COMPARISON OF 8-HR AND 1-HR OZONE EXCEEDANCES IN THE MID-ATLANTIC REGION

FINAL REPORT
STI-998482-1874-FR2

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Prepared for:
MARAMA
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July 30, 1999

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TABLE OF CONTENTS

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LIST OF FIGURES

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LIST OF TABLES

1. INTRODUCTION

On July 18, 1997, the U.S. Environmental Protection Agency (EPA) promulgated a revision to the National Ambient Air Quality Standard (NAAQS) for ozone. Previously, the standard was based on the number of times that the daily maximum hourly ozone concentration was greater than 0.12 parts per million (ppm) over a 3-yr period. The revised NAAQS is based on an 8-hr average ozone concentration. The new standard will be exceeded when the 3-yr average of the fourth maximum daily 8-hr ozone concentration is greater than 0.08 ppm (or greater than or equal to 85 parts per billion – ppb).

The revised ozone standard was designed to be more stringent and protective of public health than the previous standard. Consequently, the Mid-Atlantic region will experience an increase in the frequency and geographic extent of ozone exceedances.

This report illustrates how the characteristics of the ozone problem have changed under the revised standard. Spatial and temporal patterns of 8-hr exceedances during 1997, as an example, are evaluated and compared to those of 1-hr exceedances. Results are derived for the entire Mid-Atlantic region. This work was sponsored by the Mid-Atlantic Regional Air Management Association (MARAMA), a non-profit association of the air pollution control agencies in the states of New Jersey, Pennsylvania, Delaware, Maryland, Virginia, North Carolina, and the District of Columbia.

The intended audience for this report is state and federal air quality managers and other individuals familiar with air quality issues. Results hold implications for air quality forecasters, ambient network managers, public affairs officials, and air quality modelers and planners.

Section 2 of this report describes the database used for the analyses. The spatial and temporal analysis results are documented in Section 3, and a summary of the findings is provided in Section 4. Appendix A provides specific characteristics of 8-hr and 1-hr episodes for all of the 1997 monitoring sites within the MARAMA network.

2. DATABASE PREPARATION

2.1 INTRODUCTION

This section describes the generation and content of the ozone database used for the analyses described in this report. Hourly ozone concentrations for May through September 1997 were obtained from the EPA's Aerometric Information Retreival System (AIRS). Eight-hour averages were not available from EPA or AIRS. Although each state possessed 8-hr averages, differing database structures, content, and averaging methods made synthesis into a regional database extremely time-consuming and fraught with potential errors. Therefore, all 8-hr averages in the project database were calculated from the hourly data obtained from AIRS. The procedures followed were based on the EPA's data management procedures as described in the July 18, 1997 Federal Register notice and summarized further below.

2.2 DATA PROCESSING

The EPA's data management procedures, as specified in the July 18, 1997 Federal Register notice, provided the basis for determining 8-hr average concentrations for these analyses. In short, the process begins by downloading hourly 1-hr ozone concentrations from AIRS. Twenty-four 8-hr averages are calculated for each day and assigned to the first hour of the 8-hr block, i.e., the start hour.[1] If only six or seven hours are valid in an 8-hr block, then the valid hours are summed and divided by six or seven. If five or less hours are valid, then an 8-hr average is determined assuming a value of 0 ppb for all invalid hours and dividing the sum by eight.[2] All 8-hr averages are truncated to integer ppb values (or the third decimal place in ppm). After all of the valid 8-hr averages are determined for a given day, the highest of these is identified and termed the daily maximum 8-hr average. This marks the extent of data processing for the project database. The EPA specifies further procedures to determine design values and nonattainment status, but since this report is an analysis of 8-hr exceedances – i.e., individual 8-hr averages of 85 ppb or greater – there was no need to proceed further.

Section 3 presents analyses that were performed to assess the spatial and temporal characteristics of 8-hr ozone exceedances compared with 1-hr exceedances. All analyses are based on data from 146 monitoring sites operating during 1997 within the Mid-Atlantic region

[1] The last seven 8-hr averages of a day contain data from the following day.

[2] This differs slightly from the EPA's procedures. The EPA requires that the minimum detection limit (MDL), typically 5 ppb, be used in this case for all invalid hours. Because MDL data are monitor-specific and were not available for this report, a value of zero was assumed. Furthermore, the EPA requires that 8-hr averages in these circumstances be reported as missing unless the average is 85 ppb or greater, whereas all 8-hr averages in these circumstances were retained in the project database. These differences, however, should have no bearing on the results of this study, which are concerned exclusively with concentrations of 85 ppb or greater.

shown in **Figure 2-1**. **Table 2-1** lists the number of monitoring sites in each state in the Mid-Atlantic region.

Figure 2-1 is a map of the Mid-Atlantic region with all monitoring sites shown. It must be noted that western Virginia has a sparse ozone monitoring network compared to the rest of the region. The relative density of monitoring sites vary from area to area within the Mid-Atlantic region, this must be taken into account when viewing spatial analysis plots in Section 3.

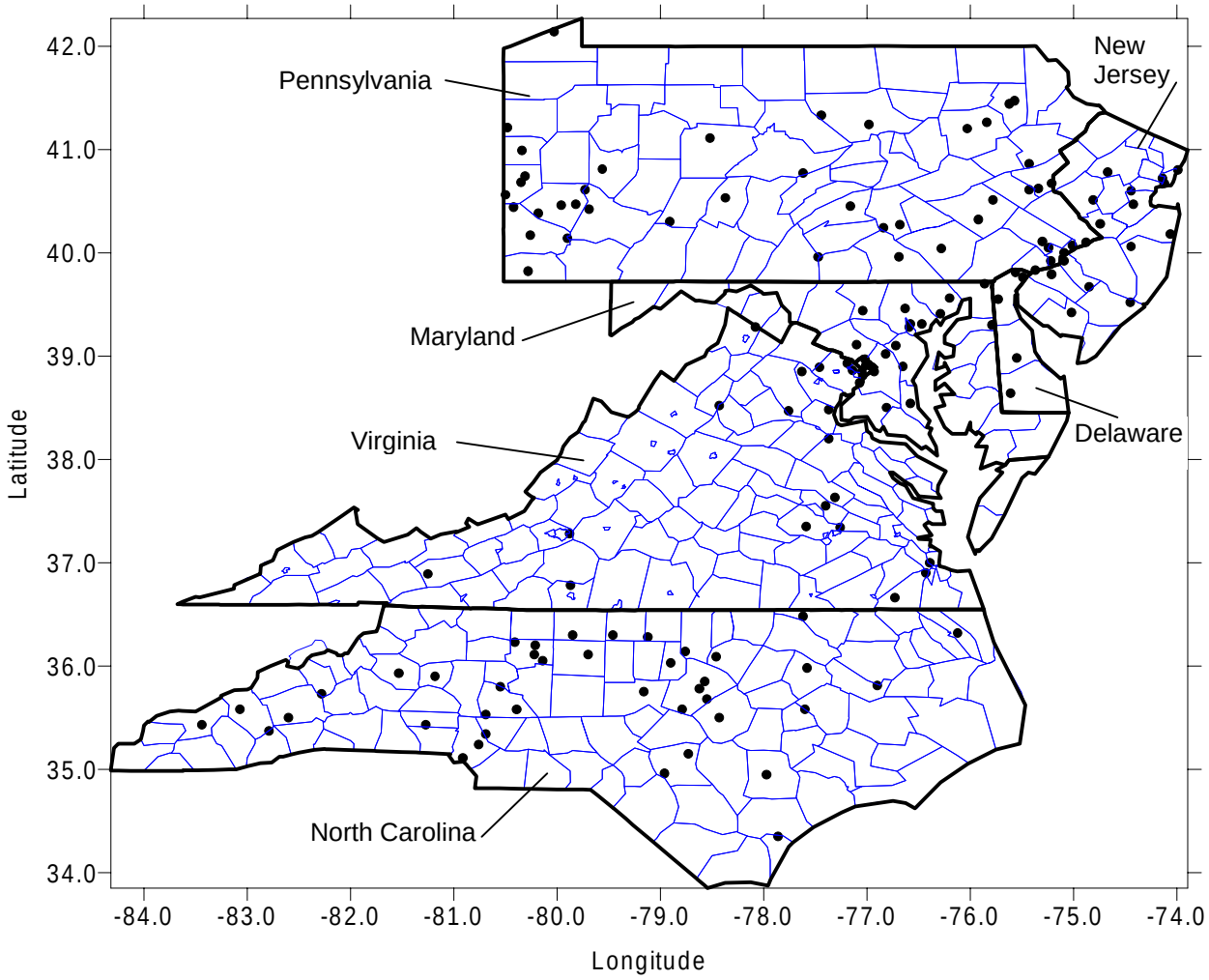

Figure 2-1. 1997 ozone monitoring network within the Mid-Atlantic region (AIRS data).

Table 2-1. Number of monitoring sites per state within the Mid-Atlantic region.

State	Number of monitoring sites
District of Columbia	3
Delaware	5
Maryland	16
North Carolina	40
New Jersey	15
Pennsylvania	45
Virginia	22

The analyses in Section 3 are based on the May through September 1997 ozone data. The 1997 data were the most recent validated data set available through AIRS at the start of this study. A secondary database provided by MARAMA was used for the trend analysis described in Section 3.5. This database consisted of fourth maximum 8-hr average ozone values and the 3-yr running average of these values for 1986 through 1997.

3. SPATIAL AND TEMPORAL ANALYSIS

3.1 INTRODUCTION

The revised standard for ozone was designed to be more stringent and protective of public health than the previous standard. As such, it should be expected that the ozone standard will be exceeded more often and in a greater number of places than in the past. This section describes where and when these exceedances tend to occur by examining 1997 ozone data. Results are presented for both 8-hr and 1-hr exceedances to provide the reader with a sense of how exceedance patterns will change under the revised standard. The types of questions that framed this analysis include:

- How many more 8-hr exceedances occur than 1-hr exceedances?
- How many of these additional exceedances occur at the same sites as 1-hr exceedances but on additional days; how many occur on the same days but at additional sites; and how many occur on different days at additional sites?
- What are the spatial distributions of 8-hr and 1-hr exceedances?
- What are the seasonal patterns of 8-hr and 1-hr exceedances?
- What are the day-of-week patterns of 8-hr and 1-hr exceedances?
- On how many days are there 8-hr and 1-hr exceedances? On how many days are there only 8-hr exceedances? How many 8-hr only exceedance days occurred immediately prior to or following a 1-hr exceedance day, and how many were more than one day removed?
- What are the respective lengths of 8-hr and 1-hr episodes?

3.2 SPATIAL ANALYSIS

The revised standard is based on an 8-hr average ozone concentration. In year 2000 regions will not meet the 8-hr ozone NAAQS if the fourth maximum 8-hr concentration, averaged over the three most recent years of complete data, is greater than or equal to 85 ppb. Due to the lowered concentration threshold and the longer averaging times, a broader range of meteorological and emission conditions will lead to ozone exceedances, and thus, a broader geographic region may be in exceedance of the ozone NAAQS than in the past. For example, sites that are affected by ozone carryover and/or ozone and ozone precursor transport may now exceed the 8-hr standard even though they might not have ozone concentrations in excess of the 1-hr NAAQS.

