CONCEPTUAL MODEL OF OZONE FORMATION IN THE DALLAS/FORT WORTH OZONE NON-ATTAINMENT AREA

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1. INTRODUCTION

Background

Draft 8-hour ozone modeling guidance from the US EPA indicates that States should develop conceptual models for describing the nature of the ozone problem. From this conceptual model, States can more effectively select ozone episodes for photochemical modeling. The Texas Commission on Environmental Quality (TCEQ) has developed a conceptual model for the Dallas/Fort Worth (DFW) ozone nonattainment area. The draft Dallas/Fort Worth conceptual model and supporting data was reviewed for accuracy and consistency. The agency's Houston conceptual model was also reviewed due to possible transport from Houston to the DFW area. The consistency between the DFW, Houston, and Beaumont/Port Arthur conceptual models and the EPA's draft guidance documents on attainment demonstration for the 8-hour ozone National Ambient Air Quality Standards (NAAQS), as well as the 1-hour standard, was evaluated. Recommendations were made regarding improvements to and completion of the DFW conceptual model. This report presents a revised conceptual model for the DFW ozone nonattainment areas based on the recommendations for improvements detailed previously (ENVIRON, 2002).

Elements of the Conceptual Model

The development of a conceptual model for ozone formation involves the compilation and analyses of various data regarding air quality, emissions and meteorology. Based on these analyses, appropriate air quality modeling episodes are selected for the purpose of attainment demonstration. In particular, the following analyses are considered:

- Ozone and air quality trends. Trends in ozone air quality within the DFW nonattainment region are considered. Both the ozone design values and Air Quality Index are evaluated with respect to variations from year to year and over the past 25 years. Comparisons with other nonattainment areas within Texas are also conducted. One-hour and eight-hour ozone exceedances are examined within the area to determine the frequency of exceedances by various time periods.
- Emission inventory trends. Trends in emissions of NOx and VOC are evaluated within the DFW area. The relationship between emission reductions from 1990 to 2001 and ozone air quality are considered. Comparisons with other nonattainment regions in Texas are also examined. These relations provide insight into the relative improvements in air quality and emission reduction strategies with respect to attainment of the NAAQS.
- Meteorological factors associated with high ozone events. The meteorological factors associated with high (and low) ozone events in the DFW area are evaluated. Surface winds provide an indication of the importance of local emission sources on air quality while upper level, or transport, winds reveal the influence of regional scale emissions and air quality. Evaluation of the general synoptic and mesoscale meteorological factors associated with ozone exceedances provide some guidelines for selection of appropriate episodes for further analysis and possible air quality modeling

- Episode selection. The development of the conceptual model provides the basis for the selection of modeling episodes required for demonstration of the ozone NAQQS. Based on the analysis conducted as part of the model development, candidate episodes are identified.
- EPA Guidance documents. The EPA has developed guidance documents for evaluating and selecting modeling episodes for demonstration of attainment of both the 1-hour and 8-hour ozone standards. These guidance documents and the recommendations therein provide a basis for the selection of candidate episodes for the DFW nonattainmnet area.

Report Organization

This report, documenting the development of the conceptual model of ozone formation in the Dallas/Fort Worth non-attainment area is organized as follows:

- Section 2 of the report presents a summary of ozone air quality trends in the DFW area.
- Section 3 discusses the emission trends and inventories that were examined and evaluated as part of the development of the conceptual model;
- Section 4 presents a review of the meteorological factors influencing high ozone events in the DFW area;
- Section 5 summarizes the episode selection process and presents candidate episodes for 1-hour and 8-hour modeling of the DFW non-attainment area; and
- Section 6 lists the references used in the development of the conceptual model.

2. OZONE TRENDS

The development of the conceptual model for the Dallas/Fort Worth metropolitan region evaluated ozone trends for the years 1971 through 2001. The model looked at trends in ozone design values as well as ozone exceedances. In addition, the EPA's Air Quality Index (AQI), which considers a number of pollutants to judge overall air quality, was evaluated for any noticeable trends over the last decade. Geographical patterns associated with elevated ozone levels were also considered, as were trends associated with particular years, months of the year, day of the week and time of day. Comparisons of various ozone air quality trends for DFW were made with those of other non-attainment regions, specifically the Houston-Galveston area.

Ozone Levels and Design Value Trends

The 1-hour design value is determined by evaluating the fourth highest monitored ozone concentration in the most recent three years. The design value is calculated for each monitor, and the non-attainment area design value is the highest over all monitors. The 8-hour ozone design value is defined as the fourth highest monitored 8-hour ozone value at a specific monitor averaged over the most recent three years of data. The design values provide an indication of the ozone air quality and can be used to gauge an area's progress towards meeting the NAAQS for ozone. As part of the development of a conceptual model for DFW design value trends were examined. Design value trends for individual monitors as well as for the nonattainment area as a whole were evaluated for various time periods. Both the 1-hour and 8-hour design values were considered. Figure 2-1 displays the location of ozone monitors within the DFW nonattainment area.

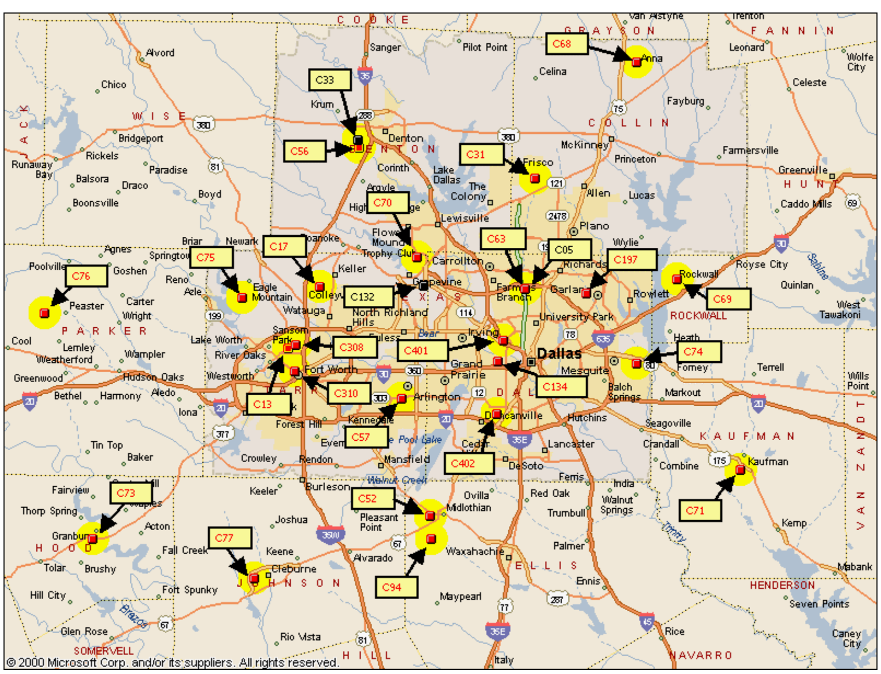


Figure 2-1. DFW region monitor locations.

The DFW 1-hour ozone area maximum design value trend for the period 1974 through 2001 is displayed in Figure 2-2. Figures 2-3 displays the DFW 1-hour design values for each individual monitor. Examination of the trends displayed in Figures 2-2 and 2-3 reveal an overall consistent downward trend in the 1-hour design values during the period 1974 through 1988. During the years 1988 through 2001 the 1-hour design value remained essentially unchanged at a value of approximately 140 ppb, in violation of the federal one-hour ozone standard. The DFW 1-hour design value is currently at 137 ppb, having dropped to a minimum value of approximately 130 ppb in 2000.

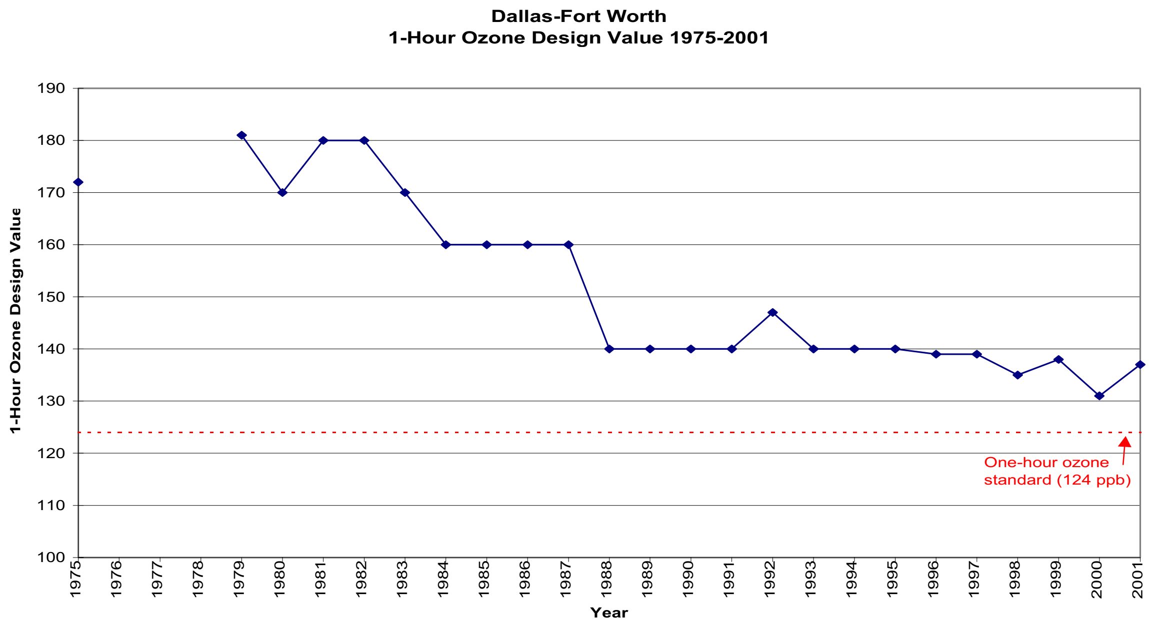


Figure 2-2. DFW 1-hour ozone design value trend for 1974-2001.

Examination of the design values for individual monitors reveals the effects on the overall trends of the introduction of new monitors through time. The increase in 1-hour DWF area design value seen in 1992 can be seen to be due to the measurement at the Keller (C17) monitor, which came on-line in 1998. Likewise, exceedances recorded at other monitors which began operation in the late 1990's contribute to the maintaining the design value at, or near, the level of 1993, of approximately 140 ppb.

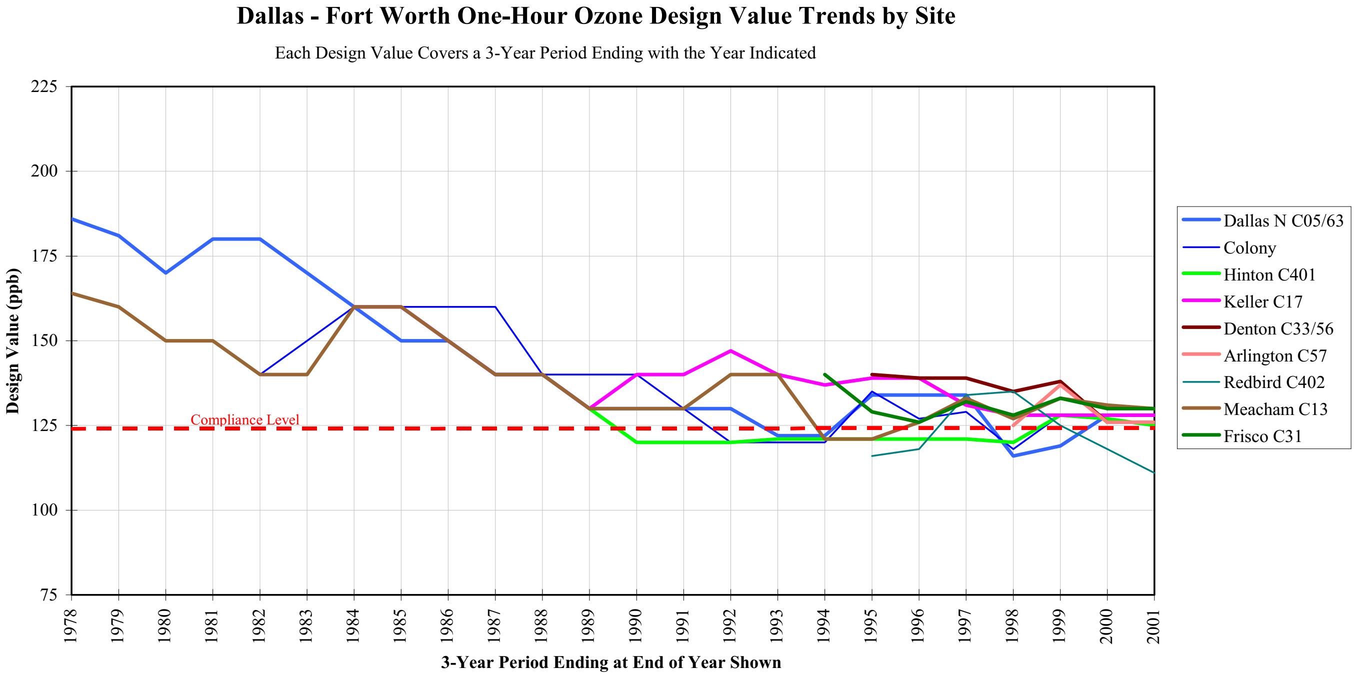


Figure 2-3. DFW 1-hour ozone design values by monitor for 1974-2001.

The 8-hour ozone design value for Dallas/Fort Worth, displayed in Figure 2-4, likewise shows an overall downward trend during the period 1974 through 1994, when the value again increases slightly to the current value of 101 ppb. An analysis of the data presented in Figure 2-5, which displays the 8-hour design values for individual monitors over the period from 1971 through 2001, reveals the influence of new monitoring stations on the region-wide design values.

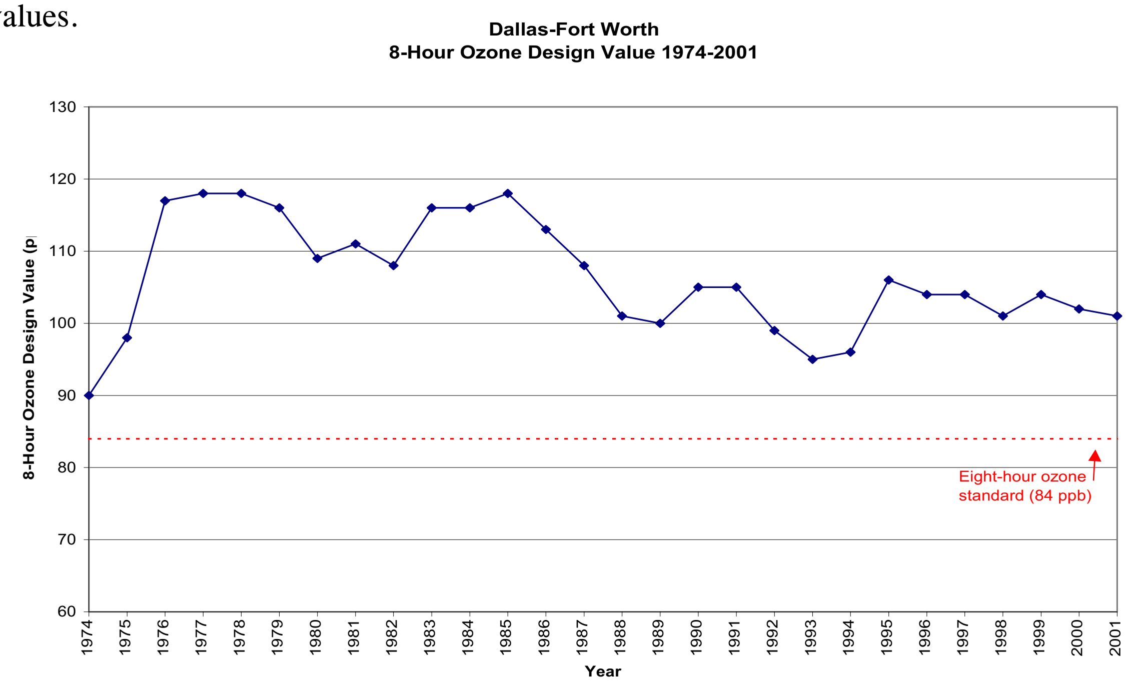


Figure 2-4. DFW 8-hour ozone design value trends for 1974-2001.

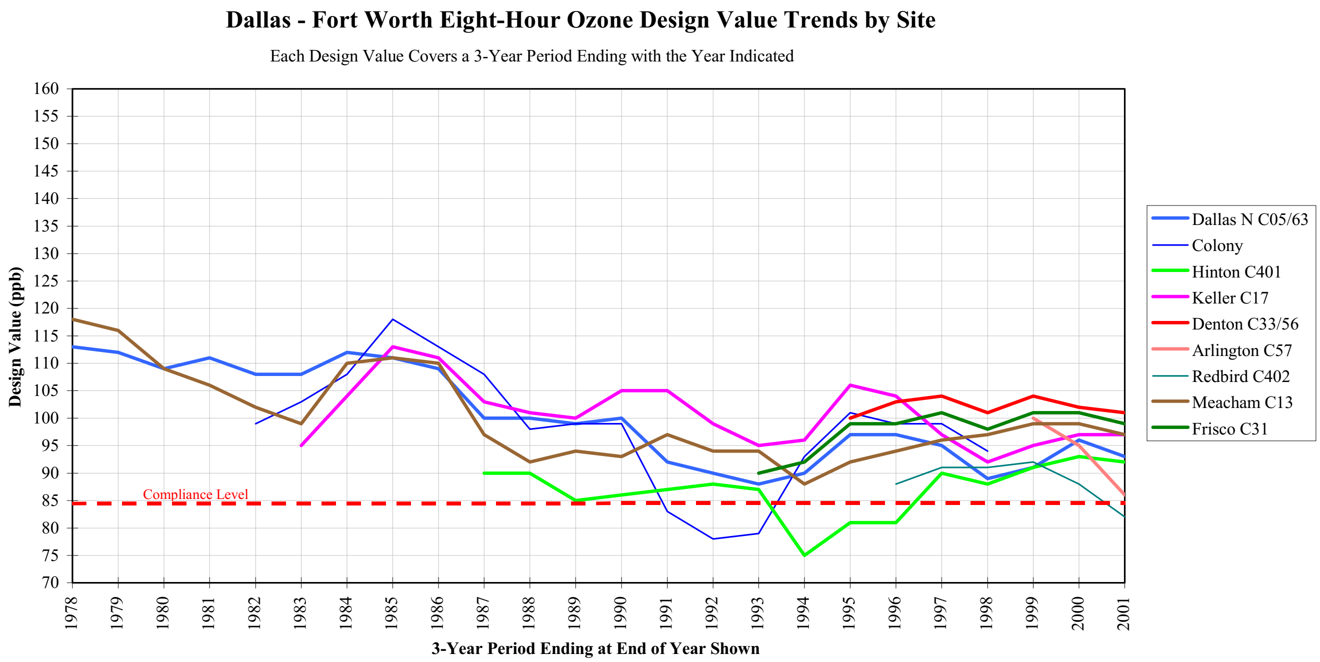


Figure 2-5. DFW 8-hour ozone design values by monitor for 1974-2001.

The downward trend in design values and the accompanying improvements in air quality are the result of several factors. The implementation of mobile source controls and the replacement of older, carbureted motor vehicles with a pool of newer, more tightly controlled vehicles, is a significant contributor to improvements in ozone air quality. This conclusion however depends on whether VOC or NOx levels are more important. Although this flattening of the 1-hour design value trend line may reflect the completions of the transition to a newer vehicle fleet, the situation is more likely complicated however, as VMT growth is outweighing emission factor reductions. In addition, although the design value has remained nearly constant, there has been a dramatic increase in the level of construction and economic activity and a substantial growth in the mobile fleet and VMT in the area during recent years. While this downward trend in design values is encouraging, suggesting that existing controls may be sufficient to maintain the 1-hour ozone standard, additional controls are likely necessary to attain the more stringent 8-hour NAAQS.

An analysis EPA's air quality trends data is also instructive. The EPA's National Air Quality and Emissions Trends Report (EPA, 2000) reports trends in 1-hour and 8-hour design values for Metropolitan Statistical Areas (MSA's) through the country. Figure 2-6 displays the 1-hour design value trends for the Dallas and Fort Worth-Arlington MSA's. The corresponding 8-hour design value trends for Dallas and Forth Worth-Arlington are displayed in Figure 2-7. These design values are based on a single year's data for the trends sites within each MSA and therefore differ from those archived by the TCEQ due to differences in the definition as well as the number of monitor sites considered. In particular, the 1-hour design value is defined as the second high maximum ozone value over all trends sites. Though not as dramatic, these data show a similar overall downward trend as for the TCEQ data during the same time period.

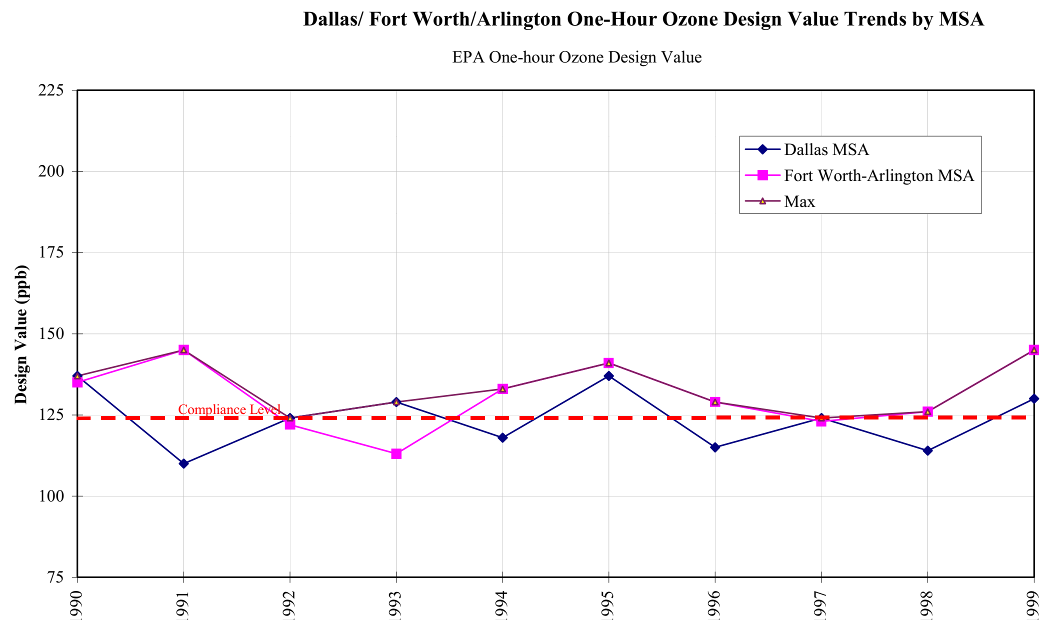


Figure 2-6. EPA 1-hour ozone design value for Dallas and Fort Worth MSA's for 1990-1999.

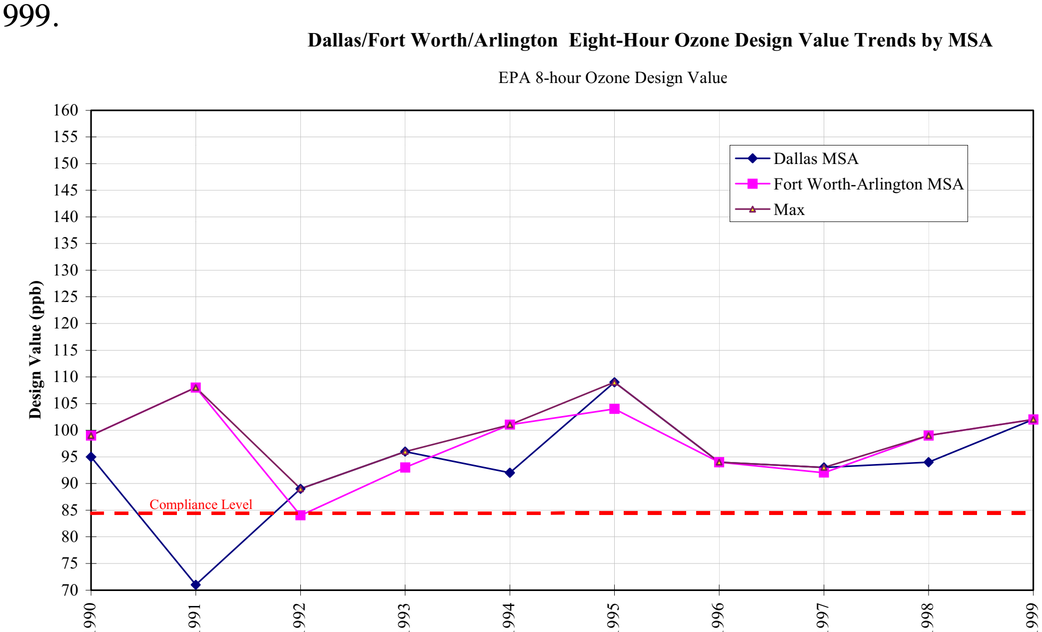


Figure 2-7. EPA 1-hour ozone design value for Dallas and Fort Worth MSA's for 1990-1999.

Trends in the Air Quality Index (AQI) were also evaluated for the DFW non-attainment area. The AQI, a measure of the overall air quality, is assessed by categorizing the number of days in a year in which the air quality ranged from good to very unhealthy. The categorization is based on the following five regulated pollutants: ozone, particulate matter, carbon monoxide, sulfur dioxide, and nitrogen dioxide. Examination of the AQI trends analysis conducted by the TCEQ (TCEQ, 2002a) on data from 1991 through 2001 show that the AQI in Dallas/Fort Worth has not improved over this time period and, in fact, has declined for the Good category. These data are summarized in Figure 2-8. Note that the data presented in Figure 2-8 is limited to the third quarter of 2001 (TCEQ, 2002a). The other AQI categories- Moderate, Unhealthy for Sensitive People, Unhealthy and Very Unhealthy- have not shown any considerable improvement nor any discernible trend.

Year	Good	Moderate	Unhealthy for sensitive	Unhealthy	Very unhealthy
1991	291	57	16	1	
1992	295	53	14	4	
1993	293	55	14	3	
1994	268	63	31	3	
1995	256	62	34	12	1
1996	258	85	18	5	
1997	254	79	25	7	
1998	235	91	34	4	1
1999	261	66	31	6	1
2000	267	64	29	6	
2001	187	62	22	2	

AQI for DFW 1991 - 2001

Figure 2-8. Air Quality Index (AQI) trends for DFW area 1991-2001. (TCEQ)

A comparison of the AQI trends in DFW and Houston is presented in Figures 2-9 and 2-10. Except for 1991, Houston's good category has outperformed Dallas while Dallas' moderate category has outperformed Houston's every year during 1991 through 2001. Dallas' unhealthy and very unhealthy categories showed fewer days than Houston in all year except 1995 and 1997, when the number of days when Dallas' unhealthy category exceeded Houston's.

