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POPULATION EXPOSURE TO OXIDANTS AND NITROGEN DIOXIDE IN LOS ANGELES VOLUME II: WEEKDAY/WEEKEND AND POPULATION MOBILITY EFFECTS

U.S. ENVIRONMENTAL PROTECTION AGENCY
Office of Air and Waste Management
Office of Air Quality Planning and Standards
Research Triangle Park, North Carolina 27711

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POPULATION EXPOSURE TO OXIDANTS AND NITROGEN DIOXIDE IN LOS ANGELES

VOLUME II: WEEKDAY/WEEKEND AND POPULATION MOBILITY EFFECTS

by

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1. INTRODUCTION

We have divided this report on the subject of population exposure to photochemical pollutants in the Los Angeles Basin into three volumes. Volume I is an executive summary which contains the highlights of Volumes II and III. Volume III is entitled, "Population Exposure to Oxidants and Nitrogen Dioxide in Los Angeles - Long Term Trends, 1965-1974." In Volume III, trends in photochemical air pollution in the Los Angeles Basin are discussed from two new aspects, characterization of air quality relative to the standards and quantification of population exposure to air pollution.

In this report, Volume II, two primary purposes of the study are described. They are:

(1) analysis of the weekday-weekend effect on photochemical air pollution and

(2) analysis of the effect of diurnal population mobility on population exposure estimates in the Los Angeles Basin.

The analyses were performed by characterizing local air quality in relation to the air quality standard and by quantifying exposure of the population to air pollution. This was accomplished through the use of O_x and NO_2 data for 1973. This year was selected because it provided the most air quality monitoring sites producing data for the analysis. Most of the past analyses of air quality data are expressed in concentration units such as ppm (parts per million) and $\mu g/m^3$ (micrograms per cubic meter). It is not that these units are hard to understand, but rather this form of air quality presentation is inadequate because it does not indicate adverse effects on public health explicitly or quantitatively.

The air quality standards have been set to protect the public health (primary standards) or the public welfare (secondary standards). Quantification of the observed air quality in relation to the primary standard should indicate explicit adverse impacts with respect to public health. Therefore, hourly O_x air quality data are examined in relation to the primary National Ambient Air Quality Standard (NAAQS, 160 $\mu g/m^3$ or approximately 8 pphm for one hour average concentration). Because there is no NAAQS for short-term NO_2 concentrations, hourly NO_2 air quality data are examined in relation to the California Ambient Air Quality Standard (CAAQS, 470 $\mu g/m^3$ or approximately 25 pphm for one hour average concentration). In this report, air quality is expressed in percentage of the time the standard was exceeded and in mean duration of the excess air pollution in hours per day.

1.1 RECEPTOR POINTS

To determine population exposure to air pollution, air quality measurements taken at widely separated monitoring stations are used to describe the spatial distribution of air pollution levels. Using the statistics of population and employment prepared by the Southern California Association of Governments (SCAG), the spatially distributed population is approximated by 99 receptor points. Each receptor point represents the local population size, the spatial position of the local population, and the area in which the local population resides. The air quality at each receptor point is estimated by spatially interpolating the air qualities observed at the three nearest monitoring stations to that receptor point. In this manner, the region's demographic data are merged with the air monitoring data to estimate short-term air quality (hourly concentration and daily maximum hourly concentration) experienced by the Los Angeles population.

1.2 WEEKDAY-WEEKEND DIFFERENCE

In order to investigate the weekday-weekend difference in air quality, hourly concentration data were divided into weekdays and weekends and were summarized in percentile concentration distributions. For each of given percentiles (maximum, 1, 3, 5, 10, 25, 50, and 75%), the percentile concentration at each receptor point was estimated by spatially interpolating the observed percentile concentrations at the nearest three monitoring stations to that receptor point. Repeating this procedure for all the percentiles, percentile statistics of interpolated concentrations at each receptor point were created for all time, weekdays, and weekends. The percentile indicating the percentage of the time (hours or days) the standard was exceeded was determined to quantify air quality at each receptor point in relation to the standard.

1.3 POPULATION MOBILITY

The population-at-risk distribution, which describes the percentages of the population exposed to a concentration above the standard for a given fraction of the time, is used to report the short-term exposure of the population quantitatively. In determining population exposure to atmospheric pollutants, a difficulty arises. Since people move around with time, the air pollution concentration must be known as a function of both time and the person's spatial position at that time. This difficulty associated with population mobility is partially solved in this report by employing the quasi-stationarity assumption that people stay near a given location during a categorized time period.

The effect of diurnal population mobility between residence and workplace on population exposure estimates was investigated in the following manner. Hourly concentration data were divided into working time (weekday 7 A.M. to 6 P.M.) and non-working time. The hourly concentration data for working time were merged with employment data to estimate exposure of the workers population at their place of employment. The hourly concentration data for nonworking time were merged with residential population data for workers to estimate the exposure of the workers population at their place of residence. Exposure of the worker population during all time was computed by combining the exposure during working time and non-working time. The exposure of non-workers was based on their place of residence and the concentration data for all time. Exposure of the total population during all time was then computed by combining two subpopulations, the workers population and the non-workers population.

1.4 ISOPLETH MAPS

The percentage of days on which the standard was exceeded was computed by using the air monitoring data of daily maximum hourly concentrations while the percentage of hours the standard was exceeded was computed from those of hourly concentrations. Using the percentage of days exceeded and the percentage of hours exceeded, the mean duration of excess air pollution in hours per day was computed at each receptor point. The spatial variations of air quality during all time, weekday, and weekend were then presented in isopleth maps of the percentage of days the standard was exceeded and of the mean duration of excess air pollution in hours per day. The isopleth maps describing the percentage of days the standard was exceeded during weekday and weekend were used to examine the weekend-weekday difference in O_x and NO_2 air quality.

2. OVERVIEW OF POPULATION AND AIR QUALITY IN THE LOS ANGELES BASIN

Among the nation's 247 Air Quality Control Regions (AQCR's), the Los Angeles AQCR is special in that it is defined by its geographical boundaries (mountains and ocean) whereas the great majority of AQCR's are defined by their administrative boundaries (state and county lines). Figure 2.1 depicts the topographical features of the Los Angeles Basin. The AQCR (the area surrounded by solid lines) covers six different counties: all of Orange and Ventura counties, and part of Santa Barbara, Los Angeles, San Bernardino, and Riverside counties.

The difference between the AQCR boundaries and the county boundaries makes it difficult to obtain demographic data specific to the AQCR. In the analysis of population exposure to air pollution, the spatial distribution of population as well as the population size must be known. However, a census tract is too small for the spatial unit because there are less than 50 air monitoring stations in the region. During our search for the population data to be used for the population exposure analysis, we found that the Regional Statistical Areas (RSA's) developed by the Southern California Association of Governments (SCAG) were a proper spatial unit for aggregating the population data.[1]

The year of 1973 was chosen for this study because in that year the largest number of stations reported at least 50% of the possible observations. Figure 2.2 depicts the location of the 26 air monitoring stations which were used for the detailed analysis made with the 1973 air quality and population data. The vast majority of stations produced data that exceeded 80% completeness. The oxidant data at four stations, Point Mugu (3), Chino (18), Upland (21), and Redlands (26), failed to meet our criterion

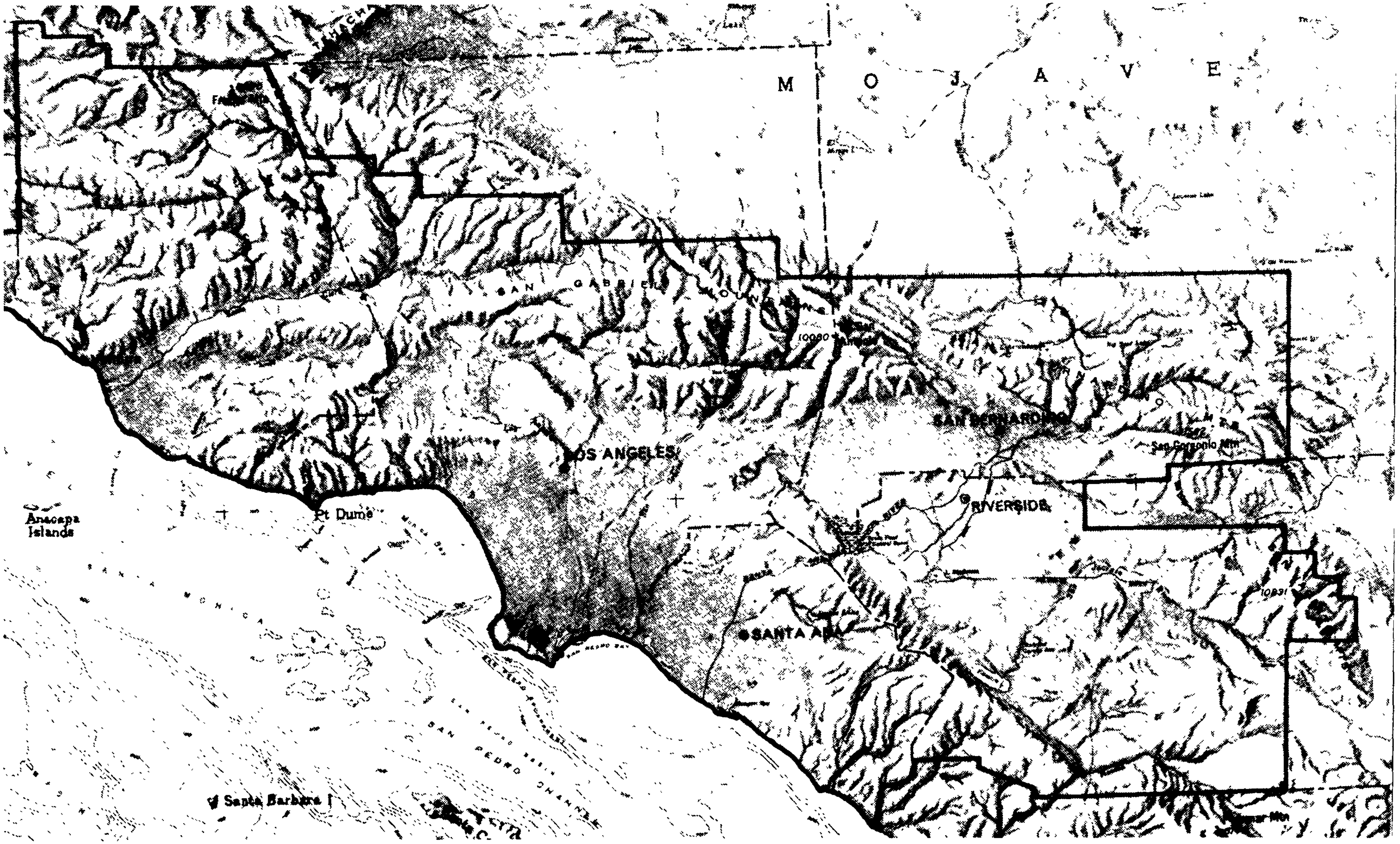


Figure 2.1. TOPOGRAPHICAL FEATURES OF THE LOS ANGELES BASIN.

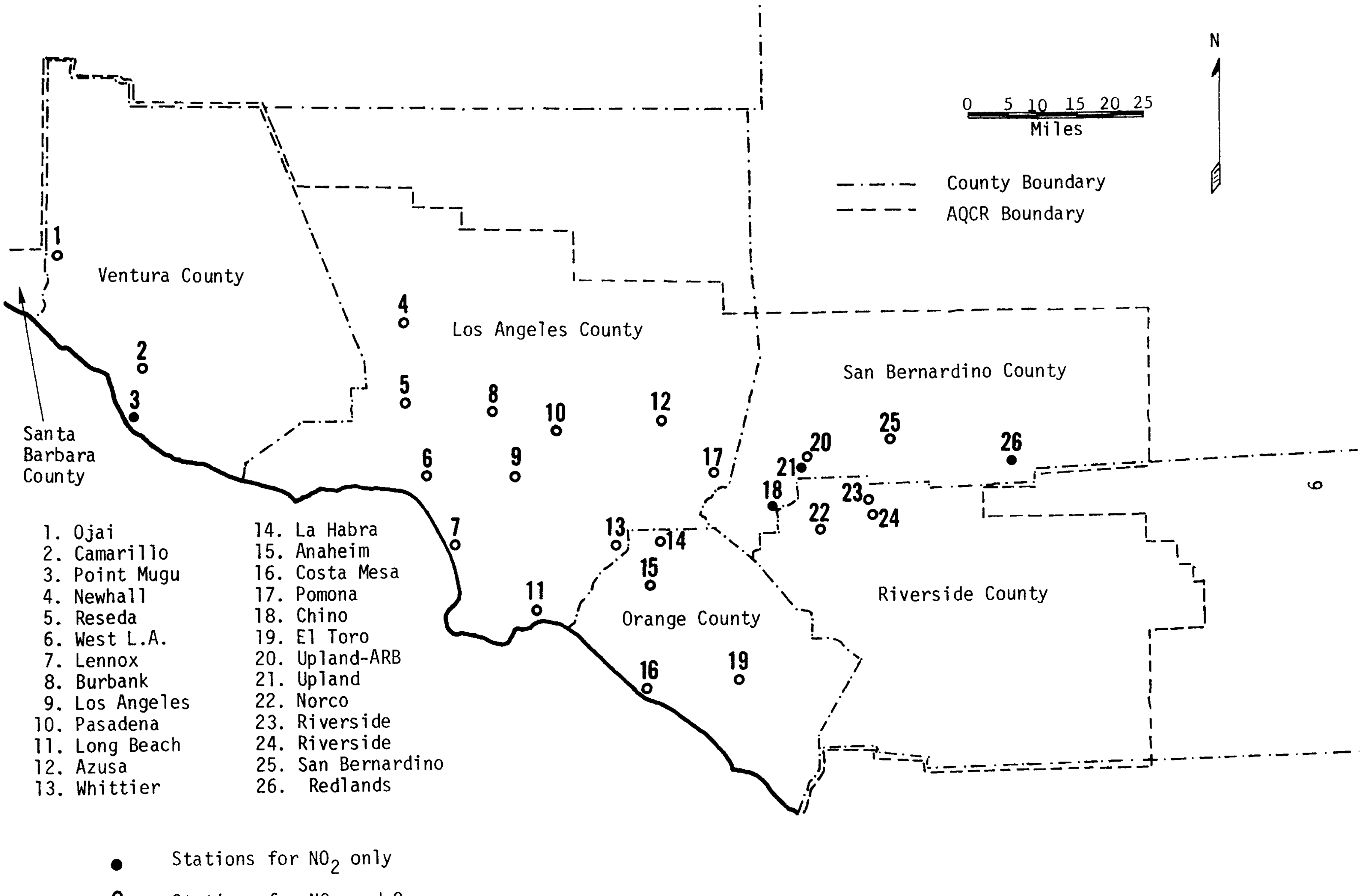


Figure 2.2 Location of Monitoring Stations.

for a valid station-year, i.e., more than 50% of possible observations. Therefore, the remaining 22 stations were selected for the analysis of population exposure to O_x air pollution, while all the 26 stations were used for the NO_2 analysis. Considering the area coverage of these stations, the study area for the 1973 analysis was selected as shown in Figure 2.3. It can be seen that the 1973 Analysis Area approximately corresponds to the Los Angeles AQCR minus a portion of Santa Barbara County whose population data were not available from the SCAG statistics.

2.1 POPULATION PROFILE

The Southern California Association of Governments (SCAG) provides statistics of total population (at place of residence) and of total employment (at place of work). These SCAG statistics are aggregated into each of the 55 Regional Statistical Areas (RSA's) which cover the six counties of Ventura, Los Angeles, Orange, San Bernardino, Riverside, and Imperial (Fig. 2.4). Because we also need to know the number of workers at their place of residence for computing population exposure during non-working time, the aggregated statistics of workers by residence for each RSA were computed from the 1970 census tract data by using the conversion table prepared by SCAG, which indicated the number of census tracts belonging to each RSA (Appendix A, Table A1).

The spatial distribution of total population density is shown in Figure 2.5. A high population density area centers at the Los Angeles CBD and extends to the southern half of Los Angeles County and portions of Orange and San Bernardino Counties. The lowest population density is found in the mountainous areas (Figs. 2.1 and 2.5).

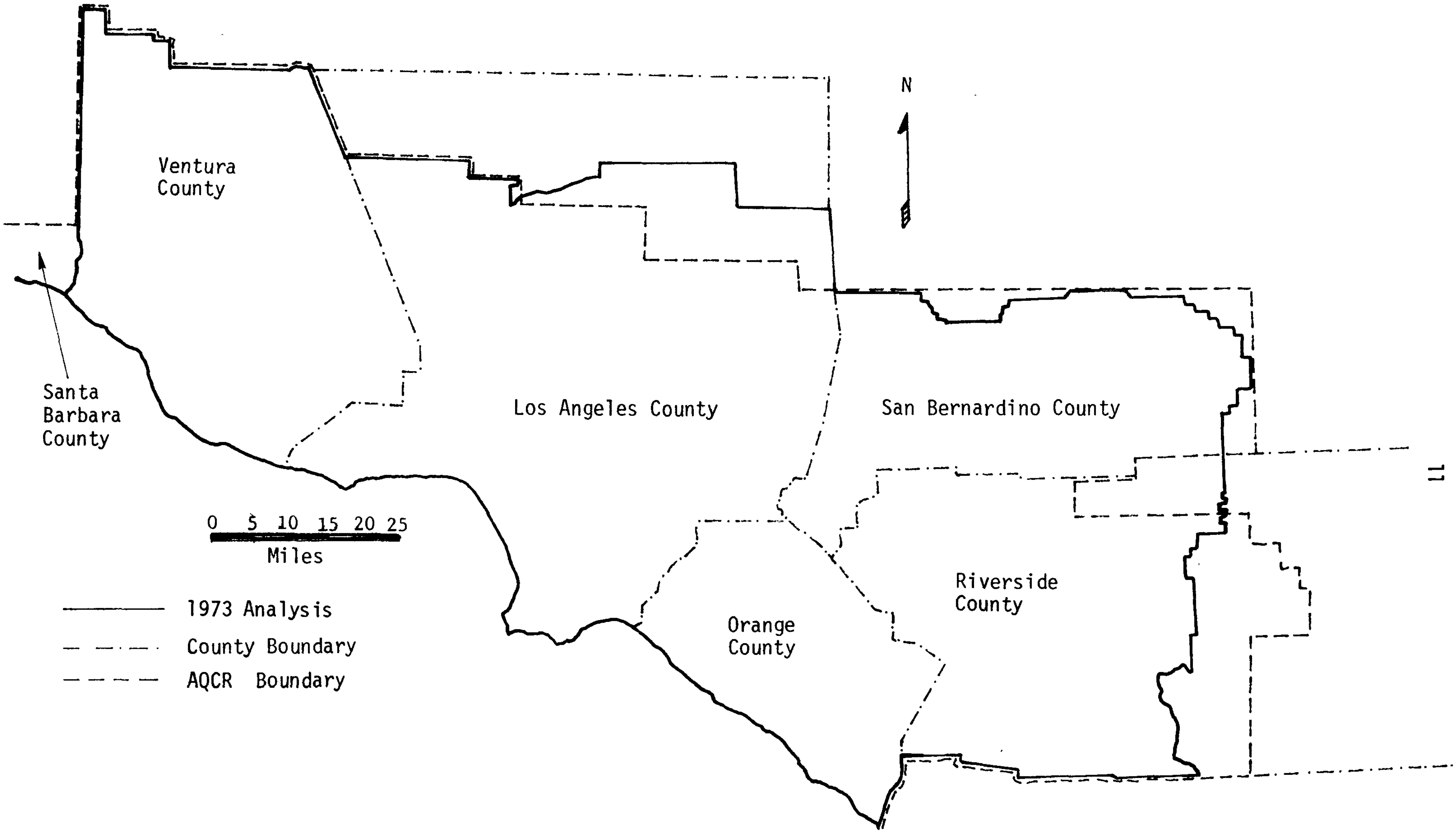


Figure 2.3. Boundaries Showing 1973 Analysis Area, and Los Angeles AQCR.

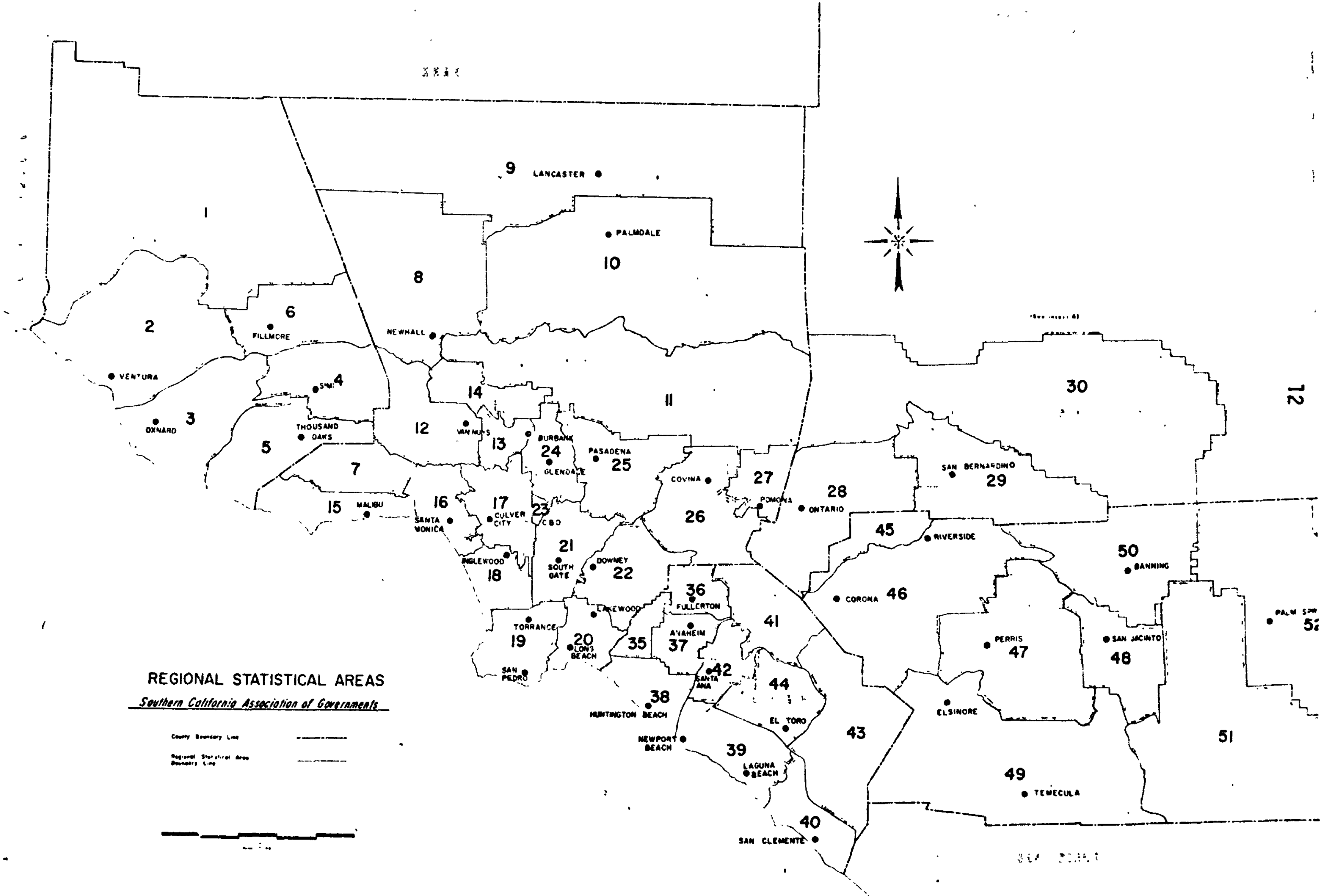


Figure 2.4. REGIONAL STATISTICAL AREAS DEVELOPED BY SOUTHERN CALIFORNIA ASSOCIATION OF GOVERNMENTS

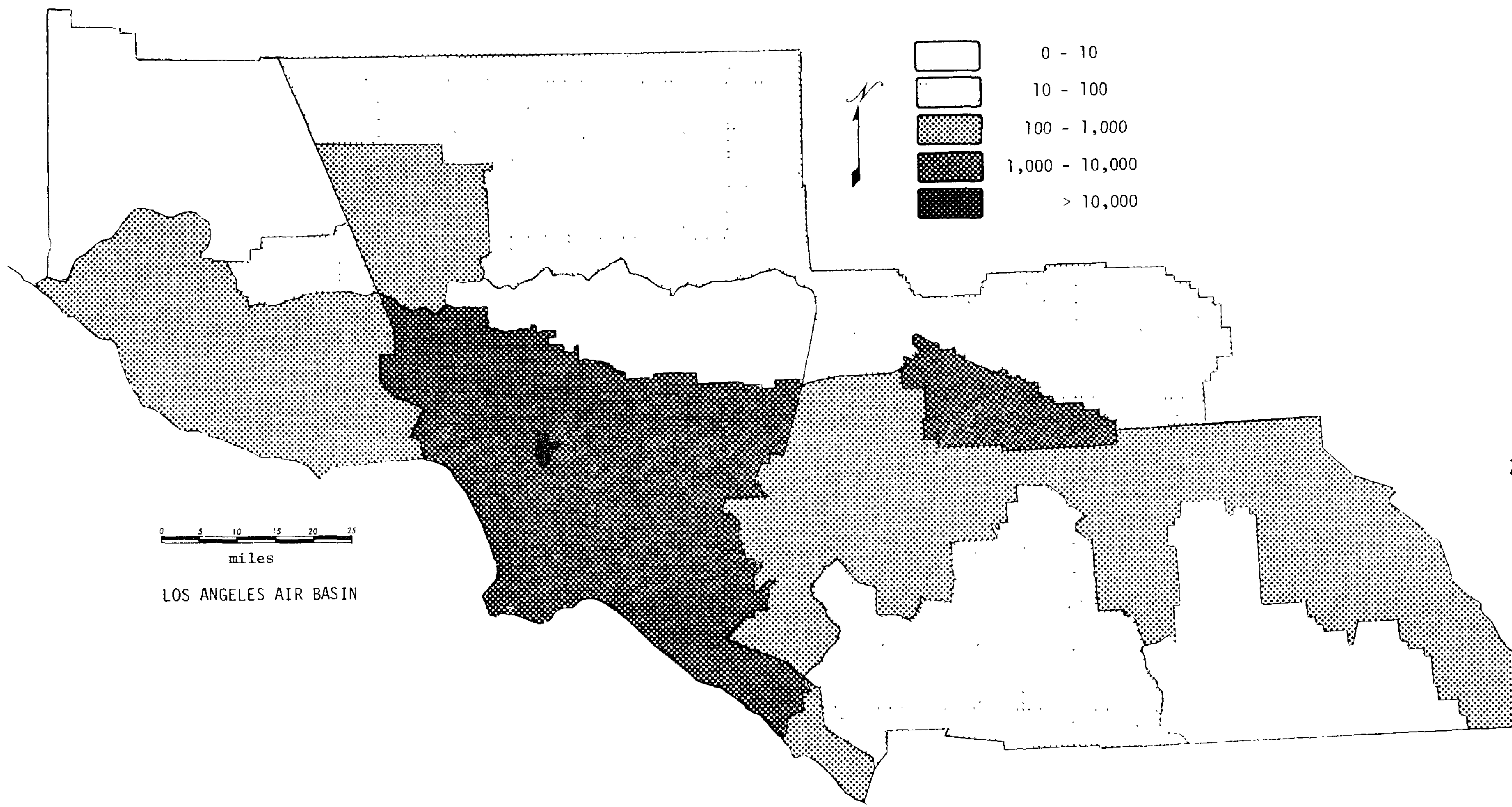


Figure 2.5. POPULATION DENSITY IN PERSONS PER SQUARE MILE IN 1970.

