Revised Final

CONCEPTUAL MODEL OF OZONE FORMATION IN THE BEAUMONT/PORT ARTHUR 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 (EPA, 1999). From this conceptual model, States can more effectively select ozone episodes for photochemical modeling. The Texas Commission on Environmental Quality (TCEQ) has developed a draft conceptual model for the Beaumont/Port Arthur (BPA) ozone nonattainment area. The draft Beaumont/Port Arthur conceptual model and supporting data was reviewed for accuracy and consistency. The agency's Houston/Galveston area (HGA) conceptual model was also reviewed due to the close proximity and possible transport between Houston area the BPA area. The consistency between the Houston, Dallas/Fort Worth and BPA conceptual models and the EPA's draft guidance documents on attainment demonstration for the 8-hour ozone National Ambient Air Quality Standards (NAAQS), as well as the 1-hour standard, was evaluated.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 BPA conceptual model. This report presents a revised conceptual model for the BPA ozone nonattainment area 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 BPA 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 BPA 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 BPA 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 NAAQS. 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 (e.g., EPA, 1991; 1997; 1999; 2002). These guidance documents and the recommendations therein provide a basis for the selection of candidate episodes for the BPA nonattainmnet area.

Report Organization

The current review of the existing draft conceptual model of ozone formation in the Beaumont/Port Arthur non-attainment area is organized as follows:

- Section 2 of the report presents a summary of ozone air quality trends in the BPA 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 BPA area;
- Section 5 summarizes the episode selection process and presents candidate episodes for 1-hour and 8-hour modeling of the BPA non-attainment area; and
- Section 6 lists the references used in the development of the conceptual model.

ENVIRON

2. OZONE TRENDS

The development of the conceptual model for the Beaumont/Port Arthur (BPA) metropolitan region evaluated ozone trends for the years 1971 through 2001. The model looks at trends in ozone design values as well as ozone exceedances. EPA air quality trends are also examined for the period 1990 to 1999. Geographical patterns associated with elevated ozone levels are also considered, as are 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 BPA are made with those of other non-attainment regions, specifically the Houston/Galveston and Dallas/Fort Worth areas.

Ozone Levels and Design Value Trends

For site with complete data capture, the 1-hour design value is defined as the fourth highest monitored 1-hour 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 three-year average of the fourth highest annual monitored 8-hour ozone value at a specific monitor for the most recent three years of data. The design values provide an indication of the ozone air quality and are used to gauge an area’s progress towards meeting the NAAQS for ozone. As part of the development of a conceptual model for BPA, 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 BPA nonattainment area.

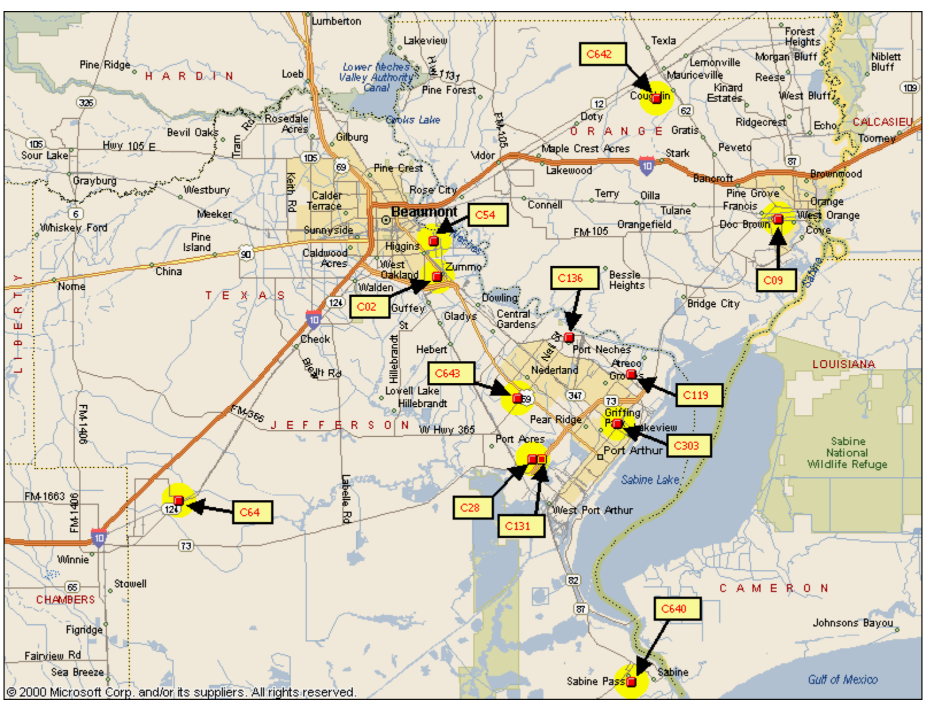

Figure 2-1. BPA region monitor locations.

Figure 2-2 displays the 1-hour ozone design value trend in the BPA non-attainment area over the last twenty-five years (1976-2001). Overall, a downward trend in the data can be seen for the period 1979 to the present year. A steady decline in the 1-hour ozone design value can be seen during the period 1978 to 1987 from approximately 210 ppb to 130 ppb. The design value increased in 1988 then declined gradually over the next six years to approximately 135 ppb in 1984. The following three years the design value increased again, to a value of 157, then declined to the present value of 134 ppb in 2001. The years in which the design value increased, 1988 and 1995, were high ozone years for many regions across the eastern U.S. characterized by unusually high temperatures (EPA, 2000).

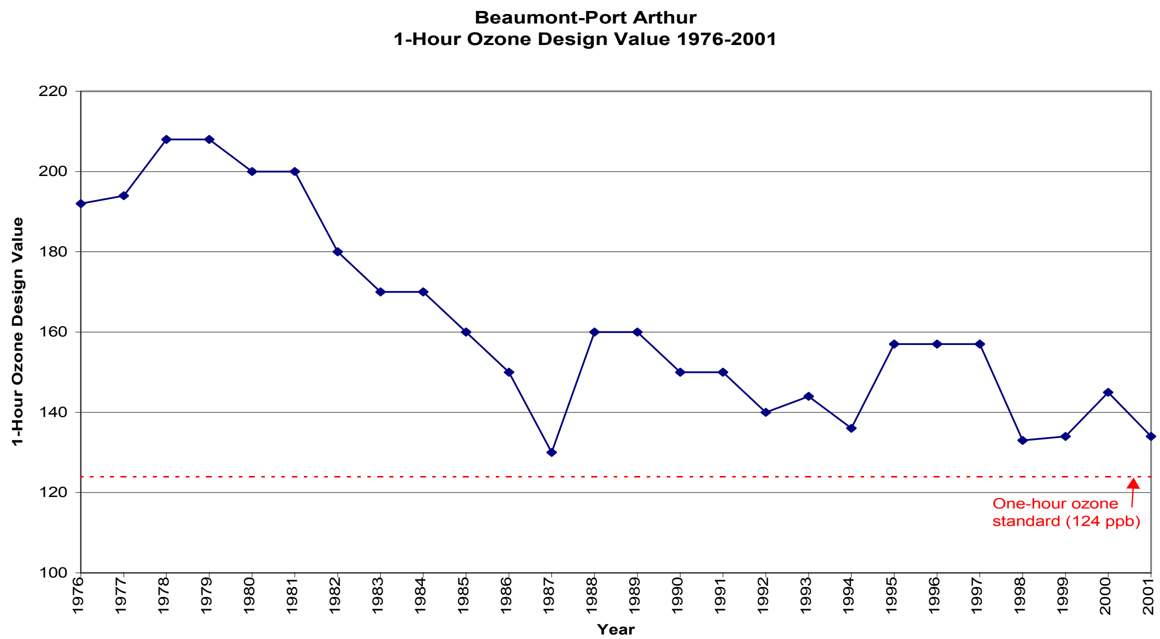

Figure 2-2. BPA 1-hour ozone design value trends for 1976-2001.

Examination of the design values for individual monitors reveals the effects on the overall trends of the introduction of new monitors through time (Figure 2-3). The BPA area 1-hour design value since 1995 is at the South East Texas Regional Planning Commission (SETRPC) monitor C640 to the south of Port Arthur near Sabine Pass, which came on-line in the early 1990's. Measurements from this monitor, as well as the new SETRPC monitor C643 at Jefferson Airport in Port Arthur contribute to sustaining the 1-hour ozone design value at approximately 134 ppb through 2001.

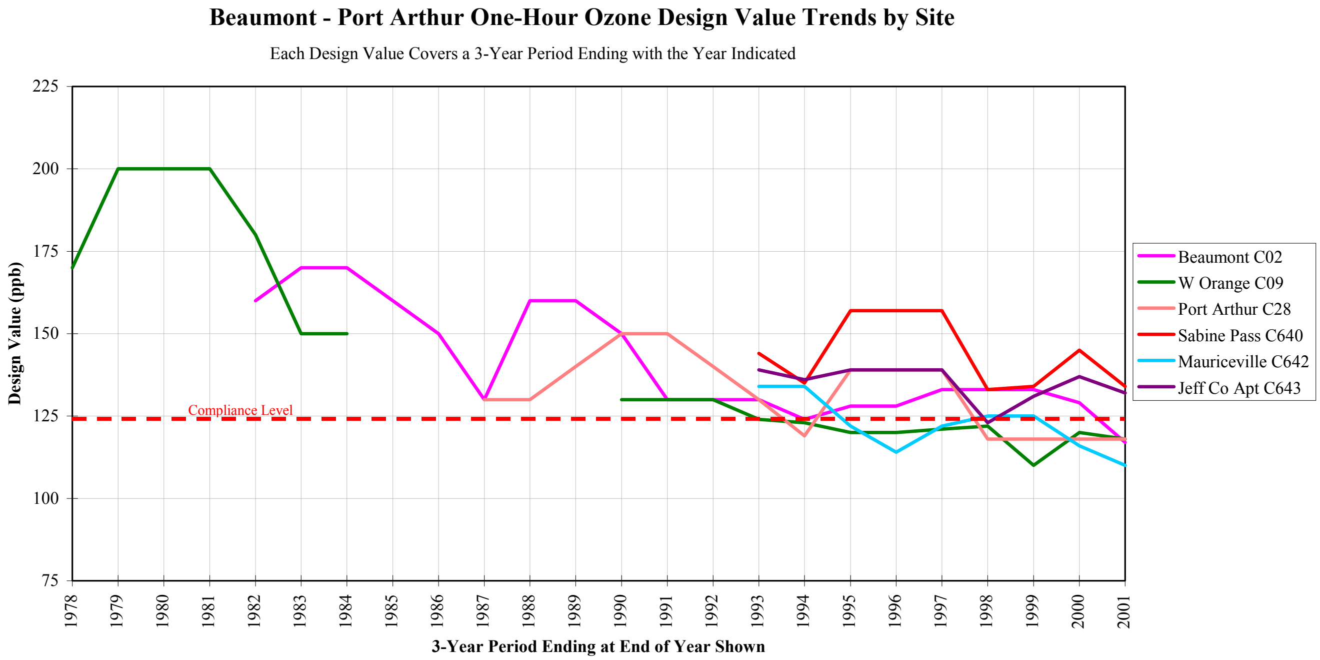

Figure 2-3. BPA 1-hour ozone design value trends by monitor for 1978-2001. (TCEQ)

The 8-hour ozone design value for BPA, displayed in Figure 2-4, likewise shows an overall downward trend during the period 1973 through 1987, when the value again increases to a value of 101 ppb in 1991. The 8-hour ozone design value then declines steadily to value of 85 ppb in 2001. Examination of the data presented in Figure 2-5, which displays the 8-hour design values for individual monitors over the period from 1978 through 2001, reveals the influence of new monitoring stations on the region-wide design values.

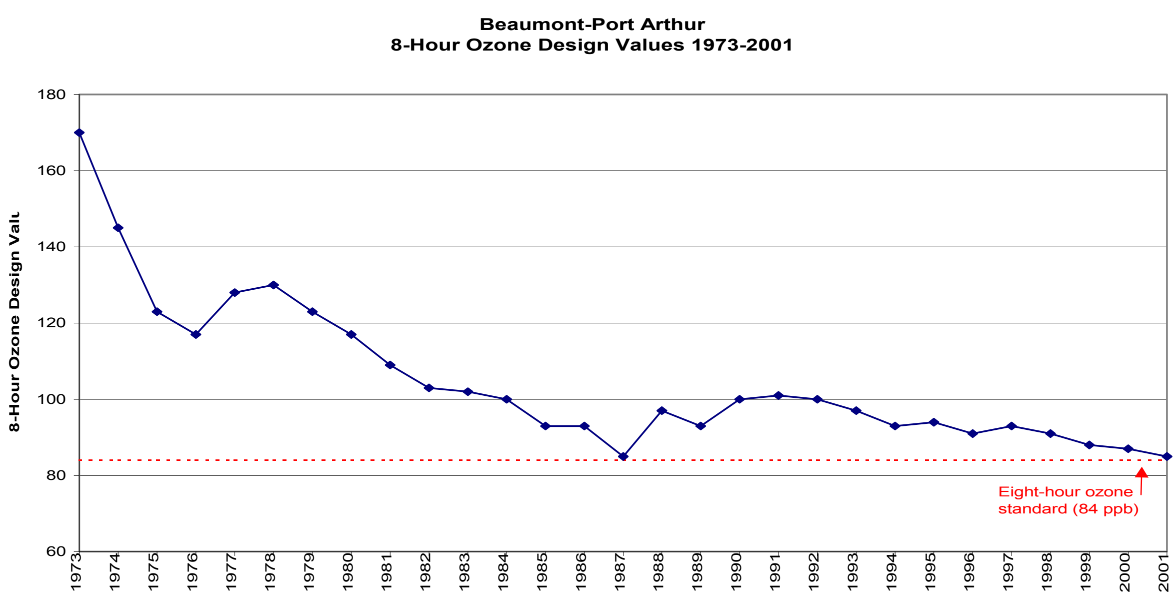

Figure 2-4. BPA 8-hour ozone design value trends for 1973-2001.

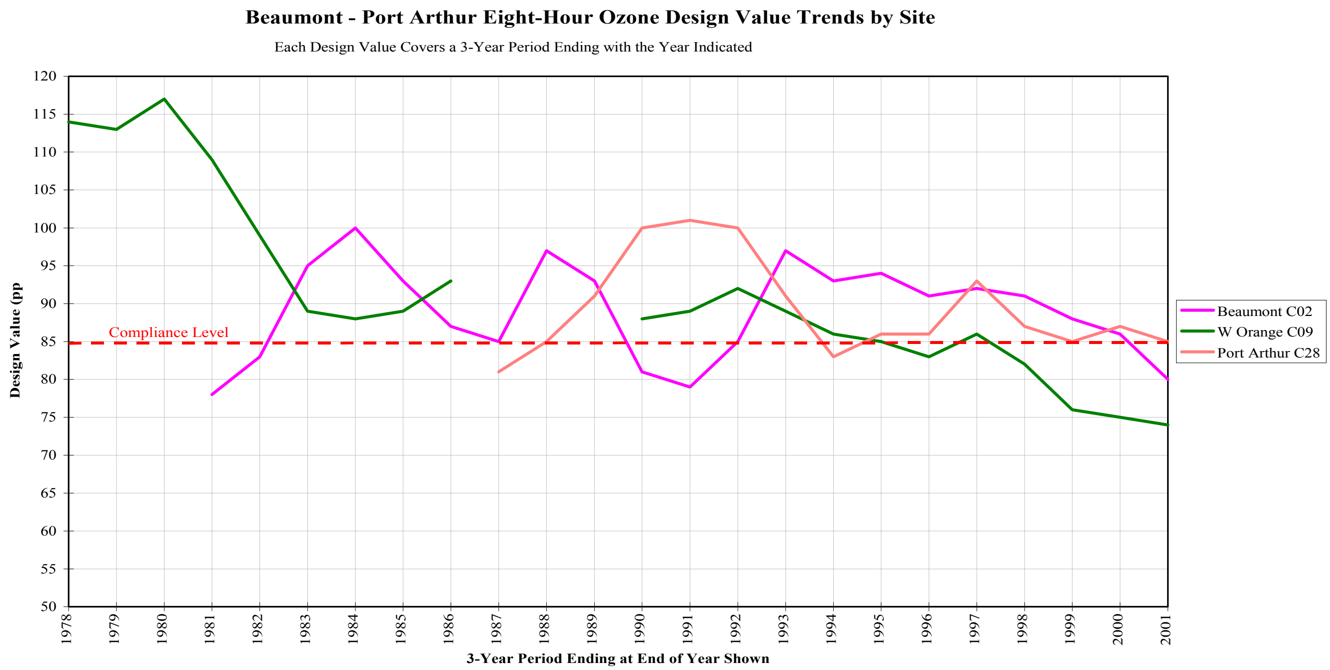

Figure 2-5. BPA 8-hour ozone design value trends by monitor for 1978-2001 (TCEQ).

A review of EPA's air quality trends analysis 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) throughout the country. Figure 2-6 displays the 1-hour design value trends for the Beaumont/Port Arthur MSA. The corresponding 8-hour design value trends for BPA are displayed in Figure 2-7. These design value trends 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 in each year. EPA selects trends sites that have a long-term data record which eliminates some of the newer sites in the BPA area. While not as dramatic, the overall downward trend in the EPA data is similar to the trend displayed in the TCEQ data.

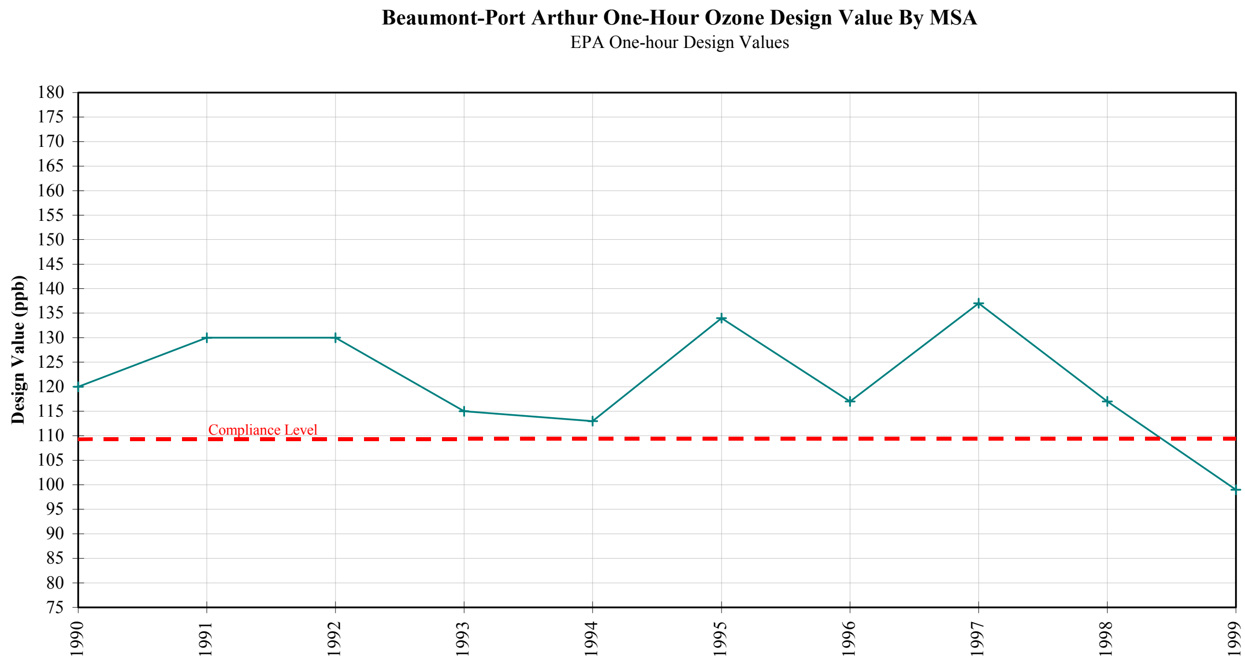

Figure 2-6. EPA 1-hour ozone design value trends for Beaumont/Port Arthur MSA for 1990-1999.

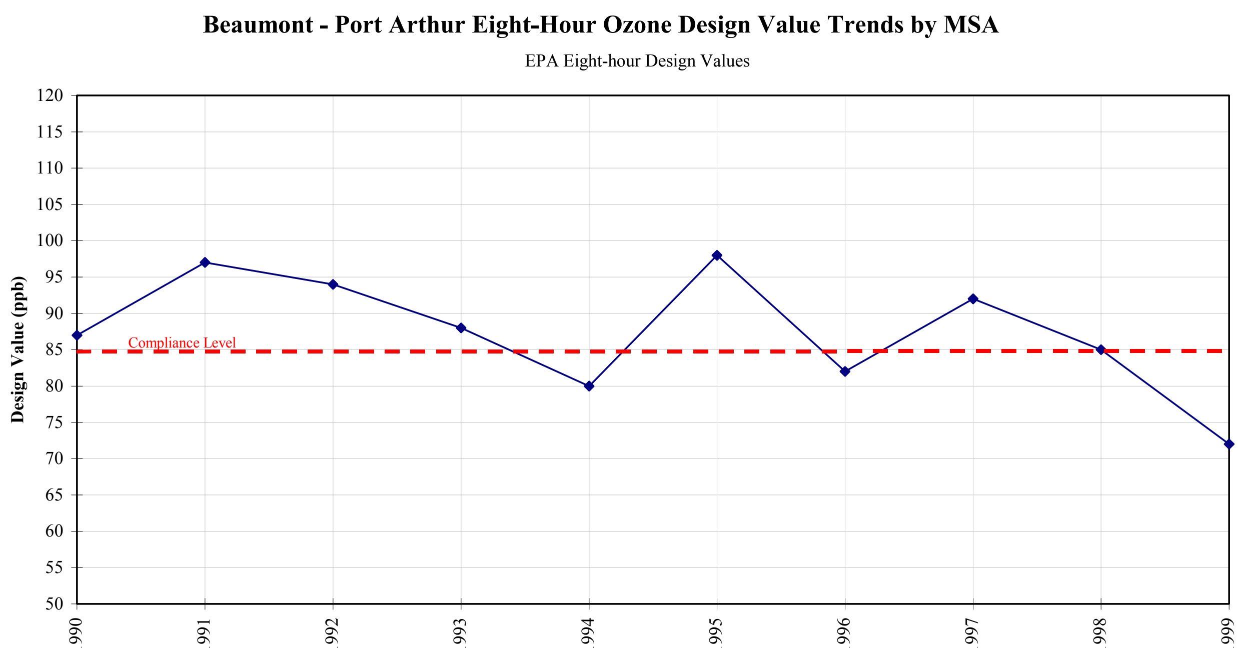

Figure 2-7. EPA 8-hour ozone design value trends for Beaumont/Port Arthur MSA for 1990-1999.

Figure 2-8 illustrates the spatial distribution of 1-hour ozone design values in the BPA region for 1999. This display was generated through interpolation of the 1-hour design values in the region. An analysis of the ozone design values with respect to geographical patterns of high ozone conducted on data from 1999 in the BPA area indicates the highest 1-hour design values are seen to surround the BPA urban areas and are concentrated to the west of BPA in Jefferson county. The maximum 1-hour design value is just south of Port Arthur at the SETRPC C640 monitor. High values are also present north of Beaumont. This spatial pattern of 1-hour design values may be due to the effects of the land/sea breeze flow reversals in the area. Pollutants built up in the urban areas during the morning hours lead to ozone formation in the region. Offshore morning winds transport the pollutants and ozone out over the Gulf of Mexico where more ozone is formed under favorable conditions, i.e., warm temperatures and plentiful sunshine. Afternoon and evening winds then reverse direction bring elevated ozone concentration back through the Port Arthur and Beaumont urban centers resulting in the high ozone levels seen to the north of the BPA area.

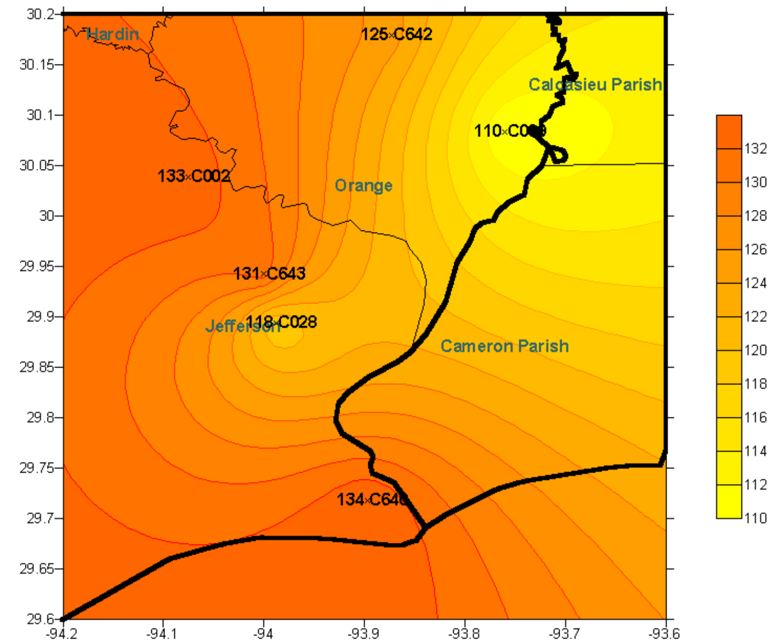

Figure 2-8. Spatial distribution of 1-hour ozone design values in BPA for 1999.

The spatial pattern or distribution of the 8-hour design values in the DFW region for 1999 is displayed in Figure 2-9. The highest 8-hour design values appear north and northwest of the BPA urban area.

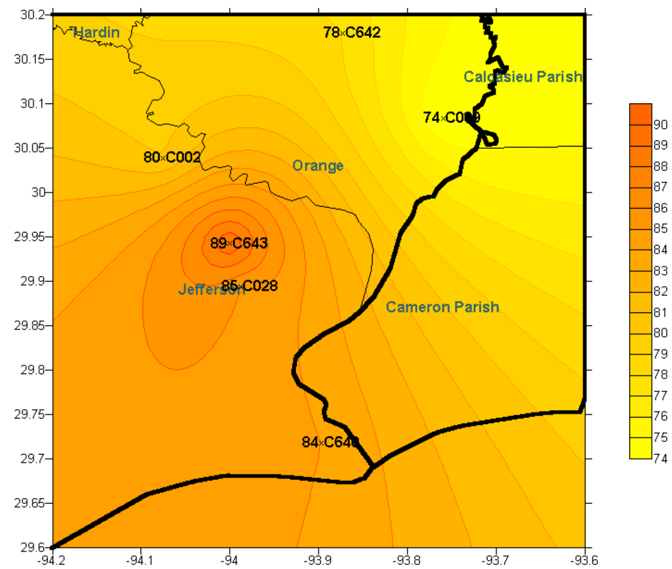

Figure 2-9. Spatial distribution of 8-hour ozone design values in BPA for 1999.

Ozone Exceedance Trends

Like many areas in Texas, the ozone season in the Beaumont/Port Arthur nonattainment area is typically eight months long, lasting from March through October with peak high ozone events occurring generally late August and September. Figure 2-10 displays the number of 1-hour ozone exceedance days in the BPA nonattainment area during this period shows an overall improvement with respect to the number of exceedance days per year between the late 1970's and early 1980's and the 1990's. 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 0 to 17 days per year in the 1990's. Prior to this period (1972-1989) exceedances ranged from zero (in 1985) to as high as 49 (in 1972). There is a general trend to fewer exceedances per decade from the 1970's to the 1990's.