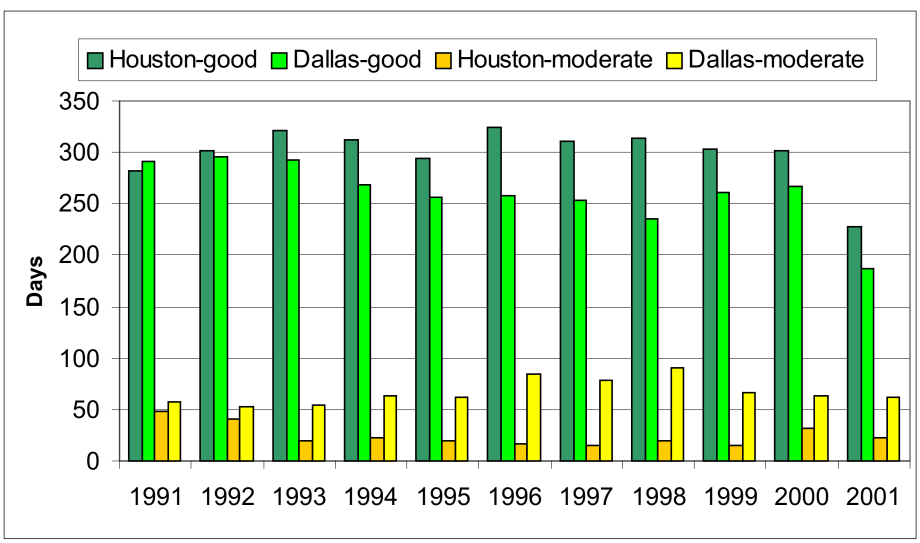


Figure 2-9. Comparison of AQI for DFW and Houston/Galveston for 1991-2001 (TCEQ).

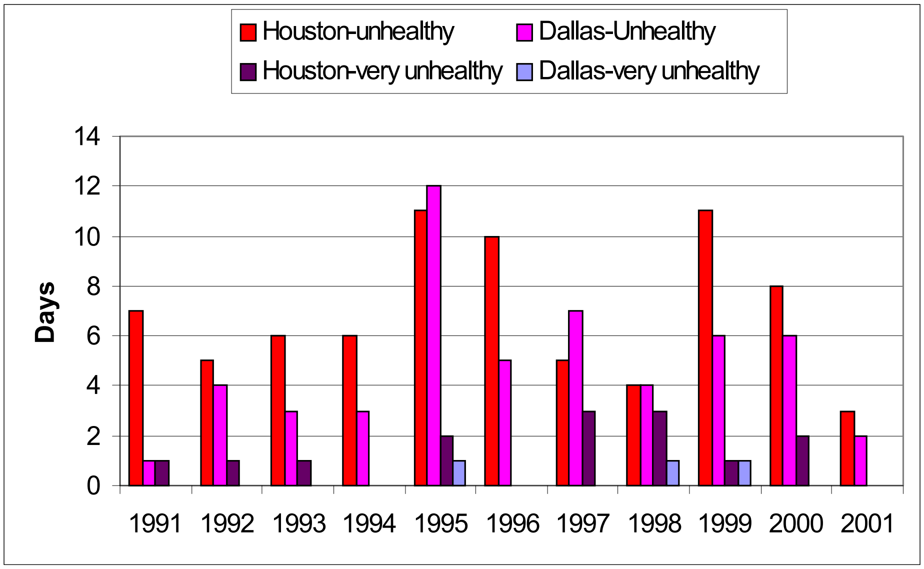


Figure 2-10. Comparison of AQI for DFW and Houston/Galveston for 1991-2001 (TCEQ).

An analysis of the ozone design values with respect to geographical patterns of high ozone conducted on data from 1999 in the DFW area indicates that higher design values are present in the west and northwest portions of the four-county nonattainment region (Dallas, Denton, Collin and Tarrant counties). Figure 2-11 displays the spatial distribution of 1-hour ozone design values in the DFW region for 1999. Also, the highest 1-hour ozone design values are seen to be located in the northeast Fort Worth area, although this is not necessarily consistent with typical transport patterns in the area. This spatial pattern of high ozone occurrences can be explained as follows. Ozone is produced from emissions released in the Dallas/Fort Worth urban core which is transported westward by the prevailing surface winds. Thus, Fort Worth has a higher ozone design value than Dallas although this may be due to the location of ozone monitors, typically on the north side of the DFW urban core. Data from a new monitor at Arlington may provide additional insight into this situation.

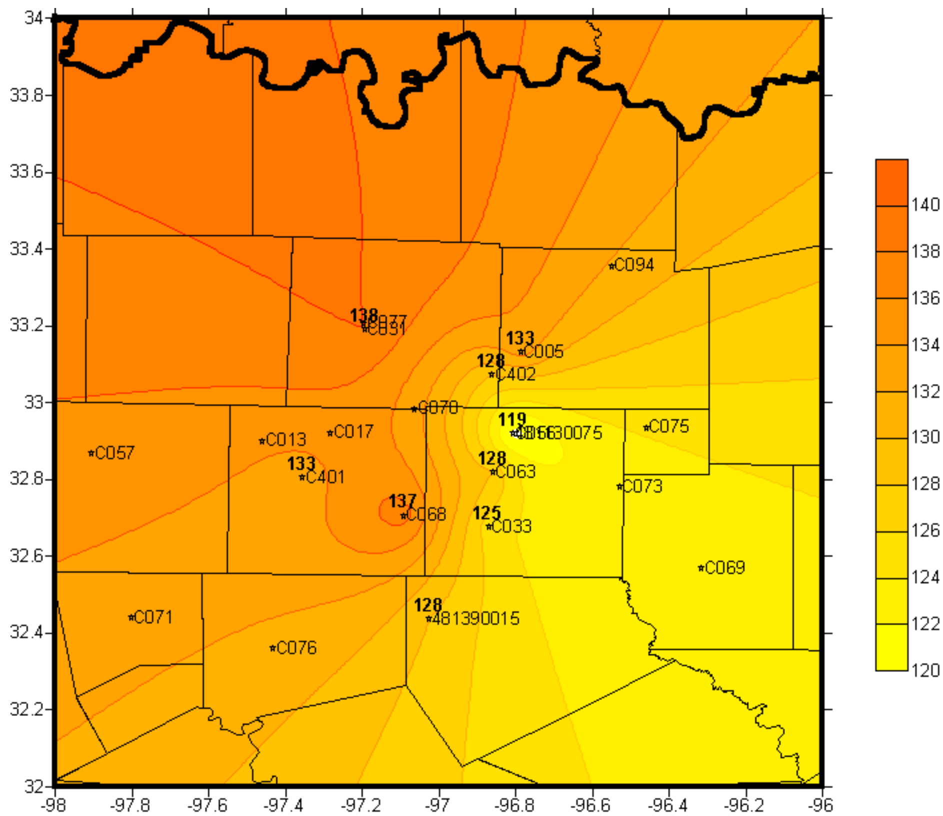


Figure 2-11. Spatial distribution of 1-hour ozone design values in DFW for 1999.

The spatial pattern or distribution of the 8-hour design values in the DFW region for 1999 is displayed in Figure 2-12. High 8-hour design values are seen primarily north of the DFW urban core.

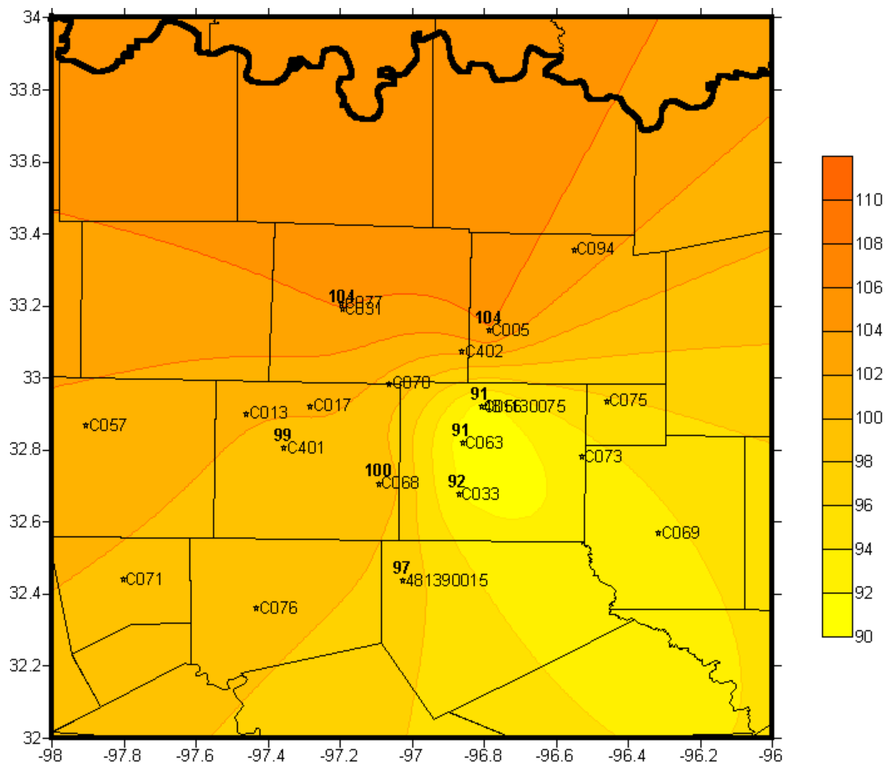


Figure 2-12. Spatial distribution of 8-hour ozone design values in DFW for 1999.

Ozone Exceedance Trends

The ozone season in the Dallas/Fort Worth area is typically eight months long, lasting from March through October and often exhibits two distinct peaks; one in late June/early July and one in late August. While this dual peak may not be apparent when considering aggregate data over several years, it is apparent when the year-by-year data is reviewed.

Figure 2-13 displays the number of 1-hour ozone exceedance days in the DFW nonattainment area during the years 1974 through 2001. While an overall downward trend is evident during the 1974-2001 time period, the analysis of ozone exceedances from the year 1990 through 2001 does not indicate any clear trend from year to year with exceedances ranging from 2 to 7 days per year. Over the entire 1974-2001 time period, 1-hour exceedances ranged from 2 to 17 days per year. Moreover, ozone exceedances in the DFW area have not shown significant improvement over this time period.

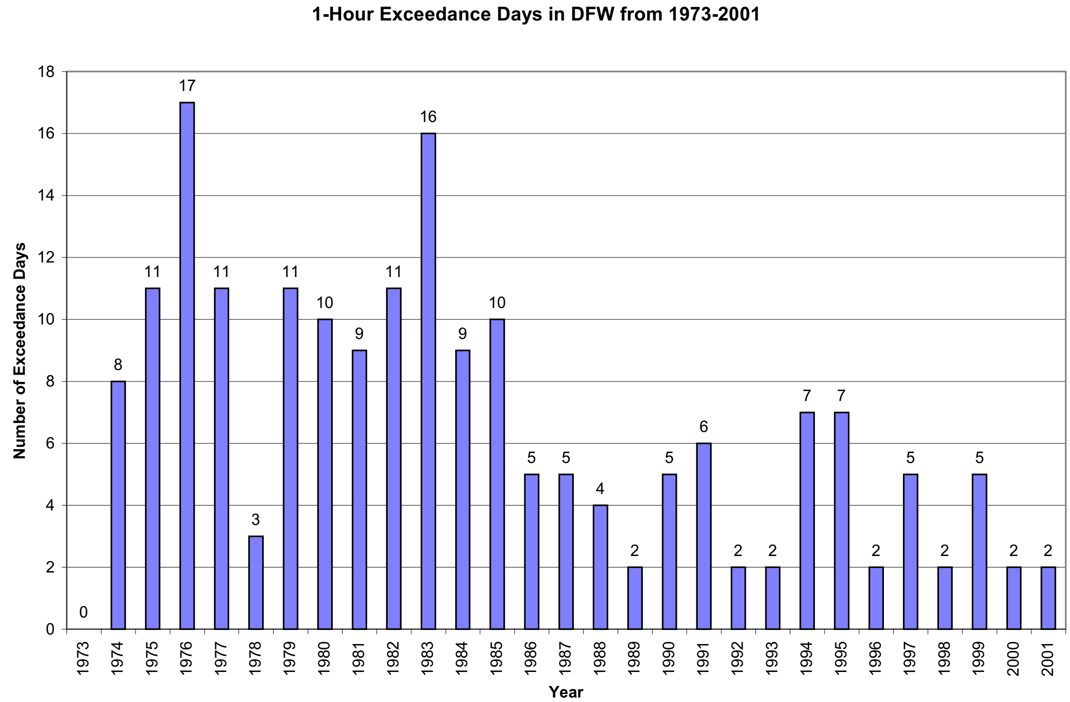


Figure 2-13. One-hour ozone exceedance days in DFW by year from 1974-2001.

The number of 8-hour ozone exceedance days in DFW are displayed in Figure 2-14. Data evaluated for the 8-hour ozone exceedances included only the years 1997 trough 2002, and only the primary ozone season months (June-September). No clear trend can be seen in the data. Exceedance days range from 28 days per year in 2001 to 35 days per year in 1999. There also does not appear to be any overall improvement during this time period.

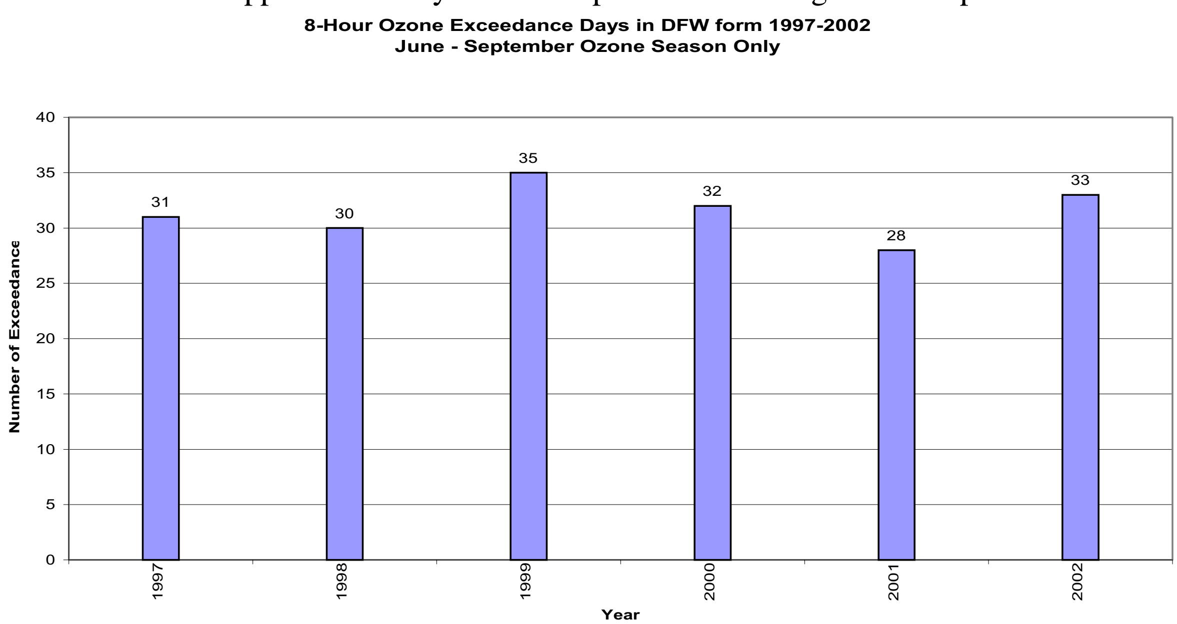


Figure 2-14. Eight-hour ozone exceedance days in DFW by year from 1997-2002 (June-September months only).

Consideration of the number of exceedance days by month-of-year clearly indicates that the most 1-hour ozone exceedances occur during the month of August followed by the month of July. These statistics are based on evaluation of ozone monitor data from the years 1997 through 2001. A previous analysis conducted by the TCEQ on data from 1990-2001 indicates the same conclusions regarding the frequency of exceedances by month of year. Figure 2-15 present these data.

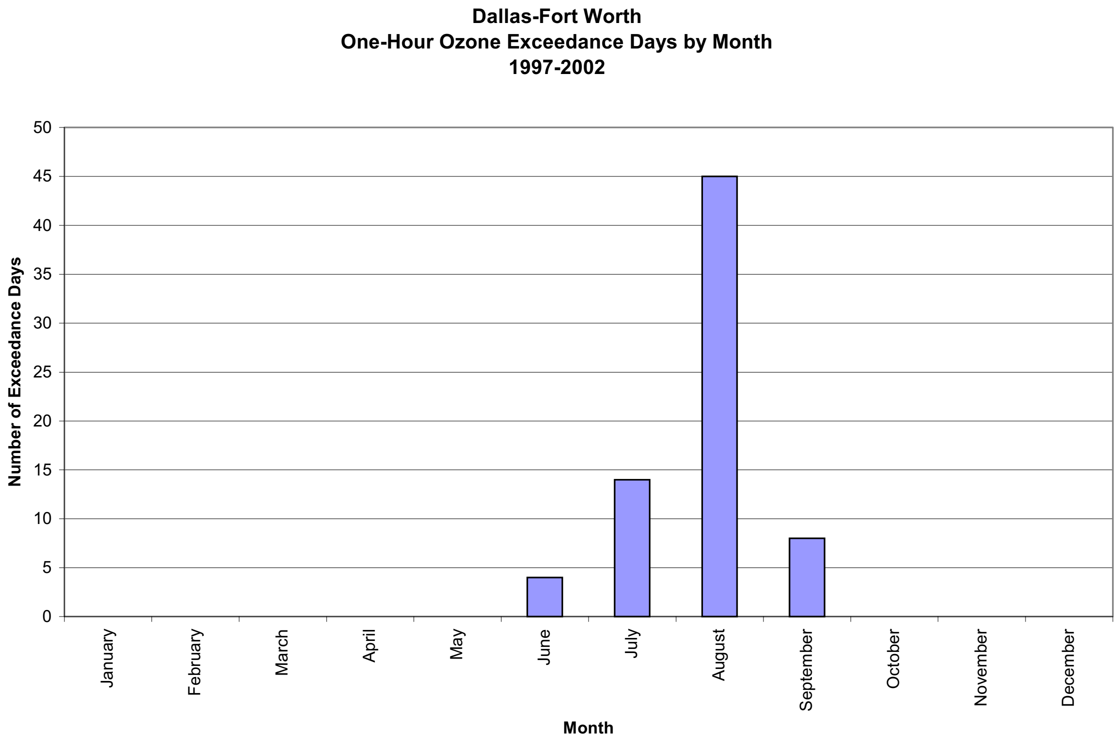


Figure 2-15. One-hour ozone exceedance days in DFW by month from 1997-2002.

Eight-hour ozone exceedance days by month of year are presented in Figure 2-16 for the years 1997 through 2002. As with the exceedance days by year, only the months of June through September were evaluated. As shown, the highest frequency of 8-hour ozone exceedances occur during the month of August followed by September.

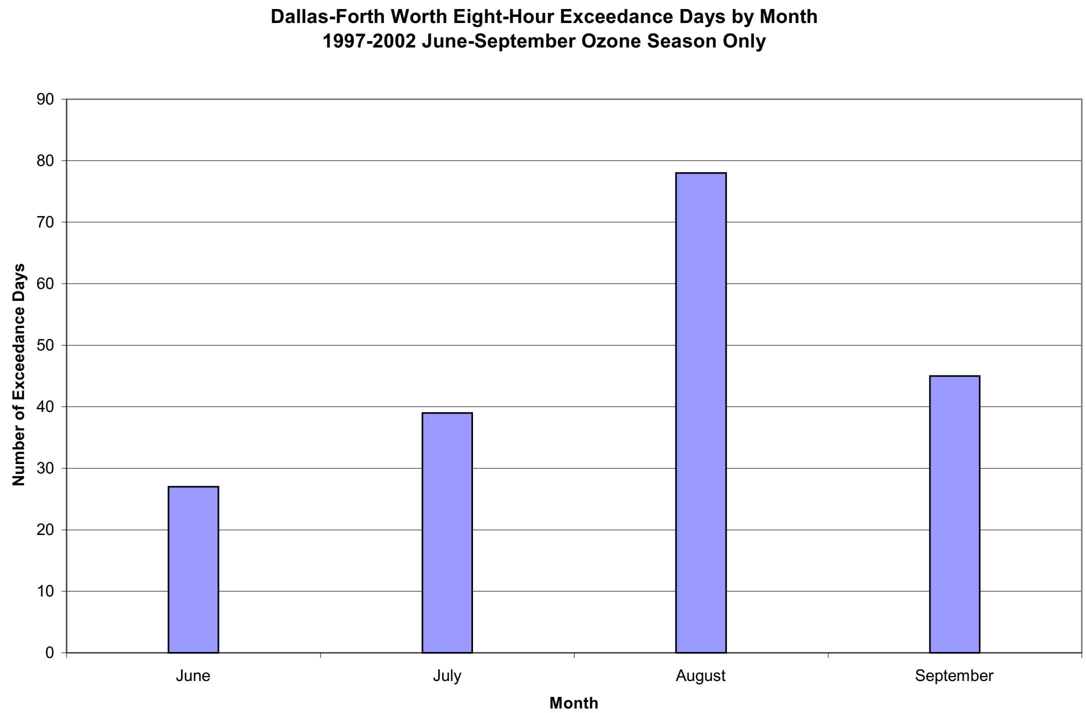


Figure 2-16. Eight-hour ozone exceedance days in DFW by month from 1997-2002 (June-September only).

Similar analyses of the data for ozone exceedances by day of week and time of day were conducted as part of the development of the conceptual model. Although the frequency of exceedances by day of week is not necessarily of particular significance with respect to modeling episode selection, it may provide an indication of the relative contribution of emission sources and source categories to ozone air quality, especially the mobile source sector. The results indicate that the majority of high ozone days occur during the Monday through Friday period with somewhat fewer exceedances occurring on Saturdays. No exceedances were recorded on Sundays during the period 1990 through 2001. That no exceedances are measured on Sundays is an indication that mobile sources may play a significant role in ozone production in the DFW non-attainment area. Furthermore, the lack of Sunday exceedances suggests that peak ozone levels are NOx limited in the DFW area. Examination of the number of ozone exceedances by time of day show that the majority of exceedances occur during the afternoon hours, peaking at 3:00 PM local time.

Bar charts illustrating the frequency of 1-hour high ozone events in the Dallas/Fort Worth area by day of week and hour of day are presented in Figures 2-17 and 2-18.

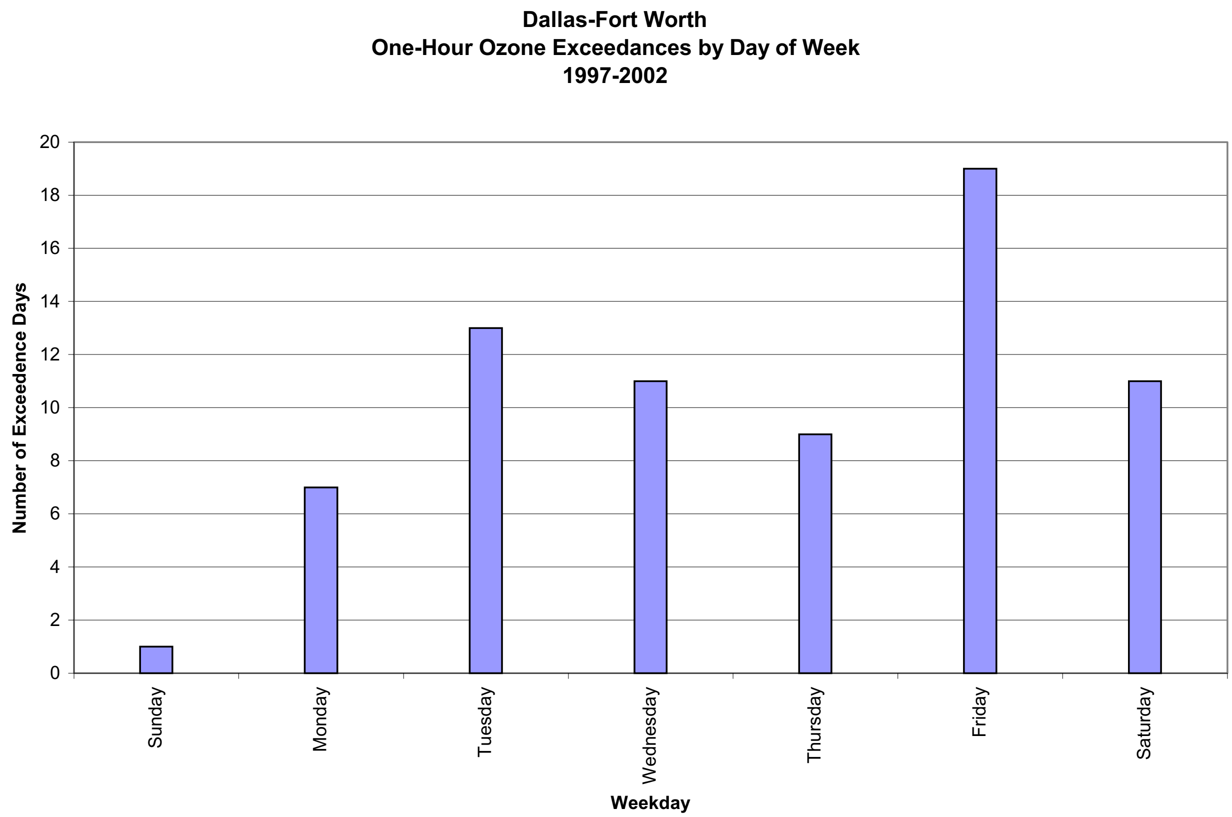


Figure 2-17. One-hour ozone exceedance days in DFW by day from 1997-2002.

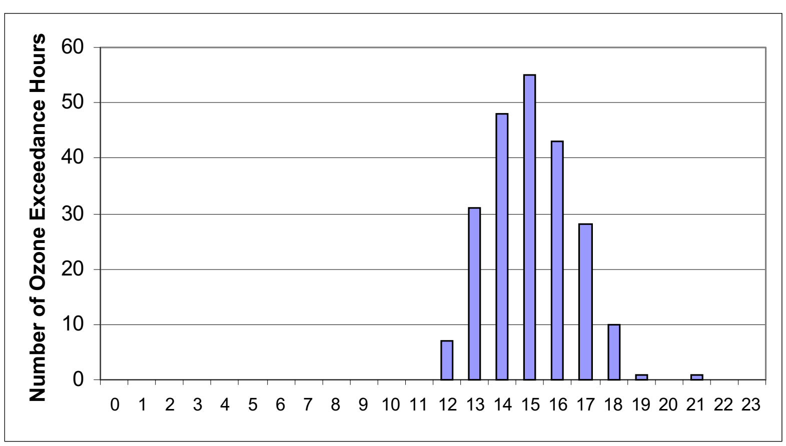


Figure 2-18. One-hour ozone exceedance days in DFW by hour from 1991-2001 (TCEQ).

3. EMISSION TRENDS AND INVENTORIES

An analysis of emission sources and trends is an important component of conceptual models of ozone formation. The relationship between ozone precursor emissions and ozone exceedances within the region can provide an indication of the efficacy of existing local controls, while an evaluation of regional emission inventories and trends provides a measure of the impact of downwind or long-range transport on high ozone events within the local region of interest.