Figure 2.6 depicts the spatial variation of workers population density at their place of employment. The spatial distribution pattern is somewhat similar to that of total population density. Because most workers commute from their residence to their workplace, the number of workers at their place of residence and that at their place of employment are quite different for individual RSA's. Workers population density at their place of residence was computed for each RSA and then was subtracted from that at their place of employment. The difference indicates the influx of workers to that RSA during working time. In this manner the daily population movement in the Los Angeles Basin was determined as shown in Figure 2.7. The greatest daily migration occurs at the Los Angeles CBD and the Southgate area. A moderate daily migration is seen at Long Beach, Inglewood, the central part of Orange county, Pomona, the central San Fernando Valley, and Oxnard.

The study region (Fig. 2.3) includes 8,612 square miles (22,295 square kilometers) and 9.9 million people. The population figure was arrived at by interpolating SCAG population estimates for 1970 and 1975. The number of workers in 1973 who worked inside of the study region were 4,083,358, while those who lived inside of the study region were 4,110,024. This small difference in the number of workers is due to the diurnal migration of workers from their place of residence to their place of employment.

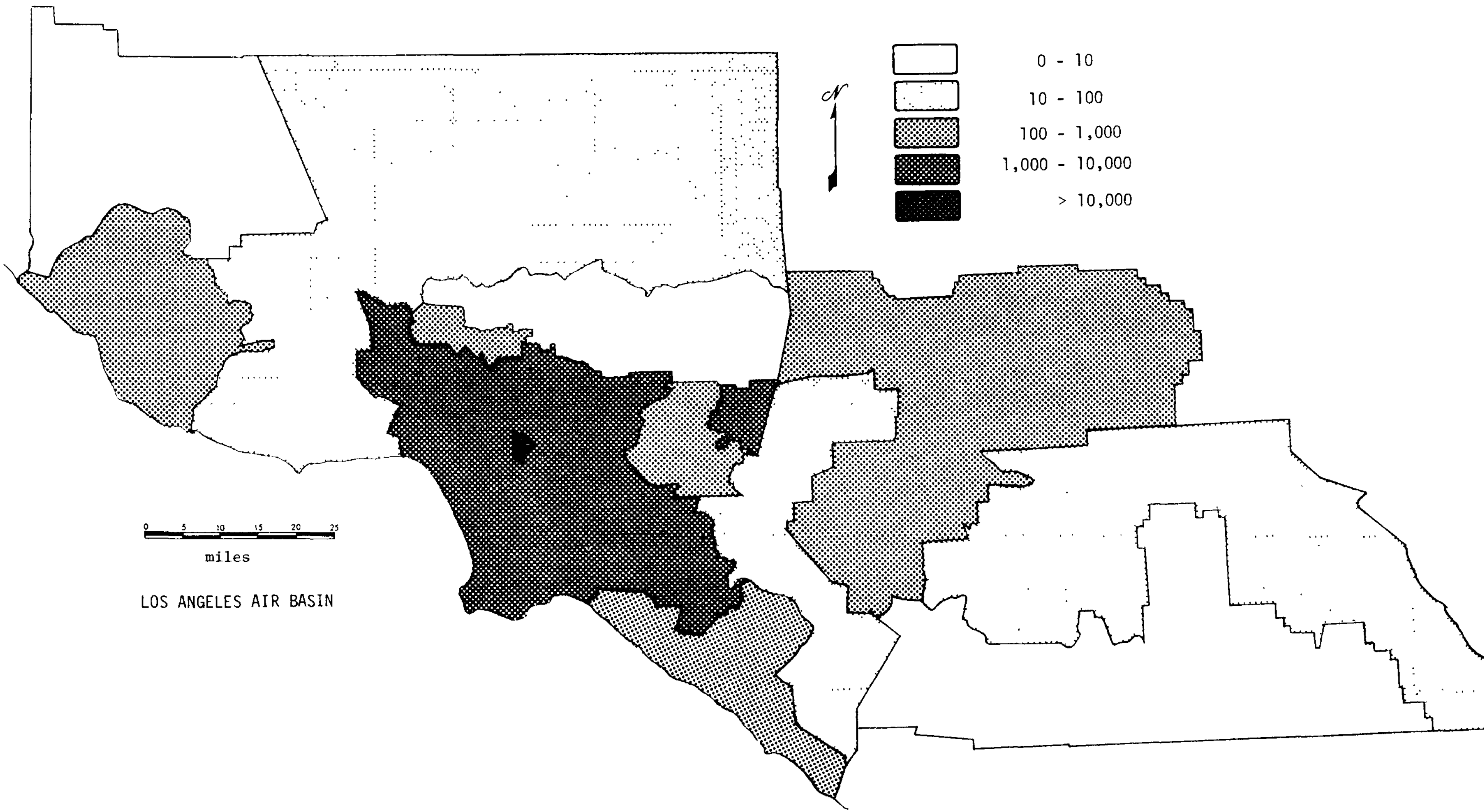


Figure 2.6. NUMBER OF PERSONS EMPLOYED PER SQUARE MILE IN 1970.

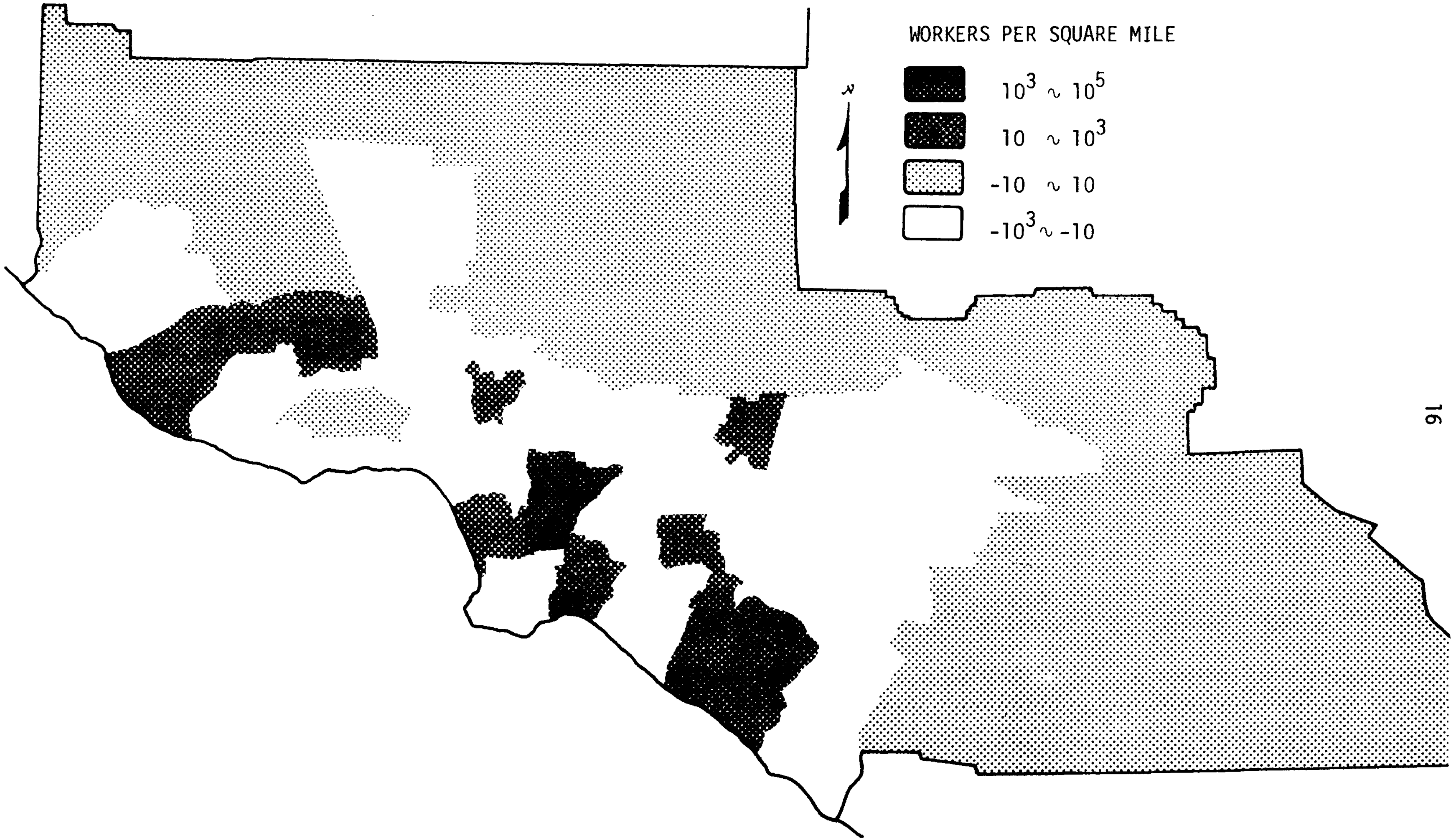


Figure 2.7. THE NET INFLUX OF POPULATION (WORKERS) DURING WORKING TIME IN PERSONS PER SQUARE MILE IN 1970

2.2 AIR POLLUTION PROFILE

A percentile concentration distribution is used in this study to characterize annual short-term (one hour) exposures of the population to O_x and NO_2 air pollution. The short-term exposure of the population is characterized by two parameters: (1) the frequency of occurrence that an ambient concentration exceeds the concentration threshold equal to the air quality standard or a multiple of the standard, and (2) the mean duration of the excess air pollution above the threshold in hours per day.

Using the California ARB data tape of hourly average concentration, the percentile concentration statistics were developed for the 22 air monitoring stations that were selected for the detailed analysis of population exposure to O_x air pollution in 1973, and for the 26 air monitoring stations selected for NO_2. In order to examine the "weekend effect" on air quality and population exposure, the percentile concentration statistics of hourly concentrations and daily maximum hourly concentrations were computed for three time categories: all time, weekday, and weekend. In order to incorporate daily population mobility between residence and workplace into the population exposure analysis, the percentile concentration statistics of hourly concentrations were computed for the three additional time categories; working time (weekday 7 A.M. to 6 P.M.), non-working time, and weekday non-working time. The percentile concentrations at each of the 22 air monitoring stations for O_x and the 26 stations for NO_2 are all presented in Appendix B(Tables B1 through B4). In those tables, time categories 1, 2, 3, 4, 5, and 6 refer, respectively, to all time, weekday, weekend, working time, non-working time, and weekday non-working time.

The O_x air quality observed at each station during weekdays and that during weekends is summarized in Table 2.1 by the percent of days on which the National Ambient Air Quality Standard (NAAQS) was violated and the mean duration in hours of such violations. Our results confirm previous reports.[3,4] Some coastal stations (Anaheim, El Toro, West L.A., Lennox) have a higher percentage of days exceeded over weekends than over weekdays, indicating that the air at these stations tends to be more polluted during weekends than weekdays. The majority of monitoring stations, however, have a lower percentage of days exceeded during weekends than weekdays. It should be noted that the mean durations of NAAQS violations at the four coastal stations are all shorter over weekends than over weekdays. Therefore, the air pollution dosage (time integral of concentration) at these station sites may not necessarily be higher during weekends than weekdays.

Table 2.2 presents the summary of weekday-weekend difference in NO_2 air quality at each monitoring station. It can be seen that the great majority of stations have a lower percentage of days exceeded and a shorter mean duration of California one-hour standard violations during weekends than weekdays. Therefore, the NO_2 air quality at these station sites is better during weekends than weekdays. However, at the three stations in Costa Mesa, Riverside-Magnolia, and Whittier, the opposite is true. The NO_2 air quality at these three stations is worse during weekends than weekdays.

Table 2.1 Percent of Days the NAAQS for O_x was Exceeded and the Mean Duration in Hours (x.x) in 1973.

NO.	STATION	WEEK-DAY	WEEK-END
1	ANAHEIM	18.4 (3.0)	21.0 (2.9)
2	LA HABRA	29.7 (4.0)	25.0 (4.8)
3	COSTA MESA	15.8 (3.2)	15.8 (4.6)
4	EL TORO	7.9 (3.0)	13.6 (2.6)
5	NORCO-PRADO PRK	39.7 (6.0)	31.5 (5.4)
6	RIVERSIDE-RUBIDOUX	50.0 (6.5)	44.0 (5.5)
7	RIVERSIDE-MAGNOLIA	46.3 (7.0)	44.0 (6.6)
8	SAN BERNARDINO	46.3 (6.7)	39.5 (6.1)
9	UPLAND-ARB	66.4 (7.5)	62.4 (7.4)
10	OJAI	31.5 (6.0)	25.0 (4.8)
11	CAMARILLO-PALM	31.5 (5.4)	25.0 (4.8)
12	L.A. DOWNTOWN	35.4 (4.3)	35.4 (4.3)
13	AZUSA	53.2 (6.7)	47.3 (6.1)
14	BURBANK-PALM	38.2 (5.3)	33.3 (4.5)
15	WEST L.A.-WSTWOOD	25.0 (3.7)	27.1 (3.4)
16	LONG BEACH	3.9 (4.5)	3.0 (3.6)
17	RESEDA	44.5 (6.5)	35.4 (6.8)
18	POMONA	50.0 (5.6)	44.5 (5.4)
19	LENNOX	5.5 (2.7)	5.6 (2.7)
20	WHITTIER	27.1 (3.4)	25.0 (4.8)
21	NEWHALL	44.1 (8.1)	38.3 (7.5)
22	PASADENA-WALNUT	54.2 (6.0)	45.3 (6.4)

Table 2.2 Percent of Days the California Standard for NO_2 was Exceeded and the Mean Duration in Hours (x.x) in 1973.

NO.	STATION	WEEK-DAY	WEEK-END
1	ANAHEIM	2.4 (5.0)	6.0 (4.0)
2	LA HABRA	3.4 (4.6)	4.4 (1.9)
3	COSTA MESA	1.1 (1.1)	1.6 (1.7)
4	EL TORO	.7 (1.9)	0.0 (0.0)
5	NORCO-PRADO PRK	0.0 (0.0)	0.0 (0.0)
6	RIVERSIDE-RUBIDOUX	0.0 (0.0)	0.0 (0.0)
7	RIVERSIDE-MAGNOLIA	.6 (1.6)	1.5 (2.7)
8	SAN BERNADINO	0.0 (0.0)	0.0 (0.0)
9	REDLANDS	0.0 (0.0)	0.0 (0.0)
10	CHINO	.7 (1.9)	0.0 (0.0)
11	UPLAND-CIVIC CTR	.9 (4.0)	0.0 (0.0)
12	UPLAND-ARB	0.0 (0.0)	0.0 (0.0)
13	OJAI	0.0 (0.0)	0.0 (0.0)
14	CAMARILLO-PALM	0.0 (0.0)	0.0 (0.0)
15	PT. MUGU	1.1 (1.7)	0.0 (0.0)
16	L.A. DOWNTOWN	5.7 (3.3)	1.0 (1.4)
17	AZUSA	4.3 (1.3)	0.0 (0.0)
18	BURBANK-PALM	9.2 (3.1)	1.3 (2.6)
19	WEST L.A.-WSTWOOD	8.5 (2.3)	3.3 (1.5)
20	LONG BEACH	6.7 (2.4)	3.5 (2.1)
21	RESEDA	3.4 (2.5)	0.0 (0.0)
22	POMONA	2.3 (3.4)	0.0 (0.0)
23	LENNOX	6.4 (2.2)	0.0 (0.0)
24	WHITTIER	3.4 (3.8)	4.7 (1.9)
25	NEWHALL	0.0 (0.0)	0.0 (0.0)
26	PASADENA-WALNUT	2.8 (2.2)	0.0 (0.0)

Referring to Figure 2.2 which shows the location of each monitoring station, we can get a rough picture of the spatial distribution of pollutant levels. Oxidant air pollution exceeded the NAAQS more than 30% of days on both weekdays and weekends at Noroco-Prado Park, Riverside (two stations), San Bernardino, Upland, L.A. Downtown, Azusa, Burbank, Reseda, Pomona, Newhall, and Pasadena. All of these stations are located in the Los Angeles Downtown area or further inland. In contrast, stations such as Costa Mesa, El Toro, Long Beach, and Lennox which exceeded the NAAQS less than 20% of days over both weekdays and weekends are all located near the coast.

For NO_2, the stations in commercial or industrial centers (L.A. downtown, Burbank, West L.A., Long Beach, and Lennox) exceeded the CAAQS more than 5% of days during weekdays but far less frequently during weekends. Stations distant from the Los Angeles CBD (El Toro, Norco Prado Park, Riverside-Rubidoux, San Bernardino, Redlands, Chino, Upland, Camarillo, and Newhall) exceeded the CAAQS less than 1% of days over both weekdays and weekends.

2.3 INTERFACING POPULATION AND AIR QUALITY DATA

The task of interfacing the population data and the air quality data starts with a search for a proper regional map on which the monitoring stations and the receptor points can be located. A receptor point is used to aggregate the local populations in the areas in which they reside. For the Los Angeles AQCR, a regional map showing the boundaries of the Regional Statistical Areas (RSA's) was available (Fig. 2.4). A number of receptor points were assigned to each RSA according to the size of the population and the land area. The criteria used for determining the number of receptor points assigned to each RSA is as follows:

1. Regardless of the size of the population and/or the land area, each RSA is represented by at least one receptor point.
2. An additional receptor point is assigned for each increment of 200 square miles or each increment of a resident population of 200,000.

For example, an RSA having a resident population of 500,000 and a land area of 70 square miles is represented by three receptor points (one for RSA and two for population of 400,000), while another RSA having a population of 150,000 and an area of 300 square miles is represented by two receptor points (one for RSA and one for land area of 200 square miles).

The number of people at each receptor point is computed in the following manner: The total population or the total employment in each RSA is computed by making a linear interpolation between the SCAG estimates for two time points. For the study year 1973, the interpolation is made of 1970 and 1975 data. The number arrived at by interpolation is divided by the number of receptor points in that RSA and the result is assigned to each receptor point. For subpopulations such as workers and non-workers population, the number of people of a given subpopulation at each receptor point are given by the product of (total population) x (percent of subpopulation) where the percentage is computed from the 1970 census data for the RSA to which the receptor point belongs.

A diagram showing how to create a demographic network is given in Figure 2.8. First, the regional map of RSA's prepared by SCAG is copied by

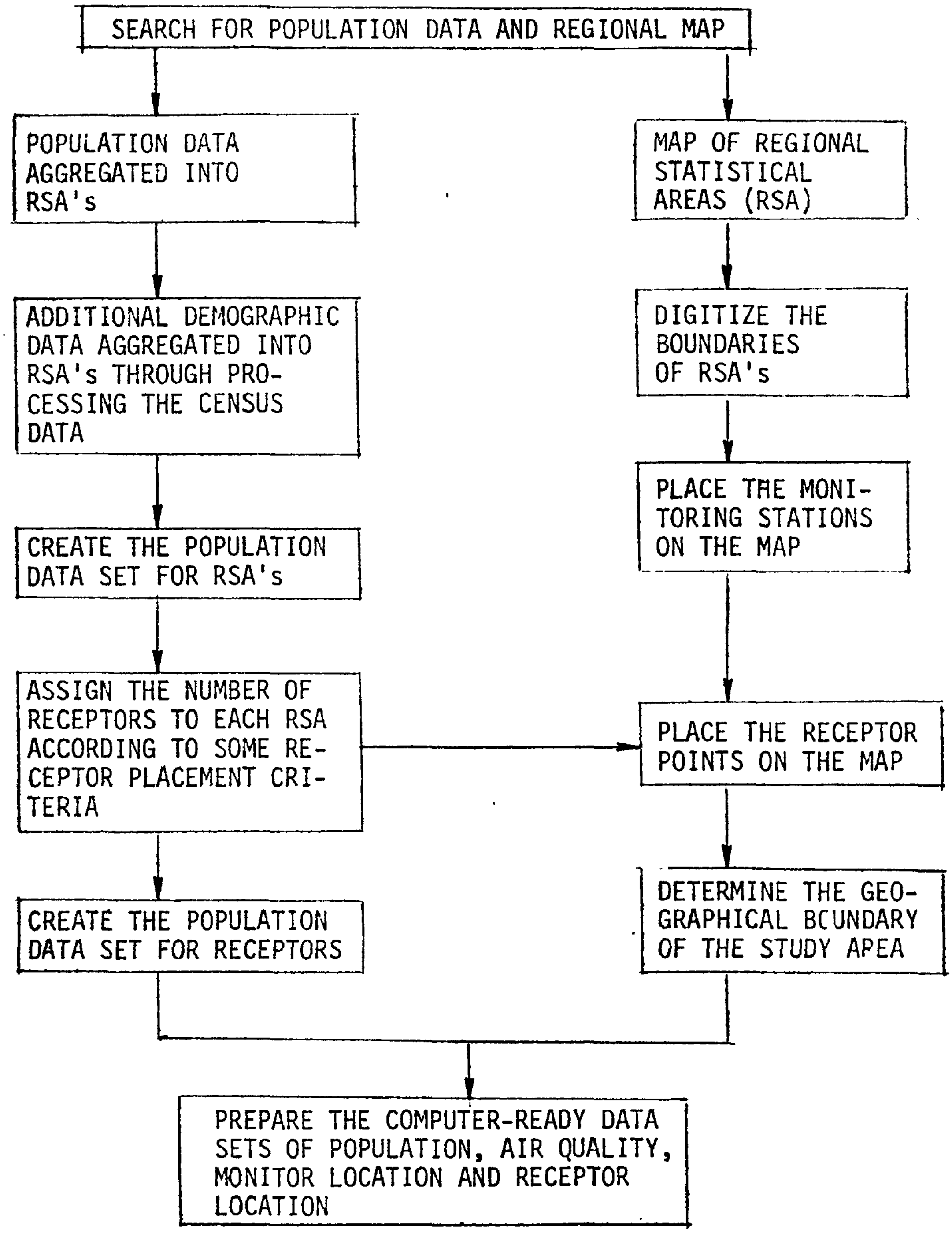


Figure 2.8. Diagram of Creating a Demographic Network for Metropolitan Los Angeles AQCR.

using a digitizer. Using the UTM coordinates given in SAROAD format or the site addresses (Appendix C, Table C1) the air monitoring stations are located on the digitized map through a coordinate transformation[3] (Fig. 2.2). In order to determine a scale factor for the coordinate transformation, the locations of the Los Angeles Downtown station and the Azusa station are determined from their site addresses. The receptor points are located at their proper places within the corresponding RSA. The receptor locations are shown in Figure 2.9; their coordinates are found in Appendix C, Table C2.

Next, we need to determine the exposure of a person to air pollution. Thus, the spatial location of the person and the air quality of his location must be known as a function of time. In the present study, however, we are not interested in the actual exposures of an individual person to air pollution, but rather we are interested in the ensemble of potential exposures of a large population, say 10,000 people. For this purpose, an appropriate estimate of air quality at each receptor point should be sufficient to make an estimate of population exposure at that particular locale, if the assumption is made that the population size and sub-population composition will be quasi-stationary over a year. This assumption should be good for the analysis of exposure of part of the population such as elderly and school-age populations because these populations tend to be locationally fixed, i.e., most school-age children and elderly people stay close to their resident locations most of the time.