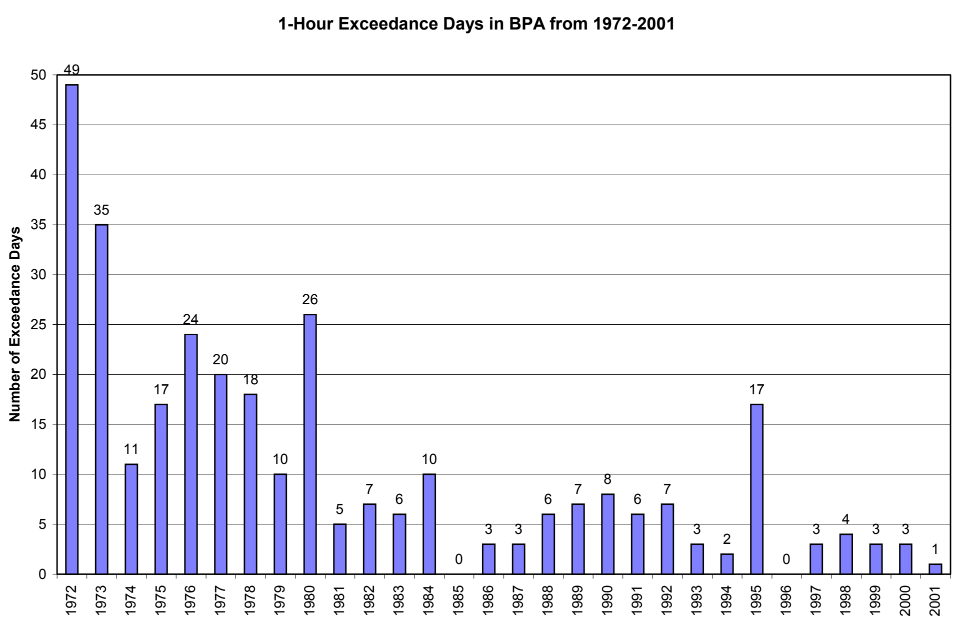

Figure 2-10. One-hour ozone exceedance days in BPA by year from 1972-2001.

The number of 8-hour ozone exceedance days in BPA are displayed in Figure 2-11. Data evaluated for 8-hour exceedances included only the years 1997 through 2002, and only the primary ozone season months (June-October). No clear trend can be seen in the data. Exceedance days range from 6 days per year in 2001 to 15 days per year in 2000.

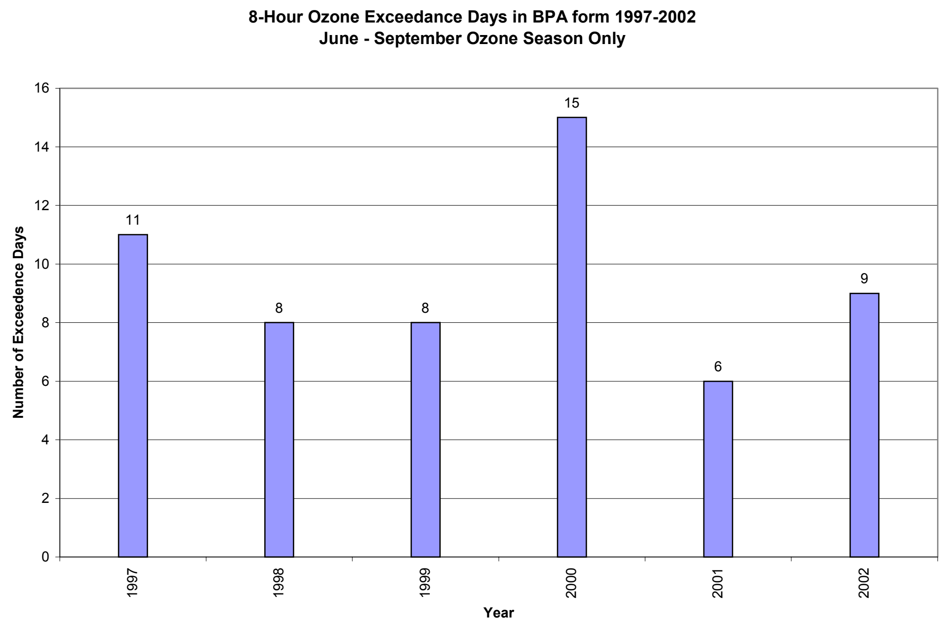

Figure 2-11. Eight-hour ozone exceedance days in BPA by year from 1997-2002 (ozone season only).

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 September. These statistics are based on evaluation of ozone monitor data from the years 1998 through 2002. Figure 2-12 presents these data for 1-hour ozone exceedances.

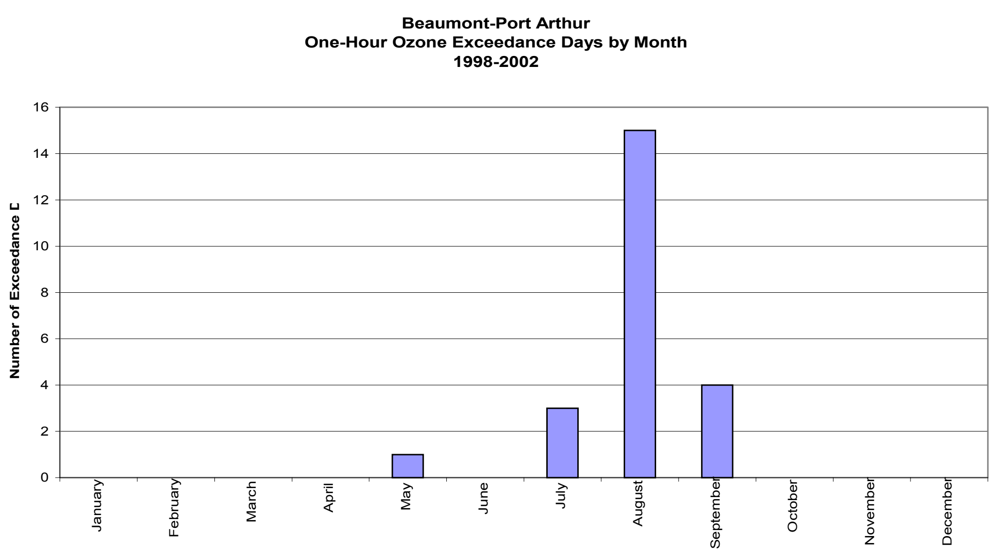

Figure 2-12. One-hour ozone exceedance days in BPA by month from 1998-2002.

Eight-hour ozone exceedance days by month of year are presented in Figure 2-13 for the years 1997 though 2002. As with the exceedance days by year, only the months of June through October were evaluated. As shown, the highest frequency of 8-hour ozone exceedances occur during the months of August and September.

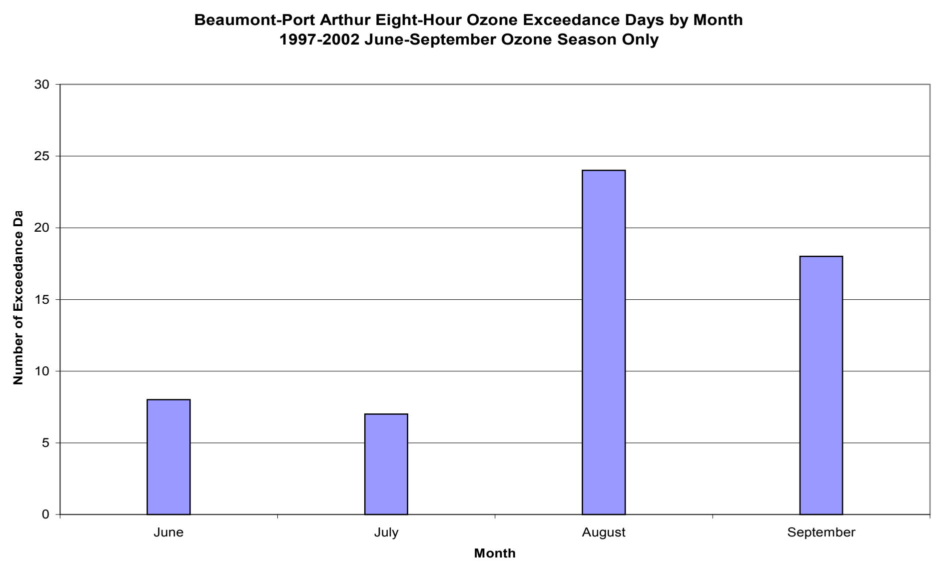

Figure 2-13. Eight-hour ozone exceedance days in BPA by month from 1997-2002 (ozone season only).

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. These results are presented as bar charts in Figure 2-14 and 2-15. 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 do not indicate any particular pattern, with exceedances occurring throughout the week. The lack of weekday/weekend difference in the number of exceedances is consistent with the emission inventory data, shown later, which show that industrial sources dominate the BPA emission inventory.

An earlier analysis of data from 1995 through 2000 conducted by the TCEQ (TCEQ, 2002b) indicated that Saturday exhibited the most frequent exceedances with considerably fewer on Sundays, possibly suggesting a mobile source dependence, although the analysis conducted for the current model development does not confirm this.

Examination of Figure 2-15, which displays the number of ozone exceedances by time of day, shows that ozone peaks most frequently at 1 p.m. local time while overall the most frequent time of ozone exceedances is between 12 noon and 3 p.m. local time.

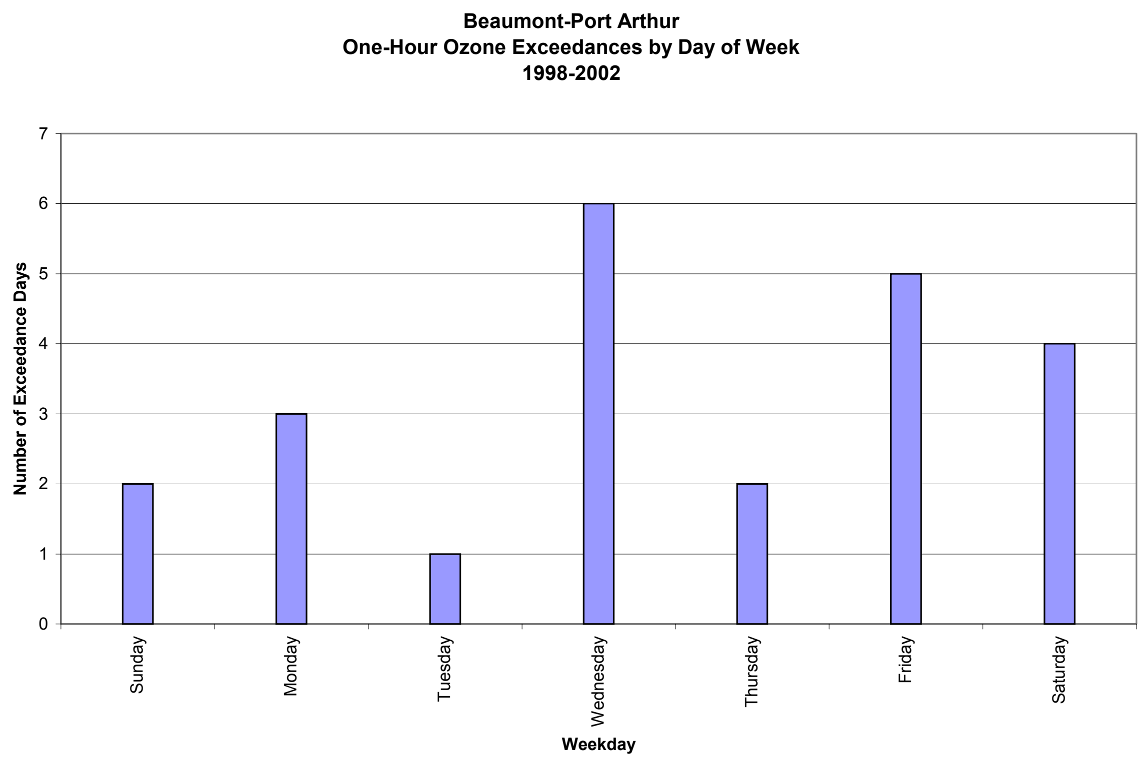

Figure 2-14. One-hour ozone exceedance days in BPA by day of week from 1998-2002.

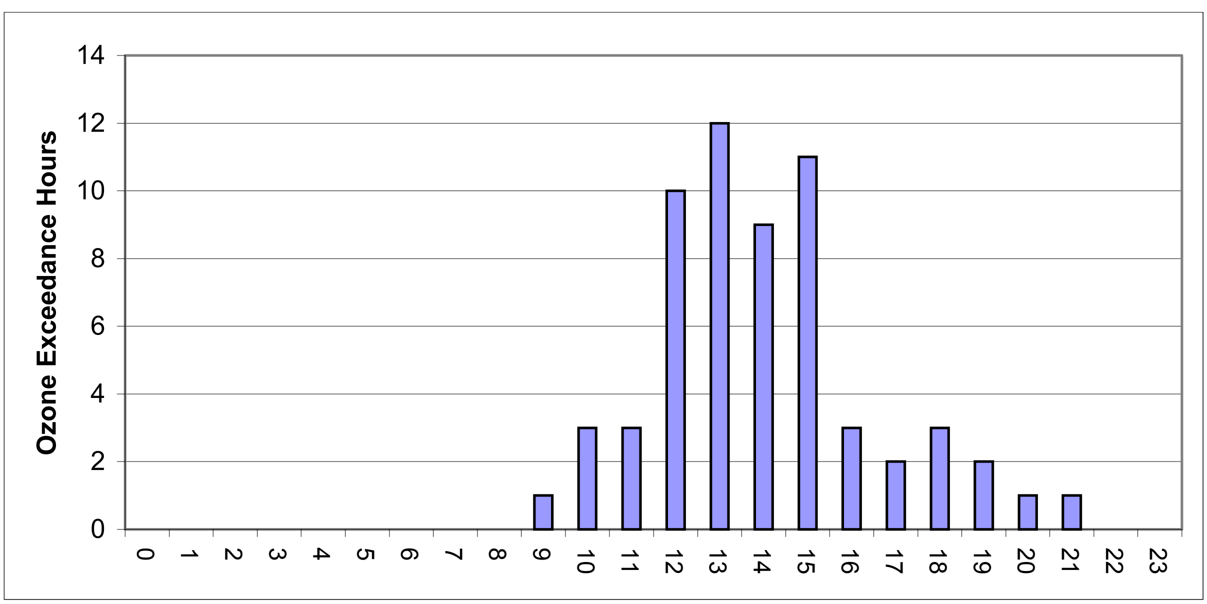

Figure 2-15. One-hour ozone exceedance days in BPA by hour of day from 1995-2000 (TCEQ).

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 potential 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 Beaumont/Port Arthur 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, off-road mobile and on-road mobile sources.

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

NOx and VOC emission trends were evaluated for the BPA metropolitan area. Trends data for 1990 through 2001 were developed by ENVIRON for area and mobile (onroad and off-road) source categories (ENVIRON, 2001). 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 1990 and the years 1992 through 2001. Emission estimates by county for the BPA and DFW 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 relative emissions trends by county and region for 1999.

Figures 3-1 and 3-2 display the total annual anthropogenic NOx and VOC emissions for the Beaumont/Port Arthur area for the years 1990 through 2001, respectively. Also shown for comparison are total anthropogenic NOx and VOC emissions for the Dallas/Fort Worth and Houston/Galveston nonattainment area. Total annual emissions of these pollutants across all source categories in the BPA region have decreased over the past decade from 115,061 tpy NOx and 43,990 tpy VOC to 30,646 tpy NOx and 22,305 tpy VOC. Based on TCEQ data, total NOx emissions in BPA decreased by approximately 2% from 1996 (81,624 tpy) to 1999 (79,923 tpy). During the same period, total VOC emissions decreased by approximately 24 % from 57,170 tpy in 1996 to 43,235 tpy in 1999, based on data presented by the TCEQ (TCEQ, 2002a). During this same period (1996 to 1999) the 1-hour ozone design value has decreased from 157 ppb to 134 ppb. The 8-hour design value decreased from 91 ppb to 88 ppb from 1996 to 1999.

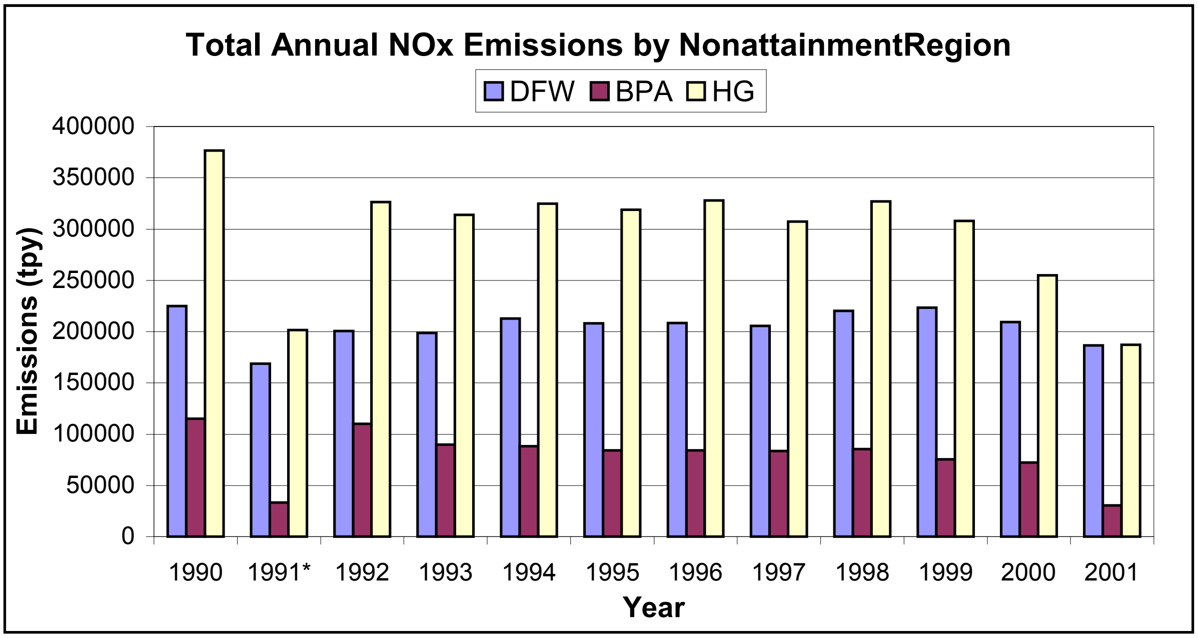

Figure 3-1. Total annual NOx emissions by nonattainment region from 1990-2001. * Point source data are missing for 1991.

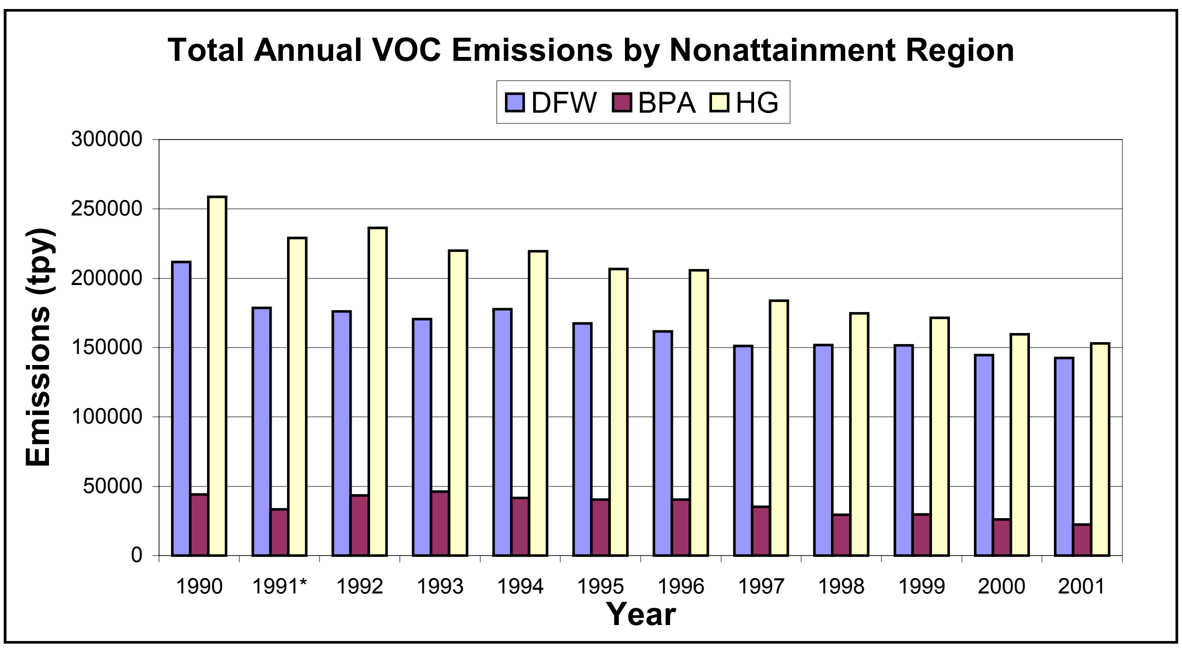

Figure 3-2. Total annual VOC emissions by nonattainment region from 1990-2001. * Point source data are missing for 1991.

Data for 1996 obtained from the TCEQ was 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 BPA area anthropogenic VOC emissions are dominated by point sources (57%). Likewise, anthropogenic NOx emissions are dominated by point sources (65%) while area source NOx emissions are only a minor contributor (1%) to the total annual NOx emissions in the region.

Emissions of both NOx and VOC are dominated by point sources in both the BPA and HGA areas, reflecting the numerous industrial sources in the region. 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 less important role in DFW than in HGA and BPA.

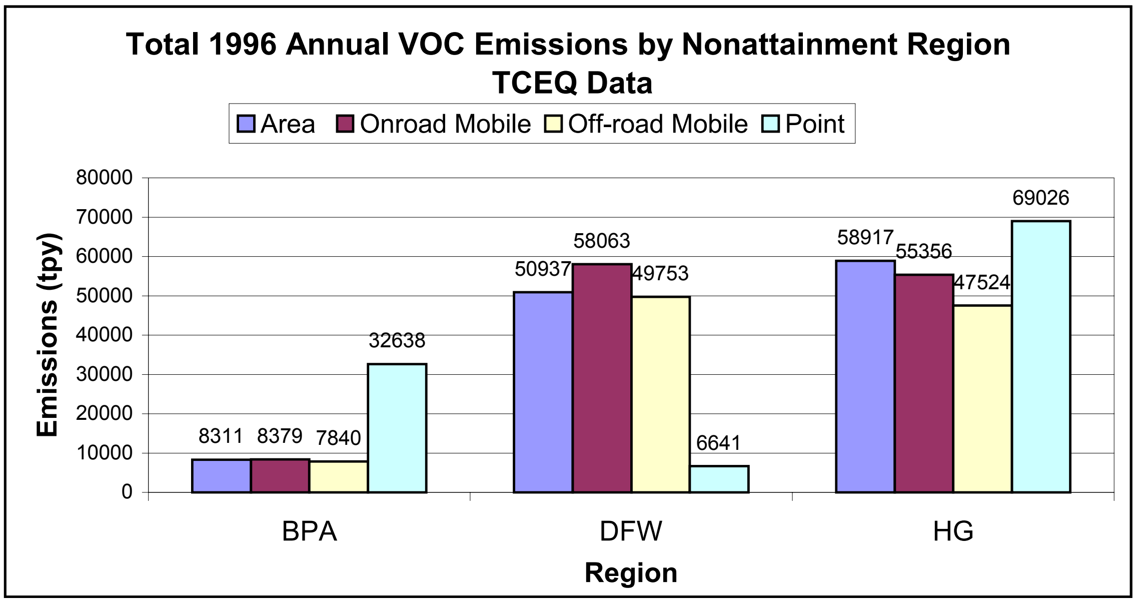

Figure 3-3. 1996 annual VOC emissions by nonattainment area.

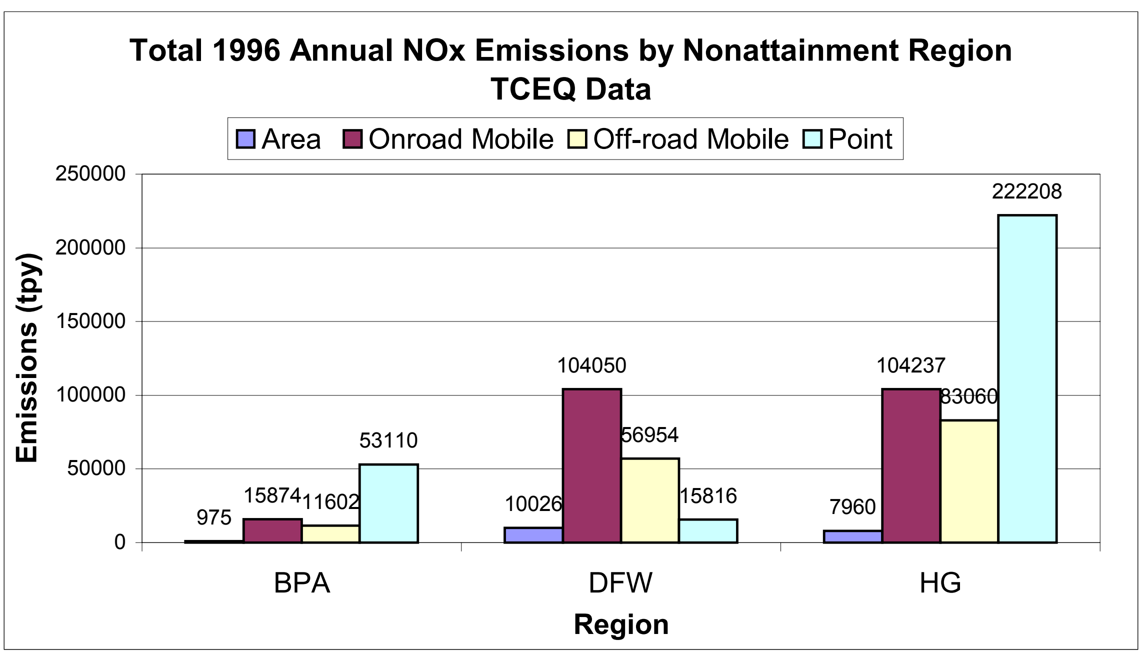

Figure 3-4. 1996 annual NOx emission by nonattainment area.

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 TCEQ emissions data 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 emissions trends from 1996 to 1999.

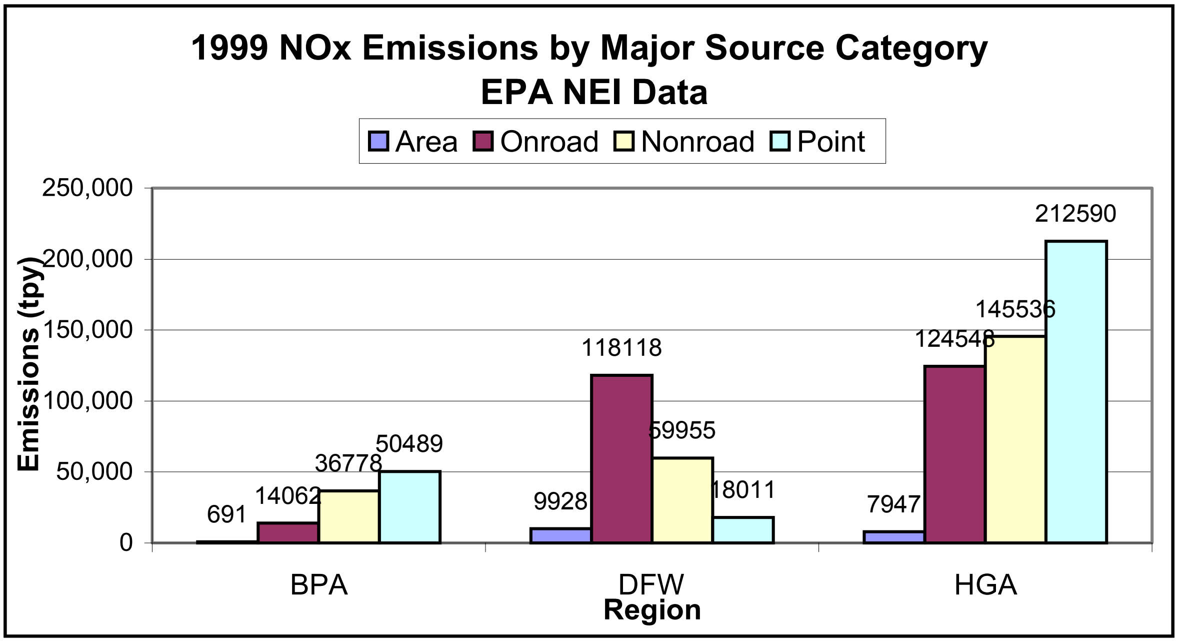

Figure 3-5. 1999 annual NOx emission by nonattainment region based on NEI99 data.

