determination of fine particle concentration and chemical composition in the South Coast air basin, 1993," Final Report to the South Coast Air Quality Management District, California Institute of Technology, Pasadena, CA.

Hildemann, L.M.; Markowski, G.R.; and Cass, G.R. (1991) "Chemical composition of emissions from urban sources of fine organic aerosol," *Environ. Sci. Technol.* **25**, pp. 744-759.

John, W.; and Reischl, G. (1980) "A cyclone for size-selective sampling of air," *J. Air Pollut. Control Assoc.* **30** 872-876.

Kaplan, I.R.; and Gordon, R.J. (1994) "Non-fossil fuel fine particle organic carbon aerosols in Southern California determined during the Los Angeles aerosol characterization and source apportionment study," *Aerosol Sci. Technol.* **21**, pp. 343-359.

Larson, S.M.; Cass, G.R.; and Gray, H.A. (1989) "Atmospheric carbon particles and the Los Angeles visibility problem," *Aerosol Science and Technology* **10** 118-130.

Lurmann, F.W; Roberts, P.T.; Main, H.H.; Hering, S.V.; Avol, E.L., and Colome, S.D. (1994) *Phase II Report – Appendix A: Exposure Assessment Methodology*, Sonoma Technology, Petaluma, CA.

Peters, J.M.; Avol, E.; Navidi, W.; London, S.J.; Gauderman, W.J; Lurmann, F.; Linn, W.S; Margolis, H.; Rappaport, E.; Gong, H., Jr.; and Thomas, D.C. (1999) "A study of twelve Southern California communities with differing levels and types of air pollution: I. Prevalence of respiratory morbidity," *Am. J. Respir. Crit. Care Med.* **159** 760-767.

Pope, C.A., III; Thun, M.J.; Namboodiri, M.M.; Dockery, D.W.; Evans, J.S.; Speizer, F.E.; and Heath, C.W., Jr. (1995a) "Particulate air pollution as a predictor of mortality in a prospective study of U.S. adults," *Am. J. Respir. Crit. Care Med.* **151**, pp. 669-674.

Pope, C.A., III; Dockery, D.W.; and Schwartz, J. (1995b) "Review of epidemiological evidence of health effects of particulate air pollution," *Inhalation Toxicol.* **7**, pp. 1-18.

Schauer, J.J.; Rogge, W.F., Hildemann, L.M.; Mazurek, M.A.; Cass, G.R.; and Simoneit, B.R.T. (1996) "Source apportionment of airborne particulate matter using organic compounds as tracers," *Atmos. Environ.* **30**, pp. 3837-3855.

Seinfeld, J.H; and Pandis, S.N. (1998) *Atmospheric Chemistry and Physics: From Air Pollution to Climate Change*, John Wiley and Sons, Inc., New York, NY.

Solomon, P.A.; Fall, T.; Salmon, L.G.; Lin, P.; Vasquez, F.; and Cass, G.R. (1988) "Acquisition of acid vapor and aerosol concentration data for use in dry deposition studies in the South Coast Air Basin," Environmental Quality Laboratory Report 25, California Institute of Technology, Final Report to the California Air Resources Board under Agreement A4-144-32.

Solomon, P.A.; Fall, T.; Salmon, L.G.; Cass, G.R.; Gray, H.A.; and Davidson, A. (1989) "Chemical characteristics of PM10 aerosols collected in the Los Angeles area," *J. Air Pollut. Control Assoc.* **39** 154-163.

Appendix

Site	Period	Start Date	End Date	Organic Carbon $\mu g\ m^{-3}$	Elemental Carbon $\mu g\ m^{-3}$	Total Carbon $\mu g\ m^{-3}$
Atascadero	1	931216	931230	10.91	.95	11.86
Lake-Elsinore	1	931216	931230	4.00	.82	4.82
Lancaster	1	931215	931229	12.42	1.30	13.72
Lompoc	1	931216	931230	5.53	.40	5.93
Long-Beach	1	931217	931229	16.26	2.06	18.32
Mira-Loma	1	931216	931230	9.43	1.21	10.64
Riverside	1	931216	931230	5.69	1.18	6.87
San-Dimas	1	931216	931230	7.86	1.07	8.93
Santa-Maria	1	931216	931230	6.24	.43	6.67
Upland	1	931216	931230	8.27	1.14	9.41
Atascadero	2	931230	940113	9.47	.86	10.33
Lake-Elsinore	2	931230	940113	6.25	1.09	7.34
Lancaster	2	931229	940112	10.70	1.15	11.84
Lompoc	2	931230	940113	3.85	.24	4.09
Long-Beach	2	931229	940112	20.92	2.94	23.85
Mira-Loma	2	931230	940109	19.04	2.34	21.38
Riverside	2	931230	940113	7.33	1.26	8.58
San-Dimas	2	931230	940113	9.50	1.25	10.75
Santa-Maria	2	931230	940113	5.15	.50	5.65
Upland	2	931230	940113	8.94	1.03	9.97
Atascadero	3	940113	940127	9.83	.87	10.70
Lake-Elsinore	3	940113	940127	8.03	.60	8.63
Lancaster	3	940112	940126	14.72	1.56	16.28
Lompoc	3	940113	940127	4.27	.43	4.70
Long-Beach	3	940112	940126	14.28	3.10	17.39
Mira-Loma	3	940113	940127	17.52	1.74	19.27
Riverside	3	940113	940127	7.72	1.59	9.32
San-Dimas	3	940113	940127	11.54	1.76	13.30
Santa-Maria	3	940113	940127	4.51	.54	5.05
Upland	3	940113	940127	11.38	1.38	12.77
Atascadero	4	940127	940210	8.10	.81	8.91
Lake-Elsinore	4	940127	940210	3.75	.52	4.27
Lancaster	4	940126	940209	7.47	.76	8.23
Lompoc	4	940127	940210	4.69	.29	4.98
Long-Beach	4	940126	940209	10.31	1.46	11.78
Mira-Loma	4	940127	940210	9.33	1.17	10.49
Riverside	4	940127	940210	5.11	.81	5.92
San-Dimas	4	940127	940210	7.52	.93	8.45
Santa-Maria	4	940127	940210	4.97	.43	5.40
Upland	4	940127	940210	6.86	.83	7.69
Atascadero	5	940210	940224	5.58	.50	6.08

Site	Period	Start Date	End Date	Organic Carbon $\mu g\ m^{-3}$	Elemental Carbon $\mu g\ m^{-3}$	Total Carbon $\mu g\ m^{-3}$
Lake-Elsinore	5	940210	940224	3.73	.60	4.33
Lancaster	5	940209	940223	6.96	.68	7.64
Lompoc	5	940210	940224	2.72	.19	2.91
Long-Beach	5	940209	940223	10.05	1.53	11.58
Mira-Loma	5	940210	940224	10.26	1.36	11.63
Riverside	5	940210	940224	5.23	.86	6.09
San-Dimas	5	940210	940224	6.81	.91	7.72
Santa-Maria	5	940210	940224	3.86	.24	4.11
Upland	5	940210	940224	6.38	.77	7.15
Alpine	6	940225	940310	3.40	.45	3.85
Atascadero	6	940224	940310	4.31	.43	4.73
Lake-Elsinore	6	940224	940310	5.38	.78	6.17
Lancaster	6	940223	940309	3.01	.22	3.23
Lompoc	6	940224	940310	2.15	.14	2.29
Long-Beach	6	940223	940309	8.39	1.67	10.06
Mira-Loma	6	940224	940310	11.08	1.00	12.08
Riverside	6	940224	940310	7.62	.86	8.48
San-Dimas	6	940224	940310	8.10	1.05	9.15
Santa-Maria	6	940224	940310	3.09	.26	3.35
Upland	6	940224	940310	9.21	1.03	10.24
Alpine	7	940310	940324	2.01	.25	2.26
Atascadero	7	940310	940324	3.23	.30	3.54
Lake-Arrowhead	7	940314	940324	-99.00	-99.00	-99.00
Lake-Elsinore	7	940310	940325	2.57	.46	3.04
Lancaster	7	940309	940323	4.26	.48	4.74
Lompoc	7	940310	940324	1.65	.12	1.76
Long-Beach	7	940309	940323	5.59	1.07	6.67
Mira-Loma	7	940310	940325	6.02	.76	6.78
Riverside	7	940310	940325	4.09	.68	4.77
San-Dimas	7	940310	940325	5.16	.86	6.03
Santa-Maria	7	940310	940324	2.77	.23	3.00
Upland	7	940310	940325	5.28	.84	6.12
Alpine	8	940324	940407	3.06	.34	3.40
Atascadero	8	940324	940407	3.69	.43	4.12
Lake-Arrowhead	8	940324	940407	2.98	.18	3.16
Lake-Elsinore	8	940325	940407	-99.00	-99.00	-99.00
Lancaster	8	940323	940406	4.15	.47	4.62
Lompoc	8	940324	940407	1.40	.16	1.55
Long-Beach	8	940323	940406	4.89	.86	5.75
Mira-Loma	8	940325	940407	8.99	1.05	10.04
Riverside	8	940325	940407	6.86	.76	7.62
San-Dimas	8	940325	940407	7.40	1.09	8.49
Santa-Maria	8	940324	940407	2.32	.42	2.74
Upland	8	940325	940407	7.64	1.04	8.68
Alpine	9	940407	940421	3.13	.34	3.47

Site	Period	Start Date	End Date	Organic Carbon $\mu g\ m^{-3}$	Elemental Carbon $\mu g\ m^{-3}$	Total Carbon $\mu g\ m^{-3}$
Atascadero	9	940407	940421	3.23	.44	3.67
Lake-Arrowhead	9	940407	940421	3.50	.36	3.86
Lake-Elsinore	9	940407	940421	-99.00	-99.00	-99.00
Lancaster	9	940406	940420	4.93	.49	5.43
Lompoc	9	940407	940421	1.08	.17	1.26
Long-Beach	9	940406	940420	4.52	1.03	5.55
Mira-Loma	9	940407	940421	9.90	.74	10.65
Riverside	9	940407	940421	6.90	.85	7.76
San-Dimas	9	940407	940421	7.13	1.14	8.27
Santa-Maria	9	940407	940421	2.42	.38	2.80
Upland	9	940407	940421	9.61	1.19	10.80
Alpine	10	940421	940505	2.72	.38	3.10
Atascadero	10	940421	940505	2.25	.37	2.62
Lake-Arrowhead	10	940421	940505	-99.00	-99.00	-99.00
Lake-Elsinore	10	940421	940505	3.43	.62	4.05
Lancaster	10	940420	940504	3.13	.27	3.40
Lompoc	10	940421	940505	.81	.15	.96
Long-Beach	10	940420	940504	4.14	1.43	5.56
Mira-Loma	10	940421	940505	6.71	.54	7.25
Riverside	10	940421	940505	5.17	.66	5.82
San-Dimas	10	940421	940505	5.42	.75	6.18
Santa-Maria	10	940421	940505	2.16	.42	2.59
Upland	10	940421	940505	5.56	.84	6.40
Alpine	11	940505	940519	1.83	.25	2.08
Atascadero	11	940505	940519	2.01	.23	2.24
Lake-Arrowhead	11	940505	940519	1.86	.21	2.07
Lake-Elsinore	11	940505	940519	2.67	.43	3.11
Lancaster	11	940505	940519	3.68	.33	4.01
Lompoc	11	940505	940519	.69	.11	.80
Long-Beach	11	940505	940519	2.94	.77	3.71
Mira-Loma	11	940505	940519	5.67	.76	6.42
Riverside	11	940505	940519	4.25	.56	4.81
San-Dimas	11	940505	940519	4.33	.70	5.03
Santa-Maria	11	940505	940519	1.96	.16	2.12
Upland	11	940505	940519	4.35	.64	4.99
Alpine	12	940519	940602	2.84	.31	3.15
Atascadero	12	940519	940602	2.87	.27	3.14
Lake-Arrowhead	12	940519	940602	4.05	.34	4.39
Lake-Elsinore	12	940519	940602	5.55	.61	6.15
Lancaster	12	940518	940601	4.95	.36	5.32
Lompoc	12	940519	940602	1.01	.00	1.00
Long-Beach	12	940518	940601	4.43	.97	5.41
Mira-Loma	12	940519	940602	-99.00	-99.00	-99.00
Riverside	12	940519	940602	6.28	.71	7.00
San-Dimas	12	940519	940602	6.85	1.12	7.97

Site	Period	Start Date	End Date	Organic Carbon $\mu g\ m^{-3}$	Elemental Carbon $\mu g\ m^{-3}$	Total Carbon $\mu g\ m^{-3}$
Santa-Maria	12	940519	940602	2.28	.21	2.48
Upland	12	940519	940602	8.05	1.04	9.09
Alpine	13	940602	940616	3.68	.39	4.08
Atascadero	13	940601	940615	3.76	.18	3.94
Lake-Arrowhead	13	940602	940616	4.60	.33	4.94
Lake-Elsinore	13	940602	940616	4.30	.48	4.79
Lancaster	13	940601	940615	5.05	.35	5.40
Lompoc	13	940602	940616	1.10	.04	1.14
Long-Beach	13	940601	940615	3.67	.98	4.65
Mira-Loma	13	940602	940616	12.00	.88	12.88
Riverside	13	940602	940616	7.02	.61	7.64
San-Dimas	13	940602	940616	6.30	.97	7.28
Santa-Maria	13	940602	940616	2.99	.39	3.37
Upland	13	940602	940616	7.50	1.18	8.68
Alpine	14	940616	940630	6.16	.31	6.47
Atascadero	14	940616	940630	4.78	.14	4.92
Lake-Arrowhead	14	940616	940630	7.13	.50	7.63
Lake-Elsinore	14	940616	940630	11.74	.86	12.60
Lancaster	14	940615	940629	6.01	.52	6.53
Lompoc	14	940616	940630	.86	.00	.85
Lompoc	14	940618	940630	-99.00	-99.00	-99.00
Long-Beach	14	940615	940629	5.55	1.34	6.89
Mira-Loma	14	940616	940630	21.40	1.54	22.93
Riverside	14	940616	940630	11.54	1.36	12.90
San-Dimas	14	940616	940630	10.52	1.26	11.78
Santa-Maria	14	940616	940630	2.38	.29	2.67
Upland	14	940616	940630	13.04	1.50	14.55
Alpine	15	940630	940714	3.70	.51	4.21
Atascadero	15	940630	940714	.85	.03	.89
Lake-Arrowhead	15	940630	940714	5.79	.45	6.24
Lake-Elsinore	15	940630	940714	4.67	.68	5.35
Lancaster	15	940629	-99.00	-99.00	-99.00	
Lompoc	15	940630	940714	.73	.01	.73
Long-Beach	15	940629	940713	3.26	.97	4.23
Mira-Loma	15	940630	940714	16.15	1.06	17.21
Riverside	15	940630	940714	7.55	.84	8.39
San-Dimas	15	940630	940714	6.73	1.10	7.84
Santa-Maria	15	940630	940714	1.90	.28	2.18
Upland	15	940630	940714	7.75	1.41	9.16
Alpine	16	940714	940728	3.81	.54	4.35
Atascadero	16	940714	940728	2.42	.19	2.61
Lake-Arrowhead	16	940714	940728	5.69	.52	6.22
Lake-Elsinore	16	940714	940728	4.93	.66	5.58
Lancaster	16	940713	940727	5.61	.46	6.07
Lompoc	16	940714	940728	.52	.00	.52

Site	Period	Start Date	End Date	Organic Carbon $\mu g\ m^{-3}$	Elemental Carbon $\mu g\ m^{-3}$	Total Carbon $\mu g\ m^{-3}$
Long-Beach	16	940713	940727	3.29	.83	4.11
Mira-Loma	16	940714	940728	17.96	1.20	19.16
Riverside	16	940714	-99.00	-99.00	-99.00	
San-Dimas	16	940714	940728	7.27	1.34	8.61
Santa-Maria	16	940714	940728	1.96	.23	2.19
Upland	16	940714	940728	10.44	1.64	12.09
Alpine	17	940728	940811	4.54	.62	5.16
Atascadero	17	940728	940811	3.29	.10	3.40
Lake-Arrowhead	17	940728	940811	5.89	.47	6.37
Lake-Elsinore	17	940728	940811	6.83	.87	7.70
Lancaster	17	940727	940810	5.77	.47	6.24
Lompoc	17	940728	940811	.74	.00	.71
Lompoc	17	940730	940811	-99.00	-99.00	-99.00
Long-Beach	17	940727	940810	6.01	1.52	7.53
Mira-Loma	17	940728	940811	19.76	1.33	21.09
Riverside	17	940728	940811	9.23	1.02	10.24
San-Dimas	17	940728	940811	8.78	1.48	10.26
Santa-Maria	17	940728	940811	2.39	.09	2.48
Upland	17	940728	940811	10.78	1.69	12.47
Alpine	18	940811	940825	4.66	.39	5.04
Atascadero	18	940811	940825	8.03	.28	8.31
Lake-Arrowhead	18	940811	940825	4.61	.43	5.04
Lake-Elsinore	18	940811	940825	5.54	.53	6.07
Lancaster	18	940810	940824	5.75	.45	6.20
Lompoc	18	940811	940825	1.34	.02	1.37
Long-Beach	18	940810	940824	7.25	.82	8.08
Mira-Loma	18	940811	940824	19.51	1.05	20.55
Riverside	18	940811	940825	8.79	.99	9.79
San-Dimas	18	940811	940825	8.11	1.10	9.21
Santa-Maria	18	940811	940825	3.46	.36	3.82
Upland	18	940811	940825	9.42	1.17	10.60
Alpine	19	940825	940908	5.19	.47	5.67
Atascadero	19	940825	940908	4.75	.33	5.07
Lake-Arrowhead	19	940825	940908	6.93	.60	7.53
Lake-Elsinore	19	940825	940908	6.58	.76	7.35
Lancaster	19	940824	940907	8.04	.69	8.73
Lompoc	19	940825	940908	1.13	.13	1.26
Long-Beach	19	940824	940907	7.35	.75	8.10
Mira-Loma	19	940825	940908	27.88	1.33	29.22
Riverside	19	940825	940908	10.66	1.22	11.88
San-Dimas	19	940825	940908	12.05	1.64	13.69
Santa-Maria	19	940825	940908	3.18	.26	3.44
Upland	19	940825	940908	13.18	1.65	14.83
Alpine	20	940908	940922	4.60	.42	5.03
Atascadero	20	940908	940923	4.81	.44	5.25

Site	Period	Start Date	End Date	Organic Carbon $\mu g\ m^{-3}$	Elemental Carbon $\mu g\ m^{-3}$	Total Carbon $\mu g\ m^{-3}$
Lake-Arrowhead	20	940908	940922	5.25	.49	5.74
Lake-Elsinore	20	940908	940922	5.75	.70	6.45
Lancaster	20	940907	940921	8.48	.82	9.30
Lompoc	20	940908	940923	1.52	.14	1.66
Long-Beach	20	940907	940921	8.15	.96	9.11
Mira-Loma	20	940908	940922	-99.00	-99.00	-99.00
Riverside	20	940908	940922	10.90	1.32	12.22
San-Dimas	20	940908	940922	11.35	1.51	12.86
Santa-Maria	20	940908	940923	3.96	.52	4.48
Upland	20	940908	940922	12.39	1.61	14.00
Alpine	21	940922	941006	3.42	.44	3.86
Atascadero	21	940922	941006	3.94	.51	4.46
Lake-Arrowhead	21	940922	941006	2.98	.30	3.28
Lake-Elsinore	21	940922	941006	5.32	.79	6.11
Lancaster	21	940921	941005	5.35	.45	5.79
Lompoc	21	940922	941006	2.24	.19	2.43
Long-Beach	21	940921	941005	5.08	1.17	6.25
Mira-Loma	21	940922	941006	17.43	1.35	18.78
Riverside	21	940922	941006	8.86	1.07	9.92
San-Dimas	21	940922	941006	9.42	1.59	11.01
Santa-Maria	21	940922	941006	2.99	.21	3.20
Upland	21	940922	941006	8.63	1.22	9.85
Alpine	22	941006	941020	2.94	.17	3.11
Atascadero	22	941006	941020	5.25	.40	5.65
Lake-Arrowhead	22	941006	941020	2.73	.20	2.93
Lake-Elsinore	22	941006	941020	4.39	.40	4.79
Lancaster	22	941005	941019	5.91	.58	6.48
Lompoc	22	941006	941020	-99.00	-99.00	-99.00
Long-Beach	22	941005	941019	8.00	1.14	9.14
Mira-Loma	22	941006	941020	11.95	1.08	13.03
Riverside	22	941006	941020	6.49	.74	7.23
San-Dimas	22	941006	941020	6.91	.76	7.67
Santa-Maria	22	941006	941020	3.90	.13	4.03
Upland	22	941006	941020	7.09	.78	7.86
Alpine	23	941020	941103	3.79	.38	4.17
Atascadero	23	941020	941103	5.28	.52	5.80
Lake-Arrowhead	23	941020	941103	3.22	.27	3.49
Lake-Elsinore	23	941020	941103	5.81	.67	6.48
Lancaster	23	941019	941102	7.71	.85	8.56
Lompoc	23	941020	941103	2.34	.10	2.45
Long-Beach	23	941019	941102	7.26	1.44	8.70
Mira-Loma	23	941020	941103	16.07	1.21	17.27
Riverside	23	941020	941103	9.26	1.11	10.37
San-Dimas	23	941020	941103	9.31	1.33	10.64
Santa-Maria	23	941020	941103	4.67	.28	4.96

Site	Period	Start Date	End Date	Organic Carbon $\mu g\ m^{-3}$	Elemental Carbon $\mu g\ m^{-3}$	Total Carbon $\mu g\ m^{-3}$
Upland	23	941020	941103	9.92	1.36	11.28
Alpine	24	941103	941117	3.38	.48	3.86
Atascadero	24	941103	941117	6.60	.60	7.20
Lake-Arrowhead	24	941103	941117	2.25	.21	2.46
Lake-Elsinore	24	941103	941117	-99.00	-99.00	-99.00
Lancaster	24	941102	941116	6.67	.93	7.60
Lompoc	24	941103	941117	2.32	.03	2.34
Long-Beach	24	941102	941116	11.29	1.81	13.10
Mira-Loma	24	941103	941117	15.04	1.49	16.53
Riverside	24	941103	941117	5.84	.92	6.76
San-Dimas	24	941103	941117	9.10	1.31	10.41
Santa-Maria	24	941103	941117	3.73	.17	3.90
Upland	24	941103	941117	8.01	1.08	9.09
Alpine	25	941117	941201	3.20	.20	3.40
Atascadero	25	941117	941201	10.78	.70	11.48
Lake-Arrowhead	25	941117	941201	1.69	.19	1.87
Lake-Elsinore	25	941117	941201	4.64	.68	5.32
Lancaster	25	941116	941130	9.19	1.03	10.22
Lompoc	25	941117	941201	3.88	.22	4.09
Long-Beach	25	941116	941130	15.68	2.09	17.77
Mira-Loma	25	941117	941201	14.90	1.55	16.45
Riverside	25	941117	941201	6.77	1.29	8.06
San-Dimas	25	941117	941201	8.91	1.22	10.13
Santa-Maria	25	941117	941201	5.75	.50	6.25
Upland	25	941117	941201	9.13	1.20	10.32
Alpine	26	941201	941215	3.45	.36	3.82
Atascadero	26	941201	941215	7.39	.64	8.03
Lake-Arrowhead	26	941201	941215	1.83	.14	1.97
Lake-Elsinore	26	941201	941215	6.76	.83	7.59
Lancaster	26	941130	941214	8.45	1.16	9.60
Lompoc	26	941201	941215	3.79	.44	4.22
Long-Beach	26	941130	941214	13.99	1.67	15.66
Mira-Loma	26	941201	941215	20.88	1.57	22.45
Riverside	26	941201	941215	9.13	1.07	10.20
San-Dimas	26	941201	941215	12.17	1.56	13.73
Santa-Maria	26	941201	941215	4.59	.59	5.19
Upland	26	941201	941215	12.82	1.46	14.28
Alpine	27	941215	941229	2.80	.29	3.09
Atascadero	27	941215	941229	10.53	.83	11.36
Lake-Arrowhead	27	941215	941230	2.22	.12	2.34
Lake-Elsinore	27	941215	941229	3.98	.71	4.68
Lancaster	27	941214	941229	8.40	.96	9.36
Lompoc	27	941215	941229	4.50	.24	4.74
Long-Beach	27	941214	941229	11.20	2.00	13.20
Mira-Loma	27	941215	941230	12.08	1.42	13.50

Site	Period	Start Date	End Date	Organic Carbon $\mu g\ m^{-3}$	Elemental Carbon $\mu g\ m^{-3}$	Total Carbon $\mu g\ m^{-3}$
Riverside	27	941215	941230	5.00	.86	5.86
San-Dimas	27	941215	941230	7.06	1.05	8.10
Santa-Maria	27	941215	941229	6.37	.55	6.91
Upland	27	941215	941230	7.92	1.04	8.96
Alpine	28	941229	950112	2.86	.30	3.16
Atascadero	28	941229	950112	5.87	.53	6.41
Lake-Arrowhead	28	941230	950113	-99.00	-99.00	-99.00
Lake-Elsinore	28	941229	950112	2.80	.67	3.46
Lancaster	28	941229	950112	6.77	.80	7.57
Lompoc	28	941229	950113	2.87	.24	3.11
Long-Beach	28	941229	950112	7.15	1.51	8.65
Mira-Loma	28	941230	950113	8.57	1.02	9.59
Riverside	28	941230	950113	4.31	.76	5.07
San-Dimas	28	941230	950113	6.46	1.11	7.57
Santa-Maria	28	941229	950113	3.65	.43	4.08
Upland	28	941230	950112	5.90	.95	6.85
Alpine	29	950112	950126	2.42	.30	2.72
Atascadero	29	950112	950126	6.01	.80	6.81
Lake-Arrowhead	29	950113	950127	1.14	.13	1.26
Lake-Elsinore	29	950112	950126	3.58	.60	4.18
Lancaster	29	950112	950126	5.81	.68	6.49
Lompoc	29	950113	950126	3.51	.29	3.79
Long-Beach	29	950112	950126	8.49	1.69	10.18
Mira-Loma	29	950113	950127	9.01	1.15	10.16
Riverside	29	950113	950127	4.88	.87	5.74
San-Dimas	29	950113	950127	6.82	1.15	7.97
Santa-Maria	29	950113	950126	3.50	.38	3.88
Upland	29	950112	950126	6.94	1.04	7.97
Alpine	30	950126	950209	4.46	.54	5.00
Atascadero	30	950126	950209	5.79	.66	6.44
Lake-Arrowhead	30	950127	950210	1.90	.10	2.00
Lake-Elsinore	30	950126	950209	4.92	.75	5.67
Lancaster	30	950126	950209	8.33	1.13	9.45
Lompoc	30	950126	950209	.41	.00	.37
Long-Beach	30	950126	950209	12.17	2.32	14.49
Mira-Loma	30	950127	950210	12.72	1.56	14.28
Riverside	30	950127	950210	6.64	1.04	7.67
San-Dimas	30	950127	950210	-99.00	-99.00	-99.00
Santa-Maria	30	950126	950209	4.88	.45	5.33
Upland	30	950126	950209	10.06	1.08	11.15
Alpine	31			-99.00	-99.00	-99.00
Atascadero	31			-99.00	-99.00	-99.00
Lake-Arrowhead	31			-99.00	-99.00	-99.00
Lake-Elsinore	31			-99.00	-99.00	-99.00
Lancaster	31			-99.00	-99.00	-99.00