However, the above assumption would not hold for the other portions of the population, particularly the All Workers population because a large

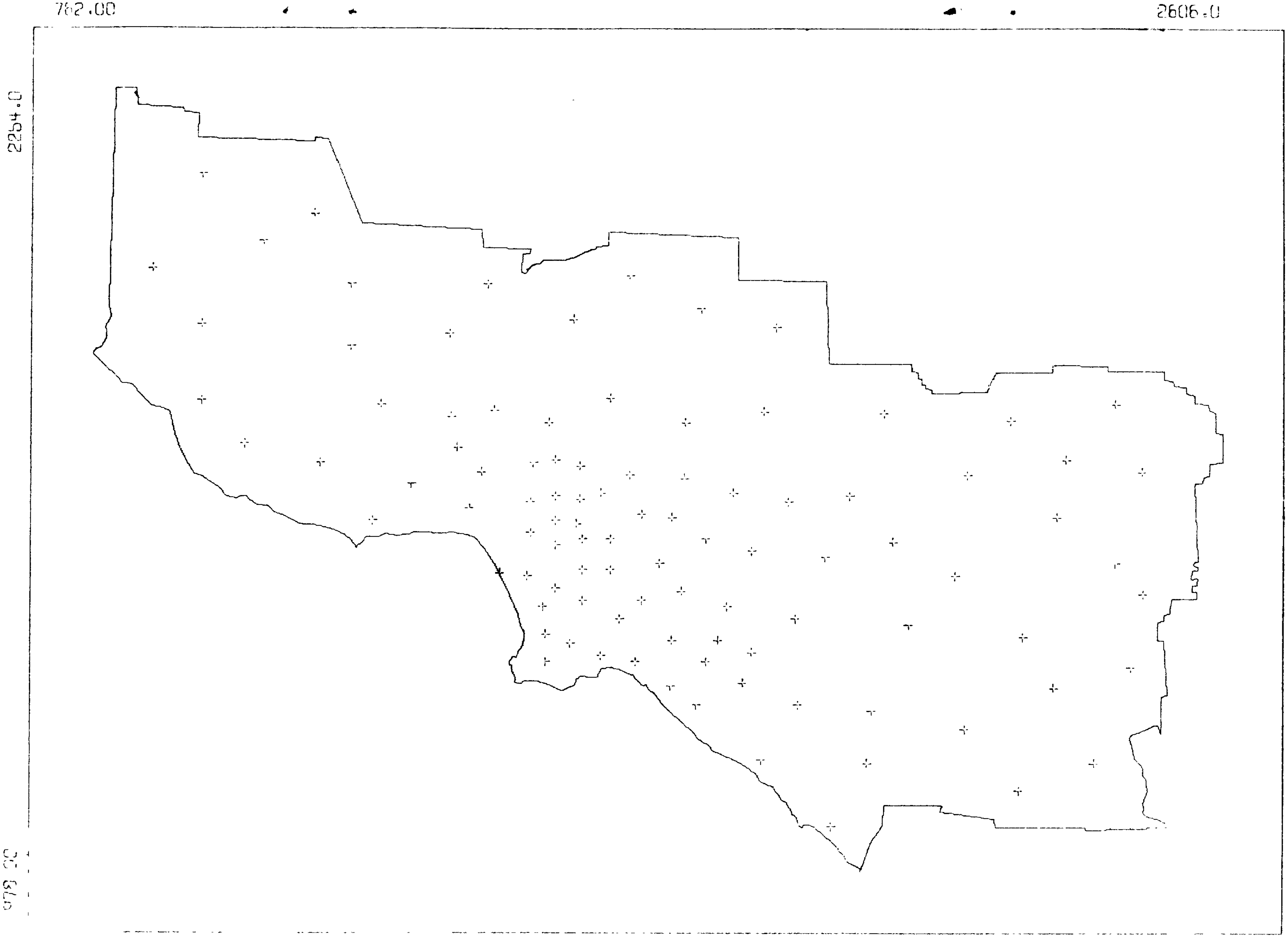


Figure 2.9. LOCATIONS OF THE 99 RECEPTOR POINTS ASSIGNED TO THE STUDY REGION

percentage of that population spends a substantial part of their time at their working places where the air environment may be quite different from that of their residential locations. Therefore, a special analysis has been performed for the 1973 air quality data and the population data. The All Workers population data are aggregated into each RSA: (1) by their residence locations and (2) by their working places. The air quality data are classified by time categories; (1) non-working time and (2) working time (weekday 7 A.M. to 6 P.M.).

As mentioned earlier, the spatially distributed population is aggregated at each receptor point. The air quality at a receptor point was estimated by interpolating the observed air quality at the three nearest neighboring monitoring stations to that point as[4]

$$C_j = \sum_{i=1}^{3} C_i d_i^{-2} \Big/ \sum_{i=1}^{3} d_i^{-2} \tag{2.1}$$

where C_j is the concentration estimated at j-th receptor point (x_j, y_j), $C_i (i=1,2,3)$ are the concentrations observed at the three nearest neighboring stations, i-th (i=1,2,3) air monitoring stations (x_i) around the j-th receptor point, and d_i is the distance between the i-th monitoring station and the j-th receptor point, i.e.,

$$d_i = \sqrt{(x_i - x_j)^2 + (y_i - y_j)^2} \quad . \tag{2-2}$$

3. WEEKDAY-WEEKEND DIFFERENCE IN AIR QUALITY AND POPULATION EXPOSURE

It is very costly to test the effectiveness of various oxidant control strategies on real-world photochemical air pollution by imposing additional emission controls. One possible way of assessing the impact of emission changes on levels of the two major photochemical pollutants, O_x and NO_2 prior to the imposition of additional controls is to examine the weekday-weekend differences in air quality of the two pollutants and relate them to the weekday-weekend differences in the level of precursor pollutant emissions. If enough weekdays and weekends are examined so that net meteorological differences between weekday and weekend are minimized, it should be possible to assess what impact the different levels of precursor emissions has had on absolute levels and spatial patterns of ambient O_x and NO_2.

In this report, the weekday-weekend differences in air quality are studied by examining the frequency of violations of the air quality standards at each of the 99 receptor points whose locations are shown in Figure 2.9. Using the local population size assigned to each receptor point, the weekday-weekend difference in population exposure to the two pollutants is thereby examined. In order to determine how often the NAAQS for O_x and the CAAQS for NO_2 were violated at various parts of the Los Angeles Basin, the percentile concentration distributions of hourly concentrations and daily maximum hourly concentrations for O_x and NO_2 were computed from the original hourly concentration data furnished by the California Air Resources Board. These percentile concentration statistics are presented in Appendix B (Tables B1 through B4), which show that the percentile concentrations for all time, weekdays, and weekends are used for the analysis of weekday-weekend difference in air quality and population exposure. The percentile concentrations for working time, non-working time, and weekday non-working time were prepared for studying the effect of diurnal population mobility.

Comparing the percentile concentration at each receptor point to the air quality standard (NAAQS for O_x and CAAQS for NO_2), the frequency of violations of the standard (hereafter termed "risk frequency") is determined by the percentile concentration which equals the air quality standard. If the standard falls between two percentile concentrations, the logarithm of the percentile is determined by linear interpolation of the corresponding concentation values. From hourly concentrations, the percentage of hours that the standard is violated (hereafter termed "hourly risk frequency") is computed. Similarly, the percentage of days that the standard is violated (hereafter termed "daily risk frequency") is computed from daily maximum hourly concentrations. Using hourly risk frequency and daily risk frequency, the average number of hours per day that the standard is violated on days with standard violations (hereafter termed "mean duration") is also computed at each receptor point. A more exact definition of each term used in this report is given in Appendix D.

3.1 Weekday-Weekend Difference in O_x

The spatial variation of O_x air quality over the Los Angeles AQCR is shown in Figure 3.1 in terms of the percent of days on which the NAAQS is exceeded. It can be seen that in the coastal areas, the NAAQS was violated about 10% of the days or about 37 days per year while in the inland

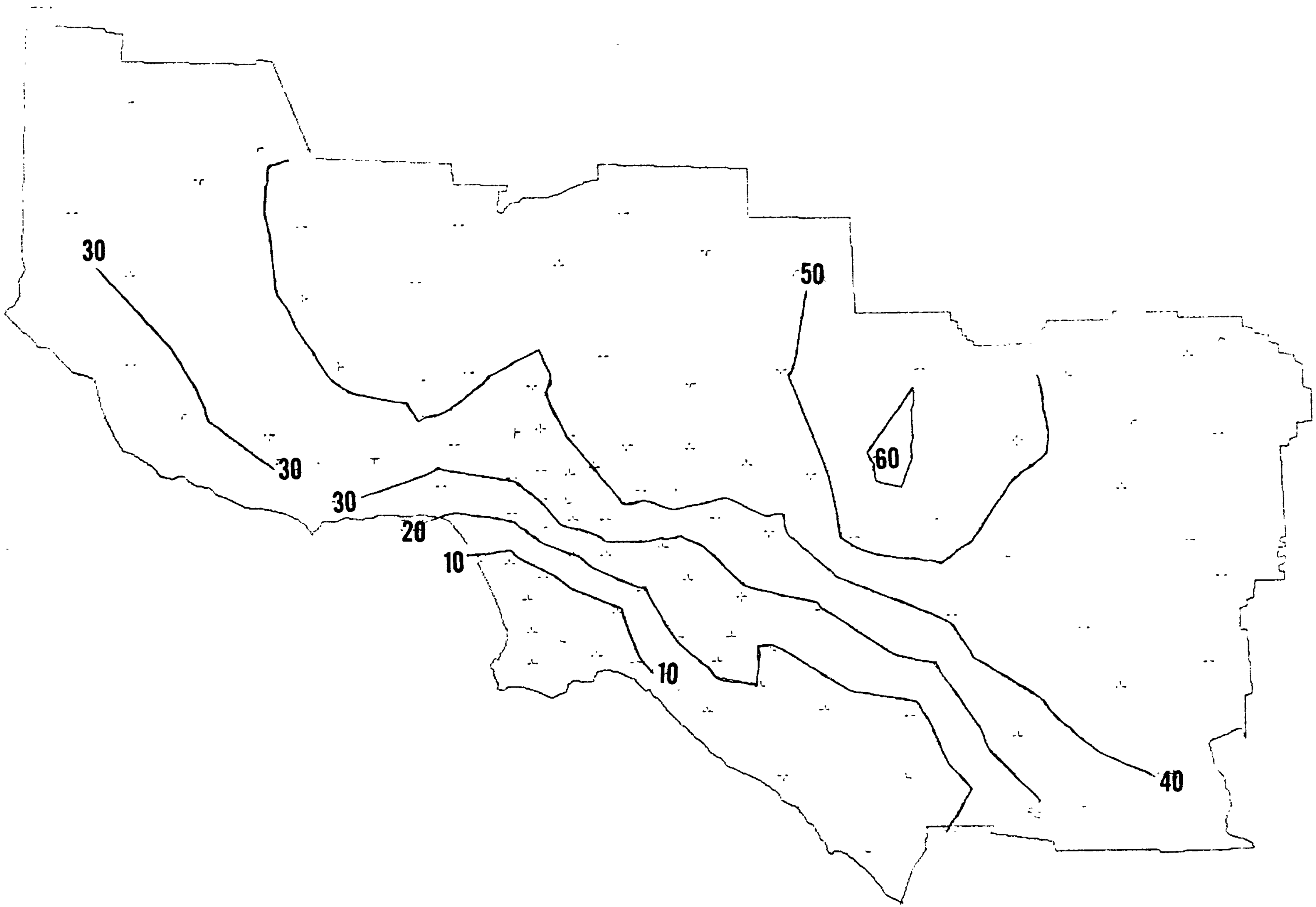


Figure 3.1. ISOPLETHS of percent of days on which the NAAQS for oxidant was exceeded in 1973.

areas it was violated as many as 50% of the days or 183 days per year. Figure 3.2 shows isopleths of the average duration in hours per day on those days with the NAAQS violations. In the coastal areas the average duration was about three hours per day while in the inland areas it was longer than five hours per day. From these two figures, we can compute the approximate number of hours the NAAQS was exceeded in 1973 at various locations. For example, in the coastal areas, the number of hours exceeded should be approximately (37 days/year) x (3 hours/day) = 111 hours per year while in the inland areas it should be 183 x 5 = 915 hours per year.

The spatial distribution of O_x air quality during weekdays and that during weekends were determined by computing the percent of days exceeded during each period. Then, subtracting the percent of days exceeded during weekends from that during weekdays, Figure 3.3 was obtained to show the weekday-weekend difference in air quality in terms of the frequency of NAAQS violations. It is seen that the coastal region has a negative value indicating poorer air quality during weekends than weekdays, and that the inland region has a positive value indicating a better air quality during weekends than weekdays. A ridge on which there is no difference in air quality between weekdays and weekends divides the Los Angeles AQCR into the above two regions. The ridge runs along the Santa Monica Mountains to the Los Angeles CBD, and along the Santa Ana Mountains that separate Orange County and Riverside County. These results are consistent with previous reports about the weekend effect on O_x air pollution.[5,6,7,8]

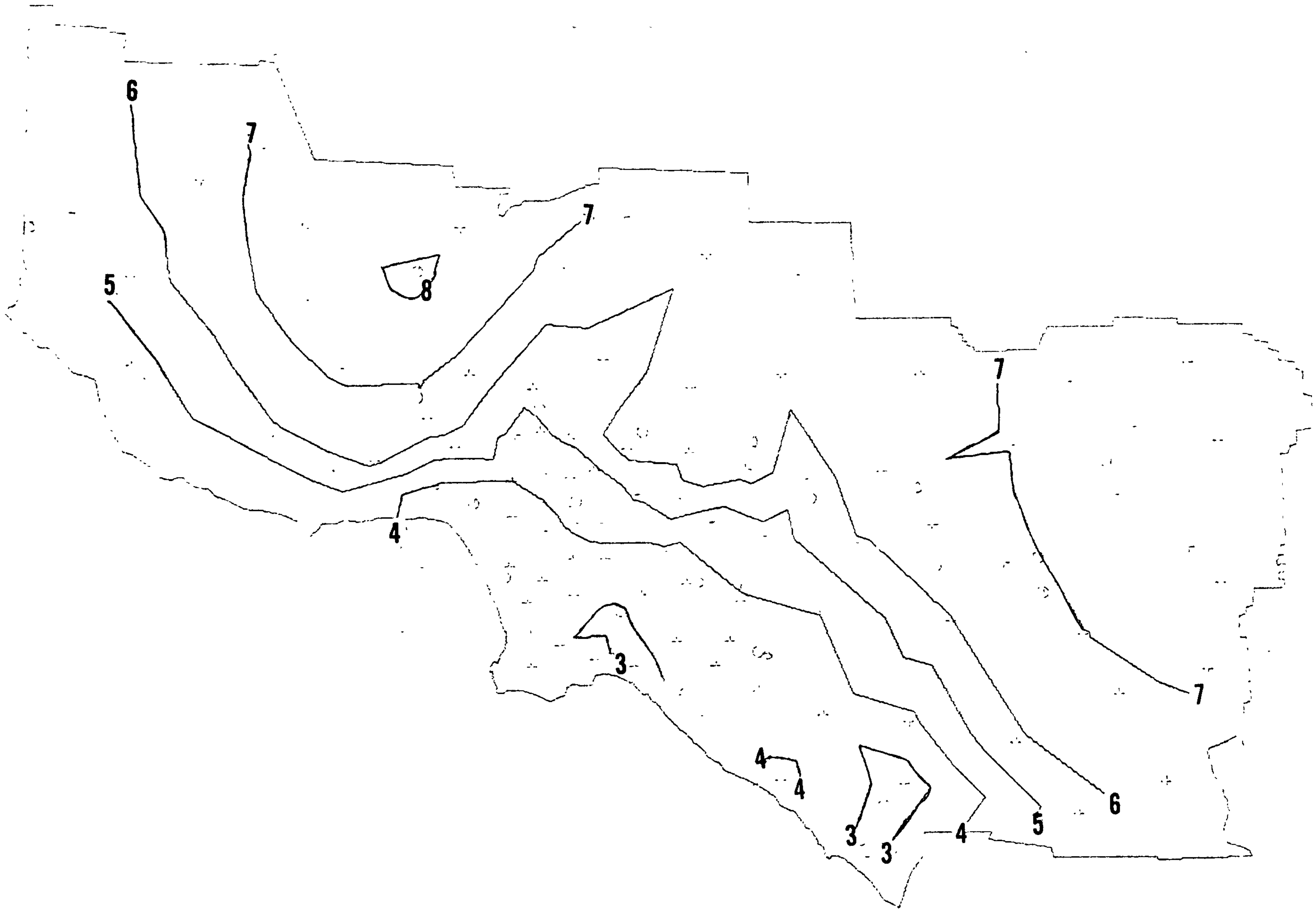


Figure 3.2 ISOPLETHS of mean duration (hours) on days when the NAAQS for oxidant was exceeded in 1973.

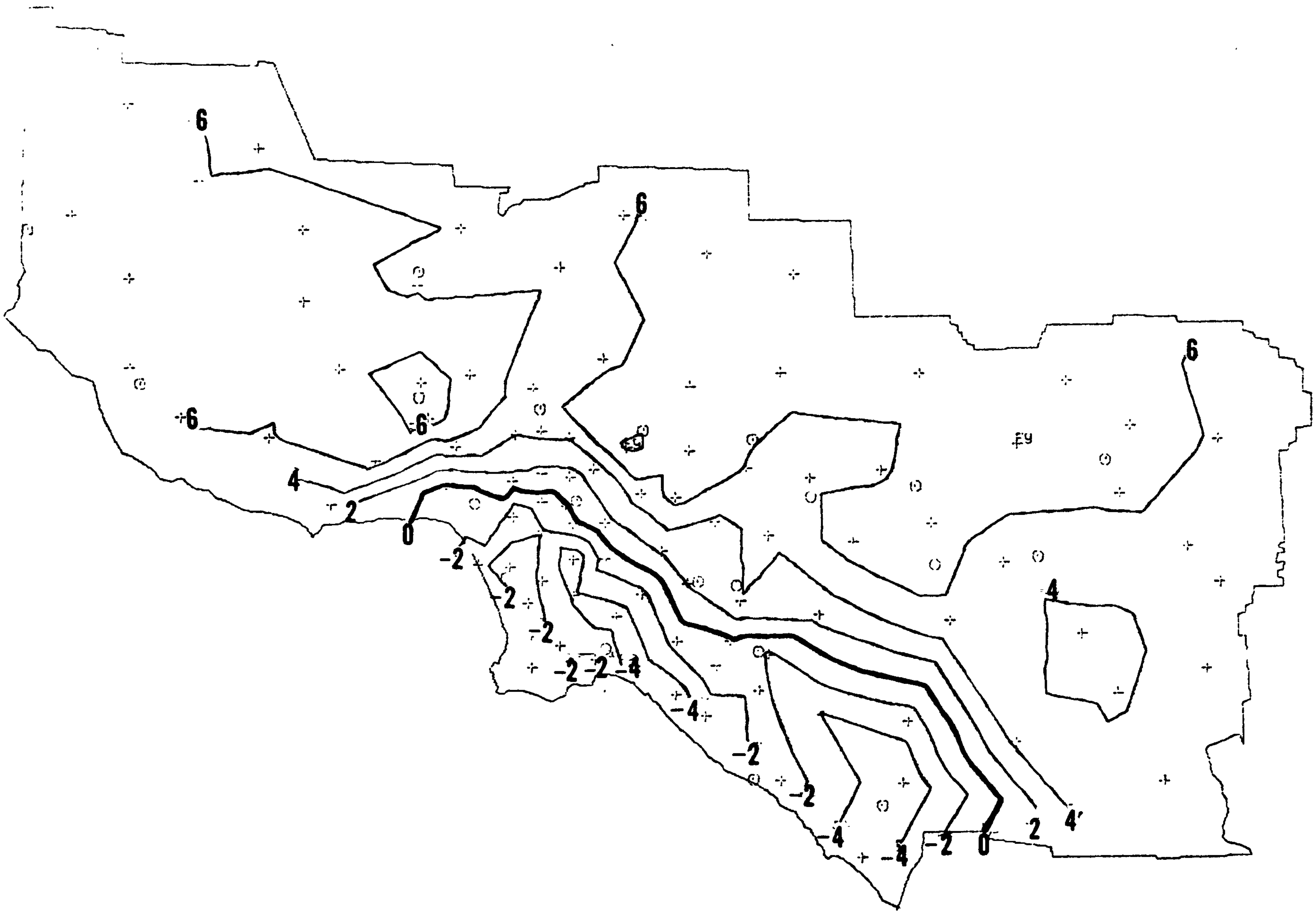


Figure 3.3. The difference in percent of the number of days on which the NAAQS for oxidant was exceeded in 1973, weekday minus weekend. (Dark line equals zero percent.)

Noting that the National Ambient Air Quality Standards (NAAQS) have been set to protect the public health, the percent of time (days or hours) the NAAQS for O_x was violated would be indicative of the state of air quality to which the public is exposed. The people in the Los Angeles AQCR, therefore, are stratified according to the frequency of the NAAQS violations. Figure 3.4 shows the three distributions of the population stratified according to the percent of days exceeded during all time, weekday, and weekend. It can be seen from the figure that more people incur the most frequent as well as the least frequent daily exposure above the NAAQS during weekdays than weekends. This is because the frequency of O_x exposure above the NAAQS is more uniform through the Basin on weekends. On the average, however, the population in the Los Angeles Basin receives 1.5 percent less frequent daily exposure above the NAAQS during weekends (Table 3.1).

Figure 3.5 shows the distribution of the population exposed at various percents of hours the NAAQS was exceeded during all time, weekday, and weekend. The relations of the three curves are essentially the same as those seen in Figure 3.4. Also recall from Table 2.1 that the average duration of O_x exposure is generally less on weekends including the coastal stations. Therefore, it can be concluded that although poeple in the coastal areas are subjected to a more frequent exposure during weekends than weekdays, the population in the Los Angeles Basin on the whole are less frequently exposed to a concentration above the NAAQS during weekends than weekdays. These findings should be emphasized because the previous reports on the weekend effect have not considered population exposure.[5,6,7,8]

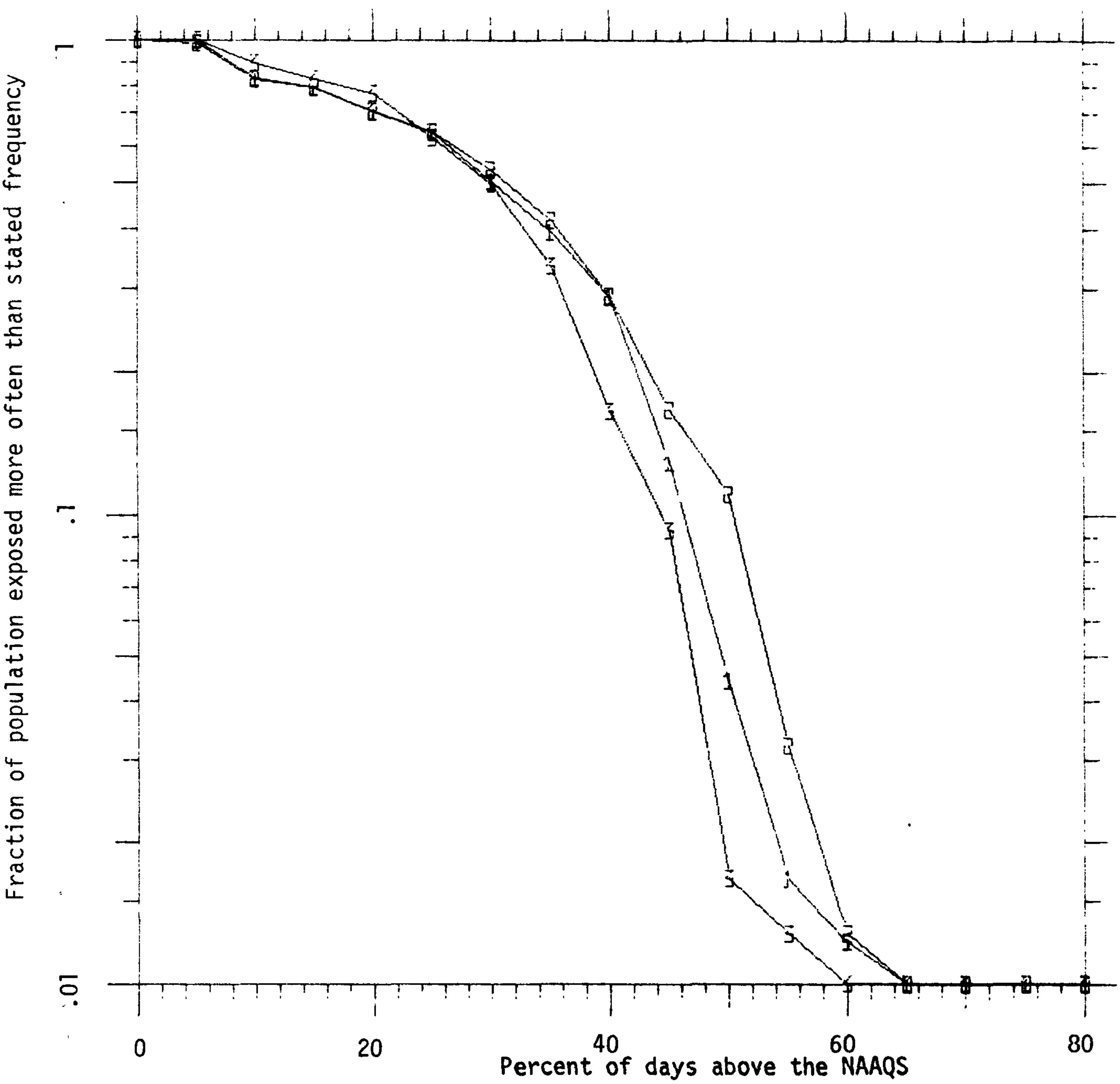


Figure 3.4 POPULATION EXPOSED TO O_x DAILY MAXIMUM HOURLY CONCENTRATION ABOVE THE NAAQS AT VARIOUS FREQUENCIES (1 FOR ALL TIME, 2 FOR WEEKDAY, 3 FOR WEEKEND).