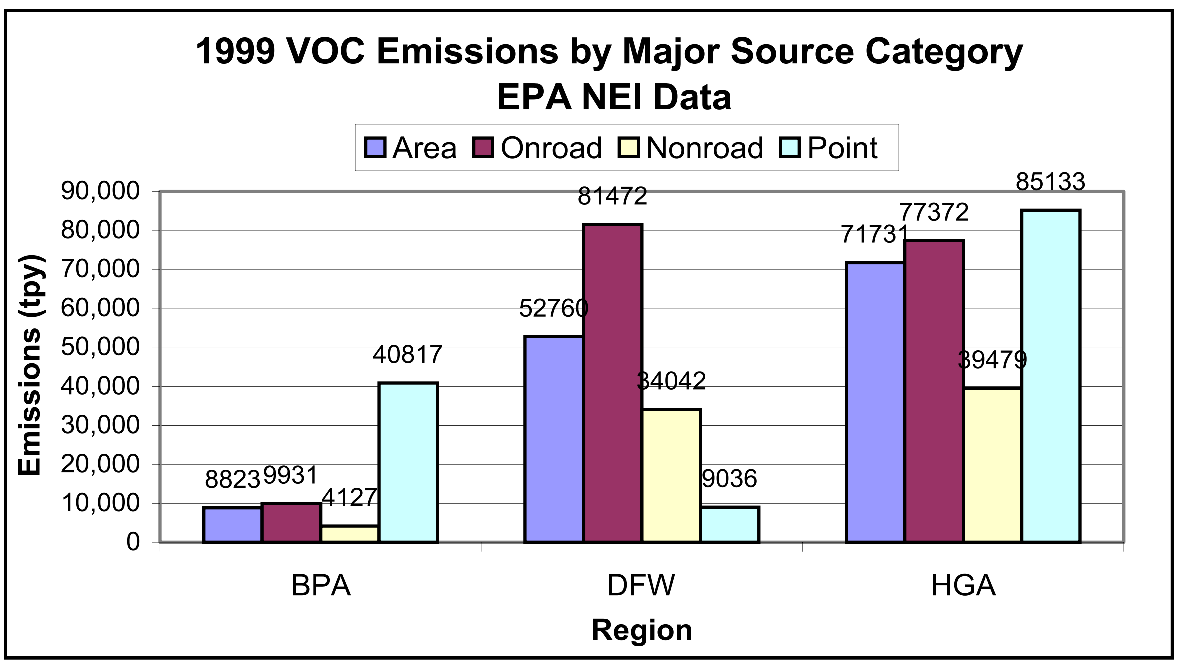

Figure 3-6. 1999 annual VOC emissions by nonattainment region based on NEI99 data.

A comparison of emission levels by regions within Texas is presented in Figures 3-7 through 3-12. These data were developed by ENVIRON (2001) 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 off-road mobile sources are displayed. Also note that the on-road mobile source emission estimates are based on a 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. Off-road mobile source NOx emissions are seen to increase from 1990 through 1999 in all areas.

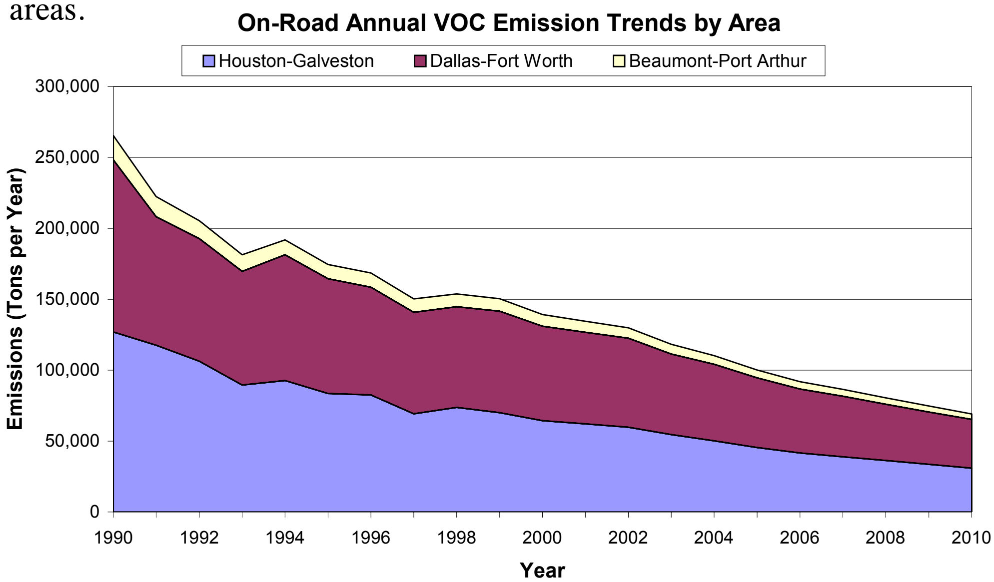

Figure 3-7. Annual on-road mobile source VOC emission trends by region for 1990-2010.

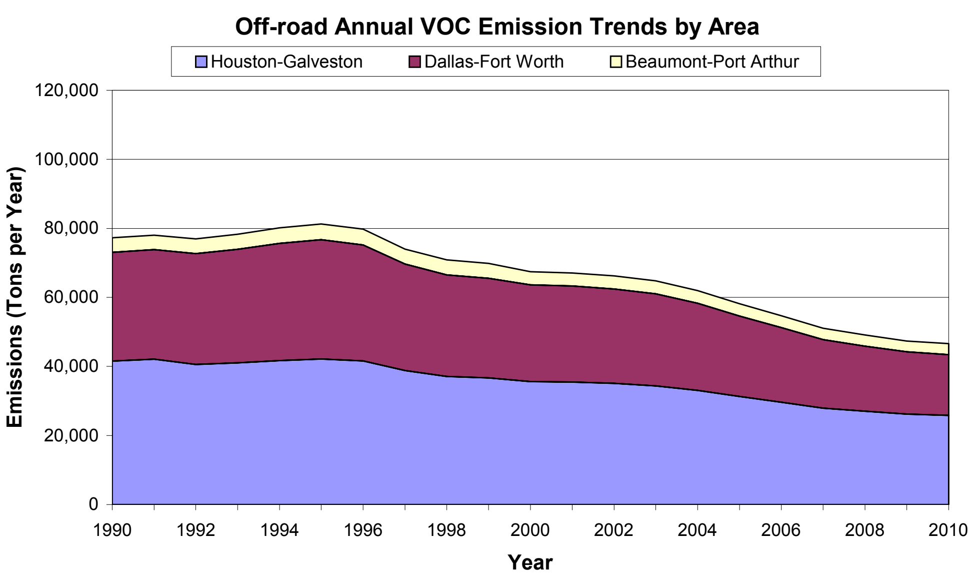

Figure 3-8. Annual off-road mobile source VOC emission trends by region for 1990-2010.

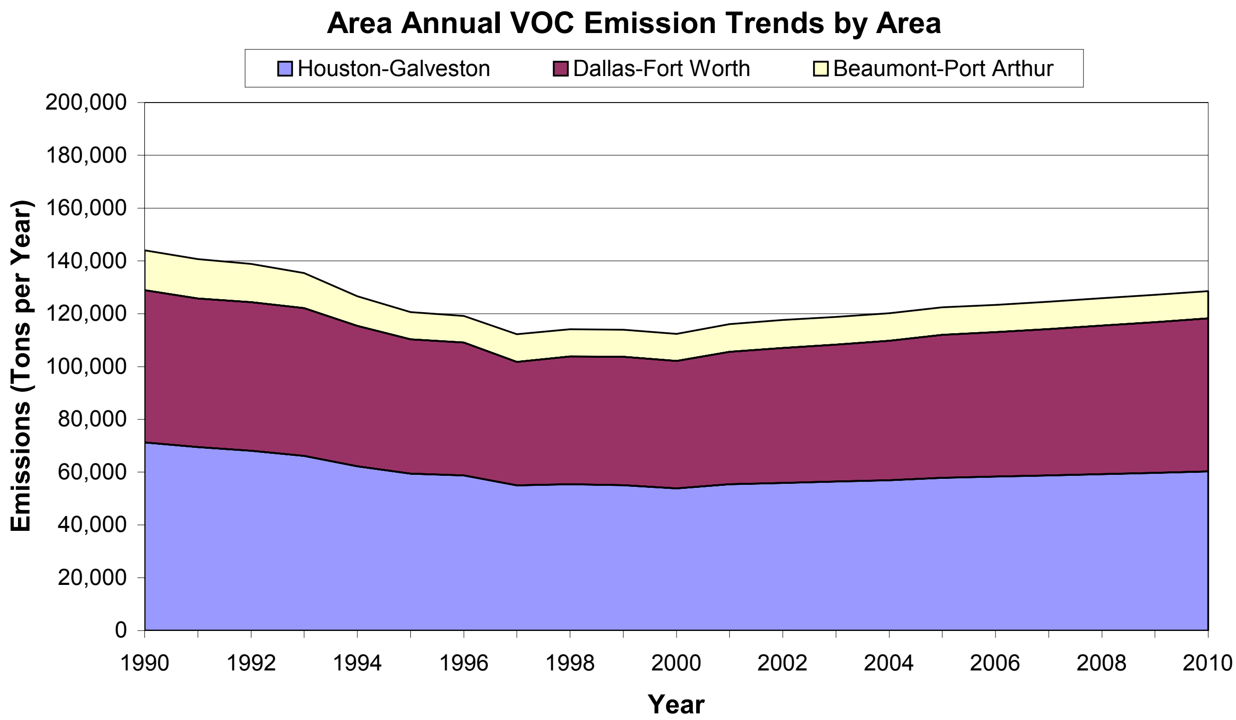

Figure 3-9. Annual area source VOC emission trends by region for 1990-2010.

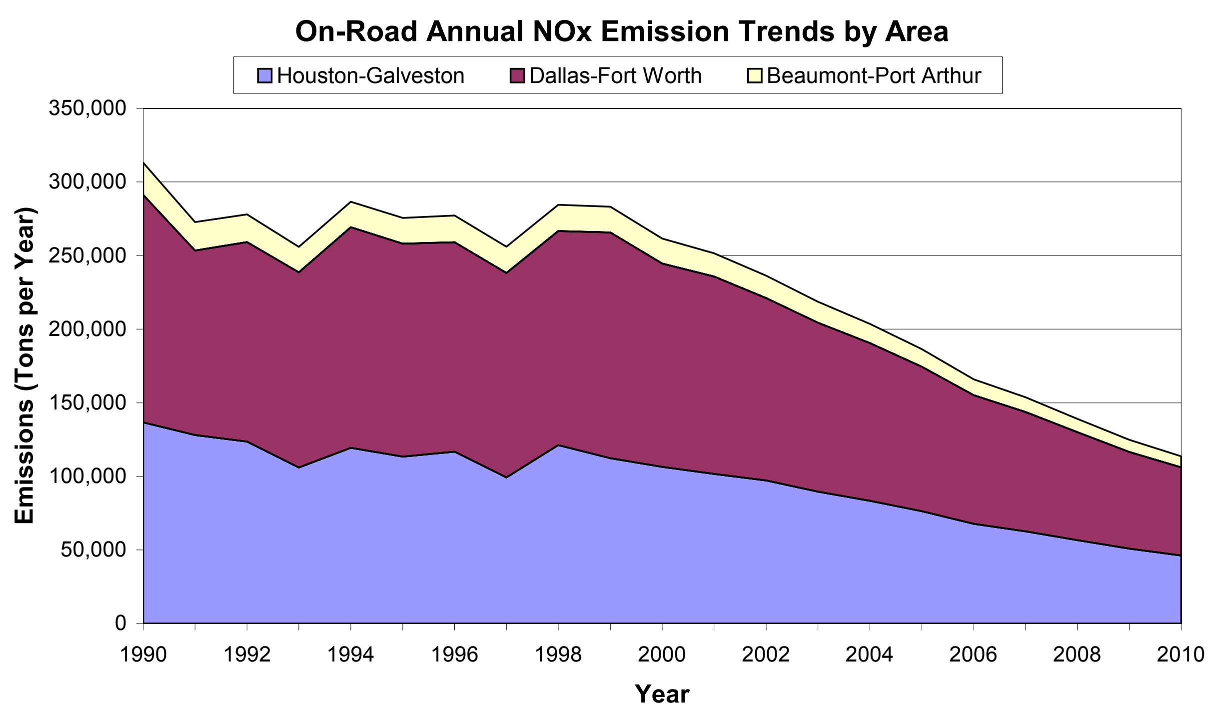

Figure 3-10. Annual on-road mobile source NOx emission trends by region for 1990-2010.

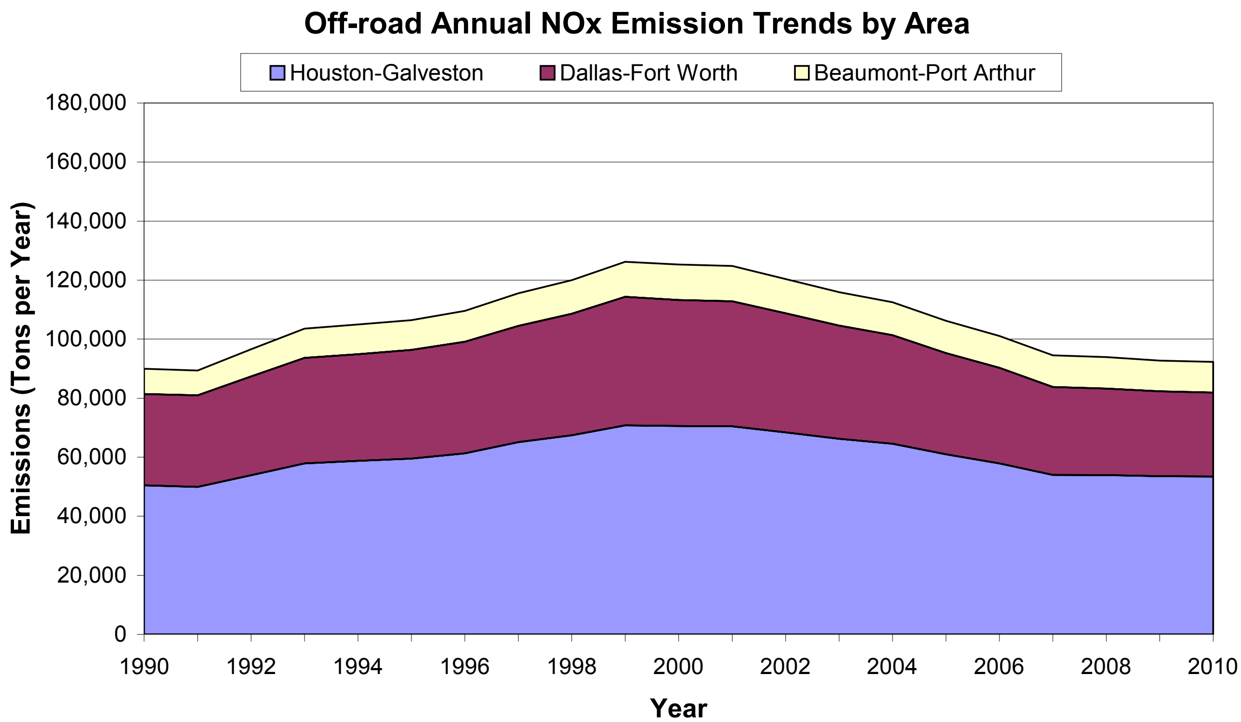

Figure 3-11. Annual off-road mobile source NOx emission trends by region for 1990-2010.

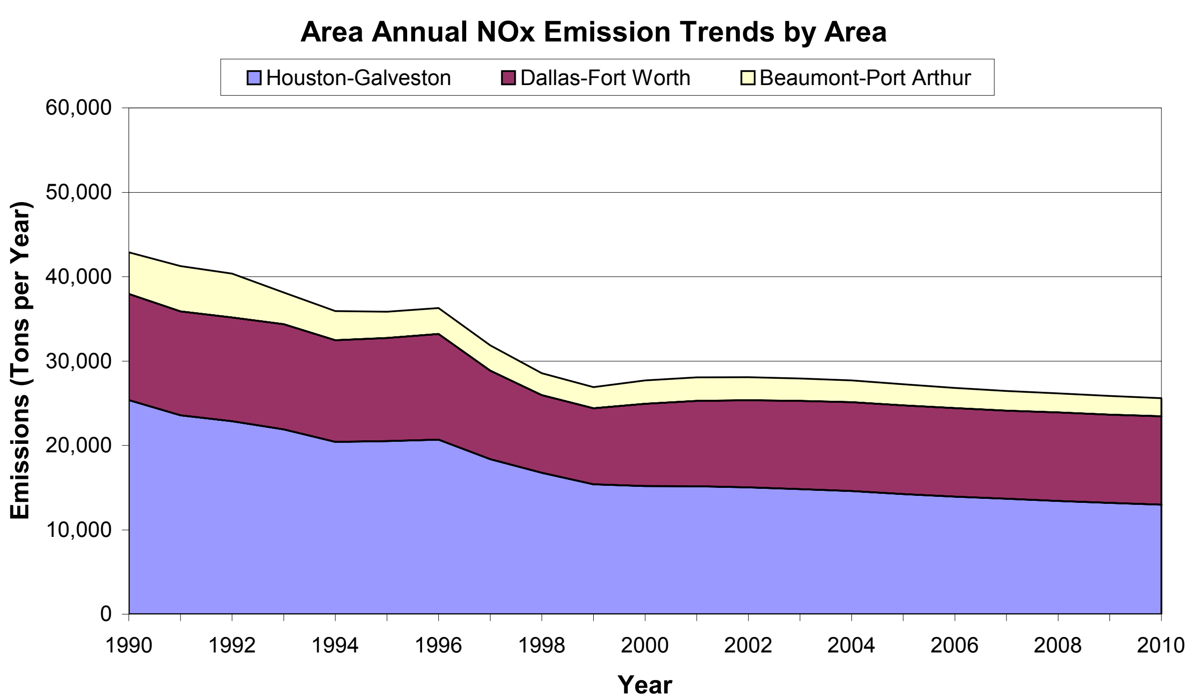

Figure 3-12. Annual area source NOx emission trends by region for 1990-2010.

Emission Summaries by Source Category

Figure 3-13 and 3-14 display NOx and VOC emissions in the BPA 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). Point source emissions data for 2001 was apparently incomplete in the database. Also note 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 off-road mobile sources while area and on-road mobile sources have decreased slightly. In the BPA region, NOx emissions are dominated by point sources while area sources contribute only a small fraction of the annual anthropogenic NOx emissions within the region. Area, on-road mobile and point sources contribute the largest amounts to the annual VOC emissions totals. Off-road mobile source VOC emissions comprise a much smaller fraction of the annual anthropogenic VOC emissions within the region and have decreased only minimally over the last decade.

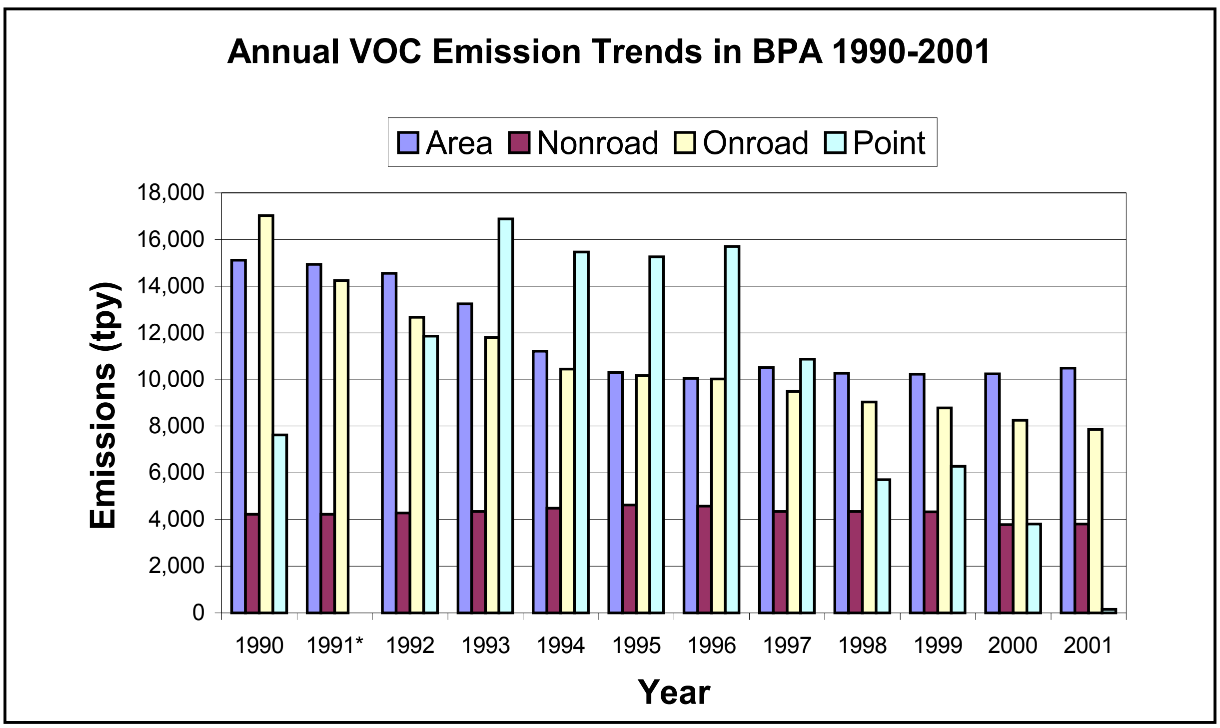

Figure 3-13. Annual VOC emission trends in BPA for 1990-2010 by source category. *Point source data are missing for 1991.

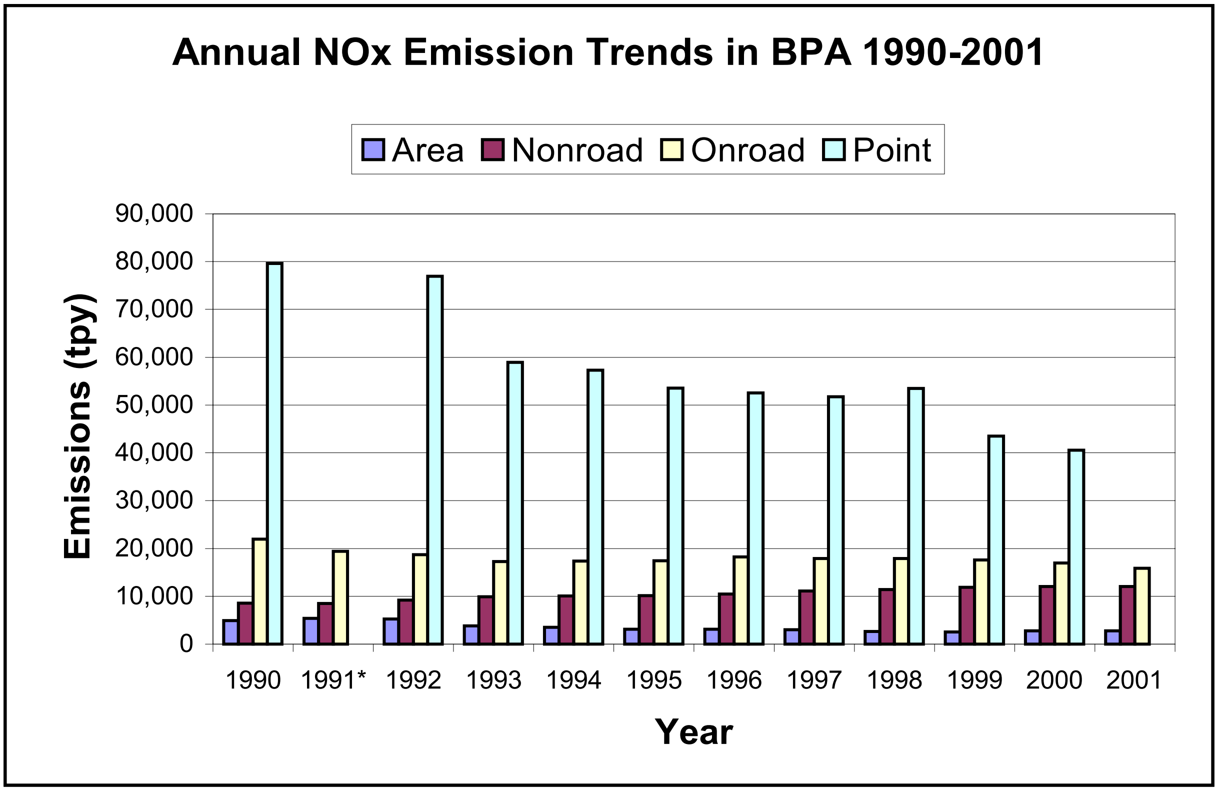

Figure 3-14. Annual NOx emission trends in BPA for 1990-2001 by source category. * Point source data are missing for 1991.

A summary of 1996 VOC and NOx emissions by county in the BPA nonattainment region is presented in Figures 3-15 and 3-16. Jefferson County contributes the majority of both NOx and VOC anthropogenic emissions for all source categories. Point source emissions dominate both NOx and VOC emission for all counties in the BPA nonattainment area except Hardin County. Within Hardin County, area source VOC emissions make up the majority of total county-level VOC emissions.

Figures 3-17 and 3-18 display the total annual anthropogenic VOC and NOx emissions in the BPA area for 1996 and 1999, respectively. The 1996 data are based on information received from the TCEQ, while the 1999 estimates are from the NEI99 database. VOC emissions increased overall from 1996 to 1999 primarily due increases in point source emissions in Jefferson and Orange counties. While off-road mobile VOC emissions have decreased for all counties, increase in on-road mobile and area VOC sources result in an overall net increase in VOC emissions in the BPA region.

Comparison of Figures 3-16 and 3-18 show that region-wide NOx emissions have increased considerably mainly due to increased off-road mobile sources in Jefferson county. Whether this is due to an increase in off-road mobile sources or differences in emission estimation methodologies in the 1996 and 1999 inventories is unclear. Area and on-road mobile source NOx emissions have decreased region-wide from 1996 to 1999, as have point source emissions.

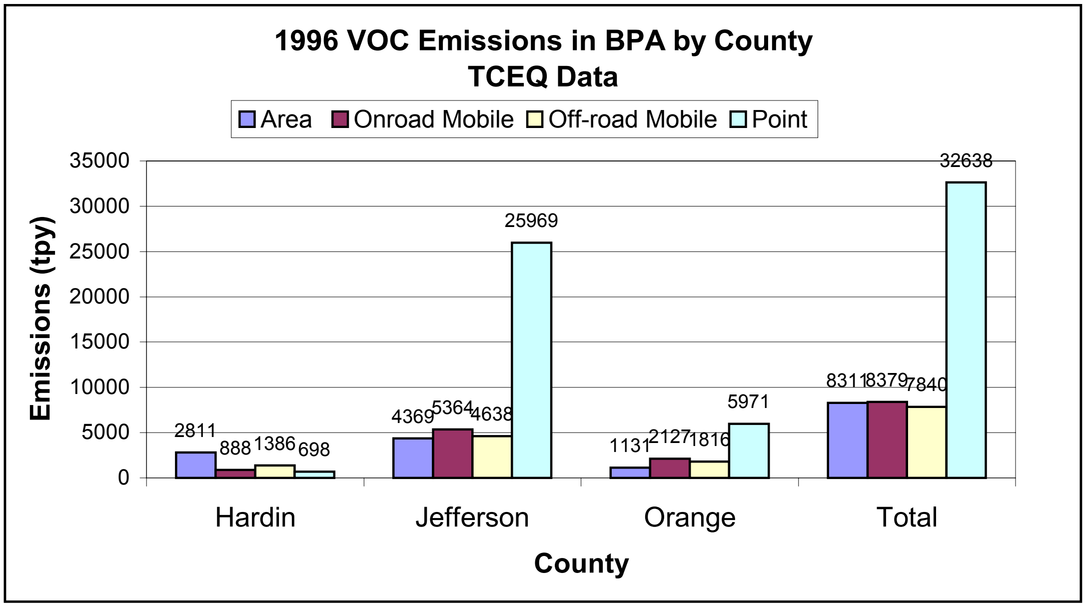

Figure 3-15. 1996 Annual VOC emissions in BPA nonattainment counties by source category.