Figure 3-1 shows the total number of sites with 1-hr and 8-hr exceedances in 1997. Of the 146 Mid-Atlantic sites, nearly all (130 sites or 89 percent) had 8-hr average concentrations greater than 84 ppb. Of these, 109 sites had fourth maximum 8-hr average concentrations in exceedance of the standard. All 52 (or 36 percent) of the Mid-Atlantic sites that had 1-hr exceedances also had 8-hr exceedances. Thus, 78 sites had ozone concentrations in excess of the 85 ppb 8-hr NAAQS that did not exceed the 1-hr standard.

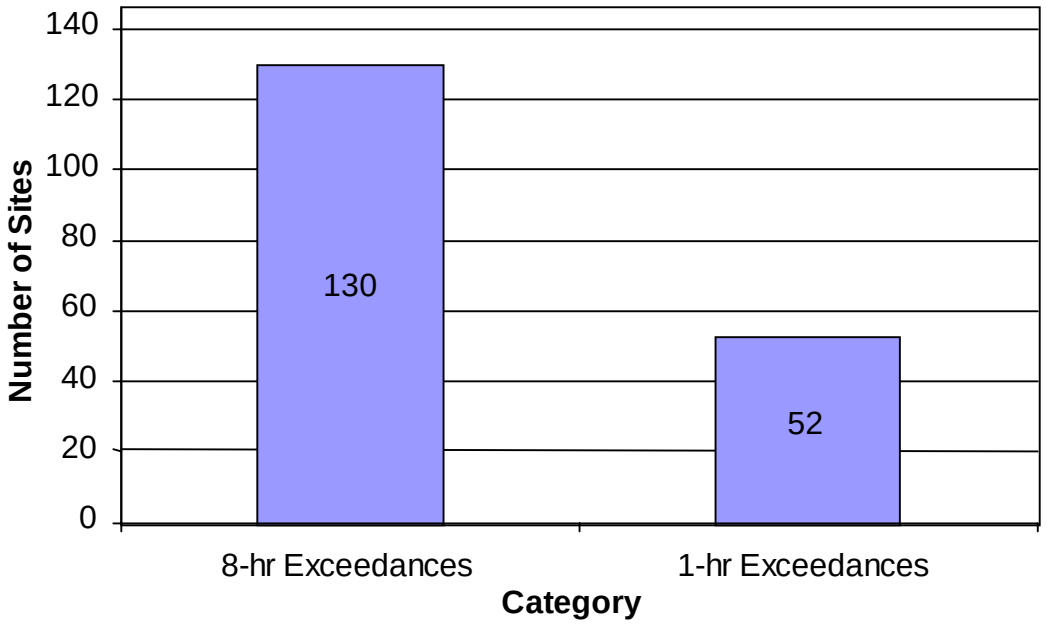

Figure 3-1. Number of Mid-Atlantic region sites with 8-hr and 1-hr exceedance days from May through September 1997. There are 146 sites in total.

Figure 3-2 shows the number of 1-hr exceedances by site. The majority of 1-hr exceedances are confined to a rather narrow metropolitan corridor, the DC-Baltimore-Philadelphia-Trenton corridor. The number of 8-hr exceedances by site is shown in **Figure 3-3**. This figure shows the extent to which the revised standard expands the area of concern. Many rural areas that did not have exceedances under the 1-hr standard had maximum 8-hr concentrations in excess of the 8-hr NAAQS. The largest concentration of 8-hr exceedances occurred in areas where the 1-hr standard was also exceeded such as the Charlotte and Raleigh areas of North Carolina, Richmond Virginia, and the DC-Baltimore-Philadelphia-Trenton metropolitan corridor. Of the 130 sites with 8-hr concentrations in excess of the new NAAQS, 109 sites had fourth maximum 8-hr concentrations exceeding the concentration threshold.

Figure 3-4 is a contour plot showing the change in the number of exceedances between the two standards. Contour lines were drawn in order to estimate the change in the number of exceedances for areas were the monitoring network is sparse (see Figure 2-1). New Jersey, much of Pennsylvania, and North Carolina show the greatest difference in the number of exceedances.

Figures 3-3 and 3-4 depict locations where the revised standard is likely to have the greatest impact in terms of number of exceedances. This depiction is important for understanding the regulatory implications of the revised standard.

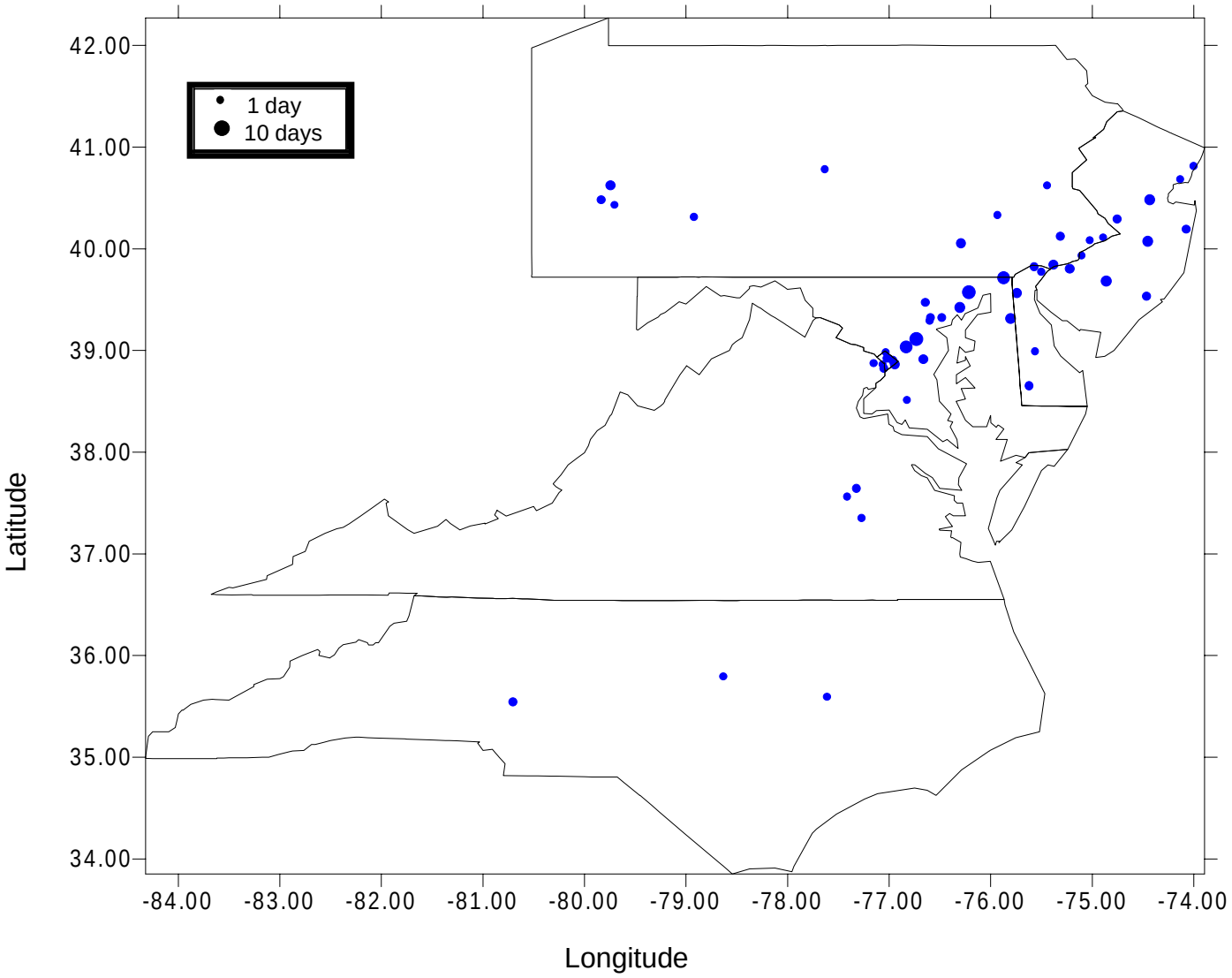

Figure 3-2. Number of 1-hr exceedances by site in 1997 for the Mid-Atlantic region. The diameter of the circle is proportional to the number of exceedances at that site. All 1997 monitoring sites are shown in Figure 2-1.

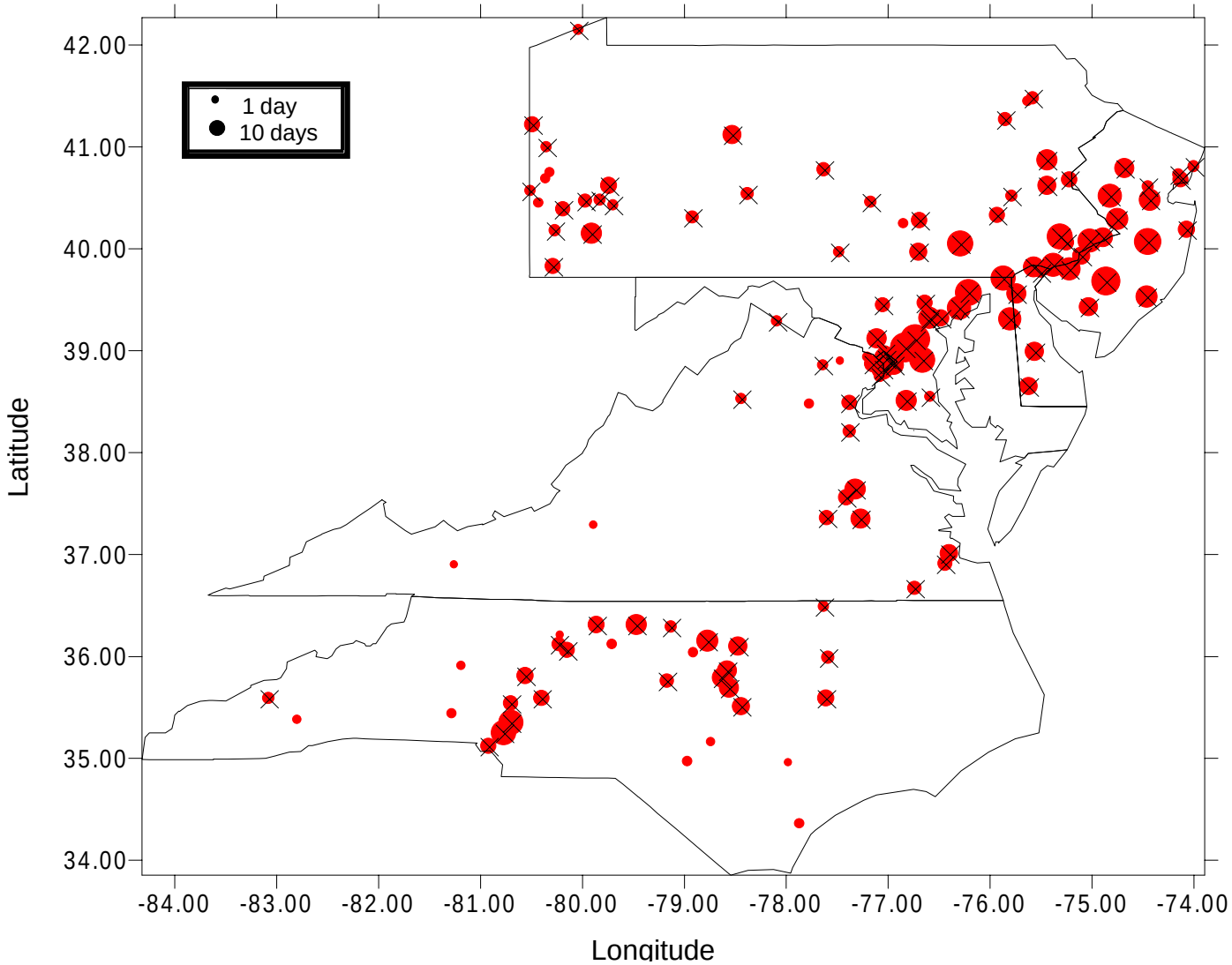

Figure 3-3. Number of 8-hr exceedances by site in 1997 for the Mid-Atlantic region. The diameter of the circle is proportional to the number of exceedances at that site. Sites with an X are locations with fourth maximum 8-hr concentrations exceeding the concentration threshold. All 1997 monitoring sites are shown in Figure 2-1.