Site	Period	Start Date	End Date	Organic Carbon $\mu g\ m^{-3}$	Elemental Carbon $\mu g\ m^{-3}$	Total Carbon $\mu g\ m^{-3}$
Lompoc	31			-99.00	-99.00	-99.00
Long-Beach	31			-99.00	-99.00	-99.00
Mira-Loma	31			-99.00	-99.00	-99.00
Riverside	31			-99.00	-99.00	-99.00
San-Dimas	31			-99.00	-99.00	-99.00
Santa-Maria	31			-99.00	-99.00	-99.00
Upland	31			-99.00	-99.00	-99.00
Alpine	32	950223	950309	2.39	.41	2.80
Atascadero	32	950222	950309	4.16	.39	4.54
Lake-Arrowhead	32	950224	950309	2.21	.59	2.80
Lake-Elsinore	32	950223	950309	3.80	.62	4.42
Lancaster	32	950223	950308	5.37	.73	6.10
Lompoc	32	950223	950309	2.57	.22	2.79
Long-Beach	32	950223	950308	5.95	1.48	7.43
Mira-Loma	32	950224	950309	7.74	1.04	8.78
Riverside	32	950224	950309	5.94	.90	6.83
San-Dimas	32	950224	950309	7.44	1.02	8.45
Santa-Maria	32	950223	950309	4.10	.46	4.56
Upland	32	950224	950309	6.72	1.05	7.77
Alpine	33	950309	950323	3.18	.32	3.50
Atascadero	33	950309	950323	3.14	.27	3.41
Lake-Arrowhead	33	950309	950322	2.96	.45	3.41
Lake-Elsinore	33	950309	950323	5.86	.83	6.69
Lancaster	33	950308	950322	4.41	.52	4.93
Lompoc	33	950309	950323	2.10	.14	2.24
Long-Beach	33	950308	950322	6.54	1.03	7.57
Mira-Loma	33	950309	950323	8.52	1.17	9.69
Riverside	33	950309	950323	7.49	1.02	8.52
San-Dimas	33	950309	950323	6.72	1.28	8.00
Santa-Maria	33	950309	950323	4.41	.24	4.65
Upland	33	950309	950323	9.79	1.61	11.40
Alpine	34	950323	950407	2.94	.27	3.21
Atascadero	34	950323	950407	4.27	.48	4.75
Lake-Arrowhead	34	950322	950406	2.16	.23	2.39
Lake-Elsinore	34	950323	950407	3.82	.44	4.26
Lancaster	34	950322	950406	5.96	.75	6.71
Lompoc	34	950323	950407	1.92	.17	2.09
Long-Beach	34	950322	950406	8.99	1.41	10.40
Mira-Loma	34	950323	950407	9.01	.84	9.85
Riverside	34	950323	950407	5.26	.69	5.95
San-Dimas	34	950323	950407	10.41	1.25	11.66
Santa-Maria	34	950323	950407	3.63	.36	3.99
Upland	34	950323	950407	7.58	.71	8.29
Alpine	35	950407	950420	2.38	.27	2.64
Atascadero	35	950407	950420	2.82	.41	3.23

Site	Period	Start Date	End Date	Organic Carbon $\mu g\ m^{-3}$	Elemental Carbon $\mu g\ m^{-3}$	Total Carbon $\mu g\ m^{-3}$
Lake-Arrowhead	35	950406	950420	-99.00	-99.00	-99.00
Lake-Elsinore	35	950407	950420	3.44	.58	4.02
Lancaster	35	950406	950420	3.43	.41	3.84
Lompoc	35	950407	950420	1.15	.00	1.15
Long-Beach	35	950406	950420	5.31	1.00	6.31
Mira-Loma	35	950407	950421	7.68	.77	8.45
Riverside	35	950407	950421	5.27	.95	6.22
San-Dimas	35	950407	950421	6.63	.89	7.52
Santa-Maria	35	950407	950420	2.82	.45	3.27
Upland	35	950407	950421	6.48	.85	7.33
Alpine	36	950420	950504	2.51	.27	2.78
Atascadero	36	950420	950504	2.93	.39	3.32
Lake-Arrowhead	36	950420	950503	4.12	.79	4.91
Lake-Elsinore	36	950420	950504	3.71	.50	4.20
Lancaster	36	950420	950503	4.37	.51	4.88
Lompoc	36	950420	950503	1.49	.14	1.63
Long-Beach	36	950420	950503	4.79	1.18	5.97
Mira-Loma	36	950421	950504	7.09	.69	7.78
Riverside	36	950421	950504	4.53	.67	5.20
San-Dimas	36	950421	950504	5.90	.88	6.78
Santa-Maria	36	950420	950503	3.41	.35	3.76
Upland	36	950421	950504	5.83	1.06	6.89
Alpine	37	950504	950518	1.52	.24	1.76
Atascadero	37	950504	950518	3.87	.21	4.08
Lake-Arrowhead	37	950503	950518	1.94	.48	2.42
Lake-Elsinore	37	950504	950518	2.01	.29	2.30
Lancaster	37	950503	950518	3.29	.39	3.68
Lompoc	37	950503	950518	.21	.00	.17
Long-Beach	37	950503	950518	3.19	.83	4.02
Mira-Loma	37	950504	950518	6.19	.64	6.83
Riverside	37	950504	950518	3.50	.68	4.18
San-Dimas	37	950504	950518	4.17	.94	5.11
Santa-Maria	37	950503	950518	2.04	.43	2.47
Upland	37	950504	950518	4.00	.89	4.89
Alpine	38			-99.00	-99.00	-99.00
Atascadero	38			-99.00	-99.00	-99.00
Lake-Arrowhead	38			-99.00	-99.00	-99.00
Lake-Elsinore	38			-99.00	-99.00	-99.00
Lancaster	38			-99.00	-99.00	-99.00
Lompoc	38			-99.00	-99.00	-99.00
Long-Beach	38			-99.00	-99.00	-99.00
Mira-Loma	38			-99.00	-99.00	-99.00
Riverside	38			-99.00	-99.00	-99.00
San-Dimas	38			-99.00	-99.00	-99.00
Santa-Maria	38			-99.00	-99.00	-99.00

Site	Period	Start Date	End Date	Organic Carbon $\mu g\ m^{-3}$	Elemental Carbon $\mu g\ m^{-3}$	Total Carbon $\mu g\ m^{-3}$
Upland	38			-99.00	-99.00	-99.00
Alpine	39	950601	950615	3.87	.57	4.45
Atascadero	39	950601	950614	3.03	.42	3.45
Lake-Arrowhead	39	950601	950615	5.05	.80	5.85
Lake-Elsinore	39	950601	950615	4.68	.69	5.37
Lancaster	39	950601	950615	6.14	.41	6.56
Lompoc	39	950601	950615	.92	.04	.96
Long-Beach	39	950601	950615	4.38	1.55	5.93
Mira-Loma	39	950601	950615	12.85	.75	13.59
Riverside	39	950601	950615	7.49	.81	8.30
San-Dimas	39	950601	950615	6.39	1.14	7.53
Santa-Maria	39	950601	950615	2.75	.51	3.26
Upland	39	950601	950615	7.69	1.46	9.16
Alpine	40	950615	950629	-99.00	-99.00	-99.00
Atascadero	40	950614	950629	3.46	.28	3.74
Lake-Arrowhead	40	950615	950629	4.82	.41	5.23
Lake-Elsinore	40	950615	950629	5.70	.82	6.52
Lancaster	40	950615	950629	5.72	.44	6.15
Lompoc	40	950615	950629	-99.00	-99.00	-99.00
Long-Beach	40	950615	950629	4.46	1.49	5.95
Mira-Loma	40	950615	950629	9.11	1.22	10.32
Riverside	40	950615	950629	7.73	.96	8.69
San-Dimas	40	950615	950629	6.66	1.17	7.83
Santa-Maria	40	950615	950629	2.55	.31	2.86
Upland	40			-99.00	-99.00	-99.00
Alpine	41	950629	950713	5.59	.85	6.45
Atascadero	41	950629	950713	2.72	.22	2.94
Lake-Arrowhead	41			-99.00	-99.00	-99.00
Lake-Elsinore	41	950629	950713	6.56	.82	7.39
Lancaster	41	950629	950713	5.57	.58	6.15
Lompoc	41	950629	950713	1.16	.01	1.17
Long-Beach	41	950629	950713	4.76	1.39	6.14
Mira-Loma	41	950629	950713	-99.00	-99.00	-99.00
Riverside	41	950629	950713	9.41	1.69	11.10
San-Dimas	41	950629	950713	8.53	1.85	10.38
Santa-Maria	41	950629	950713	2.85	.24	3.09
Upland	41	950629	950713	10.94	1.43	12.36
Alpine	42	950713	950727	6.29	.48	6.76
Atascadero	42	950713	950726	4.06	.32	4.38
Lake-Arrowhead	42			-99.00	-99.00	-99.00
Lake-Elsinore	42	950713	950727	8.65	.86	9.52
Lancaster	42	950713	950727	7.66	.67	8.33
Lompoc	42	950713	950727	1.33	.04	1.37
Long-Beach	42	950713	950727	5.98	1.67	7.65
Mira-Loma	42	950713	950727	27.81	2.00	29.81

Site	Period	Start Date	End Date	Organic Carbon $\mu g\ m^{-3}$	Elemental Carbon $\mu g\ m^{-3}$	Total Carbon $\mu g\ m^{-3}$
Riverside	42	950713	950727	11.99	1.36	13.35
San-Dimas	42	950713	950727	11.05	1.65	12.70
Santa-Maria	42	950713	950727	2.79	.33	3.12
Upland	42	950713	950727	14.80	1.57	16.37
Alpine	43	950727	950810	7.59	.67	8.26
Atascadero	43	950726	950809	4.71	.33	5.04
Lake-Arrowhead	43			-99.00	-99.00	-99.00
Lake-Elsinore	43	950727	950810	8.13	.93	9.06
Lancaster	43	950727	950810	7.26	.68	7.94
Lompoc	43	950727	950808	1.37	.04	1.42
Long-Beach	43	950727	950810	5.59	2.07	7.66
Mira-Loma	43	950727	950810	-99.00	-99.00	-99.00
Riverside	43	950727	950810	13.56	1.34	14.91
San-Dimas	43	950727	950810	11.10	1.69	12.80
Santa-Maria	43	950727	950808	3.04	.38	3.41
Upland	43	950727	950810	16.70	2.11	18.80
Alpine	44	950810	950824	5.28	.48	5.76
Atascadero	44	950809	950823	5.19	.31	5.50
Lake-Arrowhead	44			-99.00	-99.00	-99.00
Lake-Elsinore	44	950810	950824	7.07	.62	7.69
Lancaster	44	950810	950824	6.47	.61	7.09
Lompoc	44	950808	950824	1.09	.00	1.08
Long-Beach	44	950810	950824	4.67	1.74	6.41
Mira-Loma	44	950810	950824	25.26	1.25	26.51
Riverside	44	950810	950824	10.63	.97	11.60
San-Dimas	44	950810	950824	9.84	1.57	11.41
Santa-Maria	44	950808	950824	2.74	.38	3.12
Upland	44	950810	950824	12.79	1.93	14.73
Alpine	45	950824	950907	10.10	.69	10.79
Atascadero	45	950823	950907	4.58	.35	4.93
Lake-Arrowhead	45			-99.00	-99.00	-99.00
Lake-Elsinore	45	950824	950907	8.49	.74	9.22
Lancaster	45	950824	950907	6.53	.66	7.20
Lompoc	45	950824	950907	2.04	.13	2.17
Long-Beach	45	950824	950907	9.14	2.14	11.27
Mira-Loma	45	950824	950907	25.86	2.34	28.19
Riverside	45	950824	950907	12.62	1.43	14.05
San-Dimas	45	950824	950907	12.85	1.63	14.48
Santa-Maria	45	950824	950907	4.08	.56	4.64
Upland	45	950824	950907	13.86	1.67	15.53
Alpine	46	950907	950921	5.28	.50	5.78
Atascadero	46	950907	950920	5.57	.45	6.02
Lake-Arrowhead	46			-99.00	-99.00	-99.00
Lake-Elsinore	46	950907	950921	8.48	.84	9.32
Lancaster	46	950907	950921	8.27	.82	9.09

Site	Period	Start Date	End Date	Organic Carbon $\mu g\ m^{-3}$	Elemental Carbon $\mu g\ m^{-3}$	Total Carbon $\mu g\ m^{-3}$
Lompoc	46	950907	950921	2.69	.13	2.82
Long-Beach	46	950907	950921	6.36	1.99	8.35
Mira-Loma	46	950907	950921	25.39	1.45	26.84
Riverside	46	950907	950921	-99.00	-99.00	-99.00
San-Dimas	46	950907	950921	10.18	1.90	12.08
Santa-Maria	46	950907	950921	2.94	.33	3.27
Upland	46	950907	950921	15.38	2.08	17.46
Alpine	47	950921	951005	4.15	.41	4.56
Atascadero	47	950920	951004	4.90	.54	5.44
Lake-Arrowhead	47			-99.00	-99.00	-99.00
Lake-Elsinore	47	950921	951005	5.63	.63	6.26
Lancaster	47	950921	951005	6.97	.64	7.61
Lompoc	47	950921	951008	2.76	.20	2.96
Long-Beach	47	950921	951005	6.83	1.99	8.82
Mira-Loma	47	950921	951005	19.58	1.44	21.02
Riverside	47	950921	951005	9.30	1.15	10.45
San-Dimas	47	950921	951005	9.74	1.69	11.43
Santa-Maria	47	950921	951005	5.28	.57	5.85
Upland	47	950921	951005	10.52	1.53	12.05
Alpine	48	951005	951019	4.49	.80	5.29
Atascadero	48	951004	951018	7.12	.66	7.78
Glendora	48	951013	951019	-99.00	-99.00	-99.00
Lake-Arrowhead	48			-99.00	-99.00	-99.00
Lake-Elsinore	48	951005	951019	8.54	1.56	10.11
Lancaster	48	951005	951019	9.58	1.13	10.71
Lompoc	48	951005	951019	2.25	.28	2.53
Long-Beach	48	951005	951019	5.78	1.85	7.64
Mira-Loma	48	951005	951020	18.30	1.67	19.97
Riverside	48	951005	951019	9.27	1.51	10.78
San-Dimas	48	951005	951019	8.91	1.91	10.82
Santa-Maria	48	951005	951019	4.58	.61	5.19
Upland	48	951005	951020	10.50	2.21	12.71
Alpine	49	951019	951102	4.42	.66	5.07
Atascadero	49	951018	951101	7.43	.80	8.23
Glendora	49	951019	951102	9.20	1.74	10.94
Lake-Arrowhead	49	951018	951102	4.11	.47	4.58
Lake-Elsinore	49	951019	951102	6.59	1.31	7.89
Lancaster	49	951019	951102	9.94	1.47	11.41
Lompoc	49	951019	951102	2.90	.32	3.22
Long-Beach	49	951019	951102	7.87	2.26	10.14
Mira-Loma	49	951020	951102	18.06	1.76	19.82
Riverside	49	951019	951102	10.39	1.63	12.02
San-Dimas	49	951019	951102	9.66	1.89	11.55
Santa-Maria	49	951019	951102	4.45	.51	4.96
Upland	49	951020	951102	10.56	1.86	12.43

Site	Period	Start Date	End Date	Organic Carbon $\mu g\ m^{-3}$	Elemental Carbon $\mu g\ m^{-3}$	Total Carbon $\mu g\ m^{-3}$
Alpine	50	951102	951116	5.18	.66	5.83
Atascadero	50	951101	951115	7.63	.75	8.38
Glendora	50	951102	951116	-99.00	-99.00	-99.00
Lake-Arrowhead	50	951102	951116	3.41	.40	3.81
Lake-Elsinore	50	951102	951116	8.28	1.03	9.32
Lancaster	50	951102	951116	10.21	1.13	11.34
Lompoc	50	951102	951116	3.16	.24	3.39
Long-Beach	50	951102	951116	10.27	1.93	12.21
Mira-Loma	50	951102	951116	20.41	2.45	22.87
Riverside	50	951102	951116	12.51	1.42	13.93
San-Dimas	50	951102	951116	12.27	1.57	13.84
Santa-Maria	50	951102	951116	5.07	.45	5.52
Upland	50	951102	951116	13.76	1.80	15.56
Alpine	51	951116	951201	6.02	.63	6.65
Atascadero	51	951115	951129	8.03	.81	8.84
Glendora	51	951116	951130	12.03	1.36	13.39
Lake-Arrowhead	51	951116	951130	3.08	.34	3.42
Lake-Elsinore	51	951116	951130	10.66	1.13	11.79
Lancaster	51	951116	951130	15.02	1.49	16.51
Lompoc	51	951116	951130	4.09	.33	4.42
Long-Beach	51	951116	951130	16.15	3.12	19.27
Mira-Loma	51	951116	951130	28.24	3.12	31.36
Riverside	51	951116	951130	16.54	1.96	18.50
San-Dimas	51	951116	951130	15.44	2.22	17.66
Santa-Maria	51	951116	951130	6.46	.62	7.09
Upland	51	951116	951130	18.13	1.97	20.10
Alpine	52	951201	951214	5.04	.80	5.83
Atascadero	52	951129	951213	7.85	1.08	8.92
Glendora	52	951130	951214	11.19	1.73	12.93
Lake-Arrowhead	52	951130	951214	2.64	.46	3.11
Lake-Elsinore	52	951130	951213	9.38	1.54	10.92
Lancaster	52	951130	951214	8.61	1.03	9.64
Lompoc	52	951130	951214	2.29	.23	2.53
Long-Beach	52	951130	951214	11.74	2.77	14.52
Mira-Loma	52	951130	951214	25.63	3.49	29.11
Riverside	52	951130	951213	15.35	2.41	17.76
San-Dimas	52	951130	951214	14.60	3.00	17.60
Santa-Maria	52	951130	951214	4.52	.46	4.98
Upland	52	951130	951213	16.58	2.61	19.20
Alpine	53	951214	951228	3.43	.50	3.92
Atascadero	53	951213	951227	9.06	.88	9.94
Glendora	53	951214	951227	4.85	.59	5.44
Lake-Arrowhead	53	951215	951228	1.70	.27	1.97
Lake-Elsinore	53	951213	951228	5.31	.94	6.25
Lancaster	53	951214	951228	10.48	1.19	11.67

Site	Period	Start Date	End Date	Organic Carbon $\mu g\ m^{-3}$	Elemental Carbon $\mu g\ m^{-3}$	Total Carbon $\mu g\ m^{-3}$
Lompoc	53	951214	951228	4.00	.30	4.30
Long-Beach	53	951214	951228	11.29	1.30	12.59
Mira-Loma	53	951214	951227	11.73	1.49	13.22
Riverside	53	951213	951228	7.49	1.25	8.73
San-Dimas	53	951214	951228	7.88	1.27	9.15
Santa-Maria	53	951214	951228	5.24	.42	5.66
Upland	53	951213	951227	8.92	1.26	10.18
Alpine	54	951228	960111	3.97	.47	4.44
Atascadero	54	951227	960110	-99.00	-99.00	-99.00
Glendora	54	951227	960111	7.18	.85	8.03
Lake-Arrowhead	54	951228	960112	1.66	.27	1.93
Lake-Elsinore	54	951228	960111	5.95	.98	6.93
Lancaster	54	951229	960111	8.10	.84	8.94
Lompoc	54	951228	960125	2.06	.12	2.18
Long-Beach	54	951228	960111	13.42	2.48	15.90
Mira-Loma	54	951227	960110	15.98	2.31	18.29
Riverside	54	951228	960112	7.56	1.31	8.87
San-Dimas	54	960102	960110	-99.00	-99.00	-99.00
Santa-Maria	54	951228	960208	2.86	.27	3.13
Upland	54	951227	960111	11.23	1.43	12.66
Alpine	55	960111	960125	2.42	.28	2.70
Atascadero	55	960111		-99.00	-99.00	-99.00
Glendora	55	960111	960125	7.20	1.07	8.27
Lake-Arrowhead	55	960112	960125	1.66	.24	1.90
Lake-Elsinore	55	960111	960125	4.01	.72	4.73
Lancaster	55	960111	960125	6.09	.60	6.69
Lompoc	55	951228	960125	2.06	.12	2.18
Long-Beach	55	960111	960125	-99.00	-99.00	-99.00
Mira-Loma	55	960110	960119	-99.00	-99.00	-99.00
Mira-Loma	55	960110	960124	12.52	1.49	14.01
Riverside	55	960112	960124	6.83	1.25	8.07
San-Dimas	55	960110	960124	8.43	1.25	9.68
Santa-Maria	55	951228	960208	2.86	.27	3.13
Upland	55	960112	960125	9.41	1.47	10.88
Alpine	56	960125	960208	2.17	.39	2.56
Atascadero	56	960125	960207	3.86	.42	4.28
Glendora	56	960125	960208	5.43	.81	6.24
Lake-Arrowhead	56	960125	960203	-99.00	-99.00	-99.00
Lake-Elsinore	56	960125	960208	3.27	.59	3.85
Lancaster	56	960125	960208	5.37	.70	6.07
Lompoc	56	960125	960208	2.47	.25	2.72
Long-Beach	56	960125	960208	6.91	1.64	8.55
Mira-Loma	56	960124	960207	8.12	1.20	9.32
Riverside	56	960124	960207	5.23	1.01	6.24
San-Dimas	56	960124	960208	5.92	.93	6.85

Site	Period	Start Date	End Date	Organic Carbon $\mu g\ m^{-3}$	Elemental Carbon $\mu g\ m^{-3}$	Total Carbon $\mu g\ m^{-3}$
Santa-Maria	56	951228	960208	2.86	.27	3.13
Upland	56	960125	960208	6.72	1.64	8.36
Alpine	57	960208	960222	2.20	.28	2.48
Atascadero	57	960207	960222	3.69	.39	4.08
Glendora	57	960208	960222	5.35	.77	6.12
Lake-Arrowhead	57	960208	960222	-99.00	-99.00	-99.00
Lake-Elsinore	57	960208	960222	4.18	.76	4.94
Lancaster	57	960208	960222	4.30	.53	4.83
Lompoc	57	960208	960222	2.00	.11	2.10
Long-Beach	57	960208	960222	4.17	.85	5.02
Mira-Loma	57	960207	960221	7.76	1.21	8.97
Riverside	57	960207	960222	4.43	.77	5.20
San-Dimas	57	960208	960221	5.04	.97	6.01
Santa-Maria	57	960208	960222	3.24	.32	3.56
Upland	57	960208	960222	5.43	.83	6.26
Alpine	58	960222	960307	1.44	.16	1.60
Atascadero	58	960222	960306	2.84	.25	3.09
Glendora	58	960222	960321	4.87	.68	5.54
Lake-Arrowhead	58	960222	960307	.71	.07	.78
Lake-Elsinore	58	960222	960307	2.41	.33	2.75
Lancaster	58	960222	960307	4.51	.47	4.98
Lompoc	58	960222	960307	2.39	.00	2.39
Long-Beach	58	960222	960307	5.89	.84	6.73
Mira-Loma	58	960221	960306	6.09	.79	6.87
Riverside	58	960222	960306	3.89	.59	4.48
San-Dimas	58	960221	960306	4.16	.58	4.73
Santa-Maria	58	960222	960307	2.75	.08	2.83
Upland	58	960222	960307	4.96	.64	5.60
Alpine	59	960307	960321	3.01	.42	3.42
Atascadero	59	960306	960320	3.77	.45	4.22
Glendora	59	960222	960321	4.87	.68	5.54
Lake-Arrowhead	59	960307	960321	1.89	.27	2.15
Lake-Elsinore	59	960307	960320	3.98	.61	4.58
Lancaster	59	960307	960321	5.83	.66	6.49
Lompoc	59	960307	960321	1.64	.18	1.81
Long-Beach	59	960307	960321	-99.00	-99.00	-99.00
Mira-Loma	59	960306	960321	7.71	1.11	8.81
Riverside	59	960306	960320	6.78	1.19	7.97
San-Dimas	59	960306	960320	6.55	1.01	7.56
Santa-Maria	59	960307	960321	3.27	.37	3.64
Upland	59	960307	960321	7.46	.85	8.31
Alpine	60	960321	960404	2.29	.23	2.51
Atascadero	60	960320	960403	3.51	.27	3.78
Glendora	60	960321	960404	6.36	.64	7.00
Lake-Arrowhead	60	960321	960404	1.83	.32	2.14

Site	Period	Start Date	End Date	Organic Carbon $\mu g\ m^{-3}$	Elemental Carbon $\mu g\ m^{-3}$	Total Carbon $\mu g\ m^{-3}$
Lake-Elsinore	60	960320	960404	3.45	.39	3.83
Lancaster	60	960321	960404	4.59	.54	5.13
Lompoc	60	960321	960404	1.27	.04	1.31
Long-Beach	60	960321	960404	4.70	.63	5.33
Mira-Loma	60	960321	960403	6.18	.84	7.02
Riverside	60	960320	960403	4.38	.74	5.12
San-Dimas	60	960320	960404	4.73	.88	5.61
Santa-Maria	60	960321	960404	2.72	.32	3.04
Upland	60	960321	960404	6.40	.77	7.17
Alpine	61	960404	960418	2.21	.22	2.42
Atascadero	61	960403	960417	2.77	.29	3.06
Glendora	61	960404	960418	4.75	.43	5.18
Lake-Arrowhead	61	960404	960418	-99.00	-99.00	-99.00
Lake-Elsinore	61	960404	960417	3.69	.41	4.10
Lancaster	61	960404	960418	3.14	.18	3.33
Lompoc	61	960404	960418	1.41	.01	1.42
Long-Beach	61	960404	960418	4.89	.41	5.30
Mira-Loma	61	960403	960417	10.10	.79	10.89
Riverside	61	960403	960417	4.76	.47	5.23
San-Dimas	61	960404	960417	4.98	.51	5.49
Santa-Maria	61	960404	960418	2.84	.29	3.13
Upland	61	960404	960417	5.93	.72	6.65
Alpine	62	960418	960502	3.52	.20	3.73
Atascadero	62	960417	960501	3.71	.16	3.87
Glendora	62	960418	960501	6.80	.62	7.42
Lake-Arrowhead	62	960418	960502	3.55	.20	3.75
Lake-Elsinore	62	960417	960501	4.64	.40	5.05
Lancaster	62	960418	960502	4.01	.25	4.26
Lompoc	62	960418	960502	2.96	.00	2.94
Long-Beach	62	960418	960502	5.33	.70	6.03
Mira-Loma	62	960417	960501	13.60	1.01	14.61
Riverside	62	960417	960501	6.48	.70	7.19
San-Dimas	62	960417	960502	7.00	1.08	8.08
Santa-Maria	62	960418	960502	4.83	.04	4.87
Upland	62	960417	960501	8.49	.87	9.36
Alpine	63	960502	960516	5.29	1.03	6.32
Atascadero	63	960501	960515	5.80	.33	6.13
Glendora	63	960501	960515	9.18	.89	10.07
Lake-Arrowhead	63	960502		-99.00	-99.00	-99.00
Lake-Elsinore	63	960501	960515	6.42	.45	6.87
Lancaster	63	960502	960516	5.55	.33	5.88
Lompoc	63	960502	960515	1.57	.21	1.78
Long-Beach	63	960502	960516	3.80	.59	4.39
Mira-Loma	63	960501	960515	17.88	.63	18.52
Riverside	63	960501	960515	8.67	.80	9.47

Site	Period	Start Date	End Date	Organic Carbon $\mu g\ m^{-3}$	Elemental Carbon $\mu g\ m^{-3}$	Total Carbon $\mu g\ m^{-3}$
San-Dimas	63	960502	960515	9.46	.94	10.40
Santa-Maria	63	960502	960515	4.52	.14	4.67
Upland	63	960501	960515	9.75	1.13	10.87
Alpine	64	960516	960530	2.36	.28	2.64
Atascadero	64	960515	960530	2.20	.11	2.31
Glendora	64	960515	960529	4.40	.58	4.98
Lake-Arrowhead	64			-99.00	-99.00	-99.00
Lake-Elsinore	64	960515	960529	4.31	.18	4.49
Lancaster	64	960516	960530	4.18	.45	4.63
Lompoc	64	960515	960529	.98	.02	1.01
Long-Beach	64	960516	960530	3.39	.83	4.22
Mira-Loma	64	960515	960529	11.92	.57	12.49
Riverside	64	960515	960529	4.38	.67	5.05
San-Dimas	64	960515	960529	4.05	.95	5.00
Santa-Maria	64	960515	960529	2.36	.24	2.59
Upland	64	960515	960529	4.33	.86	5.19
Alpine	65	960530	960613	4.98	1.05	6.03
Atascadero	65	960530	960612	4.99	.18	5.17
Glendora	65	960529	960612	9.20	.57	9.77
Lake-Arrowhead	65	960531	960613	9.23	1.63	10.86
Lake-Elsinore	65	960529	960613	5.75	.89	6.64
Lancaster	65	960530	960612	-99.00	-99.00	-99.00
Lompoc	65	960529	960613	1.34	.14	1.47
Long-Beach	65	960530	960612	3.93	.87	4.80
Mira-Loma	65	960529	960612	15.69	1.11	16.80
Riverside	65	960529	960613	6.56	.75	7.31
San-Dimas	65	960529	960612	8.82	.74	9.56
Santa-Maria	65	960529	960613	3.25	.17	3.42
Upland	65	960529	960612	10.66	.62	11.27
Alpine	66	960613	960627	1.91	.31	2.21
Atascadero	66	960612	960626	2.28	.20	2.47
Glendora	66	960612	960628	5.40	.94	6.35
Lake-Arrowhead	66	960613	960627	3.40	.82	4.22
Lake-Elsinore	66	960613	960627	3.11	.39	3.49
Lancaster	66	960612	960627	4.35	.38	4.73
Lompoc	66	960613	960627	1.06	.07	1.12
Long-Beach	66	960612	960627	2.81	.91	3.72
Mira-Loma	66	960612	960626	14.82	1.07	15.88
Riverside	66	960613	960626	5.60	.61	6.21
San-Dimas	66	960612	960626	4.25	.94	5.19
Santa-Maria	66	960613	960627	1.69	.26	1.95
Upland	66	960612	960627	6.11	.95	7.06
Alpine	67	960627	960711	3.92	.40	4.32
Atascadero	67	960626	960711	3.04	.23	3.27
Glendora	67	960628	960711	10.51	1.33	11.84