As part of the development of the conceptual model for the Dallas/Fort Worth non-attainment area, trends in emission levels of volatile organic compounds (VOC) and oxides of nitrogen (NOx) were evaluated. The primary source categories contributing to the emission totals in the region include point, area, non-road mobile and on-road mobile sources.

Summary of NOx and VOC Emission Trends Within the DFW Urban Area

NOx and VOC emission trends were evaluated for the DFW metropolitan area. Trends data for the 1990 through 2001 as developed by ENVIRON for area and mobile (onroad and nonroad) source categories (ENVIRON, 2001) for all Texas counties was evaluated. Point source emissions data were obtained from the TCEQ's Point Source Data Base (PSDB) system for the Dallas/Fort Worth, Beaumont/Port Arthur and Houston/Galveston nonattainment areas for the years 1992 through 2001. Emission estimates by county for the DWF and BPA areas for 1996 were also available from the TCEQ for evaluation as were 1999 region-wide emission totals for the nonattainment areas. The EPA's NEI99 version 2 was also examined to determine overall trends by county and region for 1999.

Figures 3-1 and 3-2 display the total annual anthropogenic NOx and VOC emissions for the Dallas/Fort Worth area for the years 1990 through 2001, respectively. Also shown for comparison are total anthropogenic NOx and VOC emissions for the Beaumont/Port Arthur and Houston/Galveston nonattainment area. Total annual emissions of these pollutants across all source categories in the DFW region have decreased over the past decade from 225,058 tpy NOx and 211,805 tpy VOC to 186,682 tpy NOx and 142,605 tpy VOC. Based on TCEQ data, total NOx emissions in DFW decreased by approximately 10% from 1996 (186,855 tpy) to 1999 (167,195 tpy). During the same period, total VOC emissions decreased by approximately 23 % from 165,401tpy in 1996 to 127,294 tpy in 1999, based on data presented by the TCEQ (TCEQ, 2002a). Although these total emission reductions are considerable, there appears to be no corresponding decrease in the ozone design values for this time period.

A previous analysis of emission trends in the DWF area considered emission data over the period 1985-86 to 1995-96 (TCEQ, 2002a). VOC data collected during this period showed a statistically significant downward trend, with an overall reduction of approximately 62%. The analysis indicated the same downward trend when only high ozone days were considered. The conclusion was that over the past 15 years, federal and state controls, particularly on motor vehicles, has been effective in reducing emission levels of one of the ozone precursors within the DFW metropolitan area. The similar conclusions may also be made from the data analysis considered here.

The study also evaluated NOx emission levels over this same period (1985-86 to 1995-96) and noted an initial decrease followed by a subsequent increase of NOx emissions within the region. These overall decreases were attributed to increases in VMT in Dallas/Fort Worth. However, these trends were not considered statistically significant, although the recent increase supports the need for a NOx oriented strategy to control ozone concentration levels in the DFW area.

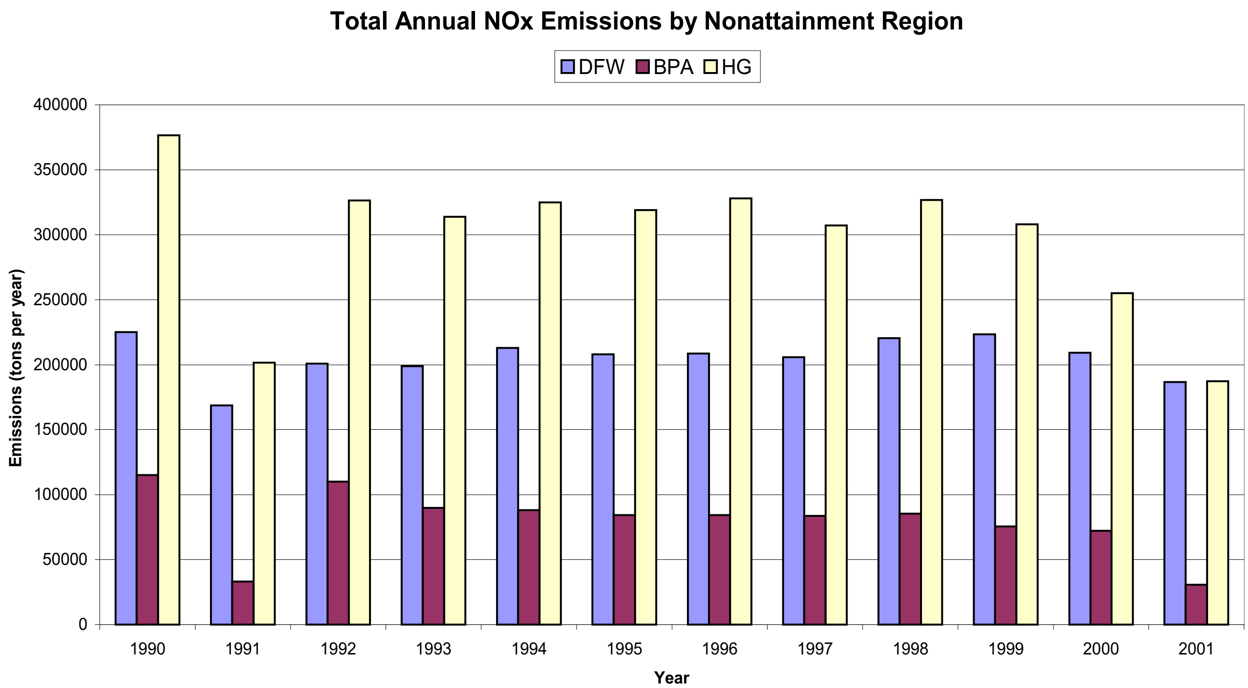


Figure 3-1. Total annual NOx emissions by nonattainment region from 1990-2001.

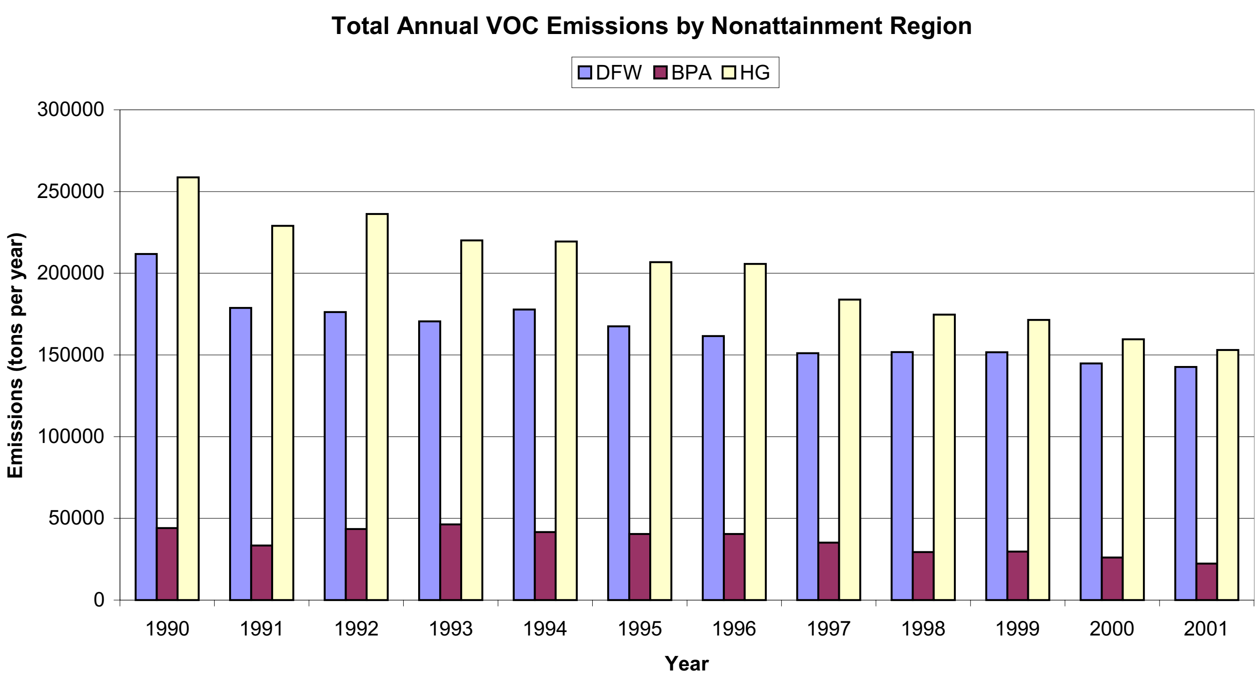


Figure 3-2. Total annual VOC emissions by nonattainment region from 1990-2001.

Data for 1996 obtained from the TCEQ has evaluated with respect to the source category breakdown. A comparison of emission levels by nonattainment area was made and the results are presented in Figure 3-3. As seen, the DFW area VOC emissions are dominated by area and mobile, while point sources are only a minor contributor to region total. NOx emissions are dominated by on-road mobile source with non-road sources making up nearly half of the total annual emissions.

By comparison, in both the BPA and HG areas, point sources are the largest source of NOx and VOC emissions. Houston and DFW are seen to have approximately the same levels of area and mobile source NOx and VOC emissions. Point source NOx and VOC emissions play a far more important role in HG and BPA than in DFW.

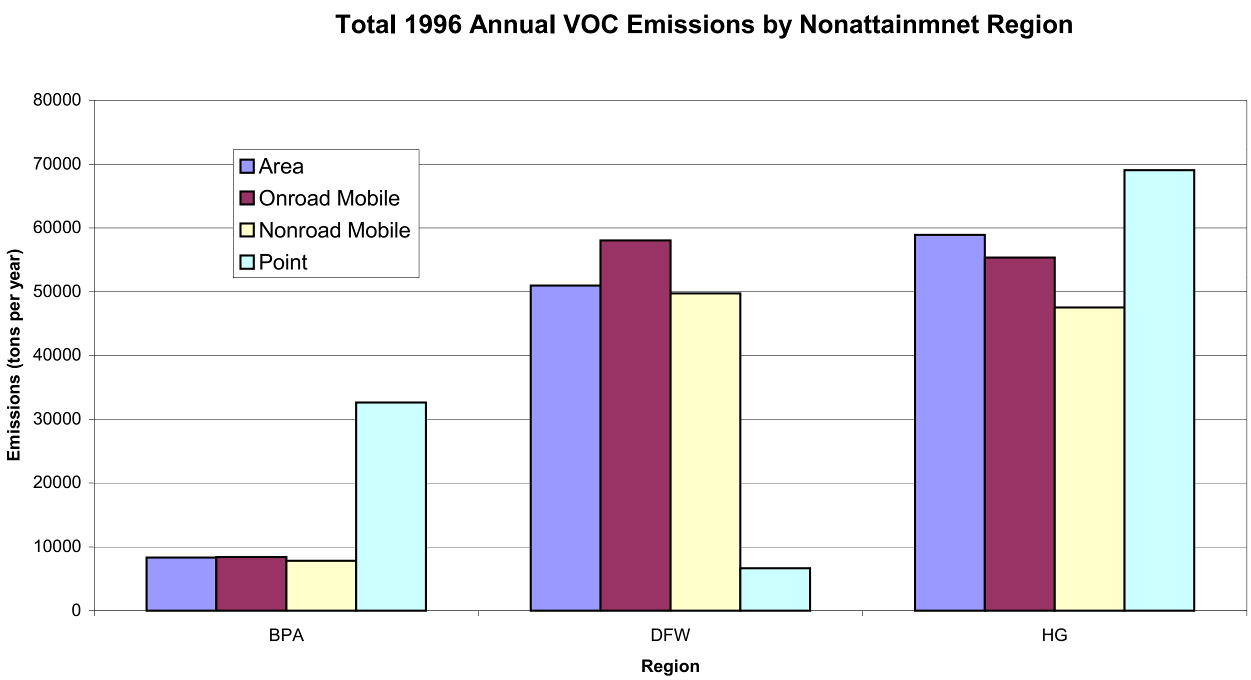


Figure 3-3. 1996 annual VOC emissions by nonattainment area.

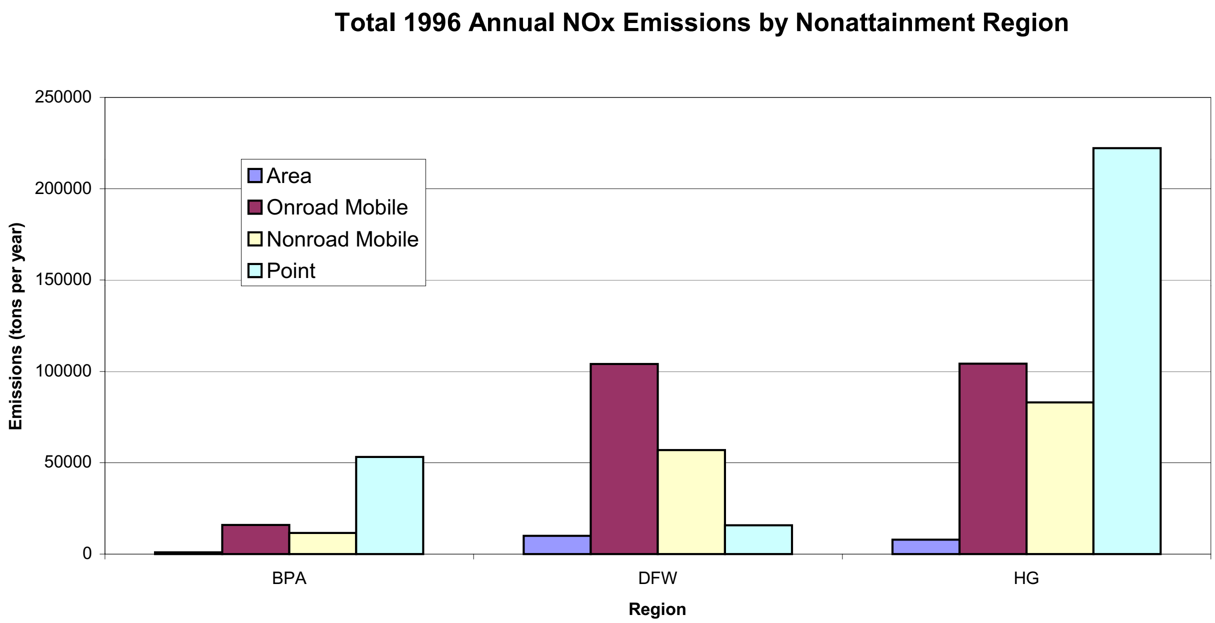


Figure 3-4. 1996 annual NOx emission by nonattainment area.

Figures 3-5 and 3-6 display the 1999 total annual emissions of NOx and VOC by nonattainment region. These data were derived from the NEI99 as similar emissions dataas for the 1996 summaries were not available. While the data contained in the NEI99 is likely not exactly the same as data archived at the TCEQ, the emission totals by nonattainment region presented in Figure 3-5 and 3-6 illustrate the general overall trend of emission decreases form 1996 to 1999.

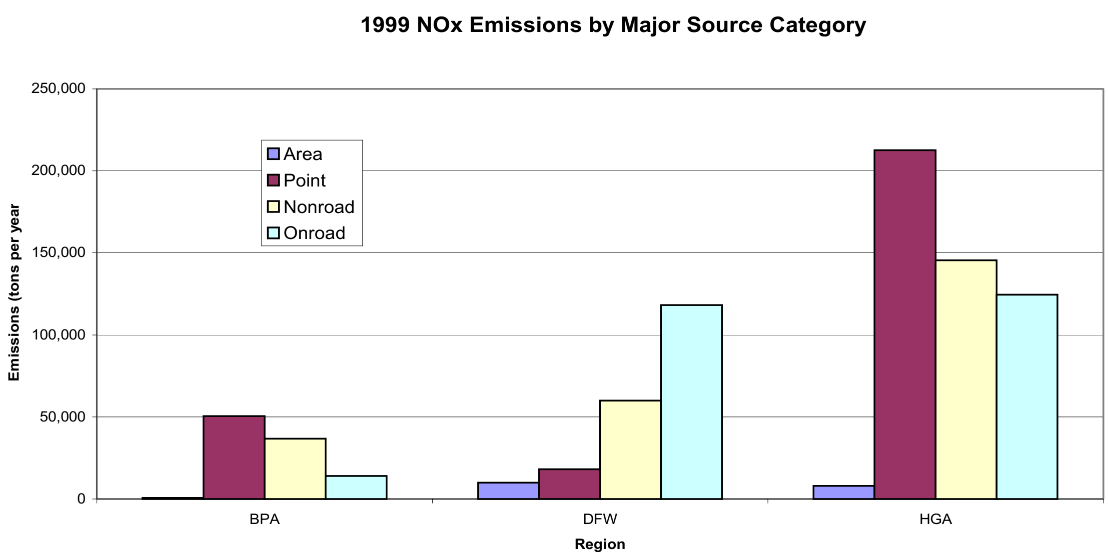


Figure 3-5. 1999 annual NOx emission by nonattainment region based on NEI99 data.

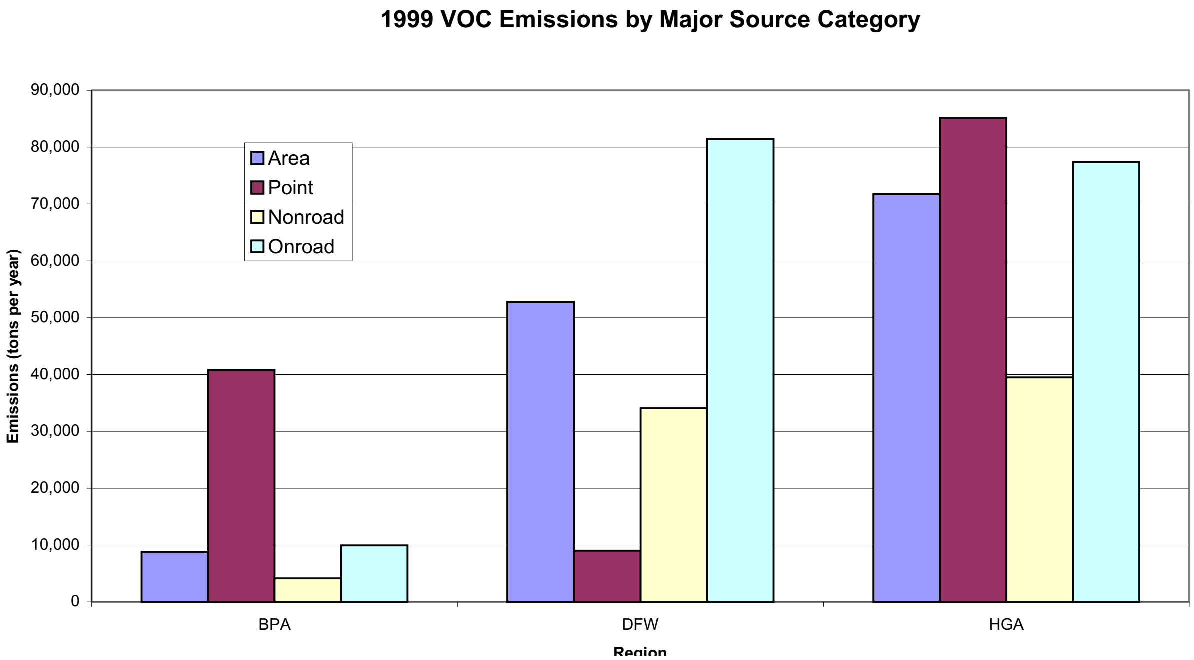


Figure 3-6. 1999 annual VOC emissions by nonattainment region based on NEI99 data.

A comparison of emission levels by regions within Texas is presented in Figures 3-7 through 3-12. These data were developed by ENVIRON and considered various significant changes in both emission estimation methodologies as well as the inclusion of new source categories throughout the time period considered. The study did not include point source emission trends and so only area, on-road mobile and non-road mobile sources are displayed. Also note that the on-road mobile source emission estimates are based on an early draft version of Mobile 6.

In general the data show an overall downward trend in annual VOC emissions from 1990 to present for all regions evaluated. NOx emission trends also exhibit a general downward trend from 1990 to present for area and on-road mobile sources. Fluctuations in on-road mobile source emissions seen in the displays are due primarily in changes in VMT in the various regions. Non-road mobile source NOx emissions are seen to increase from 1990 6through 1999 in all areas

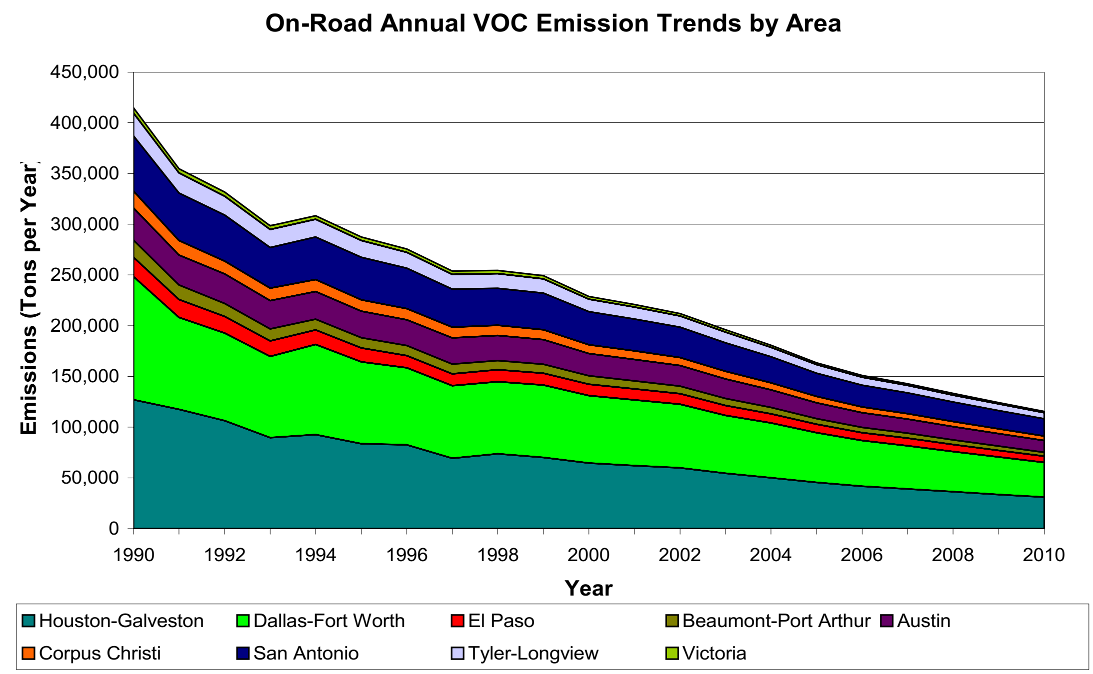


Figure 3-7. Annual on-road mobile source VOC emission trends by region for 1990-2010.

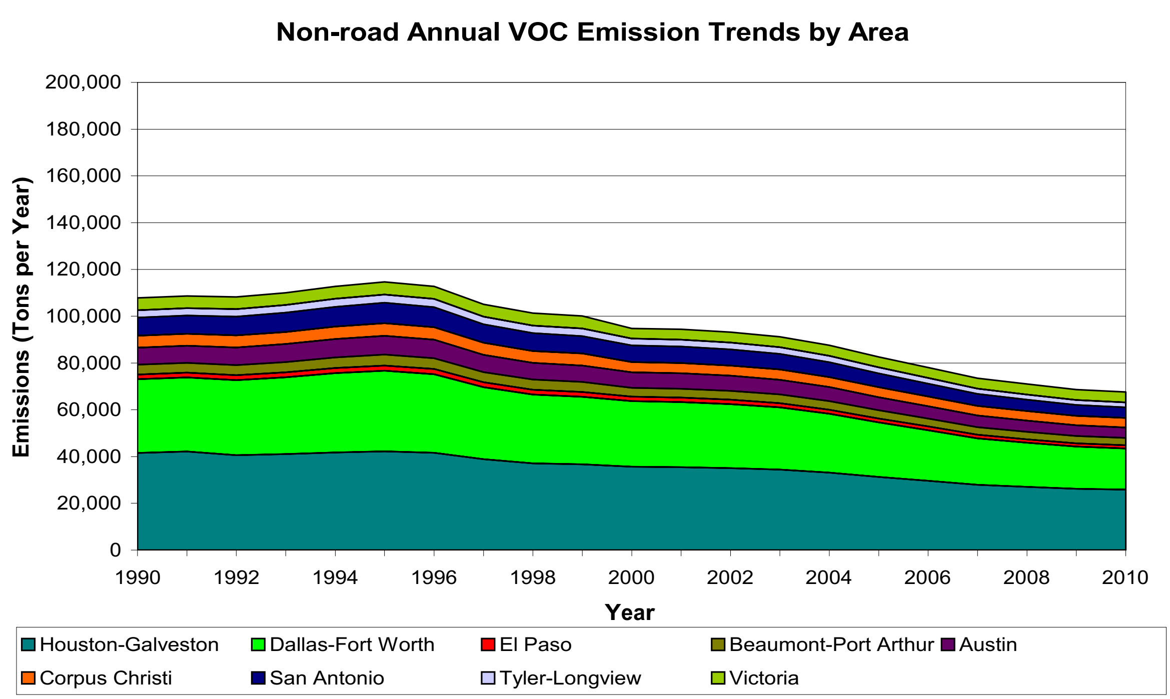


Figure 3-8. Annual non-road mobile source VOC emission trends by region for 1990-2010.

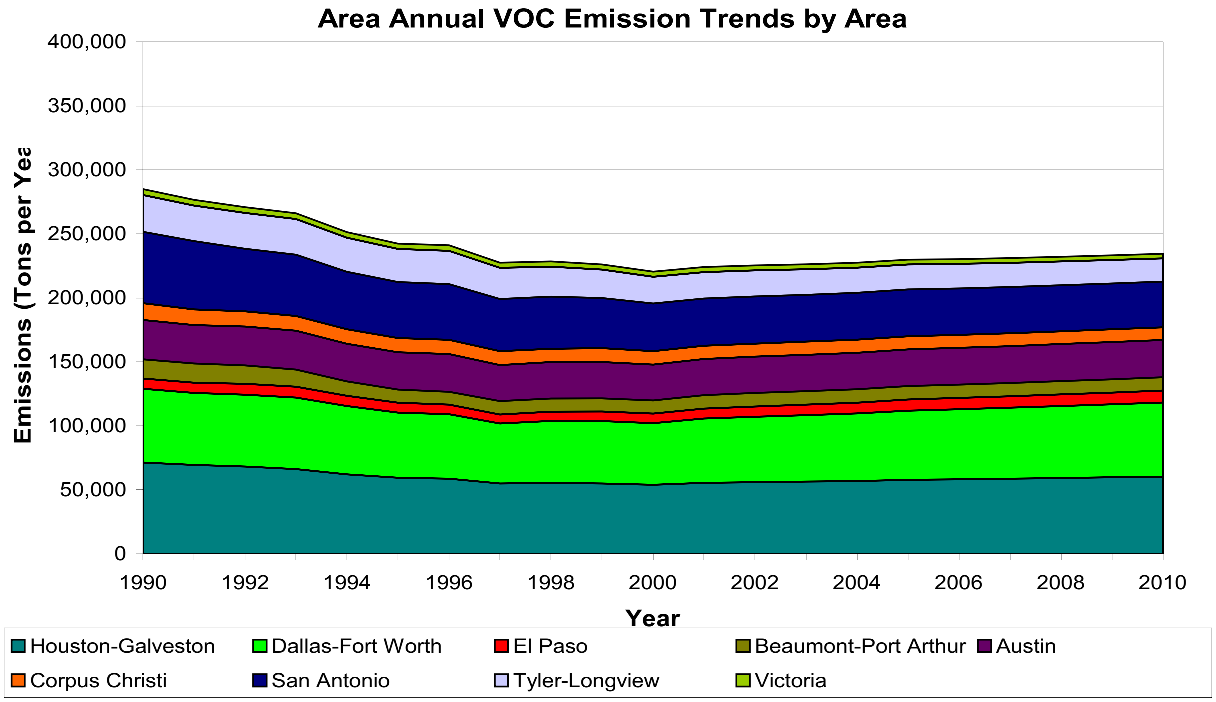


Figure 3-9. Annual area source VOC emission trends by region for 1990-2010.