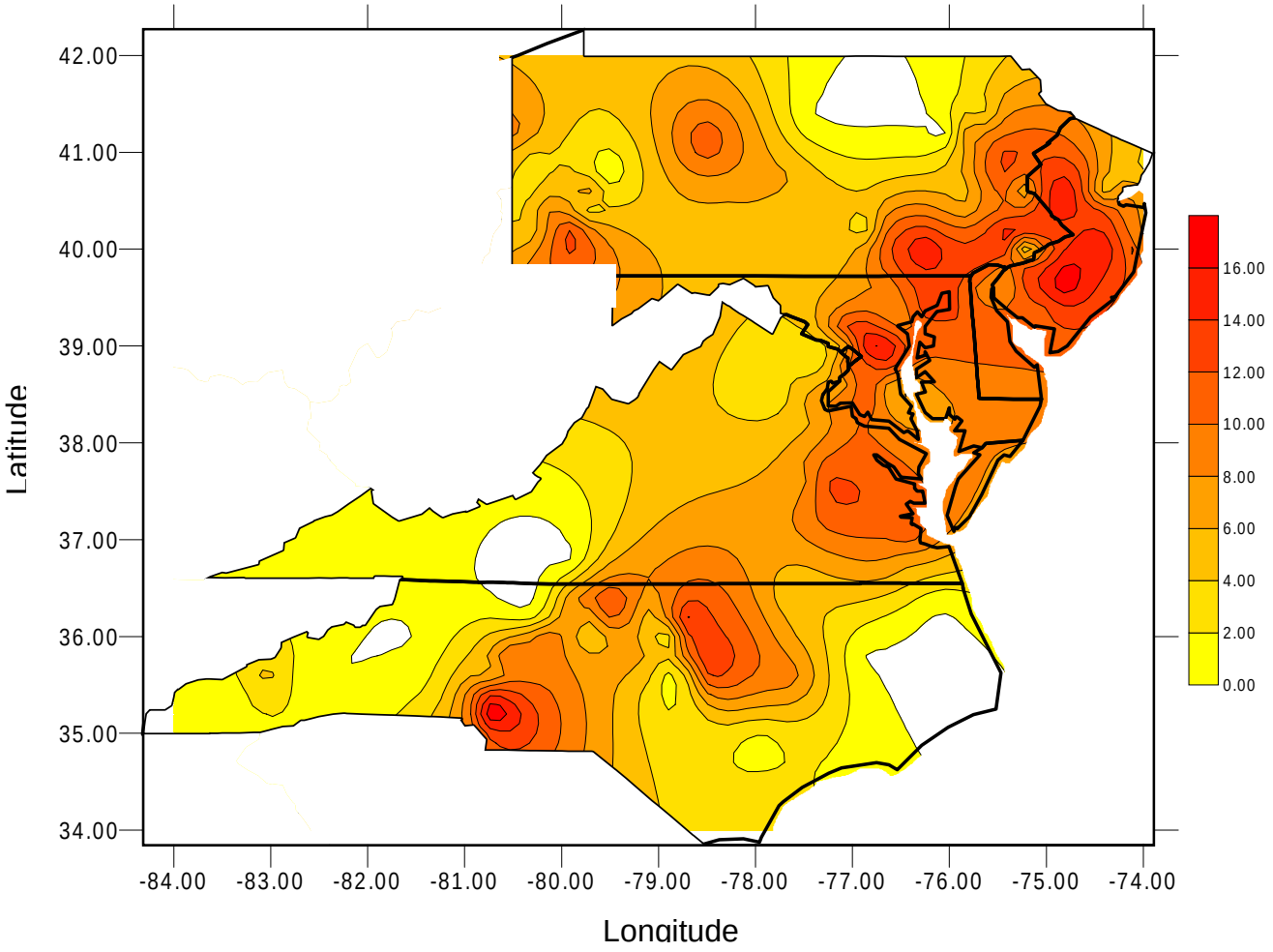

Figure 3-4. Contour plot of the difference between the number of 8-hr and 1-hr exceedances by site in the Mid-Atlantic region in 1997.

So far, this section has examined the spatial distribution of ozone exceedances. **Table 3-1** provides a more quantitative assessment of the impact of the revised ozone standard. The table ranks the top 50 monitoring sites according to the number of 8-hr exceedances. The table also shows each site's rank according to the 1-hr standard and provides ratios for the number of 8-hr to 1-hr exceedances. A table containing this information plus average 8-hr and 1 hr exceedance values for all Mid-Atlantic region study sites is shown in Appendix A. The regional average ratio is 6.9 with a median ratio of 6.2.

Table 3-1. Rank of the top 50 monitoring sites by the number of 8-hr exceedances in 1997. Also shown are the 1-hr rank, the number of 8-hr and 1-hr exceedances, and the 8-hr/1-hr ratio. Information for all Mid-Atlantic region sites is provided in Appendix A.

State	Site	Rank		Number		Ratio
		8-hr	1-hr	8-hr	1-hr	
MD	Fort Meade (240030019)	1	2	23	7	3.3
MD	Greenbelt (240330002)	2	4	23	6	3.8
NJ	Ancora State Hospital (340071001)	3	9	22	4	5.5
MD	Aldino (240259001)	4	1	20	7	2.9
NJ	Colliers Mills (340290006)	5	5	20	4	5.0
MD	Davisonville (240030014)	6	10	19	3	6.3
PA	Lancaster East (420710007)	7	13	19	3	6.3
PA	Norristown (420910013)	8	24	19	2	9.5
MD	Fair Hill (240150003)	9	3	18	6	3.0
NC	Mecklenburg Cab Co. (371191009)	10	no rank	18	none	undefined
NC	Charlotte (371190034)	11	no rank	18	none	undefined
MD	Edgewood (240251001)	12	6	17	4	4.3
PA	Chester (420450002)	13	16	17	3	5.7
NJ	Flemington (340190001)	14	no rank	17	none	undefined
PA	Philadelphia - NE (421010024)	15	33	17	1	17
DC	Washington DC - Southeast (110010043)	16	19	17	2	8.5
NJ	Clarcksboro (340150002)	17	14	16	3	5.3
MD	Millington (240290002)	18	8	16	4	4
NJ	Nacote Creek (340010005)	19	19	15	2	7.5
NJ	Rutgers University (340230011)	20	7	15	4	3.8
NJ	Rider U. (340210005)	21	29	15	2	7.5
MD	Lake Clifton (245100050)	22	21	15	2	7.5
VA	Aurora Hills / Arlington (510130020)	23	22	15	2	7.5
NC	Granville Co. - Water Treatment Plant (370770001)	24	no rank	15	none	undefined
VA	Hanover Co. (510850001)	25	20	14	2	7
DE	Brandywine Creek St. Park (100031010)	26	23	14	2	7
PA	Kunkletown (420890001)	27	no rank	14	none	undefined
PA	Charleroi (421250005)	28	no rank	14	none	undefined
MD	S. Maryland (240170010)	29	40	14	1	14
NC	Caswell Co. - Cherry Grove Recreation (370330001)	30	no rank	14	none	undefined
PA	Bristol (420170012)	31	30	13	1	13
DE	Lums Pond St. Park (100031007)	32	11	13	3	4.3
VA	Shirley Plantation (510360002)	32	35	13	1	13
MD	Suitland (240338001)	33	12	13	3	4.3
NJ	Chester (340273001)	34	no rank	13	none	undefined
NC	Raleigh - E. Millbrook Jr. High (371830014)	35	no rank	13	none	undefined
NC	Raleigh - North State Street (371830015)	36	40	13	1	13
MD	Rockville (240313001)	37	no rank	13	none	undefined

Table 3-1. Rank of the top 50 monitoring sites by the number of 8-hr exceedances in 1997. Also shown are the 1-hr rank, the number of 8-hr and 1-hr exceedances, and the 8-hr/1-hr ratio. Information for all Mid-Atlantic region sites is provided in Appendix A.

State	Site	Rank		Number		Ratio
		8-hr	1-hr	8-hr	1-hr	
NC	Garner (371830017)	38	no rank	13	none	undefined
NJ	Millville (340110007)	39	no rank	12	none	undefined
PA	S.B. Elliot State Park (420334000)	40	no rank	12	none	undefined
DE	Killens Pond St Park (100010002)	41	36	12	1	12
NC	Franklinton (370690001)	42	no rank	12	none	undefined
PA	Allentown (420770004)	43	39	12	1	12
DE	Wilmington (100051002)	44	27	11	2	5.5
NJ	Camden (340070003)	45	35	11	1	11
DC	Washington DC - Northeast (110010041)	46	17	11	2	5.5
VA	Hampton (516500004)	47	no rank	11	none	undefined
PA	York East (421330008)	48	no rank	11	none	undefined
NC	Clayton (371010002)	49	no rank	11	none	undefined
NJ	Monmouth College (340250005)	50	18	10	2	5.0

On average, an individual site in the Mid-Atlantic region could exceed the standard seven times more often under the revised standard. Out of the 15 highest ranking sites (according to the 8-hr standard), six are located in Maryland, four in Pennsylvania, three in New Jersey, and two in North Carolina.

Many sites listed in Table 3-1 experience a change in rank as a result of the revised standard. However, seven of the sites that ranked in the top ten (sites with the highest number of exceedances) under the 1-hr NAAQS are in the top ten under the 8-hr NAAQS. Three of the sites that did not rank at all (sites that experienced no exceedances in 1997) under the 1-hr NAAQS are in the top 14 sites under the 8-hr NAAQS.

3.3 TEMPORAL ANALYSIS

Section 3.2 examined the difference in the spatial distribution of 1-hr and 8-hr exceedances. This section examines temporal patterns of 1-hr and 8-hr exceedances. Comparisons of the absolute regional number of 8-hr and 1-hr exceedances, the monthly, day-of-week, and hourly patterns are summarized. Downward trends in 1-hr ozone concentrations during the past few decades have been well documented (e.g., Chinkin et al., 1996)[3]. This

[3] Chinkin L.R., Reiss R., Eisinger D.S., Dye T.S., and Jones C.M. (1996) Ozone exceedance data analysis: representativeness of 1995. Phase I. Final report prepared for American Petroleum Institute, Washington, DC by Sonoma Technology, Inc., Santa Rosa, CA, STI-996031-1574-FR, August.

section examines trends in the 8-hr exceedances to see if the same result can be found under the revised standard. Analysis results are presented in terms of two metrics:

- **Exceedance day**. An exceedance day is any day (0000 – 2300 begin hour) during which at least one monitor recorded concentrations at or above 125 ppb in the case of the 1-hr standard or at or above 85 ppb in the case of the 8-hr standard.