Site	Period	Start Date	End Date	Organic Carbon $\mu g\ m^{-3}$	Elemental Carbon $\mu g\ m^{-3}$	Total Carbon $\mu g\ m^{-3}$
Lake-Arrowhead	67	960627	960711	5.53	.60	6.13
Lake-Elsinore	67	960627	960711	-99.00	-99.00	-99.00
Lancaster	67	960627	960710	5.11	.39	5.50
Lompoc	67	960627	960712	.93	.10	1.03
Long-Beach	67	960627	960710	4.39	1.18	5.57
Mira-Loma	67	960626	960710	21.96	1.62	23.59
Riverside	67	960626	960710	9.06	.90	9.96
San-Dimas	67	960626	960710	7.76	1.13	8.88
Santa-Maria	67	960627	960712	2.08	.31	2.40
Upland	67	960627	960711	-99.00	-99.00	-99.00
Alpine	68	960711	960725	3.59	.50	4.09
Atascadero	68	960711	960724	2.79	.21	3.00
Glendora	68	960711	960725	7.29	1.03	8.32
Lake-Arrowhead	68	960710	960725	5.22	.52	5.73
Lake-Elsinore	68	960711	960725	4.86	.77	5.63
Lancaster	68	960710	960724	5.03	.49	5.52
Lompoc	68	960712	960725	.73	.02	.75
Long-Beach	68	960710	960723	4.16	1.21	5.37
Mira-Loma	68	960710	960724	21.27	1.79	23.06
Riverside	68	960710	960724	7.61	.99	8.60
San-Dimas	68	960710	960724	6.21	1.07	7.28
Santa-Maria	68	960712	960725	1.92	.28	2.20
Upland	68	960711	960725	8.26	1.42	9.69
Alpine	69	960725	960808	3.09	.52	3.61
Atascadero	69	960724	960807	3.61	.32	3.93
Glendora	69	960725	960807	9.46	1.01	10.47
Lake-Arrowhead	69	960725	960808	5.28	.51	5.78
Lake-Elsinore	69	960725	960807	4.69	.56	5.25
Lancaster	69	960724	960808	4.87	.48	5.35
Lompoc	69	960725	960807	.89	.01	.90
Long-Beach	69			-99.00	-99.00	-99.00
Mira-Loma	69	960724	960807	20.96	1.36	22.32
Riverside	69	960724	960807	7.56	.83	8.38
San-Dimas	69	960724	960807	6.79	1.14	7.93
Santa-Maria	69	960725	960807	1.95	.35	2.31
Upland	69	960725	960807	8.21	1.41	9.61
Alpine	70	960808	960822	5.67	.57	6.24
Atascadero	70	960807	960822	4.12	.35	4.46
Glendora	70	960807	960823	10.82	1.10	11.92
Lake-Arrowhead	70	960808	960822	6.12	.56	6.67
Lake-Elsinore	70	960807	960821	-99.00	-99.00	-99.00
Lancaster	70	960808	960822	8.48	.72	9.20
Lompoc	70	960807	960822	1.64	.09	1.73
Long-Beach	70			-99.00	-99.00	-99.00
Mira-Loma	70	960807	960821	24.30	1.38	25.68

Site	Period	Start Date	End Date	Organic Carbon $\mu g\ m^{-3}$	Elemental Carbon $\mu g\ m^{-3}$	Total Carbon $\mu g\ m^{-3}$
Riverside	70	960807	960821	11.01	1.18	12.19
San-Dimas	70	960807	960822	8.62	1.80	10.43
Santa-Maria	70	960807	960822	-99.00	-99.00	-99.00
Upland	70	960807	960821	11.20	1.88	13.08
Alpine	71	960822	960905	4.67	.50	5.17
Atascadero	71	960822	960905	5.12	.47	5.59
Glendora	71	960823	960906	11.89	1.43	13.31
Lake-Arrowhead	71	960822	960904	5.49	.53	6.01
Lake-Elsinore	71	960821	960904	5.49	.86	6.35
Lancaster	71	960822	960905	7.12	.55	7.66
Lompoc	71	960822	960905	1.90	.07	1.97
Long-Beach	71			-99.00	-99.00	-99.00
Mira-Loma	71	960821	960904	31.49	1.55	33.04
Riverside	71	960821	960904	11.91	1.18	13.09
San-Dimas	71	960822	960905	9.57	1.52	11.09
Santa-Maria	71	960826	960905	-99.00	-99.00	-99.00
Upland	71	960821	960905	11.60	2.14	13.74
Alpine	72	960905	960919	3.01	.57	3.57
Atascadero	72	960905	960918	3.45	.35	3.81
Glendora	72	960906	960920	7.20	1.09	8.29
Lake-Arrowhead	72	960904	960919	2.66	.53	3.19
Lake-Elsinore	72	960904	960918	3.50	.60	4.10
Lancaster	72	960905	960919	5.67	.54	6.21
Lompoc	72	960905	960918	1.23	.15	1.38
Long-Beach	72			-99.00	-99.00	-99.00
Mira-Loma	72	960904	960918	18.87	1.20	20.06
Riverside	72	960904	960918	7.15	.96	8.12
San-Dimas	72	960905	960918	6.94	1.51	8.45
Santa-Maria	72	960905	960918	2.88	.66	3.54
Upland	72	960905	960919	7.64	1.49	9.14
Alpine	73	960919	961003	2.77	.42	3.19
Atascadero	73	960918	961003	3.17	.49	3.67
Glendora	73	960920	961004	6.86	1.20	8.06
Lake-Arrowhead	73	960919	961002	3.14	.44	3.58
Lake-Elsinore	73	960918	961002	4.67	.80	5.47
Lancaster	73	960919	961003	5.97	.68	6.65
Lompoc	73	960918	961003	1.25	.25	1.50
Long-Beach	73			-99.00	-99.00	-99.00
Mira-Loma	73	960918	961002	19.74	1.38	21.11
Riverside	73	960918	961002	7.30	1.09	8.39
San-Dimas	73	960918	961003	6.69	1.25	7.94
Santa-Maria	73	960918	961003	2.09	.53	2.62
Upland	73	960919	961003	7.93	1.44	9.37
Alpine	74	961003	961017	3.80	.51	4.31
Atascadero	74	961003	961017	5.65	.57	6.22

Site	Period	Start Date	End Date	Organic Carbon $\mu g\ m^{-3}$	Elemental Carbon $\mu g\ m^{-3}$	Total Carbon $\mu g\ m^{-3}$
Glendora	74	961004	961017	11.25	1.32	12.57
Lake-Arrowhead	74	961002	961016	3.35	.33	3.68
Lake-Elsinore	74	961002	961016	6.69	.97	7.66
Lancaster	74	961003	961017	6.46	.68	7.14
Lompoc	74	961003	961016	2.04	.29	2.33
Long-Beach	74			-99.00	-99.00	-99.00
Mira-Loma	74	961002	961016	24.25	1.89	26.14
Riverside	74	961002	961016	10.37	1.62	11.99
San-Dimas	74	961003	961017	11.40	1.96	13.36
Santa-Maria	74	961003	961016	4.45	.76	5.21
Upland	74	961003	961016	12.99	1.63	14.62
Alpine	75	961017	961031	2.88	.25	3.13
Atascadero	75	961017	961030	5.01	.55	5.55
Glendora	75	961017	961030	6.57	.74	7.31
Lake-Arrowhead	75	961016	961031	2.31	.27	2.57
Lake-Elsinore	75	961016	961031	4.69	.66	5.35
Lancaster	75	961017	961030	5.09	.52	5.61
Lompoc	75	961016	961030	2.61	.26	2.86
Long-Beach	75			-99.00	-99.00	-99.00
Mira-Loma	75	961016	961031	16.32	1.37	17.70
Riverside	75	961016	961031	6.07	.84	6.91
San-Dimas	75	961017	961031	7.67	.79	8.46
Santa-Maria	75	961016	961030	3.90	.50	4.41
Upland	75	961016	961031	8.12	.96	9.08
Alpine	76	961031	961114	3.12	.37	3.49
Atascadero	76	961030	961114	6.05	.73	6.78
Glendora	76	961030	961113	6.31	.93	7.24
Lake-Arrowhead	76	961031	961113	1.97	.21	2.19
Lake-Elsinore	76	961031	961114	5.34	.70	6.04
Lancaster	76	961030	961113	8.55	.94	9.49
Lompoc	76	961030	961114	3.06	.28	3.34
Long-Beach	76			-99.00	-99.00	-99.00
Mira-Loma	76	961031	961113	13.32	1.46	14.78
Riverside	76	961031	961113	7.25	1.35	8.60
San-Dimas	76	961031	961114	7.64	1.22	8.87
Santa-Maria	76	961030	961114	4.03	.57	4.59
Upland	76	961031	961114	8.55	1.28	9.83
Alpine	77	961114	961127	2.32	.37	2.69
Atascadero	77	961114	961127	3.04	.39	3.43
Glendora	77	961113	961127	5.46	1.10	6.56
Lake-Arrowhead	77	961113	961127	1.31	.33	1.64
Lake-Elsinore	77	961114	961126	4.19	.89	5.08
Lancaster	77	961113	961126	5.24	.60	5.83
Lompoc	77	961114	961127	2.13	.20	2.33
Long-Beach	77			-99.00	-99.00	-99.00

Site	Period	Start Date	End Date	Organic Carbon μg m^{-3}	Elemental Carbon μg m^{-3}	Total Carbon μg m^{-3}
Mira-Loma	77	961113	961126	11.60	1.62	13.22
Riverside	77	961113	961127	6.25	1.35	7.60
San-Dimas	77	961114	961127	6.10	1.32	7.42
Santa-Maria	77	961114	961127	3.22	.46	3.68
Upland	77	961114	961125	7.24	1.53	8.77
Alpine	78	961127	961212	2.02	.33	2.35
Atascadero	78	961127	961211	-99.00	-99.00	-99.00
Glendora	78	961127	961211	4.21	.77	4.98
Lake-Arrowhead	78	961127	961212	.68	.13	.82
Lake-Elsinore	78	961126	961211	3.39	.73	4.12
Lancaster	78	961126	961211	6.24	.70	6.95
Lompoc	78	961127	961211	2.12	.17	2.29
Long-Beach	78			-99.00	-99.00	-99.00
Mira-Loma	78	961126	961211	-99.00	-99.00	-99.00
Riverside	78	961127	961212	5.24	1.04	6.27
San-Dimas	78			-99.00	-99.00	-99.00
Santa-Maria	78	961127	961211	2.75	.47	3.22
Upland	78	961125	961211	6.74	1.32	8.06
Alpine	79	961212	961226	2.44	.41	2.85
Atascadero	79	961211	961226	5.10	.56	5.66
Glendora	79	961211	961223	-99.00	-99.00	-99.00
Lake-Arrowhead	79	961212	961227	1.10	.65	1.75
Lake-Elsinore	79	961211	961224	3.56	.62	4.18
Lancaster	79	961211	961226	7.96	.98	8.94
Lompoc	79	961211	961224	3.59	.34	3.93
Long-Beach	79			-99.00	-99.00	-99.00
Mira-Loma	79	961211	961226	11.34	1.71	13.05
Riverside	79	961212	961226	5.12	1.27	6.39
San-Dimas	79			-99.00	-99.00	-99.00
Santa-Maria	79	961211	961228	4.54	.45	4.98
Upland	79	961211	961224	7.48	1.40	8.88
Alpine	80	961226	970109	2.23	.38	2.61
Atascadero	80	961226	970108	4.08	.49	4.57
Glendora	80	961223	970108	5.83	.84	6.67
Lake-Arrowhead	80	961227	970108	.34	.08	.42
Lake-Elsinore	80	961224	970108	4.57	.59	5.16
Lancaster	80	961226	970108	7.43	.58	8.02
Lompoc	80	961224	970108	3.29	.27	3.56
Long-Beach	80			-99.00	-99.00	-99.00
Mira-Loma	80	961226	970109	9.28	1.52	10.80
Riverside	80	961226	970108	5.65	.95	6.60
Santa-Maria	80	961228	970108	3.59	.35	3.95
Upland	80	961224	970109	10.45	.91	11.35
Alpine	81	970109	970123	1.70	.31	2.00
Atascadero	81	970108	970123	4.16	.52	4.68

Site	Period	Start Date	End Date	Organic Carbon $\mu g\ m^{-3}$	Elemental Carbon $\mu g\ m^{-3}$	Total Carbon $\mu g\ m^{-3}$
Glendora	81	970108	970122	4.06	.81	4.88
Lake-Arrowhead	81	970108	970123	.67	.08	.75
Lake-Elsinore	81	970109	970122	-99.00	-99.00	-99.00
Lancaster	81	970108	970122	5.89	.77	6.66
Lompoc	81	970108	970123	2.54	.35	2.89
Long-Beach	81	970110	970123	7.52	1.88	9.40
Mira-Loma	81	970109	970123	7.41	1.30	8.71
Riverside	81	970108	970123	4.42	1.13	5.55
Riverside	81	970109	970123	-99.00	-99.00	-99.00
Santa-Maria	81	970108	970123	3.55	.49	4.04
Upland	81	970109	970122	6.10	1.28	7.38
Alpine	82	970123	970206	2.21	.46	2.67
Atascadero	82	970123	970205	3.28	.49	3.78
Glendora	82	970122	970205	5.02	.85	5.87
Lake-Arrowhead	82	970123	970205	1.32	.33	1.65
Lake-Elsinore	82	970122	970206	3.35	.70	4.05
Lancaster	82	970122	970205	4.45	.71	5.16
Lompoc	82	970123	970205	1.93	.22	2.16
Long-Beach	82	970123	970206	7.61	1.69	9.29
Mira-Loma	82	970123	970206	8.38	1.21	9.59
Riverside	82	970123	970205	5.33	1.14	6.48
Santa-Maria	82	970123	970205	3.71	.39	4.10
Upland	82	970122	970206	6.60	1.06	7.66
Alpine	83	970206	970220	2.07	.23	2.31
Atascadero	83	970205	970220	5.24	.51	5.75
Glendora	83	970205	970219	4.24	.54	4.79
Lake-Arrowhead	83	970205	970220	.93	.12	1.05
Lake-Elsinore	83	970206	970219	2.90	.42	3.32
Lancaster	83	970205	970219	5.10	.52	5.61
Lompoc	83	970205	970220	1.76	.09	1.85
Long-Beach	83	970206	970220	7.88	1.25	9.13
Mira-Loma	83	970206	970220	8.32	1.01	9.33
Riverside	83	970205	970220	4.69	.83	5.53
Santa-Maria	83	970205	970220	3.15	.28	3.43
Upland	83	970206	970219	6.80	.87	7.66
Alpine	84	970220	970306	2.99	.43	3.42
Atascadero	84	970220	970306	4.93	.40	5.34
Glendora	84	970219	970305	4.26	.73	4.98
Lake-Arrowhead	84	970220	970306	1.41	.14	1.55
Lake-Elsinore	84	970219	970307	3.29	.51	3.80
Lancaster	84	970219	970305	2.97	.36	3.33
Lompoc	84	970220	970305	1.49	.12	1.61
Long-Beach	84	970220	970307	7.67	1.46	9.13
Mira-Loma	84	970220	970306	7.85	1.19	9.03
Riverside	84	970220	970306	3.65	.79	4.43

Site	Period	Start Date	End Date	Organic Carbon $\mu g\ m^{-3}$	Elemental Carbon $\mu g\ m^{-3}$	Total Carbon $\mu g\ m^{-3}$
Santa-Maria	84	970220	970305	3.12	.47	3.58
Upland	84	970219	970306	6.14	.90	7.03
Alpine	85	970306	970320	3.54	.36	3.89
Atascadero	85	970306	970319	4.50	.48	4.98
Glendora	85	970305	970320	6.93	1.15	8.09
Lake-Arrowhead	85	970306	970320	2.61	.33	2.94
Lake-Elsinore	85	970307	970319	5.93	.89	6.83
Lancaster	85	970305	970320	5.65	.60	6.25
Lompoc	85	970305	970319	2.18	.22	2.40
Long-Beach	85	970307	970319	7.72	1.88	9.61
Mira-Loma	85	970306	970319	17.60	1.47	19.07
Riverside	85	970306	970320	8.18	1.29	9.47
Santa-Maria	85	970305	970319	4.50	.58	5.08
Upland	85	970306	970319	11.70	1.44	13.14
Alpine	86	970320	970403	2.67	.26	2.93
Atascadero	86	970319	970403	4.04	.39	4.43
Glendora	86	970320	970403	5.59	.61	6.20
Lake-Arrowhead	86	970320	970403	1.83	.13	1.96
Lake-Elsinore	86	970319	970402	4.47	.48	4.95
Lancaster	86	970320	970403	4.00	.51	4.51
Lompoc	86	970319	970402	1.82	.11	1.93
Long-Beach	86	970319	970402	5.34	.88	6.22
Mira-Loma	86	970319	970402	10.79	.85	11.63
Riverside	86	970320	970403	4.55	.71	5.26
Santa-Maria	86	970319	970402	3.80	.39	4.20
Upland	86	970319	970402	8.06	1.05	9.11
Alpine	87	970403	970417	-99.00	-99.00	-99.00
Atascadero	87	970403	970416	2.89	.26	3.15
Glendora	87	970403	970417	5.65	.58	6.23
Lake-Arrowhead	87	970403	970417	2.78	.20	2.97
Lake-Elsinore	87	970402	970416	3.45	.32	3.76
Lancaster	87	970403	970416	4.16	.55	4.70
Lompoc	87	970402	970416	1.13	.06	1.19
Long-Beach	87	970402	970416	4.46	.75	5.21
Mira-Loma	87	970402	970416	11.12	.88	11.99
Riverside	87	970403	970416	4.91	.61	5.52
Santa-Maria	87	970402	970416	2.60	.21	2.81
Upland	87	970402	970417	6.88	.95	7.84
Alpine	88	970417	970501	-99.00	-99.00	-99.00
Atascadero	88	970416	970430	3.08	.21	3.28
Glendora	88	970417	970501	6.35	.71	7.06
Lake-Arrowhead	88	970417	970501	2.63	.17	2.80
Lake-Elsinore	88	970416	970430	4.04	.47	4.52
Lancaster	88	970416	970501	2.78	.31	3.09
Lompoc	88	970416	970501	1.06	.06	1.12

Site	Period	Start Date	End Date	Organic Carbon $\mu g\ m^{-3}$	Elemental Carbon $\mu g\ m^{-3}$	Total Carbon $\mu g\ m^{-3}$
Long-Beach	88	970416	970430	4.14	.55	4.69
Mira-Loma	88	970416	970430	15.55	.95	16.50
Riverside	88	970416	970430	5.99	.93	6.92
Santa-Maria	88	970416	970501	2.40	.28	2.68
Upland	88	970417	970501	7.01	1.04	8.05
Alpine	89	970501	970515	4.75	.62	5.37
Atascadero	89	970430	970514	3.78	.30	4.08
Glendora	89	970501	970514	8.60	1.22	9.82
Lake-Arrowhead	89	970501	970515	5.65	.58	6.23
Lake-Elsinore	89	970430	970515	5.96	.71	6.66
Lancaster	89	970501	970514	5.76	.41	6.18
Lompoc	89	970501	970514	1.45	.15	1.60
Long-Beach	89	970430	970514	4.59	1.08	5.67
Mira-Loma	89	970430	970514	21.23	1.24	22.47
Riverside	89	970430	970515	9.89	.97	10.85
Santa-Maria	89	970501	970514	2.98	.36	3.34
Upland	89	970501	970515	13.07	1.72	14.79
Alpine	90	970515	970529	3.34	.43	3.77
Atascadero	90	970514	970529	2.74	.36	3.10
Glendora	90	970514	970528	5.91	1.09	7.00
Lake-Arrowhead	90	970515	970529	3.99	.52	4.52
Lake-Elsinore	90	970515	970528	4.01	.65	4.66
Lancaster	90	970514	970529	4.97	.38	5.35
Lompoc	90	970514	970530	1.34	.10	1.44
Long-Beach	90	970514	970528	4.06	.79	4.84
Mira-Loma	90	970514	970528	15.56	1.11	16.67
Riverside	90	970515	970529	7.45	1.03	8.48
Santa-Maria	90	970514	970530	2.77	.53	3.30
Upland	90	970515	970528	7.36	1.17	8.53
Alpine	91	970529	970612	2.81	.44	3.25
Atascadero	91	970529	970610	2.28	.32	2.59
Glendora	91	970528	970612	5.89	.80	6.69
Lake-Arrowhead	91	970529	970612	3.60	.39	3.99
Lake-Elsinore	91	970528	970611	4.53	.51	5.04
Lancaster	91	970529	970612	3.25	.39	3.64
Lompoc	91	970530		-99.00	-99.00	-99.00
Long-Beach	91	970528	970611	2.90	.53	3.43
Mira-Loma	91	970528	970611	13.37	1.43	14.80
Riverside	91	970529	970612	5.41	.59	5.99
Santa-Maria	91	970530	970611	2.20	.26	2.46
Upland	91	970528	970611	5.67	.91	6.58
Alpine	92	970612	970626	5.12	.55	5.67
Atascadero	92	970610	970625	2.80	.33	3.13
Glendora	92	970612	970626	-99.00	-99.00	-99.00
Lake-Arrowhead	92	970612	970626	4.29	.52	4.81

Site	Period	Start Date	End Date	Organic Carbon $\mu g\ m^{-3}$	Elemental Carbon $\mu g\ m^{-3}$	Total Carbon $\mu g\ m^{-3}$
Lake-Elsinore	92	970611	970625	3.53	.27	3.80
Lancaster	92	970612	970627	5.05	.25	5.31
Lompoc	92	970617	970625	-99.00	-99.00	-99.00
Long-Beach	92	970611	970625	3.29	.35	3.64
Mira-Loma	92	970611	970625	19.32	.46	19.79
Riverside	92	970612	970626	5.60	.74	6.34
Santa-Maria	92	970611	970625	2.52	.30	2.82
Upland	92	970611	970625	6.63	.42	7.06
Alpine	93	970626	970710	5.41	.58	5.99
Atascadero	93	970625	970709	2.63	.18	2.82
Glendora	93	970626	970709	-99.00	-99.00	-99.00
Lake-Arrowhead	93	970626	970709	6.91	.80	7.71
Lake-Elsinore	93	970625	970709	4.60	.54	5.14
Lancaster	93	970627	970710	4.37	.54	4.91
Lompoc	93	970625	970709	.72	.06	.78
Long-Beach	93	970625	970710	3.09	1.11	4.20
Mira-Loma	93	970625	970710	22.47	1.57	24.04
Riverside	93	970626	970709	7.70	.91	8.61
Santa-Maria	93	970625	970709	1.83	.29	2.12
Upland	93	970625	970709	8.01	1.19	9.20
Alpine	94	970710	970724	3.83	.40	4.22
Atascadero	94	970709	970723	2.94	.20	3.13
Glendora	94	970709	970723	7.04	.59	7.63
Lake-Arrowhead	94	970709	970724	4.50	.57	5.08
Lake-Elsinore	94	970709	970724	5.35	.69	6.04
Lancaster	94	970710	970723	4.77	.54	5.31
Lompoc	94	970709	970723	1.08	.07	1.15
Long-Beach	94	970710	970723	3.56	.77	4.33
Mira-Loma	94	970710	970723	22.03	1.39	23.41
Riverside	94	970709	970723	9.28	1.11	10.40
Santa-Maria	94	970709	970723	2.41	.22	2.64
Upland	94	970709	970724	7.52	1.21	8.73
Alpine	95	970724	970807	3.79	.50	4.29
Atascadero	95	970723	970805	2.87	.36	3.23
Glendora	95	970723	970806	6.11	.93	7.04
Lake-Arrowhead	95	970724	970807	5.32	.53	5.84
Lake-Elsinore	95	970724	970807	6.07	.76	6.83
Lancaster	95	970723	970806	4.61	.57	5.18
Lompoc	95	970723	970807	.96	.15	1.11
Long-Beach	95	970723	970806	4.10	1.51	5.61
Mira-Loma	95	970723	970806	20.96	1.60	22.56
Riverside	95	970723	970807	8.24	1.07	9.30
Santa-Maria	95	970723	970807	1.92	.23	2.16
Upland	95	970724	970807	8.59	1.30	9.90
Alpine	96	970807	970821	2.80	.47	3.27

Site	Period	Start Date	End Date	Organic Carbon $\mu g\ m^{-3}$	Elemental Carbon $\mu g\ m^{-3}$	Total Carbon $\mu g\ m^{-3}$
Atascadero	96	970805	970820	2.49	.27	2.77
Glendora	96	970806	970821	5.80	.83	6.63
Lake-Arrowhead	96	970807	970821	3.37	.39	3.76
Lake-Elsinore	96	970807	970821	3.87	.48	4.34
Lancaster	96	970806	970820	6.74	.66	7.40
Lompoc	96	970807	970820	.79	.06	.86
Long-Beach	96	970806	970820	2.93	.73	3.66
Mira-Loma	96	970806	970820	15.83	1.09	16.92
Riverside	96	970807	970821	5.89	.63	6.52
Santa-Maria	96	970807	970820	2.08	.29	2.37
Upland	96	970807	970820	5.83	.89	6.72
Alpine	97	970821	970904	3.91	.36	4.26
Atascadero	97	970820	970903	2.89	.17	3.06
Glendora	97	970821	970903	8.07	1.29	9.36
Lake-Arrowhead	97	970821	970904	3.42	.41	3.83
Lake-Elsinore	97	970821	970904	6.06	.82	6.89
Lancaster	97	970820	970903	4.46	.52	4.99
Lompoc	97	970820	970904	.69	.08	.77
Long-Beach	97	970820	970903	3.23	.92	4.16
Mira-Loma	97	970820	970903	21.56	2.34	23.90
Riverside	97	970821	970904	10.82	1.40	12.22
Santa-Maria	97	970820	970904	1.83	.34	2.17
Upland	97	970820	970903	9.85	1.88	11.73
Alpine	98	970904	970918	4.54	.62	5.16
Atascadero	98	970903	970917	3.48	.57	4.05
Glendora	98	970903	970917	7.17	1.26	8.42
Lake-Arrowhead	98	970904	970917	2.58	.35	2.93
Lake-Elsinore	98	970904	970918	6.00	.97	6.97
Lancaster	98	970903	970916	4.87	.57	5.44
Lompoc	98	970904	970917	1.17	.26	1.42
Long-Beach	98	970903	970918	4.89	1.70	6.58
Mira-Loma	98	970903	970917	22.16	1.95	24.11
Riverside	98	970904	970917	9.25	1.78	11.03
Santa-Maria	98	970904	970917	2.68	.62	3.30
Upland	98	970903	970917	9.64	1.33	10.97
Alpine	99	970918	971002	3.35	.21	3.55
Atascadero	99	970917	971001	4.24	.51	4.75
Glendora	99	970917	971001	7.57	.75	8.32
Lake-Arrowhead	99	970917	971002	3.24	.30	3.53
Lake-Elsinore	99	970918	971002	5.70	.60	6.29
Lancaster	99	970916	970930	4.14	.58	4.72
Lompoc	99	970917	971001	4.60	.27	4.87
Long-Beach	99	970918	971001	6.41	1.07	7.49
Mira-Loma	99	970917	971001	16.72	1.26	17.98
Riverside	99	970917	971002	6.30	.99	7.29