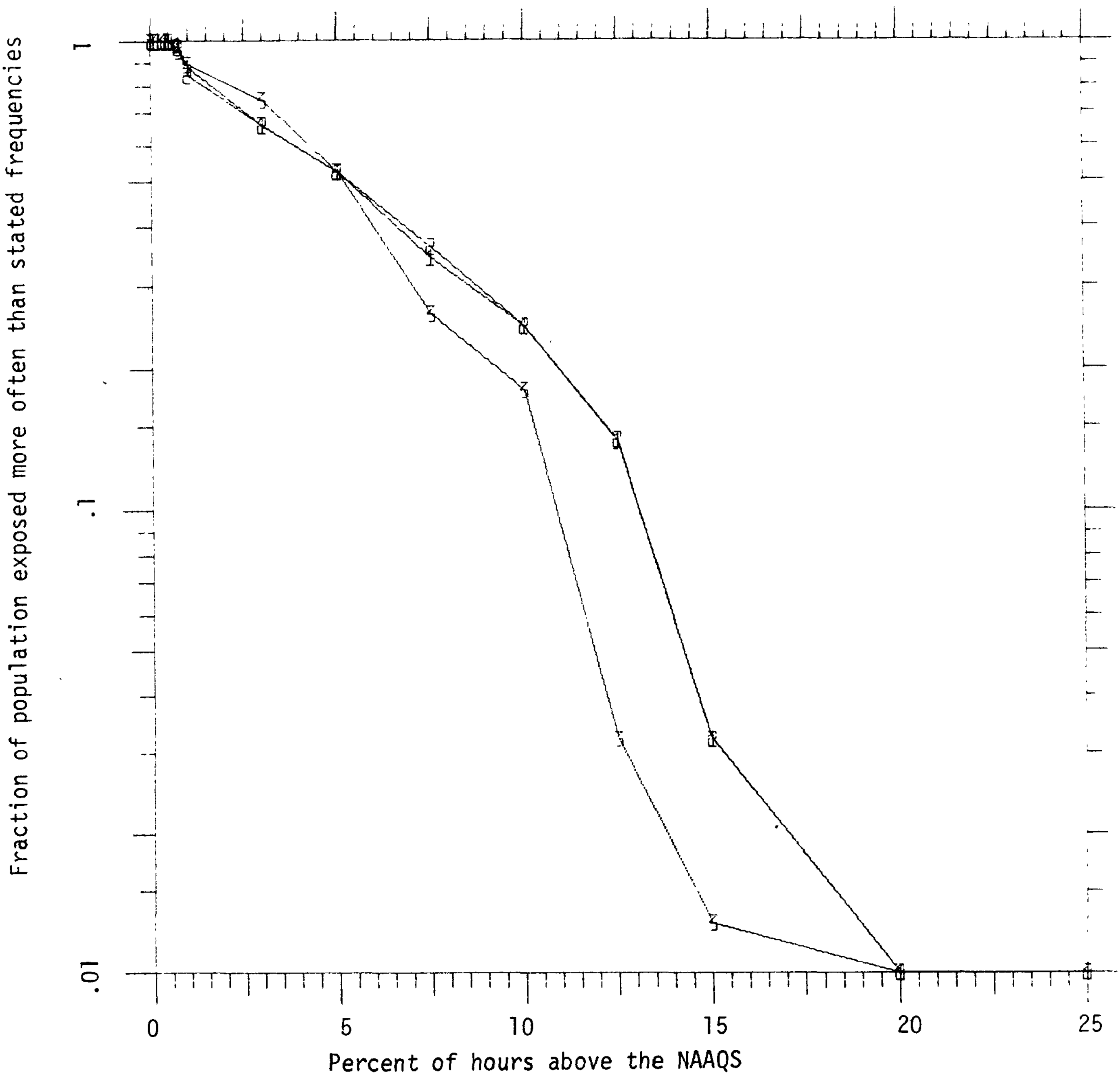


Figure 3.5 POPULATION EXPOSED TO O_x HOURLY CONCENTRATION ABOVE THE NAAQS AT VARIOUS FREQUENCIES (1 FOR ALL TIME, 2 FOR WEEKDAY, 3 FOR WEEKEND)

Table 3.1 Regionwide Impact of Weekday-Weekend Phenomena on Population Exposure to Photochemical Oxidants.

Time Period	Percent of Days Exceeded	Percent of Hours Exceeded
All Time	29.7 (29.4)	6.16 (5.96)
Weekday	30.1 (29.7)	6.31 (6.04)
Weekend	28.6 (28.6)	5.77 (5.77)
Weekday/Weekend Difference	+1.5 (+1.1)	+0.54 (+0.27)

( ): computed based on the mobile population assumption.

The regionwide impact of the weekday-weekend phenomena on population exposure to photochemical oxidants has been determined by computing the population weighted risk frequency for both hourly concentrations and daily maximum hourly concentrations. The results are summarized in Table 3.1. The regional averages of daily risk frequency and hourly risk frequency are, respectively, 29.7 percent of the days and 6.16 percent of the hours. In other words, an average person in the Los Angeles AQCR was exposed in 1973 to a concentration above the NAAQS 109 days per year or 540 hours per year.

The regional averages of daily risk frequency are 30.1 percent of the days during weekdays and 28.6 percent of the days during weekends. The regional averages of hourly risk frequency are 6.31 percent of the hours during weekdays and 5.77 percent of the hours during weekends. Therefore, it can be said that in 1973 an average person in the Los Angeles Basin received a less frequent exposure above the NAAQS during weekends than weekdays by 1.5 percent of the days or by 0.54 percent of the hours.

Table 3.1 also presents the regional averages of risk frequency, which were computed by considering diurnal population movement between residence and workplace. These refined estimates of regional average risk frequency are close to but a little less than those based on the static population assumption., i.e., people are locationally fixed to the place of their residence. According to the refined estimates, an average person in the Los Angeles Basin received less frequent exposure above the NAAQS during weekends than weekdays by 1.1 percent of the days or by 0.27 percent of the hours. The detailed method of how to compute population exposure by considering diurnal population mobility is described in Section 4.

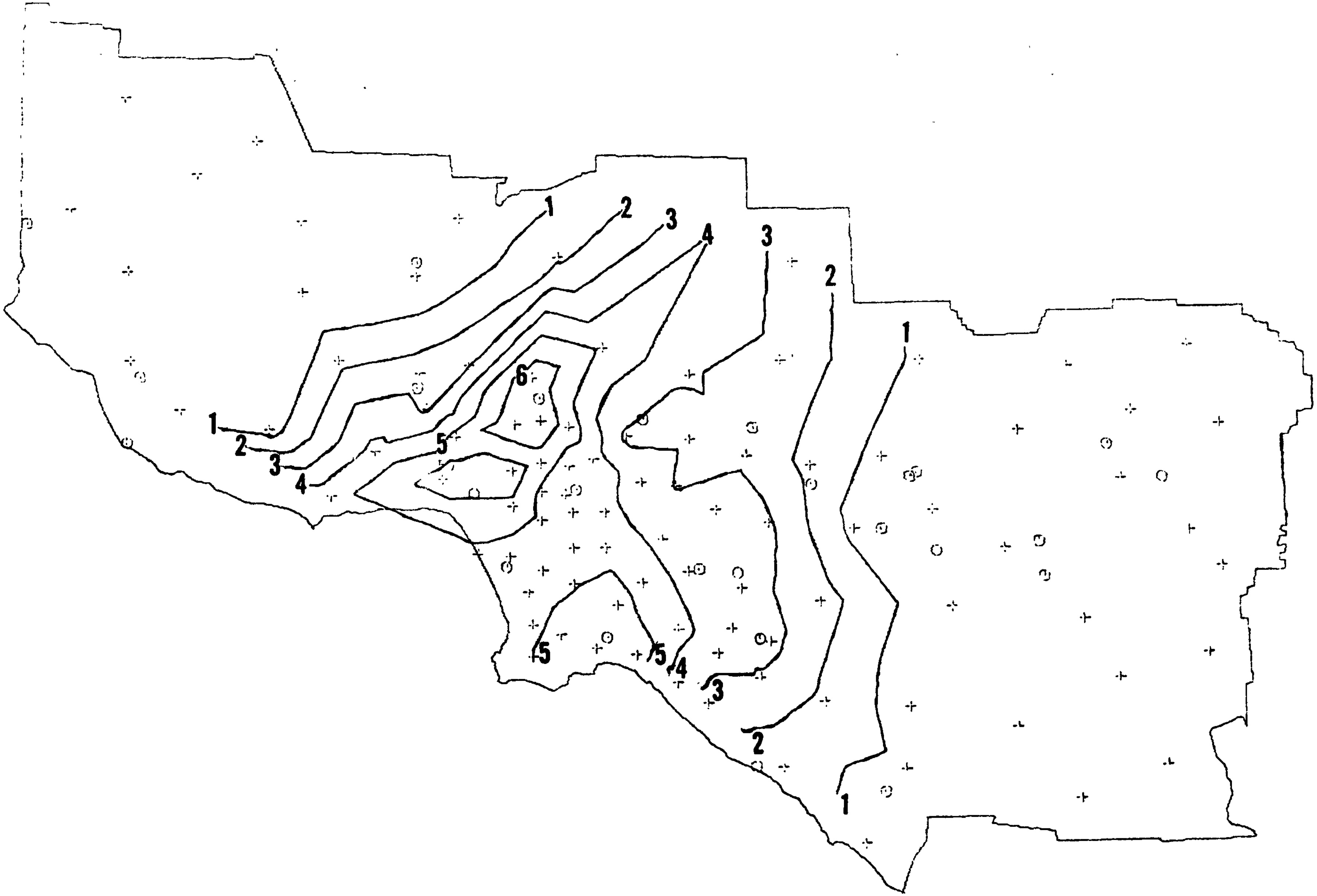


Figure 3.6 ISOPLETHS of percent of days on which the California one-hour standard for NO_2 was exceeded in 1973.

3.2 Weekday-Weekend Difference in NO_2

The spatial variation of NO_2 air quality over the Los Angeles AQCR is shown in Figure 3.6 in terms of the percentage of days on which the California Ambient Air Quality Standard (CAAQS) was exceeded. It can be seen from the figure that the percentage of days exceeded is the greatest (about 5% of days) in the urban core areas consisting mainly of Los Angeles and Long Beach Cities and decreases toward the surrounding areas where the CAAQS was exceeded only 1% of the days or less. The spatial distribution pattern of the percentage of days exceeded is somewhat similar to that of population density (Fig. 2.5) and that of employment density (Fig. 2.6). This similarity between NO_2 air quality and human activity distribution pattern would be indicative that NO_2 air quality is more strongly affected by local emissions than O_x air quality whose spatial distribution pattern does not show any particular resemblance to either the population density pattern or the employment density pattern.

Figure 3.7 shows the spatial variation of the mean duration of standard violations in hours per day. The longest duration (3.5 hours per day) occurred at the northern part of Orange County. It is interesting to note that the spatial pattern of the mean duration shifts south-eastward from that of the percentage of days exceeded.

Figure 3.8 was prepared to show the weekday-weekend difference in air quality. The air quality difference is expressed in terms of the difference in the percentage of days exceeded during weekdays and weekends. It can be seen from the figure that most of Orange and Riverside counties have a negative value indicating a poorer air quality during weekends than weekdays, and

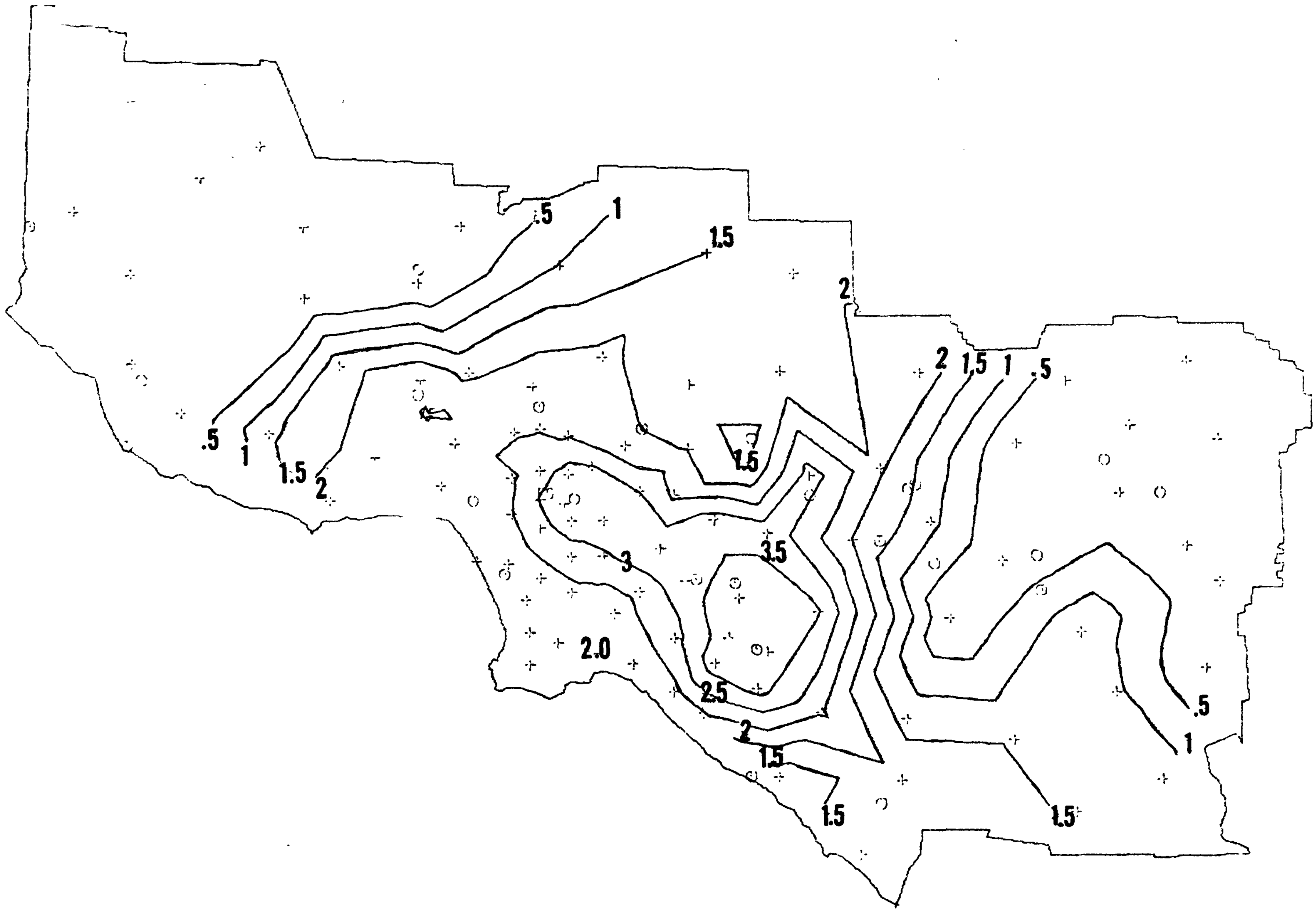


Figure 3.7. ISOPLETHS OF MEAN DURATION (HOURS) ON DAYS WHEN THE CALIFORNIA ONE-HOUR STANDARD FOR NO_2 WAS EXCEEDED IN 1973

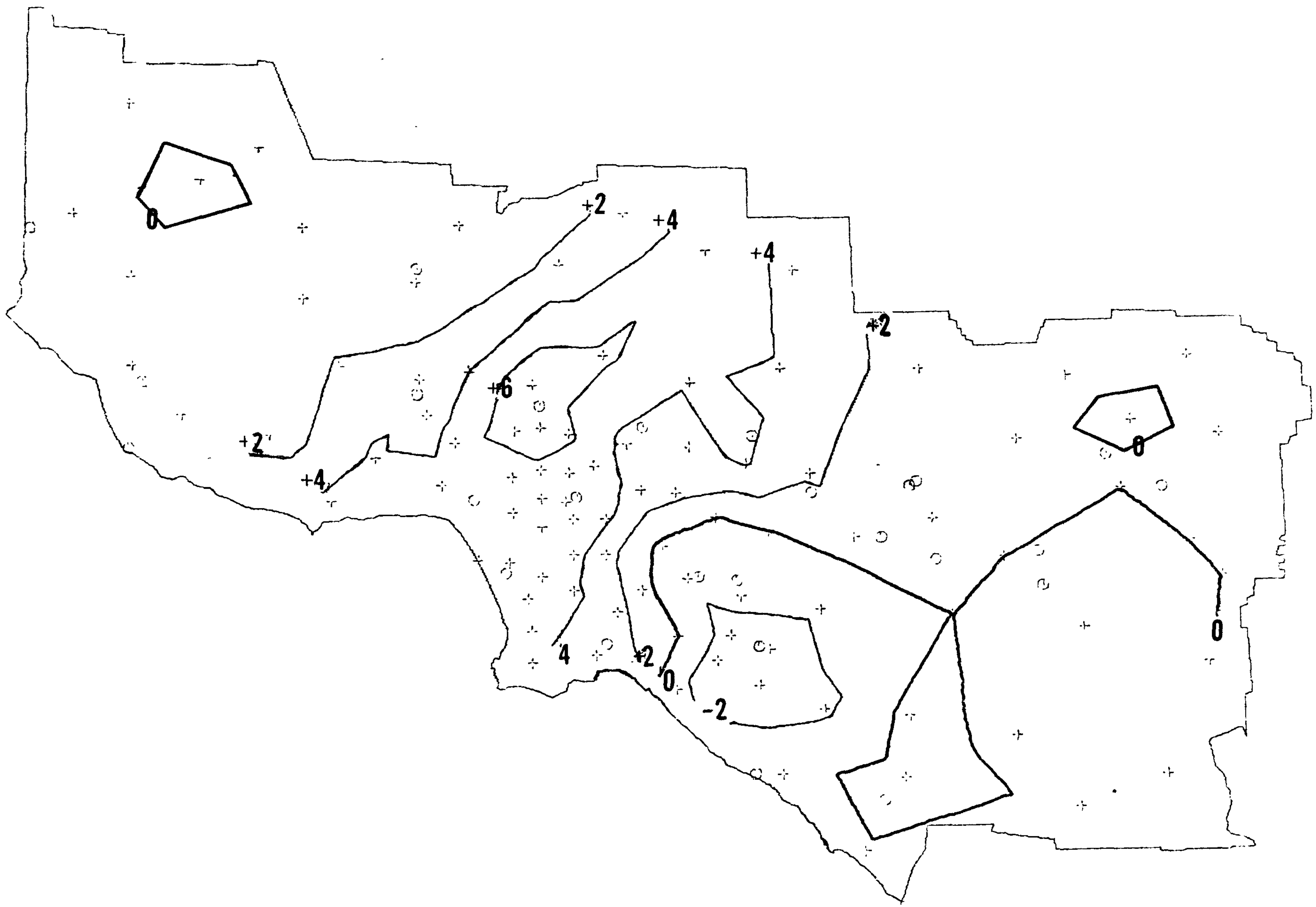


Figure 3.8. THE DIFFERENCE IN PERCENT OF DAYS ON WHICH THE CALIFORNIA ONE-HOUR STANDARD FOR NO_2 WAS EXCEEDED IN 1973, WEEKDAY MINUS WEEKEND. (DARK LINE EQUALS ZERO PERCENT.)

that the majority of Ventura, Los Angeles, and San Bernardino counties have a positive value indicating a better air quality during weekends than weekdays.

Using the static population assumption, the distribution of the population exposed at various frequencies of standard violations (population-at-risk distribution) has been determined for both NO_2 hourly average concentrations and NO_2 daily maximum hourly concentrations. Figure 3.9 shows the distributions of the population exposed at various percentages of days exceeded during three time periods; all time, weekdays, and weekends. It can be seen that the entire population is exposed for a smaller percentage of days during weekends than weekdays. An average person in the Los Angeles AQCR is exposed to NO_2 air pollution above the CAAQS 4.4% of the days during weekdays, and only 2.1% of the days during the weekends (Table 3.2).

The distribution of the population exposed at various percentages of hours exceeded is shown in Figure 3.10. Again, the entire population is exposed for a smaller percentage of hours above the CAAQS during weekends than weekdays. Therefore, it can be concluded that people in the Los Angeles AQCR are less frequently exposed to a concentration above the CAAQS during weekends than weekdays because of the markedly better NO_2 air quality over weekends.

The regionwide impacts of weekday-weekend phenomena on population exposure to NO_2 are summarized in Table 3.2. The regional averages of daily risk frequency and hourly risk frequency are, respectively, 3.7 percent of the days and 0.46 percent of the hours. In other words, an average person in the Los Angeles Basin was exposed in 1973 to a concentration above the CAAQS 14 days per year or 40 hours per year. The regional averages of

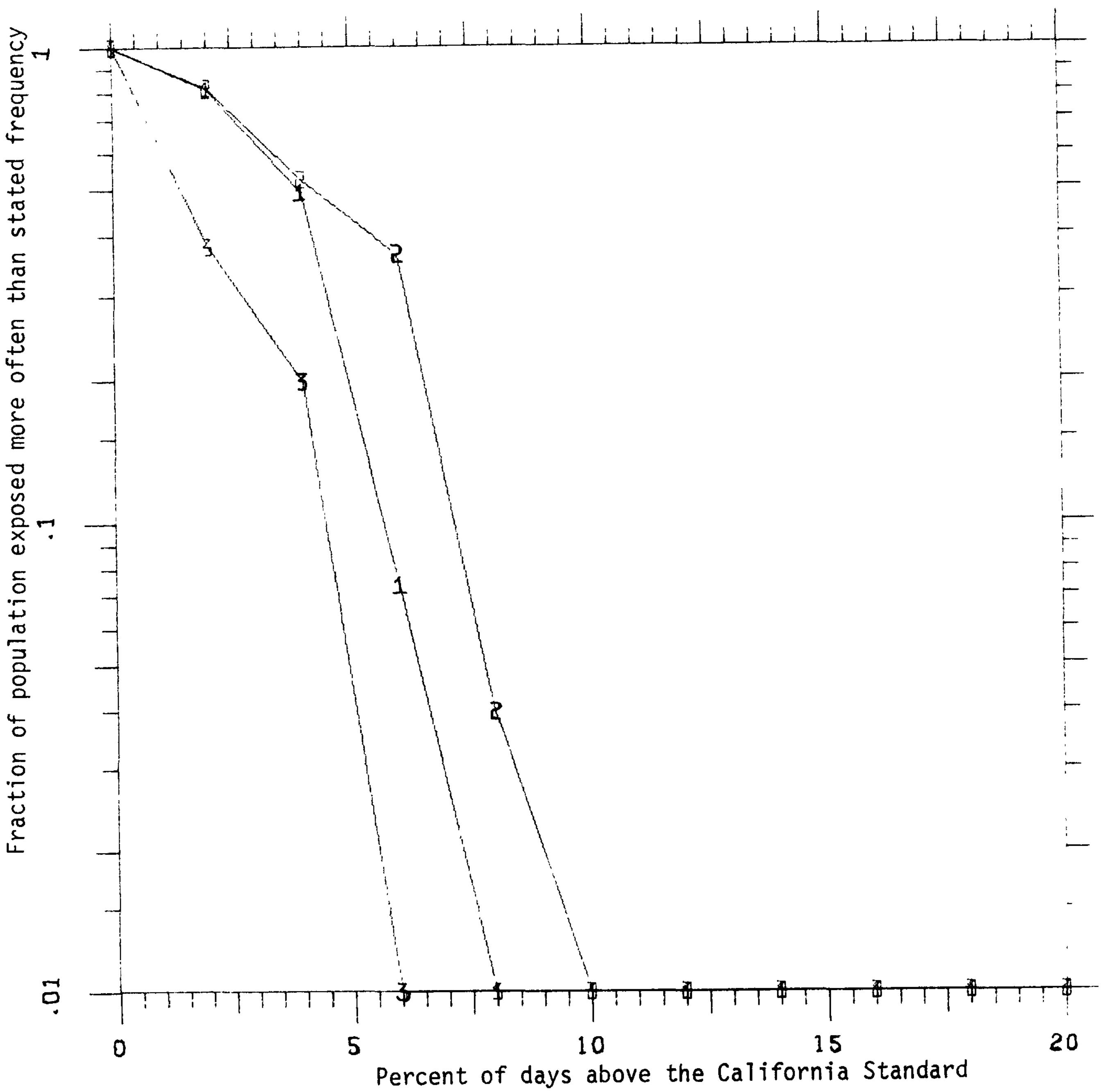


Figure 3.9. POPULATION EXPOSED TO NO_2 DAILY MAXIMUM HOURLY CONCENTRATIO ABOVE THE CALIFORNIA ONE-HOUR STANDARD AT VARIOUS FREQUENCI (1 FOR ALL TIME, 2 FOR WEEKDAY, 3 FOR WEEKEND)

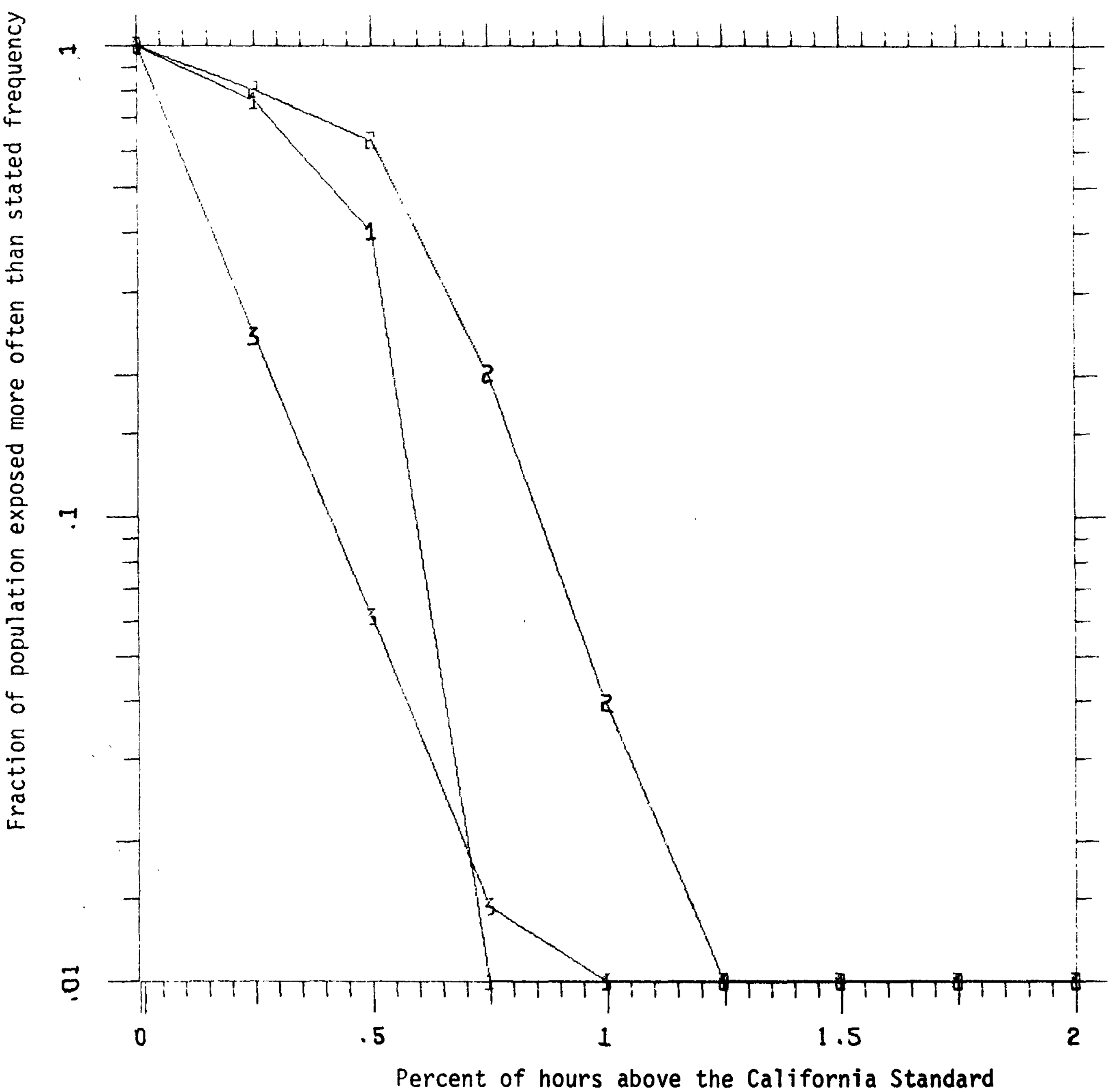


Figure 3.10 POPULATION EXPOSED TO NO_2 HOURLY AVERAGE CONCENTRATION ABOVE THE CALIFORNIA ONE-HOUR STANDARD AT VARIOUS FREQUENCIES (1 FOR ALL TIME, 2 FOR WEEKDAY, 3 FOR WEEKEND)

Table 3.2 Regionwide Impact of Weekday-Weekend Phenomena on Population Exposure to Nitrogen Dioxide.