- **Site exceedance**. The number of site exceedances (or simply exceedances) is the total number of monitoring sites recording exceedances during a given period. Hence, during a single exceedance day, there may have been as few as one or as many as 106 site exceedances in the Mid-Atlantic region.

Figure 3-5 shows the total number of 1-hr and 8-hr exceedance days for May through September 1997. **Figure 3-6** shows the number of 1-hr and 8-hr site exceedances by date for this time period. In total, there were 118 1-hr site exceedances and 1210 8-hr site exceedances from May through September 1997, an order of magnitude increase. An analysis of the data in Figures 3-5 and 3-6 shows that the 41 additional exceedance days resulting from the revised standard account for only 418 (or 38 percent) of the additional site exceedances (1210 – 118 = 1092 additional site exceedances). In other words, according to the 1997 data, the number of exceedance days in the Mid-Atlantic region can be expected to triple under the revised standard; however, these extra exceedance days will account for only a portion of the many additional site exceedances that can be expected. Again, this underscores the relatively large geographic impact (relative to the temporal impact) of the revised standard.

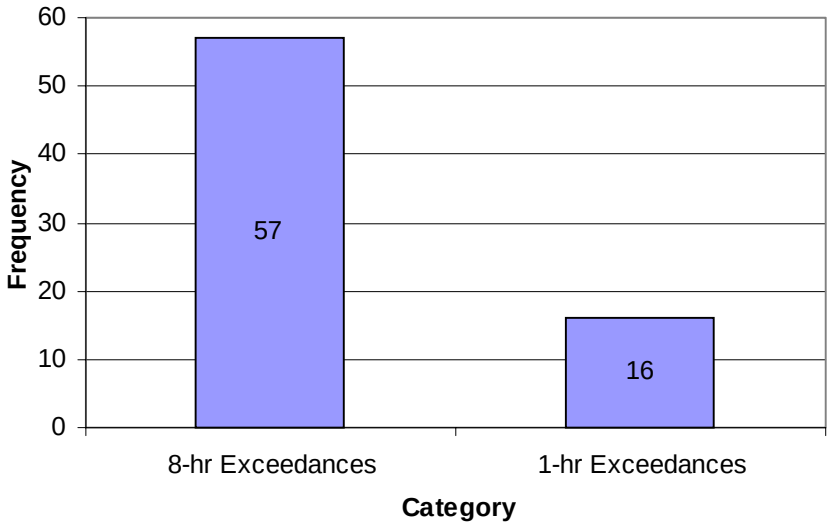

Figure 3-5. Number of 8-hr and 1-hr exceedance days in the Mid-Atlantic region from May through September 1997.

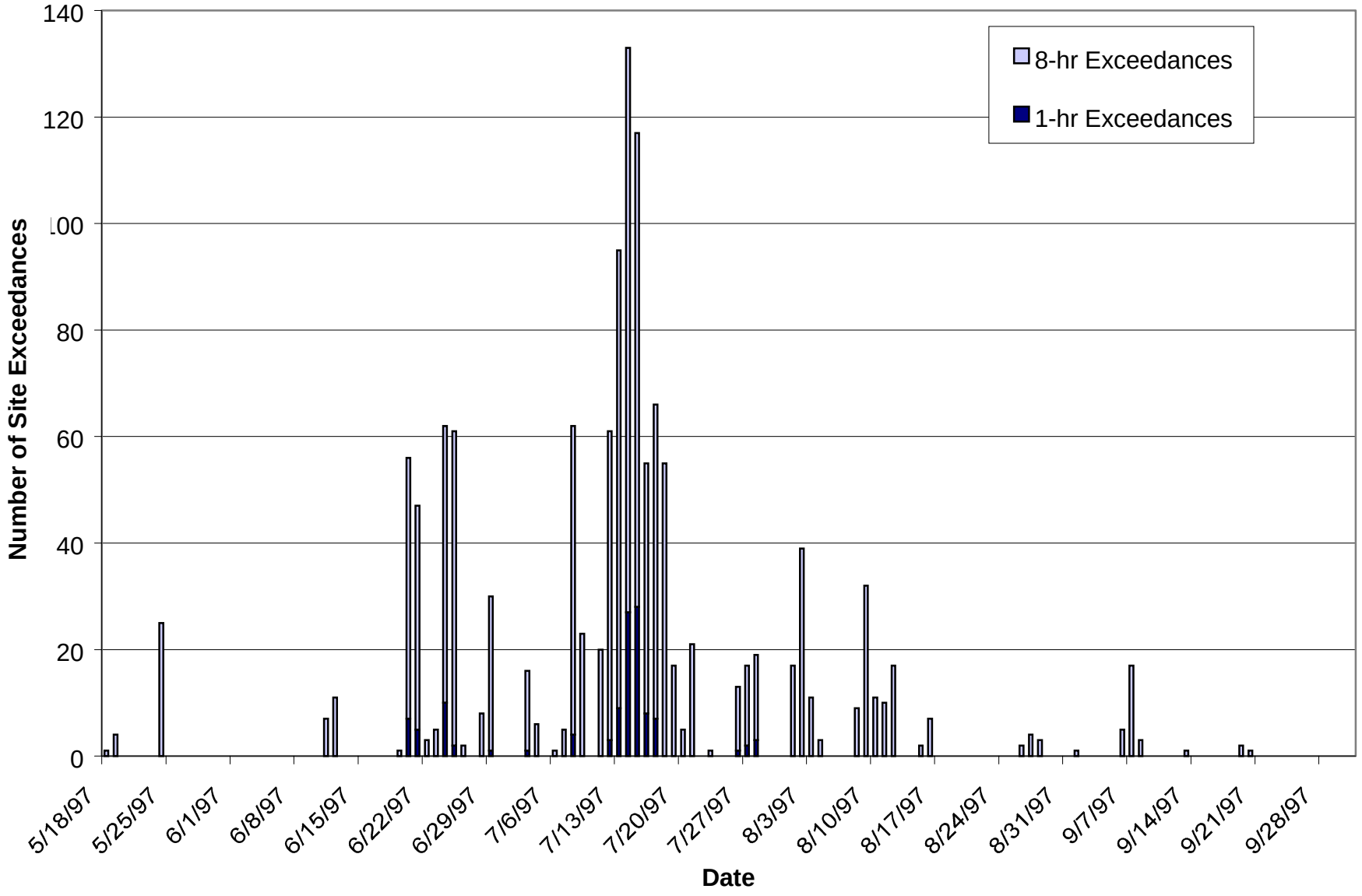

Figure 3-6. Comparison of the number of 8-hr and 1-hr site exceedances by date from May through September 1997.

The seasonal distribution of 1-hr and 8-hr exceedance days in the Mid-Atlantic region is shown in **Figure 3-7**. The number of both 1-hr and 8-hr exceedances peaks in July with 11 1-hr and 21 8-hr exceedance days. No 1-hr exceedance days occur in months other than June and July 1997, however, a significant portion of 8-hr exceedance days occur in all months shown. Additional data need to be examined (e.g., spring, winter, and fall ozone data) to assess the full seasonal distribution of 8-hr exceedances and to classify the extent to which the "ozone season" (currently April through October) has expanded under the new standard for the region.

Figure 3-8 shows the number of 8-hr and 1-hr exceedance days and site exceedances by day of the week for 1997. Note that this analysis covers only one year of data, which could be misleading. Conclusions here should be confirmed with analysis of data from other years. Due to differences between weekday and weekend driving patterns, day-of-week analyses can be used to assess the motor vehicle contribution to the regional ozone level. Passenger vehicles are the largest single source of ozone precursors and are likely to be the most significant factor in weekday/weekend differences. Two issues that may affect weekend versus weekday ozone patterns are that: (1) vehicle counts and miles traveled, therefore total vehicular emissions, may increase on weekends compared to weekdays due to commuter driving patterns, and (2) weekend vehicular emissions tend to be more dispersed over space and time than do weekday emissions.

There is no clear day-of-week pattern in the Mid-Atlantic region for 1-hr exceedances in the 1997 data. The number of 8-hr exceedance days peaks on Saturdays, Sundays, and Mondays. There is a drop in the number of exceedances on Tuesdays followed by a steady mid-week rise. The number of site exceedances shows a greater variability under the 8-hr standard compared to the 1-hr standard. Although Tuesdays have the smallest number of 8-hr exceedances, they have the second highest number of site exceedances. It is not clear why this occurs; analysis of sub-regional effects of the day-of-week activity patterns on ozone exceedances might provide additional information. Sub-regional analysis would require data for additional years in order to maintain a statistically valid sample population.

Figure 3-9 compares the diurnal patterns of 8-hr and 1-hr exceedances for the Mid-Atlantic region. The 8-hr exceedances tend to occur earlier in the day due to the fact that the 8-hr average concentrations are reported by the start hour of the 8-hr average. For example, the 1100-hour peak for 8-hr exceedances incorporates the hours from 1100 to 1900 hours. The distribution of the 8-hr and 1-hr exceedances would be similar if the midpoint of the 8-hr average period was used rather than the start hour. Some 8-hr exceedances may start in the late evening hours.