Site	Period	Start Date	End Date	Organic Carbon $\mu g\ m^{-3}$	Elemental Carbon $\mu g\ m^{-3}$	Total Carbon $\mu g\ m^{-3}$
Santa-Maria	99	970917	971001	4.02	.36	4.38
Upland	99	970917	971001	9.03	1.57	10.60
Alpine	100	971002	971016	2.56	.15	2.71
Atascadero	100	971001	971015	4.31	.44	4.74
Glendora	100	971001	971014	-99.00	-99.00	-99.00
Lake-Arrowhead	100	971002	971015	2.08	.22	2.30
Lake-Elsinore	100	971002	971015	3.75	.73	4.48
Lancaster	100	970930	971015	4.38	.70	5.08
Lompoc	100	971001	971016	1.81	.18	1.99
Long-Beach	100	971001	971014	6.20	.97	7.17
Mira-Loma	100	971001	971014	8.15	1.41	9.56
Riverside	100	971002	971015	5.39	.86	6.25
Santa-Maria	100	971001	971016	3.58	.18	3.75
Upland	100	971001	971014	6.50	1.21	7.72
Alpine	101	971016	971030	2.73	.24	2.97
Atascadero	101	971015	971028	7.06	.57	7.64
Glendora	101	971014	971029	5.85	.54	6.39
Lake-Arrowhead	101	971015	971029	2.26	.23	2.50
Lake-Elsinore	101	971015	971030	4.62	.53	5.14
Lancaster	101	971015	971029	6.27	.56	6.83
Lompoc	101	971016	971029	2.78	.03	2.81
Long-Beach	101	971014	971029	8.90	1.33	10.23
Mira-Loma	101	971014	971029	12.37	1.11	13.48
Riverside	101	971015	971030	6.56	.74	7.30
Santa-Maria	101	971016	971029	4.46	.22	4.67
Upland	101	971014	971029	7.55	.83	8.38
Alpine	102	971030	971113	2.99	.43	3.42
Atascadero	102	971028	971112	6.37	.52	6.90
Glendora	102	971029	971112	6.79	1.07	7.86
Lake-Arrowhead	102	971029	971112	-99.00	-99.00	-99.00
Lake-Elsinore	102	971030	971113	5.87	1.08	6.94
Lancaster	102	971029	971112	6.67	.72	7.38
Lompoc	102	971029	971113	2.61	.15	2.76
Long-Beach	102	971029	971112	8.65	2.16	10.81
Mira-Loma	102	971029	971112	17.72	1.66	19.39
Riverside	102	971030	971113	7.24	1.17	8.41
Santa-Maria	102	971029	971113	3.74	.40	4.14
Upland	102	971029	971112	-99.00	-99.00	-99.00
Alpine	103	971113	971126	2.71	.30	3.01
Atascadero	103	971112	971125	4.39	.45	4.84
Glendora	103	971112	971125	4.80	.70	5.50
Lake-Arrowhead	103	971112	971125	.96	.13	1.08
Lake-Elsinore	103	971113	971126	4.68	.87	5.55
Lancaster	103	971112	971201	6.10	.76	6.86
Lompoc	103	971113	971201	2.36	.06	2.42

Site	Period	Start Date	End Date	Organic Carbon $\mu g\ m^{-3}$	Elemental Carbon $\mu g\ m^{-3}$	Total Carbon $\mu g\ m^{-3}$
Long-Beach	103	971112	971125	10.99	1.73	12.72
Mira-Loma	103	971112	971125	11.94	1.60	13.53
Riverside	103	971113	971126	7.02	1.21	8.23
Santa-Maria	103	971113	971201	3.61	.24	3.85
Upland	103	971112	971126	8.93	1.33	10.26
Alpine	104	971126	971211	1.75	.28	2.03
Atascadero	104	971125	971210	4.68	.60	5.27
Glendora	104	971125	971211	4.03	.52	4.55
Lake-Arrowhead	104	971125	971210	.78	.10	.88
Lake-Elsinore	104	971126	971211	2.95	.64	3.59
Lancaster	104	971201	971209	-99.00	-99.00	-99.00
Lompoc	104	971201	971210	2.00	.28	2.28
Long-Beach	104	971125	971210	10.67	1.87	12.54
Mira-Loma	104	971125	971210	9.55	1.38	10.93
Riverside	104	971126	971211	4.26	.83	5.09
Santa-Maria	104	971201	971210	3.65	.45	4.10
Upland	104	971126	971210	5.42	.95	6.38
Alpine	105	971211	971224	2.76	.38	3.14
Atascadero	105	971210	971223	6.78	.66	7.44
Glendora	105	971211	971223	4.23	.56	4.79
Lake-Arrowhead	105	971210	971224	1.26	.23	1.48
Lake-Elsinore	105	971211	971223	4.16	.71	4.88
Lancaster	105	971209	971223	-99.00	-99.00	-99.00
Lompoc	105	971210	971224	3.30	.13	3.42
Long-Beach	105	971210	971222	14.22	2.09	16.31
Mira-Loma	105	971210	971223	10.38	1.43	11.81
Riverside	105	971211	971223	4.66	.83	5.49
Santa-Maria	105	971210	971224	4.72	.48	5.20
Upland	105	971210	971223	7.60	1.00	8.59
Alpine	106	971224	980108	2.20	.37	2.57
Atascadero	106	971223	980108	8.55	.70	9.25
Glendora	106	971223	980107	4.33	.58	4.91
Lake-Arrowhead	106	971224	980108	.63	.07	.70
Lake-Elsinore	106	971223	980108	3.58	.65	4.23
Lancaster	106	971223	980106	7.75	.85	8.60
Lompoc	106	971224	980107	3.46	.26	3.72
Long-Beach	106	971222	980107	15.22	1.97	17.20
Mira-Loma	106	971223	980107	-99.00	-99.00	-99.00
Riverside	106	971223	980108	4.72	.91	5.63
Santa-Maria	106	971224	980107	4.71	.37	5.09
Upland	106	971223	980107	6.57	.87	7.45
Alpine	107	980108	980122	1.99	.32	2.31
Atascadero	107	980108	980121	3.33	.40	3.73
Glendora	107	980107	980121	4.52	.82	5.34
Lake-Arrowhead	107	980108	980122	.68	.07	.75

Site	Period	Start Date	End Date	Organic Carbon $\mu g\ m^{-3}$	Elemental Carbon $\mu g\ m^{-3}$	Total Carbon $\mu g\ m^{-3}$
Lake-Elsinore	107	980108	980122	3.07	.74	3.82
Lancaster	107	980106	980121	3.63	.53	4.16
Lompoc	107	980107	980122	1.59	.05	1.64
Long-Beach	107	980107	980121	-99.00	-99.00	-99.00
Mira-Loma	107	980107	980121	8.41	1.11	9.52
Riverside	107	980108	980122	4.85	.93	5.78
Santa-Maria	107	980107	980122	2.55	.24	2.79
Upland	107	980107	980121	6.03	.94	6.97
Alpine	108	980122	980205	2.07	.30	2.37
Atascadero	108	980121	980204	3.69	.32	4.00
Glendora	108	980121	980204	4.42	.63	5.05
Lake-Arrowhead	108	980122	980205	-99.00	-99.00	-99.00
Lake-Elsinore	108	980122	980204	3.48	.59	4.07
Lancaster	108	980121	980204	6.60	.69	7.29
Lompoc	108	980122	980204	1.61	.06	1.68
Long-Beach	108	980121	980204	7.53	1.31	8.84
Mira-Loma	108	980121	980204	8.60	1.06	9.66
Riverside	108	980122	980204	5.24	.85	6.09
Santa-Maria	108	980122	980204	2.80	.17	2.97
Upland	108	980121	980204	6.67	.97	7.64
Alpine	109	980205	980220	1.90	.35	2.25
Atascadero	109	980205	980219	3.79	.37	4.16
Glendora	109	980204	980219	4.01	.54	4.55
Lake-Arrowhead	109	980205	980218	.85	.12	.97
Lake-Elsinore	109	980204	980218	2.91	.64	3.55
Lancaster	109	980204	980219	3.59	.52	4.11
Lompoc	109	980204	980219	1.95	.22	2.17
Long-Beach	109	980204	980219	6.76	1.21	7.98
Mira-Loma	109	980204	980219	7.80	.97	8.76
Riverside	109	980204	980218	3.90	.87	4.77
Santa-Maria	109	980204	980219	2.78	.32	3.09
Upland	109	980204	980218	5.19	.87	6.06
Alpine	110	980220	980305	1.77	.18	1.94
Atascadero	110	980219	980304	2.74	.22	2.97
Glendora	110	980219	980305	3.15	.36	3.51
Lake-Arrowhead	110	980218	980304	-99.00	-99.00	-99.00
Lake-Elsinore	110	980218	980305	2.69	.37	3.06
Lancaster	110	980219	980303	3.00	.33	3.33
Lompoc	110	980219	980305	1.01	.00	1.01
Long-Beach	110	980219	980304	5.45	.74	6.19
Mira-Loma	110	980219	980304	6.52	.72	7.24
Riverside	110	980218	980305	3.61	.47	4.07
Santa-Maria	110	980219	980305	2.58	.15	2.73
Upland	110	980218	980304	4.45	.63	5.08
Alpine	111	980305	980319	1.64	.22	1.86

Site	Period	Start Date	End Date	Organic Carbon $\mu g\ m^{-3}$	Elemental Carbon $\mu g\ m^{-3}$	Total Carbon $\mu g\ m^{-3}$
Atascadero	111	980304	980317	2.18	.22	2.40
Glendora	111	980305	980318	3.02	.34	3.36
Lake-Arrowhead	111	980304	980319	1.07	.15	1.23
Lake-Elsinore	111	980305	980319	2.66	.36	3.02
Lancaster	111	980303	980317	2.92	.43	3.35
Lompoc	111	980305	980318	1.07	.05	1.12
Long-Beach	111	980304	980318	4.78	.44	5.22
Mira-Loma	111	980304	980318	6.45	.70	7.16
Riverside	111	980305	980319	3.49	.47	3.96
Santa-Maria	111	980305	980319	2.42	.11	2.54
Upland	111	980304	980318	4.16	.58	4.74
Alpine	112	980319	980402	1.56	.15	1.71
Atascadero	112	980317	980401	2.13	.13	2.26
Glendora	112	980318	980401	3.43	.46	3.89
Lake-Arrowhead	112	980319	980402	-99.00	-99.00	-99.00
Lake-Elsinore	112	980319	980402	2.52	.33	2.85
Lancaster	112	980317	980401	2.84	.41	3.25
Lompoc	112	980318	980402	1.07	.03	1.09
Long-Beach	112	980318	980401	3.11	.59	3.70
Mira-Loma	112	980318	980401	6.01	.59	6.59
Riverside	112	980319	980402	3.20	.52	3.72
Santa-Maria	112	980319	980402	1.95	.10	2.05
Upland	112	980318	980401	4.54	.57	5.12
Alpine	113	980402	980416	1.17	.16	1.33
Atascadero	113	980401	980415	1.99	.19	2.18
Glendora	113	980401	980415	2.97	.29	3.26
Lake-Arrowhead	113	980402	980416	1.17	.18	1.35
Lake-Elsinore	113	980402	980416	1.82	.23	2.04
Lancaster	113	980401	980414	2.34	.29	2.63
Lompoc	113	980402	980416	.75	.01	.76
Long-Beach	113	980401	980415	3.39	.46	3.85
Mira-Loma	113	980401	980415	4.16	.54	4.70
Riverside	113	980402	980416	2.71	.39	3.11
Santa-Maria	113	980402	980416	2.15	.09	2.24
Upland	113	980401	980415	3.58	.49	4.07
Alpine	114	980416	980430	2.68	.26	2.94
Atascadero	114	980415	980430	3.57	.27	3.84
Glendora	114	980415	980429	4.45	.55	5.00
Lake-Arrowhead	114	980416	980430	2.25	.21	2.45
Lake-Elsinore	114	980416	980430	3.94	.47	4.41
Lancaster	114	980414	980429	3.42	.35	3.77
Lompoc	114	980416	980430	1.21	.08	1.29
Long-Beach	114	980415	980429	4.43	.96	5.38
Mira-Loma	114	980415	980429	9.27	1.13	10.39
Riverside	114	980416	980430	5.19	.71	5.90

Site	Period	Start Date	End Date	Organic Carbon $\mu g\ m^{-3}$	Elemental Carbon $\mu g\ m^{-3}$	Total Carbon $\mu g\ m^{-3}$
Santa-Maria	114	980416	980430	2.72	.22	2.94
Upland	114	980415	980429	6.13	.78	6.91
Alpine	115	980430	980514	1.59	.14	1.73
Atascadero	115	980430	980513	1.48	.18	1.66
Glendora	115	980429	980513	3.51	.35	3.86
Lake-Arrowhead	115	980430	980514	-99.00	-99.00	-99.00
Lake-Elsinore	115	980430	980513	2.13	.19	2.32
Lancaster	115	980429	980512	2.97	.37	3.34
Lompoc	115	980430	980514	.93	.06	.99
Long-Beach	115	980429	980514	3.55	.38	3.93
Mira-Loma	115	980429	980513	5.55	.32	5.87
Riverside	115	980430	980514	2.47	.21	2.68
Santa-Maria	115	980430	980514	2.30	.15	2.45
Upland	115	980429	980513	3.80	.39	4.19
Alpine	116	980514	980528	2.00	.17	2.17
Atascadero	116	980513	980528	1.62	.10	1.72
Glendora	116	980513	980527	3.20	.36	3.56
Lake-Arrowhead	116	980514	980528	2.20	.31	2.51
Lake-Elsinore	116	980513	980528	2.60	.24	2.83
Lancaster	116	980512	980527	2.86	.28	3.14
Lompoc	116	980514	980528	.53	.00	.51
Long-Beach	116	980514	980527	2.72	.41	3.13
Mira-Loma	116	980513	980527	5.05	.55	5.60
Riverside	116	980514	980528	3.26	.46	3.72
Santa-Maria	116	980514	980528	2.10	.07	2.17
Upland	116	980513	980527	3.66	.49	4.14
Alpine	117	980528	980611	2.13	.18	2.30
Atascadero	117	980528	980610	1.50	.14	1.64
Glendora	117	980527	980610	4.12	.42	4.53
Lake-Arrowhead	117	980528	980611	-99.00	-99.00	-99.00
Lake-Elsinore	117	980528	980611	3.00	.30	3.30
Lancaster	117	980527	980609	3.15	.28	3.43
Lompoc	117	980528	980611	.82	.03	.85
Long-Beach	117	980527	980610	2.87	.33	3.20
Mira-Loma	117	980527	980610	10.43	.57	11.00
Riverside	117	980528	980611	4.30	.55	4.85
Santa-Maria	117	980528	980611	1.97	.13	2.11
Upland	117	980527	980610	4.44	.55	4.99
Alpine	118	980611	980625	2.52	.21	2.74
Atascadero	118	980610	980624	1.83	.05	1.88
Glendora	118	980610	980624	4.15	.56	4.71
Lake-Arrowhead	118	980611	980625	2.83	.29	3.12
Lake-Elsinore	118	980611	980625	3.51	.26	3.77
Lancaster	118	980609	980624	3.80	.33	4.14
Lompoc	118	980611	980625	.72	.00	.73

Site	Period	Start Date	End Date	Organic Carbon $\mu g\ m^{-3}$	Elemental Carbon $\mu g\ m^{-3}$	Total Carbon $\mu g\ m^{-3}$
Long-Beach	118	980610	980624	2.53	.46	3.00
Mira-Loma	118	980610	980624	12.85	.85	13.70
Riverside	118	980611	980625	4.78	.53	5.31
Santa-Maria	118	980611	980625	1.85	.01	1.86
Upland	118	980610	980624	4.53	.67	5.20
Alpine	119	980625	980709	4.46	.46	4.92
Atascadero	119	980624	980709	3.39	.11	3.50
Glendora	119	980624	980708	8.96	1.14	10.10
Lake-Arrowhead	119	980625	980709	6.58	.60	7.18
Lake-Elsinore	119	980625	980709	6.86	.54	7.40
Lancaster	119	980624	980707	7.21	.42	7.63
Lompoc	119	980625	980708	.96	.08	1.04
Long-Beach	119	980624	980708	4.69	.73	5.41
Mira-Loma	119	980624	980708	23.12	.95	24.07
Riverside	119	980625	980709	9.35	.83	10.19
Santa-Maria	119	980625	980708	2.58	.21	2.79
Upland	119	980624	980708	9.30	1.28	10.58
Alpine	120	980709	980723	5.00	.41	5.41
Atascadero	120	980709	980723	3.57	.16	3.73
Glendora	120	980708	980722	7.88	1.01	8.89
Lake-Arrowhead	120	980709	980723	4.97	.40	5.37
Lake-Elsinore	120	980709	980722	6.91	.60	7.51
Lancaster	120	980707	980722	6.39	.42	6.82
Lompoc	120	980708	980723	.87	.00	.85
Long-Beach	120	980708	980723	3.56	.84	4.40
Mira-Loma	120	980708	980722	21.59	1.65	23.24
Riverside	120	980709	980722	8.92	1.03	9.95
Santa-Maria	120	980708	980723	2.51	.16	2.67
Upland	120	980708	980723	9.64	1.48	11.12
Alpine	121	980723	980806	4.64	.35	4.99
Atascadero	121	980723	980805	3.33	.15	3.48
Glendora	121	980722	980805	7.93	.96	8.89
Lake-Arrowhead	121	980723	980806	5.33	.37	5.70
Lake-Elsinore	121	980722	980806	5.67	.59	6.26
Lancaster	121	980722	980804	5.91	.33	6.24
Lompoc	121	980723	980806	.79	.00	.79
Long-Beach	121	980723	980805	3.61	.74	4.35
Mira-Loma	121	980722	980805	28.18	1.86	30.05
Riverside	121	980722	980806	8.90	.94	9.84
Santa-Maria	121	980723	980806	2.32	.19	2.52
Upland	121	980723	980805	9.95	1.28	11.23
Alpine	122	980806	980820	3.60	.30	3.89
Atascadero	122	980805	980819	3.40	.02	3.42
Glendora	122	980805	980819	7.34	.87	8.20
Lake-Arrowhead	122	980806	980820	4.71	.42	5.13

Site	Period	Start Date	End Date	Organic Carbon $\mu g\ m^{-3}$	Elemental Carbon $\mu g\ m^{-3}$	Total Carbon $\mu g\ m^{-3}$
Lake-Elsinore	122	980806	980820	4.98	.49	5.47
Lancaster	122	980804	980818	6.06	.47	6.53
Lompoc	122	980806	980819	.93	.00	.91
Long-Beach	122	980805	980819	5.23	1.20	6.44
Mira-Loma	122	980805	980819	21.69	1.50	23.19
Riverside	122	980806	980820	6.94	.92	7.85
Santa-Maria	122	980806	980819	2.54	.00	2.53
Upland	122	980805	980819	-99.00	-99.00	-99.00
Alpine	123	980820	980903	5.33	.27	5.60
Atascadero	123	980819	980902	4.22	.18	4.40
Glendora	123	980819	980902	8.26	.83	9.09
Lake-Arrowhead	123	980820	980903	3.54	.35	3.89
Lake-Elsinore	123	980820	980903	6.67	.67	7.34
Lancaster	123	980818	980901	5.66	.46	6.13
Lompoc	123	980819	980902	.91	.00	.91
Long-Beach	123	980819	980902	5.16	1.06	6.22
Mira-Loma	123	980819	980902	25.93	1.96	27.89
Riverside	123	980820	980903	9.54	1.04	10.58
Santa-Maria	123	980819	980902	3.54	.06	3.60
Upland	123	980819	980902	10.60	1.39	11.99
Alpine	124	980903	980917	4.44	.41	4.85
Atascadero	124	980902	980916	3.77	.20	3.97
Glendora	124	980902	980916	6.12	.89	7.02
Lake-Arrowhead	124	980903	980917	4.37	.38	4.75
Lake-Elsinore	124	980903	980917	5.49	.67	6.16
Lancaster	124	980901	980915	5.82	.44	6.27
Lompoc	124	980902	980917	1.43	.07	1.50
Long-Beach	124	980902	980916	3.86	.79	4.65
Mira-Loma	124	980902	980916	17.13	1.30	18.43
Riverside	124	980903	980917	6.91	.91	7.82
Santa-Maria	124	980902	980917	2.57	.21	2.78
Upland	124	980902	980916	7.82	1.22	9.05
Alpine	125	980917	981001	2.71	.36	3.08
Atascadero	125	980916	981001	2.64	.17	2.82
Glendora	125	980916	980930	-99.00	-99.00	-99.00
Lake-Arrowhead	125	980917	981001	3.10	.43	3.53
Lake-Elsinore	125	980917	981001	3.73	.47	4.19
Lancaster	125	980915	980929	5.13	.55	5.68
Lompoc	125	980917	980930	1.61	.17	1.78
Long-Beach	125	980916	980930	4.30	.87	5.16
Mira-Loma	125	980916	980930	18.55	.86	19.41
Riverside	125	980917	981001	5.99	.73	6.73
Santa-Maria	125	980917	980930	2.96	.23	3.19
Upland	125	980916	980930	6.88	1.01	7.89
Alpine	126	981001	981015	3.18	.32	3.50

Site	Period	Start Date	End Date	Organic Carbon $\mu g\ m^{-3}$	Elemental Carbon $\mu g\ m^{-3}$	Total Carbon $\mu g\ m^{-3}$
Atascadero	126	981001	981014	4.21	.20	4.41
Glendora	126	980930	981014	6.68	1.05	7.74
Lake-Arrowhead	126	981001	981015	-99.00	-99.00	-99.00
Lake-Elsinore	126	981001	981015	6.12	.61	6.73
Lancaster	126	980929	981014	5.57	.54	6.10
Lompoc	126	980930	981014	1.92	.02	1.95
Long-Beach	126	980930	981014	5.67	.99	6.67
Mira-Loma	126	980930	981014	17.29	1.51	18.79
Riverside	126	981001	981015	6.94	.93	7.87
Santa-Maria	126	980930	981014	3.42	.28	3.70
Upland	126	980930	981014	7.87	1.36	9.23
Alpine	127	981015	981029	2.92	.14	3.06
Atascadero	127	981014	981028	5.30	.33	5.63
Glendora	127	981014	981028	6.13	.59	6.71
Lake-Arrowhead	127	981015	981029	2.31	.19	2.50
Lake-Elsinore	127	981015	981029	5.19	.47	5.67
Lancaster	127	981014	981028	6.02	.52	6.54
Lompoc	127	981014	981029	2.57	.00	2.56
Long-Beach	127	981014	981028	6.81	.92	7.73
Mira-Loma	127	981014	981028	19.54	1.33	20.87
Riverside	127	981015	981029	6.92	.85	7.77
Santa-Maria	127	981014	981029	4.09	.22	4.31
Upland	127	981014	981028	8.42	.79	9.20
Alpine	128	981029	981112	3.94	.41	4.35
Atascadero	128	981028	981110	5.85	.44	6.28
Glendora	128	981028	981110	7.27	.84	8.10
Lake-Arrowhead	128	981029	981112	2.52	.28	2.80
Lake-Elsinore	128	981029	981112	6.12	.75	6.87
Lancaster	128	981028	981110	6.21	.55	6.76
Lompoc	128	981029	981111	2.68	.07	2.75
Long-Beach	128	981028	981110	11.66	1.33	12.98
Mira-Loma	128	981028	981110	22.11	1.14	23.25
Riverside	128	981029	981112	7.99	.99	8.97
Santa-Maria	128	981029	981111	5.17	.36	5.53
Upland	128	981028	981110	10.29	1.01	11.31
Alpine	129	981112	981125	3.93	.42	4.36
Atascadero	129	981110	981124	4.56	.49	5.05
Glendora	129	981110	981124	5.90	.70	6.60
Lake-Arrowhead	129	981112	981124	1.83	.18	2.01
Lake-Elsinore	129	981112	981125	5.18	.82	6.00
Lancaster	129	981110	981124	6.91	.79	7.70
Lompoc	129	981111	981125	2.17	.05	2.22
Long-Beach	129	981110	981124	10.48	2.03	12.52
Mira-Loma	129	981110	981124	13.79	1.65	15.43
Riverside	129	981112	981125	7.68	1.05	8.73

Site	Period	Start Date	End Date	Organic Carbon $\mu g\ m^{-3}$	Elemental Carbon $\mu g\ m^{-3}$	Total Carbon $\mu g\ m^{-3}$
Santa-Maria	129	981111	981125	4.48	.35	4.83
Upland	129	981110	981125	8.53	1.14	9.67
Alpine	130	981125	981210	2.40	.19	2.59
Atascadero	130	981124	981209	5.25	.47	5.72
Glendora	130	981124	981209	4.95	.68	5.62
Lake-Arrowhead	130	981124	981210	.92	.07	.99
Lake-Elsinore	130	981125	981210	3.38	.37	3.75
Lancaster	130	981124	981208	5.15	.54	5.68
Lompoc	130	981125	981209	1.90	.00	1.88
Long-Beach	130	981124	981209	10.05	1.24	11.29
Mira-Loma	130	981124	981209	-99.00	-99.00	-99.00
Riverside	130	981125	981210	5.28	.73	6.01
Santa-Maria	130	981125	981209	3.38	.18	3.56
Upland	130	981125	981209	7.31	.95	8.25
Alpine	131	981210	981223	2.09	.14	2.23
Atascadero	131	981209	981222	7.92	.56	8.48
Glendora	131	981209	981222	4.56	.30	4.86
Lake-Arrowhead	131	981210	981223	-99.00	-99.00	-99.00
Lake-Elsinore	131	981210	981223	3.26	.31	3.57
Lancaster	131	981208	981223	7.09	.67	7.76
Lompoc	131	981209	981223	3.46	.00	3.43
Long-Beach	131	981209	981224	12.07	1.33	13.40
Mira-Loma	131	981211	981223	10.46	1.14	11.60
Riverside	131	981210	981223	4.19	.47	4.66
Santa-Maria	131	981209	981223	4.32	.18	4.50
Upland	131	981209	981222	7.33	.63	7.97

Final Report
prepared for the
California Air Resources Board and the
California Environmental Protection Agency

Determination of the Elemental Carbon, Organic Compounds, and Source Contributions to Atmospheric Particles During the Southern California Children's Health Study

Part B: The Distribution of Particle-Phase Organic Compounds in the Atmosphere and Source Contributions to Atmospheric Particulate Matter Concentrations During the Southern California Children's Health Study, 1995.

Contract Number 98-320

Jon B. Manchester and James J. Schauer

Environmental Chemistry and Technology Program, and
The Wisconsin State Laboratory of Hygiene
University of Wisconsin-Madison
Madison, WI 53706

and

Glen R. Cass

Environmental Engineering Science Department
California Institute of Technology
Pasadena, CA 91125

February, 2001

Disclaimer

The statements and conclusion in the Report are those of the contractor and not necessarily those of the California Air Resources Board. The mention of commercial products, their sources, or their use in connection with material reported herein is not to be construed as actual or implied endorsement of such products.

Acknowledgements

This Report was submitted in partial fulfillment of ARB contract number 98-320 entitled "Determination of the Elemental Carbon, Organic Compounds, and Source Contributions to Atmospheric Particles during the Southern California Children's Health Study," by the University of Wisconsin-Madison and the California Institute of Technology under sponsorship of the California Air Resources Board. Work was completed in February, 2001.