Time Period	Percent of Days Exceeded	Percent of Hours Exceeded
All Time	3.7 (3.8)	0.46 (0.50)
Weekday	4.4 (4.5)	0.57 (0.63)
Weekend	2.1 (2.1)	0.18 (0.18)
Weekday/Weekend Difference	+2.3 (+2.4)	+0.39 (+0.45)

( ): computed based on the mobile population assumption.

daily risk frequency are 4.4 percent of the days during weekdays and 2.1 percent of the days during weekends. The regional averages of hourly risk frequency are 0.57 percent of the hours during weekdays and 0.18 percent of the hours during weekends. Therefore, it can be said that in 1973 an average person in the Los Angeles Basin received a less frequent exposure above the CAAQS during weekends than weekdays by 2.3 percent of the days or by 0.39 percent of the hours.

Table 3.2 also presents the regional averages of risk frequency, which were computed by considering diurnal population movement between residence and workplace. The refined estimates of regional average risk frequency are close to but a little greater than those based on the static population assumption. According to the refined estimates, an average person in the Los Angeles Basin received less frequent exposure above the CAAQS during weekends than weekdays by 2.4 percent of the days or by 0.45 percent of the hours. The detailed method for computing population exposure for a mobile population is discussed in the next section.

3.3 RELATING WEEKDAY-WEEKEND DIFFERENCE IN EMISSIONS TO AIR QUALITY

According to a TRW study[9], auto use on weekends is less than on weekdays in the Los Angeles Basin. It is estimated that total auto trips decrease around 22% on weekends while total VMT (Vehicle Miles Traveled) decreases around 30%. Although a number of unknown factors such as stationary source contributions and relationships between VMT and emissions are involved, we can expect similar decreases in emissions of precursor pollutants (hydrocarbons and oxides of nitrogen) on weekends.

The reduced levels of precursor pollutant emissions on weekends should be compared with decreases in population exposure to O_x and NO_2 during weekends. From Table 3.1, population exposure to O_x decreases on weekends by (1.5/30.1) x 100 = 5.0% in daily risk frequency and (0.54/6.31) x 100 = 8.6% in hourly risk frequency. From Table 3.2, population exposure to NO_2 decreases on weekends (2.3/4.4) x 100 = 52% in daily risk frequency and (0.39/0.57) x 100 = 68% in hourly risk frequency. Therefore, the decrease in population exposure to O_x is less than that in precursor pollutant emissions while that in population exposure to NO_2 is greater than that in precursor pollutant emissions.

4. EFFECTS OF DAILY POPULATION MOBILITY ON POPULATION EXPOSURE

In the preceding sections, the analysis of population exposure to photochemical air pollution was made based on the static population assumption which assumes that every person stays close to his resident location. As mentioned in Section 2.3, the static population assumption should be adequate for quasi-stationary segments of the population such as elderly and school-age, but would not hold for the working population because that population spends a large part of their time at their working places where the air environment may be quite different from that of their residential locations.

Therefore, in this section, Worker population is treated as follows: Exposure of the population to O_x air pollution above the NAAQS during working time (weekdays from 7 A.M. to 6 P.M.) occurs at their place of employment and exposure during non-working time (the rest of the time) occurs at their place of residence. Distribution of people exposed at various risk frequencies (hereafter termed "population-at-risk distributions") is computed separately during working time and non-working time. Population-at-risk distribution during all times is then computed from those during working time and non-working time. Population-at-risk distribution for the non-workers population is computed by using the static population assumption. Finally, the population-at-risk distribution for the total population is computed by combining those of Workers and Non-Workers.

4.1 POPULATION-AT-RISK DISTRIBUTION FOR STATIC AND MOBILE POPULATIONS

For the mobile population analysis, the exposure of workers during working time is assumed to occur at their place of employment. For the static population analysis, it is assumed to occur at their place of residence. Therefore, the difference in the exposure of the mobile population and the static population occurs during working time only. Figure 4.1 was prepared to show the difference in 0_x exposure of Workers during working time at their residence and at their work places. The Worker population at their work place was computed from the employment statistics prepared by the Southern California Association of Governments (SCAG)[1] (Table A1). The Workers population at their residence was computed from the 1970 census data[2] and SCAG's estimates of total population in 1970 and 1975 (Table A1). It is seen from the figure that the population exposure at their work places is less than that at their residences. Therefore, it can be said with respect to 0_x air pollution in the Los Angeles AQCR, that workers on the whole benefit by working at places with a cleaner air environment than they would have if they stayed home during working time.

In order to obtain the population-at-risk distribution for the mobile workers during all time from those during working time and non-working time, we have to go back to a risk frequency of an individual worker, and have to compute the risk frequency of that worker during all time from those during working time and non-working time (Appendix D). This is quite a contrast to the static workers whose population-at-risk distribution during all time is computed from a risk frequency during all time.

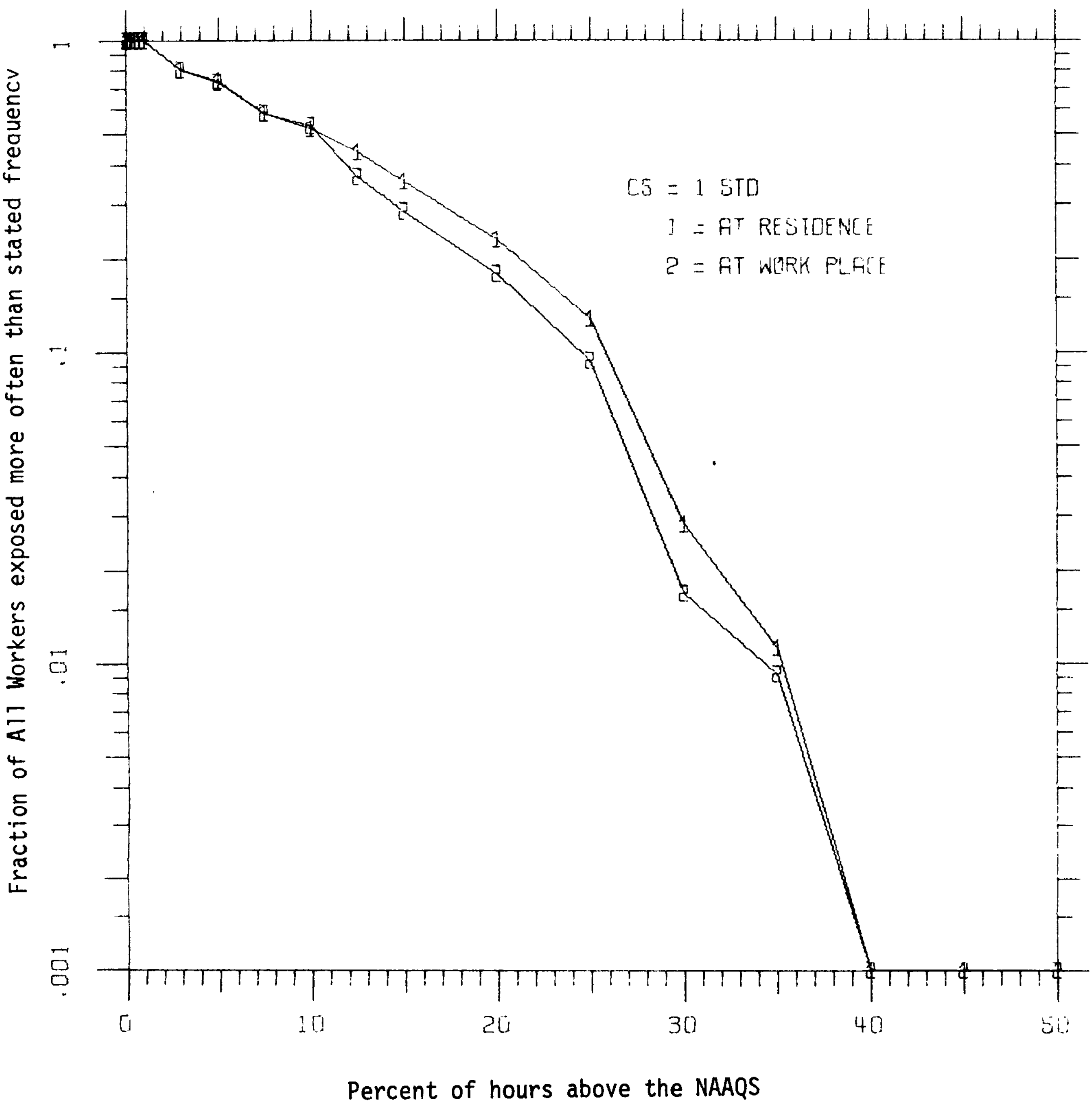


Figure 4.1. WORKERS EXPOSED TO O_x HOURLY CONCENTRATION ABOVE THE NAAQS DURING WORKING TIME AT THEIR RESIDENCE AND AT THEIR WORK PLACE

A difficulty arises in computing the risk frequency of a mobile worker during all time from that during working time at his work place and that during non-working time at his residence. The difficulty is caused by the lack of information of an individual worker's mobility between residence and work place.

Although we have information about the worker population at their work place and their residence, we do not have an origin-destination relationship that informs us of each individual worker's residence and work place.

To alleviate the difficulty caused by the lack of origin-destination information, the hypothesis is employed that exposures of a worker during working time and during non-working time are statistically independent. Under this hypothesis, the probability density of a worker having a given risk frequency during all time is given by the convolution of those during working time and non-working time as:[10]

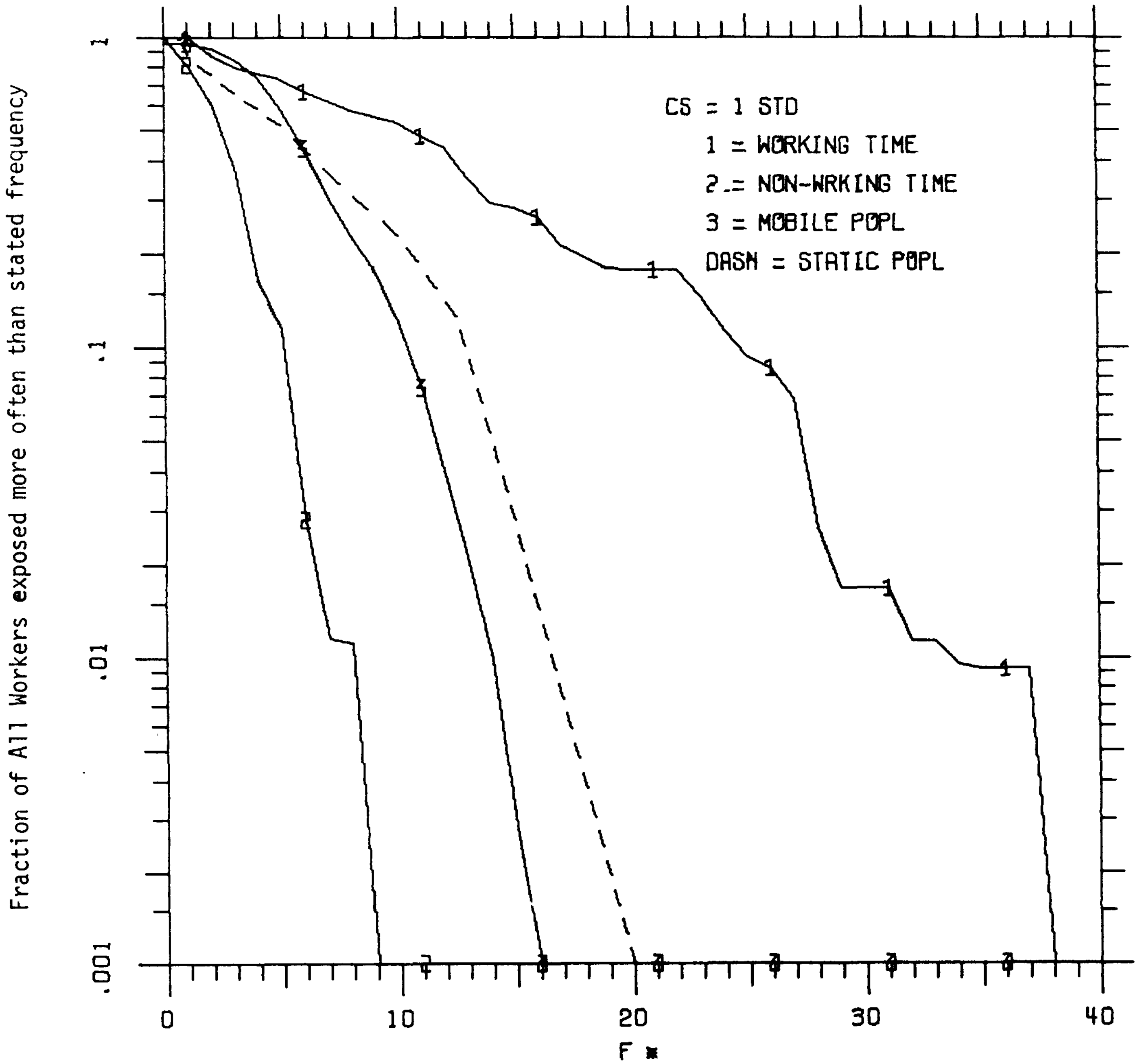
$$\mathrm{Prob}(R^* = j) = \sum_{k=o}^{j} \mathrm{Prob}(R^*_W\ T_W/T = k)\mathrm{Prob}(R^*_n\ T_n/T = j - k) \qquad (4\text{-}1)$$

where R^* is the risk frequency during all time T, R^*_W that during working time T_W and R^*_n that during non-working time T_n. The following relationship exists between R^*, R^*_W, and R^*_n,

$$R^* = R^*_W\ T_W/T + R^*_n\ T_n/T \qquad (4\text{-}2)$$

The population-at-risk distribution for the mobile workers analysis during all time was determined from those during working time and non-working time by using Eqs. (4-1) and (4-2). The resulting population-at-risk distribution during all time (curve 3) is compared in Fig. 4.2 with that for the static workers analysis during all time (dashed curve), that at work places during working time (curve 1), and that at residence locations during non-working time (curve 2). The results clearly show that irrespective of the mobile or the static assumption, the greatest exposure of the Workers population occurred during working time. This finding is consistent with our understanding that oxidant air pollution is confined to daylight hours. At the same time, this fact may support the importance of population mobility consideration in a population exposure estimate. By comparing the population-at-risk distribution for the mobile population (curve 3) to that for the static population (dashed curve) which would have resulted from workers always staying at their residence locations, some differences are noted. To highlight the differences between the two curves, their histograms are shown in Figure 4.2a. It is seen that fewer members of the mobile workers population are annually subjected to the most frequent, as well as the least frequent, exposure to 0_x above the NAAQS than those of the static workers population.

The influx of workers into the business districts during working time is exhibited in Figure 2.7. A comparison of this population mobility map and the isopleth map of oxidant air quality (Figure 3.6) shows that the daytime population moves from residential areas of the highest 0_x concentrations as well as of the lowest 0_x concentrations to the business districts where the oxidant



Percent of Hours Above the NAAQS

Figure 4.2 EXPOSURE OF ALL WORKERS TO OXIDANTS ABOVE THE NAAQS DURING WORKING TIME (1), NON-WORKING TIME (2), COMBINATION OF (1) AND (2) AS (3), AND TOTAL TIME (--). [The --- curve gives the overall percent of hours that a given fraction of all the workers is exposed to O_3 above the NAAQS under the assumption of static population, while the third curve does the overall percent of hours under the assumption of mobile population.]

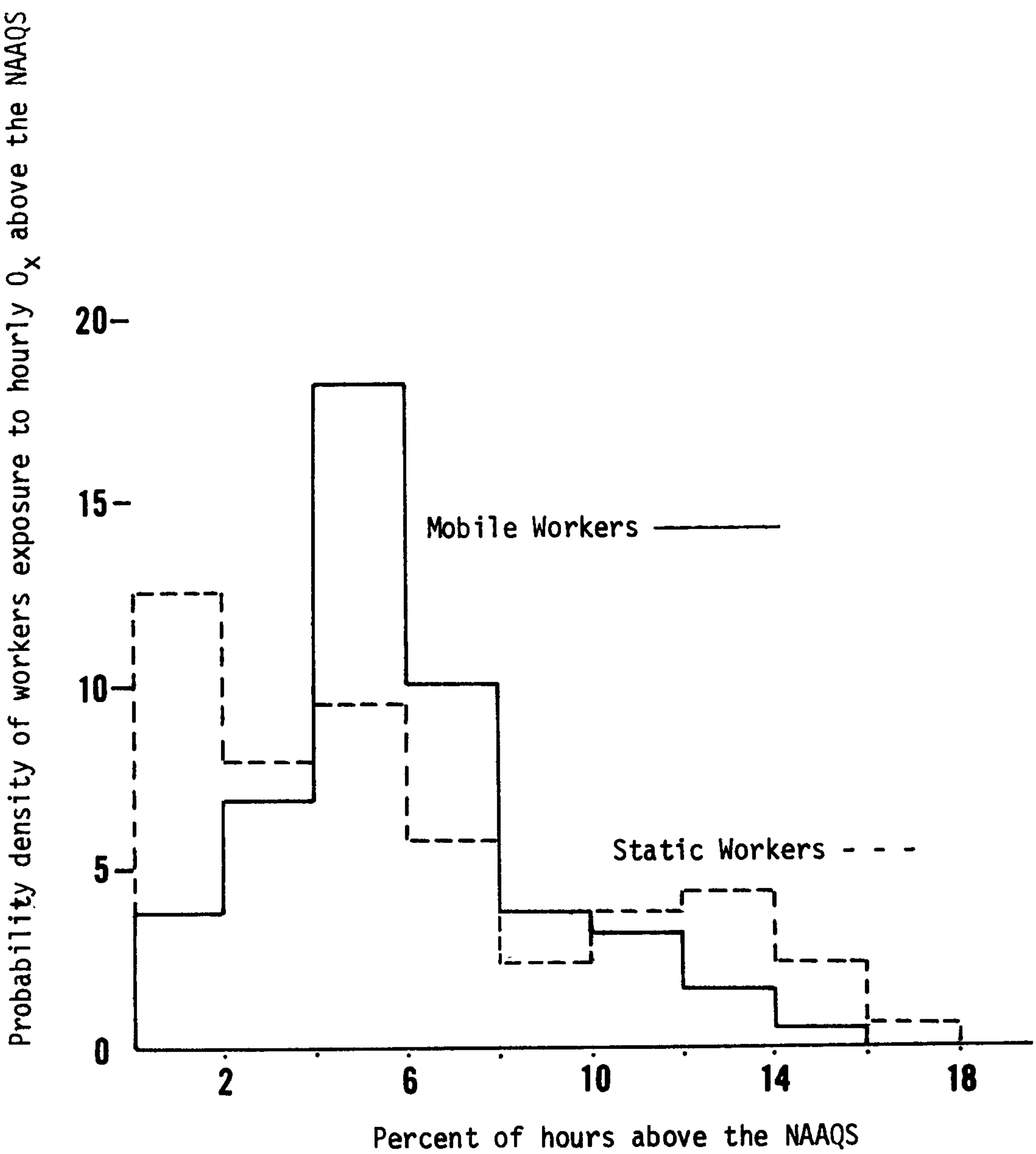


Figure 4.2a PROBABILITY DENSITY DISTRIBUTION OF WORKERS EXPOSED TO HOURLY O_X ABOVE THE NAAQS

air quality is in between the two extremes. These patterns of workers' daily mobility would explain the differences observed in the distribution of exposures between the mobile workers analysis and static workers analysis.

Although the incorporation of population mobility consideration into population exposure analysis has resulted in a lower estimate of population exposure to O_x than the static population assumption, the same consideration would result in a less conservative estimate of population exposure to NO_2. The reason for this is that the daytime population moves from residential areas of lower NO_2 concentrations to the business districts where NO_2 concentrations are higher. Therefore, the population mobility consideration in population exposure analysis for Los Angeles would be more crucial for NO_2 and primary pollutants such as TSP, CO, SO_2 and hydrocarbons produced in commercial districts in identifying the population at an extreme risk than for O_x and other secondary pollutants such as sulfate, nitrate and photochemically produced aerosols which are subject to transport.