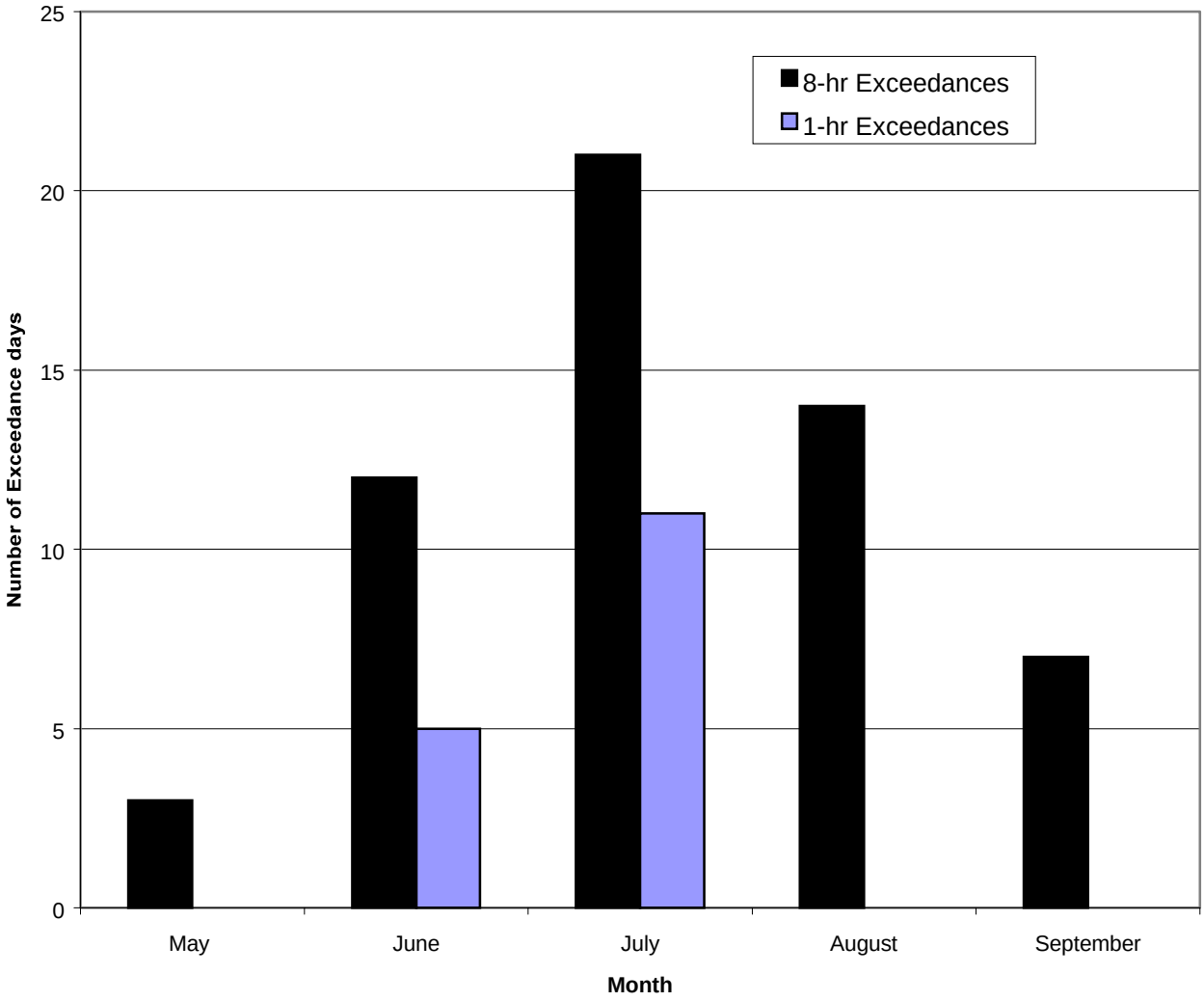

Figure 3-7. Frequency distribution of the number of exceedance days by month for the 8-hr and 1-hr standards in the Mid-Atlantic region in 1997.

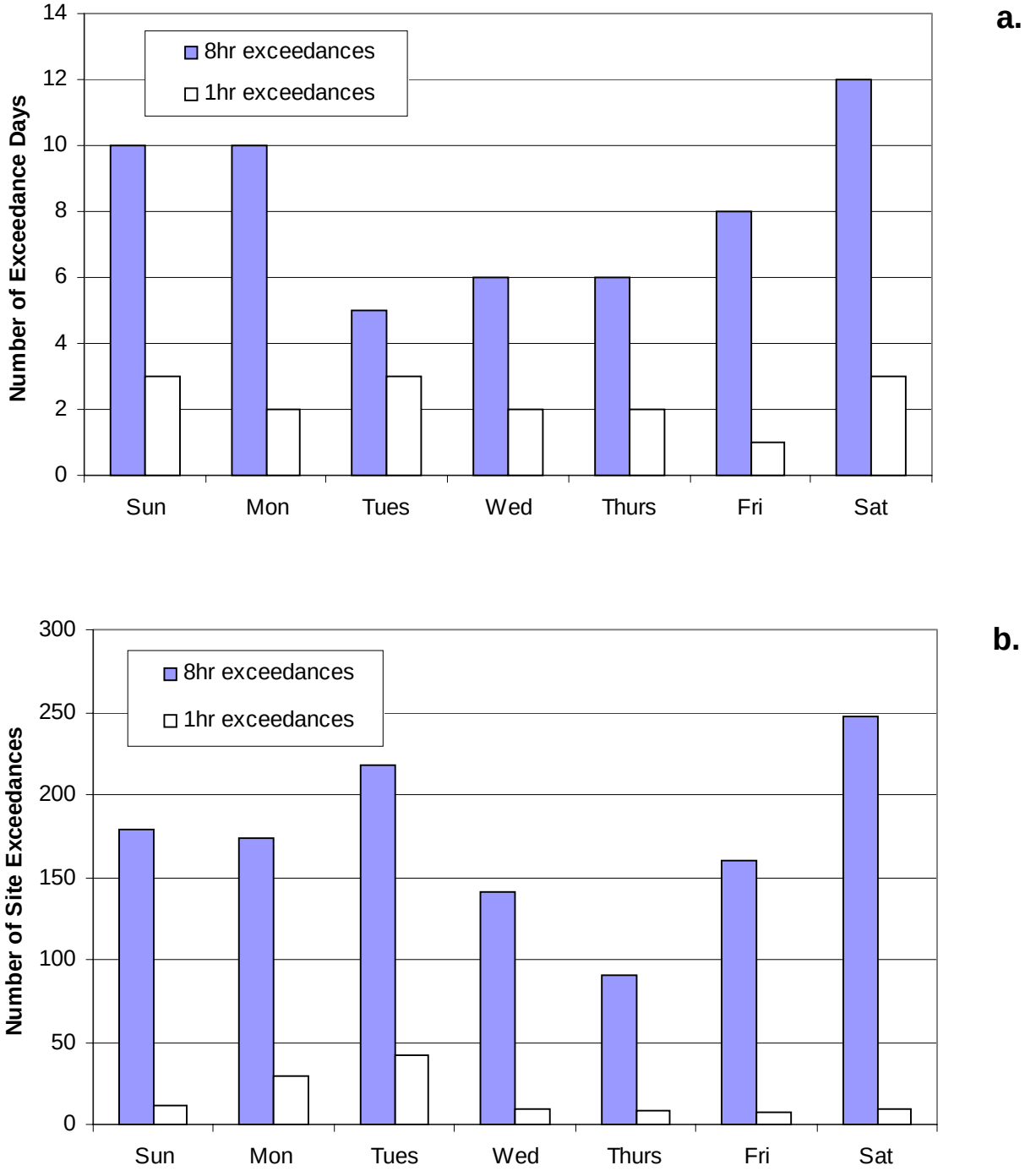

Figure 3-8. Distribution of the average number of (a) exceedance days and (b) site exceedances by day of the week for the Mid-Atlantic region in 1997.

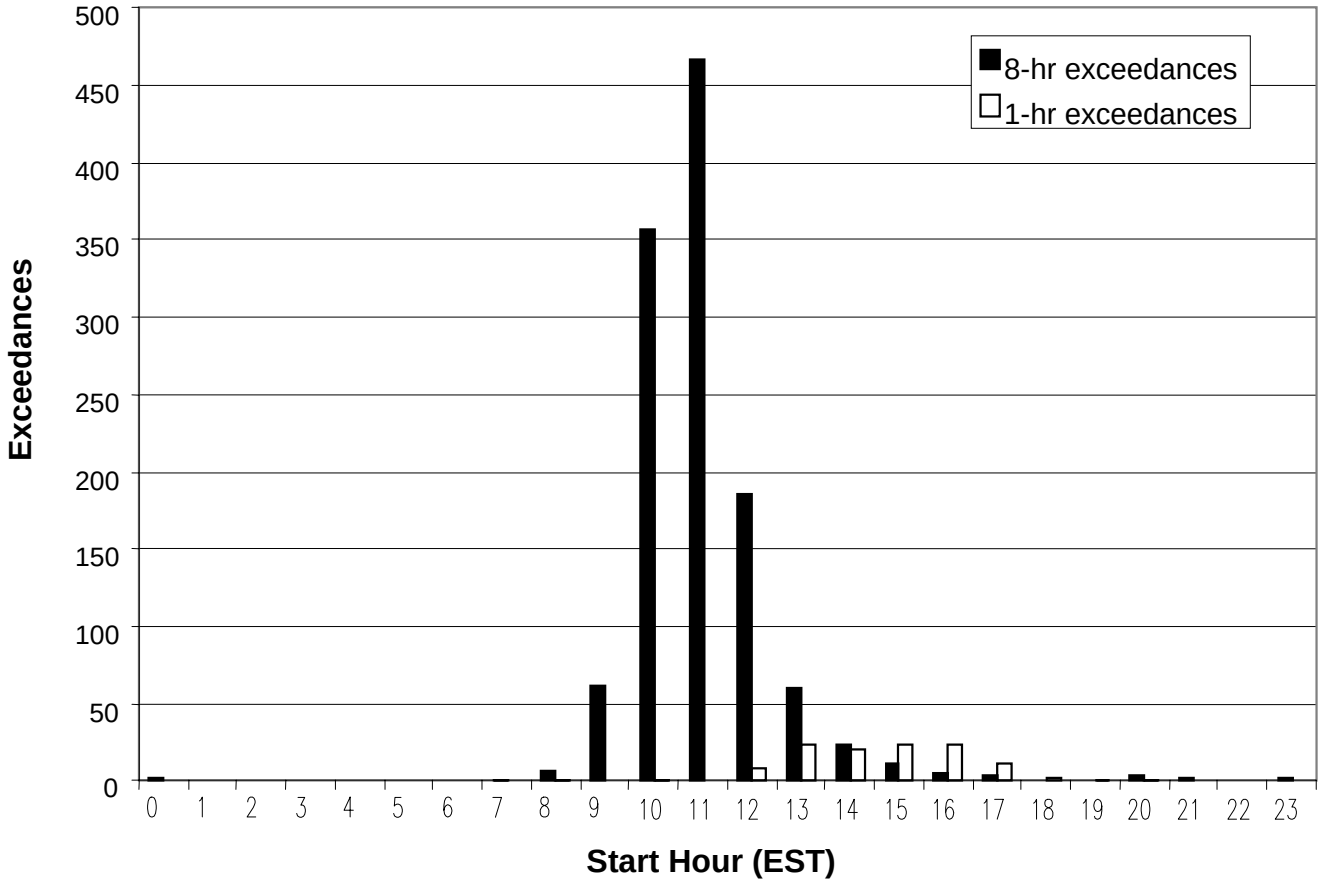

Figure 3-9. Diurnal profile of 1-hr and 8-hr exceedances in 1997 for the Mid-Atlantic region.

3.4 OTHER CHARACTERISTICS OF 1-HR AND 8-HR EXCEEDANCES

Section 3.2 showed that the number of exceedance days in the Mid-Atlantic region could triple under the revised standard. This section categorizes these additional exceedance days in terms of episode length, i.e., the number of consecutive exceedance days. Do the lengths of ozone episodes increase under the revised standard or do 8-hr exceedances occur sporadically throughout the season?

Figure 3-10 shows the length of 1-hr and 8-hr episodes for the 1997 study period. It shows that under both standards, most episodes are single-day events. However, most 8-hr exceedance days occur within episodes that are two days long or longer (i.e., there are 25 two-day 8-hr ozone episodes, thus 50 exceedance days occur within two-day episodes compared to 40 single-day 8-hr episodes). Eighty percent of 8-hr exceedance days occur within episodes that are two days long or longer while 73 percent of the 1-hr exceedance days occur within such episodes. The longest 1-hr episode was five days long, while the longest 8-hr episode was ten days long. The 10-day episode occurred in North Carolina from July 11 to July 20. All 8-hr episodes with lengths greater than four days occurred within that same July time

period. Episode lengths tend to increase under the revised standard, relative to the length of episodes under the 1-hr standard. Episode lengths were calculated separately for each state to assure that exceedances within an episode were both temporally and geographically connected. The number of episodes at each length was then counted to create Figure 3-10. An alternative approach to this analysis would be to divide the area into sub-regions using airshed boundaries.