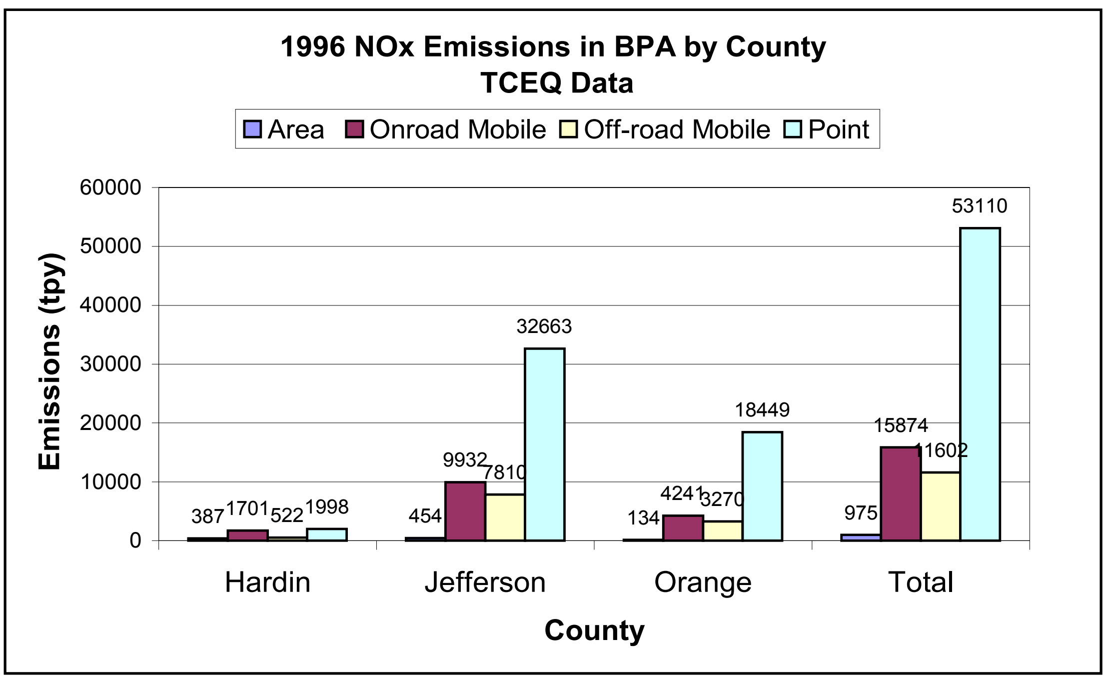

Figure 3-16. 1996 annual NOx emissions in BPA nonattainment counties by source category.

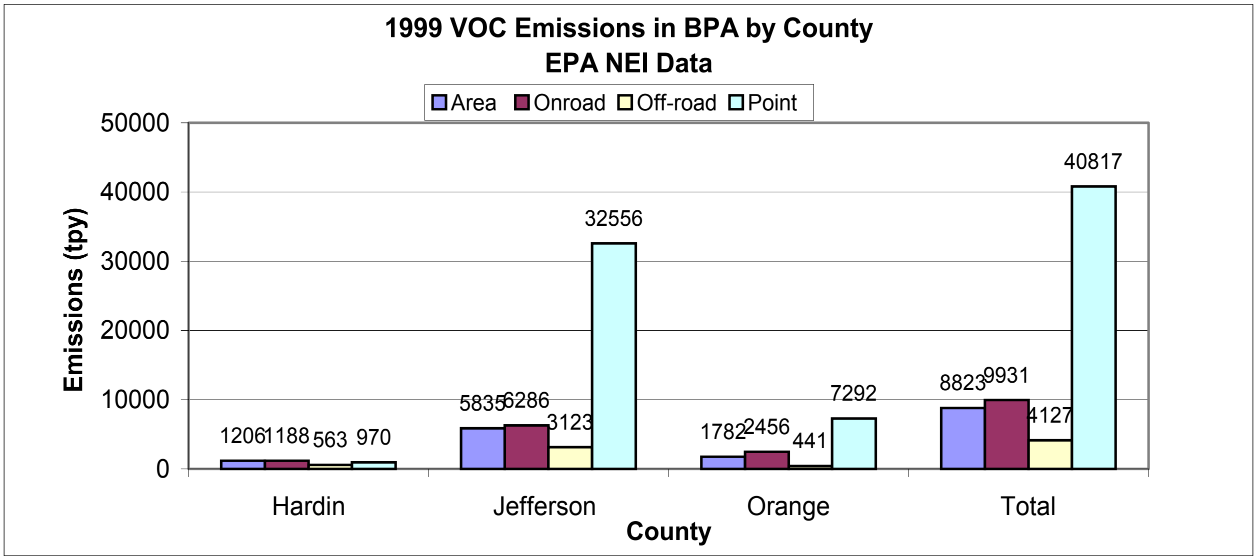

Figure 3-17. 1999 annual VOC emissions in BPA nonattainment counties by source category based on NEI99 data.

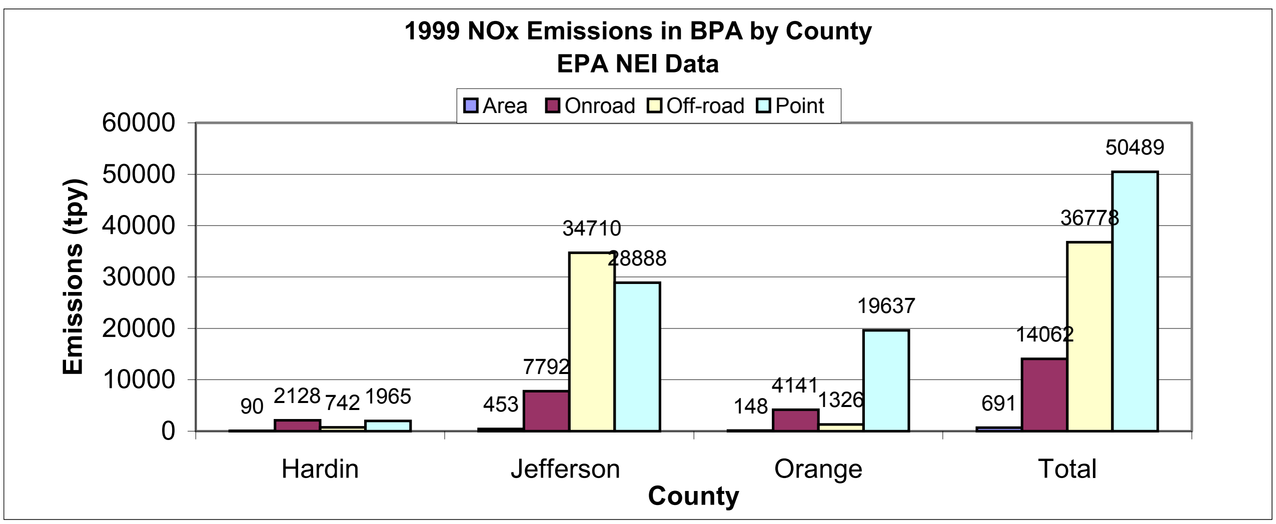

Figure 3-18. 1999 annual NOx emissions in BPA nonattainment counties by source category based on NEI99 data.

An examination of population trends from 1990 to 2000 is also of interest. Figure 3-19 displays the population for the BPA nonattainment counties for 1990 and 2000 based on US Census data. Only slight increases in population are seen in all counties in the BPA area. Figure 3-20 provides a comparison of 1990 and 2000 populations in the Dallas/Fort Worth, Beaumont/Port Arthur and Houston/Galveston nonattainmnet areas. As shown, both HGA 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.

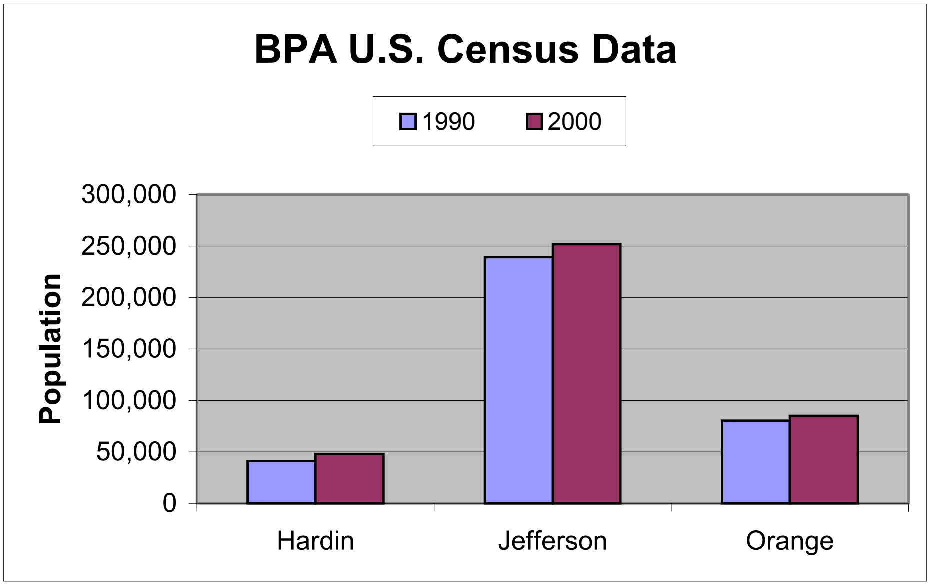

Figure 3-19. 1990 and 2000 population in BPA nonattainment area by county.

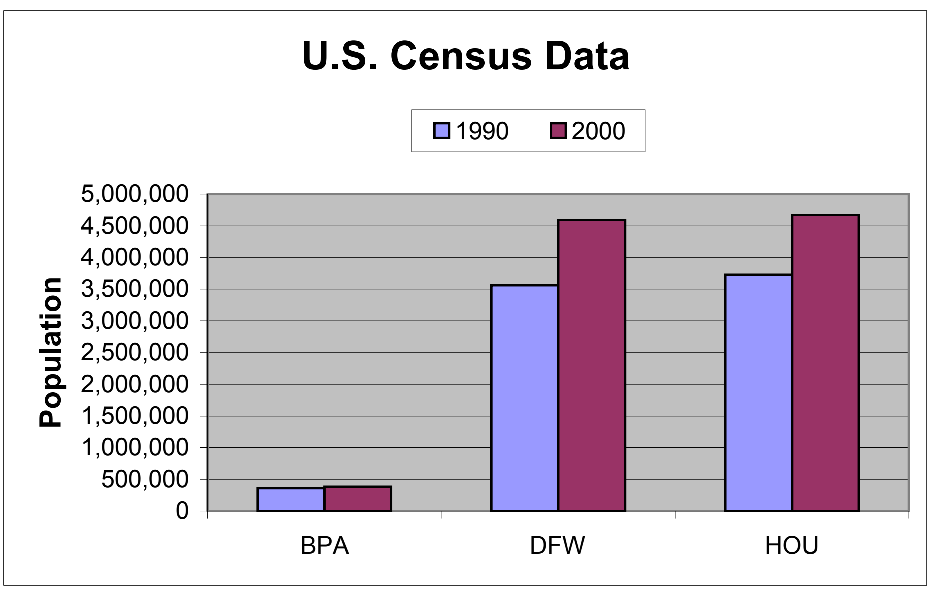

Figure 3-20. 1990 and 2000 population by nonattainment area.

4. METEOROLOGY

The development of the conceptual model for Beaumont/Port Arthur 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 by morning winds from the northwest and winds from the southwest in the afternoon. Low ozone days are associated with southerly wind flows throughout the day. Surface wind analyses examined the land/sea breeze effects on ozone concentrations in the area. The analysis also suggests possible influences from the Houston/Galveston area. Thus, the ozone air quality in the BPA region is affected both by local sources as well as regional transport.

Local Meteorology

The Beaumont/Port Arthur area is located on Gulf Coast of Texas where wind patterns during the summer months are influenced by the persistent high pressure area in the Gulf of Mexico. This situation is favorable for ozone formation in the region with relatively clear skies, light winds, abundant sunshine and warm temperatures. The influence of subsidence inversions, which reduce vertical mixing in the atmosphere, further exacerbates the problem by trapping and concentrating pollutants near the surface. The effects of land/sea breeze flow reversals also contribute to the local transport of ozone and ozone precursors in the area.

A previous analysis conducted by the TCEQ as part of the development of the draft conceptual model examined local wind patterns for both high and low ozone days from 1995 through 2000 (TCEQ, 2002a). Although the draft conceptual model did not specifically define high and low ozone days, a commonly used definition specifies high ozone days as those with 1-hour ozone maximum concentrations above 120 ppb and low ozone days as those with 1-hour ozone maximum concentrations below 80 ppb. Wind rose analyses were conducted which considered surface wind speeds and directions on high and low ozone days during this time period. The analysis was conducted separately for morning, afternoon and evening hours. Figure 4-1 displays the wind roses developed for the draft conceptual model.

Wind roses can be used to graphically depict the dominant transport direction of the winds for an area. However, due to the influences of local terrain, possible coastal effects, exposure of the instruments, and temporal variability of the wind, the wind rose statistics may not always be representative of true transport for an area. Other meteorological conditions may also be important for determining the formation and transport of certain atmospheric contaminants, particularly reactive pollutants. In general, air quality is often correlated with the dominant transport direction of the wind. The wind rose then provides information regarding the percentage of time the direction(s) and speed(s) associated with a certain air quality can be expected over a long period of time. Similarly, wind roses can be compared to trajectories. The general direction of the trajectory and the wind rose can be compared to obtain a qualitative assessment of how frequently that particular trajectory might be expected over a long period of time.

The following observations can be made from examination of the data presented in Figure 4-1 During the morning on low ozone days the surface wind speeds tend to be relatively high compared to high ozone days. On exceedance days the surface winds generally blow from the south. Less frequently, surface winds blow from northeast on high ozone days. Afternoon and evening surface winds on low ozone days blow from the south. Relatively little stagnation is present on these days. By contrast, on high ozone days, the predominant wind directions are from the northwest and southwest with relatively low speeds. In the morning hours, Beaumont/Port Arthur surface winds tend to blow from the northwest shifting to the southwest during the afternoon and evening. The frequency of stagnation winds is seen to be considerably higher than for low ozone days.

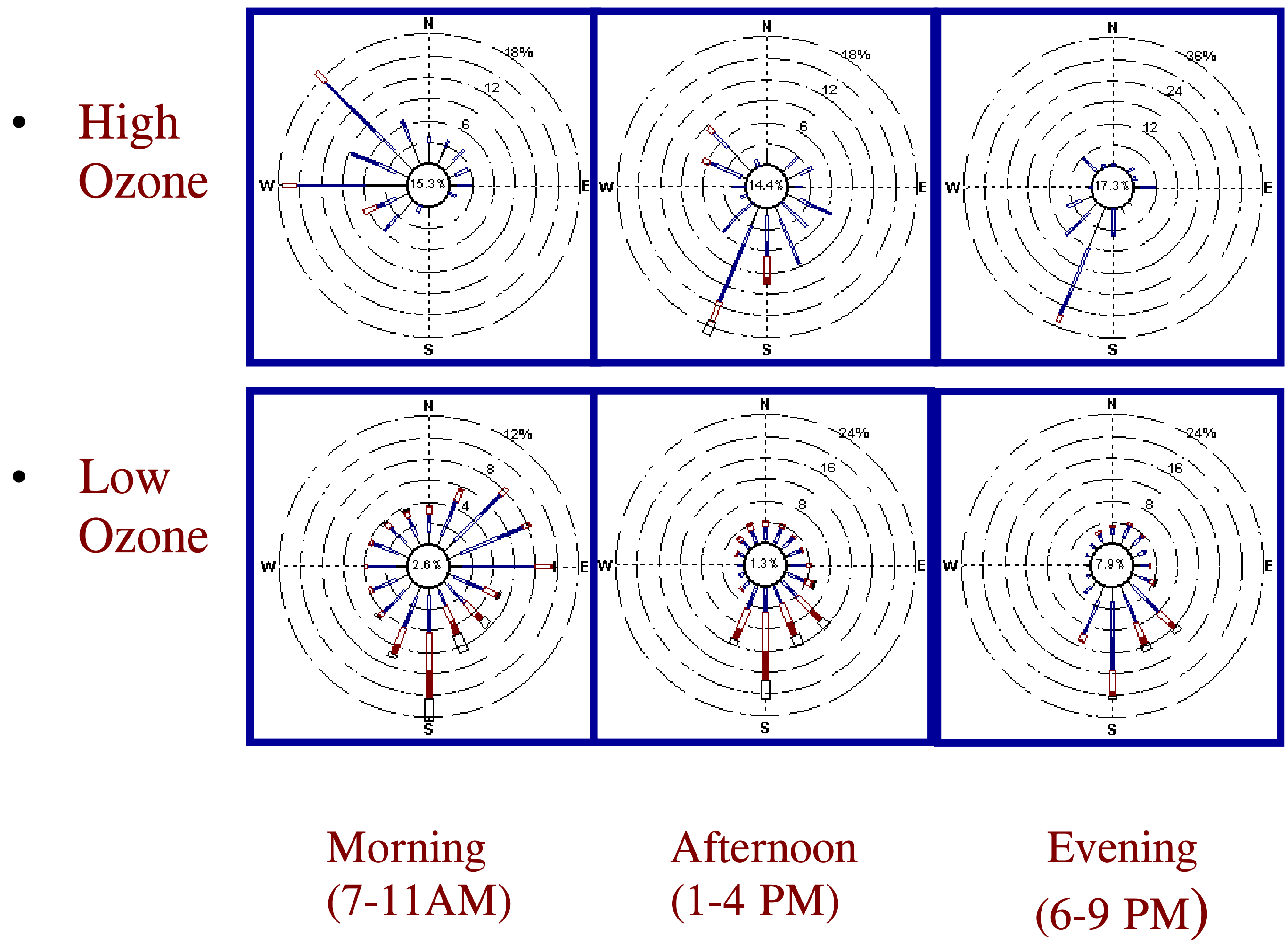

Figure 4-1. Surface wind rose analysis for 1995-2000 for BPA (Source: TCEQ, 2002b).

Figure 4-2 displays additional windroses for the BPA nonattainment area by month for June through September as well as an annual composite based on data from 1988 through 1992, as developed by the TCEQ. The months of June and July display similar patterns with winds from the south and southwest being the most frequent direction. August surface winds in the BPA area include a northwest component in addition to south and southwest winds associated with June and July. In September, a higher frequency of surface winds from the northeast, east and south are seen to occur. The annual composite wind rose displays a more frequent northeast, south and southeast wind component in the BPA area.

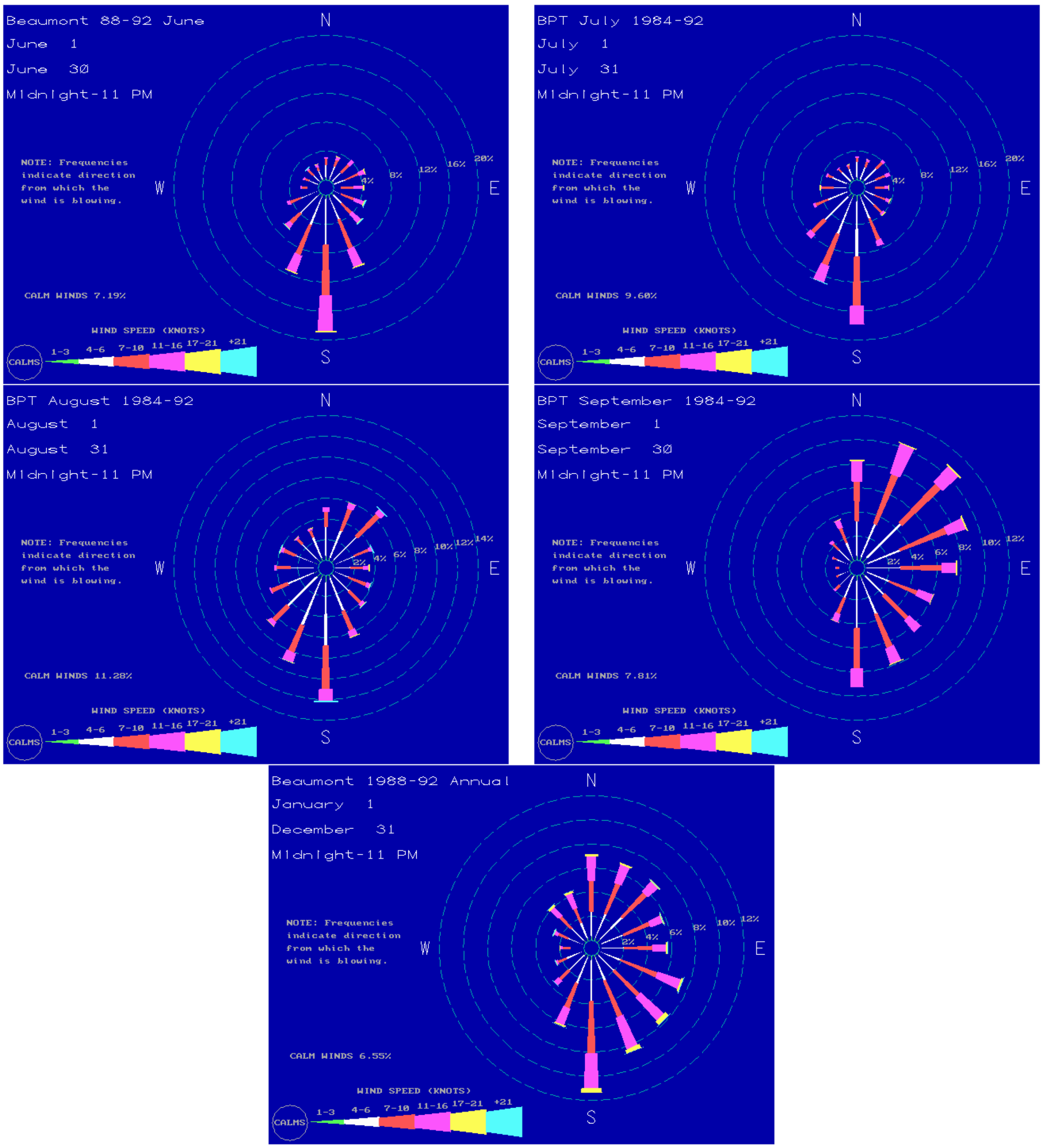

Figure 4-2. Surface windroses for the BPA nonattainment area (Source: TCEQ, 2002b).

These surface wind patterns in the BPA nonattainment area have implications for the development of elevated ozone concentrations in the region. The light morning winds and subsidence lead to a build up of local pollutants. The nighttime/early morning north-northwesterly wind flows carry these pollutants offshore where photochemical reactions lead to the formation of ozone. The land/sea breeze flow reversal then returns these elevated ozone concentrations back onshore and into the BPA urban area during the afternoon and evening hours.

The effects of land/sea breeze flow reversal are illustrated by a case study for August 12, 2000 at the CAMS28 air quality monitoring station conducted by the TCEQ (TCEQ, 2002b). The study examined the surface wind flows and relation to elevated ozone levels. The analysis examined the wind flow patterns and found that the surface winds changed direction clockwise consistently throughout the day. The analysis also concluded that these conditions were representative of surface and transport winds associated with high ozone events in the BPA area. Figure 4-3 displays ozone and SO_2 concentrations and wind directions at the Port Arthur (CAMS 28) monitor for August 12, 2002. The relationship between wind direction and monitored ozone concentrations can be seen. Low ozone concentrations in the morning hours are associated with offshore winds, while the peak ozone concentration seen in the late afternoon/early evening are associated with the onshore wind flows caused by the land/sea breeze flow reversal.

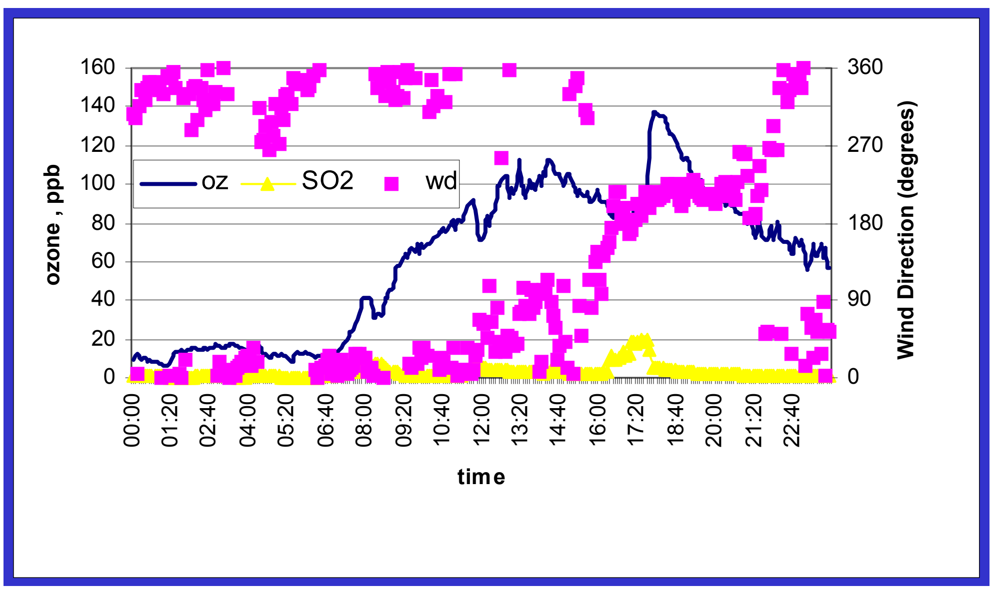

Figure 4-3. Observed ozone, SO_2, and wind directions at the C28 monitor for August 12, 2002. (Source: TCEQ, 2002b)

The traditional view of the land/sea breeze interaction in the BPA area, as presented in previous conceptual models for BPA and HGA (TCEQ, 2002b,c,d), holds that surface winds in the mornings blow offshore while the flow reverses in the afternoon and winds flow back onshore. More recent analyses (TCEQ, 2002b) have shown that the surface winds in the region are changing continuously throughout the day with wind vectors veering clockwise through all the compass directions. The traditional view is still valid in general with morning winds coming from the northwest and afternoon winds from the southeast, but the more recent analysis provides a more dynamic and complex view of the wind flows associated with high ozone events in the BPA area. Figure 4-4 displays the wind directions by hour on August 12, 2000 for monitors on the BPA region. The varying direction clockwise throughout the day is evident with winds from the north (about 0 or 360 degrees) in the night to early afternoon shifting through easterly to southerly in the late afternoon. Figure 4-5 displays similar data for August 30, 2000, where winds are from the west/northwest in the night through mid-afternoon shifting abruptly to the south/southeast in the late afternoon. The afternoon wind shift appears to be counter-clockwise in Figure 4-5, but this is likely an artifact of the very rapid wind shift resulting in a few hourly measurements when the average southwesterly and northwesterly winds was westerly.

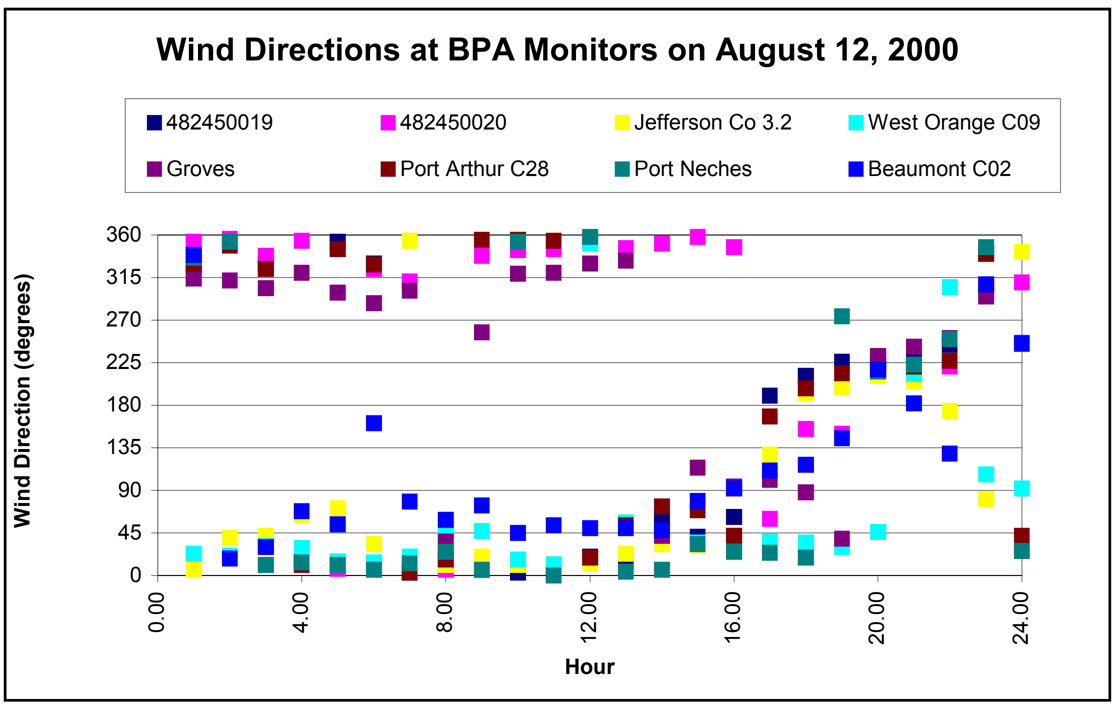

Figure 4-4. Wind directions at BPA monitors on August 12, 2000.