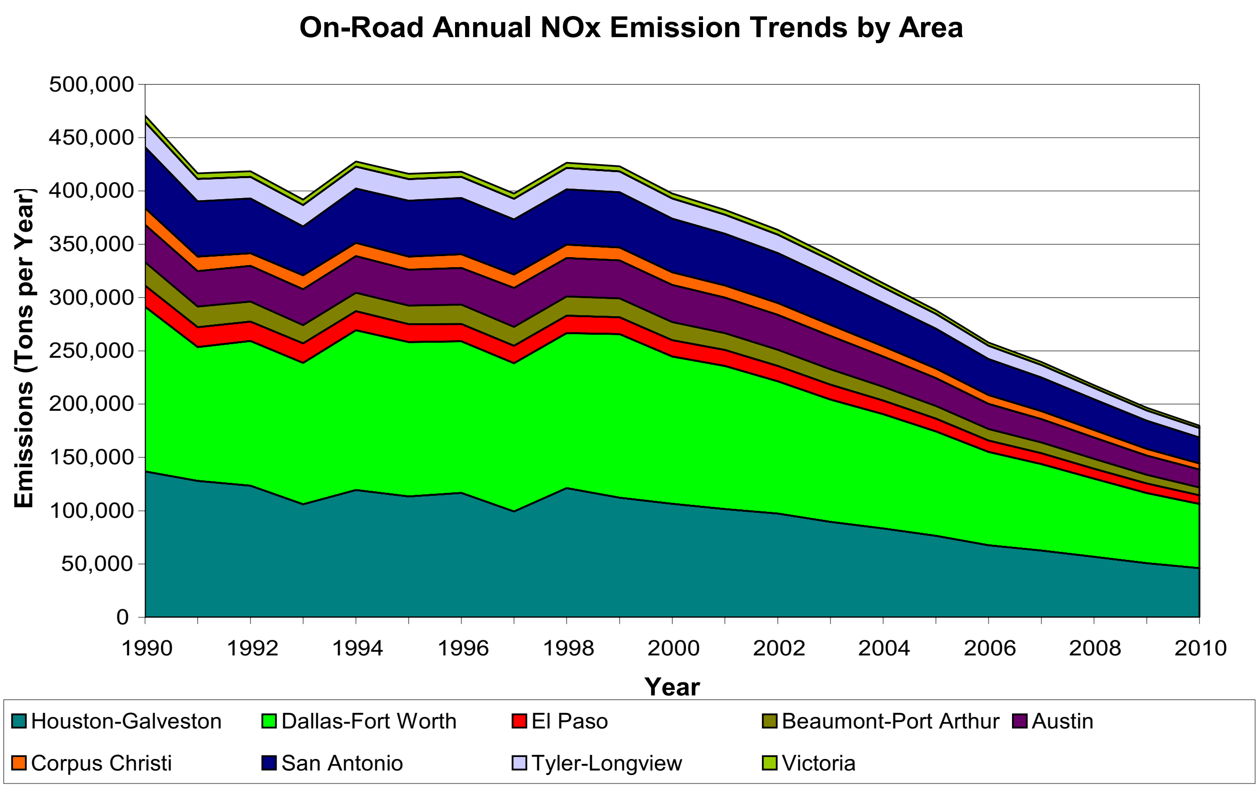


Figure 3-10. Annual on-road mobile source NOx emission trends by region for 1990-2010.

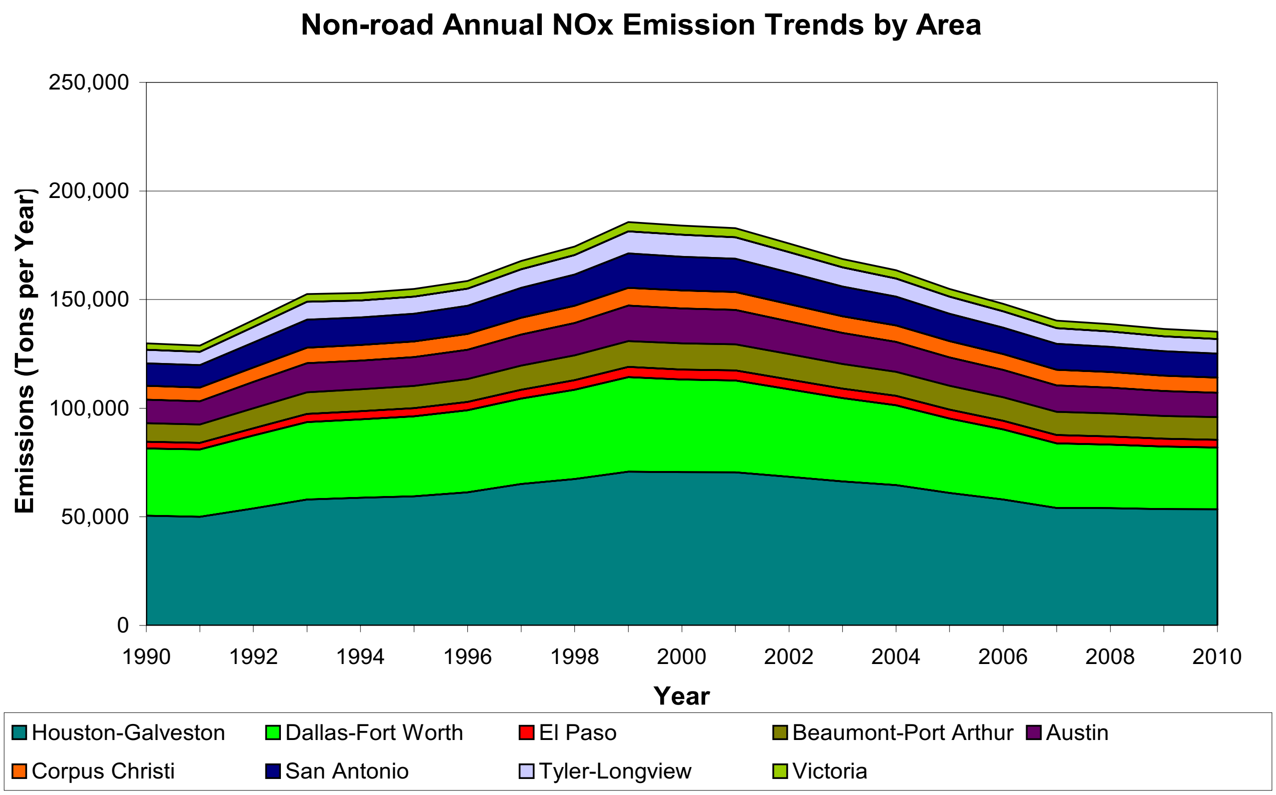


Figure 3-11. Annual non-road mobile source NOx emission trends by region for 1990-2010.

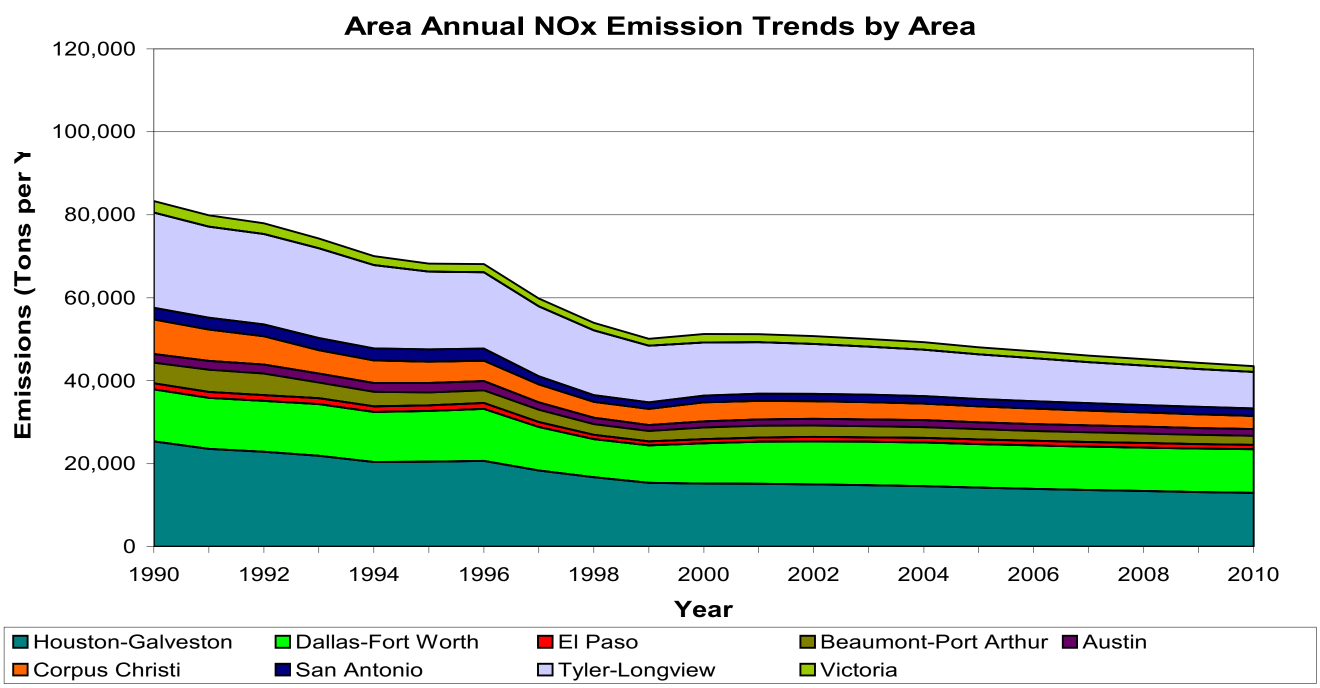


Figure 3-12. Annual area source NOx emission trends by region for 1990-2010.

Emission Summaries by Source Category

Figure 3-13 and 3-14 display NOx and VOC emissions in the DFW by source category from 1990 to 2001, respectively. During this time period an overall downward trend in anthropogenic VOC emissions are seen in all source categories. Note that the point source emission displayed in Figure 3-13 and 3-14 are based on data extracted from the TCEQ's PSDB, while all other categories are based on emissions trends developed by ENVIRON (ENVIRON, 2001). Also not that on-road mobile source emissions are based on an early version of the Mobile6 emission model and therefore may be considerably different from data archived by the TCEQ and presented in draft versions of the conceptual model.

NOx emissions over the period 1990 to 2001 have increased for non-road mobile sources while area sources have decreased slightly. Onroad mobile source NOx emissions have remained fairly constant overall, although slight variations are seen from year to year. In the DFW region, NOx emissions are dominated by mobile source, both on-road and non-road, while are and mobile source contribute the largest to the annual VOC emissions. Point source emissions comprise only a small fraction of the annual anthropogenic emissions within the region.

For comparison, annual anthropogenic NOx and VOC emissions from 1990 to 2001 for the Beaumont/Port Arthur and Houston/Galveston nonattainment regions are displayed in Figures 3-15 through 3-18. In both the BPA and HG regions, VOC emissions have experience an overall downward trend. Area and non-road VOC emissions have remained essentially unchanged in both areas over the past 5-6 years, while on-road mobile source VOC emission have continued to decrease slightly.

Figures 3-17 and 3-18 display the anthropogenic NOx emissions in BPA and HG regions, respectively. From 1990 to 2001, total NOx emission have decreased considerably in the BPA region while only slight reductions are seen in Houston. As seen in the figures, the largest NOx reductions are due to decreases in point source emissions. Non-road NOx emission are seen to increase over this time period in both the BPA and HG nonattainment regions.

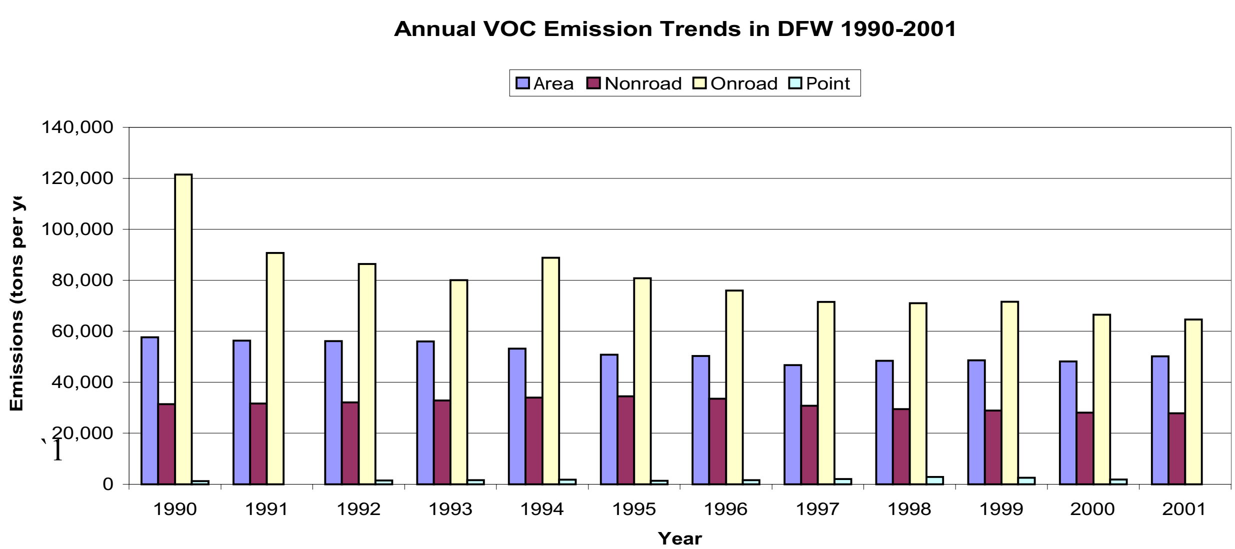


Figure 3-13. Annual VOC emission trends in DFW for 1990-2010 by source category.

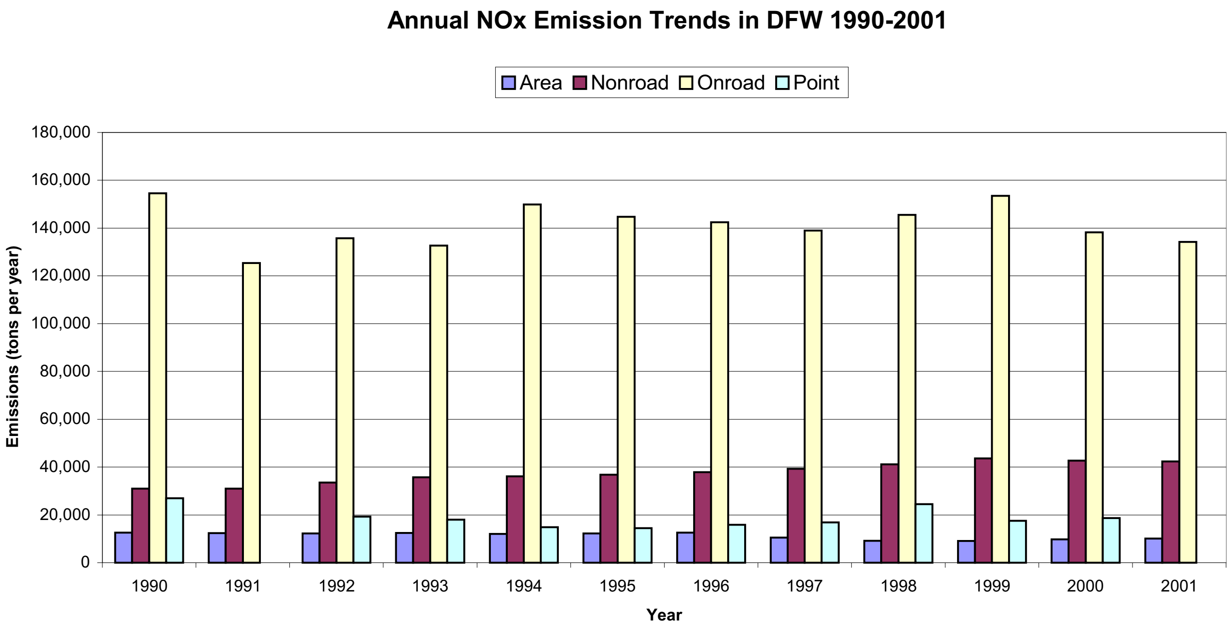


Figure 3-14. Annual NOx emission trends in DFW for 1990-2001 by source category.

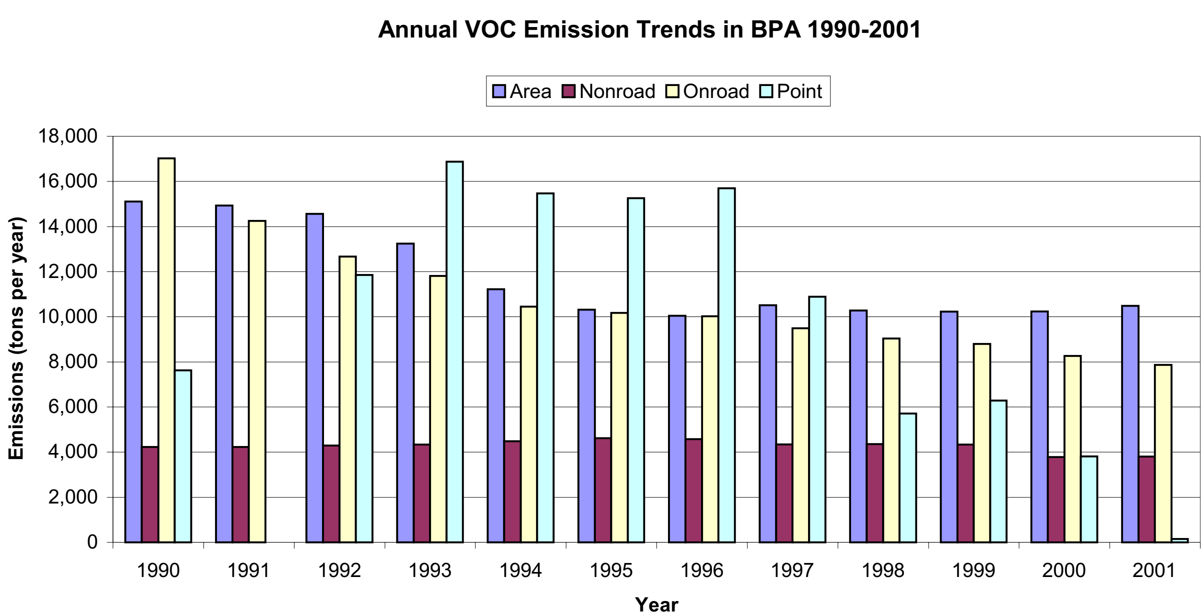


Figure 3-15. Annual VOC emission trends in BPA for 1990-2001 by source category.

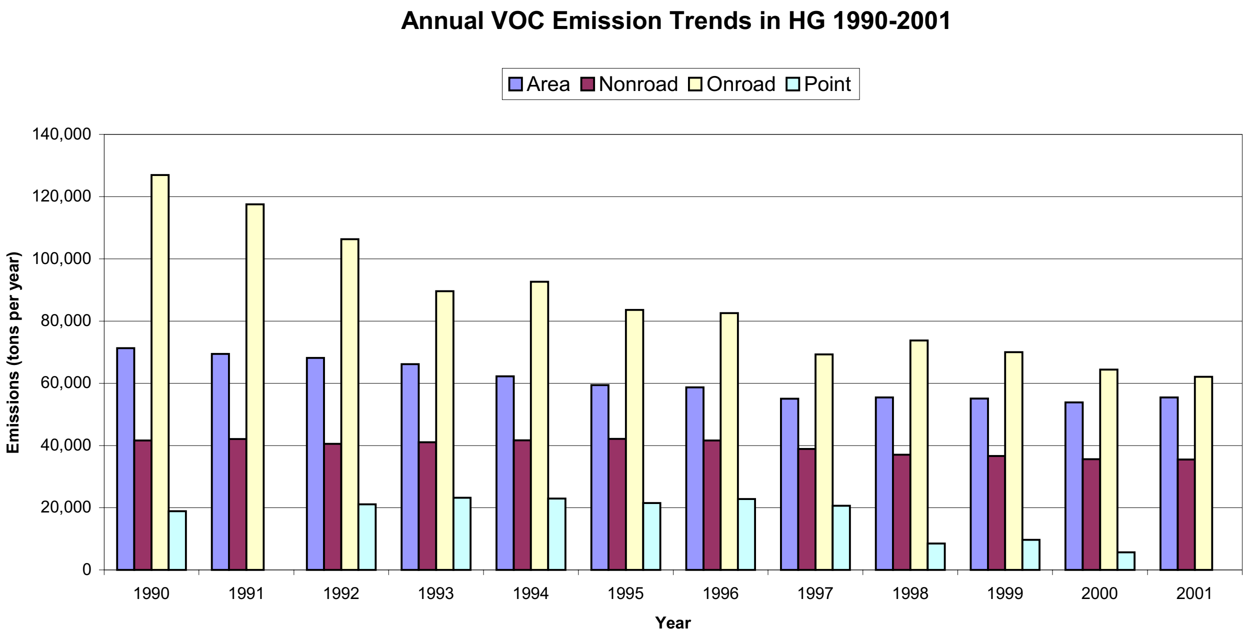


Figure 3-16. Annual VOC emission trends in HG for 1990-2001 by source category.

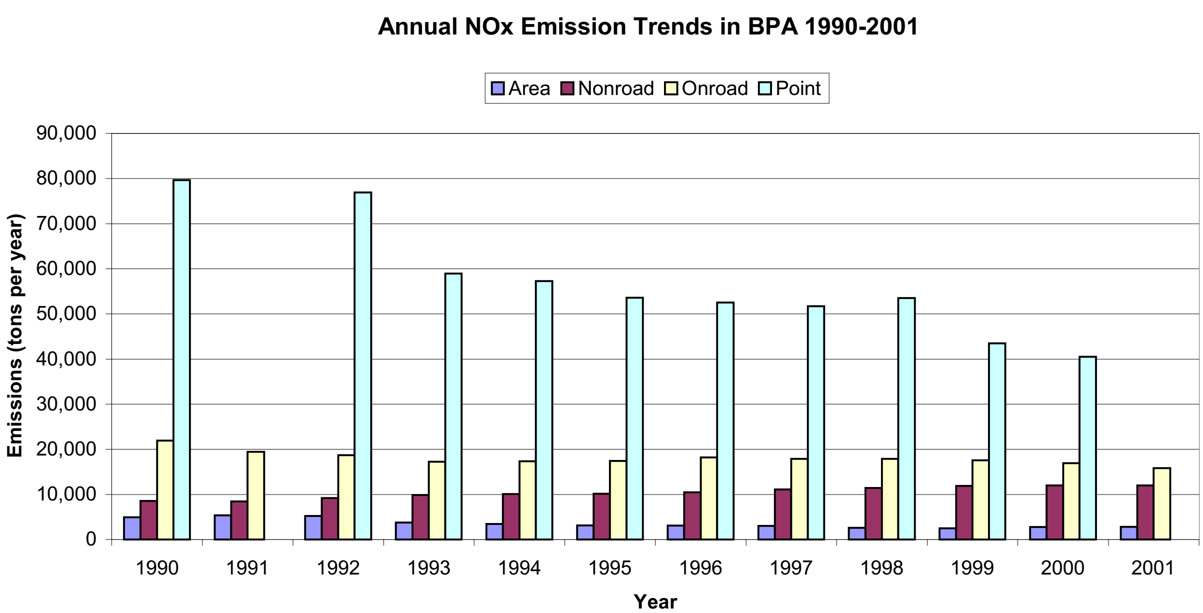


Figure 3-17. Annual NOx emission trends in BPA for 1990-2001 by source category.

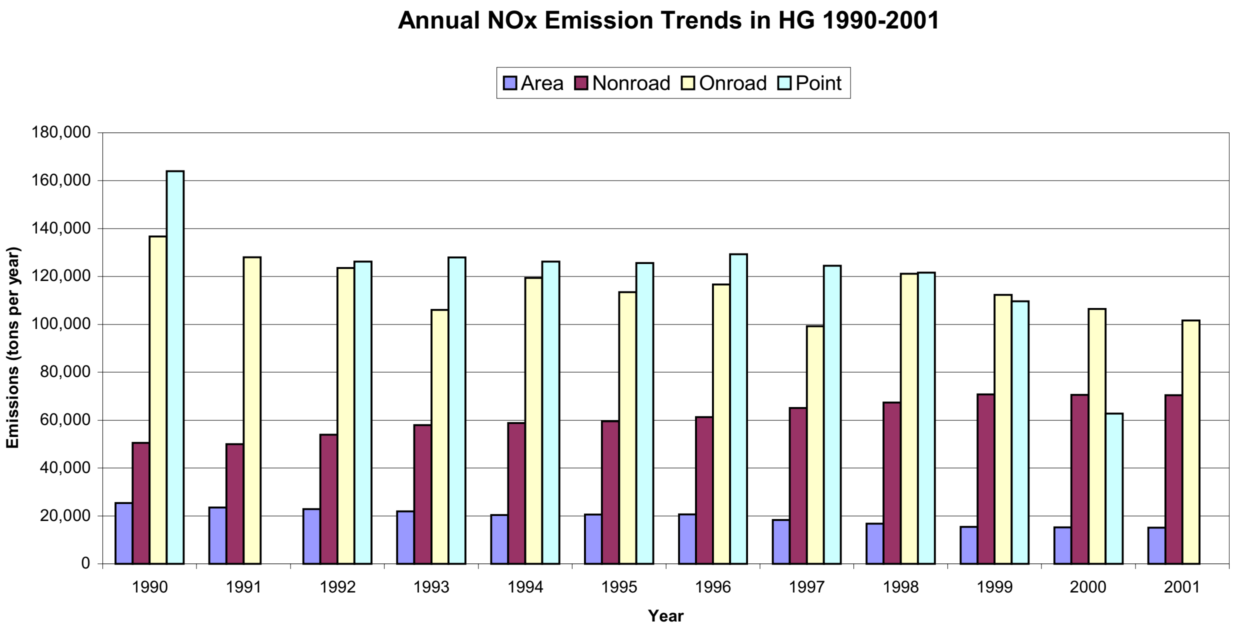


Figure 3-18. Annual NOx emission trends in HG for 1990-2001 by source category.