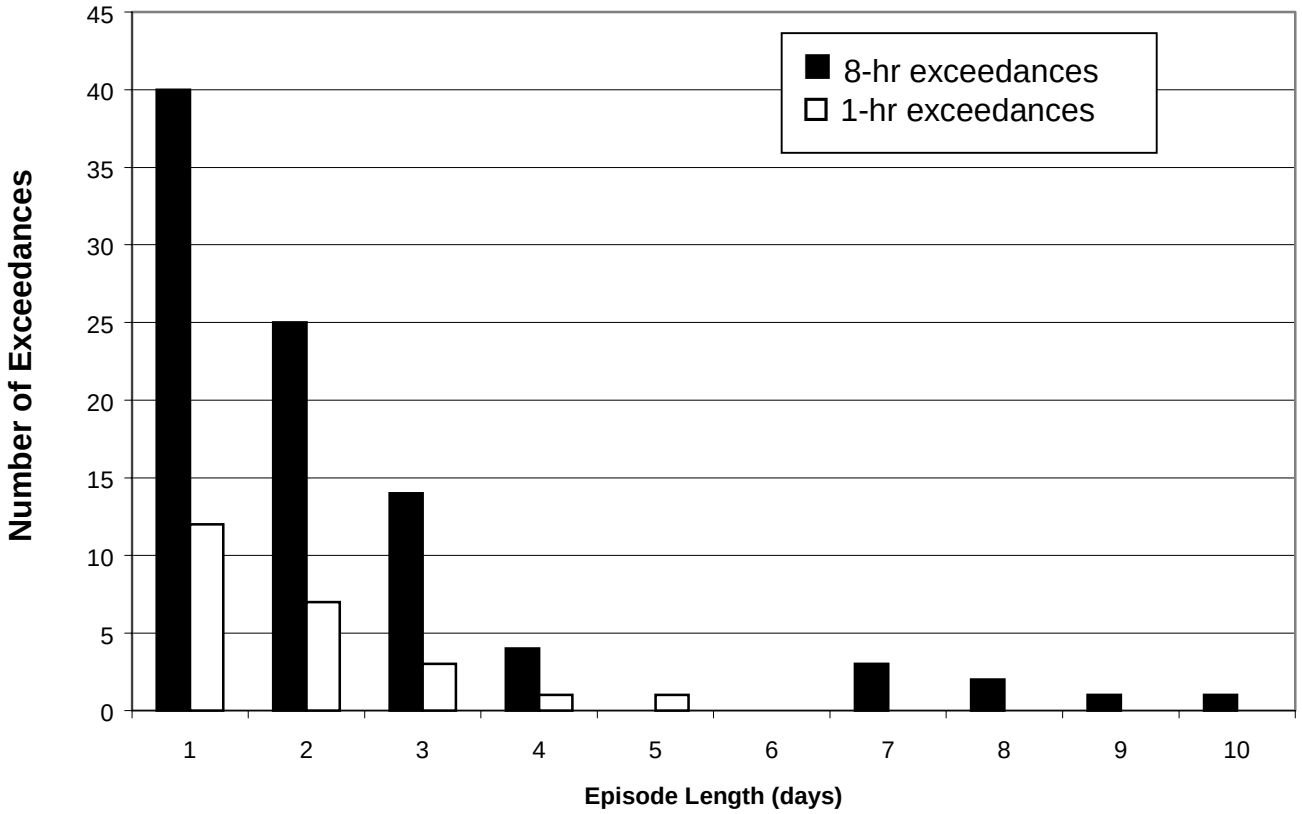

Figure 3-10. Frequency of episode length (continuous exceedance days) for the 8-hr and 1-hr standards in 1997 for the Mid-Atlantic region.

Figure 3-11a shows the coincidence of 1-hr and 8-hr exceedance days on a regional scale. This analysis helps determine whether 8-hr and 1-hr exceedances occur on the same days or whether different conditions cause one standard or the other to be exceeded. The results show that 16 (28 percent) of the 57 8-hr exceedance days coincided with 1-hr exceedance days. The remaining 72 percent of the days with an 8-hr exceedance occurred on days with no 1-hr exceedances.

The 41 days on which only the 8-hr standard was exceeded were further investigated to determine whether they were associated with a 1-hr exceedance day or were more than one non 8-hr or non 1-hr exceedance day removed. This analysis provides some insight into the extent to which the additional 8-hr exceedance days extend the 1-hr episodes or potentially result in separate, additional episodes that would not have registered under the 1-hr standard. (See Figure 3-6 for examples.)

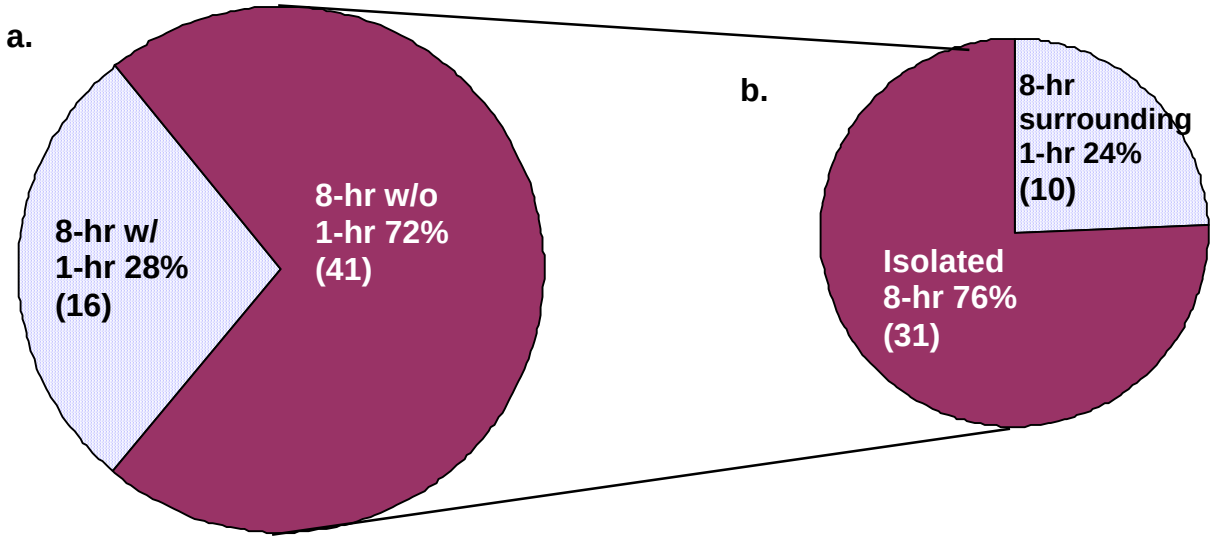

Figure 3-11. Pie charts showing (a) coincidence of the 8-hr and 1-hr exceedance days and (b) distribution characteristics of the 8-hr-only exceedance days for the Mid-Atlantic region in 1997. Included is the percentage of total days corresponding to each pie slice, with the number of days in parenthesis. An isolated 8-hr exceedance day is one that is not part of an episode that includes a 1-hr exceedance.

Figure 3-11b shows the results of this analysis. The majority, 76 percent, of the 8-hr only episodes were isolated from 1-hr exceedance days. This suggests that the adoption of the 8-hr standard results in the detection of additional episodes, as well as the extension of existing 1-hr episodes. New episodes may represent meteorological and precursor conditions somewhat different from existing 1-hr episodes and are therefore worthy of consideration by air quality control officials. In other words, given the potentially broader set of meteorological and precursor conditions leading to 8-hr episodes, emission control programs may have to be more robust than in the past.

As stated above, the analysis in Figure 3-11 was performed over the entire Mid-Atlantic region. This same analysis was also performed on a state-by-state basis. The average (over the various Mid-Atlantic states) number of sole 8-hr exceedances and coincident 8-hr and 1-hr exceedances were 78 and 22 percent, respectively, of the average total number of exceedance days. These results are consistent with the analysis performed on the regional scale.

3.5 TREND ANALYSIS

An additional database provided by MARAMA was used to analyze annual trends in the number of 8-hr exceedances using the fourth maximum exceedance value. **Figure 3-12** contains box whisker plots of fourth maximum 8-hr exceedance values for all sites operating

continuously for the time periods shown. Seventy sites were in continuous operation between 1985 and 1997, while 94 sites were operational throughout the shorter time period of 1992 through 1997. The boxes in Figure 3-12 represent the inner-quartile range of the data set (the bottom and top of the box denote the 25th and 75th percentile, respectively). The mid-line of the boxes is the median value (50th percentile) for that year. The whiskers or tails from the box, are data that fall within 1.5 times the inner-quartile range. It is the median value that is of greatest importance when looking for trends within a data set. Figure 3-12 shows no clear annual trend in the fourth maximum value for the Mid-Atlantic region. The median value for the last six years (Figure 3-12b) has consistently oscillated within the 0.08 to 0.095 ppm range (~80 to 95 ppb). Regression analysis between the fourth maximum 8-hr concentration against year of occurrence was performed on each site within the smaller data set, i.e., sites operating continuously from 1992 through 1997. Particular sites were chosen on the basis of the slope in order to select sites that displayed the most extreme upward trend (slope>1), downward trend (slope<1), and lack of trend (slope=0).

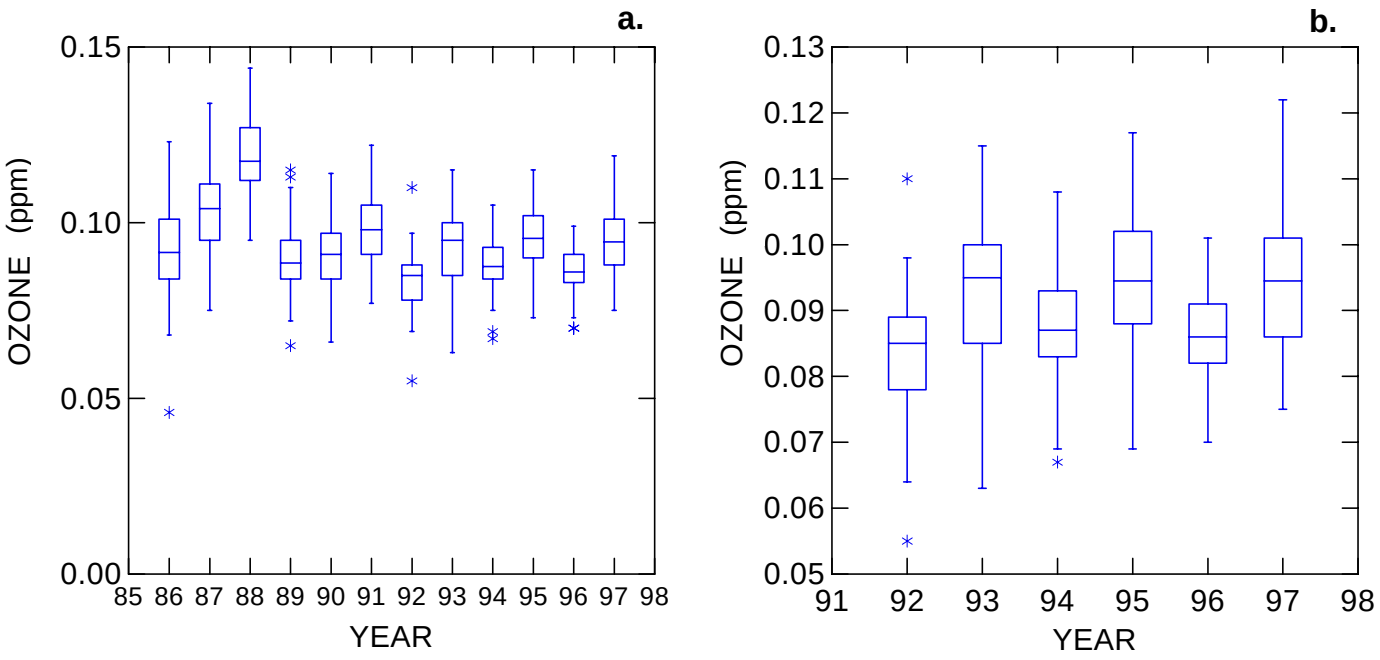

Figure 3-12. Box whisker plots of fourth maximum 8-hr average values (ppm) for continuously operating monitor sites over the time period shown. Figure 3-12 (a) is composed of 70 monitoring sites and (b) of 94 sites.