The O_x population-at-risk distribution for the mobile total population during all times was obtained by linearly combining those for the mobile workers population and the non-workers population. In Figure 4.3 the population-at-risk distribution of the mobile total population (curve 3) is compared to that of the static total population (dashed curve). The comparison shows that the static population assumption overestimates the number of people of the Total population who were exposed at the highest and the lowest risk frequency but underestimates

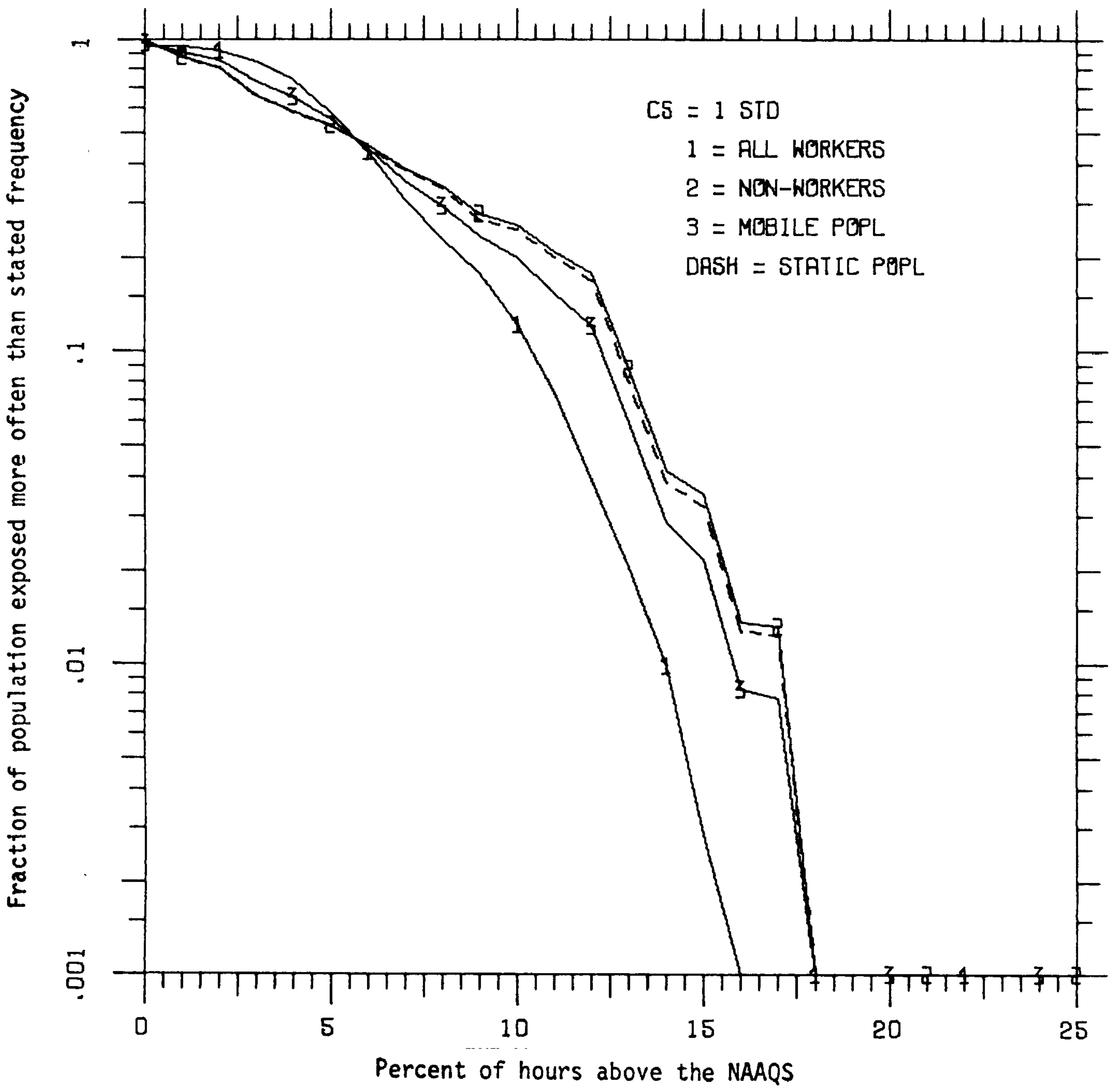


Figure 4.3 POPULATION EXPOSURE TO OXIDANTS ABOVE THE NAAQS (1 FOR WORKERS, 2 FOR NON-WORKERS, 3 FOR MOBILE TOTAL POPULATION, and -- FOR STATIC TOTAL POPULATION).

the number of people who were exposed at a risk frequency in the middle range. Figure 4.3 also shows that Workers were exposed at a smaller range of risk frequency than Non-Workers.

4.2 Significance of Population Mobility in Population Exposure Estimates

It was shown in the preceding section that incorporation of daily population mobility into the analysis improves our estimates of the distribution of population subjected to different degrees of exposure to air pollution. However, in reporting the state of air quality over a given region, it is more relevant to know the change of some index from one year to another year than to know a detailed population distribution for different degrees of exposure when the latter is difficult to estimate correctly. Thus, we ask, is the static population model adequate for estimating gross indices of population exposure such as regional average of risk frequency $\overline{R}$?

In computing the regional average of risk frequency for a mobile population, we do not have to have the population-at-risk distribution which required a complex computation involving the convolution given by Eqs. (4-1) and (4-2). The regional average of risk frequency during all time T can be computed directly from those during working time T_W and non-working time T_n as

$$R(C_S) = T_W\{\overline{R}_W(C_S) + T_n\,\overline{R}_n(C_S)\}/T \qquad (4\text{-}3)$$

where $\overline{R}(C_S)$ is the average risk frequency during all time, $\overline{R}_W(C_S)$ that during working time and $\overline{R}_n(C_S)$ that during non-working time. This was done for both weekdays and all time.

Using Eq. (4-3), the average risk frequency for the mobile workers population during weekdays was computed from that for Workers at their work place during working time and that for Workers at their residence during weekday non-work time. The average risk frequency for the static worker's population during weekdays was computed from that for Workers at their residence during working time and that during weekday non-working time. Similarly, the average risk frequency for the mobile workers population during all times was computed from that for Workers at their work place during working time and that for Workers at their residence during non-working time. And the average risk frequency for the static workers during all times was computed from that for Workers at their residence during working time and that during non-working time.

The average exposure of the mobile workers population and that of the static workers population to O_x are given in Table 4.1, while those to NO_2 are given in Table 4.2. The average exposure of the mobile total population and that of the static total population are also given in Tables 4.1 and 4.2. The average exposure of the Total population P_o (either mobile or static) was computed from that of Workers population P_W and that of Non-worker population P_n by

$$\overline{R}(C_S) = \{P_W \, \overline{R}_W(C_S) + P_n \, \overline{R}_n(C_S)\}/P_o \qquad (4\text{-}4)$$

Table 4.1 shows that the static population model estimated the average risk frequencies for Workers population during all times as 5.87 percent of the total number of hours and 28.8 percent of the total number of days, while

Table 4.1 Effect of the Consideration of Population Mobility on the Estimates of Population Exposure to O_x in the 1973 Study Area.

Time	Model	Workers	Total Population
Weekday	Static	5.96[1] (29.8)[2]	6.22 (30.1)
	Mobile	5.53 (28.8)	6.04 (29.7)
	Amount of Misestimate	+0.43 (+1.0)	+0.18 (+0.4)
All Time	Static	5.87 (29.0)	6.09 (29.7)
	Mobile	5.57 (28.7)	5.96 (29.4)
	Amount of Misestimate	+0.46 (+0.7)	+0.13 (+0.3)

1. Percent of hours above the NAAQS.
2. Percent of days above the NAAQS.

Table 4.2 Effect of the Consideration of Population Mobility on the Estimates of Population Exposure to NO_2 in the 1973 Study Area.

Time	Model	Workers	Total Population
Weekday	Static	0.594[3] (4.56)[4]	0.572 (4.37)
	Mobile	0.726 (4.92)	0.626 (4.55)
	Amount of Misestimate	-0.132 (-0.36)	-0.054 (-0.18)
All Time	Static	0.476 (3.86)	0.460 (3.74)
	Mobile	0.570 (4.12)	0.499 (3.84)
	Amount of Misestimate	-0.094 (-0.26)	-0.039 (-0.10)

3. Percent of hours above the California one-hour standard.
4. Percent of days above the California one-hour standard.

the mobile population model as 5.57 percent of the hours and 27.4 percent of the days. For the total population, the static population model estimated the average risk frequencies during all times as 6.09 percent of the hours and 29.0 percent of the days, while the mobile population model as 5.96 percent of the hours and 28.9 percent of the days. The relative misestimates of the average risk frequency for Workers population by the static population model are (0.46/5.57) x 100 = 8.3% in hourly risk frequency and (1.4/27.4) x 100 = 5.1% in daily risk frequency. These misestimates for Workers population should be compared to those for the Total population which are (0.13/5.96) x 100 = 2.2% in hourly risk frequency and (0.1/28.9) x 100 = 0.3% in daily risk frequency. Therefore it can be said that the relative misestimates for O_x by using the static population model are less than 9% for Workers population and less than 3% for Total population.

From Table 4.2, the corresponding relative misestimates for NO_2 by the static population model are (0.094/0.570) x 100 = 16.5% in hourly risk frequency and (0.26/4.12) x 100 = 6.3% in daily risk frequency for Workers population, and (0.039/0.499) x 100 = 7.8% and (0.10/3.84) x 100 = 2.6% for Total population. Therefore, it can be said that the relative misestimates for NO_2 by using the static population model are less than 17% for Workers population and 8% for Total population.

The above analysis shows that the magnitude of relative misestimates by the static population model is greater for Workers population than Total population, and for NO_2 than O_x. These findings are consistent with our understanding that since Workers population constitutes only about 40% of

Total population, the effects of diurnal population mobility are less pronounced when considered for the Total population, and that since NO_2 concentrations are highest in business districts, while O_x concentrations are moderate, the effects of population mobility are more pronounced for NO_2.

Analytical Errors

When the mobile population model is applied to estimate population exposure, the air quality data as well as the population data have to be prepared for a number of different time categories. The generation of the percentile concentration statistics from each subset of the air quality data introduce some error in the approximate population-at-risk distributions. This resulted in small errors in the computations of the population exposure parameters from each subset of the air quality and the population data. Let us compare the numbers appearing in Tables 3.1 and 3.2 with those appearing in Tables 4.1 and 4.2 which were prepared independently of Tables 3.1 and 3.2. For example, the average risk frequency of O_x for the static total population during weekday is 6.22 percent of hours in Table 4.1 while 6.31 percent of hours in Table 3.1. The error $|6.22-6.31| = 0.09$ is caused by subdivision of the air quality data during weekday into those during working time and those during weekday non-work time. This error caused by the air quality data subdivision should be compared with the error caused by the two different models, $|6.22-6.04| = 0.18$. The magnitude of the former error reaches as much as 50% of the latter.

From the facts described above, the mobile population model which demands far greater amounts of data preparation, processing, and analysis than does the static population model can be said to be of a limited value in computing the gross indices of population exposure. However, the population mobility consideration is critical for correctly identifying the population-at-risk, particularly for exposure of Workers population to primary pollutants which are spatially correlated with employment locations.

5. CONCLUDING REMARKS

Population exposure methodology was developed and applied to analyze the weekday-weekend effect and the effect of diurnal population mobility on population exposure estimates for two photochemical pollutants, O_x and NO_2 in the Los Angeles Basin. The following paragraphs summarize the findings and conclusions reached in this report.

Population Exposure Methodology

- Population exposure methodology was developed to specify local and/or regional air quality relative to the standards and to quantify population exposure to air pollution.
- Two new parameters, "risk frequency," and "mean duration" were introduced, and the method for determining these parameters from air quality and population data was developed.
- For each of the two parameters a computer algorithm was developed to obtain a distribution function and an aggregated index.
- The methodology and the computer algorithms for determining the population exposure variables for a mobile population were developed.
- Computer software for drawing a digitized regional map, isopleth map, and cumulative and density distribution charts were developed.

Weekday-Weekend Effects

- Spatial analysis of O_x and NO_2 air quality over the Los Angeles Basin was performed by (1) computing isopleths of daily risk frequency indicating a percentage of days on which the standard was exceeded and (2) computing isopleths of mean duration indicating an average number of hours per day for those days with violations of the standard.
- For O_x, the coastal region where the standard was exceeded less than 20% of the days was more polluted (by about 3% of the days) during weekends than weekdays. The inland region where the standard was exceeded more than 40% of the days was less polluted (by about 7% of the days) during weekends than weekdays.
- On an annual basis the population on the whole is exposed to O_x air pollution exceeding the NAAQS on a smaller percentage of both hours and days during weekends than weekdays. Therefore, it can be said that although oxidant concentrations become higher over weekends than weekdays at some coastal stations, the average exposure of the basinwide population to O_x is lower on weekends.

- For NO_2, the Los Angeles CBD and the surrounding area where the California standard was exceeded more than 4% of the days were less polluted (by about 4% of the days) during weekends than weekdays. Most of the Orange county and the Riverside county portion where the California standard was exceeded less than 3% of the days were more polluted (by about 1% of the days) during weekends than weekdays. This increase in NO_2 air pollution over weekends would probably be attributed to the weekend pleasure drives toward these areas.
- The population on the whole is exposed to NO_2 air pollution exceeding the California standard much less during weekends than weekdays in both the percentage of days and the percentage of hours.

Effects of Daily Population Mobility on Population Exposure

- Because of the daily population migration from residence areas of the worst O_x air pollution as well as the least O_x air pollution to the business districts of moderate O_x air pollution, fewer workers are annually subjected to the most frequent as well as the least frequent exposures above the NAAQS than there would be if they stayed home all the time. Workers on the whole benefit by receiving less frequent exposure above the NAAQS at their place of employment.

- Because of the daily population migration from residence areas of moderate to low NO_2 air pollution to the business districts of high NO_2 air pollution, most workers receive more frequent exposure above the California standard at their work places than they would have if they stayed home all the time.
- Population mobility considerations are important for determining the population-at-risk accurately. This is particularly true for the workers population.
- However, the population mobility consideration is not very critical in determining the aggregated indices of population exposure.

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APPENDIX A

DATA ON TOTAL POPULATION, WORKERS BY RESIDENCE, AND WORKERS BY EMPLOYMENT LOCATION IN 1973

Table A1. Total Population, Workers by Residence, and Workers by Employment Location in 1973.

RSA No.	Land Area (Sq. Mile)	Total Population	Workers* by Residence (%)	Workers by Employment Location
Ventura Co.				
1	919.0	358	33.6	98
2	325.0	114378	39.3	39742
3	194.0	147812	35.7	59934
4	137.0	73477	35.3	4278
5	150.0	64178	38.5	15370
6	139.0	10639	41.2	3327
Los Angeles Co.				
7	92.2	24313	40.7	9480
8	379.0	55252	37.7	7024
9	974.0	54036	39.3	14936
10	678.0	32696	35.3	14791
11	527.0	1889	34.5	1371
12	144.0	554377	45.0	202137
13	39.9	260043	48.8	136963
14	76.5	268710	39.1	58246
15	86.9	13970	46.1	2881
16	74.4	309625	48.7	137786
17	97.1	918773	48.1	440289
18	67.9	521836	47.4	256858
19	95.2	422898	39.2	151449
20	60.6	423399	41.9	194268
21	101.0	796281	35.8	480957
22	120.0	606388	41.5	163131
23	6.2	86028	44.0	326976
24	71.4	407910	45.0	140960
25	146.0	660751	43.1	246729
26	170.0	458794	38.4	121606
27	60.0	150001	38.9	66249
San Bernardino Co.				
28	236.0	244144	37.6	75212
29	231.0	304250	34.8	45054
30	806.0	22365	38.6	6125
31	9484.0	7898	20.9	4122
32	3034.0	79582	31.0	29055
33	3452.0	26400	21.1	9717
34	2880.0	5893	39.4	2513

Table A1. Total Population, Workers by Residence, and Workers by Employment Location in 1973.

RSA No.	Land Area (Sq. Mile)	Total Population	Workers* by Residence (%)	Workers by Employment Location
Orange Co.				
35	28.8	167859	38.9	37579
36	45.6	179490	42.7	92794
37	49.8	317642	42.7	111836
38	62.4	267211	38.4	53574
39	100.0	184327	42.5	88399
40	71.1	51876	36.2	12756
41	101.0	46988	37.1	10338
42	52.2	286413	41.4	119225
43	205.0	30956	36.5	5680
44	90.4	28439	19.3	24253
Riverside Co.				
45	61.1	38989	34.6	7587
46	354.0	236657	36.3	82241
47	289.0	26006	22.4	8009
48	129.0	40472	28.3	10511
49	504.0	13414	30.0	3082
50	238.0	27540	31.1	6203
51	709.0	3561	34.6	903
52	478.0	58977	39.1	19117
53	347.0	40546	39.9	15155
54	4070.0	16476	36.8	7049
Imperial Co.				
55	4241.0	79747	33.9	20937

APPENDIX B

AIR QUALITY DATA FOR O_x AND NO_2 IN

Table B1. Corrected O_x daily maximum hourly average concentrations in 1973 (1 for all times, 2 for weekdays, 3 for weekends).

Table B2. Corrected O_x hourly average concentrations in 1973 (1 for all times, 2 for weekdays, 3 for weekends, 4 for working time, 5 for non-working time, 6 for weekday non-working time).

Table B3. NO_2 daily maximum hourly average concentrations for 1973 (1 for all times, 2 for weekdays, 3 for weekends).

Table B4. NO_2 hourly average concentrations in 1973 (1 for all times, 2 for weekdays, 3 for weekends, 4 for working time, 5 for non-working time, 6 for weekday non-working time).

Table B1. Corrected Ox daily maximum hourly average concentrations in 1973 (1 for all times, 2 for weekdays, 3 for weekends). All values in pphm.

NO.	STATION	OBS.	MAX	PERCENTILE 1	3	5	10	25	50	75
1	ANAHEIM									
	1	361	26.0	20.0	17.6	14.3	10.0	7.0	4.0	2.0
	2	259	26.0	20.0	15.0	13.0	10.0	7.0	4.0	2.0
	3	102	23.0	23.0	19.3	18.0	12.2	7.0	5.0	3.0
2	AZUSA									
	1	365	46.0	35.8	30.0	28.0	23.9	16.1	8.0	3.0
	2	261	46.0	38.4	32.1	28.0	23.3	17.0	8.9	3.0
	3	104	35.0	31.8	29.3	28.2	24.0	15.0	7.4	4.0
3	BURBANK-PALM									
	1	365	29.0	23.3	20.0	18.0	16.0	11.0	6.0	3.0
	2	261	29.0	25.6	20.0	17.3	16.0	11.1	6.0	3.0
	3	104	21.0	20.4	19.0	18.0	15.0	9.4	6.0	3.0
4	CAMARILLO-PALM									
	1	357	26.0	17.8	14.0	13.0	11.0	8.1	6.0	4.0
	2	255	26.0	21.4	14.8	13.0	11.0	9.0	6.0	4.0
	3	102	17.0	15.8	13.3	11.3	9.2	8.0	6.0	4.0
5	COSTA MESA									
	1	343	21.0	17.9	14.1	12.3	9.0	7.0	5.0	4.0
	2	252	21.0	16.0	14.0	11.8	9.0	7.0	5.0	3.0
	3	91	19.0	19.0	15.7	13.8	9.0	7.0	5.0	4.0
6	EL TORO									
	1	357	19.0	15.8	11.0	10.0	8.0	5.1	4.0	3.0
	2	256	19.0	13.8	11.0	10.0	7.0	5.0	4.0	3.0
	3	101	18.0	17.4	12.5	10.3	9.0	6.0	4.0	3.0
7	LA HABRA									
	1	362	30.0	24.0	22.0	20.0	15.0	9.0	5.0	3.0
	2	260	30.0	23.8	21.0	19.0	15.0	9.0	5.0	2.4
	3	102	24.0	24.0	23.3	23.0	18.2	8.0	5.0	3.0
8	LENNOX									
	1	365	24.0	12.5	10.0	8.1	6.0	5.0	3.0	3.0
	2	261	24.0	11.0	10.0	8.3	6.0	5.0	3.0	3.0
	3	104	14.0	13.4	9.6	8.2	7.0	6.0	4.0	3.0
9	LONG BEACH									
	1	364	20.0	13.8	9.0	8.0	7.0	5.0	3.0	2.0
	2	261	20.0	16.4	9.0	7.0	6.0	5.0	3.0	2.0
	3	103	11.0	9.7	8.0	8.0	7.0	6.0	4.0	3.0
10	L.A. DOWNTOWN									
	1	365	52.0	30.8	19.4	17.0	13.0	10.0	6.0	3.0
	2	261	52.0	31.0	19.6	17.0	13.0	10.0	6.0	3.0
	3	104	25.0	23.7	17.8	17.0	14.0	10.0	6.0	4.0

Table B1 (Continued)

NO.	STATION	OBS.	MAX	PERCENTILE 1	3	5	10	25	50	75
11	NEWHALL									
	1	363	36.0	29.0	27.0	25.0	22.0	16.0	6.0	3.0
	2	260	36.0	29.0	27.6	26.0	23.0	17.0	6.0	3.0
	3	103	32.0	27.6	22.6	21.3	18.1	13.0	4.9	3.0
12	NORCO-PRADO PRK									
	1	363	35.0	25.8	23.0	20.0	16.0	11.0	6.0	3.0
	2	261	35.0	25.8	22.6	20.0	16.0	12.0	6.0	3.0
	3	102	26.0	24.8	23.3	20.6	16.2	9.0	6.0	3.0
13	OJAI									
	1	202	22.0	18.4	16.0	14.3	13.0	9.0	6.0	4.0
	2	143	22.0	19.0	16.2	15.0	13.0	9.0	6.0	4.0
	3	59	16.0	15.6	14.0	14.0	12.0	8.0	5.9	4.0
14	PASADENA-WALNUT									
	1	364	45.0	35.8	28.0	26.0	22.0	16.0	8.0	4.0
	2	260	45.0	37.8	29.2	25.8	22.0	16.0	9.0	4.0
	3	104	30.0	28.1	27.0	26.0	22.0	14.0	7.0	5.0
15	POMONA									
	1	364	32.0	29.8	24.0	24.0	20.0	14.0	7.0	3.0
	2	260	31.0	28.6	24.0	23.4	20.0	15.0	8.0	3.0
	3	104	32.0	32.0	25.7	24.0	21.0	13.0	7.0	4.0
16	RESEDA									
	1	365	28.0	24.0	22.0	20.0	17.0	13.0	6.0	3.0
	2	261	28.0	24.8	23.0	20.0	17.0	13.0	7.0	3.0
	3	104	22.0	21.4	20.0	18.2	16.0	11.0	5.0	3.0
17	RIVERSIDE-MAGNOLIA									
	1	355	36.0	30.7	25.0	23.0	20.9	15.0	7.0	3.0
	2	255	36.0	31.0	25.8	24.6	21.0	16.0	7.0	3.0
	3	100	27.0	27.0	23.4	23.0	20.0	12.4	7.0	4.0
18	RIVERSIDE-RUBIDOUX									
	1	365	31.0	27.8	24.0	23.0	21.0	14.0	7.0	3.0
	2	261	31.0	29.6	25.1	24.0	21.0	15.0	8.0	3.0
	3	104	26.0	26.0	23.3	22.0	19.0	12.4	7.0	3.0
19	SAN BERNADINO									
	1	353	34.0	28.0	26.0	23.0	19.0	15.0	6.0	3.0
	2	255	30.0	27.8	26.0	23.6	20.9	16.0	7.0	3.0
	3	98	34.0	31.7	25.4	20.5	17.0	11.9	6.0	3.0
20	UPLAND-ARB									
	1	303	51.0	41.8	35.0	32.5	29.0	22.0	14.0	5.0
	2	215	51.0	45.5	35.9	33.9	29.0	23.0	15.0	5.0
	3	88	36.0	35.5	34.0	28.0	26.6	19.0	10.4	6.0

Table B1 (Continued)

NO.	STATION	OBS.	MAX	PERCENTILE 1	3	5	10	25	50	75
21	WEST L.A.-WSTWOOD									
	1	364	39.0	21.0	14.0	13.0	11.0	8.0	5.0	3.0
	2	260	39.0	22.6	15.2	13.0	11.0	8.0	5.4	3.0
	3	104	16.0	15.4	14.0	13.0	11.0	8.4	5.0	3.0
22	WHITTIER									
	1	364	28.0	24.8	19.0	17.0	12.0	8.0	5.0	3.0
	2	260	28.0	23.0	18.6	15.4	12.0	8.4	5.0	3.0
	3	104	27.0	25.7	21.1	19.2	16.0	8.0	5.0	4.0

Table B2. Corrected Ox hourly average concentrations in 1973 (1 for all times, 2 for weekdays, 3 for weekends, 4 for working time, 5 for non-working time, 6 for weekday non-working time). All values in pphm.

NO.	STATION	OBS.	MAX	PERCENTILE 1	3	5	10	25	50	75
1	ANAHEIM									
	1	8173	26.0	11.0	7.0	6.0	4.0	2.0	0.0	0.0
	2	5820	26.0	11.0	7.0	6.0	4.0	2.0	0.0	0.0
	3	2353	23.0	13.0	7.0	6.0	5.0	3.0	1.0	0.0
	4	2735	26.0	14.0	10.0	8.0	6.0	3.0	1.0	0.0
	5	5438	23.0	9.0	6.0	5.0	3.0	1.0	0.0	0.0
	6	3085	7.0	5.0	4.0	3.0	2.0	1.0	0.0	0.0
2	AZUSA									
	1	8162	46.0	24.0	18.0	15.0	10.0	4.0	2.0	1.0
	2	5774	46.0	25.0	18.0	15.0	11.0	4.0	2.0	1.0
	3	2388	35.0	24.0	18.0	14.0	9.0	4.0	2.0	1.0
	4	2671	46.0	28.7	23.0	20.0	15.0	9.0	3.0	2.0
	5	5491	35.0	20.0	12.0	9.0	5.0	2.0	1.0	1.0
	6	3103	23.0	7.0	4.3	4.0	3.0	2.0	1.0	1.0
3	BURBANK-PALM									
	1	8315	29.0	16.0	13.0	10.0	7.0	3.0	1.0	1.0
	2	5923	29.0	16.0	13.0	11.0	7.0	3.0	1.0	1.0
	3	2392	21.0	15.0	11.0	9.0	6.0	3.0	1.0	1.0
	4	2795	29.0	19.0	15.0	14.0	11.0	6.0	3.0	1.0
	5	5520	21.0	12.0	8.0	6.0	4.0	2.0	1.0	1.0
	6	3128	11.0	5.0	3.0	3.0	2.0	1.0	1.0	1.0
4	CAMARILLO-PALM									
	1	7888	26.0	12.0	9.0	8.0	7.0	5.0	2.0	1.0
	2	5627	26.0	12.0	9.0	9.0	7.0	4.0	2.0	1.0
	3	2261	17.0	11.0	9.0	8.0	7.0	5.0	2.0	1.0
	4	2704	26.0	14.0	11.0	10.0	8.0	6.0	4.0	2.0
	5	5184	17.0	9.0	8.0	7.0	6.0	4.0	2.0	1.0
	6	2923	14.0	8.0	7.0	6.0	5.0	3.0	2.0	1.0
5	COSTA MESA									
	1	7439	21.0	10.0	8.0	6.0	5.0	3.0	2.0	[illegible]
	2	5359	21.0	10.0	7.0	6.0	5.0	3.0	1.0	0.0
	3	2080	19.0	12.0	8.0	7.0	5.0	4.0	2.0	0.0
	4	2557	21.0	12.8	9.0	8.0	6.0	4.0	3.0	1.0
	5	4882	19.0	8.6	7.0	6.0	5.0	3.0	1.0	0.0
	6	2802	14.0	7.0	5.0	5.0	4.0	2.0	0.0	0.0
6	EL TORO									
	1	8037	19.0	8.0	6.0	5.0	4.0	3.0	1.0	0.0
	2	5725	19.0	8.0	6.0	5.0	4.0	3.0	1.0	0.0
	3	2312	18.0	9.0	6.0	5.0	4.0	3.0	1.4	0.0
	4	2720	19.0	10.0	7.0	6.0	5.0	3.0	2.0	0.0
	5	5317	18.0	8.0	5.0	5.0	4.0	2.0	1.0	0.0
	6	3005	9.0	6.0	5.0	4.0	3.0	2.0	1.0	0.0

Table B2 (Continued).