Table of Contents

		Page
Cover Page		i
Disclaimer and Acknowledgement		ii
Table of Contents		iii
List of Tables		iv
List of Figures		iv
Abstract		1
Executive Summary		2
0.1	Background	2
0.2	Methods	2
0.3	Results	3
0.4	Conclusions	4
Chapter 1. Distribution of particle-phase organic compounds		5
1.1	Abstract	5
1.2	Introduction	5
1.3	Methods	6
1.4	Results and Discussion	9
Chapter 2. Source apportionment of particulate matter concentrations		
2.1	Abstract	22
2.2	Introduction	22
2.3	Methods	23
2.4	Results and Discussion	24
References		36

List of Tables

		Pages
Table 1.1	Annual average concentration of organic compounds in atmospheric PM10, Southern California Children's Health Study	10-13
Table 2.1	Source contributions to PM10 organic compound concentrations	26-29
Table 2.2	Source contributions to PM10 mass concentrations	32-35

List of Figures

Figure 1.1	Southern California Children's Health Study sampling network	7
Figure 1.2	Comparison of Measurements of compounds in atmospheric particulate matter collected by two co-located samplers at Riverside, California during Children's Health Study, 1995	14
Figure 1.3	Elemental and organic carbon in atmospheric particulate matter, Southern California Children's Heath Study, 1995	15
Figure 1.4	Hopanes & steranes in atmospheric particulate matter, Southern California Children's Health Study, 1995	17
Figure 1.5	Levoglucosan in atmospheric particulate matter, Southern California Children's Health Study, 1995	18
Figure 1.6	PAH in atmospheric particulate matter, Southern California Children's Health Study, 1995	19
Figure 1.7	Diacids in atmospheric particulate matter, Southern California Children's Health Study, 1995	21
Figure 2.1	Contributions to atmospheric PM10 organic carbon, Southern California Children's Health Study, 1995	25
Figure 2.2	Contributions to atmospheric PM10 mass, Southern California Children's Health Study, 1995	31

Abstract

As part of the Southern California Children's Health Study, a twelve-site air-sampling network has been operated since 1994. The network has been used to measure acid gases, PM2.5 mass, PM2.5 inorganic ions, and the PM10-equivalent organic and elemental carbon concentrations (described in Part A of this Report). Part B of this report covers the detailed organic compound speciation of particulate matter samples collected at the network sites during the year of 1995, along with chemical mass balance (CMB) modeling results that apportion source contributions to particulate matter concentrations at all twelve sites. The distribution of particle-phase n-alkanes, fatty acids, polycyclic aromatic hydrocarbons (PAH), hopanes, steranes, aromatic diacids, aliphatic diacids, resin acids, methoxyphenols, and levoglucosan are reported. These measurements are used in a molecular marker source apportionment model to determine the source contributions to atmospheric particulate matter concentrations, including gasoline-powered motor vehicle exhaust, diesel vehicle exhaust, wood smoke, vegetative detritus, tire wear, and particulate matter from natural gas combustion. In addition, the contributions from meat smoke and paved road dust are determined in selected samples. These results will provide additional information that can be used in the Southern California Children's Health Study to better understand the relationship between air quality and respiratory disease.

As part of this study, co-located samples collected at the Riverside sampling site were analyzed in parallel to assess the precision of the analytical measurements used for the analysis of particle-phase organic compounds. Such a comparison has not been reported in the past for the range of compounds examined in this study. Excellent agreement was observed between the annual average concentrations measured independently using the two samples for the broad range of organic compounds analyzed.

Executive Summary

0.1 Background

Particle-phase organic compound concentrations are determined at twelve sampling sites used in the Southern California Children's Health Study for three seasonal periods of the calendar year of 1995. These results are incorporated into a molecular marker chemical mass balance model to determine the source contributions to atmospheric particulate matter concentrations. These results support the efforts of the Southern California Children's Health Study by providing both the concentration of particle-phase organic compounds as well as the information on the sources of particulate matter at the twelve different sites during different seasons. The sampling sites include two sites in a mountainous region (Alpine and Lake Arrowhead), one desert site (Lancaster) and three rural coastal sites (Atascadero, Lompoc and Santa Maria). In addition, the network also includes five Southern California urban sites (San Dimas, Upland, Mira Loma, Riverside, and Long Beach) as well as a rural inland site (Lake Elsinore).

0.2 Methods

The particulate matter samples used for the measurement of particle-phase organic compounds were collected on pre-baked quartz fiber filters. Each sample was collected over a two-week interval. At the end of each sampling period a new filter was installed in the sampler, such that nominally 26 samples were collected during the calendar year of 1995. These samples, collected on the quartz fiber filters, were used for both the organic and elemental carbon analyses (described in Part A of this Report) and for organic compound speciation, which is presented in this report.

The filters from each site were individually composited into three seasonal time periods: Period 1: December 29, 1994 through May 3, 1995, Period 2: May 3, 1995 through November 1, 1995, and Period 3: November 1, 1995 through December 28, 1995. Each sample was extracted in organic solvents, concentrated, and analyzed by gas chromatography/mass spectrometry (GC/MS) using a updated version of the procedure described by Schauer and Cass [*Schauer and Cass*, 2000]. Ninety-six (96) organic compounds were quantified in each sample, which include n-alkanes, fatty acids, polycyclic aromatic hydrocarbons (PAH), hopanes, steranes, aromatic diacids, aliphatic diacids, resin acids, methoxyphenols, and levoglucosan.

Samples were analyzed for all three seasonal time periods except for the San Dimas samples where the sample from Period 1 was not analyzed. In addition, a co-located sampler was operated for the entire year of 1995 at the Riverside sampling site. Samples from this sampler were analyzed by the same methods as used for the core Riverside sampler to determine the precision of the methods used to quantify particle-phase organic compounds in atmospheric particulate matter. Such a comparison has not been reported in the past.

The particle-phase organic compound concentrations obtained through GC/MS analysis were incorporated into the molecular marker source apportionment model previously developed by Schauer et al. [*Schauer et al.*, 1996] and Schauer and Cass [*Schauer and Cass*, 2000]. Using the model, primary source contributions to atmospheric particulate matter concentrations from gasoline-powered motor vehicles exhaust, diesel vehicle exhaust, wood smoke, vegetative detritus, tire wear, and particulate matter from natural gas combustion were determined. In addition, the primary source contributions from meat smoke and paved road dust were quantified for selective sampling periods at selected sampling locations.

0.3 Results

The samples used for this study were collected using "Leg C" of the Southern California Children's Health Study sampler, which was comprised solely of inlet line (6mm diameter, 2.5 cm long) and a filter cassette, which operated at 1.3 lpm. Experiments described under Part A of this Report demonstrate that the "Leg C" sample provided an effective-PM10 sample. To this end the particle-phase organic compound concentrations reported here are effectively the concentrations of these species in the PM10 fraction of the atmospheric particulate matter concentrations. Likewise, the source apportionment results determined in the present study represent the source contributions to PM10 concentrations.

The seasonal and spatial distribution of individual organic compounds provides significant insight into the origin and composition of the particulate matter present at the sampling locations, which cannot be obtained from the mass, ionic species, organic carbon, and elemental carbon. Of specific importance is the distribution of levoglucosan, which is an important tracer for wood burning. Levoglucosan is detected in all 35 samples and shows a strong seasonal pattern that does not correlate with the organic and elemental carbon distribution. Likewise, the distribution of PAH shows important seasonal and spatial trends. As expected the presence of retene in the particulate matter samples shows a strong correlation with levoglucosan. In addition, the relative distribution of PAH shows significant differences among different locations and among seasons for some locations. Important patterns in the distribution of the hopanes and steranes, tracers for motor vehicle exhaust, are also observed.

The concentrations of particle-phase organic compounds measured with co-located samplers at the Riverside site show excellent agreement. A linear regression of the individual compound concentrations obtained from the two co-located samplers has a slope of 1.02 ± 0.01 (R^2=0.99). The compound concentrations obtained by the two samplers for seventy-six (76) of the eighty (80) compounds, which were present at an annual average concentration of greater than 0.050 ng m^{-3}, agree within 20 percent. Forty-eight (48) of the compound concentrations, obtained from the collocated samplers, agree within 10 percent. The excellent agreement between the two samplers demonstrates the precision of sampler and the analytical protocols. The precision of the measurement of this broad range of particle-phase organic compounds has not been reported in the past.

A molecular marker source apportionment model was employed to calculate the source contributions to the effective-PM10 samples analyzed for the present study. Source contributions to the PM10 samples were quantified for gasoline-powered motor vehicle, diesel vehicles, wood burning, vegetative detritus, natural gas combustion, and tire wear. The fact that trace metals were not measured as part of the sampling network limited the ability of the model to determine the source contributions of paved and unpaved road dust, as well as meat cooking operations. In previous molecular marker source apportionment models, silicon and aluminum were used to help track paved road dust. In the present study, the use of heavy molecular weight alkanoic acids are explored as possible tracers for road dust, which is successfully employed at several of the urban sampling locations. The inability of an urban road dust profile to properly apportion road dust at rural sites emphasizes the need for site-specific road dust profiles, especially when organic compounds are used for tracking road dust. The ability to apportion meat smoke in the study was limited to samples where cholesterol was detected, since other meat smoke tracers were found to be inappropriate for apportioning source contributions to PM10.

The source contributions of gasoline-powered motor vehicles, diesel vehicles, wood burning, vegetative detritus, natural gas combustion and tire wear show significant seasonal and spatial trend. As expected, the concentrations of wood smoke are significantly reduced in the summer months at all sampling locations and show important spatial variations. Likewise, the contributions of both gasoline-powered and diesel-powered vehicles vary significantly among sampling locations and demonstrate important seasonal variations for some sites.

0.4 Conclusions

The concentrations of ninety-six (96) particle-phase organic compounds were determined for the Southern California Children's Health Study sampling network for the calendar year of 1995. Average annual atmospheric concentrations and the average concentrations for three seasonal periods were measured using samples collected by the existing sampling network. Co-located samples collected at the Riverside sampling site were analyzed and demonstrated excellent precision for the quantification of these compounds. Significant seasonal and spatial variation in particle-phase organic compounds were observed including the distribution of PAH, wood smoke marker, aromatic and aliphatic diacids, as well as molecular markers for motor vehicle exhaust. These results were incorporated into a chemical mass balance (CMB) model that was used to determine the source contributions to both PM10 mass and PM10 organic carbon, which included particulate matter emitted from gasoline-powered motor vehicles exhaust, diesel vehicle exhaust, wood smoke, vegetative detritus, tire wear, and natural gas combustion. Contributions from meat cooking and paved road dust were also determined for a selected sampling periods and locations.

Chapter 1. Distribution of Particle-Phase Organic Compounds

1.1 Abstract

Atmospheric particulate matter samples, collected as part of the Southern California Children's Health study, were analyzed using gas chromatography/mass spectrometry techniques to quantify ninety-six (96) particle-phase organic compounds. Annual average concentration, along with the average atmospheric concentrations for three seasonal periods, were determined at twelve (12) sites for the calendar year of 1995. Co-located samples were collected at the Riverside sampling site, which were analyzed to assess the precision of measuring the atmospheric concentration of particle-phase organic compounds. The results of this study show excellent agreement between the measurements obtained using the co-located samplers. Such a comparison for the quantification of these molecular markers has not been reported in the past.

The study provides important information about the seasonal and spatial distribution of particle-phase organic compounds at sampling locations throughout Southern California, including n-alkanes, fatty acids, polycyclic aromatic hydrocarbons (PAH), hopanes, steranes, aromatic diacids, aliphatic diacids, resin acids, methoxyphenols, and levoglucosan. Of significant importance is the distribution of PAH, wood smoke tracers, motor vehicle tracers, and aromatic and aliphatic diacids. These results provide important information that can be used by the investigators of the Southern California Children's Heath Study to better understand the relationship between atmospheric pollutant concentrations and childhood respiratory disease. In addition, these results provide significant insight into the origin of atmospheric particulate matter throughout Southern California.

1.2 Introduction

Hundreds of organic compounds have been previously measured in atmospheric particulate matter samples [*Fraser et al.*, 1997; *Fraser et al.*, 1998; *Rogge et al.*, 1993c; *Schauer*, 1998a; *Schauer and Cass*, 2000]. Most of these efforts, however, have focussed on a limited number of sampling sites, typically 3 or 4, which are comprised of urban sampling locations with one remote background sampling location. These studies have provided significant information on the composition, origin, and potential impact of particulate matter in the urban atmosphere. These studies, however, have not provided information about the regional and seasonal distribution of particle-phase organic compounds. However, there is a great need to understand the spatial and temporal distribution of these pollutants, which is critically important in understanding human exposure to atmospheric pollutants and ultimately the relationship between air pollution and human health effects. In addition, a clear understanding of the seasonal and spatial distribution of pollutants is needed to develop effective and efficient control programs that mitigate the impact of air pollutant emissions.

The Southern California Children's Health Study [*Gauderman et al.*, 2000; *Peters et al.*, 1999] is a ten year study that began in 1994 to assess the long-term effects of exposure to air pollution in children. The study was organized by researchers at the University of Southern California and was supported by the California Air Resource Board. As part of the study, air pollutant concentrations at twelve Southern California communities are monitored and the respiratory health of more than 3,600 children is followed. Ongoing efforts have measured fine particle mass, nitrate, sulfate, ammonium, and chloride ion concentrations, along with gas-phase ozone, nitrogen dioxide, formic acid, acetic acid, hydrochloric acid, and nitric acid. Recently, particle-phase organic and elemental carbon concentrations were reported for the years 1994-1998 for all twelve sites (Part A of this report).

The present study provides particle-phase organic compound concentration data for these same sampling sites for the year 1995. These data provide unique information on the seasonal and spatial distribution of the organic compounds present in the airborne particles in these twelve communities.

1.3 Methods

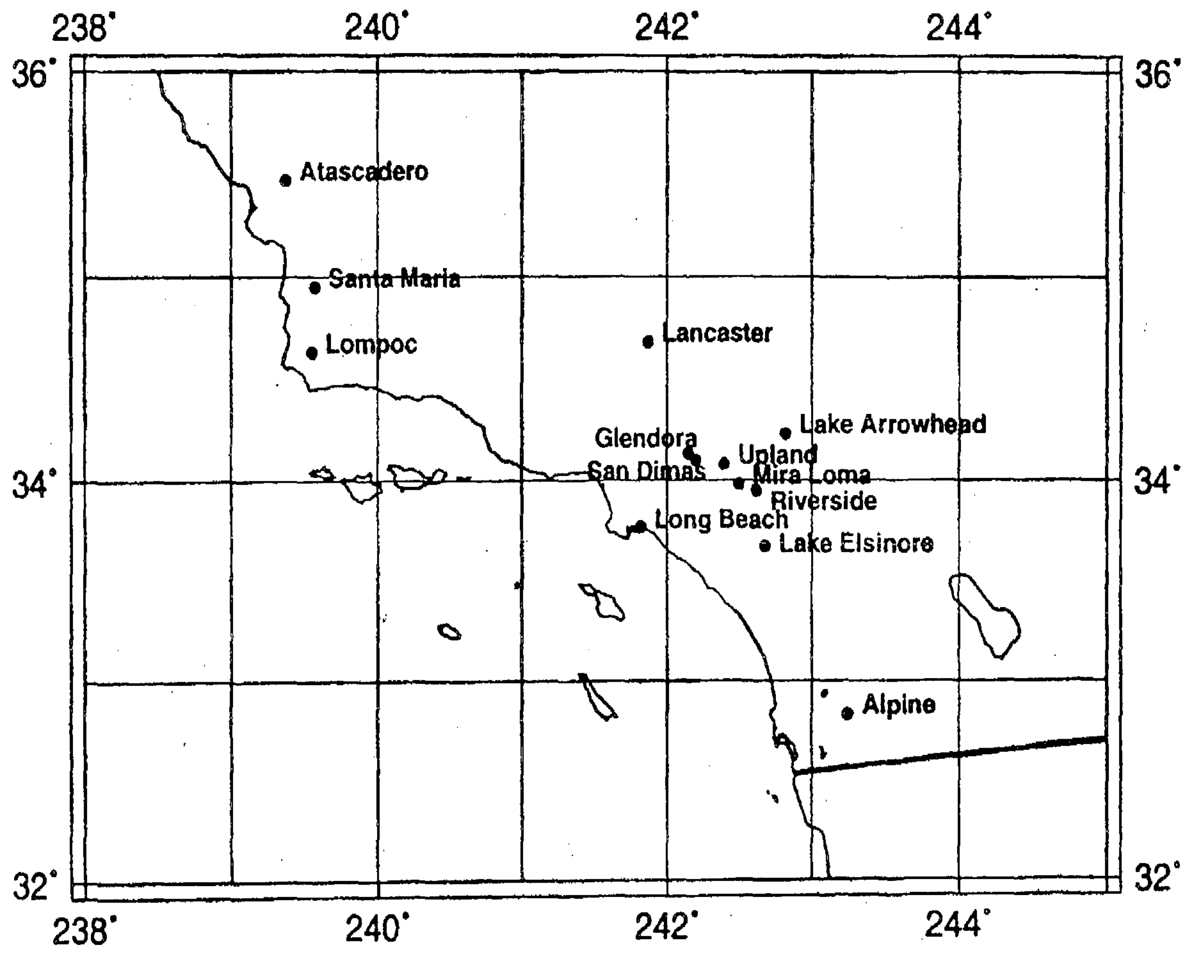
Sampling

The samples used for the study were collected by the Southern California Children's Health Study sampler described by Lurman et al. [*Lurmann et al.*, 1994] and Taylor et al. [*Taylor et al.*, 1998]. Briefly, the sampler is comprised of three sample legs. Leg A is operated to collect nitric acid, hydrochloric acid, PM2.5 mass, and PM2.5 inorganic ions. Leg B is operated to collect formic and acetic acid. Leg C of the sampler is used to collect particulate matter for organic and elemental carbon analysis and for organic compound speciation. Leg C provides the filters used for the present study. Leg C does not incorporate a size-selective inlet and is comprised of an inlet line (6mm diameter by 2.5 cm long) and a Teflon filter holder (Savilex), which operates at a 1.3 lpm. Experiments, which are described in Part A of this report, demonstrated that Leg C of the Children's Health Study sampler collects an effective-PM10 sample. All sampling legs are operated simultaneously for each two-week sampling period. Filters were replaced at the end of each two-week sampling period to yield nominally 26 two-week sampling periods per year.

The quartz fiber filters (47mm, 2500 QAO tissuequartz, Pall Gelman) used for the present study were pre-baked at 550 °C for a minimum of 12 hours prior to sampling. After sample collection, the filters were stored in foil-lined petri-dishes, which were sealed with Teflon tape and stored in a freezer until analysis. Prior to analysis, the quartz fiber filter was cut in half. One half of each filter was used for elemental and organic carbon (EC/OC) analysis and the second half was used in the present study for detailed organic compound analysis. Filters from each site were composited into 3 seasonal sample periods. Sample 1 for each site contained filters collected from December 29, 1994 through May 3, 1995, and represents the early year winter and spring period (Period 1). Sample 2 for each site contained filters from May 3, 1995 through November 1, 1995, which represent the summer and fall season (Period 2). Sample 3 contained filters from November 1, 1995 through December 28, 1995, and represents the late winter period of the calendar year (Period 3). The three seasonal periods were selected to best represent the seasonal distribution of fine particle organic compound concentration previously measured in Southern California [*Hannigan et al.*, 2001; *Rogge et al.*, 1993c].

Figure 1.1 shows the locations of the 13 sampling sites that are being used by the Southern California Children's Health Study to represent the 12 communities. The Glendora sampling site, which is in close proximity to the San Dimas site, replaced the San Dimas Site in 1996. No

Figure 1.1 Southern California Children's Health Study Sampling Network



samples from the Glendora site were analyzed as part of this project. The sampling sites include two sites in a mountainous region (Alpine and Lake Arrowhead), one desert site (Lancaster) and three rural coastal sites (Atascadero, Lompoc and Santa Maria). In addition, the network also includes five Southern California urban sites (San Dimas, Upland, Mira Loma, Riverside, and Long Beach) as well as a rural inland site (Lake Elsinore).

Co-located samplers were operated at the Riverside site, which were analyzed to better understand the precision of the measurement of particle-phase organic compounds using the Children's Health study sampler and the analytical procedure described below. Filters from the early winter and spring period (Period 1) collected at the San Dimas site were not analyzed due to sample handling problems that occurred prior to analysis. In addition, filter blanks were analyzed that comprise filters prepared and handled by the same procedures as used for the samples. In total, thirty-five (35) composite samples were analyzed along with field and laboratory QA/QC blanks.

Chemical Analysis

The analysis of the particulate matter samples conducted as part of this study is based on the procedures previously reported by Schauer and Cass [*Schauer and Cass*, 2000], Schauer et al. [*Schauer et al.*, 1999a; *Schauer et al.*, 1999b], and Schauer [*Schauer et al.*, 1998]. The same quantification standards are used in the present study as in these past studies to assure compatible results. Slight modifications to these procedures have been implemented for the present study that provide improved sensitivity and improved precision [*Sheesley et al.*, 2000]. The modifications include the implementation of a new internal standard, the use of a different gas chromatography/mass spectrometry (GC/MS) instrument equipped with a different gas chromatography (GC) column, as well as the implementation of direct internal standard normalization for quantification. These changes will not introduce biases in quantification, but will provide improved sensitivity and precision. A brief summary of the extraction and analysis protocols is presented here. More details concerning these methods have been presented previously [*Schauer*, 1998b; *Schauer and Cass*, 2000; *Schauer et al.*, 1999a; *Sheesley et al.*, 2000].

Samples are extracted in annealed glass jars equipped with Teflon lined lids. The samples are first spiked with an internal standard mix containing twelve deuterated compounds (dodecane-D_{26}, hexadecane-D_{34}, eicosane-D_{42}, octacosane-D_{58}, hexatriacontane-D_{74}, decanoic acid-D_{19}, heptadecanoic acid-D_{33}, phthalic acid-3,4,5,6-D_4, benzaldehyde-D_6, 4,4'-dimethoxybenzophenone-D_8, acenaphthene-D_{10}, chrysene-D_{12}, dibenz[ah]anthracene-D_{14}, Cholesterol-2,2,3,4,4,6-D_6, $\alpha\alpha\alpha$-20R-Cholestane-D_4) and one carbon-13 labeled compound (Levoglucosan-C^{13}). This internal standard was specifically developed for the purposes of this study to provide internal quantification references for the key particle-phase organic compounds covering their range of vapor pressures, mass spectral fragmentations, polarity, and their reactivity with derivatization reagents.

After internal standard spiking the filters are extracted twice under mild sonication with hexane (Fisher Optima Grade), followed by three successive benzene/isopropanol (2:1 mixture) extractions (benzene: E & M Scientific; isopropanol: Burdick & Jackson). The benzene used for the extraction was redistilled in the laboratory using a glass distillation column to remove trace level contaminants that are present in commercial benzene. The extracts were filtered, combined, reduced in volume to approximately 250 ml, and then split into two separate fractions. One fraction was then derivatized with diazomethane to convert organic acids to their methyl ester analogs, which are amenable to GC/MS identification and quantification.

Both the derivatized and underivatized sample fractions were analyzed by GC/MS on a Hewlett-Packard GC/MSD system (GC Model 5890, MSD Model 5973) using a 30 meter long X 0.25 mm diameter DB-5MS capillary column (Hewlett-Packard). Quantification standards were spiked with the internal standard mix to yield the same final concentrations of the internal standard compounds in both the sample extracts and the standards. Each compound was assigned a reference internal standard that was used for internal response normalization in both the standards and sample extracts

Hundreds of authentic standards have been prepared for the positive identification and quantification of the organic compounds found in atmospheric particulate matter samples. For a group of compounds with similar structure, such as the n-alkanes, standards were only prepared for some of the compounds within the series. Compounds within a homologous series for which standards were not available were identified by comparing their spectra to the standards for similar compounds within the series and by comparison to the NIST and Wiley mass spectral libraries. For these compounds, quantification was based on the response factors for the authentic standards of closely related compounds within the series.

1.4 Results

Table 1.1 presents the annual average organic compound concentrations at all twelve sampling locations for the year of 1995. Ninety-one (91) organic compounds were quantified that include n-alkanes, fatty acids, polycyclic aromatic hydrocarbons (PAH), hopanes, steranes, aromatic diacids, aliphatic diacids, resin acids, methoxyphenols, and levoglucosan. Figure 1.2 shows the annual average concentrations that were quantified using the co-located samplers operating at the Riverside sampling site. Excellent agreement is observed for the co-located samples that cover concentrations spanning over 5 orders of magnitude (i.e., from 0.002 to 200 ng m^{-3}). The slope of the linear regression line drawn through the data presented in Figure 1.2 is 1.02 ± 0.01. In addition, the concentrations of seventy-six (76) of the eighty (80) compounds, which were present at an annual average concentration of greater than 0.050 ng m^{-3} in both samples, agree within 20 percent. Forty-eight (48) of these co-located measurements agree within 10 percent. The only compound for which co-located measurements deviate by more than 25 percent, that is present at a reasonably high concentration, is 9,12-octadecanedienoic acid (linoleic acid), which contains two double bonds. It is unclear if this unsaturated compound is unstable during the sampling operations or if there are other reasons for the poor agreement. Previous spiking experiments in the lab have suggested that this compound does not react during extraction and analysis. These results suggest that the stability of this compound should be addressed in the future. Since this compound has not been used in the past as a tracer nor is the compound of specific interest for health effects, the poor agreement in the co-located measurements does not have a significant impact on this or other related studies.

