

Appendix C

ARB Air Pollutant Summaries

November 2, 2000

C.1 Introduction

Appendix C contains brief summaries of air quality, trends, emissions and sources for each criteria pollutant. There are several ways in which air quality information is commonly presented. Concentrations measured over 1-hour, 8-hours or 24-hours, annual averages, and the number of days above the State and national standards are actual measured values. These data for 1999 are presented in Table 3.3-1 on page 10.

Air quality trends are frequently reported as "Expected Peak Daily Concentrations" (EPDCs), or "peak indicators". A peak indicator is a calculated value based on measured data that represents the maximum concentration of a pollutant that is expected to occur once per year. It is based on a robust statistical calculation that provides a trend indicator that is less influenced by year-to-year changes in meteorology than actual measured data often is.

Except for sulfates, for which there are insufficient data available to calculate peak indicators, the air quality trends data presented below represent peak indicator values. All values on the x-axis are years. Further information on air quality, trends, and emissions for specific locations throughout the State, including information on site openings, site closures, and data completeness is available from the ARB's websites www.arb.ca.gov/aqd/almanac/almanac99.htm and www.arb.ca.gov, or from the ARB's Planning and Technical Support Division.

Indoor and outdoor air pollutant exposures in California are also summarized in this Appendix for the studies that provided parallel monitoring. However, note that the averaging times for the pollutants in many cases were not the averaging times for the ambient air quality standards. The information provides some relative comparisons for indoor and outdoor concentrations for the pollutants measured.

C.2 Background Pollutant Concentrations

There is a background concentration of many air pollutants. Background concentration is defined as the concentration that would be observed in the absence of anthropogenic emissions, ie., those resulting from human activities, such as from industrial facilities, and motor vehicles. Emissions of VOC, NO_x, and SO_x from natural processes are the precursors of background O₃. The background concentration of ozone is currently about 1/2 of the state standard, or about 0.04 PPM. Sources of background PM include particles of soil and crustal material, organic particles resulting from natural combustion processes such as wildfires, and organic aerosols formed from VOC emissions from vegetation. The background concentration of PM₁₀ is approximately 1/3 of the state standard, or about 10 µg/m³ annual geometric mean (Stefan and Husar, 1997). In addition, natural emissions of gaseous sulfur compounds contribute to the background sulfate concentration.

The Intergovernmental Panel on Climate Change (IPCC) Special Report on Emission Scenarios (<http://www.unep.ch/ipcc/pub/sres-e.pdf>) has presented several scenarios on growth in NO_x, VOC, CO, and methane (CH₄) emissions that suggest a significant increase in background levels of near- surface ozone throughout much of the northern mid-latitudes. As background pollution levels increase, they make up a larger

fraction of the total pollution allowed before the ambient air quality standards are exceeded. Increases in background concentrations result in the need to gain greater reductions from controllable sources. For example, if an area's background ozone concentration increased from 0.04 to 0.05 PPM, the emission reductions needed to attain the state standard could easily increase by 10 percent or more.

C.3 Airborne Particulate Matter (PM10)

C.3.1 Introduction

Airborne particulate matter with an aerodynamic diameter of 10 microns or less (PM10) is composed of a mixture of substances that includes elements (such as carbon, lead, nickel and iron), compounds (such as nitrates, sulfates, and polycyclic aromatic hydrocarbons), and complex mixtures (such as diesel exhaust and soil). Also present on particles are allergens and compounds derived from bacteria called endotoxins. Particles can be emitted directly into the atmosphere, such as from diesel vehicles, or can be formed gases that are transformed into particles through physical and chemical processes in the atmosphere (for example, nitrates from gaseous nitric acid).

C.3.2 Air Quality, Sources, and Emissions

Currently, over 99 percent of Californians breathe air that violates the State PM10 standards during at least part of the year. Consequently, particulate matter is receiving greater attention.

Maximum peak indicator concentrations of PM10 are illustrated in Figures C.3-1, C.3-2, and C.3-3. Maximum peak indicator information illustrated in Figure C.3-1 incorporates all sites in California, and shows large peaks in 1990, 1994, and 1998. The influence of specific monitoring sites on these peaks and trends can be evaluated by re-analyzing data with and without specific sites. This analysis is illustrated in Figures C.3-2 and C.3-3. When the data from the Great Basin Valley sites are excluded from the analysis (Figure C.3-2), increases are observed in 1990, and an increasing trend is observed through 1999. The increase in 1994 therefore appears to have been influenced by the Great Basin Valley sites. When in addition to the Great Basin Valley sites, the Mojave Desert and Salton Sea sites are excluded from the analyses (Figure C.3-3), there are few increases observed, indicating that these sites also were responsible for the peak occurrences for certain years. The PM sources for the Great Basin, Mojave Desert, and Salton Sea sites are thought to be wind-blown dust.

An analysis of the maximum annual geometric mean PM10 concentrations without the Great Basin Valley sites is presented in Figure C.3-4. There is a peak observed in 1996. The maximum annual geometric mean PM10 analysis without the Great Basin Valley, Mojave Desert, and Salton Sea sites is illustrated in Figure C.3-5. The maximum PM concentrations decreased throughout the years and there are no peak years observed. The Mojave Desert and Salton Sea sites therefore contribute to the highest annual geometric mean PM10 concentrations observed in the State.