NO	STATION	OBS	MAX	PERCENTILE 1	3	5	10	25	50	75
7	LA HABRA									
	1	8144	30.0	16.0	10.0	8.0	5.0	2.0	1.0	0.0
	2	5798	30.0	15.0	10.0	8.0	5.0	2.0	0.0	0.0
	3	2346	24.0	18.0	11.0	8.0	5.0	3.0	1.0	0.0
	4	2737	30.0	19.0	13.0	11.0	6.0	4.0	2.0	0.0
	5	5407	24.0	13.0	7.0	5.0	3.0	1.0	0.0	0.0
	6	3061	8.0	4.0	3.0	3.0	2.0	0.0	0.0	0.0
8	LENNOX									
	1	8316	24.0	7.0	5.0	4.0	3.0	2.0	1.0	1.0
	2	5943	24.0	6.0	5.0	4.0	3.0	2.0	1.0	1.0
	3	2373	14.0	7.0	6.0	5.0	4.0	3.0	1.0	1.0
	4	2816	24.0	8.0	5.9	5.0	4.0	2.0	1.0	1.0
	5	5500	14.0	6.0	5.0	4.0	3.0	2.0	1.0	1.0
	6	3127	10.0	5.0	4.0	3.0	3.0	2.0	1.0	1.0
9	LONG BEACH									
	1	8201	20.0	7.0	5.0	4.0	3.0	2.0	1.0	1.0
	2	5856	20.0	7.0	5.0	4.0	3.0	2.0	1.0	1.0
	3	2345	11.0	7.0	5.0	5.0	4.0	2.1	1.0	1.0
	4	2756	20.0	9.0	6.0	5.0	4.0	3.0	1.0	1.0
	5	5445	11.0	6.0	4.0	4.0	3.0	2.0	1.0	1.0
	6	3100	6.0	4.0	3.0	3.0	2.0	1.0	1.0	1.0
10	L.A. DOWNTOWN									
	1	8357	52.0	15.0	11.0	9.0	6.0	3.0	1.0	1.0
	2	5933	52.0	15.0	10.0	9.0	6.0	3.0	1.0	1.0
	3	2424	25.0	14.0	11.0	9.0	6.0	3.0	1.0	1.0
	4	2733	52.0	23.0	14.0	11.0	9.0	5.0	2.0	1.0
	5	5624	25.0	12.0	8.0	6.0	4.0	2.0	1.0	1.0
	6	3200	15.0	6.0	4.0	3.0	2.0	1.0	1.0	1.0
11	NEWHALL									
	1	8273	36.0	23.0	18.0	15.0	11.0	4.0	2.0	1.0
	2	5929	36.0	24.0	19.5	16.0	11.0	4.0	2.0	1.0
	3	2344	32.0	20.0	16.0	13.0	9.0	4.0	2.0	1.0
	4	2824	36.0	26.0	23.0	21.0	16.0	9.0	3.0	2.0
	5	5449	32.0	17.0	12.0	9.0	5.0	3.0	1.0	1.0
	6	3105	19.0	10.3	6.0	5.0	3.0	2.0	1.0	1.0
12	NORCO-PRADO PRK									
	1	8400	35.0	17.0	13.0	10.0	7.0	3.0	1.0	1.0
	2	5999	35.0	17.0	13.0	11.0	8.0	3.0	1.0	1.0
	3	2401	26.0	17.0	12.0	9.0	7.0	3.0	2.0	1.0
	4	2720	35.0	20.0	16.0	13.0	11.0	7.0	3.0	2.0
	5	5680	26.0	14.0	8.0	6.0	4.0	2.0	1.0	0.0
	6	3279	22.0	7.0	4.0	3.0	2.0	1.0	1.0	0.0

Table B2 (Continued).

				PERCENTILE							
NO.	STATION		OBS	MAX	1	3	5	10	25	50	75
13	OJAI										
		1	4365	22.0	14.0	11.0	9.0	7.0	4.0	3.0	1.0
		2	3032	22.0	15.0	11.0	10.0	7.0	4.0	2.0	1.0
		3	1333	16.0	13.0	10.0	8.0	7.0	4.0	3.0	1.0
		4	1418	22.0	16.2	13.0	12.0	9.0	6.0	4.0	2.9
		5	2947	18.0	12.0	9.0	7.0	5.0	3.6	2.0	1.0
		6	1614	18.0	10.0	7.0	5.0	4.0	3.0	1.0	1.0
14	PASADENA-WALNUT										
		1	8262	45.0	22.0	17.0	14.0	10.0	4.0	2.0	1.0
		2	5889	45.0	23.0	17.0	14.0	10.0	4.0	2.0	1.0
		3	2373	30.0	21.7	16.0	13.0	9.0	4.0	2.0	1.0
		4	2765	45.0	27.0	21.0	19.0	14.0	9.0	4.0	2.0
		5	5497	30.0	17.4	11.0	9.0	5.0	2.0	1.0	1.0
		6	3124	25.0	7.0	4.0	3.0	3.0	2.0	1.0	1.0
15	POMONA										
		1	8253	32.0	21.0	15.0	13.0	8.0	3.0	1.0	1.0
		2	5861	31.0	20.0	15.0	13.0	9.0	3.0	1.0	1.0
		3	2392	32.0	22.0	15.0	12.0	8.0	4.0	2.0	1.0
		4	2760	31.0	23.0	19.0	16.0	13.0	7.0	3.0	2.0
		5	5493	32.0	16.0	10.0	7.0	4.0	2.0	1.0	1.0
		6	3101	15.0	6.0	4.0	3.0	2.0	1.0	1.0	1.0
16	RESEDA										
		1	8358	28.0	18.0	14.0	12.0	9.0	4.0	2.0	1.0
		2	5958	28.0	18.0	14.0	12.0	9.0	4.0	[illegible]	1.0
		3	2392	22.0	16.0	13.0	10.0	8.0	4.0	[illegible]	1.0
		4	2826	28.0	21.0	17.0	15.0	13.0	8.0	[illegible]	2.0
		5	5524	22.0	14.0	9.0	7.0	5.0	3.0	[illegible]	1.0
		6	3132	15.0	7.0	5.0	4.0	3.0	2.0	1.0	1.0
17	RIVERSIDE-MAGNOLIA										
		1	7519	36.0	21.0	16.0	14.0	10.0	4.0	2.0	1.0
		2	5325	36.0	21.0	16.0	14.0	10.0	4.0	2.0	1.0
		3	2194	27.0	20.0	15.0	12.0	9.0	4.0	2.0	1.0
		4	2598	36.0	23.5	19.0	17.0	14.0	9.0	3.0	2.0
		5	4929	27.0	17.0	11.0	9.0	5.0	2.0	1.0	1.0
		6	2735	26.0	9.0	6.0	4.0	3.0	2.0	1.0	1.0
18	RIVERSIDE-RUBIDOUX										
		1	8569	31.0	21.0	16.0	13.0	10.0	4.0	1.0	1.0
		2	6094	31.0	21.0	16.0	14.0	10.0	4.0	1.0	1.0
		3	2475	26.0	20.0	14.0	12.0	8.0	4.0	2.0	1.0
		4	2770	33.0	24.0	20.0	18.0	14.0	9.0	3.0	2.0
		5	5793	26.0	16.0	11.0	8.0	5.0	2.0	1.0	[illegible]
		6	3318	21.0	10.0	6.0	4.0	3.0	1.0	1.0	1.0

Table B2 (Continued).

PERCENTILE

NO.	STATION	OBS.	MAX	1	3	5	10	25	50	75
19	SAN BERNADINO									
	1	7682	34.0	20.0	16.0	14.0	10.0	3.0	1.0	0.0
	2	5530	30.0	21.0	16.0	14.0	10.0	3.0	1.0	0.0
	3	2152	34.0	18.0	14.0	11.0	8.0	3.0	1.0	0.0
	4	2763	30.0	23.0	19.0	17.0	14.0	8.0	3.0	1.0
	5	4919	34.0	15.0	11.0	8.0	5.0	2.0	0.0	0.0
	6	2767	26.0	10.0	6.0	4.0	3.0	1.0	0.0	0.0
20	UPLAND ARB									
	1	5536	51.0	29.0	24.0	21.0	15.0	6.0	2.0	1.0
	2	4613	51.0	30.0	24.0	21.0	16.0	6.0	2.0	1.0
	3	1923	36.0	27.0	22.0	18.0	13.0	6.0	2.0	1.0
	4	2254	51.0	33.0	28.0	25.0	21.0	13.9	6.0	2.0
	5	4282	36.0	24.0	17.0	13.0	8.0	3.0	1.0	1.0
	6	2359	29.0	12.0	7.0	5.0	4.0	2.0	1.0	1.0
21	WEST L A -WESTWOOD									
	1	9222	39.0	11.2	9.0	7.0	6.0	3.0	1.0	1.0
	2	5941	39.0	12.0	9.0	7.0	6.0	3.0	1.0	1.0
	3	2381	16.0	11.0	9.0	7.0	6.0	4.0	2.0	1.0
	4	2736	34.0	14.0	10.0	9.0	7.0	5.0	2.0	1.0
	5	5486	[illegible]	10.0	7.0	6.0	5.0	3.0	1.0	1.0
	6	3105	[illegible]	7.0	5.0	5.0	4.0	2.0	1.0	1.0
22	WHITTIER									
	1	8277	28.0	14.0	9.0	7.0	5.0	3.0	1.0	1.0
	2	5894	20.0	12.0	9.0	7.0	5.0	3.0	1.0	1.0
	3	[illegible]	[illegible]	16.0	10.0	8.0	6.0	3.0	2.0	1.0
	4	1795	20.0	16.0	11.0	9.0	7.0	4.0	2.0	1.0
	5	5482	27.0	11.6	7.0	5.0	4.0	2.0	1.0	1.0
	6	3099	16.0	5.0	3.0	3.0	2.0	1.0	1.0	1.0

Table B3. NO_2 daily maximum hourly average concentrations in 1973 (1 for all times, 2 for weekdays, 3 for weekends). All values in pphm.

NO.	STATION	OBS.	MAX	PERCENTILE 1	3	5	10	25	50	75
1	ANAHEIM									
	1	329	49.0	33.1	25.5	22.0	16.5	11.0	8.0	6.0
	2	235	49.0	31.0	23.3	21.0	16.0	11.0	8.0	6.0
	3	94	35.0	34.5	33.0	27.8	17.0	9.9	6.0	5.0
2	AZUSA									
	1	361	32.0	29.0	25.0	23.3	19.0	14.0	10.0	7.0
	2	261	32.0	29.8	27.6	24.0	20.0	15.0	11.0	7.0
	3	100	22.0	21.4	18.4	17.4	15.4	11.0	8.0	6.0
3	BURBANK-PALM									
	1	364	38.0	35.5	31.0	27.0	23.0	17.0	11.0	7.0
	2	261	38.0	36.8	32.1	30.3	24.3	18.0	13.0	8.0
	3	103	29.0	26.5	20.9	20.0	17.1	11.6	8.0	7.0
4	CAMARILLO-PALM									
	1	356	18.0	14.7	10.7	10.0	8.0	6.0	5.0	4.0
	2	254	18.0	15.0	11.8	10.0	9.0	6.9	5.0	4.0
	3	102	10.0	10.0	9.3	9.0	8.0	6.0	5.0	3.9
5	CHINO									
	1	340	29.0	22.0	18.0	14.0	12.0	9.0	7.0	5.0
	2	247	29.0	22.0	18.0	16.0	12.0	10.0	7.0	5.0
	3	93	22.0	17.8	12.6	12.0	11.0	8.0	6.0	4.0
6	COSTA MESA									
	1	353	29.0	26.0	20.6	17.0	14.0	8.0	5.0	4.0
	2	259	29.0	25.8	17.6	15.0	14.0	8.0	5.0	4.0
	3	94	28.0	26.9	22.6	20.4	14.0	8.0	5.0	3.0
7	EL TORO									
	1	355	30.0	23.0	20.0	16.0	12.0	8.0	5.0	4.0
	2	255	30.0	22.8	17.5	15.0	12.9	8.0	5.0	4.0
	3	100	24.0	23.4	21.4	20.0	11.4	8.0	5.0	4.0
8	LA HABRA									
	1	356	51.0	33.0	26.0	22.0	18.0	13.0	9.0	6.0
	2	257	51.0	32.8	26.0	22.0	18.0	13.0	9.0	7.0
	3	99	35.0	33.8	27.9	24.0	16.0	10.0	7.0	5.0
9	LENNOX									
	1	363	39.0	31.0	29.5	23.5	18.1	13.0	10.0	7.0
	2	261	39.0	33.4	30.0	28.3	19.0	15.0	10.0	8.0
	3	102	25.0	25.0	22.0	19.6	14.2	10.9	8.0	7.0
10	LONG BEACH									
	1	361	35.0	32.8	29.6	26.3	20.0	15.0	10.0	7.0
	2	260	35.0	33.0	30.0	28.0	21.0	15.4	10.0	7.0
	3	101	32.0	30.8	25.5	24.0	19.0	13.0	9.0	6.0

Table B3 (Continued).

NO.	STATION	OBS.	MAX	1	3	5	10	25	50	75
				PERCENTILE						
11	L.A. DOWNTOWN									
	1	353	58.0	32.9	27.8	24.0	21.0	15.0	10.0	7.0
	2	259	58.0	34.6	30.6	26.0	21.0	15.6	10.0	8.0
	3	94	26.0	24.9	23.0	21.4	18.0	10.9	8.0	6.0
12	NEWHALL									
	1	360	20.0	17.8	14 0	13.0	11.0	9.0	6.0	4.0
	2	260	20.0	18.0	16.0	14.0	12.0	9.0	7.0	4.0
	3	100	12.0	12.0	10 8	10.0	9.0	7.0	5.4	4.0
13	NORCO-PRADO PRK									
	1	352	17.0	13.0	12.0	11.0	10.0	7.0	5.0	4.0
	2	258	17.0	14.6	13.0	12.0	9.6	7.0	5.4	4 0
	3	94	13.0	12.5	11.2	10.0	10.0	6.0	4.0	3.0
14	OJAI									
	1	322	12.0	10.2	8.7	7.0	6.0	5.0	3.0	2.0
	2	228	12.0	11.0	9.0	8.0	6.0	5.0	3.0	2.0
	3	94	10.0	8.9	7.0	6.7	6.0	5.0	3.0	2.0
15	PASADENA-WALNUT									
	1	364	33 0	29.0	24.0	23.0	20.0	15.0	11.0	8.0
	2	260	33.0	29.8	24.6	23.0	20.0	16.0	12.0	8.0
	3	104	20.0	19.4	18.3	16.0	13.0	10.4	9.0	7.0
16	PT. MUGU									
	1	342	33.0	22.0	15.1	14.0	11.0	8.0	6.0	4.0
	2	244	33.0	25.8	17 0	14.2	12.0	9.0	6.0	4.0
	3	98	14.0	13.4	10.9	10 0	9.0	8.0	5 0	4.0
17	POMONA									
	1	365	36.0	26.0	24.0	22.0	20.0	15.0	10.0	8.0
	2	261	36.0	28.4	24.0	23.0	20.3	16.0	11.0	8.0
	3	104	24 0	22.7	21.0	21.0	15.0	12.0	9.0	7 0
18	RESEDA									
	1	353	19.0	17.0	16.0	14.0	12.0	9.0	7.0	5.0
	2	255	19.0	17.0	16.0	15.0	12.0	10.0	7.9	5.0
	3	98	15.0	14.4	13.0	11.5	10.0	8.0	6.0	5 0
19	RIVERSIDE-MAGNOLIA									
	1	365	37.0	31.0	24.0	22.0	18.0	15.0	10.9	7 0
	2	261	37.0	31.0	25.6	23.0	19.3	16.0	12.0	8.0
	3	104	25.0	22.4	20.0	18.0	16.0	11.4	8.0	6 4
20	RIVERSIDE-RUBIDOUX									
	1	356	33.0	24.5	20.0	18.6	16.0	12.0	9.0	6 0
	2	256	27 0	22.0	20 0	19.0	16.0	12.0	9.0	7.0
	3	100	33 0	28.2	19.2	17.0	14.0	11.0	7.0	6 0

Table B3 (Continued).

NO	STATION	OBS	MAX	1	3	5	10	25	50	75
				PERCENTILE						
21	REDLANDS									
	1	363	18.0	16.8	14.0	13.0	11.0	8.0	6.0	4.0
	2	259	18.0	16.8	14.6	13.0	12.0	8.0	6.0	4.0
	3	104	18.0	16.7	13.3	13.0	11.0	7.0	5.0	4.0
22	SAN BERNADINO									
	1	356	19.0	16.0	14.0	13.0	12.0	10.0	7.0	5.0
	2	258	19.0	16.8	15.0	14.0	13.0	10.0	8.0	5.9
	3	98	13.0	12.4	11.0	10.5	9.0	8.0	5.0	4.0
23	UPLAND-ARB									
	1	301	24.0	23.0	20.4	19.0	17.0	13.0	10.0	8.0
	2	215	24.0	23.3	21.0	20.0	18.0	14.0	12.0	8.0
	3	86	18.0	17.1	15.8	15.0	13.0	11.0	9.0	6.0
24	UPLAND-CIVIC CTR									
	1	297	36.0	23.4	17.0	15.5	13.0	10.0	7.0	5.0
	2	211	36.0	24.0	20.0	16.8	15.0	11.0	7.0	5.0
	3	86	19.0	16.2	12.0	12.0	10.0	8.9	6.0	4.0
25	WEST L.A.-WSTWOOD									
	1	358	47.0	36.8	30.7	28.0	22.6	16.0	11.0	9.0
	2	260	47.0	39.4	32.8	28.4	24.0	17.0	12.0	9.0
	3	98	31.0	30.4	25.4	23.5	19.0	13.9	9.0	6.9
26	WHITTIER									
	1	357	48.0	31.7	26.0	23.5	20.0	14.0	9.0	7.0
	2	258	48.0	29.8	25.7	23.0	20.0	15.0	10.0	8.0
	3	99	36.0	33.6	28.4	24.4	17.0	11.0	8.0	6.0

Table B4. NO_2 hourly average concentrations in 1973 (1 for all times, 2 for weekdays, 3 for weekends, 4 for working time, 5 for non-working time, 6 for weekday non-working time). All values in pphm.

NO	STATION	OBS	MAX	PERCENTILE 1	3	5	10	25	50	75
1	ANAHEIM									
	1	7340	49.0	21.0	15.0	12.0	9.0	6.0	4.0	3.0
	2	5181	49.0	23.0	15.0	12.0	9.0	7.0	5.0	3.0
	3	2159	35.0	25.0	18.0	12.0	8.0	6.0	4.0	3.0
	4	2441	49.0	22.0	17.0	14.0	11.0	7.0	5.0	3.0
	5	4899	35.0	21.0	14.0	11.0	8.0	6.0	4.0	3.0
	6	2740	24.0	17.0	12.0	10.0	8.0	6.0	4.0	3.0
2	AZUSA									
	1	8896	32.0	20.0	16.0	14.0	12.0	8.0	5.0	3.0
	2	5832	32.0	21.1	17.0	15.0	12.0	9.0	6.0	4.0
	3	2264	22.0	16.0	12.0	11.0	9.0	6.0	4.0	3.0
	4	2513	32.0	23.0	19.0	16.0	13.0	10.0	6.0	4.0
	5	5583	31.0	19.0	15.0	13.0	11.0	8.0	5.0	3.0
	6	3319	31.0	20.0	16.0	14.0	12.0	8.0	6.0	3.0
3	BURBANK-PALM									
	1	8462	38.0	24.0	19.0	16.0	13.0	9.0	6.0	4.0
	2	6013	38.0	26.0	20.0	17.0	14.0	10.0	7.0	4.0
	3	2449	29.0	19.0	15.0	12.0	10.0	7.0	6.0	4.0
	4	2666	38.0	28.0	23.0	20.0	16.0	12.0	8.0	5.0
	5	5796	36.0	21.0	16.0	14.0	11.0	8.0	6.0	4.0
	6	3347	36.0	22.0	17.0	14.0	12.0	8.0	6.0	4.0
4	CAMARILLO-PALM									
	1	7778	18.0	8.0	7.0	6.0	5.0	4.0	2.0	1.0
	2	5533	18.0	9.0	7.0	6.0	5.0	4.0	3.0	2.0
	3	2245	10.0	8.0	6.0	6.0	5.0	3.0	2.0	1.0
	4	2691	16.5	9.0	7.0	6.0	5.0	3.0	2.0	1.0
	5	5087	18.0	8.0	7.0	6.0	5.0	4.0	3.0	2.0
	6	2842	18.0	9.0	7.0	6.0	5.0	4.0	3.0	2.0
5	CHINO									
	1	7458	29.0	14.0	11.0	10.0	8.0	6.0	4.0	3.0
	2	5332	29.0	15.0	11.0	10.0	8.0	6.0	4.0	3.0
	3	2126	22.0	11.0	10.0	9.0	7.0	5.0	3.0	2.0
	4	2286	23.0	15.0	11.0	10.0	8.0	6.0	4.0	3.0
	5	5172	29.0	13.0	10.0	9.0	8.0	5.0	4.0	3.0
	6	3046	29.0	14.9	11.0	10.0	8.0	6.0	4.0	3.0
6	COSTA MESA									
	1	7634	29.0	17.0	12.0	10.0	7.0	4.0	2.0	1.0
	2	5486	29.0	15.0	11.8	10.0	7.0	5.0	2.0	1.0
	3	2148	28.0	19.0	15.0	11.0	8.0	4.0	2.0	1.0
	4	2598	29.0	16.0	11.0	9.0	7.0	4.0	2.0	1.0
	5	5036	28.0	17.0	13.0	10.0	7.0	4.0	2.0	1.0
	6	2888	28.0	15.0	12.0	10.0	7.0	5.0	3.0	1.0

Table B4 (Continued).

PERCENTILE

NO	STATION	OBS	MAX	1	3	5	10	25	50	75
7	EL TORO									
	1	7952	30.0	15.0	11.0	9.0	7.0	4.0	2.0	1.0
	2	5652	30.0	14.0	11.0	9.0	7.0	4.0	2.0	1.0
	3	2300	24.0	17.0	11.0	9.0	6.0	4.0	2.0	1.0
	4	2672	30.0	16.0	12.0	11.0	8.0	5.0	3.0	1.0
	5	5280	24.0	15.0	10.0	8.0	6.0	4.0	2.0	1.0
	6	2980	21.0	12.0	9.0	7.0	5.0	3.0	2.0	1.0
8	LA HABRA									
	1	7932	51.0	21.0	15.0	13.0	10.0	7.0	5.0	3.0
	2	5676	51.0	22.0	15.1	13.0	11.0	8.0	5.0	3.0
	3	2256	35.0	20.0	14.0	11.0	9.0	6.0	4.0	3.0
	4	2671	51.0	24.0	18.0	15.0	12.0	8.0	5.0	3.0
	5	5261	35.0	19.8	14.0	12.0	9.0	7.0	5.0	3.0
	6	3005	33.0	19.0	14.0	12.0	10.0	7.0	5.0	3.0
9	LENNOX									
	1	8294	39.0	21.0	16.0	13.0	11.0	8.0	6.0	4.0
	2	5895	39.0	23.0	17.0	14.0	11.0	8.0	6.0	4.0
	3	2399	25.0	16.0	12.0	11.0	9.0	7.0	5.0	4.0
	4	2563	39.0	26.0	19.0	17.0	14.0	10.0	7.0	5.0
	5	5731	33.0	17.0	13.0	11.0	9.0	7.0	5.0	4.0
	6	3332	33.0	17.0	13.0	11.0	10.0	7.0	5.0	4.0
10	LONG BEACH									
	1	6108	35.0	23.0	17.0	15.0	12.0	8.0	6.0	4.0
	2	5791	35.0	24.0	18.0	15.0	12.0	9.0	6.0	4.0
	3	2317	32.0	21.0	15.0	13.0	11.0	8.0	5.0	4.0
	4	2472	35.0	27.0	20.2	17.0	14.0	10.0	7.0	5.0
	5	5636	32.0	20.0	15.0	13.0	11.0	7.0	5.0	4.0
	6	3319	31.0	19.0	14.8	13.0	10.0	7.0	5.0	4.0
11	L.A. DOWNTOWN									
	1	7717	58.0	21.0	16.0	14.0	11.0	8.0	6.0	4.0
	2	5631	58.0	23.0	16.0	14.0	12.0	9.0	6.0	4.0
	3	2086	26.0	18.0	13.0	11.0	9.0	7.0	5.0	3.0
	4	2422	58.0	26.0	19.7	17.0	14.0	10.0	7.0	5.0
	5	5295	33.0	18.0	14.0	12.0	10.0	8.0	6.0	4.0
	6	3209	33.0	17.0	14.0	13.0	10.0	8.0	6.0	4.0
12	NEWHALL									
	1	8180	20.0	11.0	9.0	8.0	7.0	5.0	3.0	2.0
	2	5881	20.0	12.0	9.0	8.0	7.0	5.0	3.0	2.0
	3	2299	12.0	9.0	8.0	7.0	6.0	4.0	3.0	2.0
	4	2601	19.0	12.0	9.0	9.0	7.0	5.0	3.0	2.0
	5	5579	20.0	10.0	9.0	8.0	7.0	5.0	3.0	2.0
	6	3280	20.0	12.0	9.0	8.0	7.0	5.0	4.0	2.0

Table B4 (Continued).