Table 1.1 Annual Average Concentration of Organic Compounds in Atmospheric PM10
Southern California Children's Health Study, 1995

Compound (ng/m^3)	Alpine	Atas cadero	Lake Arrow head	Lake Elsinore	Lan caster	Lompoc	Long Beach	Mira Loma	River Side	San Dimas*	Santa Maria	Upland
Alkanes												
Tetracosane	2.04	2.95	2.17	2.29	1.92	1.29	5.07	2.92	3.12	2.89	2.48	4.15
Pentacosane	1.47	1.98	0.81	2.18	2.05	0.46	5.98	3.90	3.27	3.72	1.33	3.52
Hexacosane	1.23	1.65	0.65	1.83	1.89	0.52	6.05	3.66	4.08	4.24	1.52	3.21
Heptacosane	2.29	2.66	1.21	2.70	2.24	0.88	5.36	5.08	5.26	4.05	2.11	4.12
Octacosane	1.59	1.59	0.96	1.69	1.97	0.78	4.52	4.01	4.59	3.25	1.90	2.87
Nonacosane	4.37	5.34	2.32	4.77	4.01	1.65	5.61	9.40	7.78	5.60	4.00	6.31
Triacontane	0.81	1.00	0.41	1.12	1.24	0.59	2.61	2.58	2.97	1.86	1.14	2.09
Hentriacontane	2.16	3.30	1.20	3.00	2.82	0.98	3.81	11.21	5.72	3.92	2.33	4.56
Dotriacontane	0.46	0.61	ND	0.70	0.83	0.34	1.66	1.73	1.82	1.23	0.63	1.38
Tritriacontane	0.69	0.63	ND	1.02	1.15	0.30	1.80	2.49	1.85	1.30	0.74	1.64
Tetratriacontane	0.17	0.56	ND	1.01	1.66	0.18	2.17	1.70	1.94	0.41	0.84	0.69
Total	17.27	22.25	9.74	22.30	21.77	7.99	44.65	48.70	42.40	32.46	19.02	34.55
Saturated Cycloalkanes												
Pentadecylcyclohexane	0.029	0.042	0.028	0.034	0.055	0.013	0.053	0.033	0.061	0.066	0.036	0.064
Hexadecylcyclohexane	0.033	0.078	0.027	0.034	0.089	0.021	0.073	0.071	0.078	0.061	0.055	0.091
Heptadecylcyclohexane	0.036	0.065	0.032	0.044	0.088	0.021	0.113	0.094	0.085	0.080	0.065	0.100
Octadecylcyclohexane	0.034	0.097	0.032	0.052	0.091	0.025	0.136	0.109	0.080	0.100	0.073	0.116
Total	0.132	0.281	0.119	0.164	0.324	0.080	0.375	0.306	0.304	0.308	0.228	0.370
Alkanoic Acids												
Tetradecanoic acid	5.65	6.69	3.60	5.48	4.41	2.72	6.37	7.59	5.59	6.61	4.90	8.67
Pentadecanoic acid	3.99	3.87	2.47	3.81	2.75	1.78	3.66	4.69	3.62	4.97	2.88	5.42
Hexadecanoic acid	18.97	33.08	5.47	20.56	21.64	8.60	47.41	63.37	33.06	48.74	23.34	88.54
Heptadecanoic acid	2.44	2.84	1.42	2.50	2.28	1.08	3.50	5.27	3.07	3.89	2.03	5.94
Octadecanoic acid	9.15	15.79	5.07	11.15	13.84	3.85	25.92	106.50	29.54	27.74	12.06	52.21
Nonadecanoic acid	0.90	0.93	0.35	0.87	0.76	0.25	1.07	1.28	0.95	0.92	0.61	1.30
Eicosanoic acid	1.69	2.60	0.69	1.64	1.80	0.64	2.28	5.05	2.18	2.11	1.42	2.77
Heneicosanoic acid	0.66	1.07	0.17	0.54	0.72	0.25	0.86	1.15	0.64	0.55	0.49	0.78
Docosanoic acid	2.32	5.28	0.77	1.72	2.99	1.14	2.33	5.41	2.08	2.01	2.21	2.80
Tricosanoic acid	0.83	1.31	0.15	0.50	0.82	0.24	0.79	1.69	0.55	0.50	0.54	0.73
Tetracosanoic acid	2.44	6.60	0.70	2.08	2.70	1.40	1.94	5.81	2.16	2.00	2.43	2.61

Compound (ng/m^3)	Alpine	Atas cadero	Lake Arrow head	Lake Elsinore	Lan caster	Lompoc	Long Beach	Mira Loma	River Side	San Dimas*	Santa Maria	Upland
Pentacosanoic acid	0.39	0.54	0.10	0.36	0.47	0.11	0.28	0.92	0.29	0.22	0.25	0.34
Hexacosanoic acid	1.22	2.44	0.42	1.74	1.55	0.40	0.80	4.54	1.13	1.07	0.96	1.35
Heptacosanoic acid	0.19	0.15	0.04	0.13	0.23	ND	ND	0.69	0.13	0.08	0.03	0.08
Octacosanoic acid	0.60	0.75	0.23	0.98	1.02	0.12	0.42	4.22	0.71	0.46	0.40	0.53
Nonacosanoic acid	0.05	ND	ND	0.10	0.13	ND	ND	1.24	0.05	0.02	ND	0.03
Triacontanoic acid	0.29	0.40	0.11	0.43	0.72	0.03	0.19	9.93	0.52	0.34	0.16	0.32
Total	51.76	84.34	21.75	54.58	58.83	22.60	97.82	229.34	86.27	102.21	54.71	174.43
Alkenoic Acids												
9-Hexadecenoic acid	1.157	0.857	1.147	0.433	0.935	0.915	0.126	0.185	0.813	0.333	1.463	0.375
9,12-Octadecadienoic acid	0.162	0.399	0.085	0.011	0.342	0.020	0.018	ND	0.291	ND	0.074	0.029
9-Octadecenoic acid	1.359	0.887	1.091	0.315	0.997	1.273	0.504	1.000	0.928	0.281	1.620	0.503
Total	2.679	2.142	2.323	0.758	2.273	2.208	0.649	1.185	2.031	0.614	3.157	0.907
Resin Acids												
Pimaric acid	0.042	0.183	0.046	0.043	0.132	0.009	0.132	0.102	0.054	ND	0.050	0.179
Sandaracopimaric acid	0.034	0.076	0.017	0.029	0.098	ND	0.105	0.013	0.060	ND	0.016	ND
Isopimaric acid	0.149	0.138	0.050	ND	0.158	ND	ND	0.922	0.114	ND	ND	0.293
Dehydroabietic acid	1.710	17.139	1.063	2.960	10.357	3.231	12.072	8.976	4.568	5.568	5.127	9.053
Abietic acid	ND	0.060	ND	ND	0.079	ND	ND	ND	ND	ND	ND	ND
Abieta-6,8,11,13,15-pentaen-18-oic acid	0.037	0.400	0.021	0.147	0.311	0.017	0.448	0.423	0.385	0.160	0.136	0.505
Abieta-8,11,13,15-tetraen-18-oic acid	0.082	0.464	0.073	0.122	0.260	0.096	0.488	0.584	0.366	0.239	0.149	0.536
7-Oxodehydroabietic acid	8.420	35.849	5.542	15.955	15.134	12.209	31.570	22.888	14.675	13.298	13.260	24.808
Total	10.473	54.307	6.811	19.256	26.529	15.562	44.813	33.908	20.221	19.265	18.739	35.374
Alkanedioic Acids												
Propanedioic acid	5.32	2.22	8.02	3.45	1.71	0.44	4.20	1.19	6.97	5.66	0.76	2.85
Butanedioic acid	18.60	17.93	24.44	12.31	12.62	8.95	30.63	8.99	20.12	4.48	13.50	7.14
Methylbutanedioic acid	5.54	5.00	7.09	3.19	4.04	2.81	6.52	3.30	5.95	3.18	4.71	2.69
Pentanedioic acid	10.69	10.13	16.24	7.96	7.97	5.81	12.08	5.61	10.15	7.01	8.50	7.55
Hexanedioic acid	4.33	4.46	6.69	3.32	4.30	2.36	3.46	2.35	4.65	2.88	3.12	3.31
Heptanedioic acid	1.68	2.93	1.89	1.14	2.17	1.65	0.89	0.79	1.61	0.81	1.68	1.22
Octanedioic acid	3.24	6.87	4.45	2.46	4.78	3.01	1.71	2.71	3.29	1.86	3.96	2.71
Nonanedioic acid	3.22	13.13	2.60	2.58	8.07	3.27	3.32	3.87	4.27	3.36	5.78	6.70
Total	47.30	60.46	63.40	32.96	43.95	27.87	58.60	27.62	50.05	23.58	41.26	31.32
Aromatic Acids												
1,2-Benzenedicarboxylic acid	4.606	4.133	8.172	3.010	2.988	1.389	3.515	3.193	4.514	4.541	1.974	4.073

Compound (ng/m^3)	Alpine	Atas cadero	Lake Arrow head	Lake Elsinore	Lan caster	Lompoc	Long Beach	Mira Loma	River Side	San Dimas*	Santa Maria	Upland
1,4-Benzenedicarboxylic acid	0.514	0.658	0.691	0.338	0.555	0.297	0.256	0.358	0.380	0.292	0.700	0.303
1,3-Benzenedicarboxylic acid	0.359	0.449	0.616	0.233	0.341	0.235	0.319	0.255	0.377	0.322	0.385	0.287
4-Methyl-1,2-Benzenedicarboxylic acid	1.818	1.416	3.157	1.314	1.485	0.470	1.402	1.670	2.212	1.926	0.865	1.857
Benzenetricarboxylic acids	0.930	0.478	1.004	0.667	0.301	0.104	0.523	0.118	0.590	1.065	0.197	0.637
Total	8.228	7.134	13.640	5.562	5.670	2.496	6.015	5.595	8.073	8.147	4.120	7.157
						Hopanes						
22,29,30-Trisnorhopane	0.054	0.066	0.046	0.055	0.083	0.037	0.125	0.096	0.068	0.056	0.040	0.067
17α(H),21β(H),29-Norhopane	0.253	0.285	0.162	0.311	0.322	0.151	0.543	0.483	0.329	0.340	0.248	0.351
18α(H),29-Norneohopane	0.080	0.102	0.059	0.108	0.110	0.049	0.157	0.135	0.139	0.086	0.092	0.122
17α(H),21β(H)-Hopane	0.301	0.346	0.208	0.412	0.430	0.213	0.704	0.673	0.435	0.537	0.362	0.538
22S, 17α(H),21β(H),30-Homohopane	0.142	0.152	0.172	0.179	0.184	0.080	0.305	0.286	0.205	0.179	0.153	0.222
22R, 17α(H),21β(H),30-Homohopane	0.142	0.094	0.080	0.166	0.165	0.115	0.294	0.306	0.202	0.173	0.165	0.172
22S, 17α(H),21β(H),30,31-Bishomohopane	0.081	0.057	0.061	0.097	0.112	0.033	0.222	0.193	0.133	0.108	0.086	0.128
22R, 17α(H),21β(H),30,31-Bishomohopane	0.073	0.043	0.028	0.085	0.098	0.021	0.144	0.138	0.104	0.068	0.052	0.073
Total	1.127	1.144	0.816	1.414	1.505	0.700	2.493	2.310	1.616	1.547	1.198	1.672
						Steranes						
20R+S, 5α(H),14β(H),17β(H)-Cholestane	0.198	0.277	0.106	0.222	0.304	0.127	0.470	0.403	0.288	0.345	0.287	0.334
20R, 5α(H),14α(H),17α(H)-Cholestane	0.180	0.205	0.083	0.188	0.234	0.096	0.390	0.359	0.239	0.251	0.190	0.250
20R+S, 5α(H),14β(H),17β(H)-Ergostane	0.131	0.169	0.055	0.172	0.180	0.061	0.375	0.309	0.226	0.202	0.174	0.229
20R+S, 5α(H),14β(H),17β(H)-Sitostane	0.177	0.266	0.078	0.201	0.263	0.121	0.512	0.437	0.276	0.315	0.276	0.311
Total	0.687	0.917	0.323	0.782	0.981	0.405	1.748	1.508	1.030	1.114	0.926	1.124
						PAHs						
Fluoranthene	0.038	0.070	0.042	0.050	0.091	0.007	0.141	0.107	0.117	0.132	0.092	0.153
Acephenanthrylene	ND	0.001	ND	0.004	0.006	ND	0.004	0.007	0.006	0.004	ND	0.006
Pyrene	0.033	0.064	0.030	0.047	0.098	0.007	0.143	0.108	0.108	0.139	0.067	0.158
Retene	ND	0.624	ND		0.443	ND	0.808	0.638	0.242	ND	ND	0.727
Benzo[ghi]fluoranthene	0.012	0.041	ND	0.028	0.066	0.003	0.081	0.065	0.048	0.073	0.034	0.099
Cyclopenta[cd]pyrene	0.004	0.010	0.004	0.006	0.014	ND	0.028	0.020	0.007	0.016	ND	0.013
Benz[a]anthracene	0.008	0.014	0.037	0.016	0.032	0.000	0.185	0.059	0.030	0.037	0.011	0.040
Chrysene/Triphenylene	0.028	0.101	0.057	0.054	0.128	0.017	0.332	0.160	0.124	0.146	0.075	0.168
Benzo[k]fluoranthene	0.027	0.131	0.479	0.092	0.182	0.012	0.334	0.231	0.124	0.143	0.058	0.173
Benzo[b]fluoranthene	0.046	0.083	0.666	0.098	0.178	0.009	0.411	0.231	0.116	0.109	0.057	0.151
Benzo[j]fluoranthene	ND	0.002	ND	0.005	ND	ND	0.002	ND	ND	ND	ND	ND
Benzo[e]pyrene	ND	0.088	ND	ND	ND	ND	0.075	0.052	ND	0.180	ND	0.051

Compound (ng/m^3)	Alpine	Atas cadero	Lake Arrow head	Lake Elsinore	Lan caster	Lompoc	Long Beach	Mira Loma	River Side	San Dimas*	Santa Maria	Upland
Benzo[a]pyrene	0.003	0.028	0.280	0.011	0.049	ND	0.213	0.092	0.055	0.050	0.029	0.059
Perylene	ND	0.002	0.008	0.001	0.004	ND	0.005	ND	0.002	ND	ND	0.001
Indeno[cd]pyrene	0.031	0.031	0.088	0.050	0.100	0.003	0.148	0.164	0.087	0.065	0.031	0.115
Benzo[ghi]perylene	0.062	0.074	0.340	0.110	0.251	0.002	0.314	0.286	0.157	0.195	0.069	0.271
Indeno[cd]fluoranthene	0.004	0.014	ND	0.017	0.031	ND	0.027	0.028	0.021	0.016	ND	0.039
Coronene	0.004	0.040	ND	0.013	0.110	0.000	0.105	0.109	0.055	0.121	0.036	0.184
Total	0.300	1.417	2.031	0.602	1.785	0.060	3.358	2.357	1.297	1.426	0.558	2.410
Oxy-PAHs												
1H-Phenalen-1-one	0.003	0.064	0.012	0.022	0.067	0.004	0.079	0.029	0.038	0.051	0.038	0.068
Anthracen-9,10-dione	0.075	0.112	0.011	0.077	0.132	0.027	0.218	0.121	0.159	0.140	0.202	0.198
1,8-Naphthalic Anhydride	0.266	0.221	0.030	0.400	0.207	0.031	0.816	0.517	0.620	0.894	0.250	0.932
Benz[de]anthracen-7-one	0.004	0.107	ND	0.027	0.064	0.002	0.140	0.092	0.052	0.095	0.013	0.092
Benz[a]anthracene-7,12-dione	0.012	0.029	ND	0.007	0.038	ND	0.098	0.059	0.028	0.041	0.009	0.050
Total	0.360	0.535	0.052	0.533	0.508	0.064	1.350	0.819	0.897	1.220	0.512	1.340
Substituted Phenols												
Propionylsyringol	0.120	ND	0.174	0.086	ND	ND	0.091	0.075	0.079	ND	ND	ND
Butyrylsyringol	ND	ND	ND	ND	0.008	ND	ND	ND	ND	ND	ND	ND
Total	0.120		0.174	0.086	0.008		0.091	0.075	0.079			
Other Compounds												
Levoglucosan	55.6	300.8	20.6	81.9	144.5	89.7	105.6	207.0	104.2	109.1	132.3	123.3
Squalene	4.783	1.406	2.323	1.627	1.419	0.850	1.266	0.323	3.644	7.692	3.602	5.290
Cholesterol	ND	0.159	ND	ND	ND	ND	ND	ND	0.248	ND	0.223	
Total	60.4	302.4	22.9	83.5	145.9	90.5	106.9	207.4	108.1	116.8	136.1	128.6
Carbon												
Organic carbon	4458	5137	3215	6028	7136	2074	7390	15533	8675	9981	3822	10605
Elemental carbon	512	510	455	815	786	150	1719	1478	1179	1700	426	1507
Total	4970	5647	3671	6843	7922	2224	9109	17010	9854	11681	4248	12111
Particle Mass												
Particle mass	8429	7461	8374	15193	8601	5953	21559	36782	26873	29099	8356	26723

* San Dimas site values are the average of the second and third sampling periods.

Figure 1.2 Comparison of Measurements of Compounds in Atmospheric Particulate Matter Collected by Two Co-located Samplers at Riverside, California during Childrens Health Study, 1995

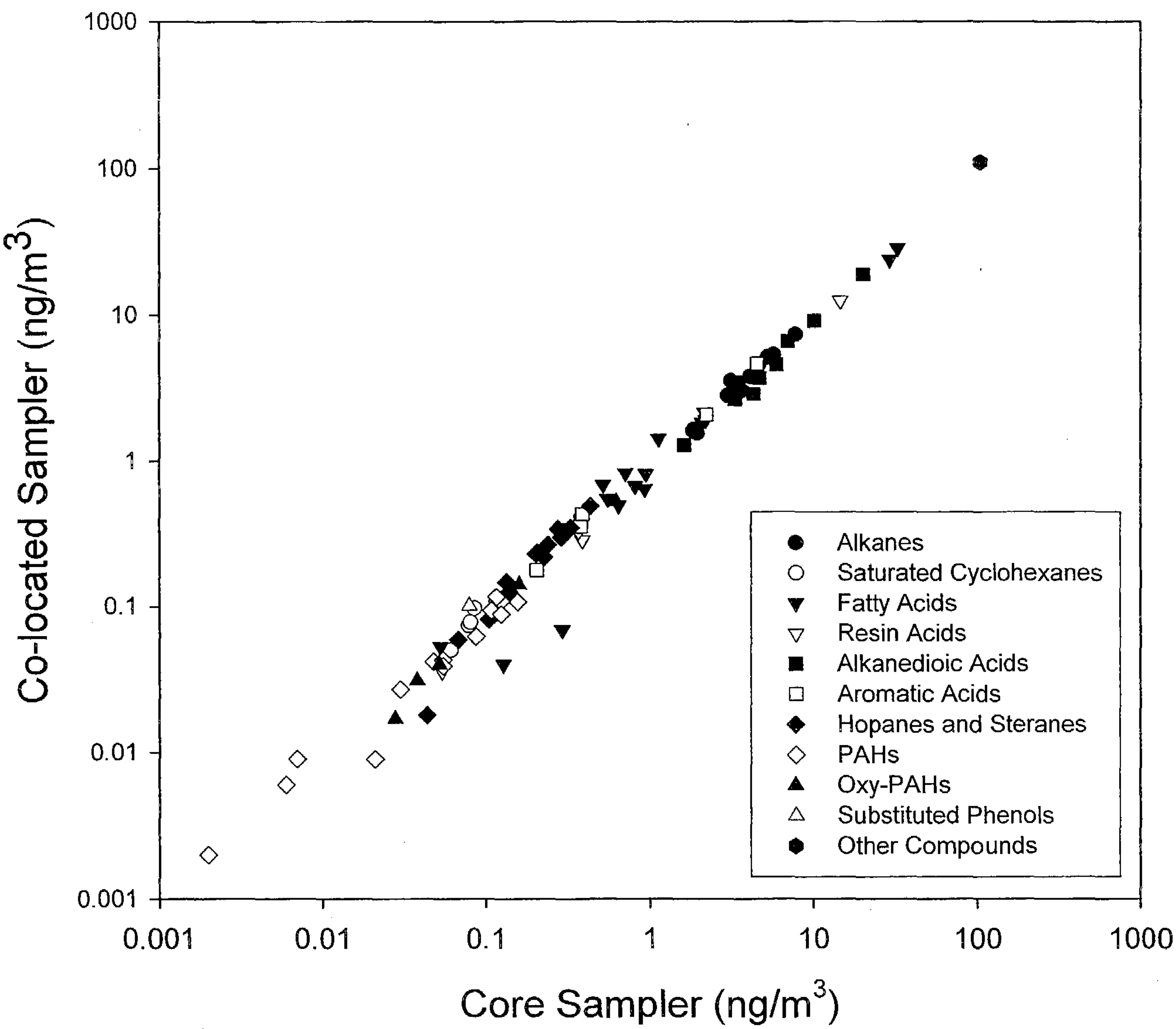


Figure 1.3 Elemental and Organic Carbon in Atmospheric Particulate Matter
Southern California Children's Health Study, 1995

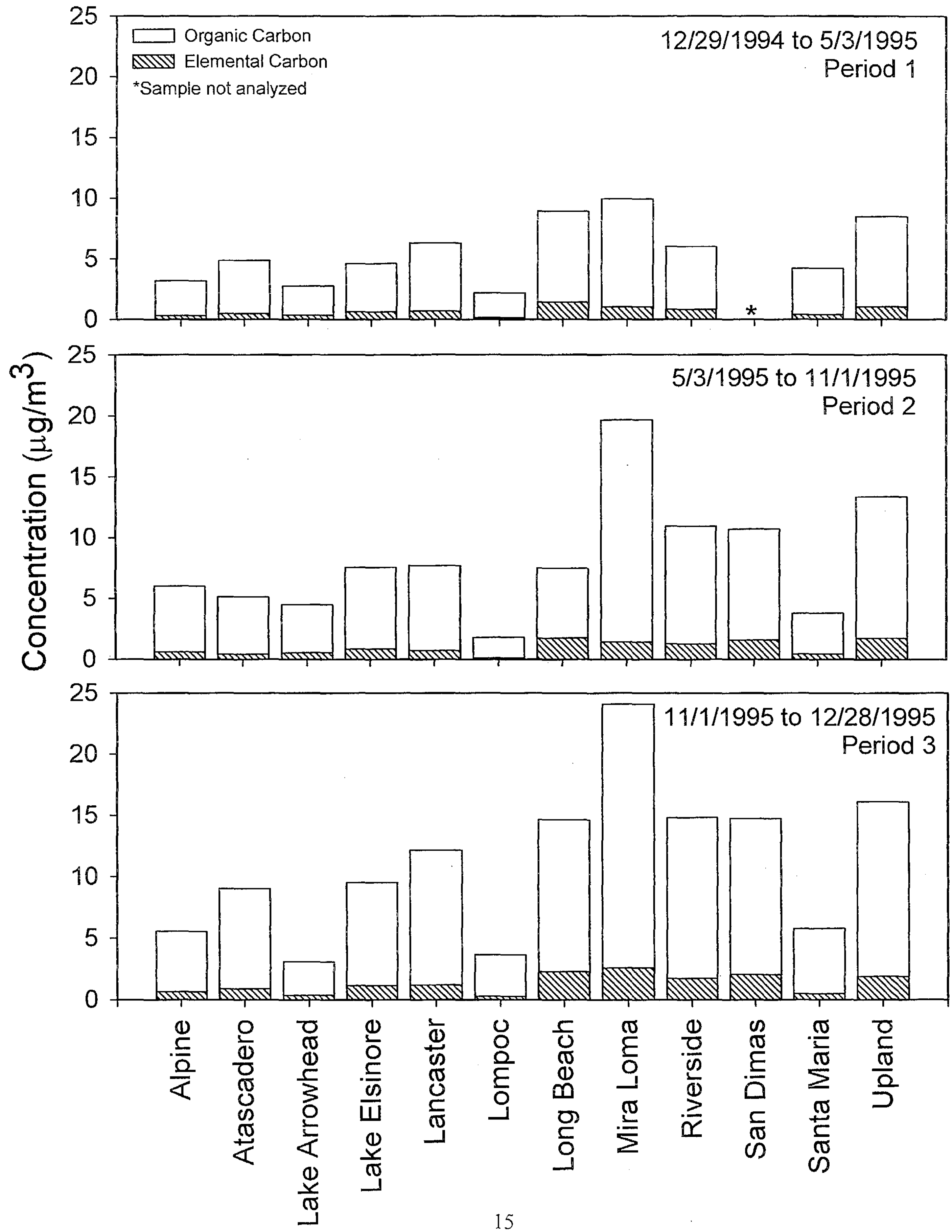


Figure 1.3 presents the seasonal and spatial distribution of the organic and elemental carbon measured in the PM10 samples for the twelve sampling sites during the calendar year of 1995 (results are from Part A of this report). It is interesting to note, that although important concentration differences exist between the sampling sites, a pronounced seasonal trend does not exist at many of the sites. Likewise, these measurements provide only limited information on the source of the carbonaceous aerosol.

Figure 1.4 presents the seasonal and spatial distribution of the hopanes and steranes that are present in the PM10 concentrations at the twelve sampling sites. Hopanes and steranes are biomarkers which are present in heavy petroleum distillates [*Simoneit*, 1985; *Simoneit*, 1999; *Simoneit et al.*, 2000]. In the Southern California atmosphere, it has been shown that these compounds are predominately from the exhaust emissions of gasoline and diesel powered motor vehicles and result from the presence of lubricating oils in the particulate matter emissions [*Rogge et al.*, 1993a; *Rogge et al.*, 1996; *Rogge et al.*, 1993c; *Schauer*, 1998c; *Schauer and Cass*, 2000; *Schauer et al.*, 1998; *Schauer et al.*, 1996]. During the summer/fall season, the hopanes and steranes show a good correlation with the carbonaceous particulate matter. A similar but weaker correlation is observed for the other season of 1995. It is important to note that diesel vehicles are important sources of both elemental carbon and the hopanes and steranes, while gasoline powered vehicles are important sources of hopanes and steranes but not elemental carbon. To this end, higher hopanes and steranes concentrations at fixed elemental carbon concentrations indicate higher contributions from gasoline-powered motor vehicles.

Figure 1.5 shows the distribution of levoglucosan in the atmosphere at each site during the three sample periods of 1995. Levoglucosan is a major component of wood smoke aerosol from both conifer and deciduous trees, and has been shown to be a good tracer for wood burning [*Schauer and Cass*, 2000; *Schauer et al.*, 1998; *Schauer et al.*, 2001; *Simoneit et al.*, 1999]. As expected, the levoglucosan concentration is low in the summer and fall seasons at all of the sampling sites within the heavily populated region of Southern California (Long Beach, Mira Loma, Riverside, San Dimas, and Upland). The average concentration increases substantially during the winter as would be expected for a wood smoke tracer. The concentrations of levoglucosan are noticeably higher at the coastal Atascadero site than at any other community in the study.

The distribution of polycyclic aromatic hydrocarbons is presented in Figure 1.6. The seasonal periods at each site that have high total particle-phase PAH concentrations do not necessarily correlate with conditions of high levoglucosan or high hopanes and steranes. This supports the notion that there are other important sources of particle-phase PAH in the atmosphere. Previous studies have shown that natural gas combustion can be an important source of PAH in the atmosphere [*Rogge et al.*, 1993b; *Schauer et al.*, 1996]. The distribution among particle-phase PAH compounds varies significantly according to season and location. Retene, a semi-volatile PAH that predominately originates from the combustion of wood from conifer trees, is not present in any sample during the summer and fall period, but is present at significant levels during the winter and fall periods at Lancaster, Long Beach, Mira Loma, and Upland. The very high retene level measured at Atascadero in the late winter period (Period 3) is consistent with the high levoglucosan concentration measured at this time in Atascadero. Periods with high levoglucosan and low retene suggest that either the predominate wood burned was hardwood or that retene degraded or volatilized from the particle-phase. The distribution of PAH at the Lake

Figure 1.4 Hopanes & Steranes in Atmospheric Particulate Matter
Southern California Children's Health Study, 1995

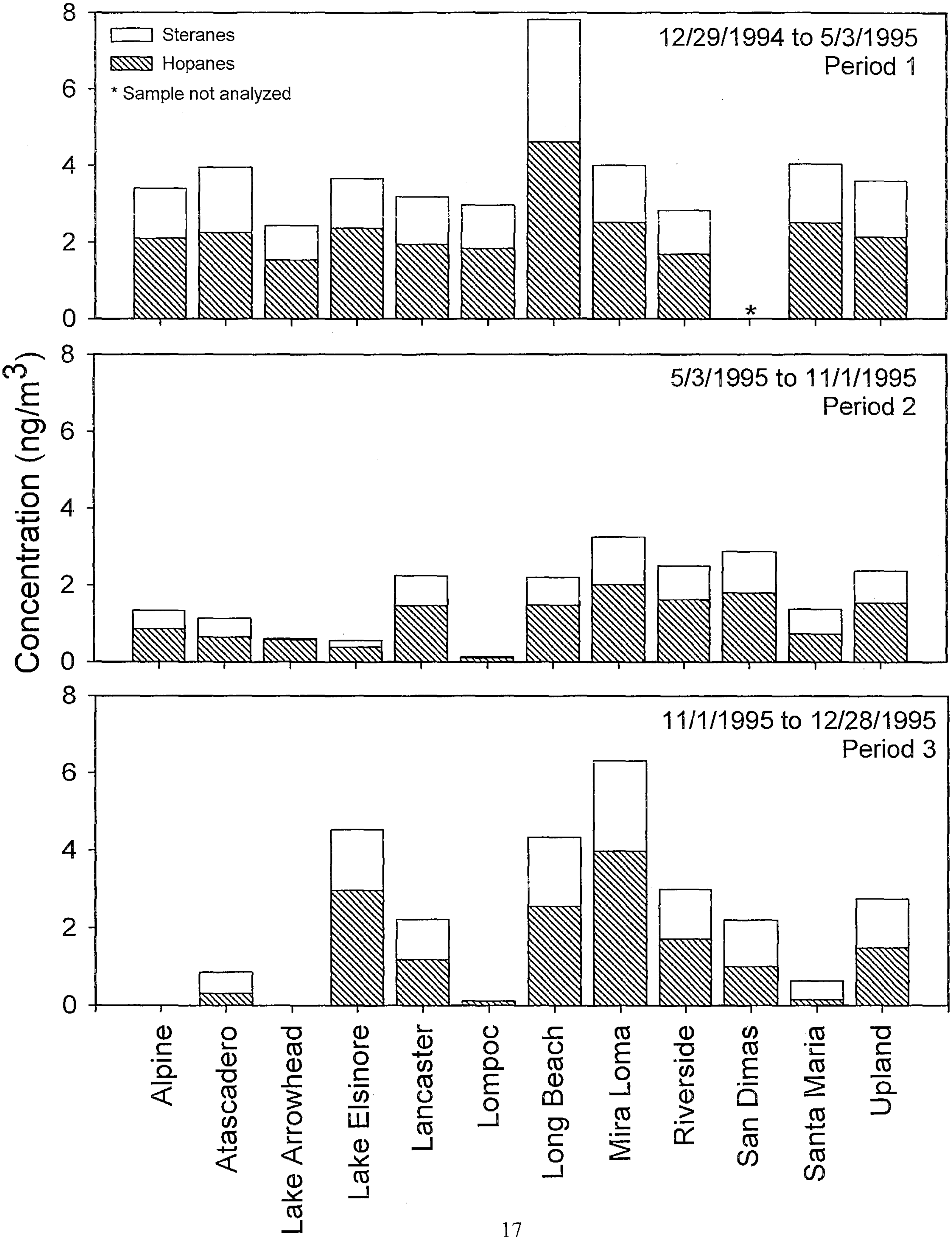


Figure 1.5 Levoglucosan in Atmospheric Particulate Matter
Southern California Children's Health Study, 1995