The emissions and sources of PM10 statewide are illustrated in Figure C.3-6. The most prominent source is "area-wide" that includes wind-blown dust, and dust from roadways. Activities that contribute to high PM10 can include wood burning, agricultural activities, and driving on unpaved roads. The PM10 concentrations do not relate well to

population growth or vehicle usage, and high PM10 concentrations do not always occur in high population areas.

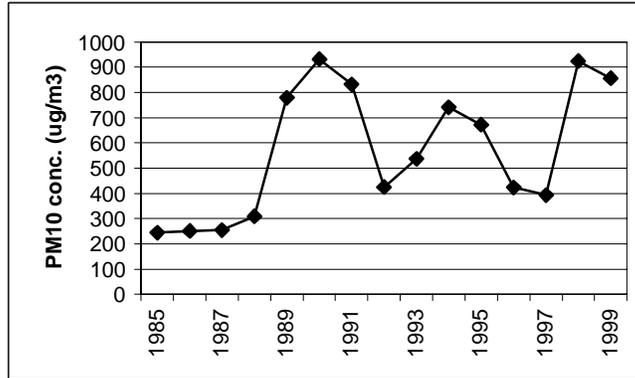


Figure C.3-1. Maximum 24-hour peak indicator for Statewide PM10 ($\mu\text{g}/\text{m}^3$).

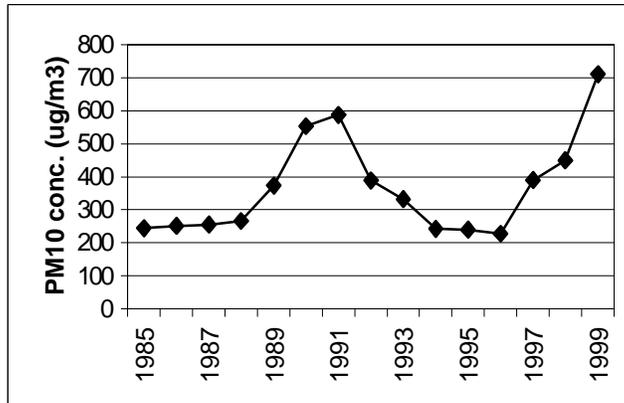


Figure C.3-2. Maximum 24-hour peak indicator for Statewide PM10 ($\mu\text{g}/\text{m}^3$), not including Great Valley Basin sites

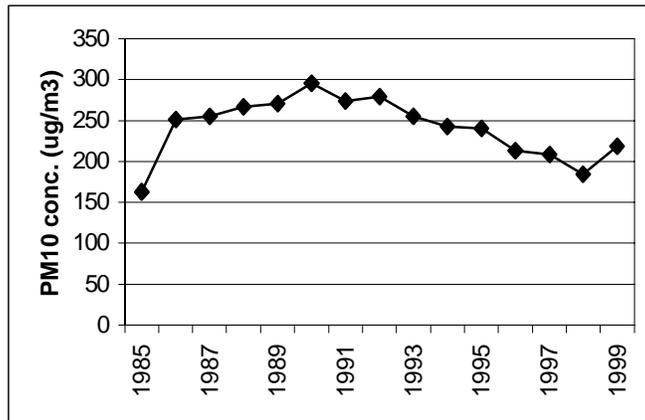


Figure C.3-3. Maximum 24-hour peak indicator for Statewide PM10 ($\mu\text{g}/\text{m}^3$), not including Great Basin Valley, Mojave Desert, and Salton Sea sites.

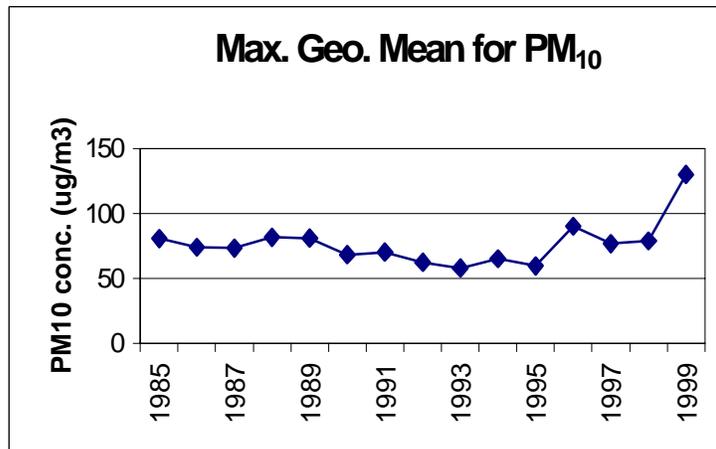


Figure C.3-4. Maximum annual geometric mean concentrations of PM10, not including the Great Basin Valley sites ($\mu\text{g}/\text{m}^3$).

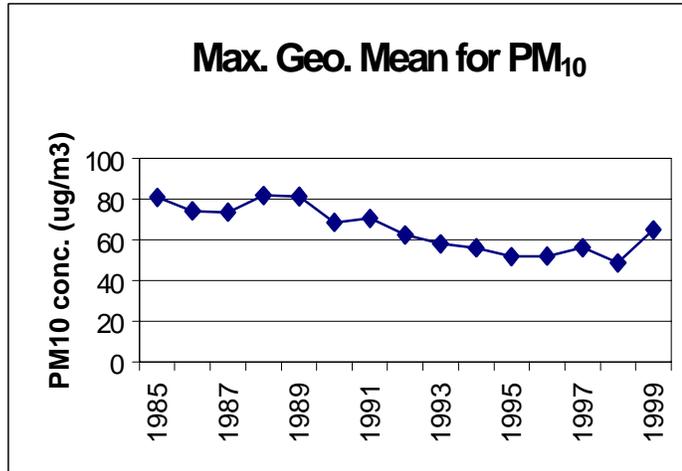


Figure C.3-5. Maximum annual geometric mean concentrations of PM₁₀, not including the Great Basin Valley, Mojave Desert, and Salton Sea sites ($\mu\text{g}/\text{m}^3$).