A summary of 1996 NOx and VOC emission by county in the DFW nonattainment region is presented in Figures 3-19 and 3-20. Dallas and Tarrant counties contribute the majority of both NOx and VOC anthropogenic emissions. Area and on-road mobile source emissions dominate the NOx annual emission totals while area, on-road and no-road VOC are the dominant sources of VOC emissions in the area. Point sources contribute relatively minor amounts of both NOx and VOC emissions for all DFW nonattainment counties.

Figures 3-21 and 3-22 display the total annual anthropogenic VOC and NOx emissions in the DFW area for 1996 and 1999, respectively. These data are based on information received from the TCEQ. As shown, both point source NOx and VOC increase slightly from 1996 to 1999. VOC emissions in the DFW region have decreased from 1996 to 1999 for area, on-road mobile and non-road mobile sources. NOx emissions from mobile (both on-road and non-road) and area sources are seen to decrease from 1996 to 1999. A previous analysis of emission trends (TCEQ, 2002a) has attributed the decrease in mobile source emissions to fleet turnover with newer less polluting vehicles replacing older more polluting vehicles, while area source emission increases were attributed in part to increases in population. However, VMT in the four county DFW region has been outpacing population increases over thepast decade. Figures 3-25 and 3-26 display the DFW region VMT and population trends for 1984 through 2030. While VMT and population closely follow each other from 1984 to 1990, growth in VMT is seen to outpace population growth from 1990 to 1999 and is projected to continue this trend through 2030.

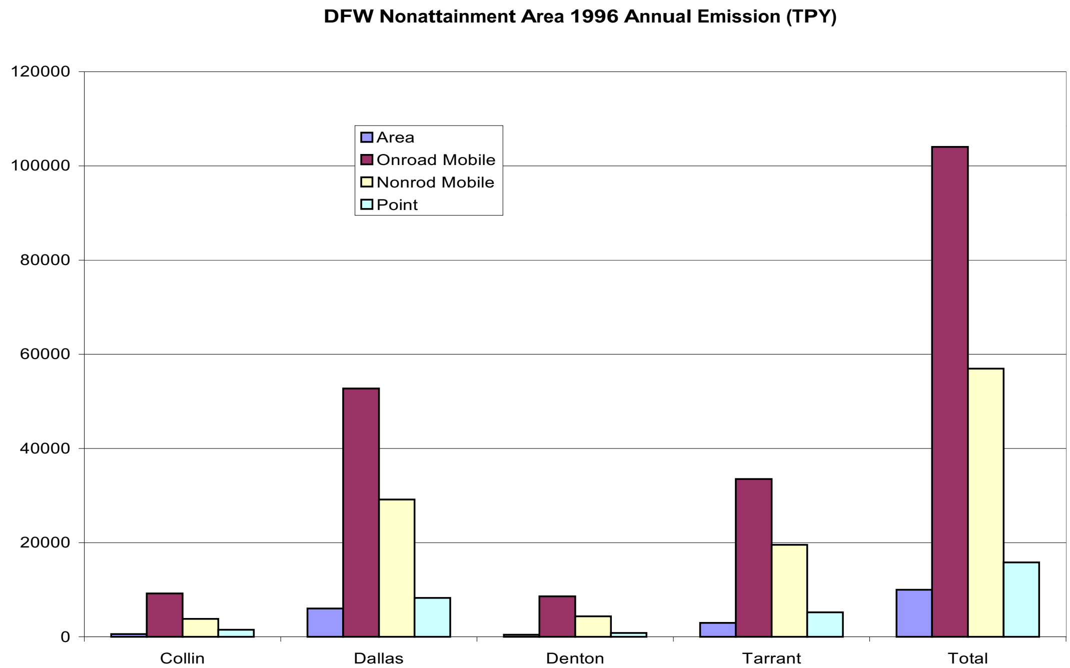


Figure 3-19. 1996 Annual NOx emissions in DFW nonattainment counties by source category.

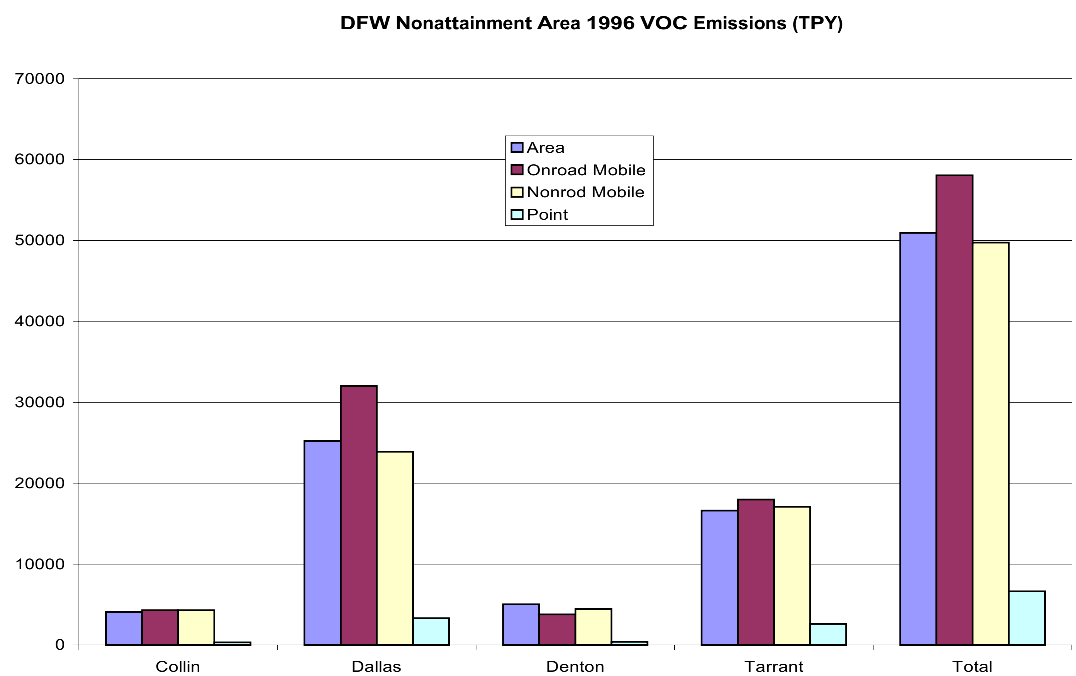


Figure 3-20. 1996 annual VOC emissions in DFW nonattainment counties by source category.

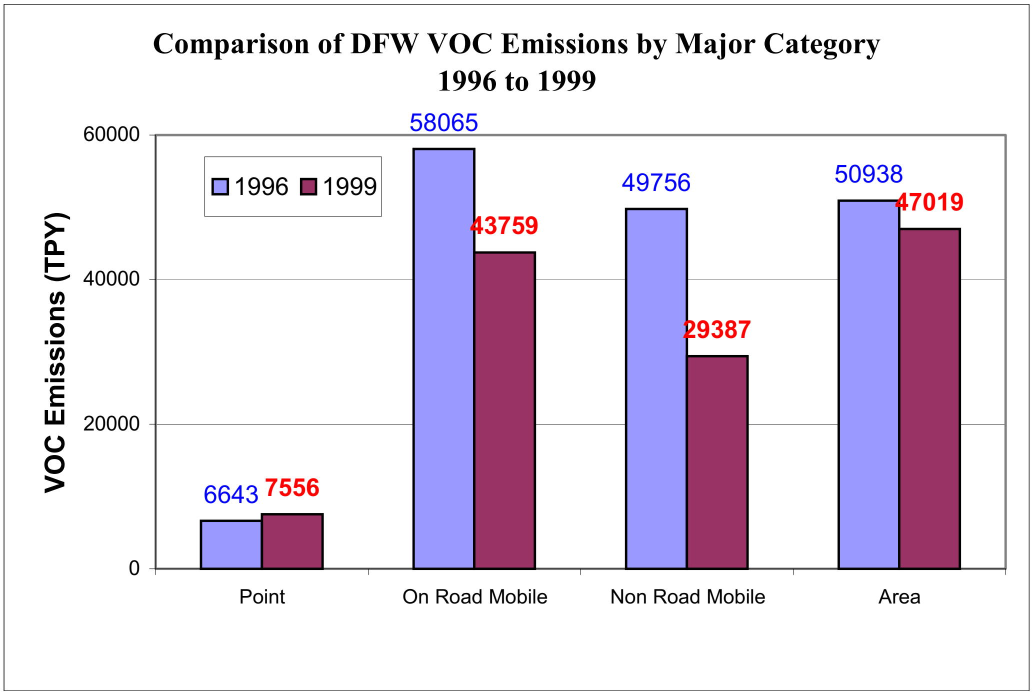


Figure 3-21. Comparison of DFW area VOC emissions by source category for 1996 and 1999 (TCEQ).

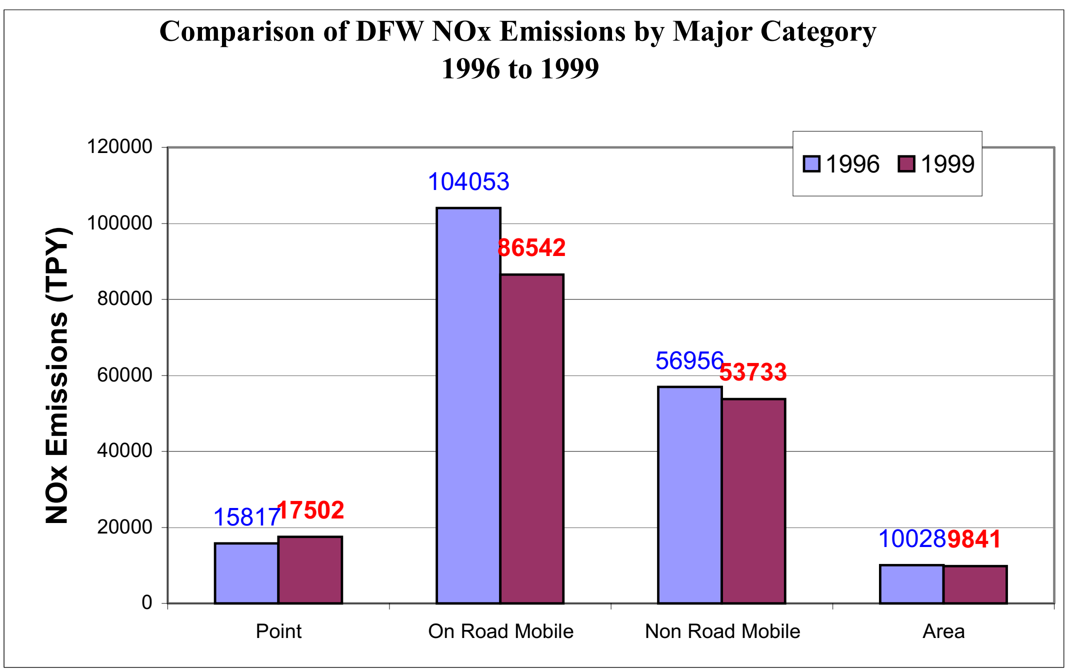


Figure 3-22. Comparison of DFW area NOx emissions by source category for 1996 and 1999 (TCEQ).

An examination of population trends from 1990 to 2000 is also of interest. Figure 3-23 displays the population for the DFW nonattainment counties for 1990 and 2000 based on US Census data. Dallas and Tarrant counties show the largest population in the region, consistent with the higher emission levels in these counties. Collin County is seen to nearly double from 1990 to 2000. Figure 3-24 provides a comparison of 1990 and 2000 populations in the Dallas/Fort Worth, Beaumont/Port Arthur and Houston/Galveston nonattainmnet areas. As shown, both HG and DFW have nearly the same total population and correspondingly, area and mobile source NOx and VOC emission levels are comparable. However, point source NOx and VOC are much greater in the Houston area, reflecting the numerous industrial sources in the region.

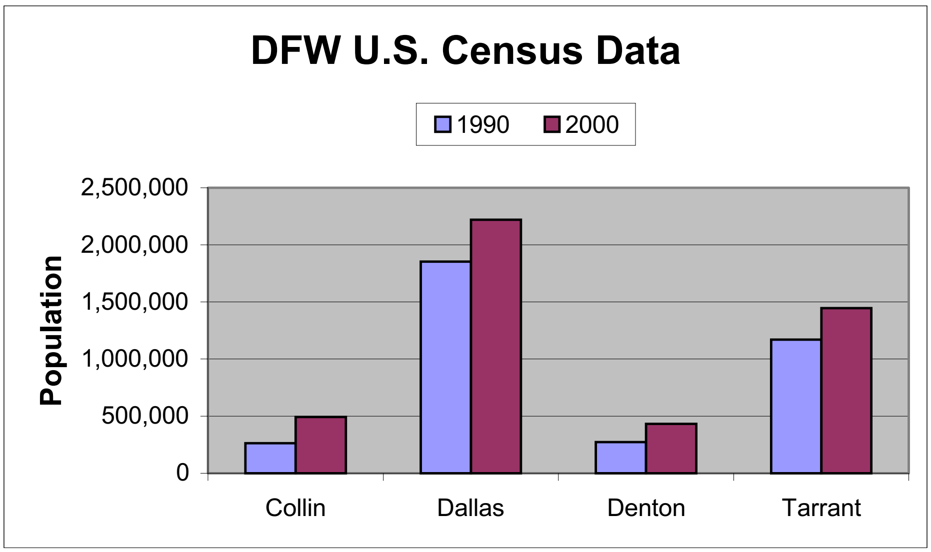


Figure 3-23. 1990 and 2000 population in DFW by county.

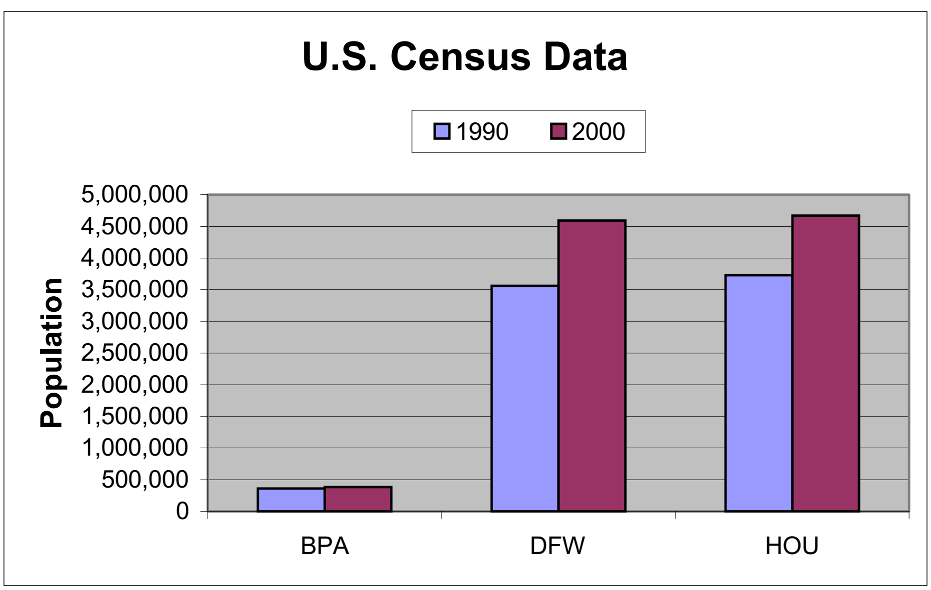


Figure 3-24. 1990 and 2000 population by nonattainment area.

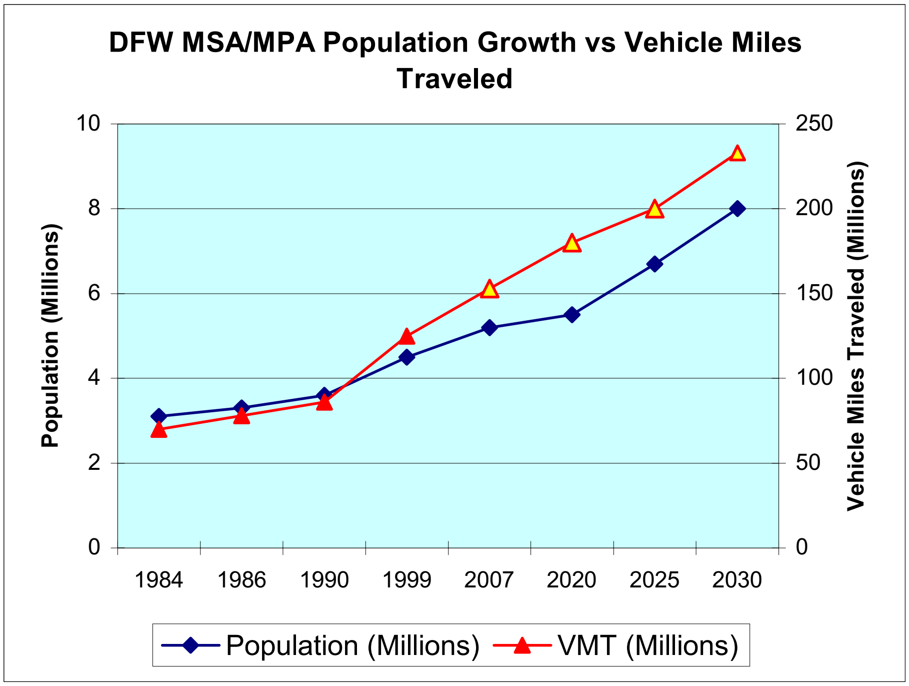


Figure 3-25. DFW nonattainment area VMT and population growth from 1984 to 2030 (TCEQ).

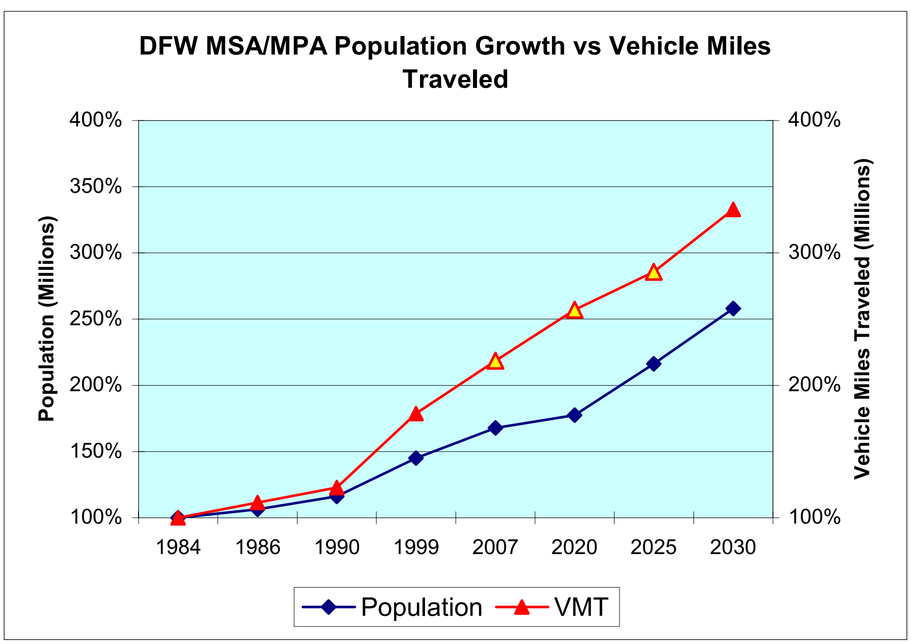


Figure 3-26. DFW nonattainment area VMT and population growth as a percentage from 1984 to 2030 (TCEQ).

4. METEOROLOGY

The DFW conceptual model considered the meteorological factors associated with both low and high ozone days within the region. Upper level, or transport winds, as well as surface wind flows were evaluated. The flow associated with high ozone days can be characterized as light early morning winds from the southwest, and light winds from the southeast in the afternoon. Low ozone days are associated with relatively strong southerly wind flows. The analysis of transport winds suggest evidence of transport of ozone and ozone precursors from south and south central Texas. Evidence of transport between Dallas and Fort Worth was also noted. Thus, the ozone air quality in the DFW region is affected both by local sources as well as regional transport.

Local Meteorology

The Dallas/Fort Worth metropolitan area is located on the plains of Northeast Texas where the lack of major geographic features means that wind patterns are driven primarily by synoptic scale meteorological influences. Nonetheless, an analysis of local surface winds provides an understanding of the effects of local transport on ozone levels within the DFW urban area and can provide evidence of transport between Dallas and Fort Worth.

An analysis of surface winds trajectories was conducted by the TCEQ (TCEQ, 2002a; 2002b). The analysis examined local wind patterns for both high ($O3 > 125$ ppb) and low ($O3 < 80$ ppb) ozone days. Wind rose analyses were conducted which considered surface wind speeds and directions on high and low ozone days during the period 1990 through 2001. The analysis was conducted separately for morning and afternoon hours. Displays of wind roses for Dallas and Fort Worth separately for morning and afternoon surface winds are displayed in Figure 4 1 through Figure 4-4.

The conclusions reached from these analyses can be summarized as follows. On low ozone days, the surface wind speeds tend to be relatively high compared to high ozone days. The winds generally blow from the south during both morning and afternoon. These wind speeds and directions are similar for both Dallas and Fort Worth. The relatively high wind speeds tend to ventilate the area of ozone and ozone precursors, limiting the potential for high ozone buildup. By contrast, on high ozone days, the predominant wind directions are from the south and south-southwest with relatively low speeds. In the morning hours, Dallas surface winds tend to blow from the south-southwest shifting to the South and south-southeast during the afternoon. Winds from the north are relatively rare during the ozone season in Dallas and Fort Worth. In Fort Worth, high ozone days experience low wind speeds, with generally more random directions although an easterly wind component is present in the morning hours. The afternoons on high ozone days experience a more pronounced easterly component in surface winds compared to morning winds.

High Ozone (O3 > 125) for Dallas

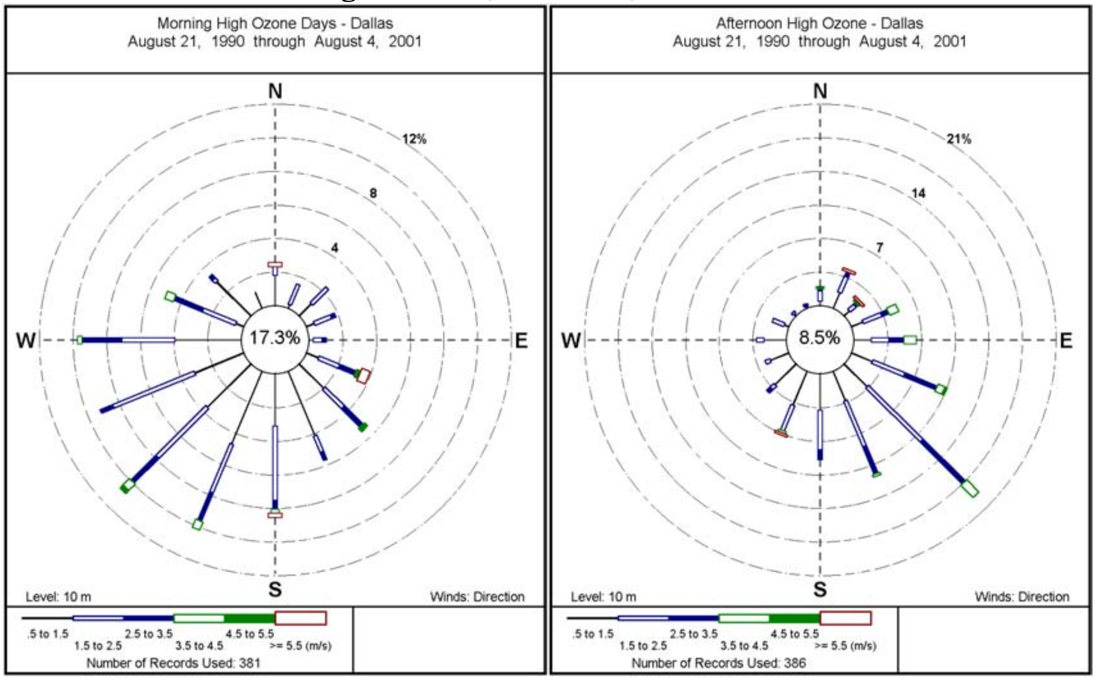


Figure 4-1. Surface wind roses for Dallas high ozone days 1990-2001 (TCEQ).

High Ozone (O3 > 125) for Fort Worth

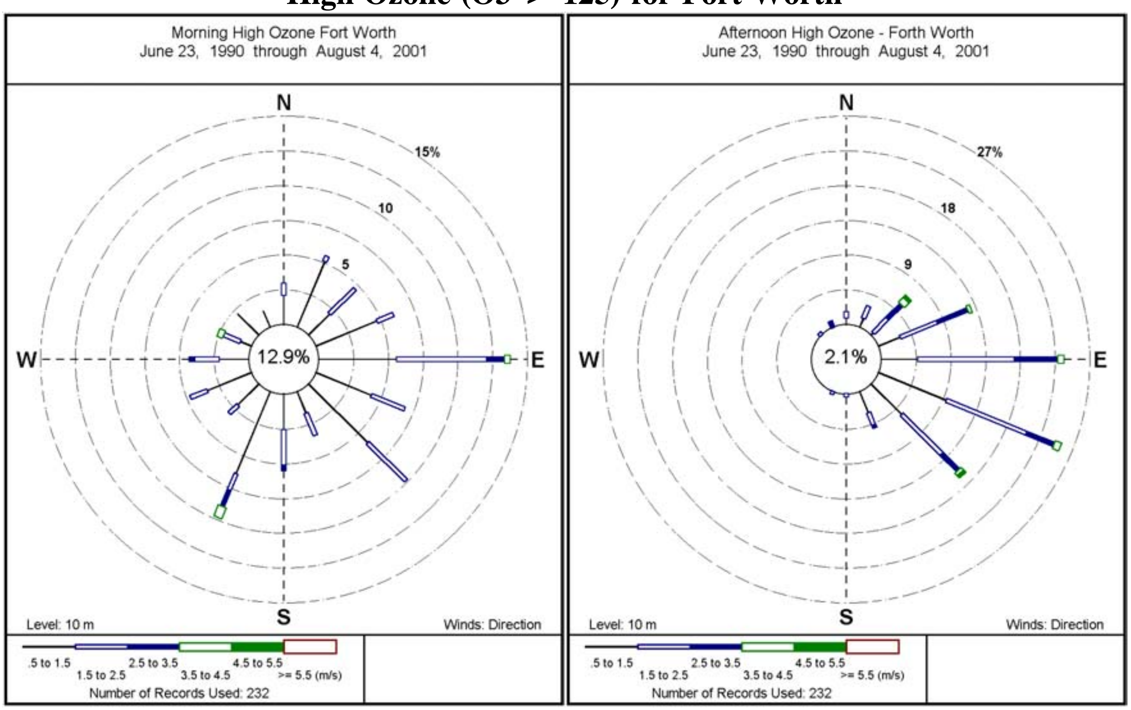


Figure 4-2. Surface wind roses for Fort Worth high ozone days 1990-2001 (TCEQ).