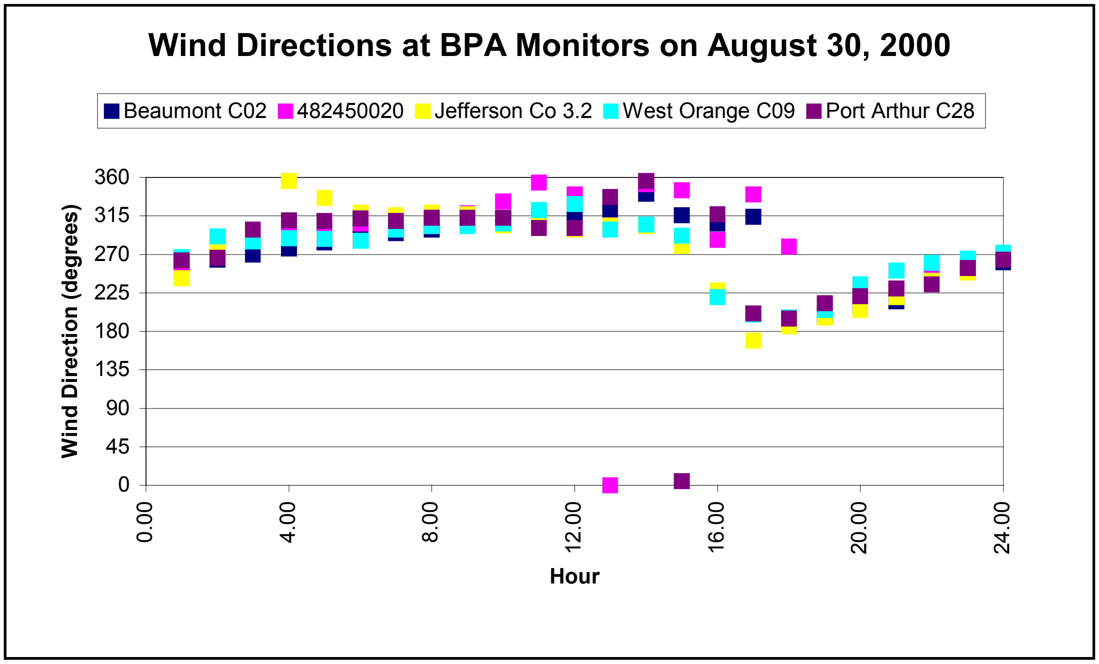

Figure 4-5. Wind directions at BPA monitors on August 30, 2000.

A recent high ozone event in the BPA area further illustrates the influence of local transport on elevated ozone concentration in the region. On August 5, 2002 high ozone levels were measured in the southern portion of the BPA area. The Sabine Pass monitor (CAMS 640) measured a 1-hour average ozone concentration of 130 ppb and an 8-hour average ozone concentration of 92 ppb, in exceedance of both the 1-hour and 8-hour ozone NAAQS. Regional background ozone levels in the region were as high as approximately 50 ppb as indicated by measurements at numerous sites (CAMS2, 68 ppb; CAMS64, 61 ppb; CAMS642, 46 ppb). Figure 4-6 displays the daily maximum 1-hour ozone concentrations at monitors in the BPA area on August 5, 2002. Daily maximum 8-hour ozone concentrations by monitor are displayed in Figure 4-7. Time series of monitored 1-hour ozone concentrations in the BPA region are displayed in Figure 4-8. The rapid increase in ozone concentrations seen at each monitor station successively through out the afternoon is typical of the local land/sea breeze flow reversal influence. Figure 4-9 displays the surface wind directions in BPA for August 5, 2002. The similarity with Figure 4-4 is apparent.

A plume animation developed by the TCEQ graphically illustrates the land/sea breeze flow reversal phenomenon and the accompanying impacts on ozone levels in the region. Figure 4-10 displays selected frames of the animation series. Shown are the estimated plume tracks from large clusters of industrial NOx and VOC sources, along with plume tracks for the center of the broad urban plumes coming from the Beaumont, Port Arthur, and Lake Charles urban areas. The plumes shown in the figure are color coded according to the source strengths. The animation frames shown in Figure 4-10 show that the winds were generally from the north early in the day and carried the urban and industrial plumes south out over the Gulf of Mexico. The abrupt shift in winds to the south/southwest in the afternoon, as a result of the afternoon sea breeze, brings the plumes back onshore to the general area where they originated. Peak ozone levels increased rapidly at this time with the highest levels occurring near the coast where the daytime atmospheric mixing layer is the lowest.

The long-range back trajectory displayed in Figure 4-11 show that air pollution sources in the southern U.S. contributed to the background ozone levels in the region. The trajectories are based on the Hysplit model and EDAS data sets provided by the National Oceanic and Atmospheric Administration (NOAA) Applied Research Laboratory (ARL) and show the path of air parcels back 72 hours from the time of the ozone peak in BPA. Note that there is no indication that Houston air pollution sources could have contributed to the elevated ozone levels measured in the BPA region on this day.

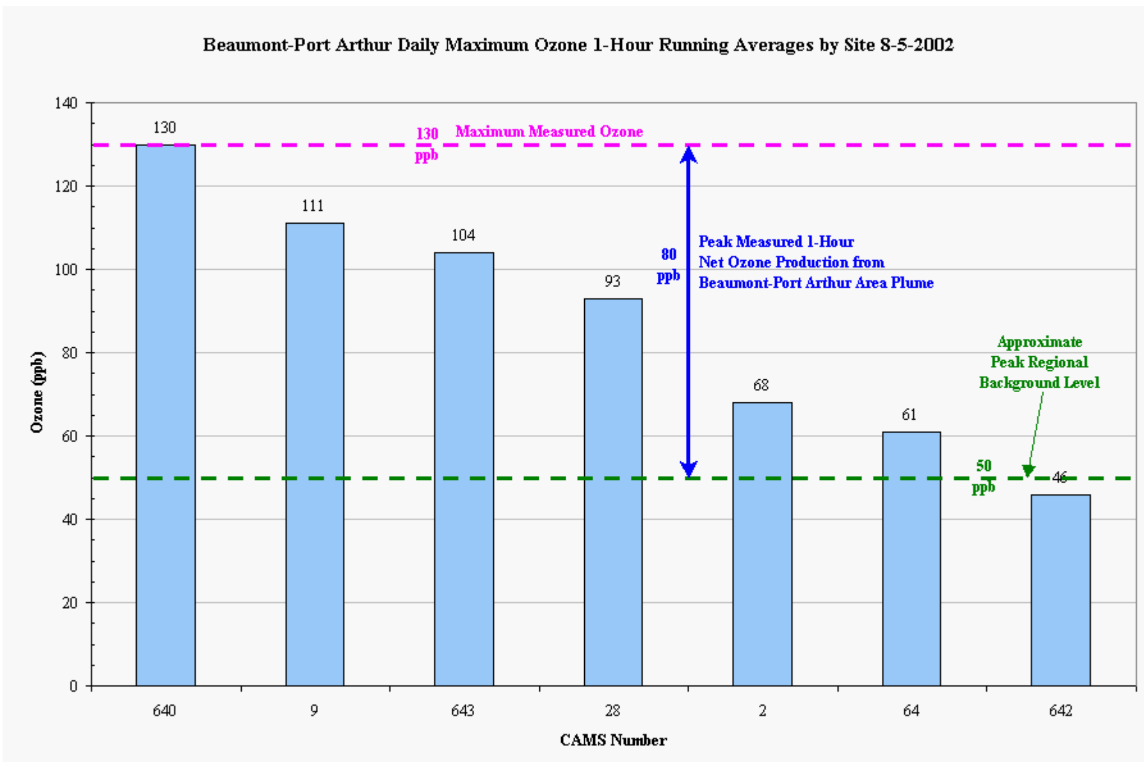

Figure 4-6. Daily maximum 1-hour ozone concentrations in the BPA region on August 5, 2002 (Source: TCEQ).

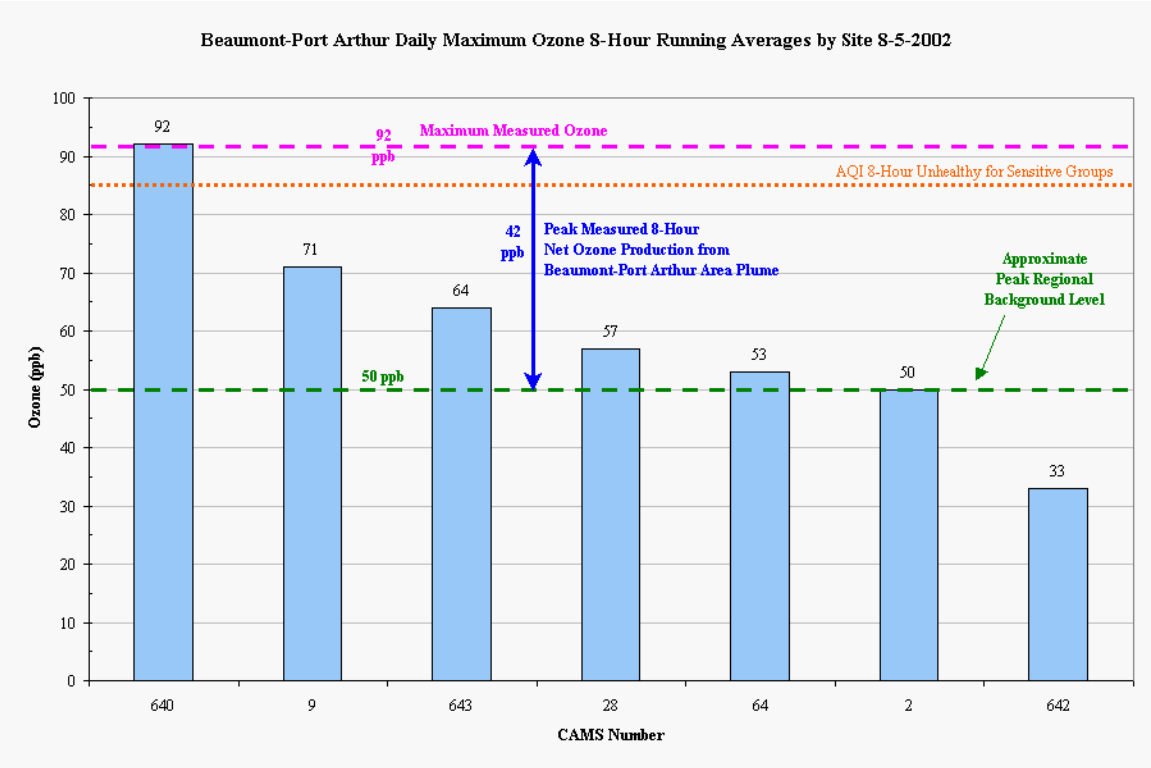

Figure 4-7. Daily maximum 8-hour ozone concentrations in the BPA region on August 5, 2002 (Source: TCEQ).

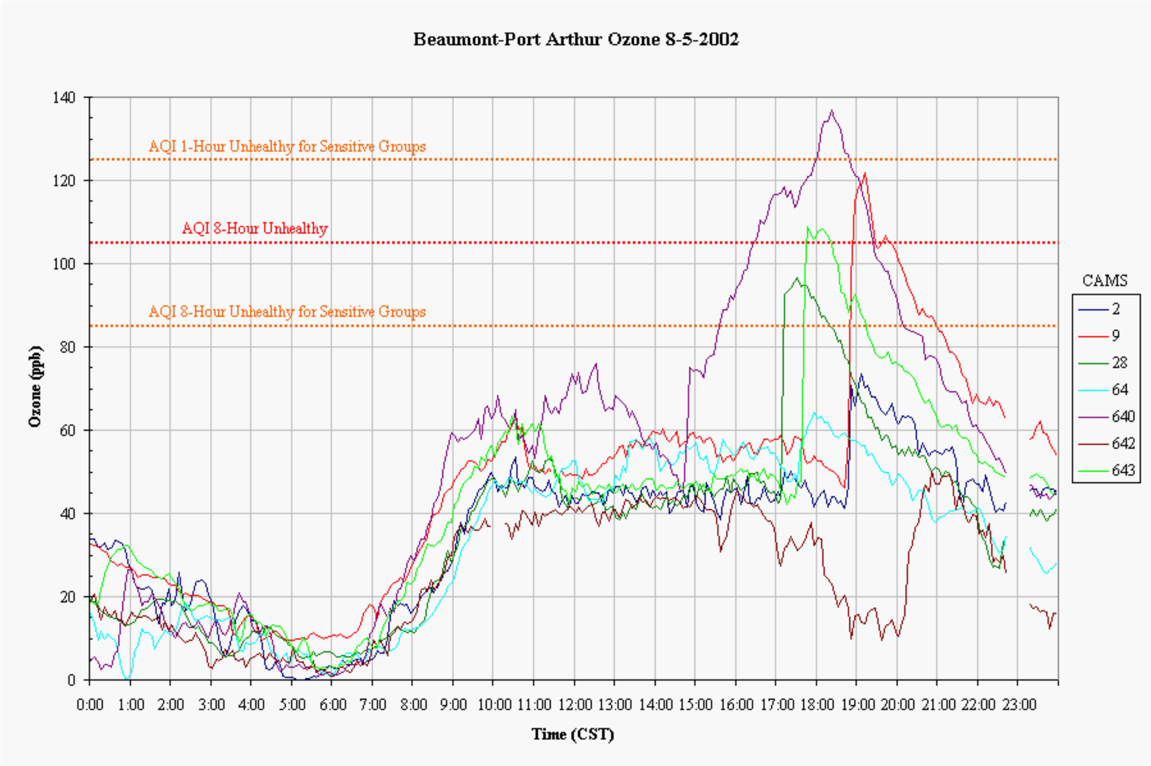

Figure 4-8. Measured ozone concentration at BPA monitors on August 5, 2002 (Source: TCEQ).

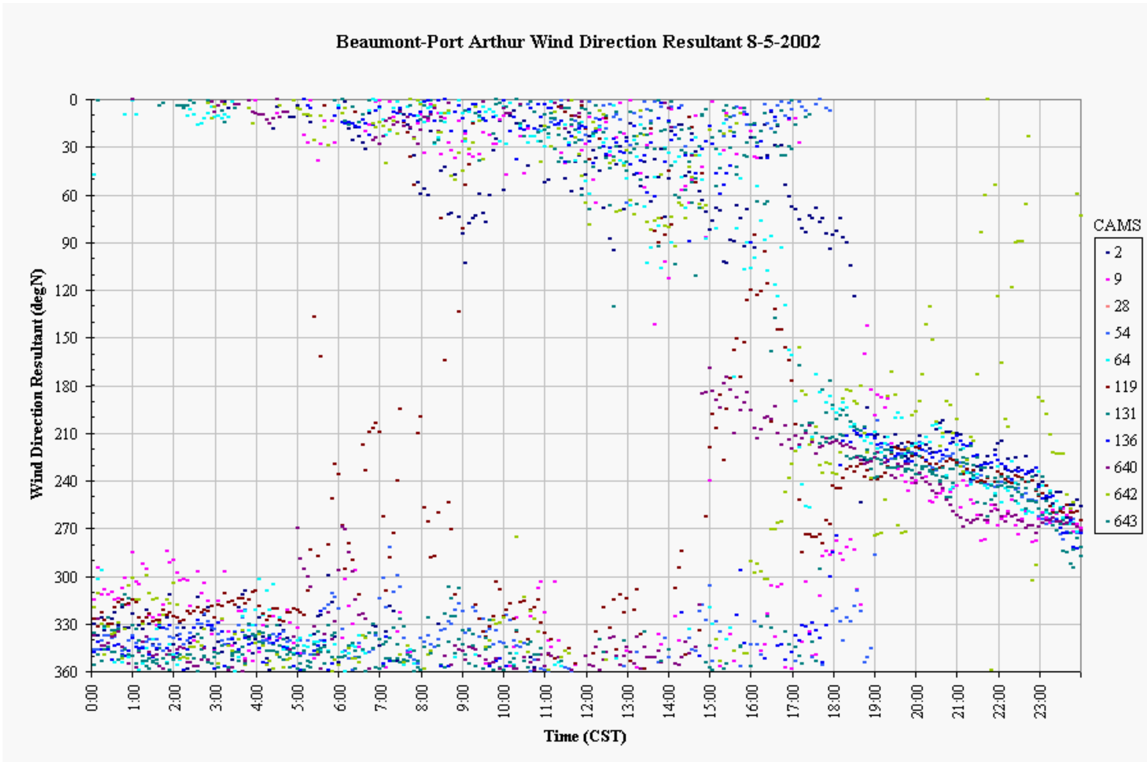

Figure 4-9. Wind directions at BPA monitors on August 5, 2002 (Source: TCEQ).

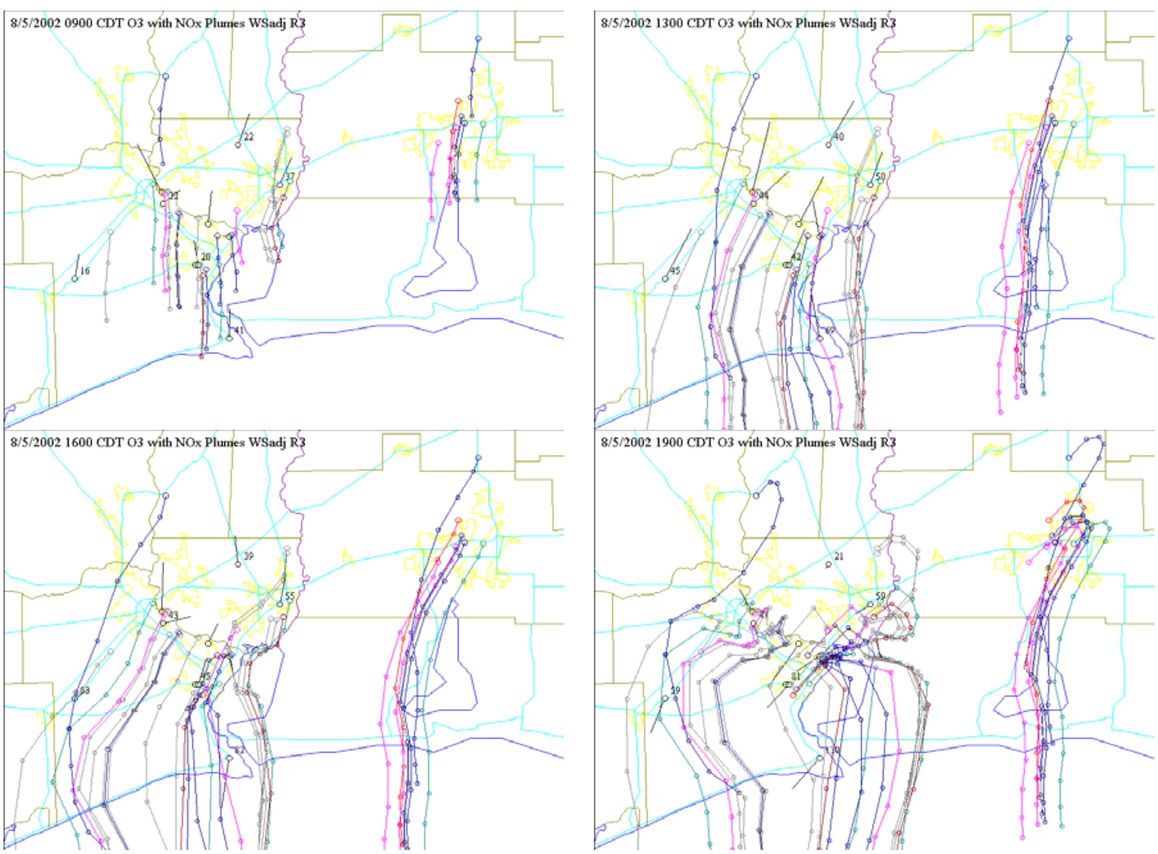

Figure 4-10. Plume animation frames for the BPA region on August 5, 2002 (Source: TCEQ).

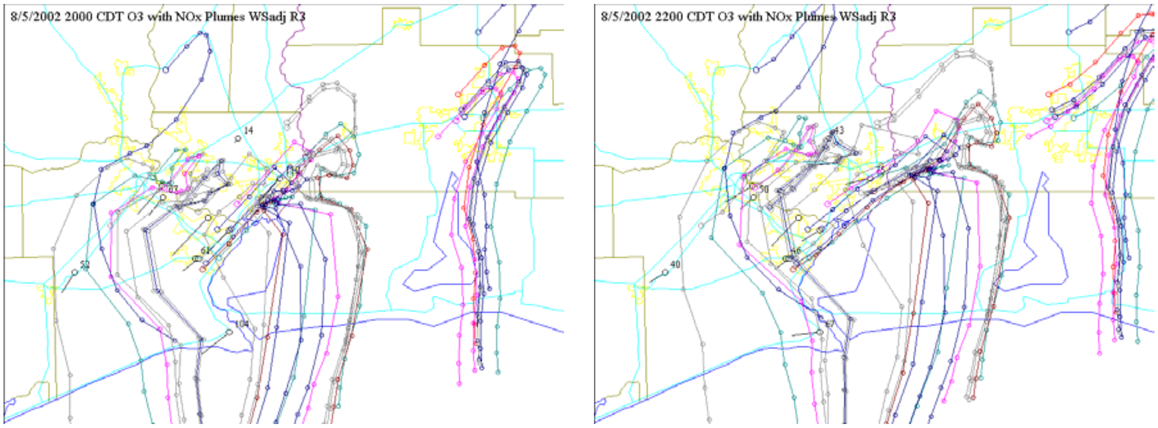

Figure 4-10 (Concluded). Plume animation frames for the BPA region on August 5, 2002 (Source: TCEQ).

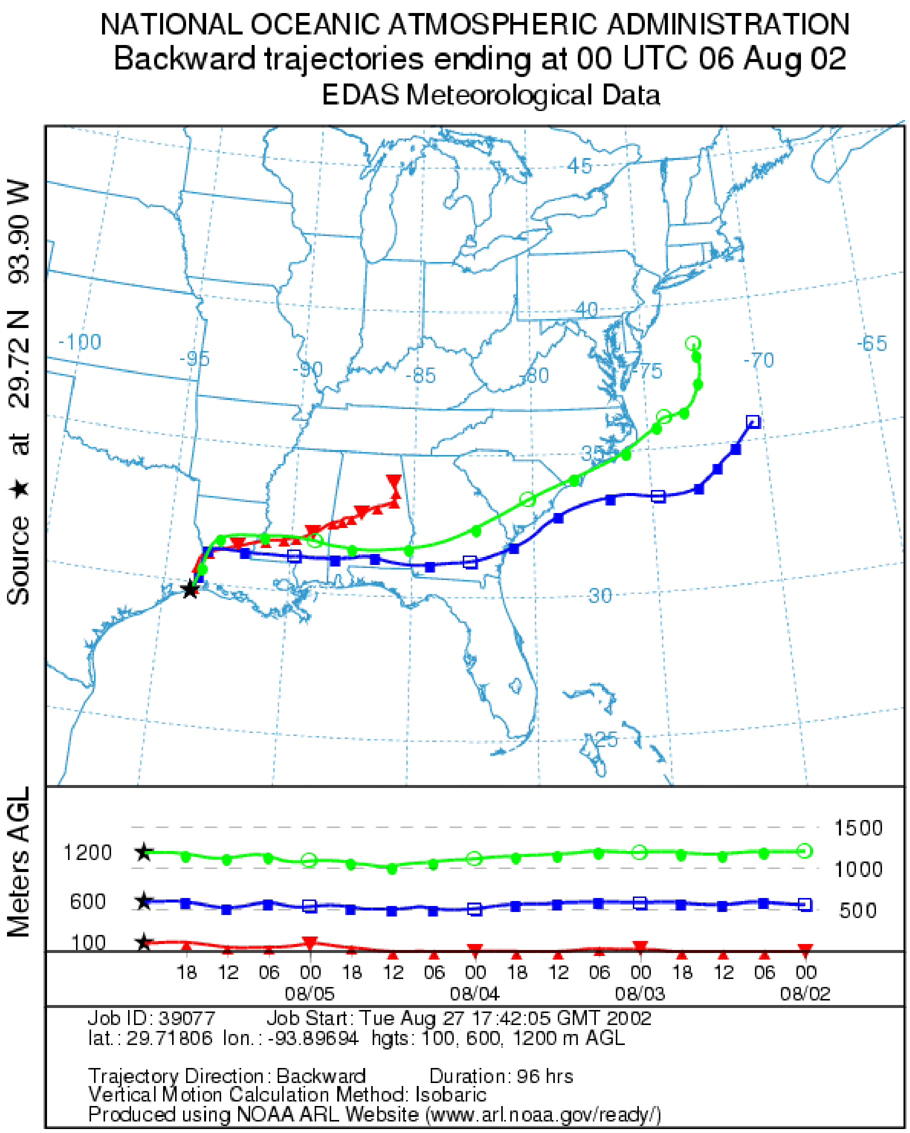

Figure 4-11. Long-range back trajectory for BPA on August 5, 2002 (Source: TCEQ).

A similar situation occurs in the nearby Houston/Galveston nonattainment area, and thus it is quite possible that ozone formed in Houston and subsequently carried offshore over the Gulf of Texas, may then return onshore in the BPA urban area. This situation is also illustrated by the recent July 12, 2002 high ozone event in the BPA area.

On July 12, 2002 high ozone levels were measured in the southern portion of the BPA area. The Sabine Pass monitor (CAMS 640) measured a 1-hour average ozone concentration of 156 ppb and an 8-hour average ozone concentration of 116 ppb, in exceedance of both the 1-hour and 8-hour ozone NAAQS. Regional background ozone levels in the region were as high as approximately 69 ppb as indicated by measurements at numerous sites (CAMS2, 69 ppb; CAMS643, 78 ppb; CAMS642, 53 ppb; CAMS9, 75 ppb; CAMS28 61 ppb). Figure 4-12 displays the daily maximum 1-hour ozone concentrations at monitors in the BPA area on July 12, 2002. Daily maximum 8-hour ozone concentrations by monitor are displayed in Figure 4-13. Time series of monitored 1-hour ozone concentrations in the BPA region are displayed in Figure 4-14. In figure 4-14, the increased ozone concentrations measured at the southernmost monitor in the area (CAMS640) can be attributed to the influence of the Houston urban plume as a result of the land/sea breeze flow reversal in the Houston/Galveston area.

A plume animation developed by the TCEQ graphically illustrates the transport from HGA and the impact on ozone levels in the BPA area. Figure 4-15 displays selected frames of the animation series. Shown are the estimated plume tracks from large clusters of industrial NOx and VOC sources, along with plume tracks for the center of the broad urban plumes coming from the Houston urban area. The plumes shown in the figure are color coded according to the source areas. Bright red plumes are those originating from large industrial NOx and VOC sources in Houston. The animation frames shown in Figure 4-15 show that the winds were generally from the west to northwest early in the day and carried the Houston urban and industrial plumes southeast slightly out over the Gulf of Mexico. Winds out of the west to southwest in the afternoon brings the plumes back onshore into the southern portion of the BPA area at the time of the measured peak ozone levels. Peak ozone levels decreased rapidly shortly after the time of the peak due to rapidly developing thunderstorms in the area on the afternoon of July 12, 2002.