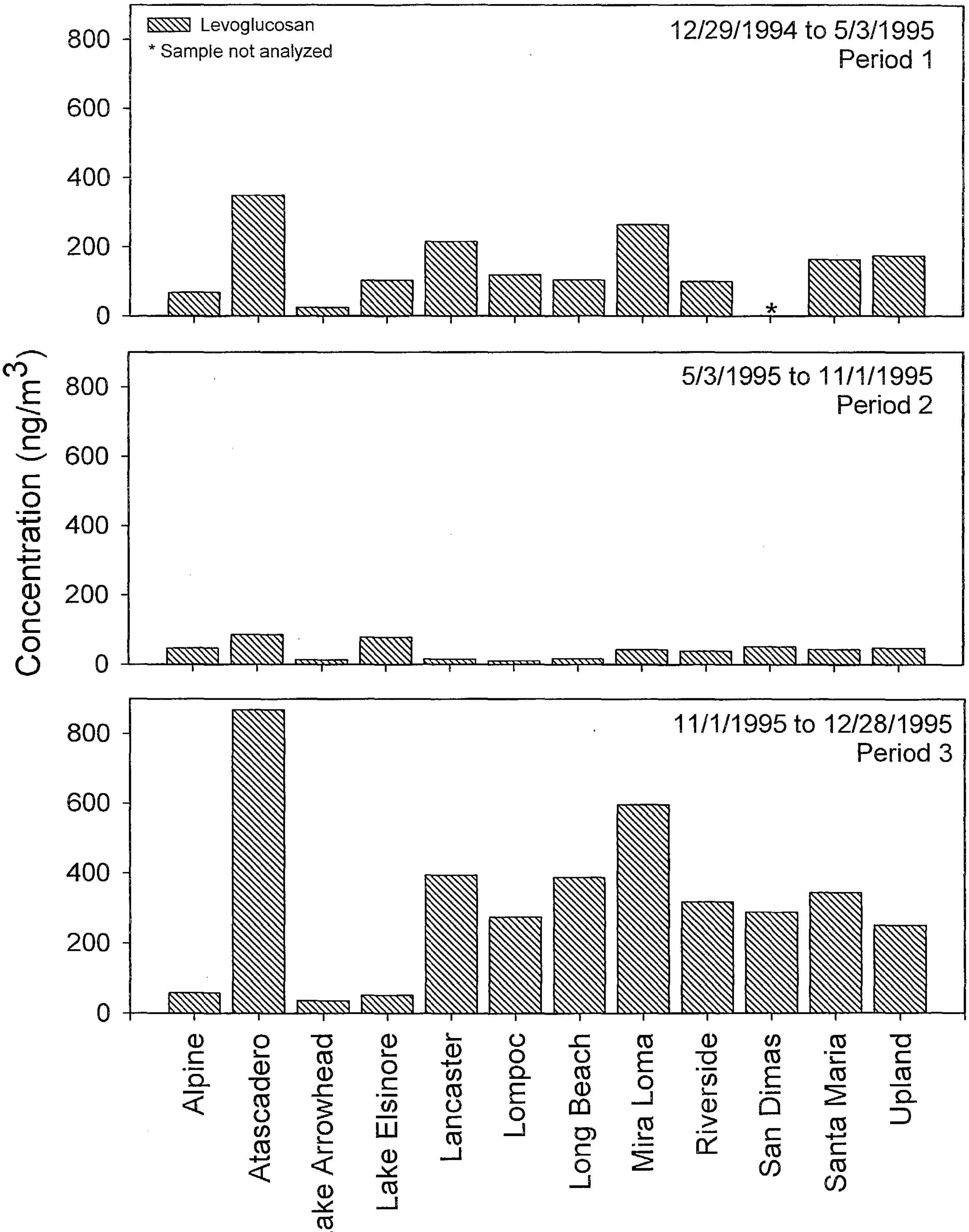
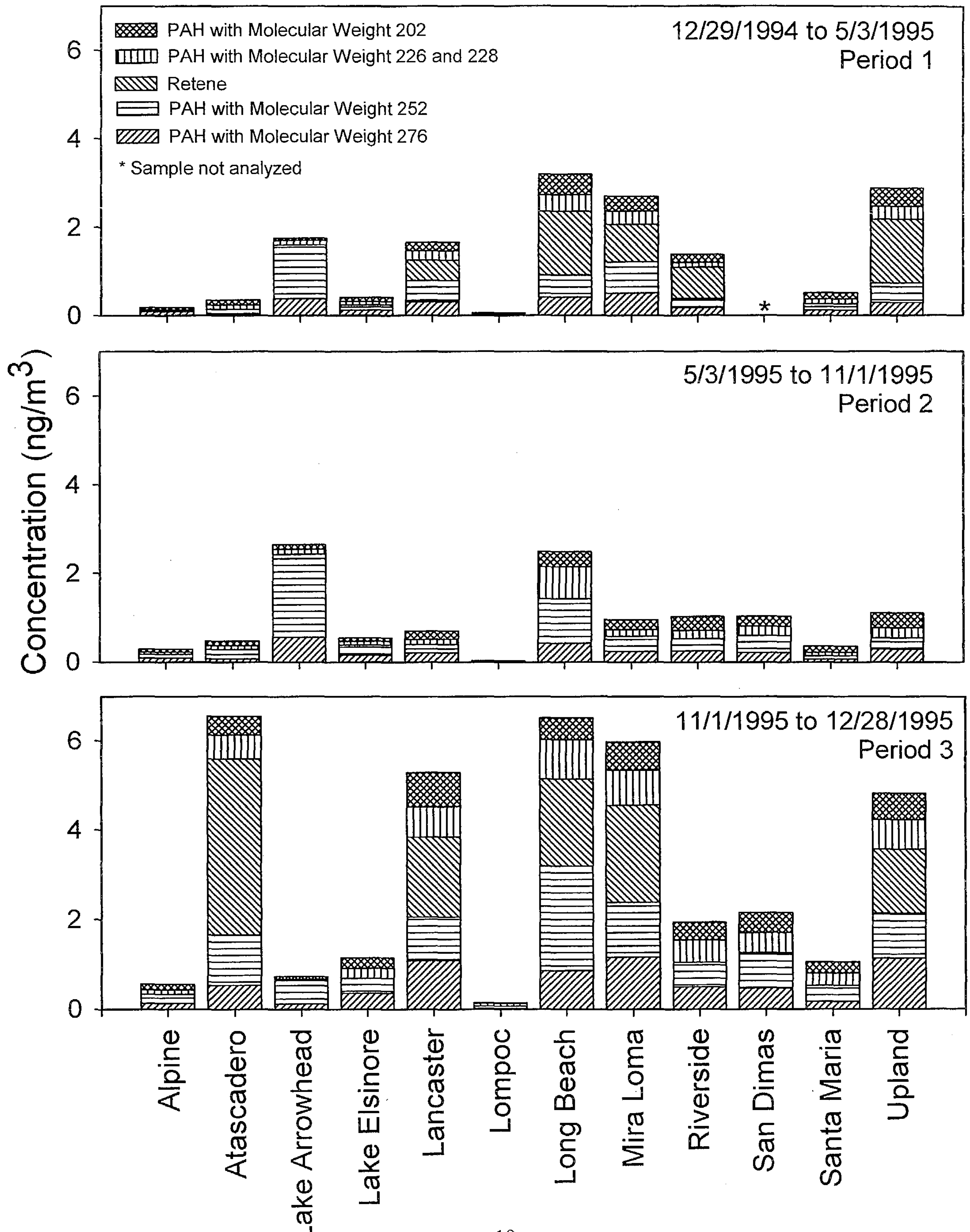


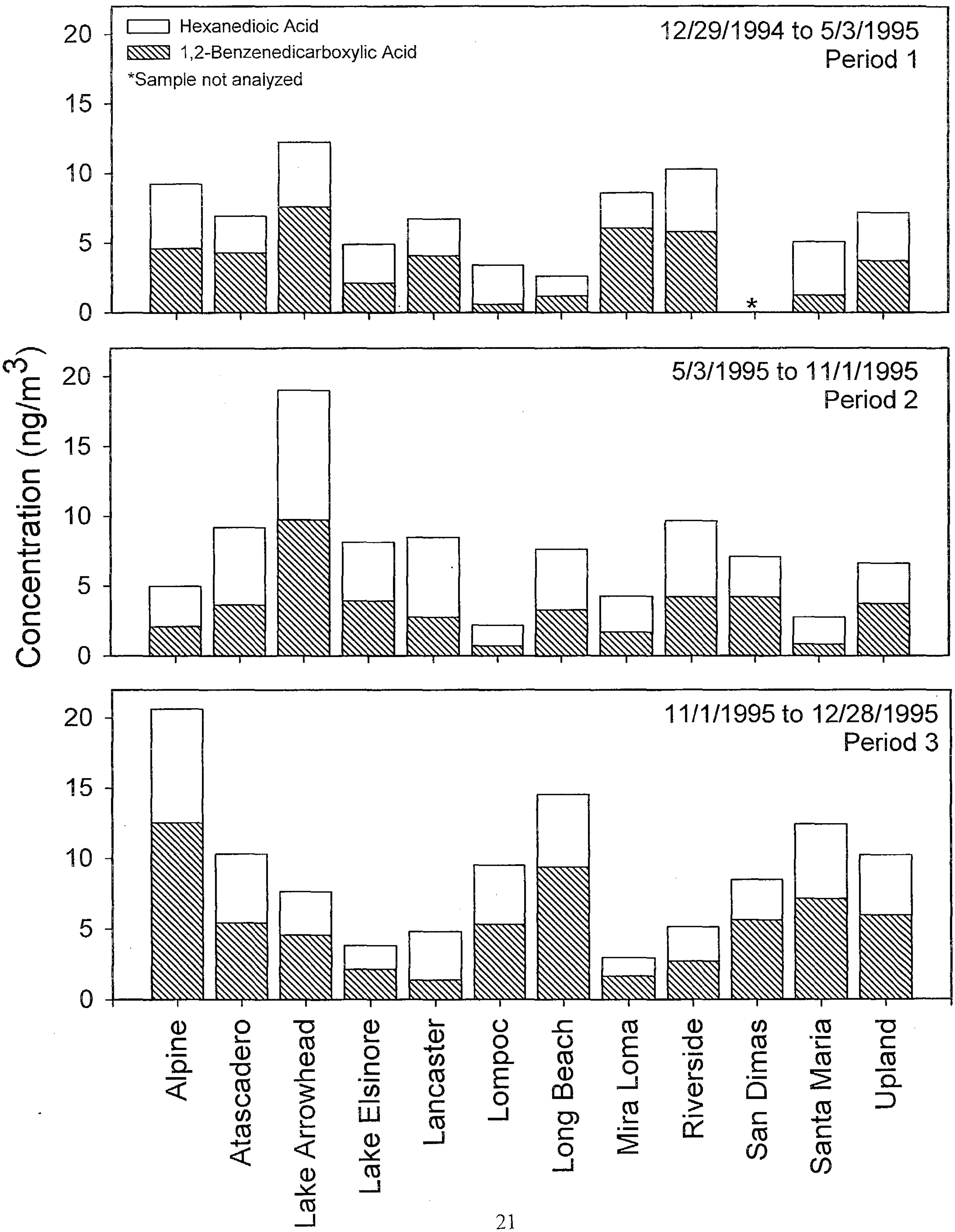
Figure 1.6 PAH in Atmospheric Particulate Matter
Southern California Children's Health Study, 1995



Arrowhead site is very different than that observed at virtually all other sampling sites. At Lake Arrowhead the absolute concentration of PAH with molecular weights of 252 are much higher than at any other site during the early winter and spring period (Period 1) and the summer and fall period. In contrast, these PAH are at lower concentrations than other sites during the late winter period (Period 3). On a relative scale, however, the total concentration of these PAH is the largest contributor to particle-phase PAH at only the Lake Arrowhead sampling site for all three seasons.

The origin of aromatic diacids and aliphatic diacids in the atmosphere is still not completely understood. There is significant reason to believe that formation by atmospheric chemical reaction is the predominate source of these compounds [*Rogge et al.*, 1993b; *Rogge et al.*, 1993c; *Schauer et al.*, 1996]. Figure 1.7 shows the distribution of two of these diacids, hexanedioic acid and 1,2-benzenedicarboxyic acid. The distribution of these compounds is very different than the distribution of the compounds presented in Figures 1.3-1.6. Lake Arrowhead has the highest concentration of all sites during the summer and fall period. In contrast, the highest concentration in the late winter period (Period 3) is measured at the Alpine site.

Figure 1.7 Diacids in Atmospheric Particulate Matter Southern California Children's Health Study, 1995



Chapter 2. Source apportionment of particulate matter concentrations

2.1 Abstract

A molecular marker source apportionment model previously developed by Schauer et al. [*Schauer et al.*, 1996] and Schauer and Cass [*Schauer and Cass*, 2000] was used to quantify the primary source contributions to the PM10 organic carbon concentration and the PM10 mass concentrations in twelve communities, which are being studied through the Southern California Children's Health Study. Primary particle emissions from gasoline-powered motor vehicle exhaust, diesel vehicle exhaust, wood smoke, vegetative detritus, tire wear, and natural gas combustion are quantified at the twelve sites during three seasons that make up the entire calendar year of 1995. Season 1 is from December 29, 1994 through May 3, 1995, and represents the early year winter and spring period (Period 1). Season 2 is from May 3, 1995 through November 1, 1995, which represents the summer and fall season (Period 2). Season 3 is from November 1, 1995 through December 28, 1995, and represents the late winter period of the calendar year (Period 3). Important trends in the seasonal and spatial patterns of the impact of these 6 primary air pollution sources are observed. The source contributions from meat cooking operations and paved road dust were determined for selected samples where cholesterol was detected and where an appropriate road dust profile was available for inclusion in the model.

2.2 Introduction

Epidemiological studies have shown relationships between atmospheric particulate matter concentrations and adverse health effects [*Fairley*, 1999; *Levy et al.*, 2000; *Linn et al.*, 2000; *Ritz et al.*, 2000; *Smith et al.*, 2000; *Zanobetti et al.*, 2000]. As a result of these studies, great interest exists within the health effects community and the regulatory community in understanding which components or physical characteristics of atmospheric particulate matter act to cause the observed adverse health effects. It is important to note, however, that hundreds of chemical species, both organic and inorganic, can be measured in atmospheric particulate matter. It is unlikely that epidemiological studies will be able to clearly identify which compounds from this long list of chemicals associated with atmospheric particulate matter actually produce adverse health effects within an exposed population. An alternative approach, however, is to conduct epidemiological studies that relate adverse health effects to the concentrations of different sources of particulate matter in the atmosphere. This source-oriented approach provides a framework within which epidemiological studies can examine a reduced number of parameters. Using such an approach, it may be that the source or sources of the constituents in atmospheric particulate matter that are causing adverse health effects can be identified. This approach also can be linked directly to policies and control strategies that are designed to reduce the pollutant concentrations caused by specific types of sources.

The development of organic molecular marker source apportionment models recently has provided a powerful tool to better understand the contributions of different air pollution sources to atmospheric particle concentrations [*Schauer and Cass*, 2000; *Schauer et al.*, 1998; *Schauer et al.*, 1996]. These efforts, however, have not yet been integrated into health effects studies conducted to better understand the relationship between source contributions to atmospheric particulate matter and adverse health effects. It is therefore a goal of this study to provide the foundation for such integration. To this end, the present study quantifies the source contributions from 6 separate source categories to atmospheric particle concentrations during three seasonal periods in the 12 communities studied in the Southern California Children's Health Study.

2.3 Methods

The molecular marker source apportionment model used in this study is based on work previously reported by Schauer et al. [*Schauer et al.*, 1996] and Schauer and Cass [*Schauer and Cass*, 2000]. Using the EPA chemical mass balance receptor modeling software, the best fit combinations of source effluents needed to reproduce the organic compound distribution in atmospheric particle samples is computed, and from knowledge of the ratio of compound concentrations to mass concentrations at the source, source contributions to atmospheric particle mass concentrations are revealed. The methodologies for the measurement of source profiles, the selection of chemical mass balance species, and the implementation of the molecular marker source apportionment calculations are discussed in detail in the references just cited and are only summarized briefly here. Source samples were collected using the dilution source sampler described by Hildemann et al. [*Hildemann et al.*, 1989] and Schauer et al. [*Schauer et al.*, 1999a]. Source samples were analyzed by the same laboratory procedures described in Chapter 1 of this report using the same quantification standards as used in this study.

The selection of source profiles and the chemical mass balance species is based on the work by Schauer et al. [*Schauer et al.*, 1996] and Schauer and Cass [*Schauer and Cass*, 2000]. Minor modifications to these criteria were necessary to accommodate differences in the sampling and bulk chemical analysis procedures between these previously reported studies and the present study. In the previous studies, silicon and aluminum were used as important tracers for paved road dust. Unfortunately, silicon and aluminum were not measured as part of the Children's Health Study. For this reason, an alternative approach for tracking the impact of paved road dust was implemented for a selected number of sampling sites. Selected high molecular weight n-alkanoic acids (n-heptacosanoic acid, n-octacosanoic acid, n-nonacosanoic acid, and n-triacontanoic acid) originate predominately from paved road dust in the urbanized regions of the South Coast Air Basin of California [*Schauer et al.*, 1996]. These compounds were employed to apportion the contribution of paved road dust to atmospheric particulate matter samples at locations where local road dust source profiles were available. A PM2.5 paved road dust profile for the urbanized region of Southern California is presented by Schauer [*Schauer et al.*, 1998]. This profile was used to estimate the PM10 paved road dust profile for the Long Beach, the San Dimas, and the Upland communities in the present study.

In previous studies, meat smoke in the atmosphere was quantified using cholesterol and 9-hexadecenoic acid [*Schauer and Cass*, 2000; *Schauer et al.*, 1996]. In these PM2.5 apportionment studies, meat smoke emissions were the dominant source of 9-hexadecenoic acid, with smaller contributions from road dust. In the current study, however, PM10 is being apportioned such that the contributions of road dust to the atmospheric concentrations of 9-hexadecenoic acid are very important. For this reason, 9-hexadecenoic acid cannot be used as a tracer unless an accurate apportionment of road dust is achieved. As indicated above, the absence of adequate road dust profiles for areas outside the central Los Angeles basin prevents the quantification of atmospheric road dust at many sites. For these reasons, meat smoke is only quantified in samples where cholesterol is detected.

2.4 Results

The base case source apportionment model calculations for the present study consist of 35 model runs that incorporate 7 source types that include gasoline-powered motor vehicle exhaust, diesel vehicle exhaust, hardwood combustion, softwood combustion, vegetative detritus, tire wear debris, and particulate matter emissions from natural gas combustion. The model is constructed to apportion source contributions to atmospheric PM10 organic carbon concentrations. In model runs, where hardwood and softwood combustion profiles were found to be co-linear, the profiles were replaced with an average wood combustion profile. The source apportionment results for PM10 organic carbon are presented in Figure 2.1 and Table 2.1. The average correlation coefficient between predicted and observed organic compound correlations for the model runs (R) was 0.88. Only two runs demonstrated correlation coefficients less than 0.84, the late winter season (Period 3) in Lompoc and the late winter season (Period 3) in Santa Maria. In general, there existed very good agreement between the predicted and measured atmospheric organic compound concentrations. In addition to these seven primary sources, road dust source contributions were estimated for all three seasons for Long Beach, San Dimas and Upland. These estimates were generated by incorporating the high molecular weight n-alkanoic acids as fitting species and incorporating the Los Angeles urban paved road dust profile reported by Schauer [*Schauer et al.*, 1998]. The road dust apportionment for these 8 periods, along with the other 7 primary sources, account for an average of 86 ± 9 percent (average ± standard error) of the PM10 organic carbon concentration. Additional contributions at these sites from meat smoke and secondary organic aerosol cannot be estimated. These results are presented in Table 2.1 and demonstrate the importance of road dust to PM10 organic carbon in the atmosphere. Although the contribution from road dust to the other communities is not estimated, it is reasonable to assume that road dust is also an important source of PM10 at these locations. The contribution from meat smoke to PM10 organic carbon is quantified for two sampling periods at Lake Arrowhead, one sampling period at Riverside and one sampling period at Santa Maria, and these results are also presented in Table 2.1. The decision to include or exclude road dust and meat smoke within the CMB model does not change the other source contributions using a 95% confidence interval t-test.

It is important to note, however, that the particulate matter emissions from gasoline-powered motor vehicles, diesel vehicles, wood burning, natural gas combustion, and meat cooking operations are virtually all PM2.5, such that the PM2.5 and PM10 emissions from these sources are practically the same. In contrast, tire wear emissions, road dust emissions and vegetative detritus have noticeable coarse fractions such that the PM10 and PM2.5 emissions cannot be assumed to be identical. In the present study, we assume that the relative chemical composition of PM2.5 and PM10 tire wear, road dust and vegetative detritus are similar while the mass concentration of PM10 from these sources exceeds the PM2.5 emissions. This is consistent with the fact that the contributions from tire wear debris to PM10 organic carbon quantified in the current study are significantly greater than the contributions quantified in previous PM2.5 apportionment studies [*Schauer et al.*, 1998; *Schauer et al.*, 1996].

Figure 2.1: Contribution to Atmospheric PM10 Organic Carbon
Southern California Children's Health Study, 1995

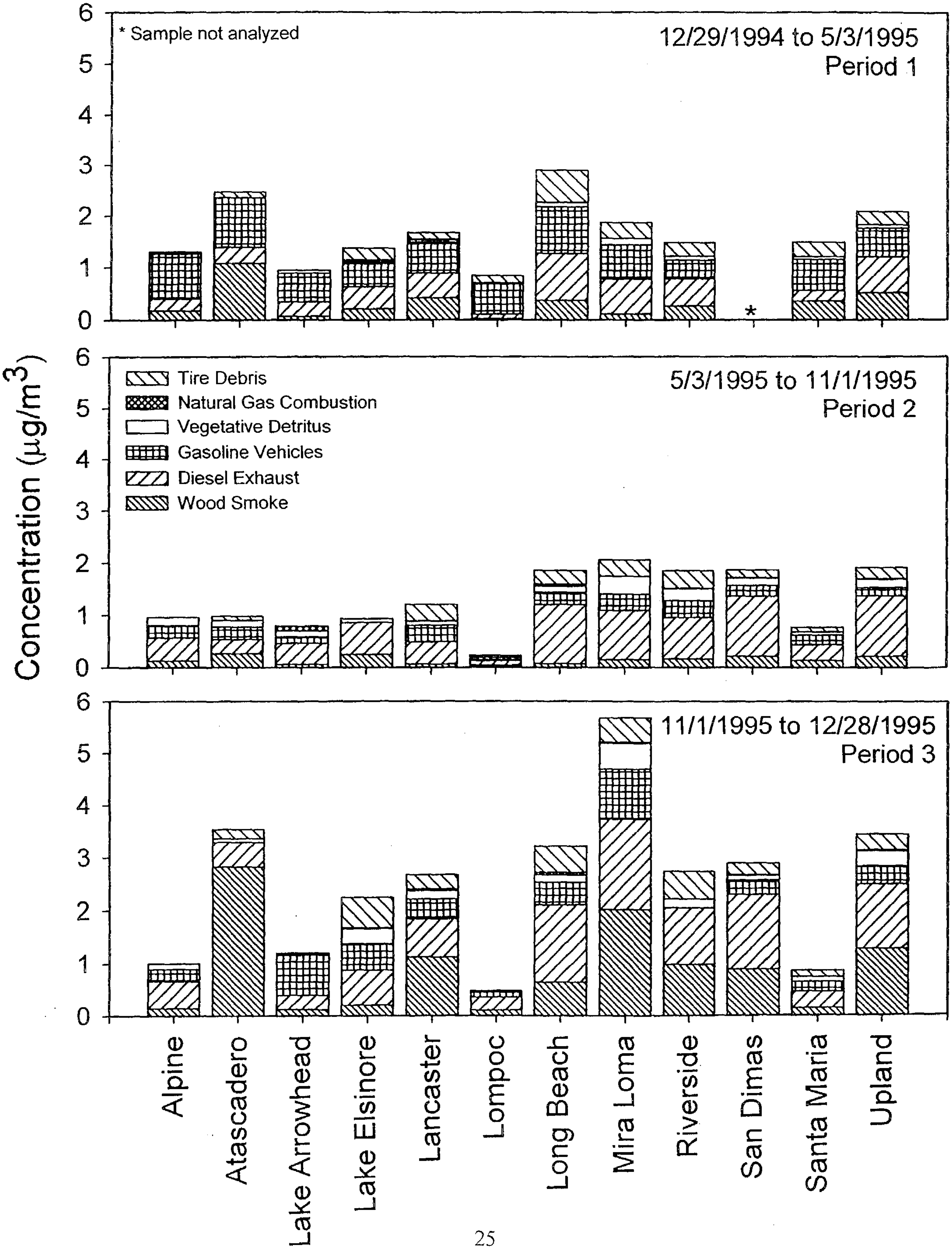


Table 2.1 Source Contributions to PM10 Organic Compound Concentrations

Source (ug/m3)	Alpine	Atascadero	Lake Arrowhead	Lake Elsinore	Lancaster	Lompoc
Period 1 (12/29/94 to 5/3/95) Average ± Std in $\mu g/m^3$						
Hardwood Smoke	0.175 ± 0.054		0.053 ± 0.019		0.414 ± 0.142	
Softwood Smoke			0.017 ± 0.006			
Wood Smoke		1.077 ± 0.252		0.212 ± 0.070		0.028 ± 0.059
Diesel Exhaust	0.231 ± 0.042	0.307 ± 0.047	0.276 ± 0.051	0.419 ± 0.057	0.474 ± 0.059	0.079 ± 0.038
Gasoline Vehicle	0.855 ± 0.091	0.975 ± 0.109	0.543 ± 0.060	0.469 ± 0.062	0.599 ± 0.067	0.571 ± 0.068
Vegetative Detritus	0.039 ± 0.006		0.058 ± 0.011	0.042 ± 0.014	0.043 ± 0.011	0.027 ± 0.008
Meat Cooking			1.425 ± 0.362			
Natural Gas Combustion					0.014 ± 0.004	
Tire Wear Debris		0.112 ± 0.027		0.227 ± 0.046	0.125 ± 0.032	0.134 ± 0.027
Paved Road Dust						
Sum of Sources	1.300 ± 0.114	2.471 ± 0.280	2.371 ± 0.371	1.370 ± 0.120	1.670 ± 0.171	0.811 ± 0.083
Measured OC	2.890 ± 0.103	4.378 ± 0.135	2.401 ± 0.108	3.986 ± 0.125	5.620 ± 0.166	2.037 ± 0.088
Period 2 (5/3/95 to 11/1/95) Average ± Std in $\mu g/m^3$						
Hardwood Smoke	0.112 ± 0.036					
Softwood Smoke	0.014 ± 0.006					
Wood Smoke		0.263 ± 0.064	0.054 ± 0.015	0.245 ± 0.060	0.060 ± 0.017	0.039 ± 0.011
Diesel Exhaust	0.445 ± 0.049	0.274 ± 0.031	0.409 ± 0.060	0.611 ± 0.057	0.429 ± 0.056	0.086 ± 0.027
Gasoline Vehicle	0.230 ± 0.032	0.231 ± 0.032	0.123 ± 0.030		0.311 ± 0.046	0.066 ± 0.017
Vegetative Detritus	0.156 ± 0.021	0.132 ± 0.022	0.117 ± 0.020	0.067 ± 0.010	0.080 ± 0.021	0.036 ± 0.005
Meat Cooking						0.260 ± 0.069
Natural Gas Combustion			0.086 ± 0.017	0.006 ± 0.002	0.005 ± 0.002	
Tire Wear Debris		0.077 ± 0.020			0.316 ± 0.065	
Paved Road Dust						
Sum of Sources	0.956 ± 0.072	0.977 ± 0.084	0.788 ± 0.074	0.929 ± 0.083	1.201 ± 0.101	0.487 ± 0.077
Measured OC	5.410 ± 0.138	4.704 ± 0.042	3.943 ± 0.173	6.704 ± 0.151	6.968 ± 0.156	1.683 ± 0.064