Low Ozone (O3 <80) for Dallas

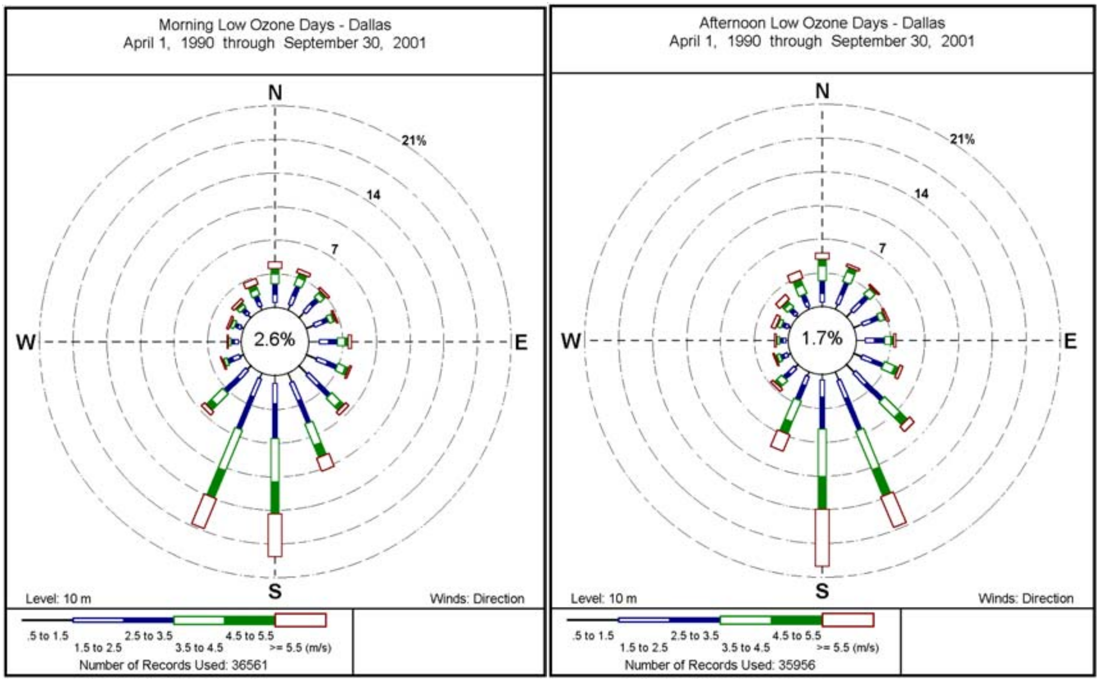


Figure 4-3. Surface wind roses for Dallas low ozone days 1990-2001 (TCEQ).

Low Ozone (O3 < 80 ppb) for Fort Worth

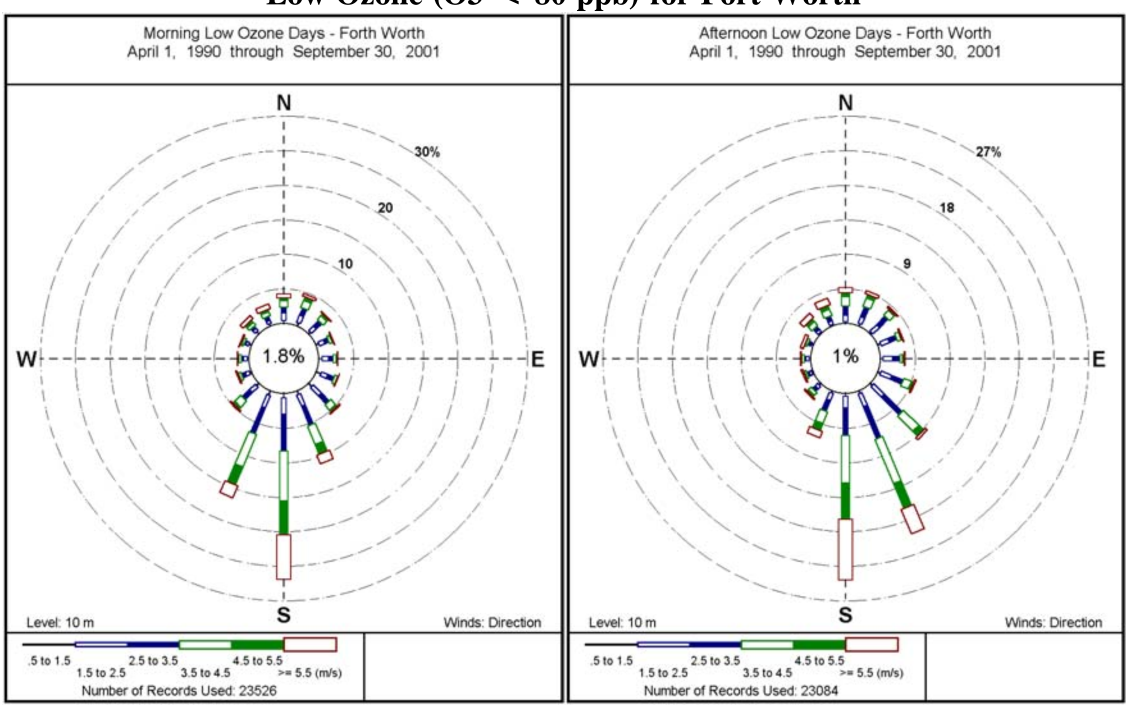


Figure 4-4. Surface wind roses for Fort Worth low ozone days 1990-2001 (TCEQ).

A comparison of surface winds on high ozone versus low ozone days reveals that winds on high ozone days tend to be lighter than on low ozone days, with calm winds much more frequent, increasing from approximately 2.6% to 17.3% of the time during the morning hours for Dallas. In Fort Worth calm morning winds occur approximately 1.8 percent of the time increasing to 12.9 % on high ozone days. High ozone days also exhibit more variation in wind direction, with morning winds blowing from the South-Southwest and afternoon winds shifting to the South-Southeast.

Meteorological conditions associated with the above situation provides evidence for local transport of ozone between Dallas and Fort Worth. Low wind speeds in the morning hours allows for ozone production in the urban areas. The easterly wind directions in Fort Worth during the morning hours may transport ozone and ozone precursors from Dallas. Likewise, the westerly winds in Dallas may lead to transport ozone and precursors from Fort Worth. The relatively low wind speeds on high ozone days cause ozone levels to build up. The shift in wind direction in the afternoon then leads to transport from Dallas back to Fort Worth of elevated ozone levels.

An analysis conducted by the TCEQ considered a case study for a single high ozone day in DFW to support this premise regarding transport between Dallas and Fort Worth (TCEQ, 2002a). The study examined the surface back trajectories and their relation to local NOx and VOC sources and elevated ozone concentrations for August 2, 2000.

Figure 4-5 displays surface back trajectories and the path of industrial plumes in the DFW area on 8/2/2000. The purple traces in the Figure 4-5 show the path of a particle released at midnight and ends at the time of ozone peak. The trajectories show that early morning winds flow easterly, then reverse direction in the afternoon and flow west by northwest. In Figure 4-5, NOx sources are indicated by triangles and VOC sources are indicated by circles. The analysis illustrates the re-circulation of ozone and precursor emissions between Dallas and Fort Worth.

Surface Back Trajectory CAMS 63 (8/2/2000)

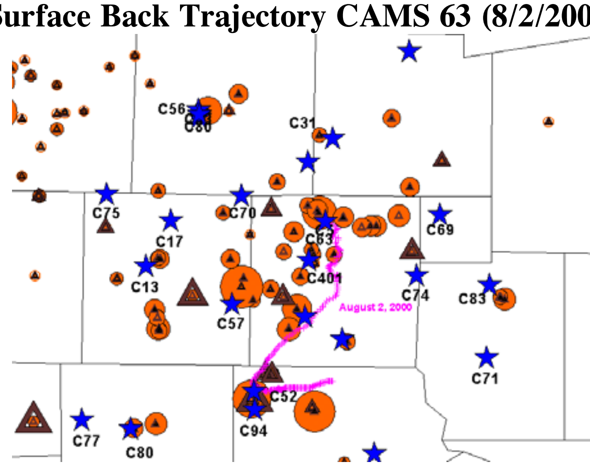


Figure 4-5. Surface back trajectory for August 2, 2000. NOx sources indicated by triangles; VOC sources indicated by circles (TCEQ).

The displays in Figures 4-6 and 4-7 show the path an industrial source plume may have taken on a typical high ozone day in the DFW region. The analysis shows that an air mass collects VOC and NOx from local sources within and south of the DFW metroplex. Local stagnation during mid-day provides favorable conditions for ozone formation. Afternoon wind flow reversal then transports elevated ozone concentrations westward from Dallas to Fort Worth. While this situation is typical of the wind flows and meteorology of high ozone events in DFW, back trajectories contain uncertainties and the analysis of single trajectories for specific days, as shown in Figures 4-6 and 4-7, should be viewed with caution. Groups of back trajectories for similar types of days are generally considered to be more reliable.

Surface Plume Trajectories At 12:00 CST (8/2/2000)

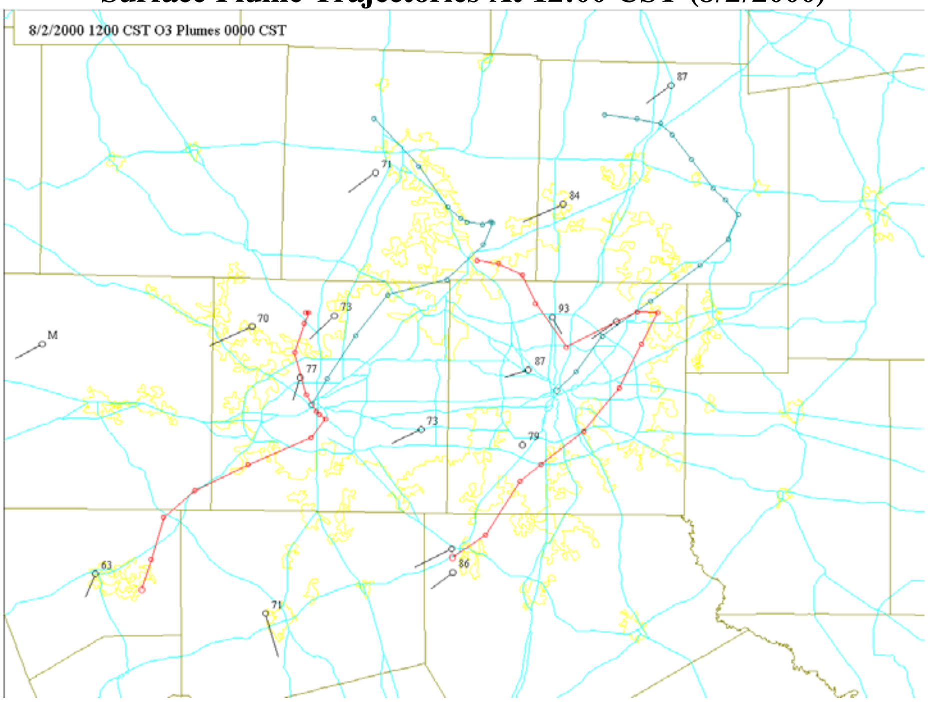


Figure 4-6. Surface plume trajectory at 1200 CST on August 2, 2000 (TCEQ).

Surface Plume Trajectories At 16:00 CST (8/2/2000)

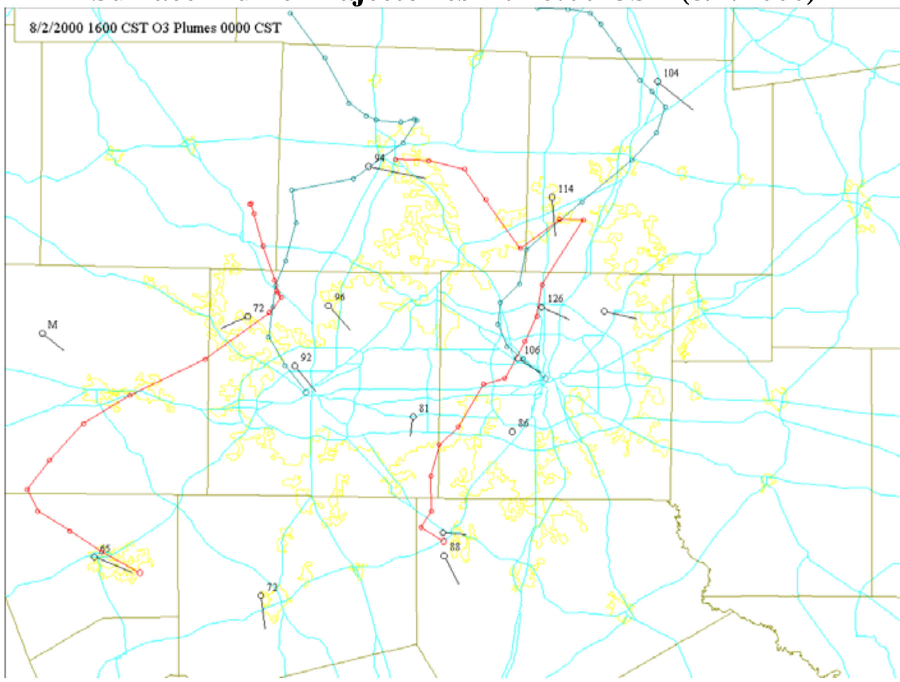


Figure 4-7. Surface plume trajectory at 1600 CST on August 2, 2000 (TCEQ).

These surface wind analyses and local transport effects provide an indicaiton that the influence of local sources on ozone exceedances within the region is important with respect to addressing the 1-hour ozone standards. With respect to the 8-hour ozone standard, the effect of upper air, or long-range regional transport, must be considered as well.

Regional Transport

An analysis of upper level winds provides information concerning the effects of long-range, or regional, transport on ozone levels within the DFW non-attainment area. NOAA's Air Resources Laboratory HySplit model was used to compute backward trajectories for air masses terminating in the DFW area. In addition, analyses of National Weather Service (NWS) weather maps were conducted in order to further characterize meteorology typical of the peak ozone seasons (June/July and August/September) in the DFW area.

Based on analyses of NWS weather maps the following observations concerning high ozone events in Texas can be made. High ozone events occur when the air becomes stagnant, typically in the summer when temperatures are higher and when there are more hours of sunshine. In June and July of 1999, for example, the Bermuda High frequently sat offshore of Florida. The clockwise flow around the high often enhanced the afternoon sea breeze and produced thunderstorms, helping dilute ozone. Other times, the jet slid to the south to create a storm where the stronger winds near the front could dilute the pollutants.

In all of the high-ozone periods in August and September, the Bermuda High was outside the analyzed weather map domain. A slow-moving surface high could be found passing through the Northern Plains and Great Lakes, and the pressure gradients across Texas were very weak during most of the episode. In the upper atmosphere, a ridge of high pressure over thecentral US was clearly defined on four of five high ozone events. Four had 500mb heights over 5880m with the jet stream over Canada and weak upper level winds over Texas. The fifth period considered – September 15-21, 1999 – had heights near 5820m; the jet split near the west coast with the stronger branch staying in Canada while the weaker southerly branch headed eastward through all the southern states.

Figure 4-8 displays a back trajectory scatter plot developed as part of the conceptual model. Displayed are upper air back trajectories ending in the DFW area on all 1-hour and 8-hour ozone exceedance days during the years 1997 through 2002. The trajectories show the path an air parcel follows which originated the previous day. As can be seen, thewind trajectories tend to favor northeasterly, southeasterly and southerly directions. In very few instances, the trajectories come from the north and west.

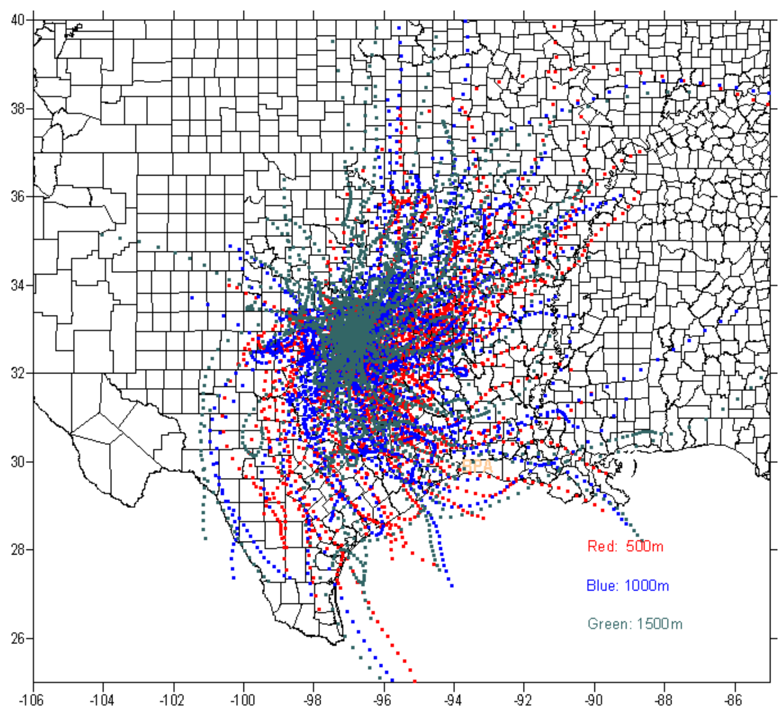


Figure 4-8. Back trajectory scatter plot on 1-hour and 8-hour ozone exceedance days during 1997-2002 in DFW.

Back trajectories ending in the DFW area associated with 1-hour exceedances during the years 1997 through 2002 are displayed in Figure 4-9. The preferred trajectory direction for 1-hour exceedances is seen to be easterly, southeasterly, and southerly.

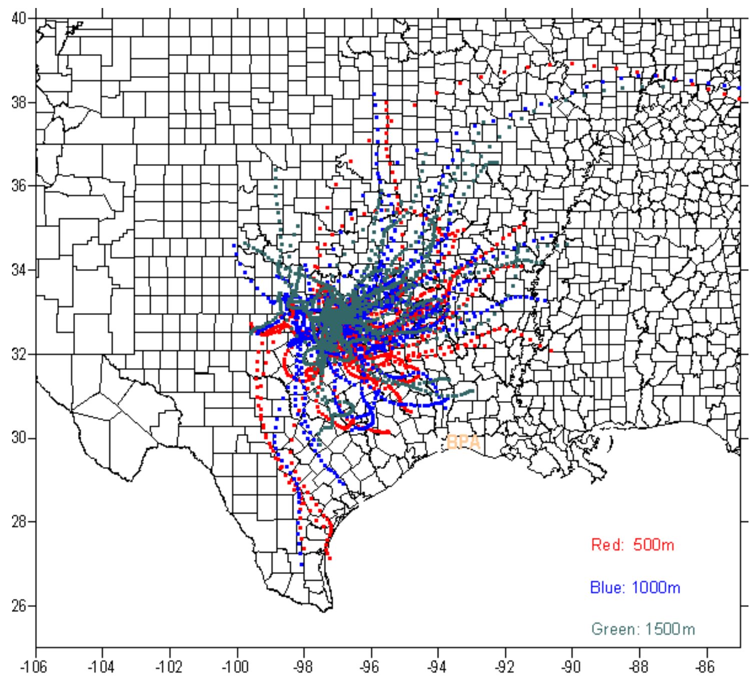


Figure 4-9. Back trajectory scatter plot on 1-hour ozone exceedance days during 1997-2002 in DFW.

Back trajectories ending in the DFW area associated with 8-hour exceedances during the years 1997 through 2002 are displayed in Figure 4-10. The preferred trajectory directions for 8-hour exceedances is seen to be northeast, southeast and south.

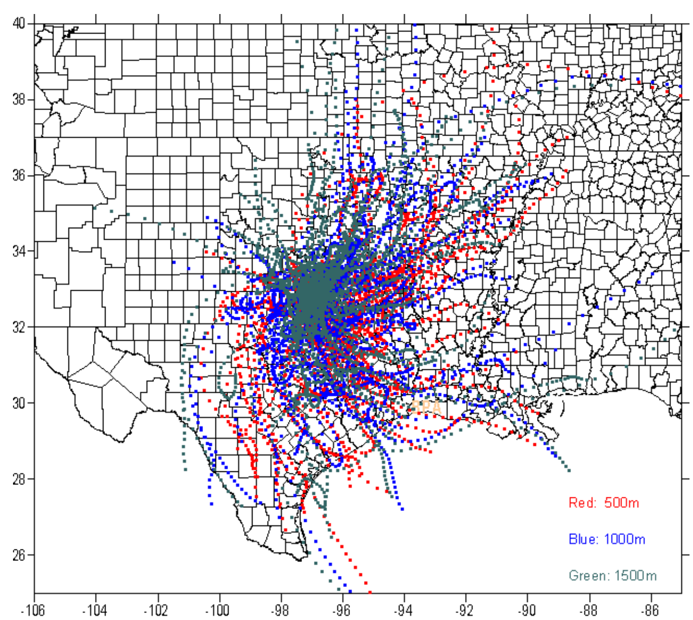


Figure 4-10. Back trajectory scatter plot on 8-hour ozone exceedance days during 1997-2002 in DFW.

Examination of Figures 4-8 and Figure 4-10 reveals that a significant number of trajectories originate in the upper Gulf Coast region, near Houston/Galveston and Beaumont/Port Arthur, particularly on 8-hour ozone exceedance days. A previous analysis completed by the TCEQ showed that approximately 13-22% of the time, the upper air trajectories originate from the Houston area. Trajectories which pass closer to Houston tend to have higher ozone and those which spend more time near Houston likewise have higher ozone levels. Thus, regional transport from the Houston non-attainment area has some affect on ozone air quality in the DFW region. This fact has implications for the 8-hour ozone standard as regional ozone levels will potentially raise the background levels contributing to high 8-hour ozone events.

As part of the development of the draft conceptual model for ozone formation in the DFW nonattainment area, the TCEQ performed statistical analyses on back trajectory data (TCEQ, 2002b). Figure 4-11 displays a statistical frequency plot for the DFW area. for the years 1993 through 1998. Examination of Figure 4-11 reveals that for trajectories originating near DFW (within 50 miles) the most frequent direction if from the southeast. For longer range trajectories (from 50 to 250 miles), the most frequent wind direction is from the south. Thus, the air quality in Dallas may be affected by sources in Houston since Houston sources may add to the background ozone concentration levels which are then transported long distances by upper air winds.

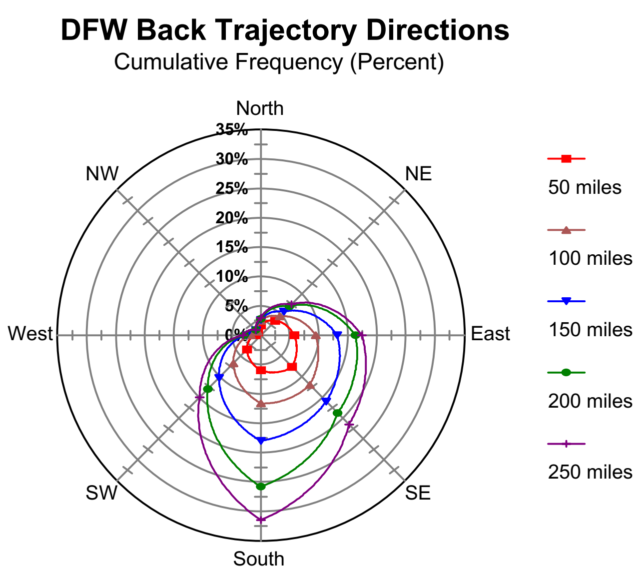


Figure 4-11. Back trajectory statistical frequency plot for DFW (TCEQ).

Evidence for long-range transport from Houston, as well as Beaumont/Port Arthur is further supported by previous analyses conducted by the TCEQ as part of the development of the draft conceptual model (TCEQ, 2002a; 2002b). This analysis used two previously modeled 8-hour ozone episodes (June 18-22, 1995 and June 30- July 4, 1996)

A number of air quality model simulations were performed to investigate the potential for transport from the Houston/Galveston and Beaumont/Port Arthur nonattainment areas. The model simulations consisted of a number of experimental scenarios as well as source apportionment analyses. Simulations were conducted in which anthropogenic emissions were zeroed out in various source regions and the modeling results were then evaluated to determine what, if any, impact was realized within the DFW non-attainment region. The analyses showed that for the 1995 and 1996 ozone episodes, the Houston plume produced impacts in DFW on the order of 2 ppb to 10 ppb depending on the episode day.

As another case, the modeling considered a situation wherein synthetic winds blow directly from Houston to Dallas. Anthropogenic emissions in the Houston area were also zeroed out. These results indicated a plume of ozone reductions greater than 20 ppb stretching from northwest of Houston towards Dallas. In Fort Worth, ozone reductions of 5-10ppb were realized, depending on the time of day. Finally, Ozone Source Apportionment Technology (OSAT) was used to assess the contributions of various source regions on elevated ozone concentrations within the DFW area. These modeling results indicated measurable contributions from both Houston/Galveston and Beaumont/Port Arthur non-attainment areas on the ozone maximums in DFW. The result of these analyses, as well as a more detailed discussion of the simulations performed may be found in TCEQ, 2000b.

5. EPISODE SELECTION

Based on the analyses conducted for the development of the conceptual model for ozone formation within the Dallas/Fort Worth non-attainment area, candidate modeling episodes are identified. This section summarizes the episode selection procedures used for the DFW area.

Episode Selection Criteria

The US EPA has developed guidelines for the selection of modeling episodes in support of 1-hour and 8-hour attainment demonstrations (EPA, 1997; EPA, 1999). The approach established by the EPA involves identification of the meteorological regimes associated with high ozone events and generally recommends that candidate episodes include periods of observed average ozone concentrations within 10 ppb of the applicable design value (1-hour or 8-hour design values). The quality and availability of observed data during the candidate period is also of particular importance.

The primary episode selection criteria can be summarized as follows:

- Choose the most frequently occurring types of ozone episodes reflecting a variety of wind directions;
- Choose episodes with observed 1-hour (or 8-hour) average ozone within 10 ppb of the applicable design value;
- Choose episodes with robust data sets of precursor and upper air measurements; and,
- Choose episodes with enough high ozone days at each monitor to satisfy the multi-day attainment test.

In addition a number of secondary selection criteria should be considered:

- Give preference to previously modeled episodes;
- Give preference to episodes from the current 3-year design value window;
- Include weekends among the selected days, if relevant; and,
- Give preference to episodes that are applicable to other 1-hour and 8-hour non-attainment areas.

The conceptual model for DFW considered these criteria in the selection of candidate modeling episodes.

Previous Air Quality Modeling

The TCEQ has previously developed and modeled two ozone episodes for the Dallas/Fort Worth non-attainment area. These consisted of the June 18-22, 1995 and June 30 – July 4, 1996 episodes and were used for attainment demonstrations of the 1-hour ozone standard. It is desirable to develop a single episode that would be applicable to both the 1-hour and 8-hour.

In addition, candidate episode(s) should satisfy the current 3-year design value window criteria listed above.