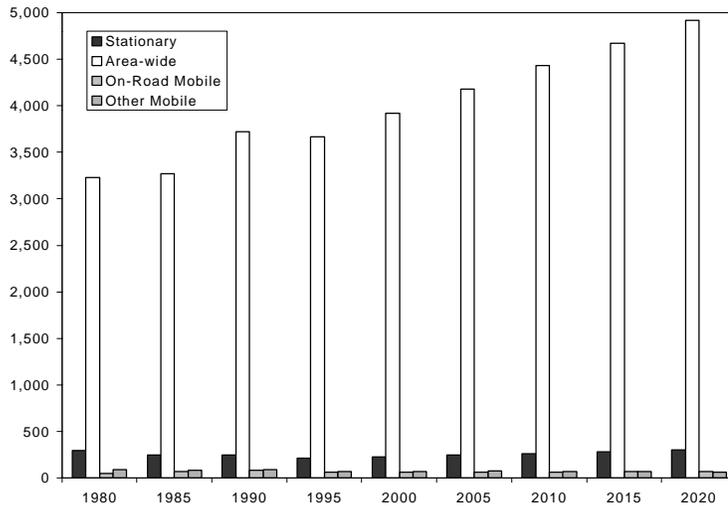


Figure C.3-6. Emissions (tons/day) and sources of PM₁₀, projected through 2020.

C.4 Sulfates

C.4.1 Introduction

Sulfates are present in the atmosphere typically in combination with other substances to form compounds such as ammonium sulfate and sulfuric acid. Sulfates are typically present on particulate matter that can be directly emitted (primary particles) or formed in the atmosphere (secondary particles). Examples of sources for primary sulfate particles include dry lakebeds, desert soils, and emissions from combustion of fossil fuels from stationary and mobile sources. Secondary sulfate particles are produced in the atmosphere from directly emitted oxides of sulfur (SO_x). These SO_x emissions are generally from fossil fuel combustion. Secondary sulfate particles are transported over long distances.

C.4.2 Air Quality

Sulfate concentrations have steadily decreased in California, with some notable exceptions. The maximum concentration of sulfates for the years 1980 through 1999 is illustrated in Figure C.8-1 (Note: 1999 data is only for the South Coast Air Quality Management District). There is an observed increase in maximum concentration during 1985 and 1986. Following this increase, the maximum concentration is observed to be approximately 20-30 $\mu\text{g}/\text{m}^3$ except for 1994. To evaluate the influence of a single site for the 1985-1986 increase, the highest maximum site (China Lake) was not included in the analysis. The results are presented in Figure C.4-2. When the China Lake site is not included in the analysis, a decreasing trend is observed.

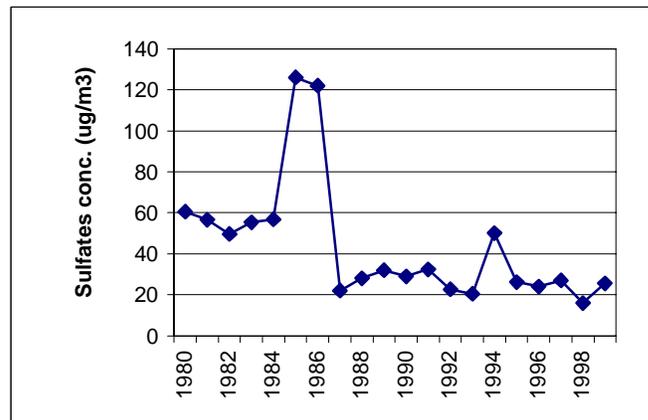


Figure C.4-1. Maximum concentration for sulfates ($\mu\text{g}/\text{m}^3$). All statewide sites.

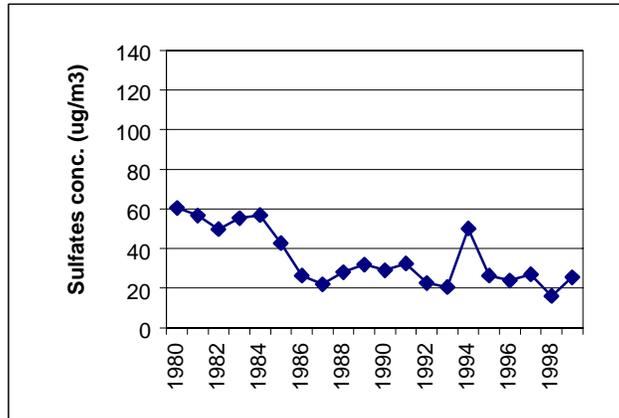


Figure C.4-2. Maximum concentration for sulfates not including the China Lake site ($\mu\text{g}/\text{m}^3$).