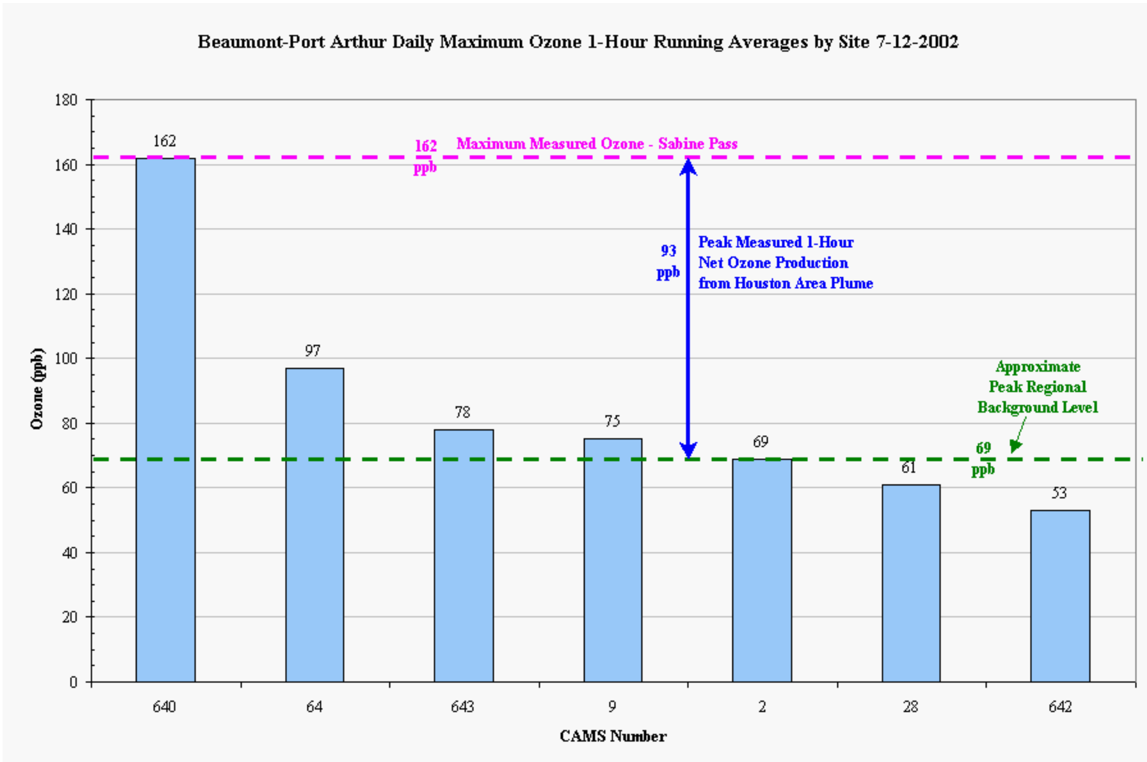

Figure 4-12. Daily maximum 1-hour ozone concentrations in the BPA region on July 12, 2002 (Source: TCEQ).

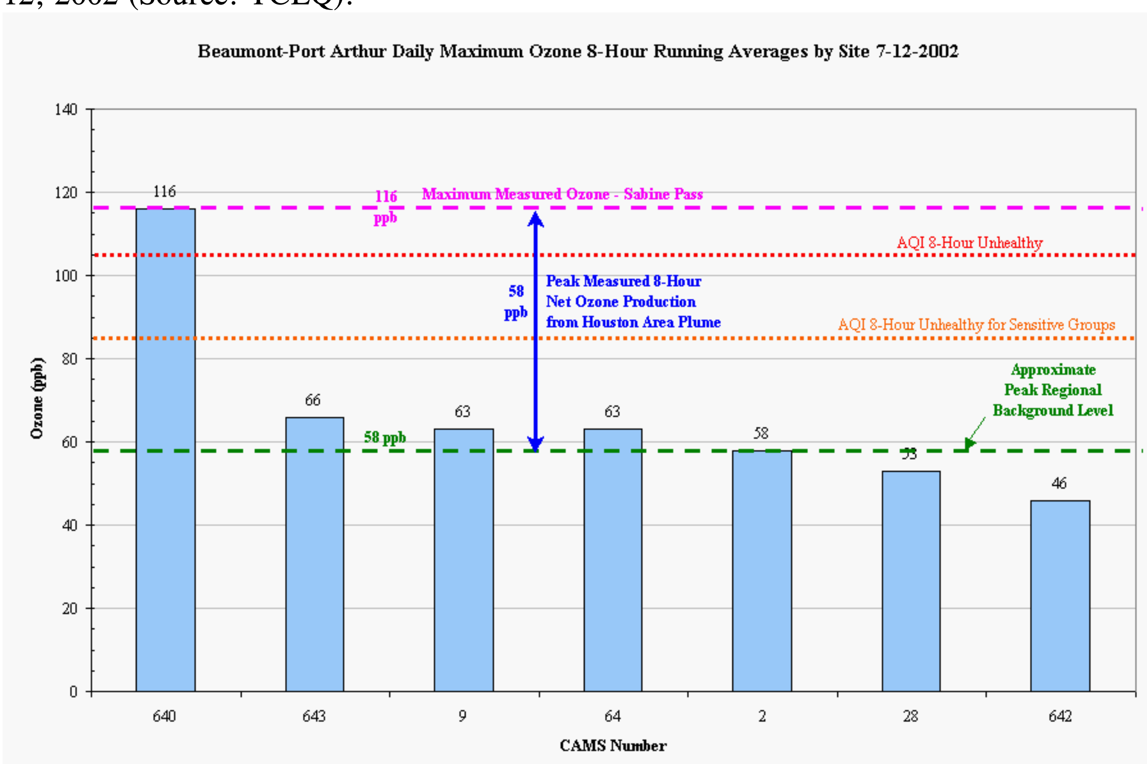

Figure 4-13. Daily maximum 8-hour ozone concentrations in the BPA region on July 12, 2002 (Source: TCEQ).

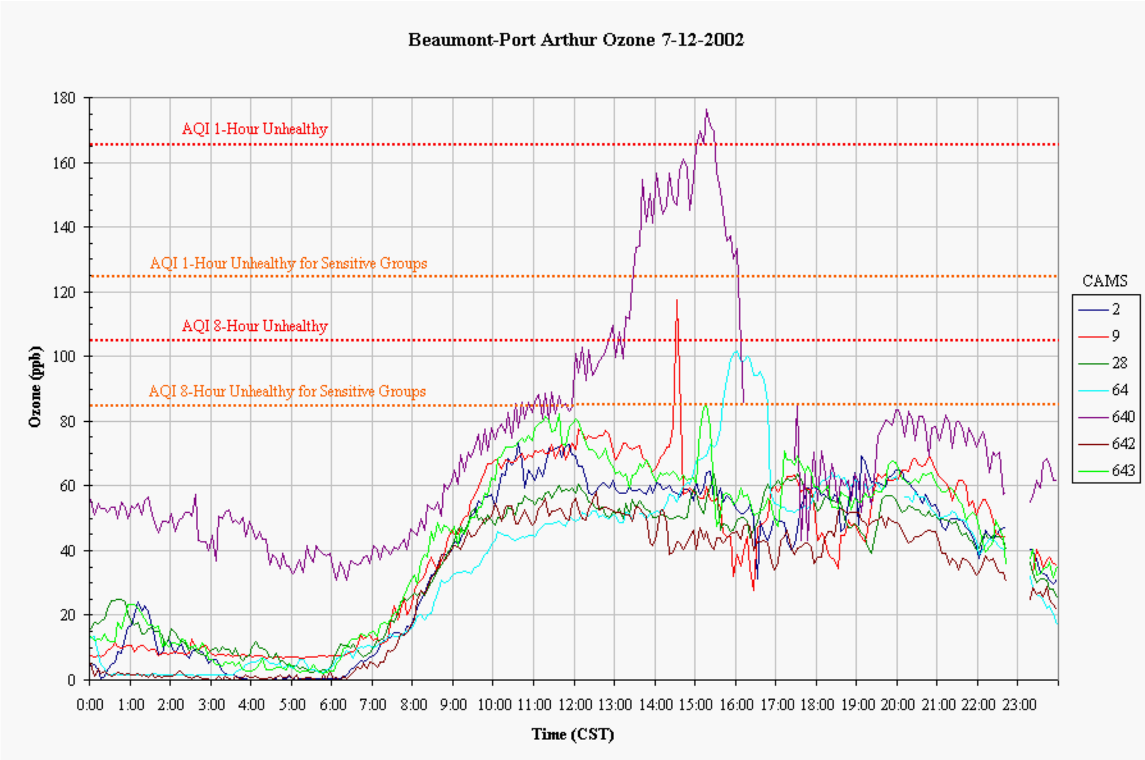

Figure 4-14. Measured ozone concentrations at BPA monitors on July 12, 2002 (Source: TCEQ).

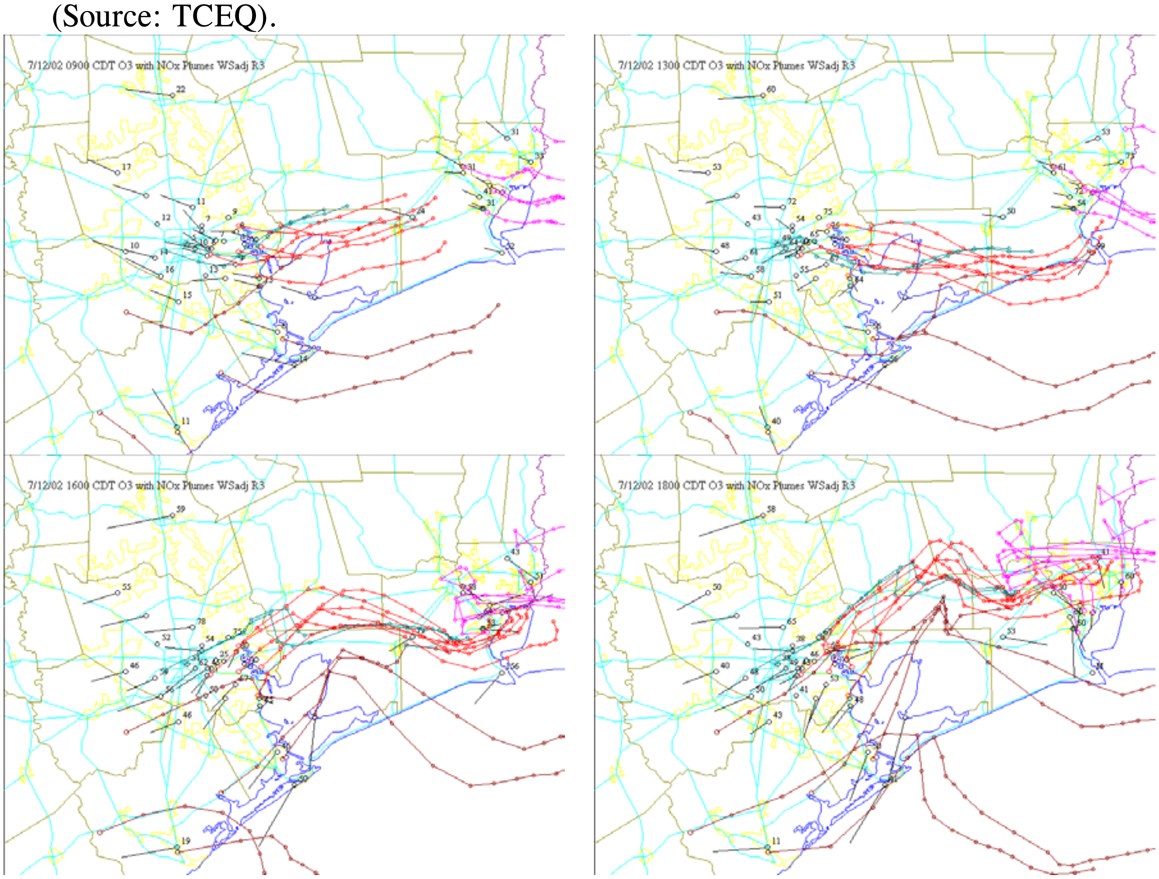

Figure 4-15. Plume animation frames for the BPA region on July 12, 2002 (Source: TCEQ).

These surface wind analyses and local transport effects provide an indication 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 BPA non-attainment area. NOAA's Air Resources Laboratory HySplit model was used to compute backward trajectories for air masses terminating in the BPA area. In addition, analyses of National Weather Service (NWS) weather maps were conducted in order to further characterize meteorology typical of the peak ozone season, June through September, in the BPA 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 polar front 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 the central US was clearly defined on most high ozone events evaluated. 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 500 mbar 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.

Individual back trajectories contain significant uncertainties due to (1) the accuracy of the underlying meteorological data and (2) the fact that each trajectory follows a single path whereas atmospheric mixing and wind shear mean that a range of back trajectories are important. To mitigate these uncertainties, we consider differences between groups of trajectories for high and low ozone days. When back trajectories are shown for individual days (in Section 5), they are shown for 3 ending heights so that the spread in direction over starting height can indicate the range of upwind areas that are potentially important.

Figure 4-16 displays a back trajectory scatter plot developed as part of the current conceptual model. Displayed are upper air back trajectories ending in the BPA area on all 1-hour and 8-hour exceedance days during the period 1997 through 2000. The trajectories show the path an air parcel follows which originated the previous day. Trajectories were run back 36 hours from mid-afternoon on each high ozone day. As can be seen, the wind trajectories tend to favor southeasterly, southerly and northeasterly directions.

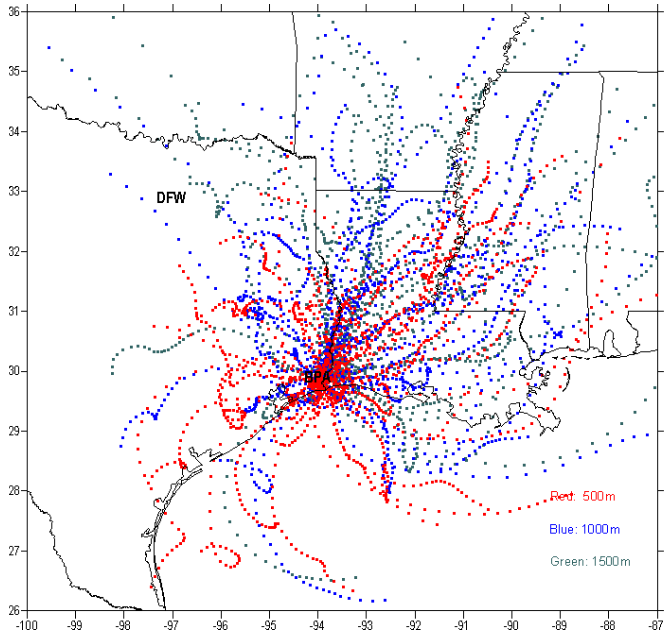

Figure 4-16. Back trajectory scatter plot on 1-hour and 8-hour ozone exceedance days during 1997-2002 in BPA. Colors indicate the ending heights for each trajectory.

Back trajectories ending in the BPA area associated with 1-hour ozone exceedances during 1997 through 2002 are displayed in Figure 4-17. Wind directions are generally from the south, southeast and northeast on 1-hour ozone exceedance days. Rarely do the winds blow from the north and northeast. Upper level trajectories (1000m and 1500m) originate as far away as the Ohio Valley on a few 1-hour exceedance days.

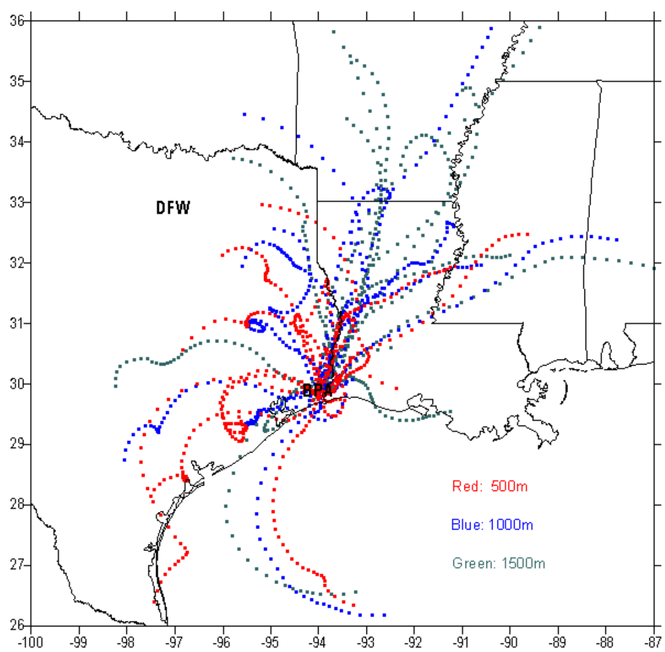

Figure 4-17. Back trajectory scatter plot on 1-hour ozone exceedance days during 1997-2002 in BPA. Colors indicate the ending heights for each trajectory.

Back trajectories associated with 8-hour exceedance days during 1997 through 2002 are displayed in Figure 4-18. The most frequent trajectory directions are from the south, southeast and northeast. Both the 1-hour and 8-hour trajectories provide evidence for potential transport from surrounding areas such as the Houston/Galveston nonattainment area and Louisiana.

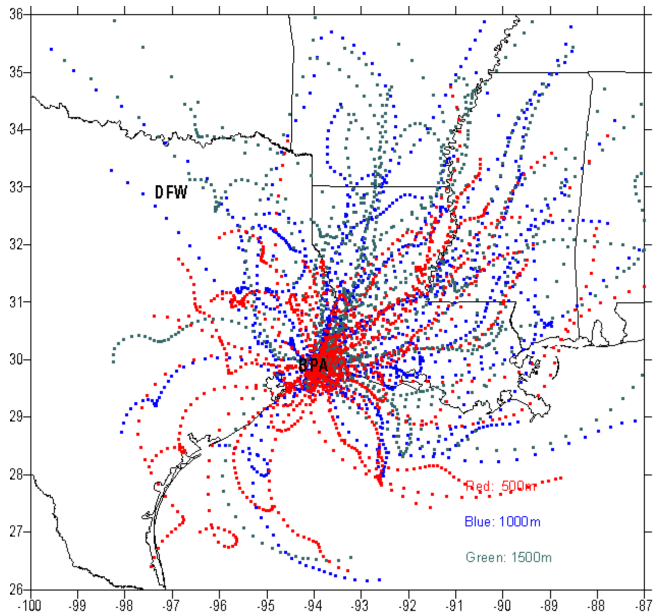

Figure 4-18. Back trajectory scatter plot on 8-hour ozone exceedance days during 1997-2002 in BPA.

A number of observations can be made based on these back trajectory scatter plots. The back trajectory plots show many easterly winds (northeast through southeast), which contrasts with the wind rose plots of Figure 4-1. This is likely due to the fact that the NOAA back trajectory meteorological data may not adequately resolve local influences (i.e., land/sea breeze) because these data are derived from coarse resolution, continental scale meteorological models. In addition, NOAA back trajectories are less representative for the BPA region than for inland areas, such as Dallas/Fort Worth. A more representative analysis might be obtained through evaluation of local back trajectories (driven by surface wind data from the CAMS network) for approximately 12 hours back on high ozone days.

To further illustrate the influence of regional transport on high ozone events in the BPA region, a recent 8-hour high ozone event was examined. On May 22, 2002, high ozone levels were measured in parts of the BPA nonattainment area. The Sabine Pass monitor (CAMS640) measured a 1-hour peak ozone concentration of 94 ppb. An 8-hour peak ozone concentration of 91 ppb was measured at CAMS640 while both the Jefferson County Airport CAMS643 and the West Orange CAMS9 measured peak 8-hour average ozone concentrations of 85 ppb. Figure 4-19 displays a time series of monitored ozone concentrations for the BPA region on May 22, 2002. The gradual rise in ozone concentrations at most monitors across the region contrasts with Figure 4-8,which displays a typical ozone time series due to high ozone events driven by local air pollution sources.

Figure 4-20 displays the wind directions in the region on this day. The wind direction is primarily from the southeast. As the CAMS640 monitor was upwind of all the local sources of ozone precursors during the period when the 8-hour ozone exceedance occurred, this implies that elevated ozone concentrations already existed in the air mass as it moved into the areas. In addition, as the winds were fairly strong and temperatures were in the range of 75 to 80 degrees Fahrenheit, local influences were minimal. The long-range back trajectory plot displayed in Figure 4-21 shows that the air parcel arriving in the BPA area on May 22, 2002 passed across the Mobile-Pensacola area on the previous day and northern Georgia and eastern Tennessee two days previous. Peak 1-hour ozone levels in these areas were in the range of 60 to 80 ppb on May 20 and May 21, 2002. Thus, this particular event is seen to be primarily due to the influence of regional transport.

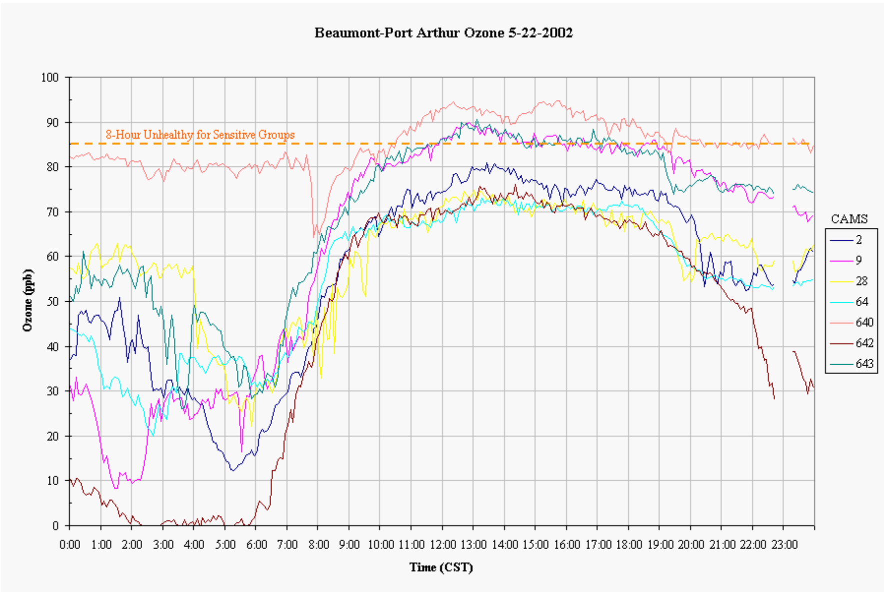

Figure 4-19. Measured ozone concentrations at BPA monitors on May 22, 2002. (Source: TCEQ)

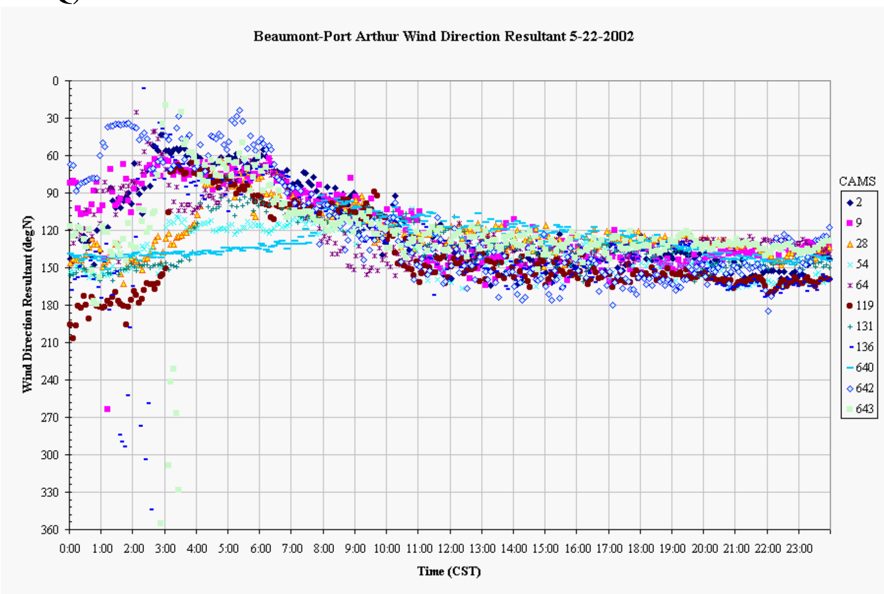

Figure 4-20. Wind directions at BPA monitors on May 22, 2002. (Source: TCEQ)

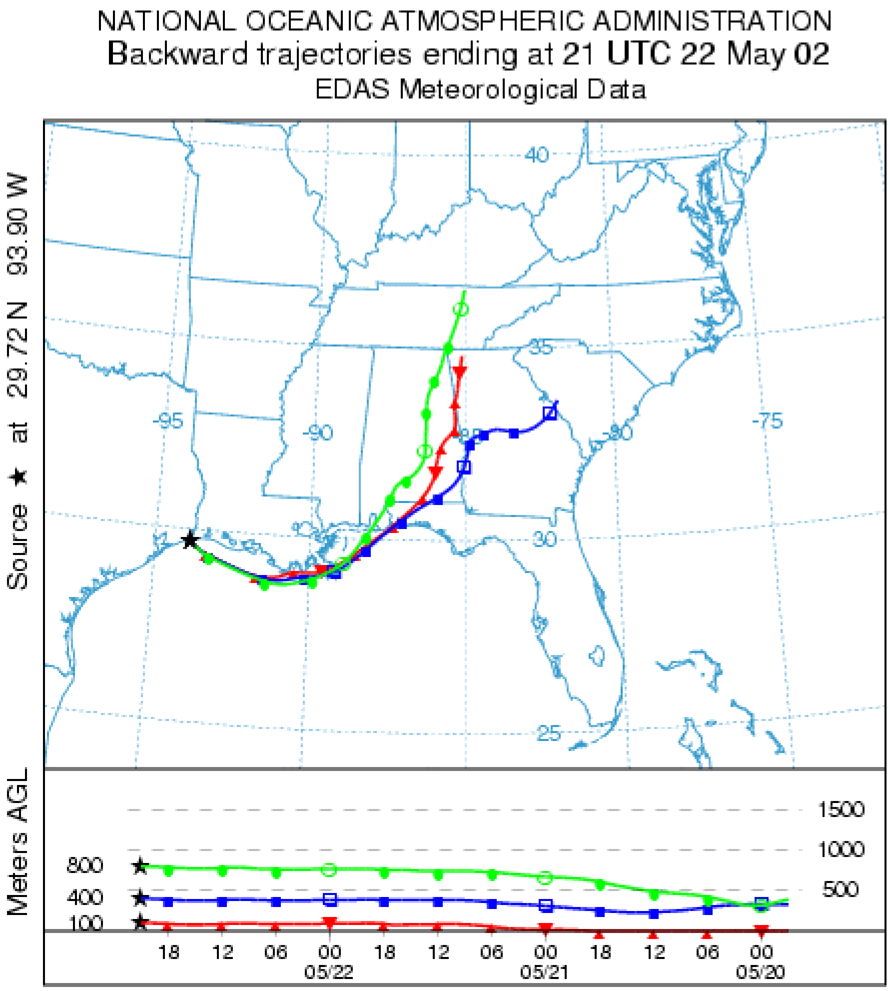

Figure 4-21. Long-range back trajectory for BPA on May 22, 2002. (Source: TCEQ)

5. EPISODE SELECTION

Based on the analyses conducted for the development of the conceptual model for ozone formation within the Beaumont/Port Arthur non-attainment area, candidate modeling episodes are identified. This section summarizes the episode selection procedures used for the BPA 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; 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 BPA considers these criteria in the selection of candidate modeling episodes.

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 two possible episodes from 2000. 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 BPA nonattainment area from 1998 through 2002 were first identified from data obtained from the TCEQ. All 1-hour and 8-hour exceedances in the BPA area are tabulated in Tables 5-1 and 5-2, respectively.

Table 5-1. One-hour ozone exceedances in BPA from 1998-2002.

Site	Date	Max 1-hour Ozone (ppb)
Beaumont C2/C112	05/18/98	143
Beaumont C2/C112	07/16/98	129
West Orange C9/C141	07/18/98	126
Beaumont C2/C112	08/30/98	149
SETRPC 43 Jefferson Co Airport C643	08/03/99	146
SETRPC 43 Jefferson Co Airport C643	08/20/99	126
SETRPC 43 Jefferson Co Airport C643	08/28/99	131
Port Arthur West C28/C128/C228	08/12/00	126
Beaumont C2/C112	08/30/00	134
West Orange C9/C141	08/30/00	133
Port Arthur West C28/C128/C228	08/30/00	165
Hamshire C64	08/30/00	131
SETRPC 40 Sabine Pass C640	08/30/00	162
SETRPC 43 Jefferson Co Airport C643	08/30/00	143
SETRPC 40 Sabine Pass C640	08/31/00	152
Port Arthur West C28/C128/C228	09/01/00	160
Hamshire C64	09/01/00	144
SETRPC 43 Jefferson Co Airport C643	09/01/00	145
SETRPC 43 Jefferson Co Airport C643	08/05/01	126
SETRPC 40 Sabine Pass C640	08/06/01	127
SETRPC 40 Sabine Pass C640	07/12/02	156
SETRPC 40 Sabine Pass C640	08/05/02	130
SETRPC 40 Sabine Pass C640	09/14/02	144

Table 5-2. Eight-hour ozone exceedances in BPA from 1998-2002.