NO.	STATION	OBS.	MAX	1	3	5	10	25	50	75
				PERCENTILE						
13	NORCO-PRADO PRK									
	1	8029	17.0	10.0	7.0	7.0	5.0	4.0	2.0	2.0
	2	5798	17.0	10.0	8.0	7.0	6.0	4.0	2.0	2.0
	3	2231	13.0	9.0	7.0	6.0	5.0	3.0	2.0	1.0
	4	2616	16.0	10.0	8.0	7.0	5.0	4.0	2.0	2.0
	5	5413	17.0	9.3	7.0	6.0	5.0	4.0	2.0	1.0
	6	3182	17.0	10.0	8.0	7.0	6.0	4.0	3.0	2.0
14	OJAI									
	1	7234	12.0	7.0	5.0	4.0	4.0	3.0	2.0	1.0
	2	5092	12.0	7.0	5.0	5.0	4.0	3.0	2.0	1.0
	3	2142	10.0	6.0	5.0	4.0	4.0	2.0	2.0	1.0
	4	2363	12.0	7.0	5.0	4.0	3.1	2.0	2.0	1.0
	5	4871	11.0	6.0	5.0	5.0	4.0	3.0	2.0	1.0
	6	2729	11.0	7.0	5.0	5.0	4.0	3.0	2.0	1.0
15	PASADENA-WALNUT									
	1	8394	33.0	20.0	16.0	14.0	12.0	9.0	6.0	4.0
	2	5935	33.0	21.0	17.0	15.0	13.0	10.0	7.0	5.0
	3	2459	20.0	14.0	11.0	10.0	9.0	7.0	6.0	4.0
	4	2610	33.0	23.0	18.0	16.0	14.0	10.0	8.0	5.0
	5	5784	30.0	18.0	14.0	13.0	11.0	8.0	6.0	4.0
	6	3325	30.0	20.0	16.0	14.0	12.0	9.0	7.0	5.0
16	PT. MUGU									
	1	7317	33.0	12.0	9.0	8.0	6.0	4.0	2.0	1.0
	2	5184	33.0	12.6	10.0	8.0	7.0	5.0	2.0	1.0
	3	2133	14.0	9.0	8.0	7.0	5.0	4.0	2.0	1.0
	4	2320	33.0	14.0	11.0	9.0	7.0	4.0	2.0	1.0
	5	4997	16.0	10.0	8.0	7.0	6.0	4.0	2.0	1.0
	6	2864	16.0	11.0	9.0	8.0	6.0	5.0	3.0	1.0
17	POMONA									
	1	8353	36.0	20.0	16.0	15.0	12.0	9.0	6.0	5.0
	2	5961	36.0	21.0	17.0	15.0	13.0	10.0	7.0	5.0
	3	2392	24.0	18.0	14.0	12.0	10.0	7.0	6.0	4.0
	4	2570	36.0	21.0	17.3	16.0	13.0	10.0	7.0	5.0
	5	5783	33.0	20.0	16.0	14.0	11.0	8.0	6.0	4.0
	6	3391	33.0	20.5	17.0	15.0	12.0	9.0	7.0	5.0
18	RESEDA									
	1	8063	19.0	12.0	10.0	9.0	8.0	6.0	4.0	3.0
	2	5809	19.0	13.0	10.0	9.0	8.0	6.0	4.0	3.0
	3	2254	15.0	10.0	9.0	8.0	7.0	5.0	4.0	2.0
	4	2598	19.0	13.0	11.0	9.0	8.0	5.0	4.0	2.0
	5	5465	19.0	12.0	10.0	9.0	7.0	6.0	4.0	3.0
	6	3211	19.0	12.0	10.0	9.0	8.0	6.0	4.0	3.0

Table B4 (Continued).

PERCENTILE

NO.	STATION	OBS	MAX	1	3	5	10	25	50	75
19	RIVERSIDE-MAGNOLIA									
	1	8506	37.0	20.0	16.0	14.0	11.0	8.0	6.0	4.0
	2	6054	37.0	21.0	16.0	15.0	12.0	9.0	6.0	4.0
	3	2452	25.0	16.0	12.0	10.0	9.0	7.0	5.0	3.0
	4	2666	37.0	23.0	17.4	15.0	13.0	9.0	6.0	4.0
	5	5840	31.0	18.0	14.0	13.0	10.0	8.0	5.0	3.0
	6	3388	31.0	18.5	16.0	13.0	12.0	8.0	6.0	4.0
20	RIVERSIDE-RUBIDOUX									
	1	7545	33.0	16.0	13.0	11.0	10.0	7.0	5.0	4.0
	2	5345	27.0	16.9	13.0	12.0	10.0	8.0	5.0	4.0
	3	2200	33.0	15.0	12.0	10.0	8.0	6.0	4.0	3.0
	4	2565	25.0	18.0	14.0	12.0	10.0	8.0	5.0	4.0
	5	4980	33.0	15.6	12.0	11.0	9.0	7.0	5.0	4.0
	6	2780	27.0	16.0	13.0	12.0	10.0	8.0	5.0	4.0
21	REDLANDS									
	1	8509	18.0	12.0	10.0	8.0	6.0	4.0	3.0	1.0
	2	6031	18.0	12.0	10.0	9.0	7.0	5.0	3.0	1.0
	3	2478	18.0	12.0	9.0	8.0	6.0	4.0	2.0	1.0
	4	2743	17.0	12.0	9.0	8.0	6.0	4.0	2.0	1.0
	5	5766	18.0	12.0	10.0	9.0	7.0	5.0	3.0	2.0
	6	3288	18.0	12.0	10.0	9.0	7.0	5.0	4.0	2.0
22.	SAN BERNADINO									
	1	7480	19.0	12.0	10.0	9.0	7.0	5.0	4.0	2.0
	2	5413	19.0	12.0	10.0	9.0	8.0	6.0	4.0	2.0
	3	2067	13.0	9.0	8.0	7.0	6.0	4.0	3.0	2.0
	4	2220	19.0	14.0	12.0	11.0	8.4	6.0	4.0	3.0
	5	5260	15.0	11.0	9.0	8.0	7.0	5.0	3.0	2.0
	6	3193	15.0	11.0	9.0	8.0	7.0	6.0	4.0	2.0
23	UPLAND-ARB									
	1	6371	24.0	17.7	14.0	13.0	11.0	8.0	6.0	4.0
	2	4495	24.0	18.0	15.0	13.0	12.0	9.0	6.0	4.0
	3	1876	18.0	13.0	12.0	10.6	9.0	7.0	4.0	3.0
	4	2157	23.0	18.0	15.0	13.0	11.0	8.0	5.0	3.0
	5	4214	24.0	17.0	14.0	12.0	11.0	8.0	6.0	4.0
	6	2338	24.0	19.0	15.0	14.0	12.0	9.0	7.0	5.0
24	UPLAND-CIVIC CTR									
	1	6560	36.0	15.0	12.0	10.0	9.0	6.0	4.0	3.0
	2	4575	36.0	16.0	13.0	11.0	9.0	7.0	4.0	3.0
	3	1985	19.0	11.0	9.0	8.0	7.0	5.0	3.0	2.0
	4	2046	24.0	16.0	13.0	12.0	10.0	7.0	5.0	3.0
	5	4514	36.0	14.3	11.0	10.0	8.0	6.0	4.0	2.0
	6	2529	36.0	16.0	12.0	11.0	9.0	6.0	4.0	2.0

Table B4 (Continued).

				PERCENTILE						
NO.	STATION	OBS.	MAX	1	3	5	10	25	50	75
25	WEST L.A.-WSTWOOD									
	1	8207	47.0	23.0	18.0	15.0	12.0	8.0	6.0	4.0
	2	5908	47.0	24.0	18.0	16.0	13.0	9.0	6.0	4.0
	3	2299	31.0	19.4	15.0	14.0	11.0	8.0	6.0	4.0
	4	2609	47.0	28.0	22.0	19.0	15.0	10.0	7.0	5.0
	5	5598	31.0	19.0	15.0	13.0	11.0	8.0	6.0	4.0
	6	3299	31.0	18.0	15.0	13.0	11.0	8.0	6.0	4.0
26	WHITTIER									
	1	8064	48.0	20.8	16.0	14.0	11.0	8.0	6.0	4.0
	2	5775	48.0	21.0	16.0	14.0	12.0	8.0	6.0	4.0
	3	2289	36.0	20.0	15.0	13.0	10.0	7.0	5.0	4.0
	4	2491	48.0	22.5	18.0	16.0	13.0	9.0	6.0	5.0
	5	5573	36.0	19.7	15.0	13.0	10.0	7.0	5.0	4.0
	6	3284	29.0	18.6	14.0	13.0	10.0	8.0	6.0	4.0

APPENDIX C

MONITORING STATIONS AND RECEPTOR POINTS

Table C1. Locations and Addresses of Air Monitoring Stations

	UTM	X-Y Coord.
1. Anaheim #050230001I01 (30176) 1010 S. Harbor Blvd., Anaheim, Orange County	N = 3,742,467 E = 415,477	Y = 1340 X = 1824
2. Azusa #050500002I01 (70060) 803 Loren Ave., Azusa, Los Angeles County	N = 3,777,371 E = 414,892	Y = 1634 X = 1819
3. Burbank #050900002I01 (70069) 228 W. Palm, Burbank, Los Angeles County	N = 3,782,904 E = 379,355	Y = 1681 X = 1520
4. Camarillo-Palm #051030001I01 (56408) 70 Palm Drive, Camarillo, Ventura County	N = 3,787,765 E = 312,275	Y = 1722 X = 954
5. Chino-Riverside Ave. #051300001I01 (36173) Central & Riverside, Chino, San Bernardino Cty.	N = 3,760,145 E = 436,087	Y = 1489 X = 1998
6. Costa Mesa-Harbor #052390001I01 (30186) 2631 Harbor Blvd., Costa Mesa, Orange County	N = 3,721,444 E = 414,449	Y = 1124 X = 1998
7. El Toro #052390001I01 (30186) 3022 El Toro Rd., El Toro, Orange County	N = 3,716,916 E = 436,027	Y = 1124 X = 1998
8. La Habra #053620001I01 (30177) 621 W. Lambert, La Habra, Orange County	N = 3,753,372 E = 411,824	Y = 1432 X = 1794
9. Lennox #053900001I01 (70076) 11408 La Cienega Blvd., Lennox, LA County	N = 3,755,070 E = 373,477	Y = 1446 X = 1470
10. Long Beach #054100002I01 (70072) 3648 N. Long Beach Blvd., Long Beach, LA Cty.	N = 3,743,190 E = 390,007	Y = 1346 X = 1610
11. L.A. Down-town #054180001I01 (70001) 434 S. San Pedro St., Los Angeles County	N = 3,767,650 E = 385,310	Y = 1552 X = 1570

Table C1 (Continued).

	UTM	X-Y Coord.
12. Newhall #055120001I01 (70081) 24811 San Fernando Rd., Newhall, LA Cty.	N = 3,805,831 E = 359,188	Y = 1874 X - 1350
13. Norco-Prado Park #055160001I01 (33140) 8850 Archibald Ave., Norco, Riverside Cty.	N - 3,756,446 E = 445,122	Y = 1458 X = 2074
14. Ojai #055340001I01 (56402) 401 Signal Hill St., Ojai, Ventura Cty.	N = 3,813,704 E = 293,772	Y = 1940 X = 798
15. Pasadena-Walnut #05570004I01 (70083) 1196 E. Walnut St., Pasadena, LA County	N = 3,779,120 E = 396,420	Y = 1649 X - 1664
16. Point Mugu #056030001I01 (56409) Naval Air Station, Ventura County		Y = 1630 X = 933
17. Pomona #056040001I01 (70075) 924 N. Garey Ave., Pomona, LA County	N = 3,767,844 E = 430,882	Y = 1554 X = 1900
18. Redlands #056200001I01 (36165) 216 Brookside Ave., Redlands, San Bernardino County	N = 3,768,069 E = 482,902	Y = 1556 X = 2393
19. Reseda #054200001I01 (70074) 18330 Gault St., Reseda, Los Angeles County	N = 3,785,129 E = 358,851	Y = 1699 X = 1347
20. Riverside-Magnolia #056400003F01 (33146) 9002 Magnolia Ave., Riverside, Riverside Cty.	N = 3,751,835 E = 463,036	Y = 1419 X = 2225
21. Riverside-Rubidoux #056535001I01 (33144) 5888 Mission Blvd., Rubidoux, Riverside Cty.	N = 3,757,641 E = 462,161	Y - 1468 X = 2218

Table C1 (Continued).

	UTM	X-Y Coord.
22. San Bernardino #05668000lI01 (36151) 172 W. 3rd St., San Bernardino, S.B. Cty.	N = 3,773,634 E = 473,637	Y = 1602 X = 2315
23. Upland-Civic Center #058440003I01 (36174) 155 D Street, Upland, San Bernardino Cty.	N = 3,768,863 E = 440,989	Y = 1562 X = 2039
24. Upland-ARB #058440004F01 (36175) 1350 San Bernardino Rd., Upland, S.B. Cty.	N = 3,769,410 E = 442,043	Y = 1567 X = 2048
25. West L.A. #054180002I01 (70071) 2351 Westwood Blvd., Los Angeles County	N = 3,767,403 E = 368,178	Y = 1550 X = 1426
26. Whittier #058720001I01 (70080) 14427 Leffingwell Rd., Whittier, LA Cty.	N = 3,754,019 E = 405,436	Y = 1437 X = 1740

Table C2. Receptor Points Assigned to the Los Angeles AQCR

No.	County	RSA #	Code #	X-Coord.	Y-Coord.
1	Los Angeles	7	2071	1285	1610
2	Los Angeles	12	2121	1361	1670
3	"	12	2122	1351	1720
4	"	12	2123	1400	1630
5	Los Angeles	13	2131	1485	1645
6	"	13	2132	1521	1650
7	Los Angeles	14	2141	1421	1730
8	"	14	2142	1510	1710
9	Los Angeles	15	2151	1221	1550
10	Los Angeles	16	2161	1380	1570
11	"	16	2162	1430	1465
12	Los Angeles	17	2171	1521	1510
13	"	17	2172	1521	1550
14	"	17	2173	1521	1590
15	"	17	2174	1480	1530
16	"	17	2175	1480	1580
17	Los Angeles	18	2181	1521	1440
18	"	18	2182	1475	1460
19	"	18	2183	1500	1410
20	Los Angeles	19	2191	1505	1320
21	"	19	2192	1505	1365
22	Los Angeles	19	2193	1545	1350
23	Los Angeles	20	2201	1595	1330
24	"	20	2202	1650	1320
25	"	20	2203	1625	1390
26	Los Angeles	21	2211	1565	1420
27	"	21	2212	1565	1470
28	"	21	2213	1565	1520
29	"	21	2214	1610	1520
30	"	21	2215	1610	1470

Table C2 (Continued).

No.	County	RSA #	Code #	X-Coord.	Y-Coord.
31	Los Angeles	22	2221	1660	1420
32	"	22	2222	1690	1480
33	"	22	2223	1725	1435
34	Los Angeles	23	2231	1555	1545
35	Los Angeles	24	2241	1561	1585
36	"	24	2242	1561	1640
37	"	24	2243	1595	1595
38	Los Angeles	25	2251	1641	1625
39	"	25	2252	1660	1560
40	"	25	2253	1710	1555
41	"	25	2254	1730	1620
42	Los Angeles	26	2261	1765	1520
43	Los Angeles	26	2262	1810	1595
44	"	26	2263	1840	1500
45	Los Angeles	27	2271	1900	1580
46	Orange	35	3351	1710	1355
47	Orange	36	3361	1800	1410
48	Orange	37	3371	1765	1320
49	"	37	3372	1785	1355
50	Orange	38	3381	1708	1280
51	"	38	3382	1750	1250
52	Orange	41	3411	1911	1390
53	Orange	42	3421	1825	1285
54	"	42	3422	1840	1335
55	San Bernardino	28	4281	1960	1490
56	"	28	4282	2000	1590
57	San Bernardino	29	4291	2190	1625
58	"	29	4292	2335	1555
59	Ventura	1	1011	860	1960
60	"	1	1012	1125	2050

Table C2 (Continued).

No.	County	RSA #	Code #	X-Coord.	Y-Coord.
61	Ventura	1	1013	1040	2005
62	"	1	1014	941	2115
63	"	1	1015	1185	1935
64	Ventura	2	1021	940	1745
65	"	2	1022	940	1870
66	Ventura	3	1031	1010	1675
67	Ventura	4	1041	1235	1740
68	Ventura	5	1051	1135	1645
69	Ventura	6	1061	1185	1835
70	Los Angeles	8	2081	1410	1935
71	"	8	2082	1348	1855
72	Los Angeles	10	2101	1550	1878
73	"	10	2102	1641	1950
74	"	10	2103	1757	1895
75	"	10	2104	1880	1865
76	Los Angeles	11	2111	1610	1750
77	"	11	2112	1732	1710
78	"	11	2113	1860	1728
79	Orange	39	3391	1855	1160
80	Orange	40	3401	1970	1052
81	Orange	43	3431	2028	1155
82	"	43	3432	2035	1240
83	Orange	44	3441	1915	1250
84	San Bernardino	30	4301	2055	1725
85	"	30	4302	2260	1713
86	"	30	4303	2430	1740
87	"	30	4304	2473	1630
88	"	30	4305	2350	1650
89	Riverside	45	5451	2070	1515

Table C2 (Continued).

No.	County	RSA #	Code #	X-Coord.	Y-Coord.
90	Riverside	46	5461	2095	1380
91	"	46	5462	2170	1460
92	Riverside	47	5471	2280	1360
93	"	47	5472	2330	1277
94	Riverside	48	5481	2455	1310
95	Riverside	49	5491	2185	1210
96	"	49	5492	2273	1110
97	"	49	5493	2395	1155
98	Riverside	50	5501	2430	1480
99	"	50	5502	2475	1430

APPENDIX D

METHODOLOGY TO CHARACTERIZE POPULATION EXPOSURE

FORMULATION OF POPULATION EXPOSURE PARAMETERS

Suppose a person stays at a place where the air quality is continuously monitored. Then, the pollution "dose" of that person over a time period T can be given by[1]

$$\text{DOSE} = \int_0^T C(t)\, dt \qquad \text{(D-1)}$$

where C(t) is the concentration reading at time t. A pollutant concentration is usually measured at a constant time interval, say, every hour. Monitored concentrations are often sorted in ascending order and summarized in percentile concentration statistics. In this case, Eq. (D-1) reduces to

$$\text{DOSE} = T\int_0^1 C(f)\, df \qquad \text{(D-2)}$$

where C(f) is the concentration at the f^{th} percentile.

From the quantities in Eq. (D-2) we will derive the three exposure parameters; "dose rate," "risk frequency," and "mean duration." The dose rate is the average concentration with respect to a subject person and is given, for the above example, as

$$D = \int_0^1 C(f)\, df \qquad \text{(D-3)}$$

Namely, the dose rate is equal to the arithmetic mean concentration averaged over the time period T, i.e., a year in this study. The risk frequency is the percentage of time that a subject person is exposed to a concentration above a given concentration threshold C_S.[2]

$$R(C_S) = 1 - f_s \qquad \text{(D-4)}$$

where f_s is the percentile given by a solution to $C(f) = C_S$. The mean duration can be determined when the percentile concentration statistics are available for both hourly average concentrations and daily maximum hourly average concentrations. It is given by

$$\tau(C_S) = 24\ R_{hour}/R_{day} \qquad \text{(D-5)}$$

where R_{hour} is the risk frequency for hourly average concentrations (hourly risk frequency) and R_{day} the risk frequency for daily maximum hourly average concentrations (daily risk frequency).

In the real world each individual moves around in space. Therefore, the pollution dose of Eq. (D-1) should be rewritten as

$$\mathrm{DOSE} = \int_0^T C[\underline{r}(t),t]\ dt \qquad \text{(D-6)}$$

where $\underline{r}(t)$ is the spatial position of the subject person at time t. Under this situation, the conversion from Eq. (D-1) to Eq. (D-2) is not applicable to Eq. (D-6). Therefore, there is no easy way to determine, for the subject person, the three exposure parameters defined by Eqs. D-3) through (D-5).

In order to resolve the above problem, we propose to use the quasi-stationarity assumption, i.e., each individual stays close to a receptor point, say, his office on weekdays from 8 A.M. to 5 P.M. Suppose that we divide the total time period T into two non-overlapping time periods, working time T_w and non-working time T_n. Then, the three exposure parameters can be given by the following equations:

$$D = (T_W D_W + T_n D_n)/T \qquad \text{(D-7)}$$

$$R(C_S) = \{T_W R_W(C_S) + T_n R_n(C_S)\}/T \qquad \text{(D-8)}$$

$$\tau(C_S) = 24\left(R_{hour}/R_{day}\right) \qquad \text{(D-5)}$$

where D_w is the dose rate during working time, D_n that during non-working time, $R_w(C_S)$ the risk frequency during working time, and $R_n(C_S)$ that during non-working time.

The above formulation is derived for a single person. The next step is to extend the population exposure formulation for a single person into that for a population of millions of persons. Suppose that the spatial position of the local population is approximated by a receptor point located approximately at the center of their residence locations, and that the air quality at that receptor point is estimated from the nearby monitoring stations by using the interpolation equation (D-1). Then, the distribution function for each of the three population exposure parameters is given as:[3]

$$S(D^*) = \sum_i P_i \, U(D_i - D^*)/P_0 \tag{D-9}$$

$$S(R^*) = \sum_i P_i \, U[R_i(C_S) - R^*]/P_0 \tag{D-10}$$

$$S(\tau^*) = \sum_i P_i \, U[\tau_i(C_S) - \tau^*]/P_0 \tag{D-11}$$

where P_i is the size of the local population at the i-th receptor point, P_0 the total number of people of the population, and $U(x)$ the step function that becomes unity when x is zero or positive and zero when x is negative. D^*, R^*, and τ^* are, respectively, the threshold values of D, $R(C_S)$ and $\tau(C_S)$.

Once the distribution function is determined for a parameter D, R, or τ, the mean value of that parameter over the entire population is given by the integral of the distribution function with respect to the threshold of that parameter.[4] The average dose rate $\overline{D}$, the average risk frequency $\overline{R}(C_S)$ and the average mean duration $\overline{\tau}(C_S)$ over the entire population are given as

$$\overline{D} = \int_0^\infty S(D^*) \, dD^* \tag{D-12}$$

$$\overline{R}(C_S) = \int_0^\infty S(R^*) \, dR^* \tag{D-13}$$

$$\overline{\tau}(C_S) = \int_0^\infty S(\tau^*) \, d\tau^* \tag{D-14}$$

The actual computation of $\overline{D}$, $\overline{R}(C_S)$ and $\overline{\tau}(C_S)$ was done by numerically integrating the distribution functions $S(D^*)$, $S(R^*)$, and $S(\tau^*)$, respectively.

Suppose that a distribution function is determined for two mutually exclusive populations, working population and non-working population. Then, the distribution function, $S(R^*)$ for the total population (sum of the two populations) can be computed from $S_w(R^*)$ of the working population and $S_n(R^*)$ of the non-working population as:

$$S(R^*) = [P_w \, S_w(R^*) + P_n \, S_n(R^*)]/P_o \qquad \text{(D-15)}$$

where P_o is the size of total population that is given by the sum of the working population P_w and the non-working population P_n. The linear property of Eq. (D-15) is also applicable to the other two distribution functions $S(D^*)$ and $S(\tau^*)$.

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16. ABSTRACT

A new methodology was developed to characterize population exposure to air pollution and was applied to analyses of photochemical air pollution and population exposure to O_x and NO_2 in the Los Angeles Basin. The analysis was made on the 1973 air quality and population data to examine the weekend effect and the population mobility effect on population exposure to the two pollutants.

NO_2 air quality was found to be better during weekends than weekdays throughout the region except for Orange County. O_x air quality was found to be poorer in the coastal region but better in the inland region during weekends than weekdays. Although the daily maximum O_x concentration became slightly higher over weekends at some stations in the coastal region, the majority of air monitoring stations in the Los Angeles Basin showed a lower O_x concentration during weekends than weekdays. As a result, the population on the whole received less exposure to O_x above the NAAQS during weekends than weekdays.

Because of daily migration from their residence areas to the business districts, workers receive less exposure to O_x and greater exposure to NO_2 than do non-workers who stay near their residences all of the time. The inclusion of population mobility in the population exposure estimates proved to be important for determining a distribution of the population-at-risk, but it turned out not to be crucial for determining an aggregated index of population exposure.

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