C.5 Ozone (O_3)

C.5.1 Introduction

Ozone is a colorless gas with a pungent odor. It is the chief component of urban smog. Ozone is not directly emitted as a pollutant, but is formed in the atmosphere when hydrocarbon and NO_x precursor emissions react in the presence of sunlight. Meteorology and terrain play major roles in ozone formation. Generally, low wind speeds or stagnant air coupled with warm temperatures and cloudless skies provide for the optimum ozone conditions. As a result, summer is generally the peak ozone season. Because of the reaction time involved, peak ozone concentrations often occur far downwind of the precursor emissions. Therefore, ozone is a regional pollutant that often impacts a widespread area.

C.5.2 Air Quality, Emissions, and Sources

Air quality with respect to ozone has improved greatly in all areas of California over the last 19 years, despite significant population growth. The statewide trend is illustrated in Figure C.5-1, and principally reflects values for the Southern California area. The maximum peak 1-hour indicator declined 53 percent from 1980 to 1999. During this same time period, however, the State's population has grown by 43 percent and the number of vehicle miles traveled each day has increased by more than 75 percent. Motor vehicles are the largest source of hydrocarbon precursor emissions as illustrated in Figure C.5-2, followed by stationary source emissions. Motor vehicles are also the largest source of NO_x precursor emissions as illustrated in Figure C.5-2. Reducing vehicular emissions with ARB's low emission vehicle standards will help to reduce ROG's considerably. However, increases in population and driving will partially offset the benefits of cleaner vehicles. In addition to motor vehicle controls, the ARB is establishing controls for other sources of ozone precursor emissions, such as consumer

products. The ARB and other agencies are also investigating new approaches such as implementing market incentives to improve air quality.

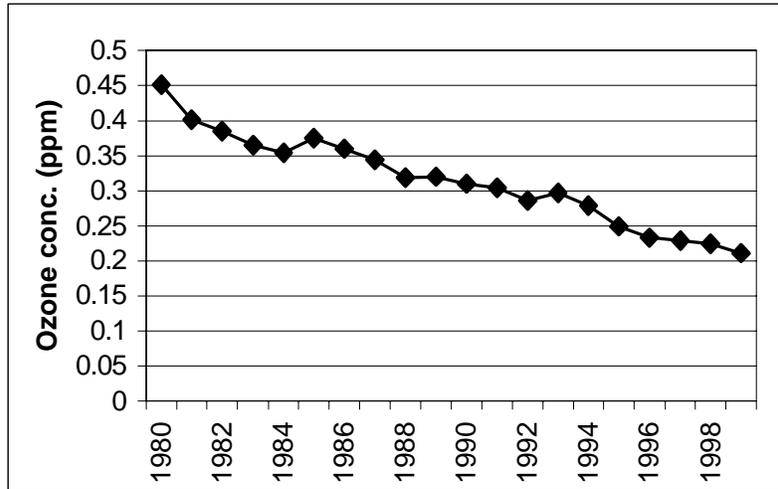


Figure C.5-1. Maximum 1-hour peak indicator for statewide ozone concentrations from 1980 through 1999 (ppm).

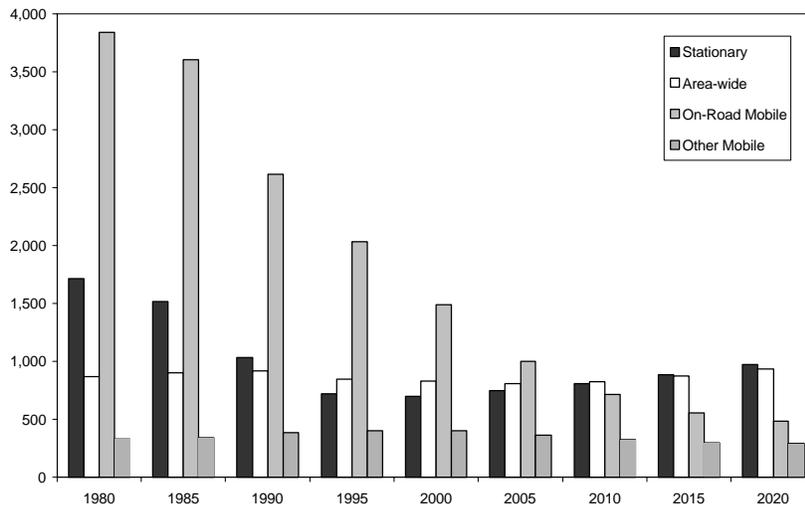


Figure C.5-2. Emissions (tons/day) and sources of reactive organic gases (ROG) that form ozone, projected through 2020.

C.6 Nitrogen Dioxide (NO₂)

C.6.1 Introduction

Nitrogen dioxide (NO₂) is a red-brown gas that is derived from both direct emissions (generally from the combustion of fossil fuels) and from the conversion of nitric oxide (NO) to nitrogen dioxide (NO₂). During combustion, nitrogen, present as a major component of air, combines with oxygen to produce oxides of nitrogen. Both NO and NO₂ are important compounds in a series of chemical reactions in the ambient air to produce secondary compounds including ozone, nitrate aerosols, nitric acid, and other nitrogen-containing compounds that are toxic.

C.6.2 Air Quality, Sources, and Emissions

The concentrations of nitrogen dioxide have decreased by 57% since 1980, as illustrated by the maximum 1-hour peak indicator concentrations in Figure C.6-1. The decrease is directly attributed to more stringent controls on both mobile and stationary sources.