Figure 3-13 shows the fourth maximum ozone concentration for each year from 1986 through 1997. Even after selecting for only the extreme sites, no trend, specifically no downward trend, can be found.

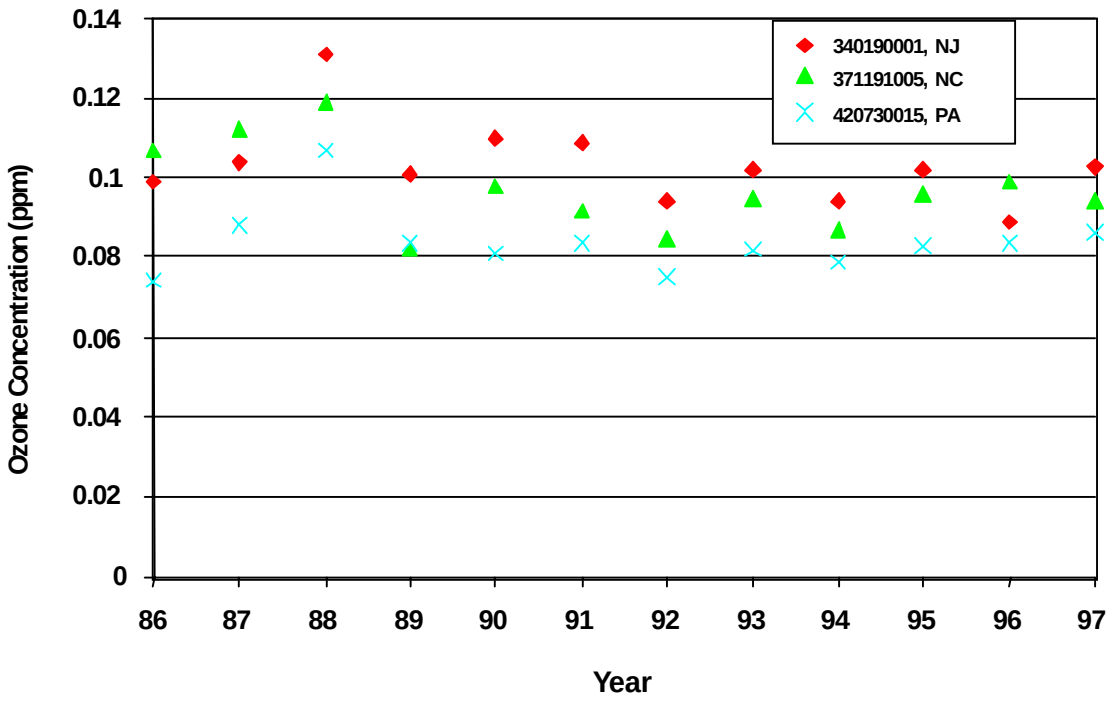

Figure 3-13. Plot of fourth maximum 8-hr ozone concentration (ppm) versus year of occurrence. Sites were selected to show the most extreme trends. The sites shown are Three Bridges, New Jersey; Westinghouse Blvd., North Carolina; and Croton & Jefferson St., Pennsylvania. The AIRS site codes are provided.

Figures 3-12 and 3-13 show that the magnitude and relative distribution of fourth maximum 8-hr ozone concentrations for 1997 are similar to other recent years such as 1991, 1993, and 1995. Thus, at least for concentrations, 8-hr ozone data for 1997 are representative of other recent years; no analyses or conclusions can be made regarding the spatial or temporal representativeness of data from 1997. This analysis was intended to be a preliminary overview of the characteristics of 8-hr ozone episodes compared to 1-hr episodes in the Mid-Atlantic region. A more in-depth trend analysis, inclusive of meteorological adjustments on the regional and sub-regional scales, should be performed in order to make conclusive statements regarding trends in 8-hr concentrations for the Mid-Atlantic region.

4. SUMMARY OF CONCLUSIONS

In this report, the spatial and temporal characteristics of 1-hr and 8-hr ozone exceedances were compared using data from 146 monitors within the Mid-Atlantic region in 1997. The key conclusions from this analysis are:

Spatial Characteristics of 8-hr Ozone

There were nearly four times as many 8-hr exceedance days as 1-hr exceedance days, and over ten times as many 8-hr site exceedances as 1-hr site exceedances in the Mid-Atlantic region in 1997. Due to the broader set of meteorological and precursor conditions leading to 8-hr episodes, emission control programs may have to be more robust than in the past.

Most (68 percent) of the additional site exceedances resulting from the revised standard occurred on days already containing 1-hr exceedances. Nearly all, 89 percent, of the Mid-Atlantic sites recorded 8-hr concentrations above the threshold while only 36 percent had 1-hr exceedances. These points underscore the relatively large geographic impact (relative to the temporal impact) of the revised standard, i.e., 8-hr exceedances occur over a much larger area than 1-hr exceedances. In terms of compliance with the revised the NAAQS, seventy-two percent of the Mid-Atlantic sites had fourth maximum 8-hr concentrations above 85 ppb in 1997.

The greatest increase in site exceedances occurred in areas that were already experiencing significant amounts of 1-hr site exceedances. However, large areas that did not exceed the 1-hr standard in 1997 (such as western and central Pennsylvania and central North Carolina) can be expected to exceed the revised standard, thereby expanding the area of concern for air quality officials. The larger area of concern implies that regional emission control programs will be more effective at mitigating the ozone problem than will localized control strategies. Additional work is needed to evaluate the benefit of various control programs under the new standard.

Temporal Characteristics of 8-hr Ozone

There is a significant seasonal impact from the revised standard. All 1997 1-hr exceedance days occurred in June and July, while a significant portion of 8-hr exceedance days occurred in May, August, and September. Further research, utilizing multiple years of data is required in order to characterize a change in the ozone season. If the ozone season is extended under the 8-hr NAAQS, ozone and ozone precursor monitoring activities may be affected.

The majority (76 percent) of the 8-hr exceedance days that occurred in the absence of 1-hr exceedances were not associated with an episode that included a 1-hr exceedance day. This suggests that the adoption of the 8-hr standard results in the detection of additional episodes, as well as the extension of existing 1-hr episodes. In addition, analysis of the revised standard reveals that the length of ozone episodes (in terms of the number of consecutive exceedance days) tends to be longer than under the 1-hr standard. Exceedances of the 8-hr

NAAQS ozone concentration threshold occurred over a broader range of months than 1-hr exceedances in 1997. The potential seasonal impact and the increase in the number of 8-hr ozone episodes suggest that any seasonal characteristics of ozone controls may need to be reviewed to ensure that these controls are in place throughout the ozone season.

The New Standard Will Have a Large Impact on the Mid-Atlantic Region

If ozone values do not improve in comparison to the 1997 ozone season, the majority, 75 percent, of the Mid-Atlantic region will not meet the revised NAAQS for ozone.

APPENDIX A

COMPARISON OF 8-HR AND 1-HR OZONE EXCEEDANCES IN THE MID-ATLANTIC REGION

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Table A-1. Rank of Mid-Atlantic sites by the number and average value of 8-hr exceedances in 1997. Also shown are the 1-hr rank, the number and average value of 1-hr exceedances, and the 8-hr/1-hr ratio.

State	Site	Rank		8-hr		1-hr		Ratio
		8-hr	1-hr	Number	Average Value	Number	Average Value	
MD	Fort Meade (240030019)	1	2	23	103.3	7	143.7	3.3
MD	Greenbelt (240330002)	2	4	23	99.9	6	136.8	3.8
NJ	Ancora State Hospital (340071001)	3	9	22	98.0	4	135.0	5.5
MD	Aldino (240259001)	4	1	20	103.4	7	145.0	2.9
NJ	Colliers Mills (340290006)	5	5	20	101.1	4	149.0	5.0
MD	Davisonville (240030014)	6	10	19	99.4	3	146.7	6.3
PA	Lancaster East (420710007)	7	13	19	97.5	3	133.3	6.3
PA	Norristown (420910013)	8	24	19	96.1	2	133.0	9.5
MD	Fair Hill (240150003)	9	3	18	105.0	6	147.5	3.0
NC	Mecklenburg Co. - Mecklenburg Cab Co. (371191009)	10	NA	18	94.8	0	NA	NA
NC	Charlotte (371190034)	11	NA	18	94.5	0	NA	NA
MD	Edgewood (240251001)	12	6	17	100.6	4	139.0	4.3
PA	Chester (420450002)	13	16	17	97.2	3	127.0	5.7
NJ	Flemington (340190001)	14	NA	17	96.5	0	NA	NA
PA	Philadelphia - NE (421010024)	15	33	17	96.3	1	133.0	17
DC	Washington DC - Southeast (110010043)	16	19	17	95.4	2	137.5	8.5
NJ	Clarcksboro (340150002)	17	14	16	99.1	3	131.3	5.3
MD	Millington (240290002)	18	8	16	96.3	4	135.5	4
NJ	Nacote Creek (340010005)	19	19	15	99.3	2	137.5	7.5
NJ	Rutgers University (340230011)	20	7	15	98.1	4	137.3	3.8
NJ	Rider U. (340210005)	21	29	15	97.5	2	126.5	7.5
MD	Lake Clifton (245100050)	22	21	15	96.8	2	135.5	7.5
VA	Aurora Hills / Arlington (510130020)	23	22	15	95.9	2	135.0	7.5
NC	Granville Co. - Water Treatment Plant (370770001)	24	NA	15	93.6	0	NA	NA
VA	Hanover Co. (510850001)	25	20	14	96.3	2	137.0	7
DE	Brandywine Creek St. Park (100031010)	26	23	14	96.0	2	133.5	7
PA	Kunkletown (420890001)	27	NA	14	95.4	0	NA	NA
PA	Charleroi (421250005)	28	NA	14	93.6	0	NA	NA
MD	S. Maryland (240170010)	29	40	14	93.4	1	126.0	14
NC	Caswell Co. - Cherry Grove Recreation (370330001)	30	NA	14	91.5	0	NA	NA
PA	Bristol (420170012)	31	30	13	99.1	1	144.0	13
DE	Lums Pond St. Park (100031007)	32	11	13	98.8	3	137.7	4.3
VA	Shirley Plantation (510360002)	32	35	13	95.8	1	131.0	13
MD	Suitland (240338001)	33	12	13	95.5	3	137.7	4.3
NJ	Chester (340273001)	34	NA	13	94.5	0	NA	NA
NC	Raleigh - E. Millbrook Jr. High (371830014)	35	NA	13	93.3	0	NA	NA
NC	Raleigh - North State Street (371830015)	36	40	13	93.1	1	126.0	13
MD	Rockville (240313001)	37	NA	13	92.8	0	NA	NA
NC	Garner (371830017)	38	NA	13	91.6	0	NA	NA

Table A-1. Rank of Mid-Atlantic sites by the number and average value of 8-hr exceedances in 1997. Also shown are the 1-hr rank, the number and average value of 1-hr exceedances, and the 8-hr/1-hr ratio.