Site	Date	Max 8-Hour Ozone (ppb)
West Orange C9/C141	05/18/1998	80
Port Arthur West C28/C128/C228	05/19/1998	92
West Orange C9/C141	05/19/1998	85
West Orange C9/C141	07/18/1998	93
Beaumont C2/C112	07/18/1998	96
Port Arthur West C28/C128/C228	08/28/1998	91
Port Arthur West C28/C128/C228	08/29/1998	87
Beaumont C2/C112	08/30/1998	99
Port Arthur West C28/C128/C228	09/03/1998	94
Beaumont C2/C112	09/04/1998	97
Beaumont C2/C112	10/01/1998	98
SETRPC 43 Jefferson Co Airport C643	08/03/1999	94
Beaumont C2/C112	08/06/1999	86
Port Arthur West C28/C128/C228	08/28/1999	85
SETRPC 43 Jefferson Co Airport C643	08/28/1999	112
SETRPC 43 Jefferson Co Airport C643	09/18/1999	101
SETRPC 43 Jefferson Co Airport C643	09/19/1999	100
SETRPC Mauriceville 42 C642/C311	10/14/1999	88
SETRPC 40 Sabine Pass C640	10/22/1999	92
SETRPC Mauriceville 42 C642/C311	05/22/2000	86
West Orange C9/C141	05/22/2000	88
SETRPC 43 Jefferson Co Airport C643	07/24/2000	84
Beaumont C2/C112	07/25/2000	94
Beaumont C2/C112	07/26/2000	90
Port Arthur West C28/C128/C228	08/12/2000	99
Hamshire C64	08/12/2000	85
SETRPC 40 Sabine Pass C640	08/12/2000	88
Hamshire C64	08/13/2000	89
West Orange C9/C141	08/19/2000	92
Beaumont C2/C112	08/21/2000	96
Port Arthur West C28/C128/C228	08/30/2000	115
SETRPC 40 Sabine Pass C640	08/30/2000	115
SETRPC 43 Jefferson Co Airport C643	08/30/2000	95
West Orange C9/C141	08/30/2000	94
Port Arthur West C28/C128/C228	08/31/2000	105
SETRPC 40 Sabine Pass C640	08/31/2000	104
Hamshire C64	08/31/2000	85
Hamshire C64	09/01/2000	91
SETRPC 43 Jefferson Co Airport C643	09/01/2000	90
West Orange C9/C141	09/01/2000	87
SETRPC 40 Sabine Pass C640	09/04/2000	97
Port Arthur West C28/C128/C228	09/04/2000	97
SETRPC Mauriceville 42 C642/C311	09/18/2000	86
Beaumont C2/C112	09/18/2000	89
West Orange C9/C141	05/23/2001	85
SETRPC Mauriceville 42 C642/C311	05/23/2001	91
Port Arthur West C28/C128/C228	05/23/2001	86
SETRPC 43 Jefferson Co Airport C643	05/23/2001	92
Hamshire C64	06/24/2001	85
SETRPC 40 Sabine Pass C640	08/04/2001	102

Site	Date	Max 8-Hour Ozone (ppb)
Port Arthur West C28/C128/C228	08/05/2001	94
SETRPC 40 Sabine Pass C640	08/05/2001	104
SETRPC 43 Jefferson Co Airport C643	08/05/2001	98
SETRPC 40 Sabine Pass C640	08/06/2001	100
SETRPC 43 Jefferson Co Airport C643	08/06/2001	90
SETRPC 40 Sabine Pass C640	08/23/2001	87
SETRPC 43 Jefferson Co Airport C643	09/15/2001	90
SETRPC 43 Jefferson Co Airport C643	05/22/2002	85
SETRPC 40 Sabine Pass C640	07/12/2002	116
West Orange C9/C141	07/24/2002	87
SETRPC 40 Sabine Pass C640	09/11/2002	95
West Orange C9/C141	09/11/2002	85
Port Arthur West C28/C128/C228	09/12/2002	87
SETRPC 43 Jefferson Co Airport C643	09/12/2002	91
West Orange C9/C141	09/12/2002	91
SETRPC 40 Sabine Pass C640	09/12/2002	95
SETRPC 40 Sabine Pass C640	09/14/2002	121
West Orange C9/C141	09/14/2002	94
SETRPC 43 Jefferson Co Airport C643	09/14/2002	87

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 ozone season. 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:

- July 16-18, 1998
- August 3-6, 1999
- August 10-14, 2000
- August 29 – September 2, 2000
- August 3-6, 2001

Each of these preliminary episode periods was further evaluated with respect to EPA episode selection criteria.

July 16-18, 1998

Figure 5-1 displays back trajectories for the BPA nonattainment area on July 16-18, 1998. As seen, the long-range transport is from the southwest, northwest and northeast. It should be noted that back trajectories for this period were developed from NOAA's Hysplit model using FNL meteorological data fields since EDAS data are unavailable for these dates. This has important consequences for episode selection since the required meteorological modeling may be missing key input data that could compromise the modeling.

Figures 5-2 and 5-3 display time series of measured 1-hour and 8-hour ozone concentrations on July 16-18, 1998 in the BPA area, respectively. Both the Beaumont (CAMS2) and West Orange (CAMS9) measured 1-hour exceedances during this period, although the daily maximum 1-hour ozone concentrations were only slightly above the standard (129 and 126 ppb, respectively) and well below the current 1-hour design value of 134 ppb but within 10 ppb as required by EPA guidance. Measured 8-hour ozone concentrations exceeded the standard at both the CAMS2 and CAMS9 monitors on July 18, 1998. Eight-hour ozone exceedances of 93 ppb and 96 ppb at these monitors fall within approximately 10 ppb of the current design value of 85 ppb in BPA and therefore satisfies this EPA criteria for candidate episodes. Thus, this episode may be acceptable for attainment demonstration modeling for the 8-hour standard, but is less than ideal for addressing 1-hour attainment demonstration. On the downside, the episode occurred just outside the current design value 3-year window and, in addition, was not during the most frequent exceedance period of August/September.

Based on the analysis of this episode with respect to ozone exceedances, meteorological factors, data availability, currentness, and current design values, the episode was eliminated from further consideration as a candidate modeling episode.

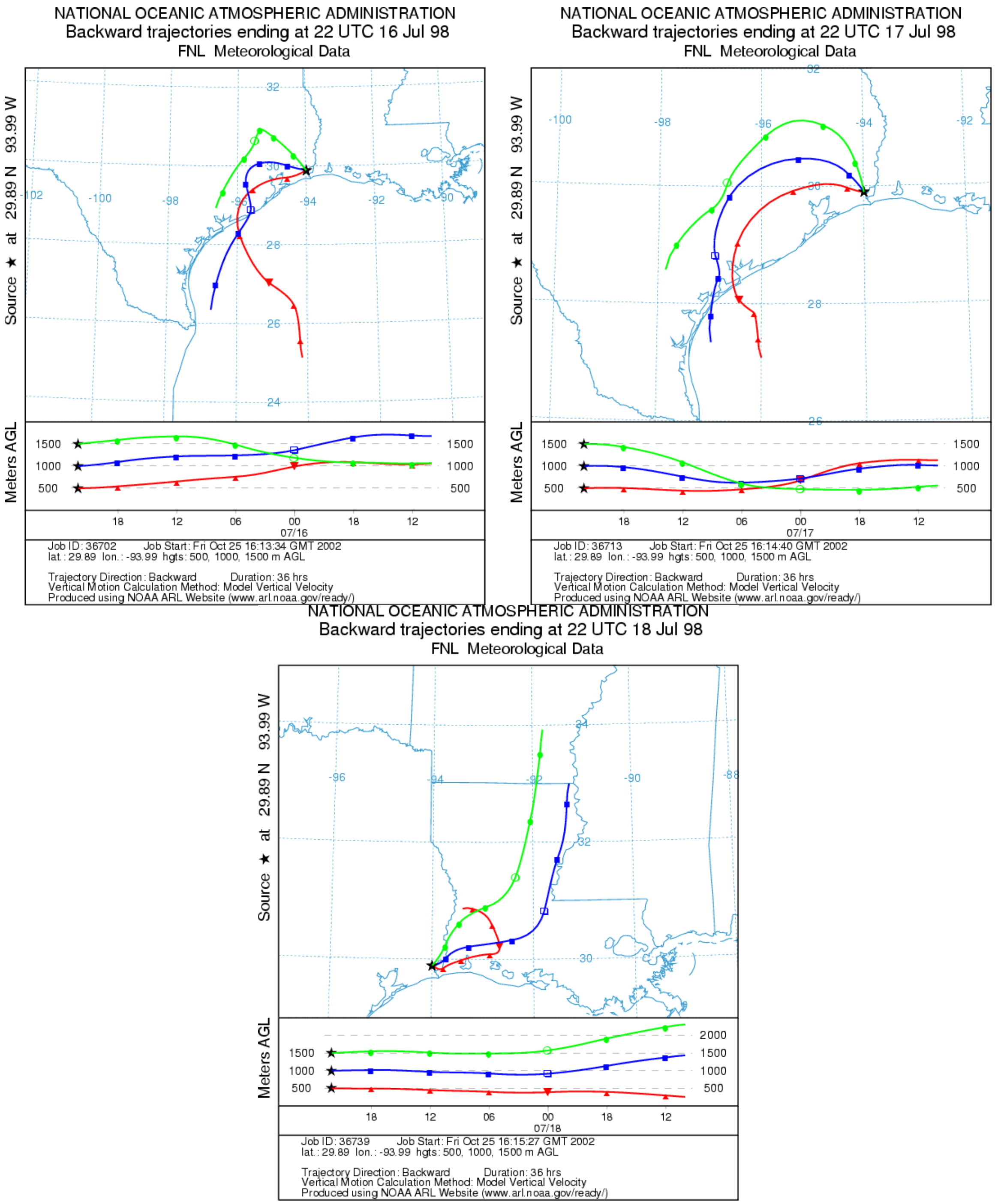

Figure 5-1. BPA back trajectories for July 16-18, 1998.

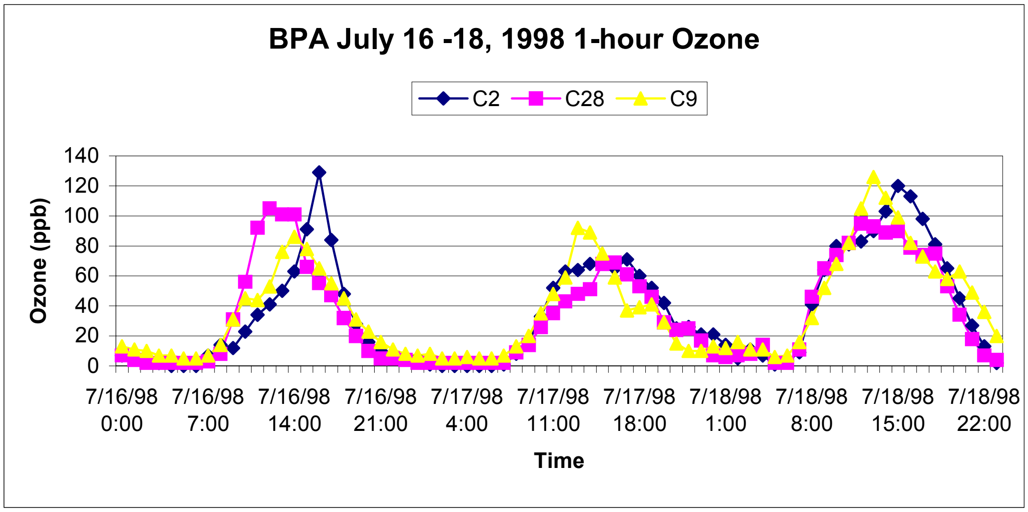

Figure 5-2. Time series of observed 1-hour ozone concentrations in BPA for July 16-18,1998.

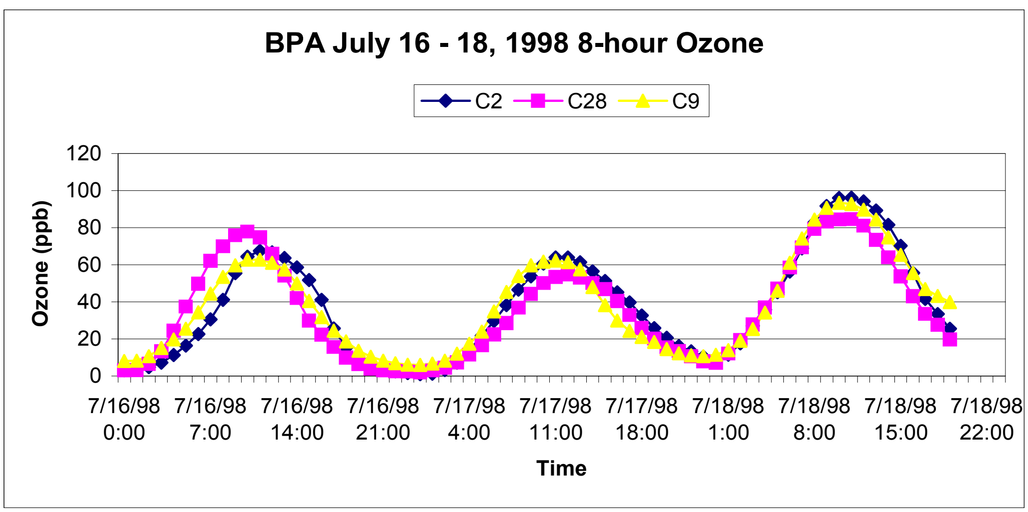

Figure 5-3. Time series of observed 8-hour ozone concentrations in BPA for July 16-18,1998.

August 3-6, 1999

The August 3-6, 1999 episode exhibits both 1-hour and 8-hour ozone exceedances at the SETRPC 43 monitor (CAMS643). Measured 8-hour ozone concentrations at the CAMS2 monitor exceeded the standard on August 6, 1999. Back trajectories for this episode in BPA are displayed in Figure 5-4. Long-range transport is mainly from the north-northeast, typical of high ozone events in the region. Time series of observed 1-hour and 8-hour ozone concentrations are displayed in Figures 5-5 and 5-6, respectively. Given that one monitor measured 1-hour ozone exceedances and only two monitors measured 8-hour ozone exceedances during this period it does not satisfy the EPA's multi-day attainment test criteria and is therefore not recommended as a candidate modeling episode.

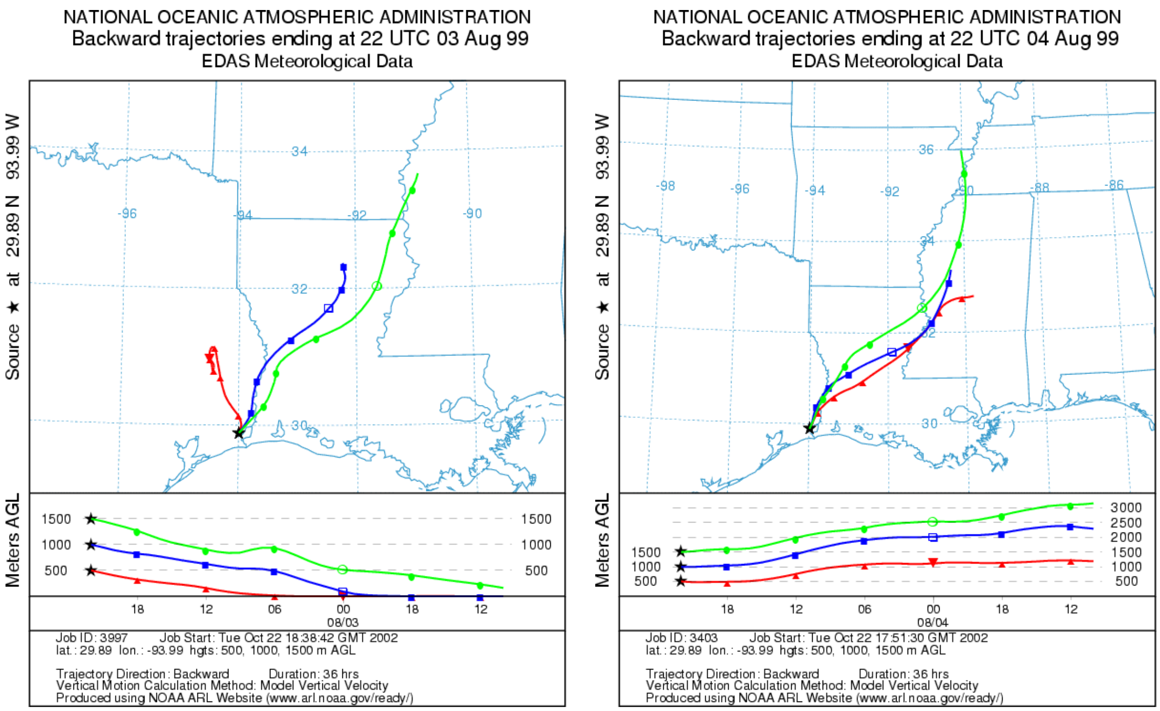

Figure 5-4. BPA back trajectories for August 3-6, 1999.

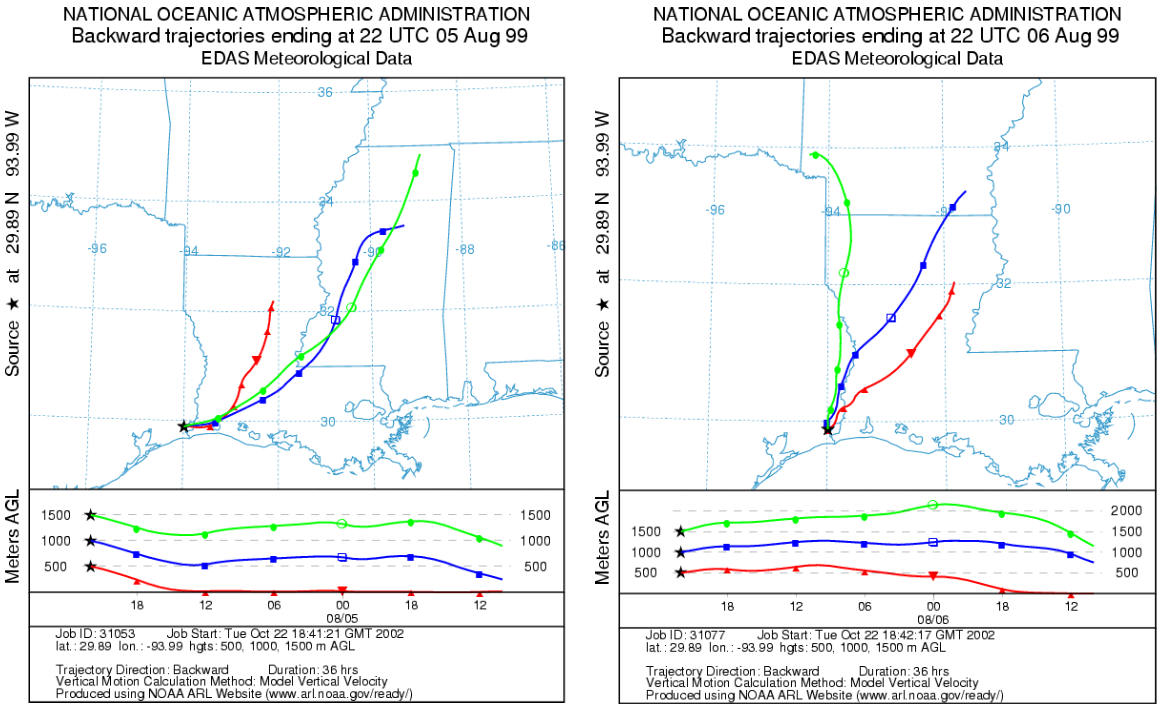

Figure 5-4. (concluded). BPA back trajectories for August 3-6, 1999.

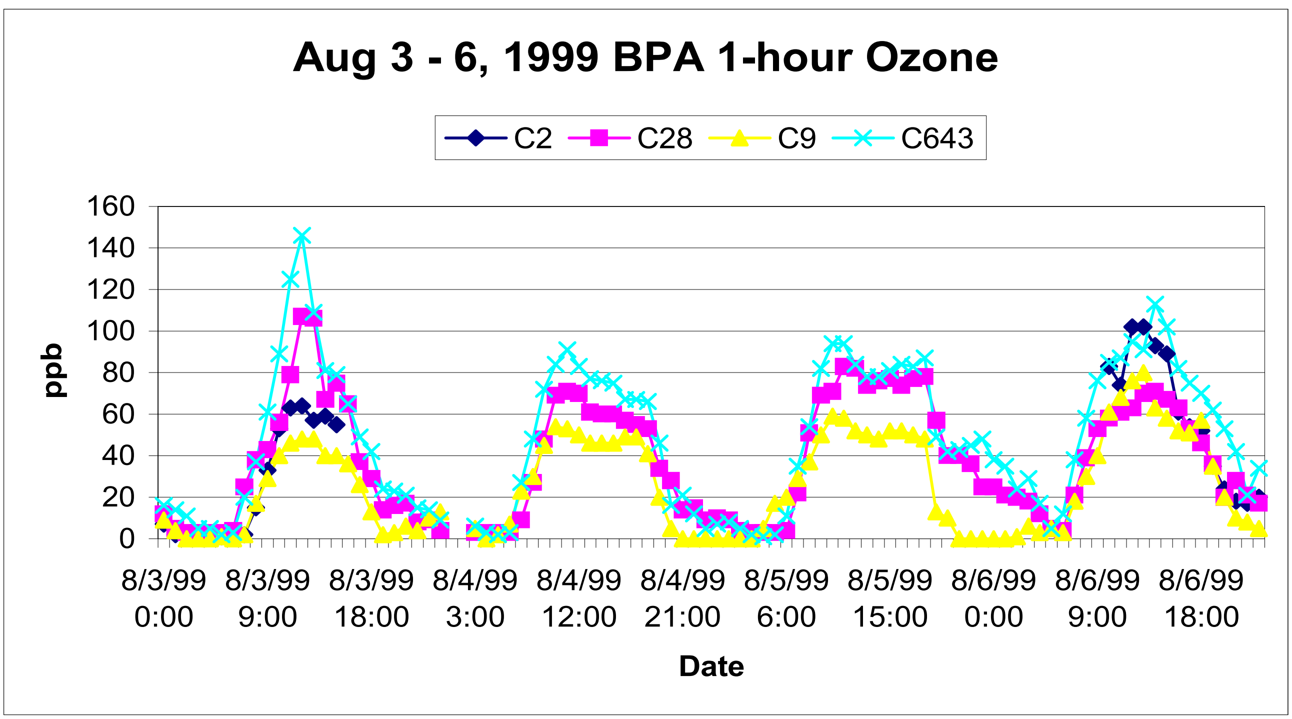

Figure 5-5. Time series of observed 1-hour ozone concentrations in BPA for August 3-6, 1999.

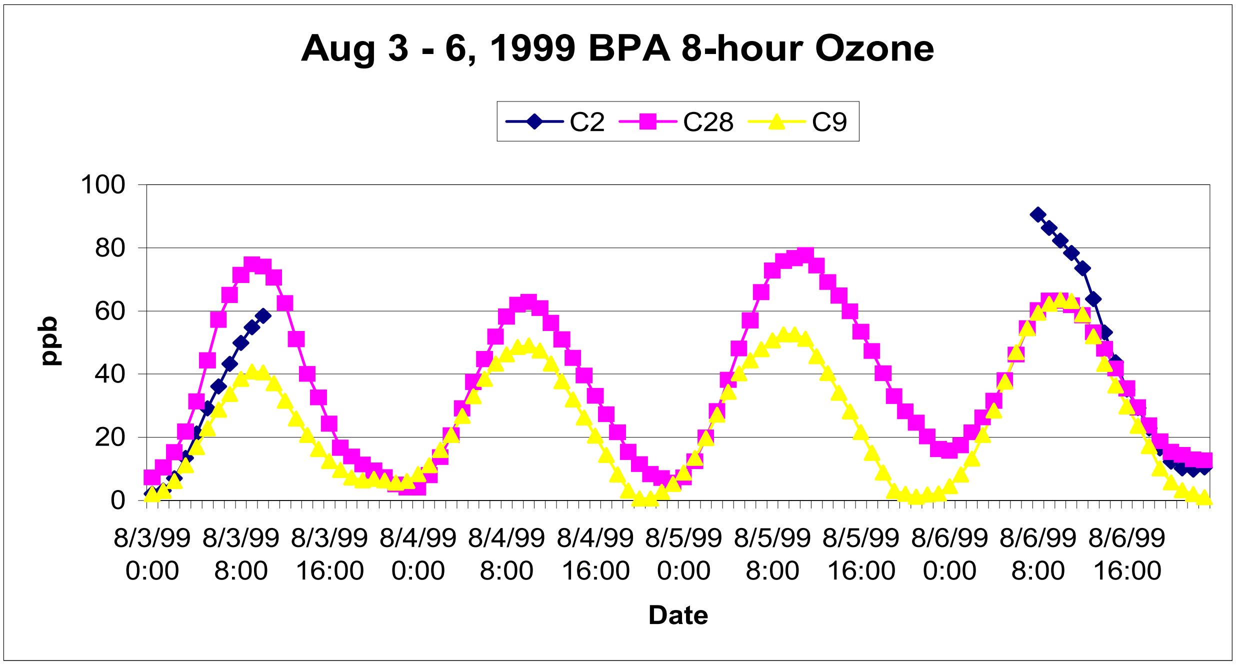

Figure 5-6. Time series of observed 8-hour ozone concentrations in BPA for August 3-6, 1999.

<u>August 10-14, 2000</u>

Two potential episodes in 2000 were identified for consideration; August 10-14 and August 29-September 2, 2000. Back trajectories for BPA on August 10-14, 2000 are displayed in Figure 5-7 while time series of observed 1-hour and 8-hour ozone concentrations are displayed in Figures 5-8 and 5-9, respectively. During this period only one monitor measured a 1-hour ozone exceedance on August 12, 2000 (CAMS28; 126 ppb) although the exceedance was only slightly above the standard. Three monitors measured 8-hour exceedances on August 12 and one 8-hour exceedance was measured on August 13, 2000, as shown in Tables 5-1 and 5-2.

Based on the trajectory plots of Figure 5-7, both local and long-range transport is seen to influence ozone air quality in BPA during this episode. In addition, possible transport from the Houston region and East Texas can be seen during the first two days of the episode. The final days of this period (August 12 and August13) during which both the 1-hour and 8-hour exceedances were measured represent transport from the east and northeast, characteristics of high 8-hour ozone events as illustrated by the case studies presented in Section 4. This episode may be acceptable for attainment demonstration of the 8-hour standard, but is not ideal for 1-hour ozone modeling as only one exceedance was measured and that exceedance was only slightly above the 1-hour standard.