The emissions of nitrogen dioxide are projected to decrease through 2020 with the emissions principally from mobile sources as illustrated in Figure C.6-2.

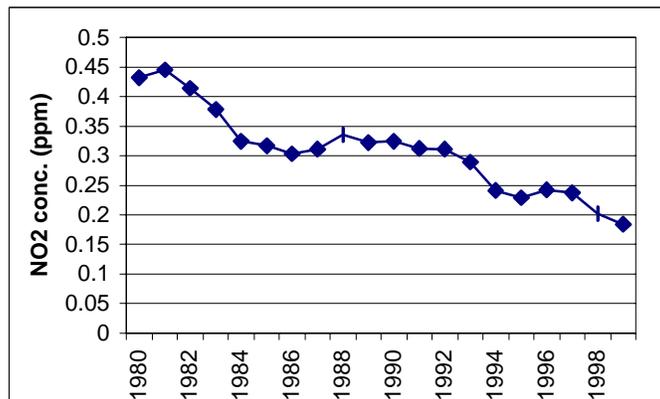


Figure C.6-1. Maximum 1-hour peak indicator concentrations for nitrogen dioxide (ppm).

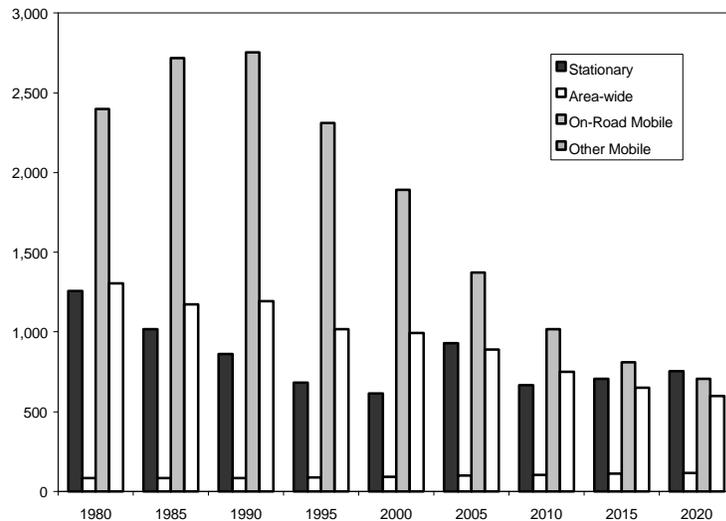


Figure C.6-2. Emissions (tons/day) and sources of nitrogen dioxide, projected through 2020..

C.7 Carbon Monoxide (CO)

C.7.1 Introduction

Carbon monoxide is a colorless and odorless gas that is directly emitted as a product of incomplete combustion. The highest concentrations are generally associated with cold stagnant weather conditions that occur during winter. In contrast to ozone, which tends to be a regional pollutant, CO problems tend to be localized.

C.7.2 Air Quality, Sources, and Emissions

The maximum 1-hour peak indicator for carbon monoxide concentrations statewide is illustrated in Figure C.7-1. As with ozone, carbon monoxide concentrations in all areas of California have decreased substantially over the last 19 years. Statewide, the maximum peak 8-hour indicator declined 35 percent from 1980 to 1999. Currently, the State carbon monoxide standard is violated in two areas: the South Coast Air Basin portion of Los Angeles County and the city of Calexico, in Imperial County.

The emissions for carbon monoxide are predominantly from mobile sources, followed by area-wide and other mobile sources as illustrated in Figure C7-2. By year 2015, these sources are projected to have similar emissions.

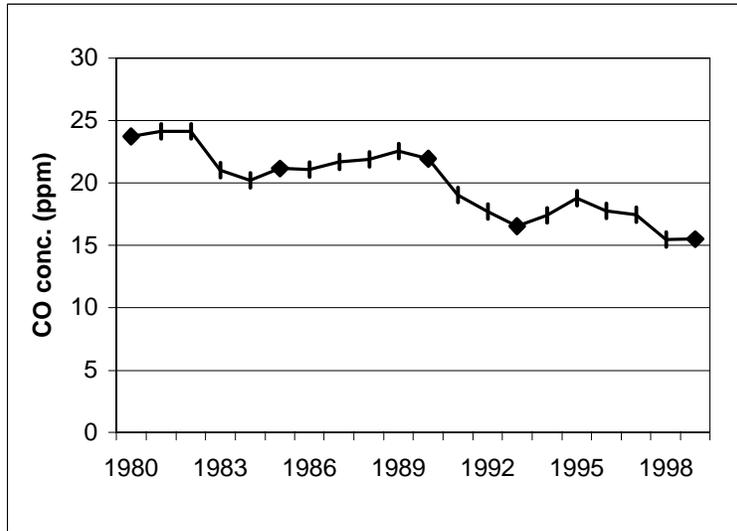


Figure C.7-1. Maximum 8-hour peak indicator carbon monoxide (ppm).