Source (ug/m3)	Alpine	Atascadero	Lake Arrowhead	Lake Elsinore	Lancaster	Lompoc
Period 3 (11/1/95 to 12/28/95) Average ± Std in μg/m^3						
Hardwood Smoke	0.147 ± 0.046	2.820 ± 0.688	0.034 ± 0.010		1.122 ± 0.319	
Softwood Smoke			0.089 ± 0.022			
Wood Smoke				0.208 ± 0.054		0.106 ± 0.077
Diesel Exhaust	0.523 ± 0.070	0.466 ± 0.078	0.272 ± 0.059	0.670 ± 0.099	0.715 ± 0.095	0.254 ± 0.050
Gasoline Vehicle	0.229 ± 0.076		0.766 ± 0.214	0.499 ± 0.080	0.372 ± 0.065	0.087 ± 0.038
Vegetative Detritus	0.106 ± 0.015	0.075 ± 0.018	0.027 ± 0.006	0.284 ± 0.061	0.157 ± 0.029	0.037 ± 0.006
Meat Cooking		3.794 ± 0.894	0.492 ± 0.135			
Natural Gas Combustion			0.016 ± 0.005	0.010 ± 0.003	0.032 ± 0.008	
Tire Wear Debris		0.174 ± 0.044		0.570 ± 0.123	0.267 ± 0.065	
Paved Road Dust						
Sum of Sources	1.005 ± 0.114	7.329 ± 1.132	1.697 ± 0.261	2.241 ± 0.195	2.665 ± 0.347	0.484 ± 0.100
Measured OC	4.900 ± 0.205	8.146 ± 0.301	2.709 ± 0.141	8.355 ± 0.314	10.949 ± 0.398	3.371 ± 0.155

Table 2.1 Source Contributions to PM10 Compound Concentrations (Con't)

Source (ug/m3)	Long Beach	Mira Loma	Riverside	San Dimas*	Santa Maria	Upland
			Period 1 (12/29/94 to 5/3/95) Average ± Std in μg/m^3			
Hardwood Smoke			0.241 ± 0.074			0.431 ± 0.131
Softwood Smoke			0.024 ± 0.010			0.084 ± 0.023
Wood Smoke	0.368 ± 0.101	0.112 ± 0.030			0.360 ± 0.116	
Diesel Exhaust	0.896 ± 0.106	0.666 ± 0.079	0.517 ± 0.065		0.201 ± 0.050	0.692 ± 0.082
Gasoline Vehicle	0.909 ± 0.125	0.656 ± 0.083	0.353 ± 0.054		0.597 ± 0.081	0.558 ± 0.073
Vegetative Detritus	0.087 ± 0.029	0.126 ± 0.028	0.080 ± 0.020		0.050 ± 0.016	0.071 ± 0.022
Meat Cooking					1.786 ± 0.340	
Natural Gas Combustion	0.008 ± 0.004					
Tire Wear Debris	0.629 ± 0.116	0.311 ± 0.068	0.263 ± 0.058		0.284 ± 0.058	0.257 ± 0.078
Paved Road Dust	6.140 ± 1.350					7.500 ± 1.140
Sum of Sources	9.037 ± 1.369	1.870 ± 0.140	1.477 ± 0.128		3.277 ± 0.377	9.593 ± 1.156
Measured OC	7.491 ± 0.207	8.898 ± 0.238	5.190 ± 0.151		3.820 ± 0.123	7.441 ± 0.207
			Period 2 (5/3/95 to 11/1/95) Average ± Std in μg/m^3			
Hardwood Smoke		0.151 ± 0.033				
Softwood Smoke						
Wood Smoke	0.067 ± 0.018		0.164 ± 0.042	0.214 ± 0.054	0.131 ± 0.040	0.215 ± 0.052
Diesel Exhaust	1.128 ± 0.107	0.934 ± 0.097	0.786 ± 0.086	1.141 ± 0.104	0.303 ± 0.039	1.148 ± 0.108
Gasoline Vehicle	0.232 ± 0.052	0.306 ± 0.060	0.317 ± 0.056	0.207 ± 0.050	0.181 ± 0.031	0.155 ± 0.048
Vegetative Detritus	0.115 ± 0.024	0.343 ± 0.059	0.230 ± 0.044	0.141 ± 0.025	0.058 ± 0.012	0.162 ± 0.030
Meat Cooking						
Natural Gas Combustion	0.038 ± 0.007		0.007 ± 0.002	0.007 ± 0.002	0.004 ± 0.001	0.008 ± 0.002
Tire Wear Debris	0.265 ± 0.064	0.319 ± 0.083	0.336 ± 0.087	0.147 ± 0.036	0.086 ± 0.020	0.220 ± 0.054
Paved Road Dust	2.980 ± 0.707			5.120 ± 0.977		5.340 ± 1.090
Sum of Sources	4.825 ± 0.720	2.053 ± 0.156	1.839 ± 0.148	6.976 ± 0.986	0.763 ± 0.068	7.246 ± 1.099
Measured OC	5.727 ± 0.131	18.235 ± 0.419	9.689 ± 0.229	9.112 ± 0.195	3.342 ± 0.089	11.645 ± 0.260

Source (ug/m3)	Long Beach	Mira Loma	Riverside	San Dimas*	Santa Maria	Upland
			Period 3 (11/1/95 to 12/28/95) Average ± Std in µg/m^3			
Hardwood Smoke						
Softwood Smoke						
Wood Smoke	0.645 ± 0.130	2.010 ± 0.405	0.979 ± 0.192	0.888 ± 0.189	0.142 ± 0.095	1.288 ± 0.246
Diesel Exhaust	1.455 ± 0.159	1.715 ± 0.181	1.064 ± 0.128	1.408 ± 0.149	0.317 ± 0.057	1.214 ± 0.132
Gasoline Vehicle	0.417 ± 0.093	0.960 ± 0.149		0.273 ± 0.075	0.189 ± 0.034	0.338 ± 0.077
Vegetative Detritus	0.144 ± 0.036	0.495 ± 0.084	0.164 ± 0.040	0.089 ± 0.027	0.093 ± 0.018	0.283 ± 0.049
Meat Cooking			0.715 ± 0.175			
Natural Gas Combustion	0.051 ± 0.011	0.020 ± 0.012		0.015 ± 0.006	0.008 ± 0.003	0.024 ± 0.009
Tire Wear Debris	0.496 ± 0.116	0.472 ± 0.119	0.523 ± 0.121	0.218 ± 0.101	0.116 ± 0.030	0.299 ± 0.077
Paved Road Dust	4.390 ± 1.090			8.170 ± 1.580		5.940 ± 1.139
Sum of Sources	7.598 ± 1.120	5.673 ± 0.490	3.444 ± 0.316	11.061 ± 1.603	0.865 ± 0.121	9.386 ± 1.179
Measured OC	12.352 ± 0.439	21.510 ± 0.767	13.080 ± 0.472	12.691 ± 0.463	5.321 ± 0.214	14.228 ± 0.509

* San Dimas Period 1 was not analyzed

As shown in Figure 2.1 and Table 2.1, the relative contributions of gasoline-powered motor vehicles as compared to diesel-powered vehicles to the PM10 organic carbon concentrations have a strong seasonal dependence. In the early winter season (Period 1) contributions from gasoline-powered motor vehicles to organic carbon PM10 concentrations are greater than or equal to the contributions from diesel vehicles. In contrast, diesel vehicle contributions to PM10 organic carbon are significantly greater than the contributions from gasoline-powered motor vehicles in the summer and fall period. The likely cause of this seasonal variation is the effect of cold start conditions on gasoline-powered motor vehicles. Dynamometer tests reported by Cadle et al. [*Cadle et al.*, 1999] showed significantly higher particulate matter emissions from properly operating gasoline-powered motor vehicles in winter as compared to summer in the Denver area. Wood smoke concentrations are highest in the winter, as expected.

Using knowledge of the ratio of organic carbon to particle mass for each of the sources used in the model, the source contributions to PM10 mass can be estimated. These contributions are presented in Figure 2.2 and Table 2.2. It is important to note, however, that the PM10 mass concentration was not directly measured by the Children's Health Study network, such that a mass balance closure check cannot be performed.

Figure 2.2: Contribution to Atmospheric PM10 Mass
Southern California Children's Health Study, 1995

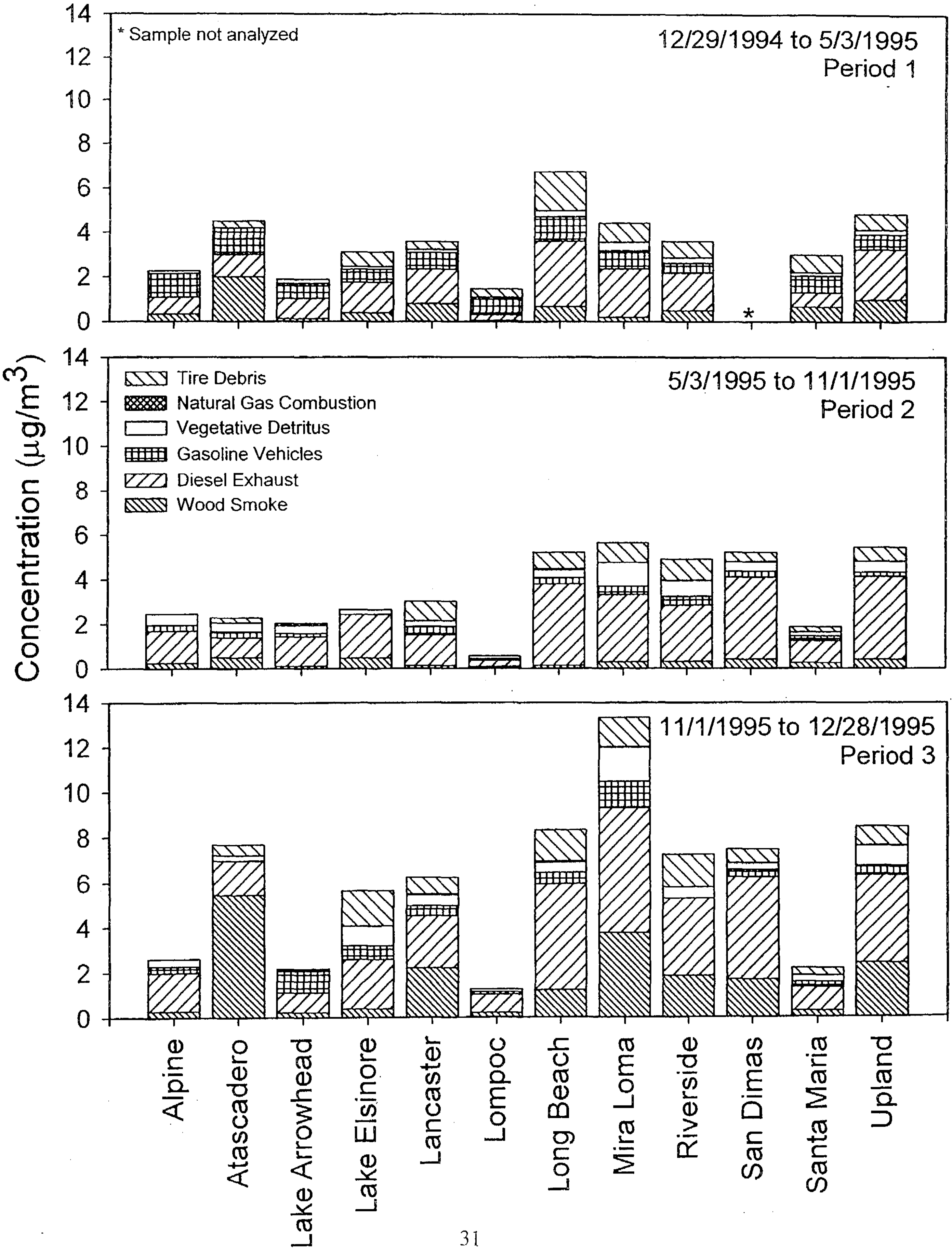


Table 2.2 Source Contributions to PM10 Mass Concentrations
Southern California Children's Health Study, 1995

Source (ug/m3)	Alpine	Atascadero	Lake Arrowhead	Lake Elsinore	Lancaster	Lompoc
			Period 1 (12/29/94 to 5/3/95) Average ± Std in $\mu g/m^3$			
Hardwood Smoke	0.339± 0.105		0.103± 0.036		0.803± 0.276	
Softwood Smoke			0.030± 0.010			
Wood Smoke		1.994± 0.467		0.393± 0.130		
Diesel Exhaust	0.750± 0.136	0.997± 0.151	0.894± 0.164	1.362± 0.185	1.538± 0.191	0.256± 0.123
Gasoline Vehicle	1.048± 0.112	1.195± 0.134	0.665± 0.074	0.575± 0.076	0.734± 0.082	0.700± 0.083
Vegetative Detritus	0.120± 0.019		0.180± 0.035	0.130± 0.043	0.133± 0.035	0.083± 0.025
Meat Cooking			2.518± 0.640			
Natural Gas Combustion					0.016± 0.005	
Tire Wear Debris		0.311± 0.076		0.631± 0.129	0.349± 0.088	0.372± 0.075
Paved Road Dust						
Sum of Primary Sources	2.257± 0.206	4.497± 0.514	4.390± 0.666	3.091± 0.274	3.573± 0.358	1.412± 0.169
			Period 2 (5/3/95 to 11/1/95) Average ± Std in $\mu g/m^3$			
Hardwood Smoke	0.217± 0.069					
Softwood Smoke	0.026± 0.010					
Wood Smoke		0.487± 0.119	0.099± 0.027	0.454± 0.111	0.111± 0.031	0.072± 0.020
Diesel Exhaust	1.444± 0.160	0.889± 0.101	1.327± 0.195	1.982± 0.185	1.391± 0.182	0.279± 0.088
Gasoline Vehicle	0.281± 0.039	0.283± 0.039	0.151± 0.037		0.381± 0.056	0.081± 0.021
Vegetative Detritus	0.481± 0.065	0.408± 0.068	0.360± 0.063	0.207± 0.030	0.247± 0.065	0.111± 0.015
Meat Cooking						0.459± 0.122
Natural Gas Combustion			0.101± 0.020	0.007± 0.003	0.006± 0.002	
Tire Wear Debris		0.215± 0.056			0.878± 0.180	
Paved Road Dust						
Sum of Primary Sources	2.449± 0.191	2.281± 0.183	2.038± 0.211	2.651± 0.218	3.014± 0.271	1.003± 0.154

Source (ug/m3)	Alpine	Atascadero	Lake Arrowhead	Lake Elsinore	Lancaster	Lompoc
Period 3 (11/1/95 to 12/28/95) Average ± Std in μg/m^3						
Hardwood Smoke	0.284± 0.089	5.465± 1.333	0.066± 0.019		2.174± 0.619	
Softwood Smoke			0.159± 0.039			
Wood Smoke				0.386± 0.100		0.196± 0.143
Diesel Exhaust	1.698± 0.227	1.513± 0.253	0.883± 0.191	2.174± 0.323	2.322± 0.307	0.826± 0.163
Gasoline Vehicle	0.280± 0.093		0.939± 0.263	0.612± 0.098	0.456± 0.079	0.106± 0.047
Vegetative Detritus	0.328± 0.047	0.231± 0.056	0.083± 0.018	0.877± 0.188	0.484± 0.091	0.113± 0.018
Meat Cooking		6.703± 1.580	0.870± 0.238			
Natural Gas Combustion			0.019± 0.005	0.012± 0.004	0.038± 0.010	
Tire Wear Debris		0.483± 0.122		1.583± 0.341	0.742± 0.180	
Paved Road Dust						
Sum of Primary Sources	2.591± 0.265	14.396± 2.087	3.019± 0.406	5.643± 0.525	6.216± 0.724	1.242± 0.223

Table 2.2 Source Contributions to PM10 Mass Concentrations (Con't)
Southern California Children's Health Study, 1995

Source (ug/m3)	Long Beach	Mira Loma	Riverside	San Dimas*	Santa Maria	Upland
			Period 1 (12/29/94 to 5/3/95) Average ± Std in μg/m^3			
Hardwood Smoke			0.467± 0.144			0.835± 0.254
Softwood Smoke			0.042± 0.018			0.151± 0.041
Wood Smoke	0.681± 0.187	0.207± 0.056			0.667± 0.216	
Diesel Exhaust	2.910± 0.344	2.161± 0.257	1.678± 0.211		0.651± 0.162	2.248± 0.266
Gasoline Vehicle	1.114± 0.154	0.804± 0.102	0.433± 0.066		0.731± 0.099	0.683± 0.089
Vegetative Detritus	0.267± 0.089	0.389± 0.087	0.246± 0.061		0.154± 0.050	0.218± 0.067
Meat Cooking					3.155± 0.601	
Natural Gas Combustion	0.009± 0.005					
Tire Wear Debris	1.747± 0.322	0.863± 0.190	0.731± 0.160		0.790± 0.161	0.713± 0.217
Paved Road Dust	41.208± 9.060					50.336± 7.651
Sum of Primary Sources	47.938± 9.076	4.424± 0.351	3.597± 0.315		6.148± 0.688	55.184± 7.664
			Period 2 (5/3/95 to 11/1/95) Average ± Std in μg/m^3			
Hardwood Smoke		0.293± 0.064				
Softwood Smoke						
Wood Smoke	0.124± 0.034		0.303± 0.078	0.396± 0.100	0.242± 0.074	0.398± 0.097
Diesel Exhaust	3.663± 0.347	3.031± 0.314	2.551± 0.280	3.706± 0.336	0.983± 0.125	3.726± 0.350
Gasoline Vehicle	0.285± 0.064	0.375± 0.074	0.388± 0.069	0.253± 0.061	0.222± 0.038	0.190± 0.059
Vegetative Detritus	0.354± 0.075	1.059± 0.183	0.711± 0.136	0.434± 0.076	0.180± 0.036	0.499± 0.091
Meat Cooking						
Natural Gas Combustion	0.045± 0.008		0.008± 0.002	0.008± 0.002	0.005± 0.001	0.009± 0.003
Tire Wear Debris	0.735± 0.177	0.886± 0.230	0.932± 0.242	0.408± 0.100	0.239± 0.055	0.611± 0.150
Paved Road Dust	20.000± 4.745			34.362± 6.557		35.839± 7.315
Sum of Primary Sources	25.206± 4.762	5.644± 0.441	4.893± 0.408	39.568± 6.568	1.871± 0.164	41.271± 7.327

Source (ug/m3)	Long Beach	Mira Loma	Riverside	San Dimas*	Santa Maria	Upland
			Period 3 (11/1/95 to 12/28/95) Average ± Std in $\mu g/m^3$			
Hardwood Smoke						
Softwood Smoke						
Wood Smoke	1.194± 0.241	3.722± 0.750	1.812± 0.356	1.644± 0.349	0.262± 0.176	2.385± 0.456
Diesel Exhaust	4.724± 0.516	5.567± 0.586	3.454± 0.416	4.572± 0.485	1.031± 0.184	3.941± 0.429
Gasoline Vehicle	0.511± 0.114	1.177± 0.183		0.334± 0.092	0.231± 0.042	0.415± 0.095
Vegetative Detritus	0.444± 0.110	1.529± 0.260	0.505± 0.122	0.276± 0.083	0.286± 0.057	0.872± 0.151
Meat Cooking			1.263± 0.309			
Natural Gas Combustion	0.060± 0.012	0.024± 0.014		0.017± 0.007	0.010± 0.004	0.028± 0.011
Tire Wear Debris	1.377± 0.323	1.312± 0.330	1.452± 0.336	0.607± 0.281	0.322± 0.085	0.831± 0.215
Paved Road Dust	29.463± 7.315			54.832± 10.604		39.866± 7.644
Sum of Primary Sources	37.774± 7.346	13.331± 1.057	8.487± 0.723	62.282± 10.625	2.143± 0.277	48.338± 7.675

* San Dimas Period 1 was not analyzed

References

Cadle, S.H., P.A. Mulawa, E.C. Hunsanger, K. Nelson, R.A. Ragazzi, R. Barrett, G.L. Gallagher, D.R. Lawson, K.T. Knapp, and R. Snow, Composition of light-duty motor vehicle exhaust particulate matter in the Denver, Colorado area, *Environmental Science & Technology*, *33* (14), 2328-2339, 1999.

Fairley, D., Daily mortality and air pollution in Santa Clara County, California: 1989-1996, *Environmental Health Perspectives*, *107* (8), 637-641, 1999.

Fraser, M.P., G.R. Cass, B.R.T. Simoneit, and R.A. Rasmussen, Air quality model evaluation data for organics .4. C-2-C-36 non-aromatic hydrocarbons, *Environmental Science & Technology*, *31* (8), 2356-2367, 1997.

Fraser, M.P., G.R. Cass, B.R.T. Simoneit, and R.A. Rasmussen, Air quality model evaluation data for organics. 5. C-6-C-22 nonpolar and semipolar aromatic compounds, *Environmental Science & Technology*, *32* (12), 1760-1770, 1998.

Gauderman, W.J., R. McConnell, F. Gilliland, S. London, D. Thomas, E. Avol, H. Vora, K. Berhane, E.B. Rappaport, F. Lurmann, H.G. Margolis, and J. Peters, Association between air pollution and lung function growth in southern California children, *American Journal of Respiratory and Critical Care Medicine*, *162* (4), 1383-1390, 2000.

Hannigan, M.P., G.R. Cass, A. Lafleur, W. Busby Jr., and W. Thilly, Source Contributions to the Human Cell Mutagenicity of Urban Particulate Air Pollution, *Environmental Science & Technology*, *Accepted with Revisions*, 2001.

Hildemann, L.M., G.R. Cass, and G.R. Markowski, A Dilution Stack Sampler for Collection of Organic Aerosol Emissions - Design, Characterization and Field-Tests, *Aerosol Science and Technology*, *10* (1), 193-204, 1989.

Levy, J.I., J.K. Hammitt, and J.D. Spengler, Estimating the mortality impacts of particulate matter: What can be learned from between-study variability?, *Environmental Health Perspectives*, *108* (2), 109-117, 2000.

Linn, W.S., Y. Szlachcic, H. Gong, P.L. Kinney, and K.T. Berhane, Air pollution and daily hospital admissions in metropolitan Los Angeles, *Environmental Health Perspectives*, *108* (5), 427-434, 2000.

Lurmann, F.W., P.T. Robertz, H.H. Main, S.V. Hering, E.L. Avol, and S.D. Colome, Phase II Report - Appendix A: Exposure Assessment Methodology, Sonoma Technology, Petaluma, CA, 1994.

Peters, J.M., E. Avol, W. Navidi, S.J. London, W.J. Gauderman, F. Lurmann, W.S. Linn, H. Margolis, E. Rappaport, H. Gong, and D.C. Thomas, A study of twelve southern California communities with differing levels and types of air pollution - I. Prevalence of respiratory morbidity, *American Journal of Respiratory and Critical Care Medicine*, *159* (3), 760-767, 1999.

Ritz, B., F. Yu, G. Chapa, and S. Fruin, Effect of air pollution on preterm birth among children born in Southern California between 1989 and 1993, *Epidemiology*, *11* (5), 502-511, 2000.

Rogge, W.F., L.M. Hildemann, M.A. Mazurek, G.R. Cass, and B.R.T. Simoneit, Sources of Fine Organic Aerosol .2. Noncatalyst and Catalyst- Equipped Automobiles and Heavy-Duty Diesel Trucks, *Environmental Science & Technology*, *27* (4), 636-651, 1993a.

Rogge, W.F., L.M. Hildemann, M.A. Mazurek, G.R. Cass, and B.R.T. Simoneit, Sources of Fine Organic Aerosol .5. Natural-Gas Home Appliances, *Environmental Science & Technology*, *27* (13), 2736-2744, 1993b.

Rogge, W.F., L.M. Hildemann, M.A. Mazurek, G.R. Cass, and B.R.T. Simoneit, Mathematical modeling of atmospheric fine particle-associated primary organic compound concentrations, *Journal of Geophysical Research-Atmospheres*, *101* (D14), 19379-19394, 1996.

Rogge, W.F., M.A. Mazurek, L.M. Hildemann, G.R. Cass, and B.R.T. Simoneit, Quantification of Urban Organic Aerosols at a Molecular-Level - Identification, Abundance and Seasonal-Variation, *Atmospheric Environment Part a-General Topics*, *27* (8), 1309-1330, 1993c.

Schauer, J.J., Source Contributions to Atmospheric Organic Compound Concentrations: Emissions Measurement and Model Predictions, Califronia Institute of Technology, Pasadena, 1998a.

Schauer, J.J., Technical Report 1: Chemical Analysis for Molecular Marker Source Apportionment of Atmospheric Fine Particulate Matter, US EPA, 1998b.

Schauer, J.J., Technical Report 2: Source Sampling for Molecular Marker Source Apportionment of Atmospheric Fine Particulate Matter, UE EPA, 1998c.

Schauer, J.J., and G.R. Cass, Source apportionment of wintertime gas-phase and particle-phase air pollutants using organic compounds as tracers, *Environmental Science & Technology*, *34* (9), 1821-1832, 2000.

Schauer, J.J., M.J. Kleeman, G.R. Cass, and B.R.T. Simoneit, Characterization and Control of Airborne Particles Emited from Air Pollution Sources, Califronia Air Resources Board, 1998.

Schauer, J.J., M.J. Kleeman, G.R. Cass, and B.R.T. Simoneit, Measurement of emissions from air pollution sources. 1. C_1 through C_{29} organic compounds from meat charbroiling, *Environmental Science & Technology*, *33* (10), 1566-1577, 1999a.

Schauer, J.J., M.J. Kleeman, G.R. Cass, and B.R.T. Simoneit, Measurement of emissions from air pollution sources. 2. C_1 through C_{30} organic compounds from medium duty diesel trucks, *Environmental Science & Technology*, *33* (10), 1578-1587, 1999b.

Schauer, J.J., M.J. Kleeman, G.R. Cass, and B.R.T. Simoneit, Measurement of Emissions from Air Pollution Source. 3. C_1 through C_{29} Organic Compounds from Fireplace Combustion of Wood, *Environmental Science & Technology*, *In Press*, 2001.

Schauer, J.J., W.F. Rogge, L.M. Hildemann, M.A. Mazurek, and G.R. Cass, Source apportionment of airborne particulate matter using organic compounds as tracers, *Atmospheric Environment*, *30* (22), 3837-3855, 1996.

Sheesley, R.J., J.J. Schauer, N.D. Smith, and M.D. Hays, Development of a Standardized Method for the Analysis of Organic Compounds Present In PM2.5, in *Proceedings of the AWMA Annual Meeting 2000*, Salt Lake City, Utah, 2000.

Simoneit, B.R.T., Application of Molecular Marker Analysis to Vehicular Exhaust for Source Reconciliations, *International Journal of Environmental Analytical Chemistry*, *22* (3-4), 203-233, 1985.

Simoneit, B.R.T., A review of biomarker compounds as source indicators and tracers for air pollution, *Environmental Science and Pollution Research*, *6* (3), 159-169, 1999.

Simoneit, B.R.T., T.A.T. Aboul-Kassim, and J.J. Tiercelin, Hydrothermal petroleum from lacustrine sedimentary organic matter in the East African Rift, *Applied Geochemistry*, *15* (3), 355-368, 2000.

Simoneit, B.R.T., J.J. Schauer, C.G. Nolte, D.R. Oros, V.O. Elias, M.P. Fraser, W.F. Rogge, and G.R. Cass, Levoglucosan, a tracer for cellulose in biomass burning and atmospheric particles, *Atmospheric Environment*, *33* (2), 173-182, 1999.

Smith, R.L., J.M. Davis, J. Sacks, P. Speckman, and P. Styer, Regression models for air pollution and daily mortality: analysis of data from Birmingham, Alabama, *Environmetrics*, *11* (6), 719-743, 2000.

Taylor, C.A., C.A. Stover, and F.D. Westerdahl, Speciated Fine Particle (<2.5 μm aerodynamic diameter) and Vapor-Phase Acid Concentration in Southern California, in *Air and Waster Management Annual Meeting*, 1998.

Zanobetti, A., J. Schwartz, and D.W. Dockery, Airborne particles are a risk factor for hospital admissions for heart and lung disease, *Environmental Health Perspectives*, *108* (11), 1071-1077, 2000.