The 1995 and 1996 episodes previously modeled both occurred during the June/July secondary seasonal peak ozone period. The meteorological regime represented the most frequent transport direction, flow from the south. The draft conceptual model also considered candidate episodes which represent characteristics from missing time periods and/or transport directions. Thus the model considered episodes from the missing August/September seasonal peak ozone period and those representing transport from the east and/or southeast. However, some selected episode must represent transport from the primary direction.

Episode Selection Procedures

The selection and evaluation of candidate modeling episodes should be based on EPA guidance and also should consider the applicability and consistency with other non-attainment areas within the region. The draft conceptual model evaluated several possibilities from 1998 and 1999, as well as some possible 2000/2001 episodes. The goal was to select possibly a single episode that could be utilized for both the 1-hour and 8-hour attainment demonstration applied for several areas.

For the current analysis, all 1-hour and 8-hour exceedance days in the DFW nonattainmnet area from 1997 through 2002 were first identified from data obtained from the TCEQ. Back trajectory plots developed using the HySplit model were analyzed for each exceedance day to identify days associated with the primary transport directions. Preference was given to exceedance days and episodes that occurred during the primary and secondary ozone seasons. While the current focus is on selection of 8-hour ozone modeling episodes, consideration was also given to periods that experienced 1-hour ozone exceedances. In addition, in accordance with EPA guidance, exceedance days occurring within the current 3-year design value period were given preference. Based on these criteria, a number of preliminary episodes were identified for further analysis. The preliminary episodes identified are as follows:

- August 25-27, 1997
- July 14-18, 1998
- September 1-5, 1998
- August 4-7, 1999
- August 16-21, 1999
- August 31 – September 5, 2000

Each of these preliminary episode periods was further evaluated with respect to EPA episode selection criteria. Note that a third episode in 1999 was also identified (September 16-20, 1999) and has been previously analyzed by the TCEQ but was not considered further here since no 1-hour exceedances were measured during this time period.

Transport directions associated with the 1997 episode were determined to be from the south. The episode occurred during the primary ozone season and exhibited both 1-hour and 8-hour exceedances in DFW. Maximum 1-hour and 8-hour ozone concentrations during the episode ranged from 127 ppb to 133 ppb and 86 ppb to 113 ppb, respectively. While these features make this episode attractive for a number of reasons, the episode was eliminated from further consideration since it s outside the current 3-year design value window recommended by the EPA.

The July 1998 episode also exhibited multiple days with both 1-hour and 8-hour exceedances in DFW. Long-range transport was not, however, from the primary direction. The episode also occurred during the secondary ozone season and is also just outside the current design value 3-year window. In addition, meteorological data availability is rather poor for this time period. Therefore this episode was eliminated form further consideration. The September 1998 episode also exhibited a number of 1-hour and 8-hour exceedances in the region. However, long-range transport is mainly from the west and east and therefore this episode was also eliminated from further consideration.

Three periods in 1999 were identified as potential candidates for statewide 1-hour and 8-hour episodes -- August 4-7, August 16-21, and September 16-20, 1999. As with the 1998 episodes considered, these episodes included several 8-hour exceedances in many areas of Texas. While the September 16-20, 1999 episode exhibited 8-hour exceedances in most non-attainment areas in Texas, the transport directions were from the northeast. As mentioned previous, this episode also did not exhibit any 1-hour ozone exceedances in DFW during this time. Therefore this episode did not satisfy the requirement for transport from the primary direction, although it may be useful if more episodes were to be added to the attainment demonstration modeling efforts.

The August 4-7, 1999 period shows numerous exceedances of both the 1-hour and 8-hour ozone standards. Long-range transport is primarily from the east, northeast and southeast. Surface winds in the DFW area during this period are generally moderate and out of the east and north-northwest in the mornings and moderate winds from the northeast and south-southeast in the afternoon. Meteorological data availability is adequate although a number of complex weather systems and thunderstorms were present in the area during this time period that makes meteorological modeling difficult.

Figure 5-1 displays back trajectories ending in the DFW area during the August 2-7, 1999 episode. During the first couple days of the episode, long-range transport is primarily from the east and northeast. During the last days of the episode, transport is from the southeast, including potential transport from the Houston/Galveston area. This episode represents flow from previously un-modeled transport directions, and therefore would be attractive for modeling purposes if multiple episodes were to be considered. However, the remaining episodes identified were considered more appropriate for both the 1-hour and 8-hour attainment demonstration modeling for the DFW region.

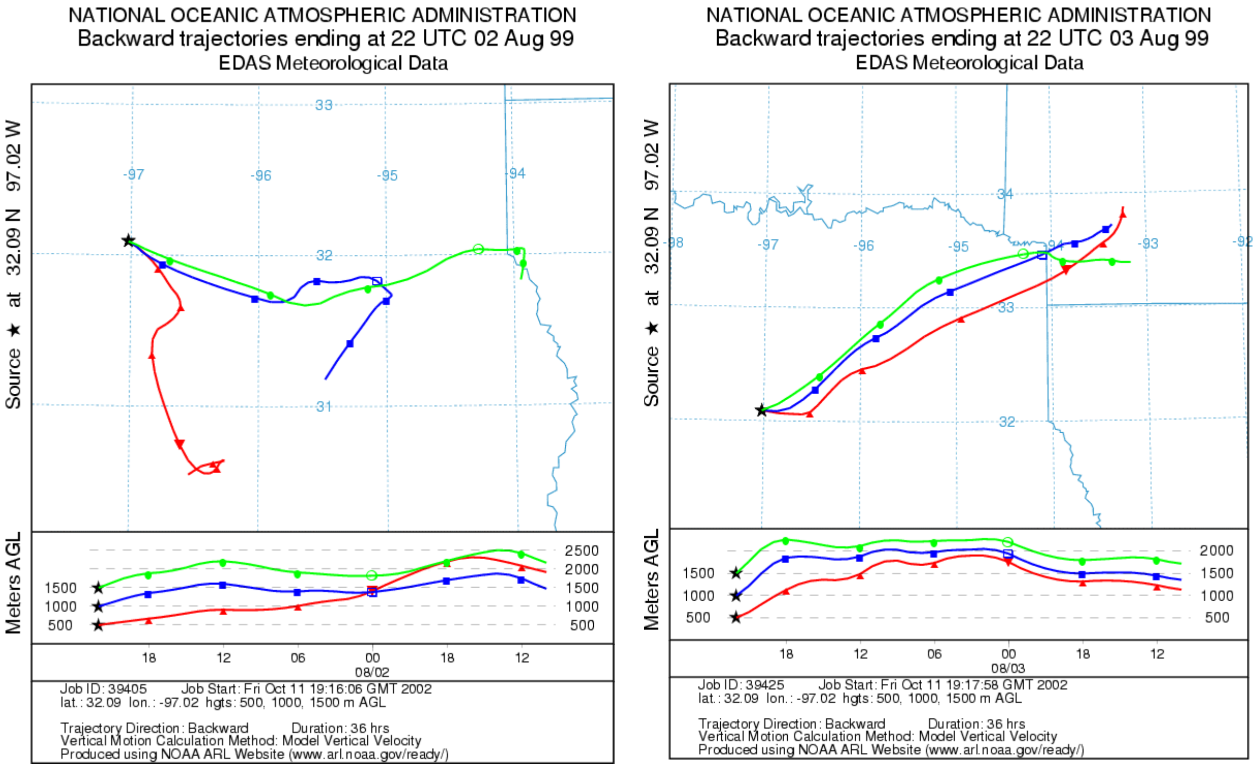


Figure 5-1. DFW back trajectories for August 2-7, 1999.

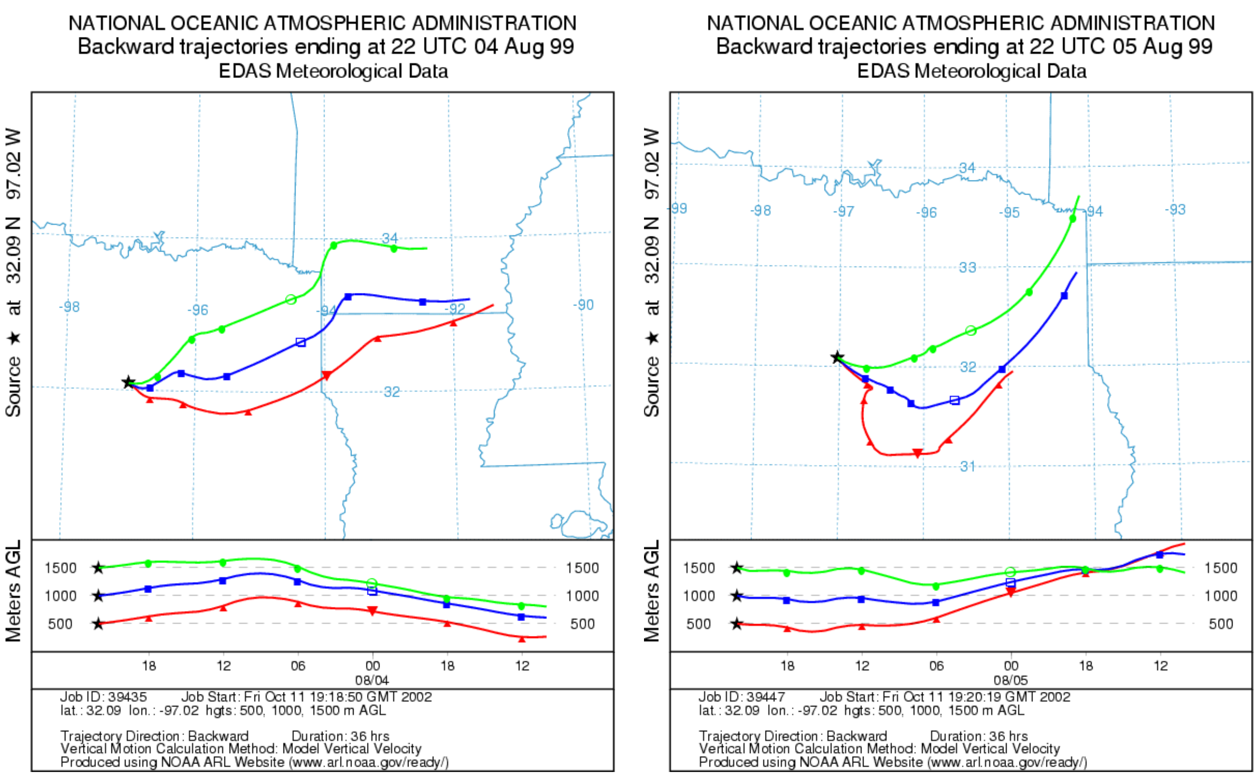


Figure 5-1. (Continued). DFW back trajectories for August 2-7, 1999.

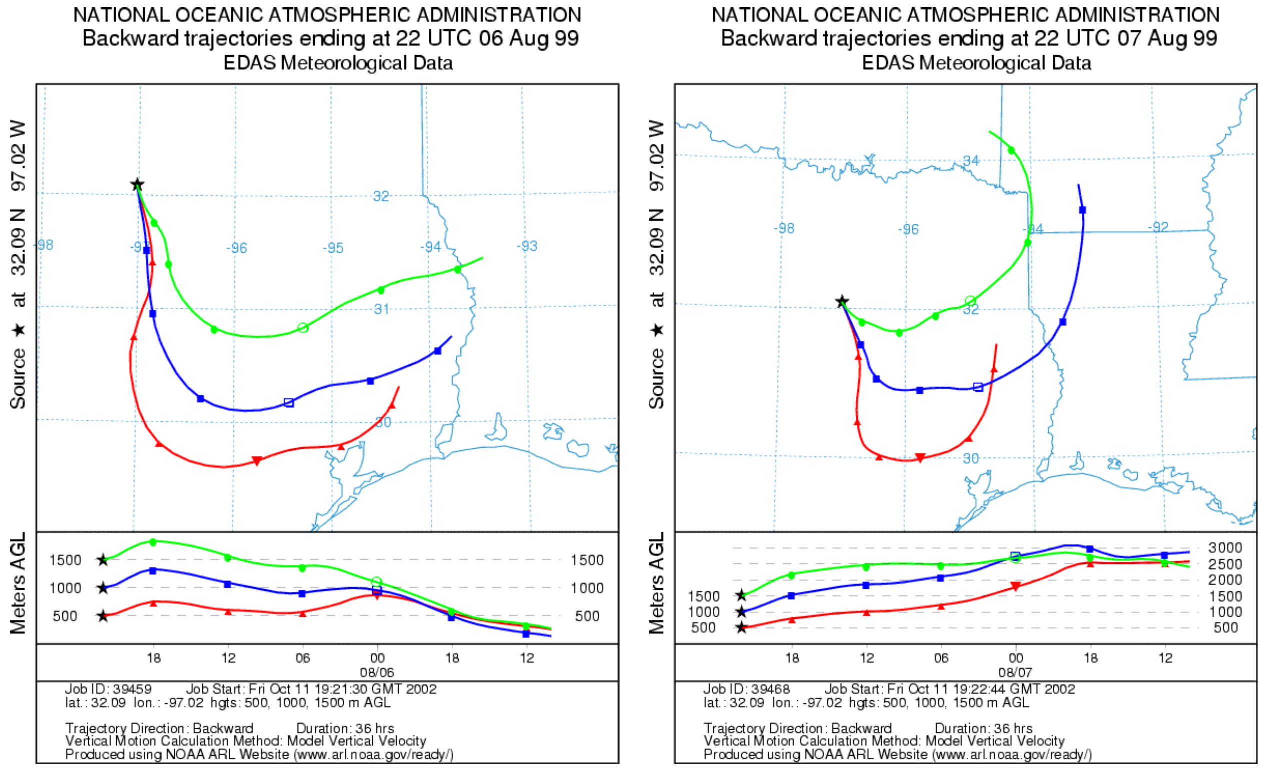


Figure 5-1. (Concluded). DFW back trajectories for August 2-7, 1999.

The remaining 1999 episode considered (August 16-21) was attractive for a number of reasons. The episode occurred during the primary ozone season and represents long-range transport from east/northeast, and transport from southeast. The episode had multiple 1-hour exceedances in the DFW area (some days higher than the design value), as well as some exceedances in the Tyler/Longview area. Finally, the episode occurs during the most current 3-year design value period and is supported by robust meteorological data.

Figure 5-2 displays the DFW back trajectories for the August 14-23, 1999 period. Long-range transport is seen to be from the north, northeast and southeast. This period is also conducive to ozone formation. Based on analyses of NWS weather maps, meteorology associated with this episode can be characterized as follows. Strong high pressure aloft and temperatures close to 100F on most days were recorded. Aloft, pressure was strongest during August 15-18, when the Dallas Ft Worth region was enclosed in a 5940m 500mb height contour with 10-20kt winds. At the surface, a positively tilted 1023mb high was centered over the Great Lakes on August 15. To its east and south, a cold front stretched from eastern Maine to eastern Texas. As this high drifted eastward the next couple of days, a weak low followed, but stayed well to the north of Texas. Pressure gradients were very weak over Texas during the first four days. Winds were calm to 5kts in the morning and southerly or easterly at 5-10kts in the afternoon.

On August 19, 500mb heights fell below 5940m, but stayed above 5880m through August 31. A 1011mb surface low was observed over southern Illinois on this morning with the associated cold front crossing the Dallas region around midday. Afternoon thunderstorms were detected near Dallas on that afternoon.

Behind this front, weak high pressure settled over the Great Lakes from August 20-22. Near Dallas, winds were north northeasterly following the frontal passage and then southeasterly late on August 21 and all day August 22. On August 22, Hurricane Bret made landfall near the southern tip of Texas. Clouds spread over Dallas on August 22 and 23, but precipitation was confined to its south and west.

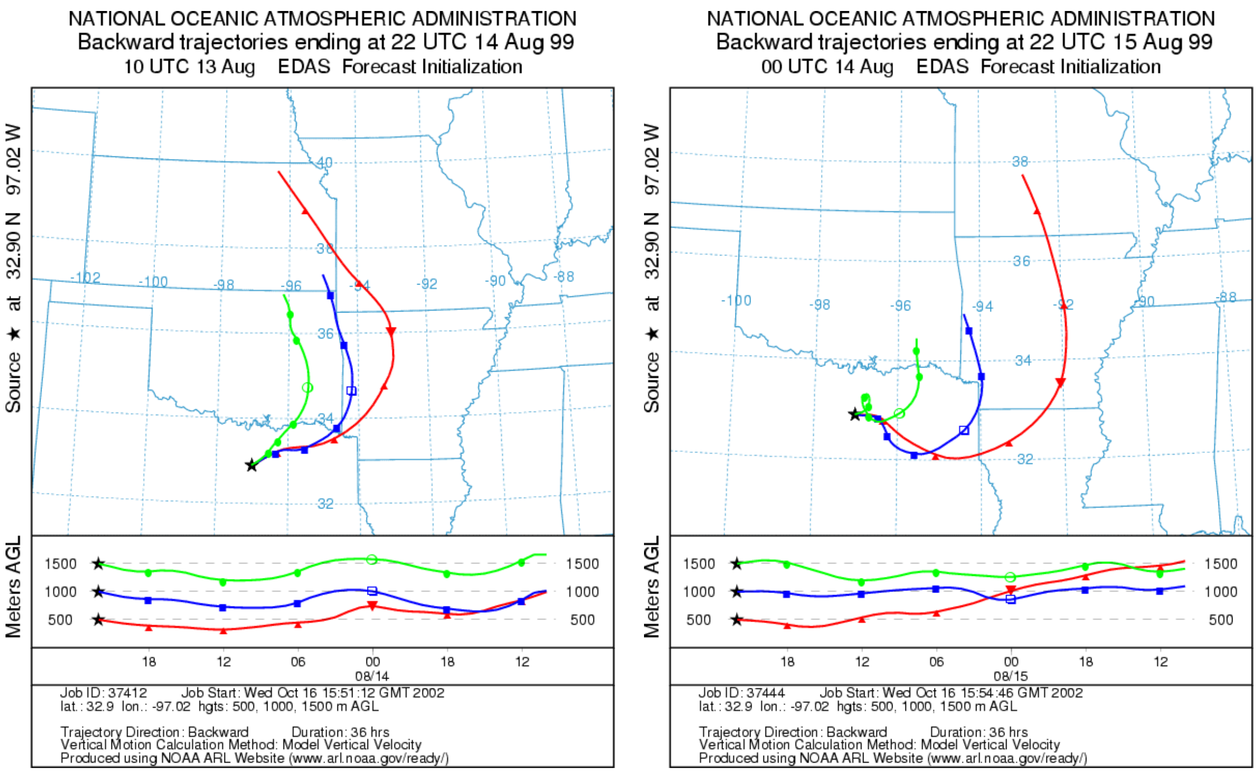


Figure 5-2. DFW back trajectories for August 14-23, 1999.

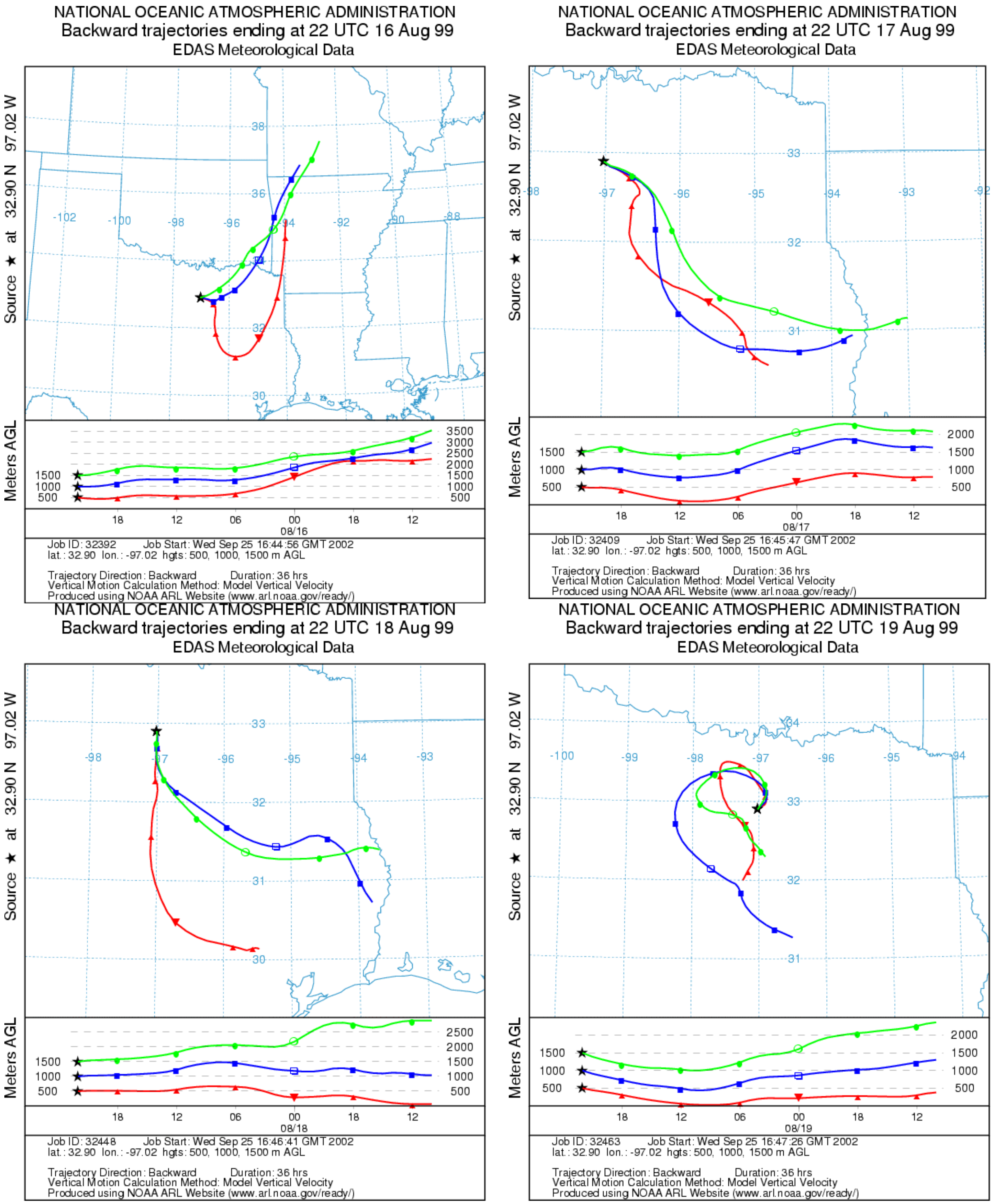


Figure 5-2. (Continued). DFW back trajectories for August 14-23, 1999.

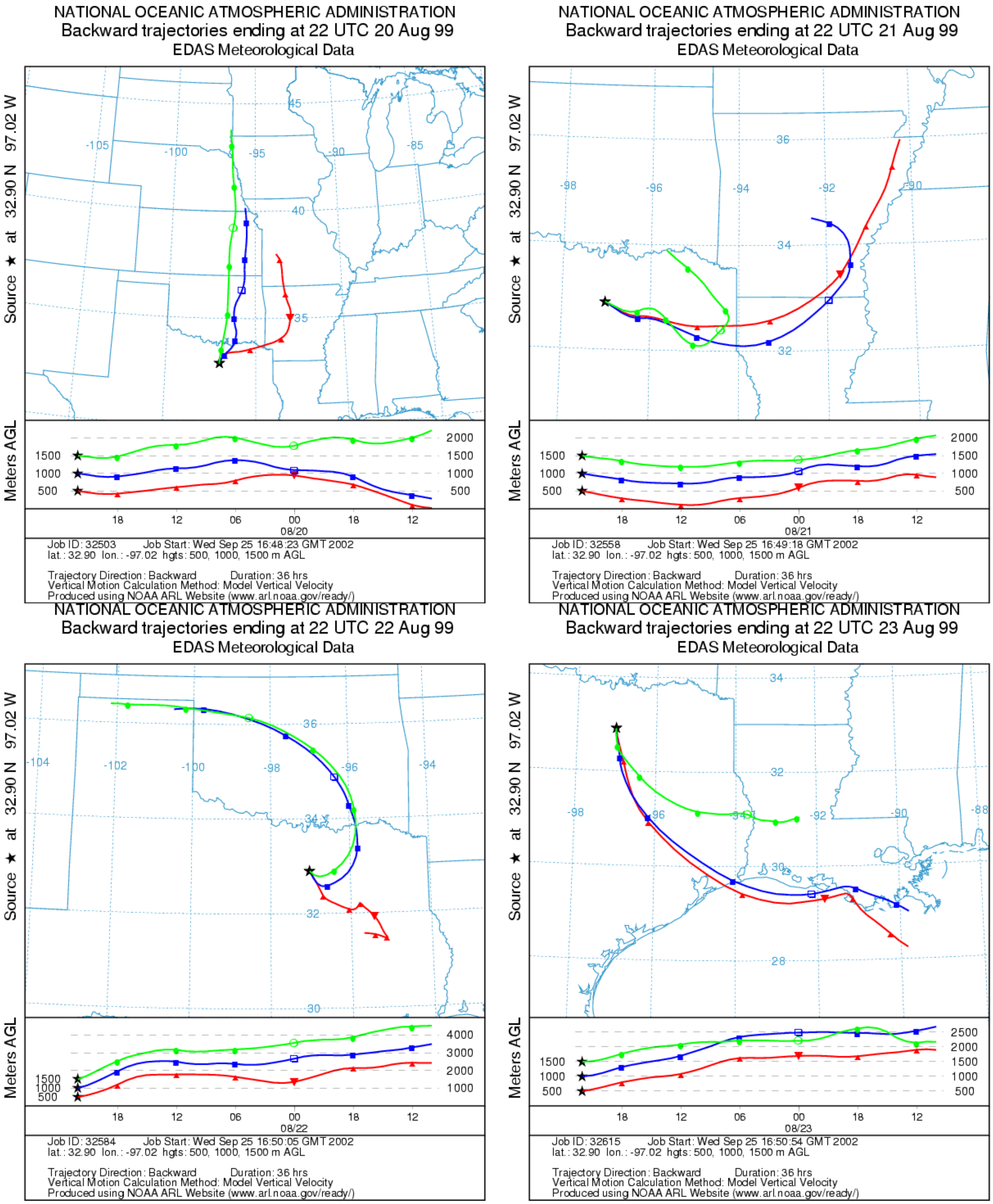


Figure 5-2. (Concluded). DFW back trajectories for August 14-23,1999.

An analysis of local DFW surface winds and average monitored ozone concentrations in the area indicates that this episode is characteristic of typical conditions associated with elevated ozone concentrations. Figure 5-3 displays the average morning and afternoon surface wind speeds and ozone concentrations during the period August 13-22, 1999. Examination of Figure 5-3 reveals the relationship between surface wind speed and 1-hour and 8-hour ozone concentrations. During the period August 16-19, 1999, wind speeds are seen to be very low and corresponds to the peak 1-hour and 8-hour ozone concentrations. During the beginning and end of the episode, surface wind speeds are considerably higher, with correspondingly lower ozone concentrations. Time series of 1-hour ozone concentrations at monitor in the DFW area are displayed in Figure 5-4. One-hour exceedances were measured at several monitors on a number of days during the episode.