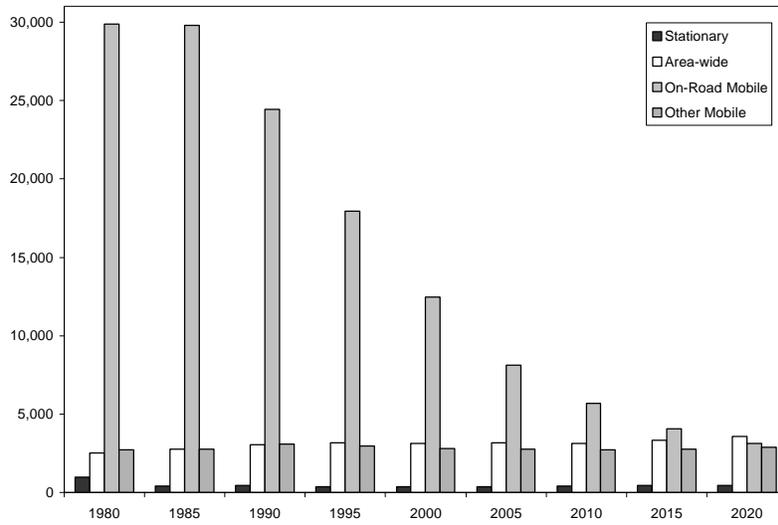


Figure C.7-2. Emissions (tons/day) and sources for carbon monoxide, projected through 2020..

C.8 Hydrogen Sulfide (H₂S)

C.8.1 Introduction

Hydrogen sulfide (H₂S) is a colorless, acidic gas with a strong unpleasant (rotten egg) odor. At the highest concentrations measured in California, hydrogen sulfide is considered a nuisance.

Statewide 1-hour peak indicator concentrations are illustrated in Figure C.8-1 from 1980 to 1999. There are increases observed in peak concentrations in 1982 (approximately 0.2 ppm), 1996 (approximately 0.35 ppm), and for 1991 through 1995 (approximately 0.3 ppm). Again, an analysis of the dependence of peak occurrence on certain sites was conducted. The city of Trona had the highest maximum concentrations. When the Trona site was not included in the analyses, the only increase remaining was for 1981-1982 (Figure C.8-2). The rest of the years from approximately 1985 through 1999 had concentrations of approximately 0.03 ppm.

Trona is the site of an industrial plant that uses salts from the Searles dry lake. The hydrogen sulfide may be attributable to the mining of the salts.

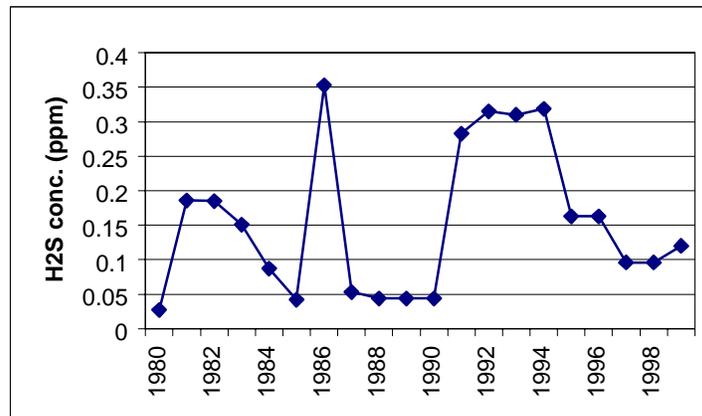


Figure C.8-1. Maximum 1-hour peak indicator for hydrogen sulfide (ppm), including Trona.

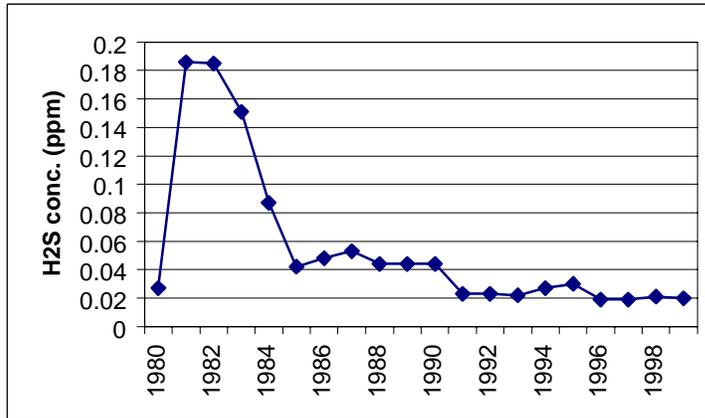


Figure C.8-2. Maximum 1-hour peak indicator for hydrogen sulfide (ppm), not including the Trona site.

C.9 Lead (Pb)

C.9.1 Introduction

Lead (Pb) is a bluish-gray metal that occurs naturally in the earth's crust. Lead typically is present in the environment in combination with organic or inorganic compounds. Organic lead consists of compounds containing carbon, while inorganic lead consists of compounds containing lead but no carbon. Airborne lead in California is generally inorganic lead.

C.9.2 Air Quality

The maximum 30-day average concentrations of airborne lead are presented in Figure C.9-1. There has been a rapid decrease in airborne lead concentrations due to removal of lead from gasoline. This phase-out began during the 1970s, and subsequent ARB regulations have virtually eliminated all lead from the gasoline now sold in California. All areas of the State are currently designated as attainment for the State lead standard. Although the ambient lead standards are no longer violated, lead emissions from stationary sources still pose "hot spot" emissions in some areas. Because of this, the ARB identified lead as a toxic air contaminant (TAC) in 1997.