State	Site	Rank		8-hr		1-hr		Ratio
		8-hr	1-hr	Number	Average Value	Number	Average Value	
NJ	Millville (340110007)	39	NA	12	96.8	0	NA	NA
PA	S.B. Elliot State Park (420334000)	40	NA	12	96.4	0	NA	NA
DE	Killens Pond St Park (100010002)	41	36	12	95.7	1	130.0	12
NC	Franklinton (370690001)	42	NA	12	94.3	0	NA	NA
PA	Allentown (420770004)	43	39	12	93.3	1	127.0	12
DE	Wilmington (100051002)	44	27	11	96.6	2	129.5	5.5
NJ	Camden (340070003)	45	35	11	96.5	1	131.0	11
DC	Washington DC - Northeast (110010041)	46	17	11	94.1	2	141.0	5.5
VA	Hampton (516500004)	47	NA	11	93.2	0	NA	NA
PA	York East (421330008)	48	NA	11	92.6	0	NA	NA
NC	Clayton (371010002)	49	NA	11	89.5	0	NA	NA
NJ	Monmouth College (340250005)	50	18	10	99.0	2	139.5	5.0
PA	Harrison TWP (420031005)	51	15	10	98.8	3	129.3	3.3
MD	Essex (240053001)	52	26	10	97.9	2	130.5	5.0
VA	Seven Corners (510591004)	53	35	10	94.7	1	131.0	10
NC	Farmville (371470099)	54	36	10	93.1	1	130.0	10
NC	Davie Co. - Main St. (370590002)	55	NA	10	91.0	0	NA	NA
NC	Bethany School (371570099)	56	NA	10	88.5	0	NA	NA
NJ	Bayonne (340170006)	57	39	9	99.0	1	127.0	9
MD	Padonia (240051007)	58	19	9	97.1	2	137.5	4.5
PA	Reading (420110009)	59	35	9	96.2	1	131.0	9.0
PA	Roxborough (421010014)	60	NA	9	94.7	0	NA	NA
VA	Henrivo Co. (510870014)	61	37	9	94.3	1	129.0	9.0
NC	Mecklenburg Co. - Westinghouse Blvd. (371191005)	62	NA	9	93.0	0	NA	NA
PA	Holbrook (420590002)	63	NA	9	92.4	0	NA	NA
PA	Hershey (420431100)	64	NA	9	91.9	0	NA	NA
PA	Farell (420850100)	65	NA	9	91.8	0	NA	NA
PA	Easton (420950100)	66	NA	9	91.6	0	NA	NA
NC	Forsyth Co. - Piedmont Memorial Drive (370671008)	67	NA	9	91.0	0	NA	NA
NC	Rowan Co. - West St. & Gold Hill Rd. (371590021)	68	NA	9	89.6	0	NA	NA
MD	Baltimore - S. Caroline St. (245100051)	69	40	8	95.5	1	126.0	8.0
PA	S. Fayette (420030067)	70	NA	8	92.9	0	NA	NA
MD	S. Caroll (240130001)	71	NA	8	92.6	0	NA	NA
NC	Rowan Co. - Enochville Ave. (371590022)	72	28	8	92.3	2	127.0	4
VA	Suffolk - Tidewater Community College (518000004)	73	NA	8	92.0	0	NA	NA
VA	Widewater Elementary (511790001)	74	NA	8	91.0	0	NA	NA
VA	Beach Road (510410004)	75	NA	8	88.8	0	NA	NA
PA	Centre Co. - Penn Nursery (420274000)	76	40	7	98.0	1	126.0	7.0
DC	Washington DC - Takoma School (110010025)	77	37	7	95.9	1	129.0	7.0
PA	Wilkes-Barre (420791101)	78	NA	7	95.1	0	NA	NA

Table A-1. Rank of Mid-Atlantic sites by the number and average value of 8-hr exceedances in 1997. Also shown are the 1-hr rank, the number and average value of 1-hr exceedances, and the 8-hr/1-hr ratio.

State	Site	Rank		8-hr		1-hr		Ratio
		8-hr	1-hr	Number	Average Value	Number	Average Value	
PA	Lawrenceville (420030008)	79	NA	7	94.7	0	NA	NA
NC	Winston-Salem (370670022)	80	NA	7	92.9	0	NA	NA
VA	Suffolk - Tidewater Research Station (518000005)	81	NA	7	90.4	0	NA	NA
NC	Pittsboro (370370004)	82	NA	7	89.4	0	NA	NA
PA	Altoona (420130801)	83	NA	6	96.8	0	NA	NA
PA	Johnstown (420210011)	84	34	6	95.3	1	132.0	6
VA	Corbin (510330001)	85	NA	6	93.5	0	NA	NA
NC	Tarboro (370650099)	86	NA	6	91.0	0	NA	NA
PA	Peckville (420690101)	87	NA	6	89.5	0	NA	NA
NJ	Cliffside Park (340030001)	88	31	5	101.2	1	137.0	5.0
PA	Penn Hills (420030088)	89	25	5	100.2	2	131.5	2.5
NJ	Newark (340130011)	90	NA	5	97.2	0	NA	NA
PA	Washington (421250200)	91	NA	5	95.6	0	NA	NA
PA	Kutztown (420110001)	92	NA	5	94.0	0	NA	NA
VA	Mt. Vernon (510590018)	93	NA	5	93.0	0	NA	NA
PA	Perry County (420990301)	94	NA	5	92.2	0	NA	NA
NJ	Plainfield - Rock Ave (340390008)	94	NA	5	92.2	0	NA	NA
NC	Person Co. SR 1102 (371450099)	95	NA	5	90.4	0	NA	NA
NC	Great Smokey Mountain National Park (370870036)	96	NA	5	90.0	0	NA	NA
PA	Murrysville (421290006)	97	38	4	98.3	1	128.0	4.0
DE	Bellefonte (100031003)	98	32	4	98.0	1	135.0	4.0
PA	Methodist Hill (420550001)	98	NA	4	98.0	0	NA	NA
VA	Shenandoak NP Big Meadows (511130003)	99	NA	4	92.5	0	NA	NA
MD	Calvert Co. - Prince Frederick Health Dept. (240090010)	100	NA	4	92.3	0	NA	NA
PA	Erie (420490003)	101	NA	4	91.5	0	NA	NA
PA	Beaver Co. - Rte. 168 (420070002)	102	NA	4	91.3	0	NA	NA
VA	James S. Long Park (511530009)	103	NA	4	90.8	0	NA	NA
VA	Rest (510690010)	103	NA	4	90.8	0	NA	NA
PA	New Castle (420730015)	104	NA	4	90.3	0	NA	NA
NC	Gaston (371310002)	105	NA	4	88.0	0	NA	NA
VA	Alexandria (515100009)	106	34	3	103.3	1	132.0	3.0
PA	Harrisburg (420430401)	107	NA	3	97.7	0	NA	NA
VA	Mc Lean / Lewinsville (510595001)	108	NA	3	94.3	0	NA	NA
PA	Hillman State Park (421255001)	109	NA	3	94.0	0	NA	NA
NC	New Hanover Co. - Holly Shelter Co. (371290002)	110	NA	3	92.7	0	NA	NA
PA	Brighton (420070005)	111	NA	3	90.0	0	NA	NA
VA	Sumerduck (510610002)	111	NA	3	90.0	0	NA	NA
NC	Hope Mills (370511003)	112	NA	3	89.7	0	NA	NA
NC	Durham (370630013)	113	NA	3	88.0	0	NA	NA
PA	Beaver Falls (420070014)	114	NA	3	87.7	0	NA	NA

Table A-1. Rank of Mid-Atlantic sites by the number and average value of 8-hr exceedances in 1997. Also shown are the 1-hr rank, the number and average value of 1-hr exceedances, and the 8-hr/1-hr ratio.

State	Site	Rank		8-hr		1-hr		Ratio
		8-hr	1-hr	Number	Average Value	Number	Average Value	
NC	Lincolnton (371090004)	114	NA	3	87.7	0	NA	NA
NC	Keely Park (370810011)	115	NA	3	87.3	0	NA	NA
PA	Scranton (420692006)	116	NA	3	86.0	0	NA	NA
NC	Cumberland County (370510008)	117	NA	2	89.0	0	NA	NA
NC	Alexander Co. - SR 1177 (370030003)	118	NA	2	88.0	0	NA	NA
NC	Haywood Co. - Tower Blue Ridge Parkway (370870035)	119	NA	2	87.0	0	NA	NA
NC	Kenansville (370610002)	120	NA	1	89.0	0	NA	NA
VA	Rural Retreat (511970002)	120	NA	1	89.0	0	NA	NA
VA	Cub Run / Chantilly (510590005)	121	NA	1	88.0	0	NA	NA
VA	Vinton (511611004)	121	NA	1	88.0	0	NA	NA
NC	Winston-Salem - Baux Mt. Road (370670028)	122	NA	1	86.0	0	NA	NA
NC	Asheville (370210030)	NA	NA	0		0	NA	NA
NC	Blue Ridge Parkway (371990003)	NA	NA	0		0	NA	NA
NC	Camden Co. - Co. Road 1136 & 1134 (370290099)	NA	NA	0		0	NA	NA
VA	Figsboro Ruritan (510890006)	NA	NA	0		0	NA	NA
NC	Forsyth Co. - Hollyberry Lane (370670027)	NA	NA	0		0	NA	NA
PA	Freemansburg (420950025)	NA	NA	0		0	NA	NA
NC	Fuquay - Varina (371830016)	NA	NA	0		0	NA	NA
PA	Kittanning (420050001)	NA	NA	0		0	NA	NA
NC	Lenoir (370270003)	NA	NA	0		0	NA	NA
NC	Martin Co. - Hayes St. (371170001)	NA	NA	0		0	NA	NA
PA	Nantocoke (420791100)	NA	NA	0		0	NA	NA
PA	Philadelphia - Downtown (421010004)	NA	NA	0		0	NA	NA
PA	Philadelphia - Elmwood (421010136)	NA	NA	0		0	NA	NA
NC	Swain Co. - Parks 7 Rec Facility (371730002)	NA	NA	0		0	NA	NA
PA	Tiadaghton Sportsman Club (420814000)	NA	NA	0		0	NA	NA
PA	Williamsport (420810403)	NA	NA	0		0	NA	NA