Finally, this episode is currently being used for air quality modeling for the 8-hour ozone standard in East Texas. ENVIRON is currently modeling the Tyler/Longview/Marshall area for the East Texas Council of Governments. The MM5 meteorological model has been applied for this time period with high resolution nested grids over both East Texas and the Dallas/Fort Worth areas. Thus, DFW may be able to take advantage of previous air quality and meteorological modeling completed to data, including any issues and/or problems encountered.

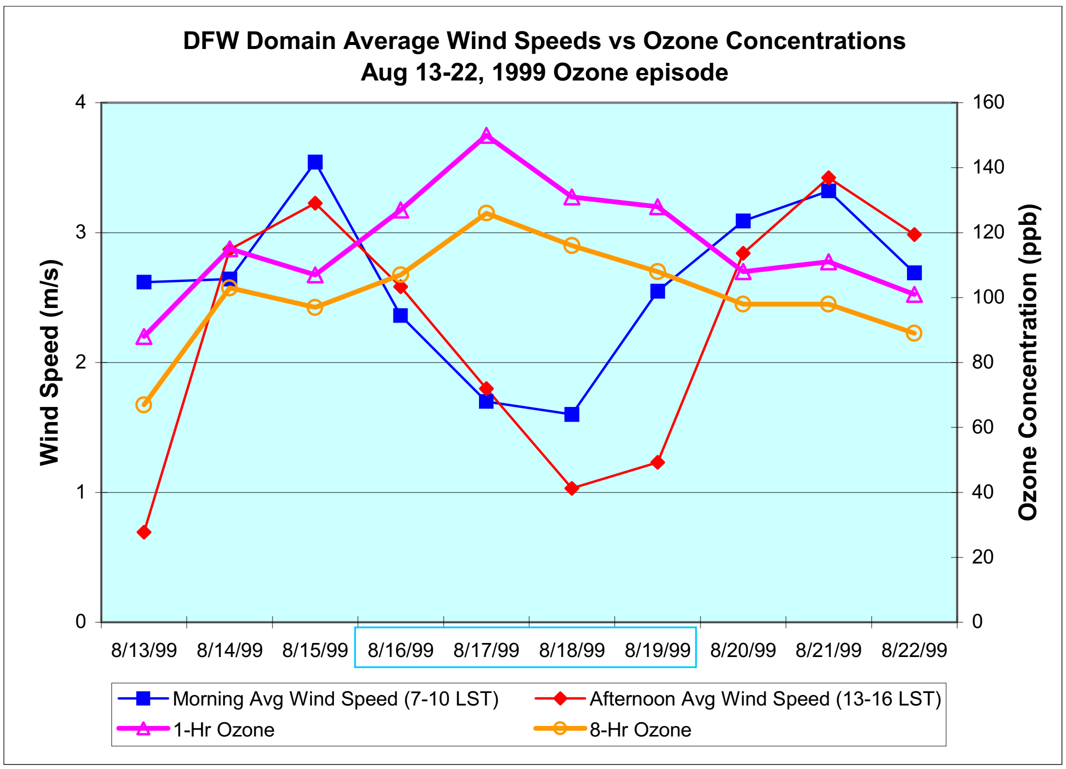
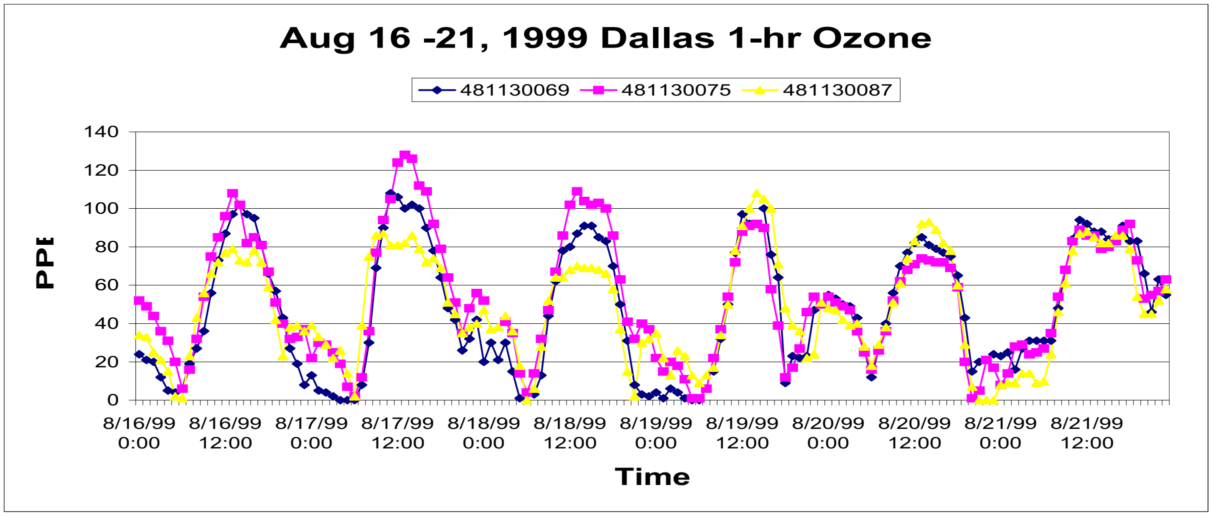
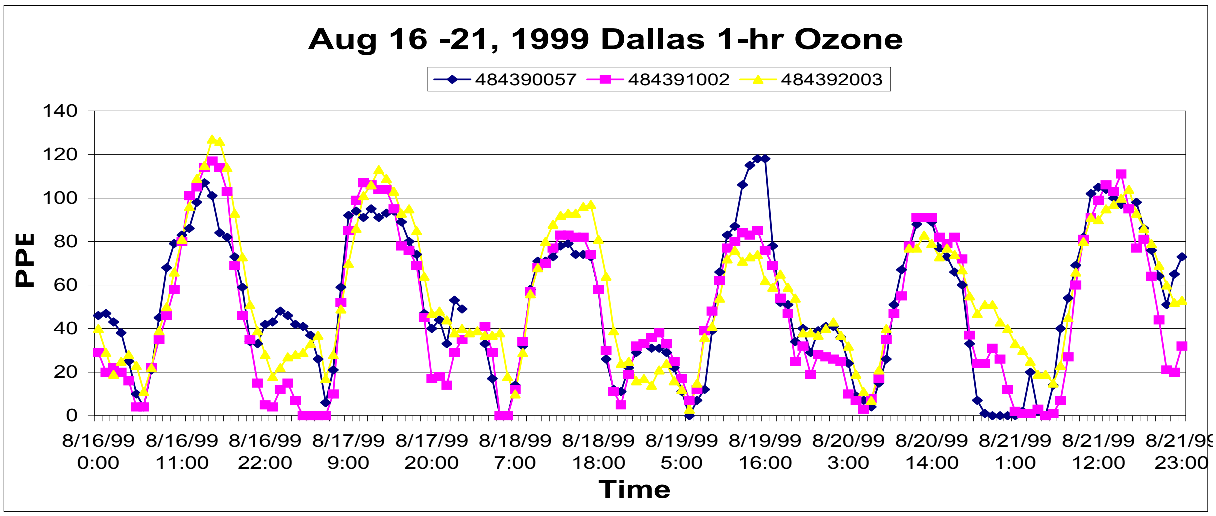


Figure 5-3. DFW domain average wind speeds and ozone concentrations (TCEQ).





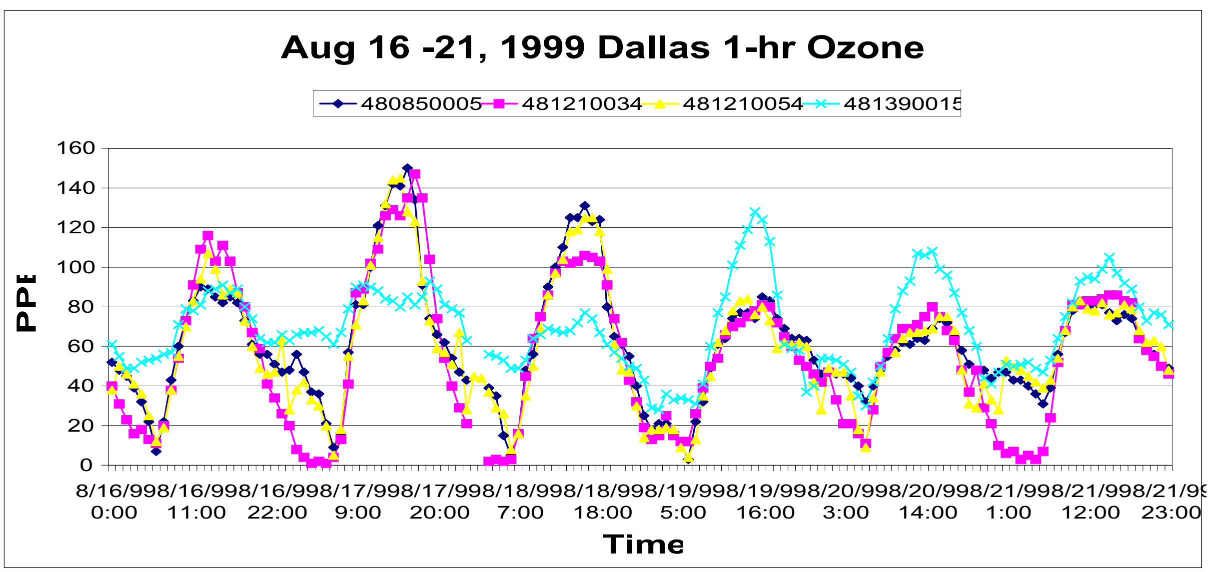


Figure 5-4. Time series of 1-hour ozone concentrations in DFW for August 16-21, 1999.

The final episode evaluated for potential modeling is the August 31-September 5, 2000. This period exhibit multiple 8-hour ozone exceedances in the DFW region, as well as a number of 1-hour exceedances. In addition, both 1-hour and 8-hour exceedances were recorded in the Beaumont/Port Arthur nonattainmnet area during this time period. The episode occurs during the primary ozone season and falls within the current 3-year design value window.

Figure 5-5 displays DFW back trajectories for August 31-September 5, 2000. Long-range transport is primarily form the south, southeast and northeast and thus represents transport from the primary direction and includes potential transport form the Houston and Beaumont regions.

Based on analysis of NWS weather maps, winds were light in Dallas with high temperature readings in the region. During this episode, a 1030+ mb high pressure system was found over central Canada. A cold front was located to its east and south, but did not reach Texas until September 5. Prior to this frontal passage, pressure gradients over Texas were very weak. In eastern Texas, wind speeds were 5kts or less in the mornings and 5-10kts in the afternoons. Local surface troughs were observed over eastern Texas on most afternoons. From August 31 to September 3, overcast skies or afternoon showers were detected near Dallas. Skies were mostly clear in the mornings except September 1, when skies were mostly cloudy. High temperatures were reported over much of Texas during this episode. Temperatures exceeded 100F on all days near Dallas. Four of these dates exceeded 105F.

Aloft, a trough was over the west and ridging was found in the central and eastern US. Winds were around 10kts during the first few days. From September 3 to 5, the ridgeaxis was over western Texas and wind speeds increased to over 30kts with a northerly flow over Dallas and northeasterly flow over Beaumont.

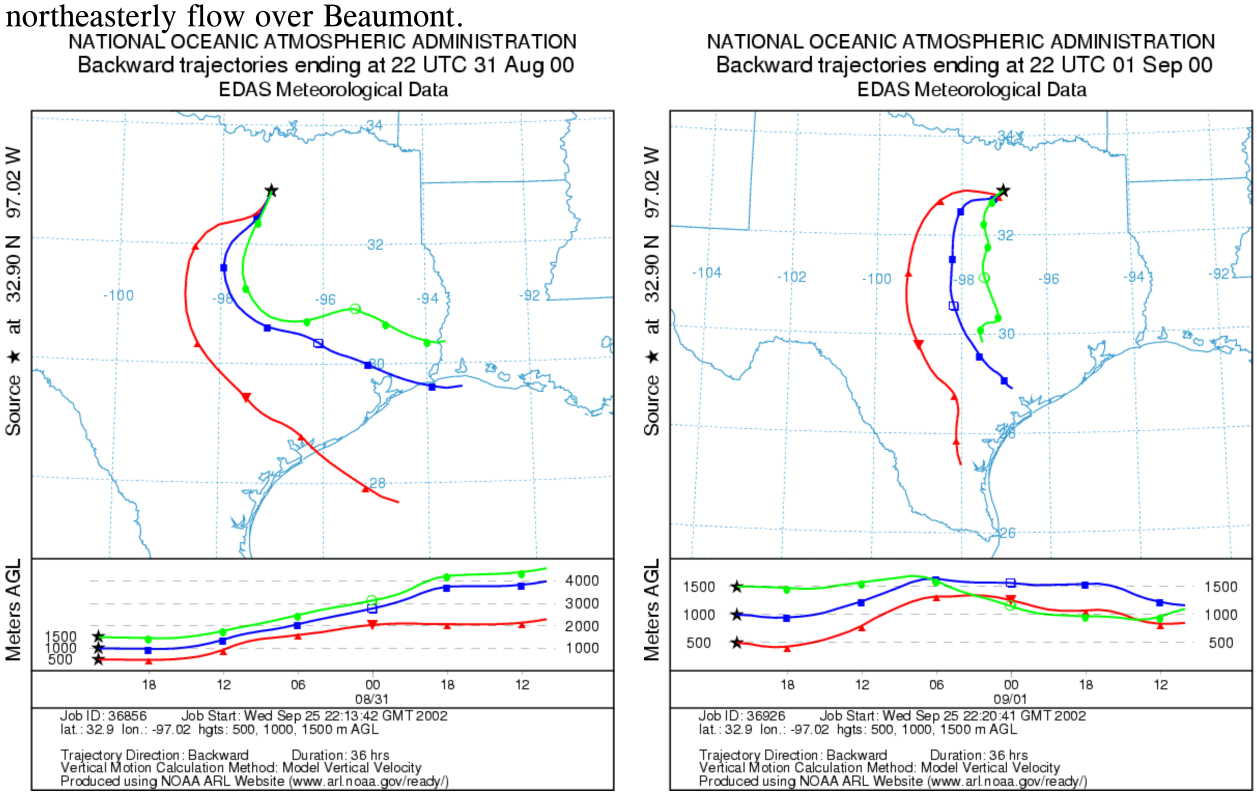


Figure 5-5. DFW back trajectories for August 31-September 5, 2000.

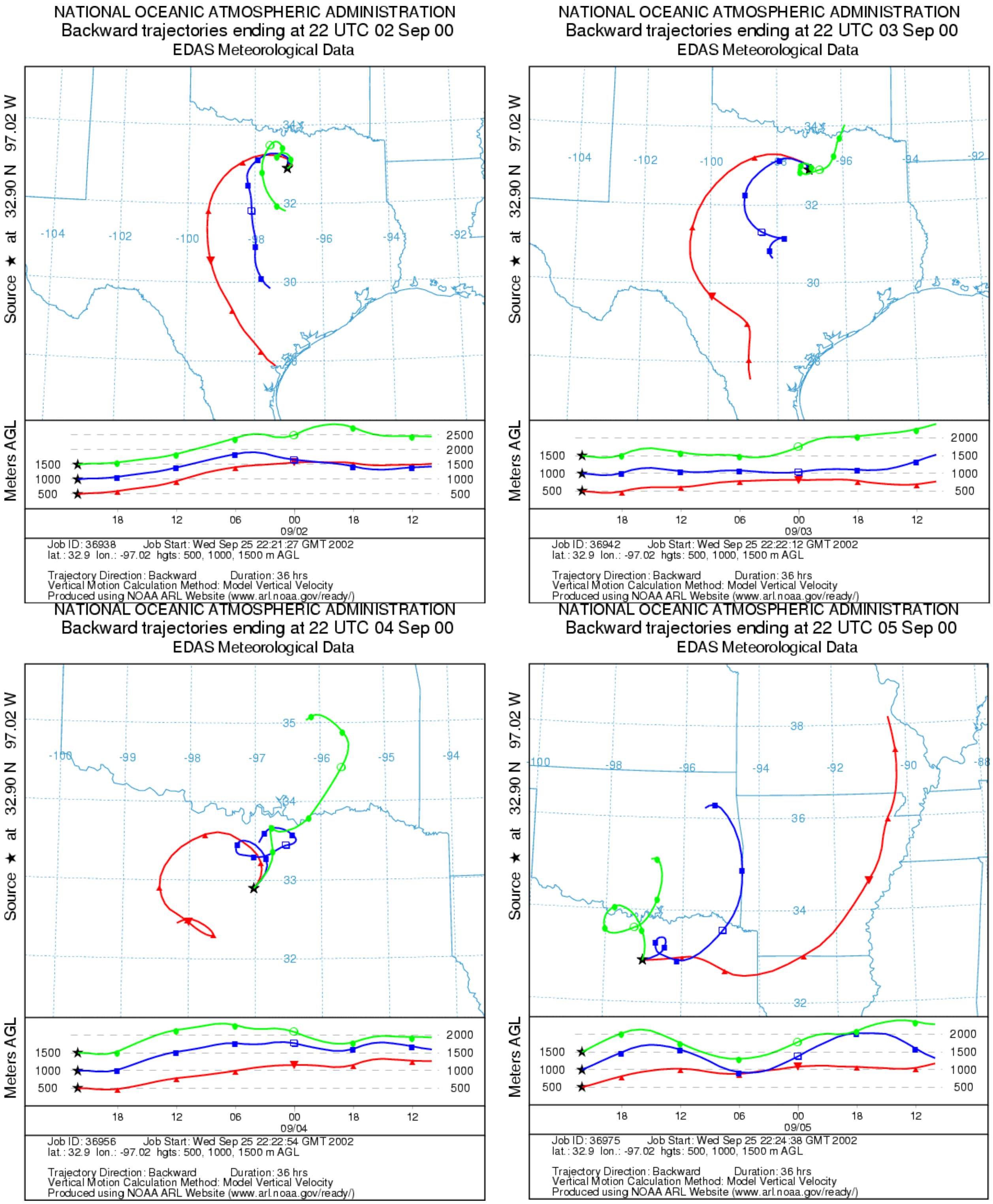
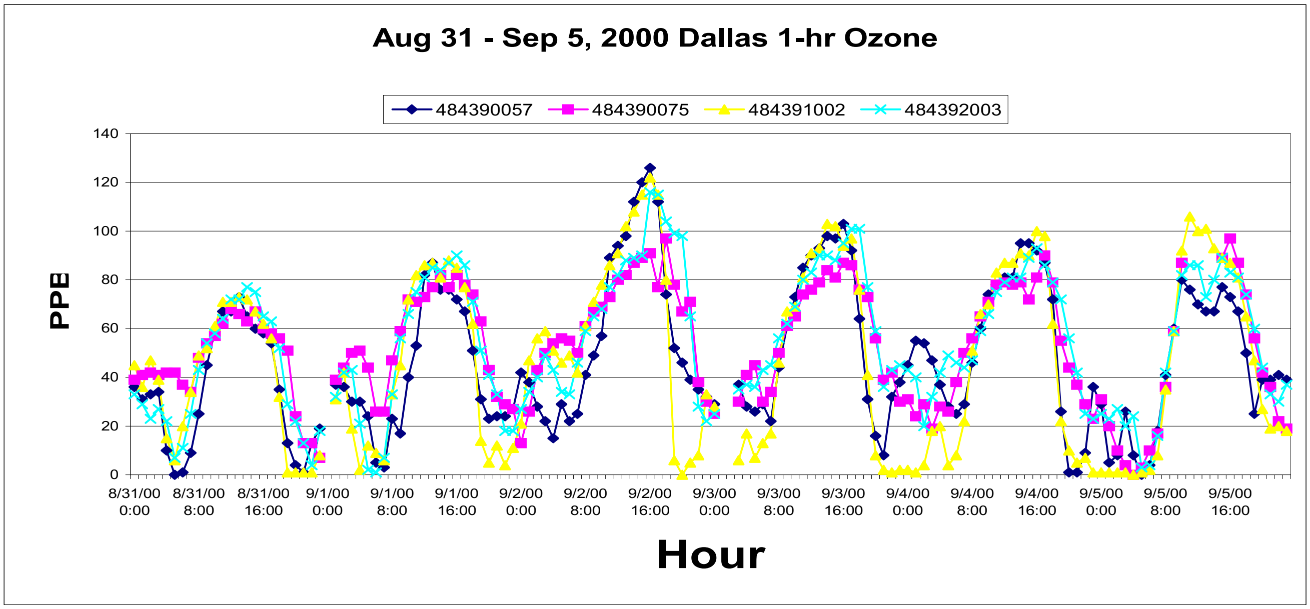


Figure 5-5. (Concluded). DFW back trajectories on August 31-September 5, 2000.

Figure 5-6 displays time series of 1-hour ozone concentrations at DFW monitors for August 31-September 5, 2000. One-hour ozone exceedances are seen at several monitors on September 1-2, 2000, although the maximum 1-hour ozone levels are only slightly over the standard, and just barely within 10 ppb of the 1-hour ozone design value. Meteorological data available is adequate and robust observational databases exist for ozone and precursor pollutants. Therefore, while this episode exhibited several 8-hour ozone exceedances on all episode days, and may also be useful for attainment demonstration in the Beaumont/Port Arthur nonattainmnet area, the lack of 1-hour ozone exceedances makes the episode less appropriate than others evaluated for the purpose of addressing both the 1-hour and 8-hour NAAQS in Dallas/Fort Worth.



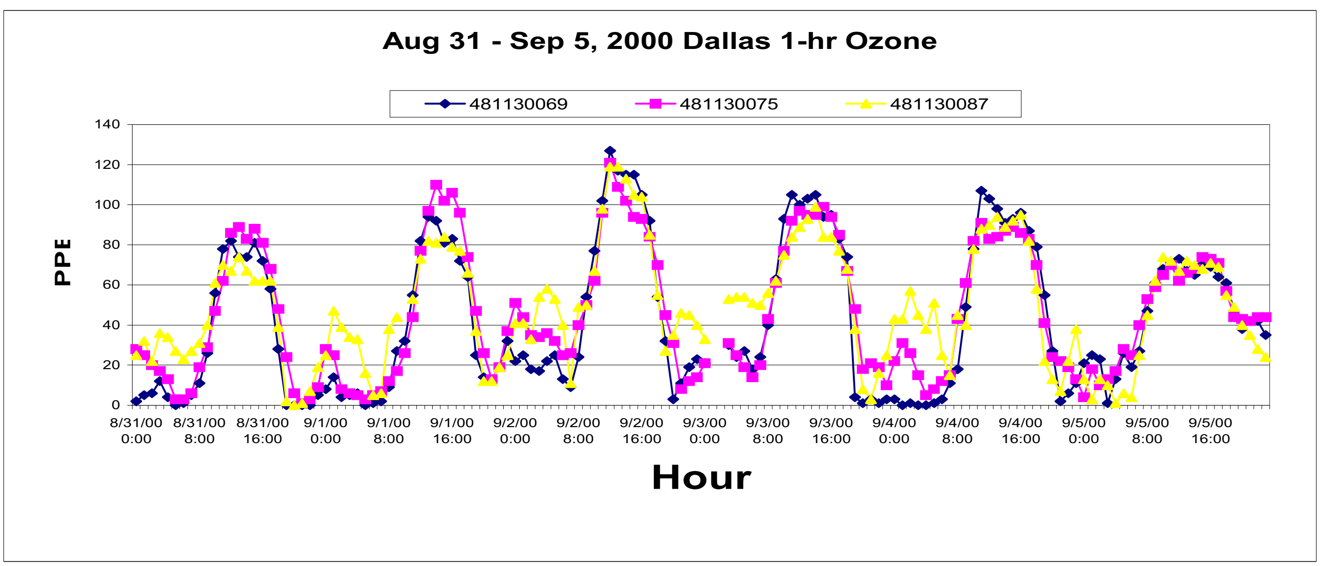


Figure 5-6. Time series of 1-hour ozone concentrations at DFW monitors for August 31-September 5, 2000.

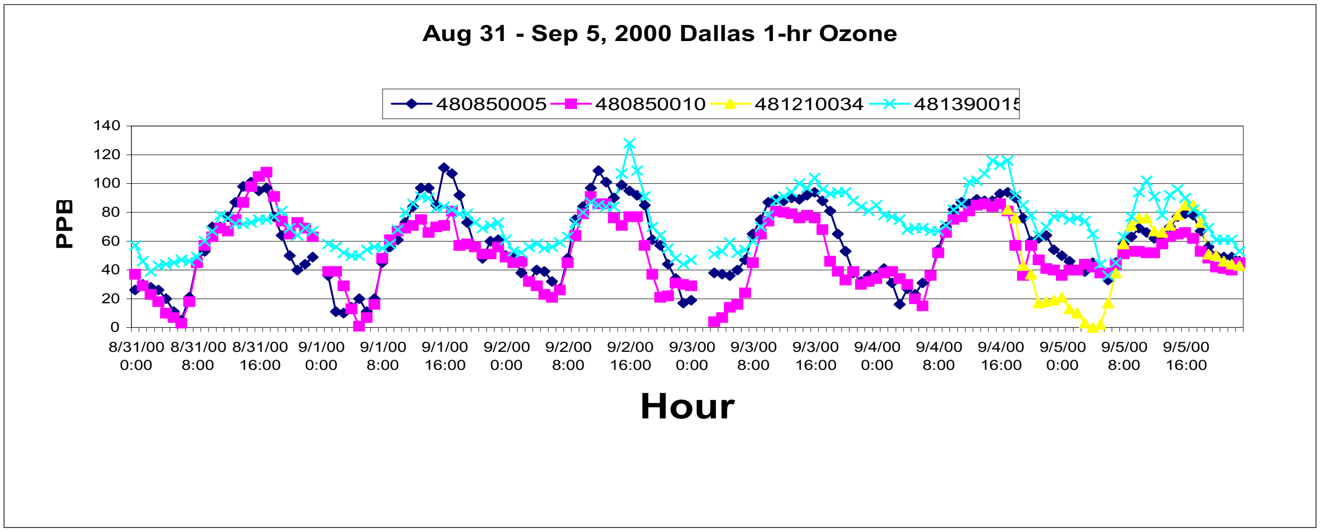


Figure 5-6. (Concluded). Time series of 1-hour ozone concentrations at DFW monitors for August 31-September 5, 2000.

Recommended Episodes

Based on the analyses conducted as part of the development of the conceptual model of ozone formation in the Dallas/Fort Worth nonattainment area, two candidate episodes are identified for the 1-hour and 8-hour ozone attainment demonstration air quality modeling in DFW. The candidate episodes are August 16-21, 1999 and August 4-7, 1999. The primary reasons for selection of these episodes are as follows:

- Both episodes occur during the seasonal peak ozone period of August/September;
- Both episodes represent previously un-modeled trajectory directions, transport from east southeast;
- Both have multiple 1-hour and 8-hour ozone exceedances in Dallas/Fort Worth;
- Both supported by robust meteorological data; and,
- Both occur during the last 3 years.

As it is desirable to replace the existing 1995 and 1996 episodes with a single modeling episode and the candidate episode must represent transport from the primary direction (i.e., flow from the South/Southeast), selection of a single episode makes the August 16-21, 1999 episode the primary candidate.

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