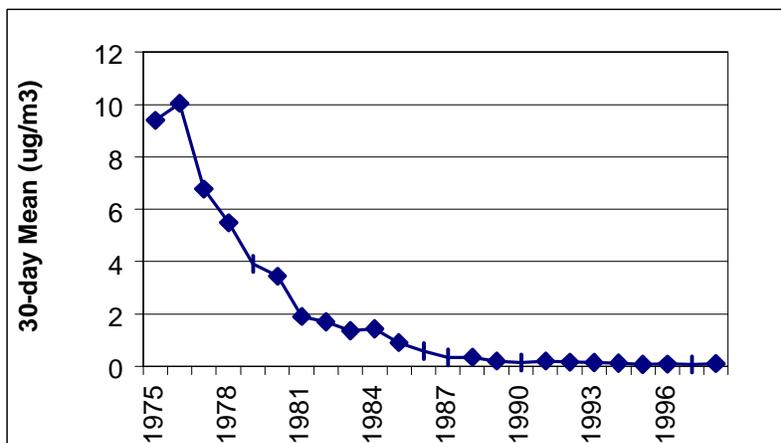


Figure C.9-1. Maximum 30-day average statewide lead concentrations ($\mu\text{g}/\text{m}^3$).

C.10 Sulfur Dioxide (SO_2)

C.10.1. Introduction

Sulfur dioxide (SO_2) is a colorless, non-flammable gas with a sulfurous odor. Sulfur dioxide is primarily produced from the combustion of sulfur-containing fuels and can be chemically transformed in the atmosphere into sulfuric acid and sulfates.

C.10.2. Air Quality, Sources, and Emissions

Sulfur dioxide emissions are from both mobile and stationary sources. While SO_2 poses significant problems in other parts of the nation such as the East Coast, emissions in California have been reduced sufficiently over the last 20 years so that all areas of California now attain both of the State standards for sulfur dioxide. The ambient concentrations of SO_2 have decreased over the last 20 years as illustrated in Figure C.10-1 for the 1-hour peak indicator for SO_2 concentrations and illustrated in Figure C.10-2 for the 24-hour peak indicator for SO_2 . The decrease is attributed to a number of control measures implemented during this time period including: 1) the use of alternative fuels such as natural gas; 2) the use of lower sulfur-containing fuels; and 3) emission controls on sources. The emissions and sources of SO_2 are illustrated in Figure C-10-3. The two source categories that have the highest, yet similar emissions starting from 1985 through 2020, are stationary and other mobile sources.

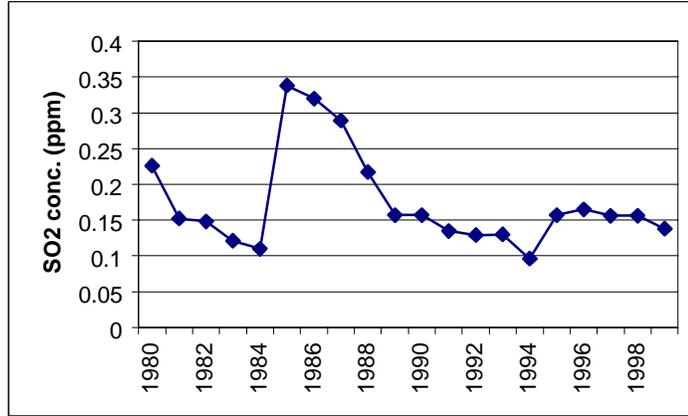


Figure C.10-1. Maximum 1-hour peak indicator for sulfur dioxide (ppm). Note that in 1985 a new site opened in Nipomo (San Luis Obispo County), near a petroleum reprocessing plant.

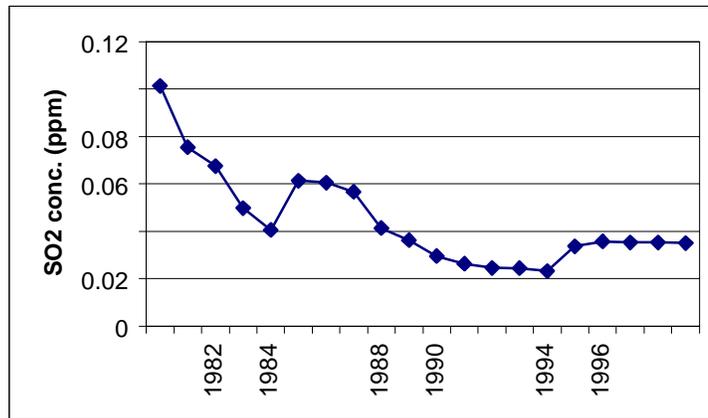


Figure C.10-2. Maximum 24-hour peak indicator for sulfur dioxide (ppm).

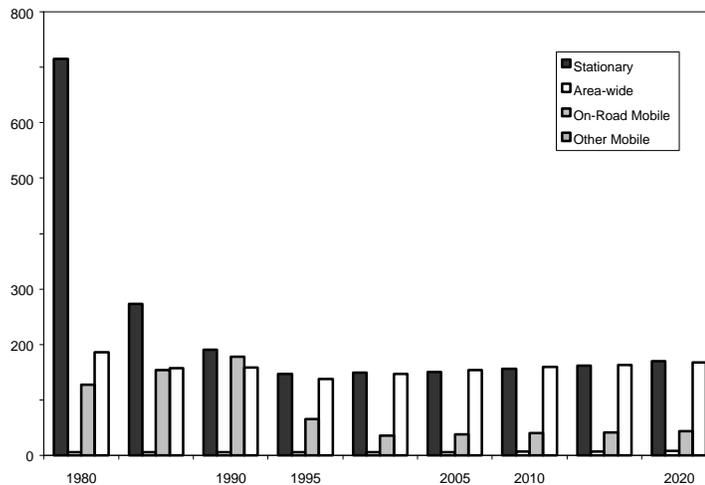


Figure C.10-3. Emissions (tons/day) and sources of sulfur dioxide (SO₂), projected through 2020.

C.11 Indoor and Outdoor Measurements of Criteria Pollutants

Indoor and outdoor concentrations of criteria pollutants are summarized in Table C.11-1. Parallel indoor and outdoor samples were obtained during each of the reported studies. However, the sampling times are generally longer than the averaging times of the ambient air standards. The one exception was for PM₁₀, which was studied for a 24-hour sampling time. The indoor and outdoor PM₁₀ was investigated in 90 homes in Southern California and there were slightly higher indoor concentrations (median concentrations: indoor = 33 µg/m³; outdoor = 29 µg/m³).

Table C11-1. Residential Concentrations of Criteria Pollutants Recent California Studies*

Pollutant	Concentrations			Comments	Reference
	Indoor	Outdoor	Averaging Time		
Ozone	6 ppb (median) 2-16 ppb (25-75 percentile) 50 ppb (99 percentile)	34 ppb (median) 23-51 ppb (25-75 percentile) 89 ppb (99 percentile)	24 hour	Southern California 241 homes	Avol et al., 1996
Particulate Matter (PM10)	98 μm^3 (daytime mean) 65 μm^3 (nighttime mean)	97 μm^3 (daytime mean) 87 μm^3 (nighttime mean)	12 hour	Riverside, CA 165 homes, Fall, 1990 PTEAM Study	Clayton et al., 1993 Ozkaynak et al., 1996
	33 μm^3 (median) 24-47 μm^3 (25-75 percentile) 295 μm^3 (99 percentile)	29 μm^3 (median) 18-44 μm^3 (25-75 percentile) 141 μm^3 (99 percentile)	24 hour	Southern California 90 homes	Avol et al., 1996
Fine Particulate Matter (PM2.5)	49 μm^3 (daytime mean) 37 μm^3 (nighttime mean)	48 μm^3 (daytime mean) 52 μm^3 (nighttime mean)	12 hour	Riverside, CA, 167 homes, Fall, 1990 PTEAM Study	Clayton et al., 1993 Ozkaynak et al., 1996
	13.7 μm^3 (median) 10-23 μm^3 (25-75 percentile) 107 μm^3 (99 percentile)	10.7 μm^3 (median) 7-20 μm^3 (25-75 percentile) 77 μm^3 (99 percentile)	24 hour	Southern California 67 homes	Avol et al., 1996
Carbon Monoxide	2.93 ppm (arithmetic mean) 0.26-7.45 ppm (range)	5.10 ppm (arithmetic mean) 0.21-16.74 ppm (range)	48 hour	passive samplers statewide monitoring 102 homes	Wilson et al., 1993
Nitrogen Dioxide	25 ppb (arithmetic mean) 0-177 ppb (range)	23 ppb (arithmetic mean) 0-80 ppb (range)	48 hour	passive samplers statewide monitoring 214 homes	Wilson et al., 1993

*Note—Direct comparison with ambient air quality standards can not be made because averaging times are not comparable. Residential indoor data for criteria pollutants are very limited.

C.12 References

- Avol, E., M. Estes, W. Navidi, E. Rappaport, S. Colome, F. Lurmann, and S. Hering (1996), *Residential Microenvironmental and Personal Sampling Project for Exposure Classification*, Draft Final Report to the California Air Resources Board, Contract No. 92-317.
- California Air Resources Board (1999), *The 1999 California Almanac of Emissions and Air Quality*.
- Clayton, C.A., R.L. Perritt, E.D. Pellizarri, K.M. Thomas, R.W. Whitmore, L.A. Wallace, H. Ozkaynak, and J.D. Spengler (1993), *Particle Total Exposure Assessment Methodology (PTEAM) Study: Distribution of Aerosol and Elemental Concentrations in Personal, Indoor, and Outdoor Air Samples in a Southern California Community*, *Journal of Exposure Analysis and Environmental Epidemiology* 3(2): 227-250.
- National Research Council (1991) *Human Exposure Assessment for Airborne Pollutants. Advances and Opportunities*. National Academy of Sciences, National Academy Press, Washington, D.C.
- Ozkaynak, H., J. Xue, R. Weker, D. Butler, P. Koutrakis, and J. Spengler (1996), "The Particle TEAM (PTEAM) Study: Analysis of the Data," August 1996, EPA/600/R-95/098, Volume III of Final Report.
- Falke, S.R. and R.B. Husar. Maps of PM_{2.5} over the U.S. derived from regional PM_{2.5} and surrogate visibility and PM₁₀ monitoring data. Presented at the Air & Waste Management Association's 90th Annual Meeting & Exhibition, June 8-13, 1997, Toronto, Ontario, Canada.
- Wilson, A.L., S.D. Colome, and Y. Tian (1993) *California Residential Indoor Air Quality Study*, Sponsored by Gas Research Institute, Pacific Gas and Electric Company, San Diego Gas and Electric Company, and Southern California Gas Company, Volume 1, Methodology and Descriptive Statistics.