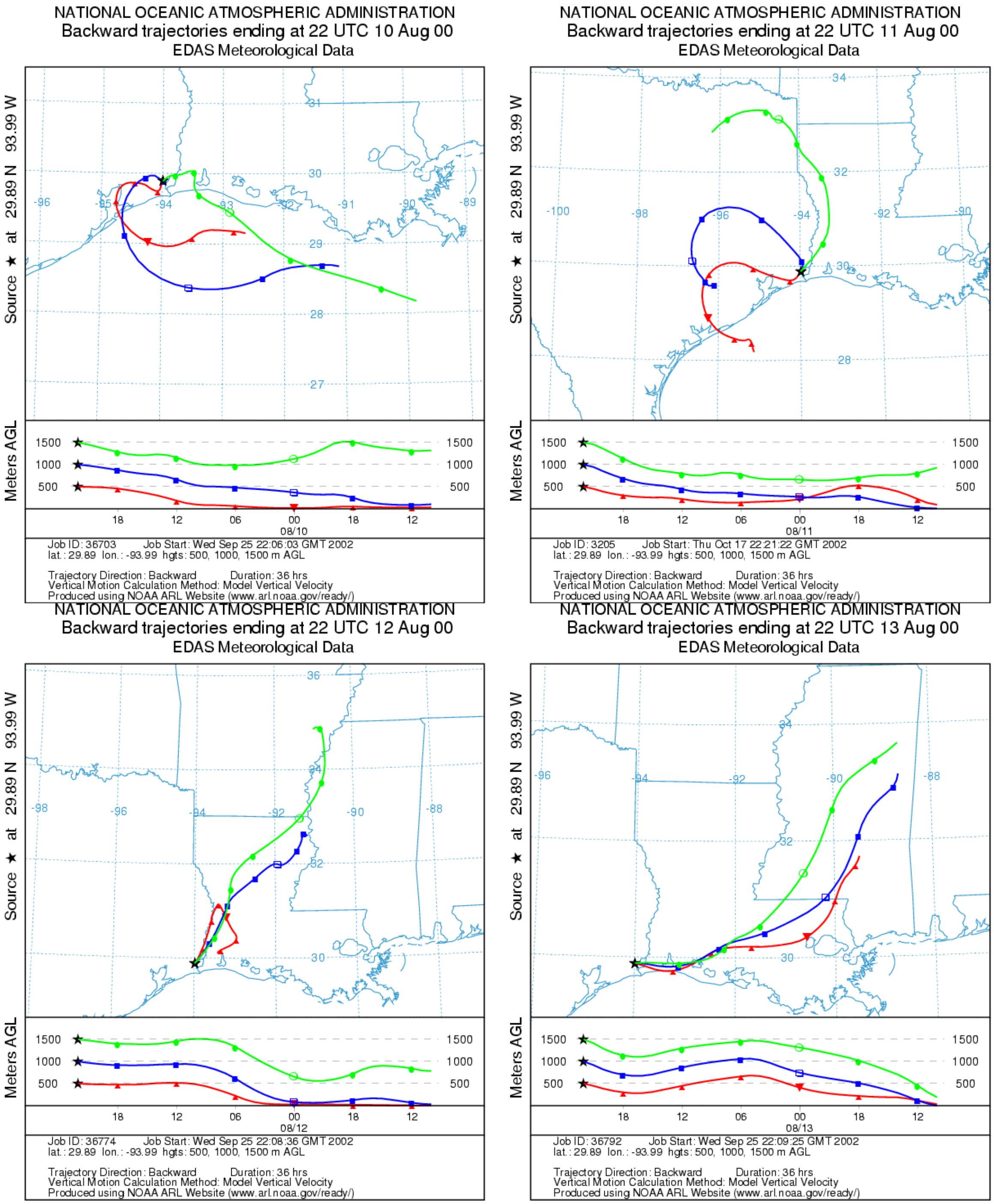

Figure 5-7. BPA back trajectories for August 10-13, 2000.

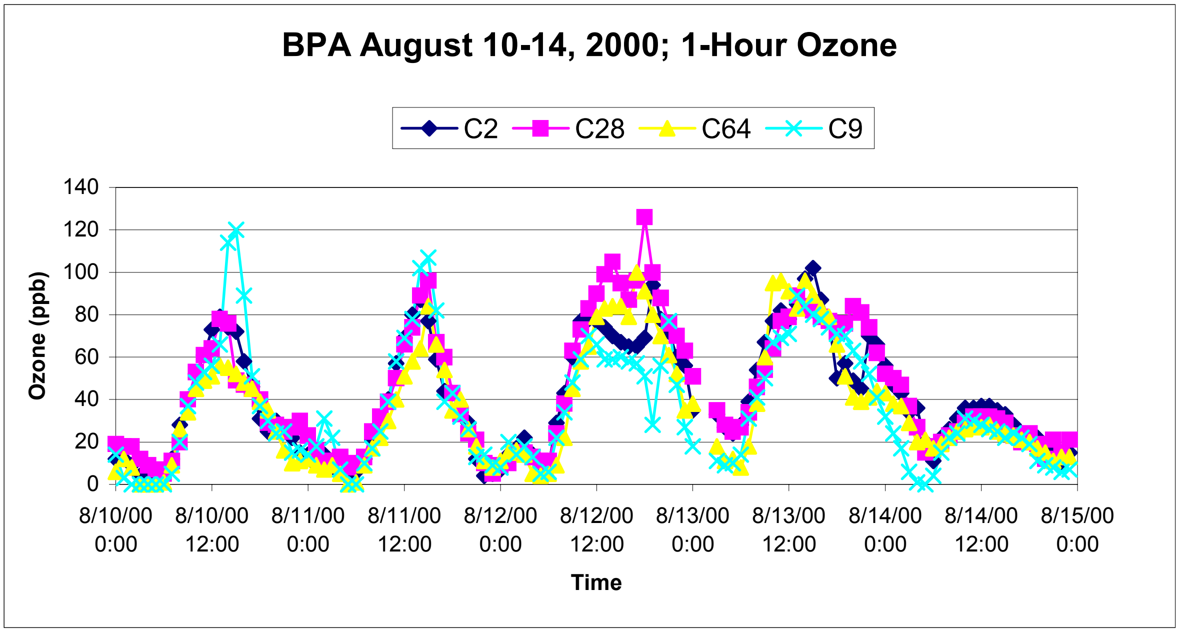

Figure 5-8. Time series of observed 1-hour ozone concentrations in BPA for August 10-14, 2000.

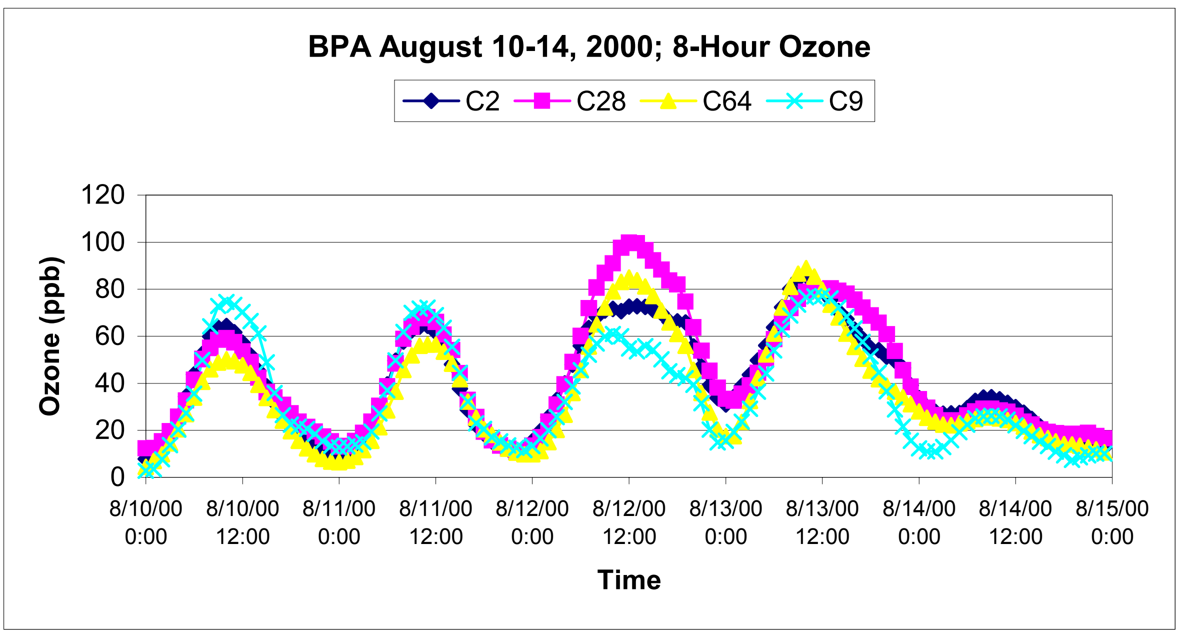

Figure 5-9. Time series of observed 8-hour ozone concentrations in BPA for August 10-14, 2000.

August 29 – September 2, 2000

The remaining 2000 episode identified for consideration is August 29-September 2, 2000. Back trajectories for BPA on these days are displayed in Figure 5-10. As seen, transport during this time period varied from east/southeast to north and northeast. Synoptic-scale meteorology during this time period can be summarized as follows based on examination of NWS weather maps.

A strong ridge over the central US kept storms well to the north of Texas on August 29 and 30. From August 31 to the end of the episode, the ridge was over the eastern US while a deep slow-moving trough was on the west. The jet stream stayed north of Texas throughout the period, but was sagging southwards on September 2.

On August 29, a 1021mb surface high was over Nebraska and a stronger 1027mb high was centered over Maine. In between, a cold front crossed through Wisconsin and ended in eastern Colorado. In Texas, pressure gradients were weak with coastal areas reporting slightly higher pressure compared to the interior. In the morning, winds near Beaumont were 5kts from the west-northwest; in the afternoon, there was a 5-10kt southerly onshore flow.

All systems moved eastward during the next two days as the high that was originally over Nebraska reached northern Maine by August 31. Behind it, a low-pressure system was falling apart as it moved into the Northern Plains, and a high in central Canada was strengthening. Pressure gradients remained very light throughout Texas. On August 30, winds were light and variable near Beaumont. On the 31st, a light afternoon sea breeze was detected with light rain showers in the vicinity.

On September 1 and 2, the area of lower pressure moved eastward without impacting Texas. Behind it, strong high pressure was observed in central Canada, while surface pressure gradients continued to be weak over Texas. In the mornings, conditions were muggy with haze, fog, and nearly calm winds. In the afternoon, thunderstorms were observed on both afternoons as short convergence bands were observed in Louisiana and eastern Texas.

As shown in Tables 5-1 and 5-2, several exceedances of both the 1-hour and 8-hour ozone standards were measured at many monitoring sites in the BPA region. One-hour ozone exceedances as high as 165 ppb were measured at the Port Arthur West (CAMS28) monitoring station on August 30, with a measured 1-hour ozone concentration of 162 ppb measured at CAMS640. A 1-hour ozone exceedance of 160 ppb was also measured on September 1 at the CAMS28 monitor. Several other monitors in the region recorded high 1-hour ozone concentrations ranging from 131 ppb to 145 ppb during the episode.

Multiple 8-hour ozone exceedances also were measured at several monitors during this episode. Table 5-2 displays the monitored 8-hour ozone concentrations in the BPA nonattainment area. Both Port Arthur West (CAMS28) and Sabine Pass (CAMS640) measured an 8-hour ozone concentration of 115 ppb on August 30. These same monitors measured high 8-hour ozone concentrations the following day as well (CAMS28, 105 ppb; CAMS640, 104 ppb). The remaining 8-hour ozone exceedances during this episode ranged from 85 ppb to 96 ppb. Figures 5-11 and 5-12 display time series of observed 1-hour and 8-hour ozone concentration in the region, respectively.

This episode represents a good candidate for both 1-hour and 8-hour attainment demonstration modeling due to the multiple high ozone measurements through the period. This time period also coincides with Texas Air Quality Study of 2000 (TexAQS2000) and so is supported by robust data sets for ozone and precursor pollutants. Meteorological modeling databases are also fairly robust for this episode. The episode occurs during the primary ozone season in BPA of August/September and is also within the current design value 3-year window as recommended by EPA guidance, with several measured exceedances within 10 ppb of the 1-hour and 8-hour design values. It should be noted, however, that the relatively high 1-hour ozone concentrations of 165 ppb and 162 ppb on August 30 and the measured 1-hour ozone concentration of 160 ppb on September 1 might pose potential air quality model performance issues. Modeled peak ozone concentrations are likely to suffer from under-predictions, which in turn will impact other model performance statistical metrics. Nevertheless, this episode is an attractive choice for both 1-hour and 8-hour ozone air quality modeling.

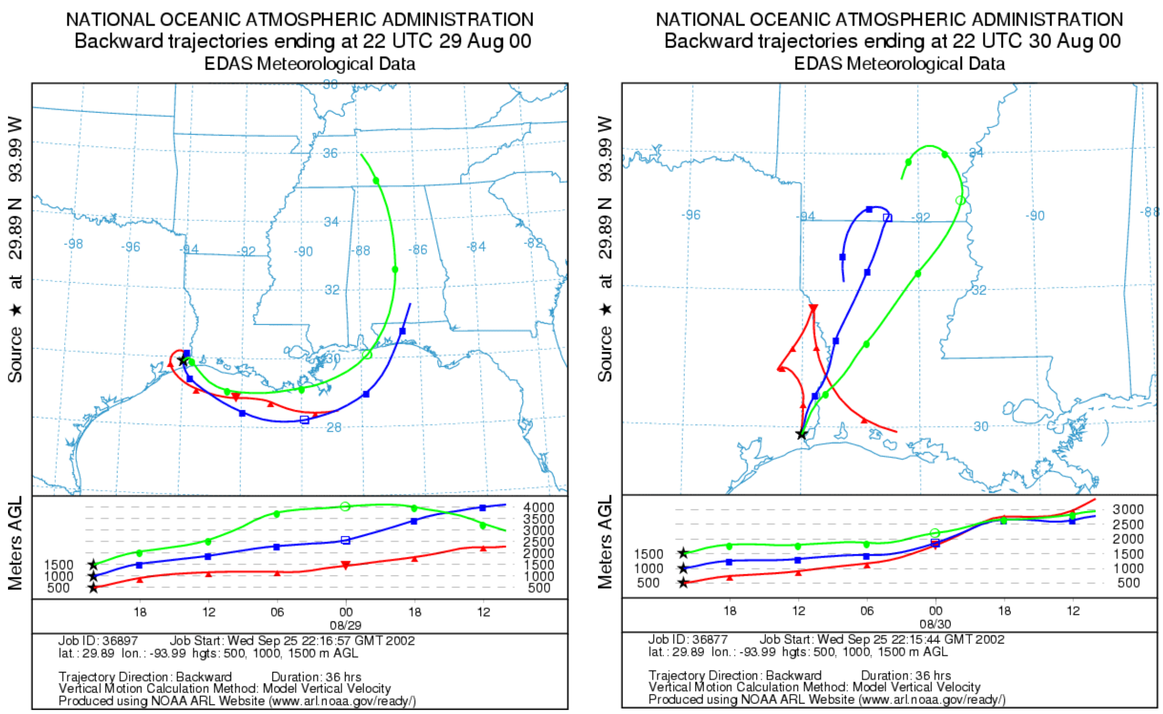

Figure 5-10. BPA back trajectories for August 29-September 2, 2000.

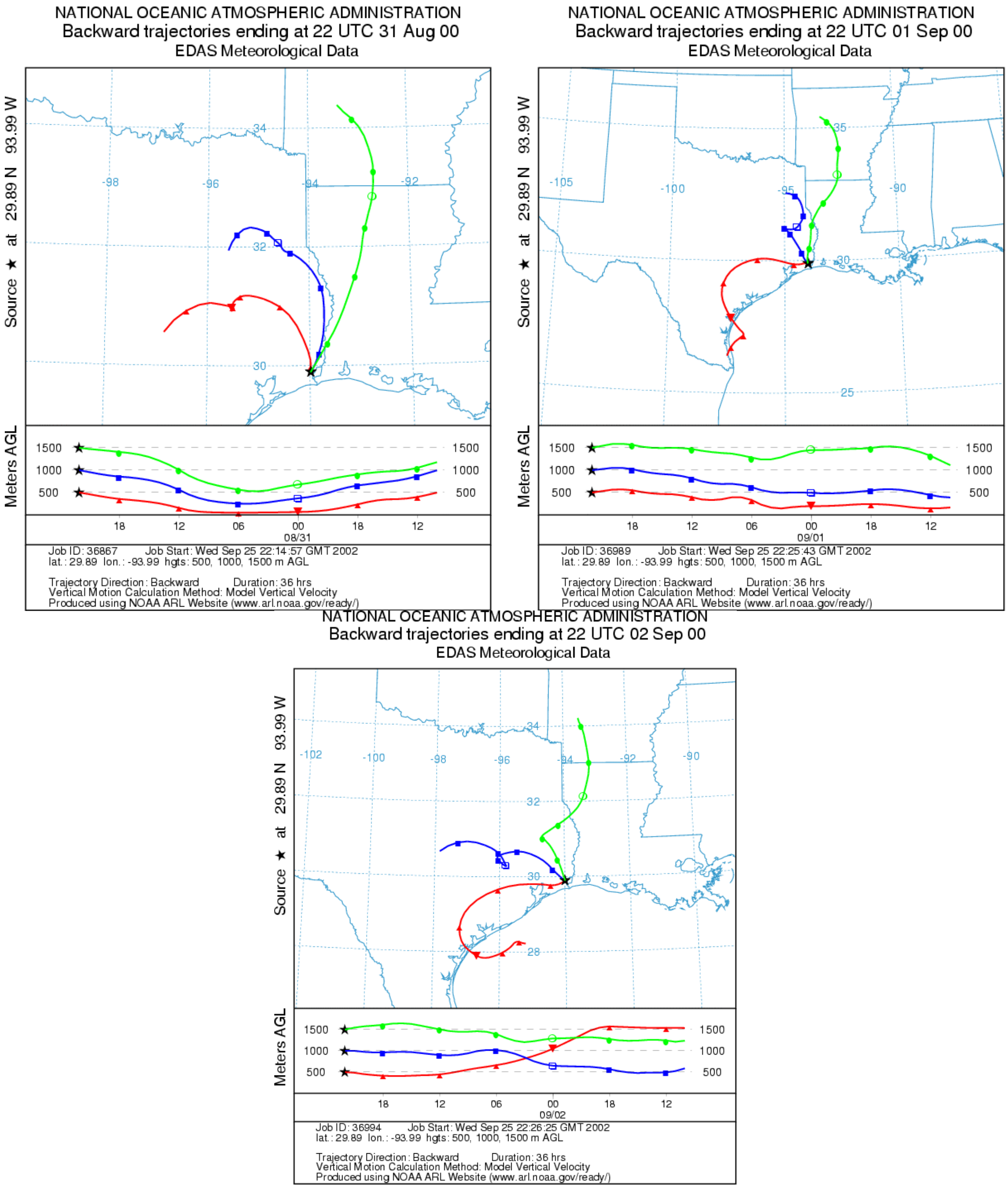

Figure 5-10. (concluded). BPA back trajectories for August 29-September 2, 2000.

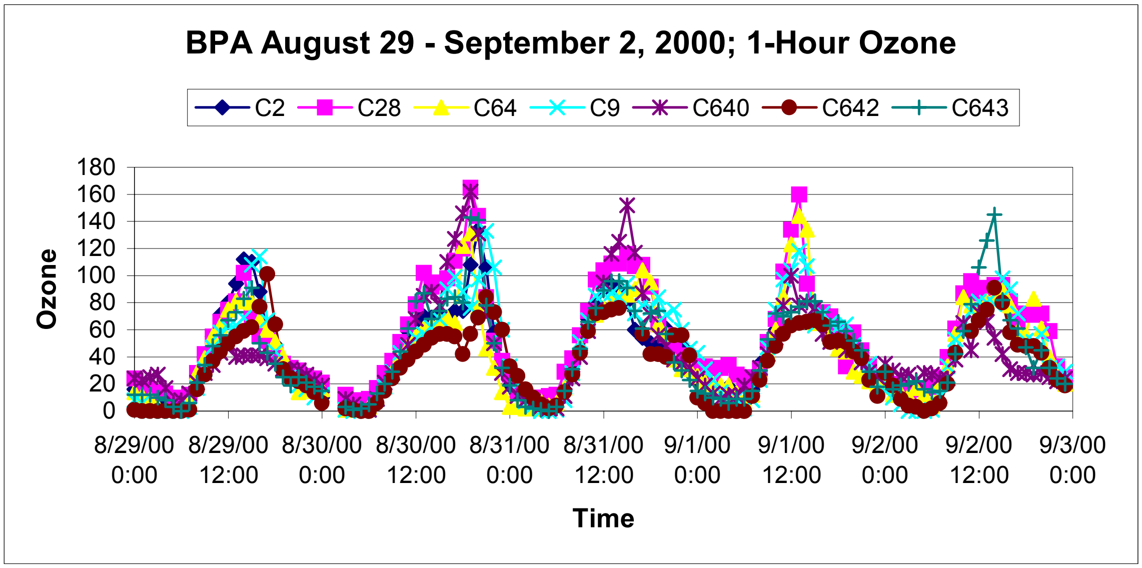

Figure 5-11. Time series of observed 1-hour ozone concentrations in BPA for August 29-September 2, 2000.

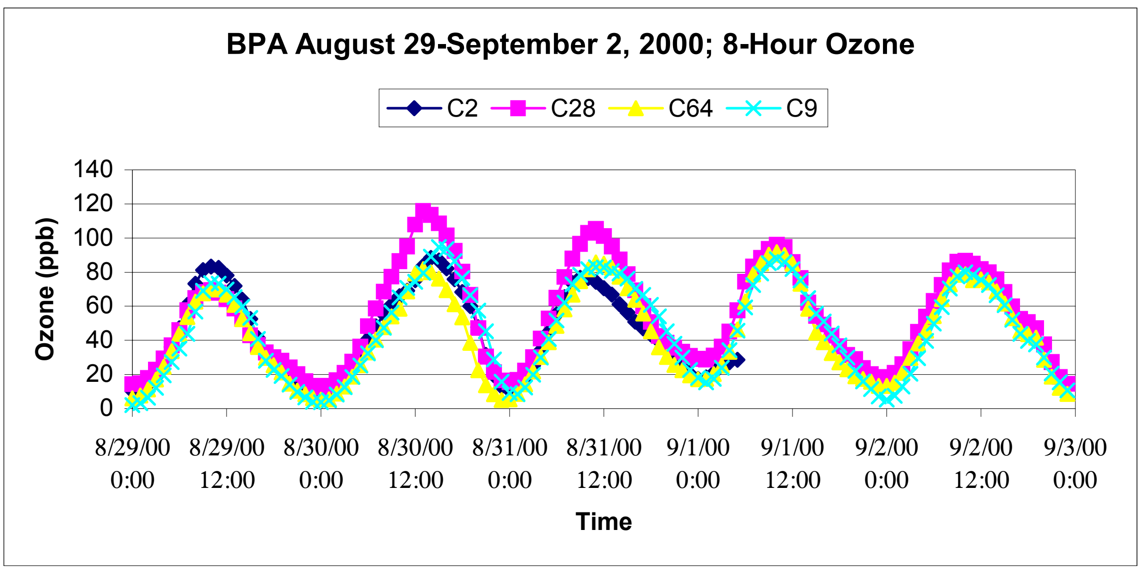

Figure 5-12. Time series of observed 8-hour ozone concentrations in BPA for August 29-September 2, 2000.

August 3-6, 2001

The final candidate episode identified for further evaluation is August 3-6, 2001. During this episode, several monitors recorded exceedances of the 8-hour ozone standard. Peak 8-hour ozone concentrations were 102 ppb on August 4, 104 ppb on August 5, and 100 ppb on August 6, 2001, all measured at the Sabine Pass monitor, CAMS640 (see Table 5-2). One-hour ozone exceedances were also measured on the 5th and 6th of August, although the exceedances were only slightly above the standard.

Back trajectory plots for BPA during this episode are displayed in Figure 5-13. The primary transport directions are from the east and northeast representing transport from the southern tier of states. This situation is similar to the May 22, 2002 case study discussed in Section 4. Figures 5-14 and 5-15 present time series of observed 1-hour and 8-hour ozone concentrations at selected monitors in the BPA region. While this episode may be a good candidate for 8-hour ozone air quality modeling, the lack of multiple high 1-hour exceedances makes the episode less attractive for addressing attainment demonstration for the 1-hour NAAQS.

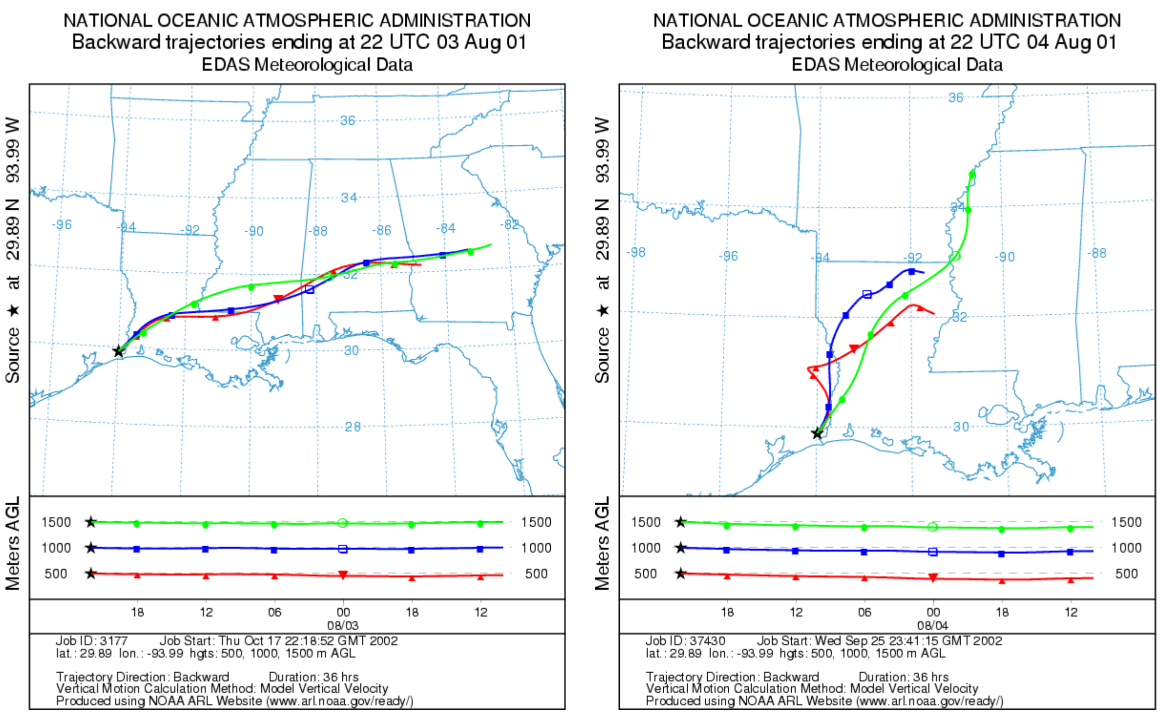

Figure 5-13. BPA back trajectories for August 3-6, 2001.

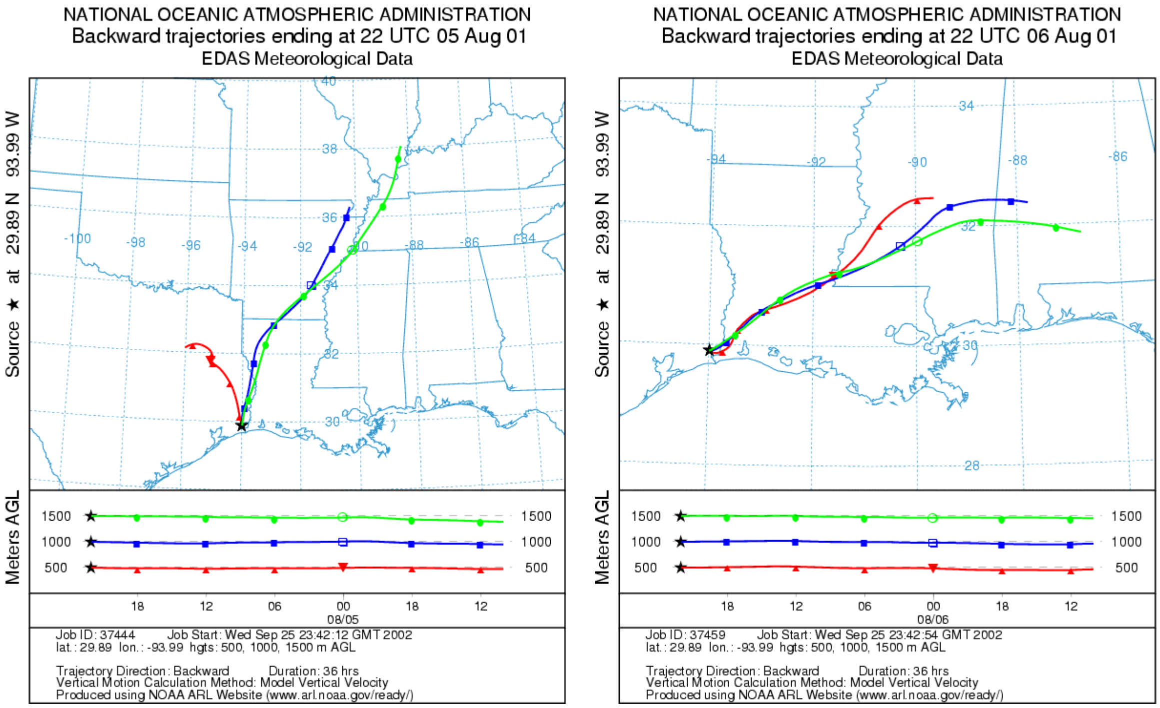

Figure 5-13. (concluded). BPA back trajectories for August 3-6, 2001.

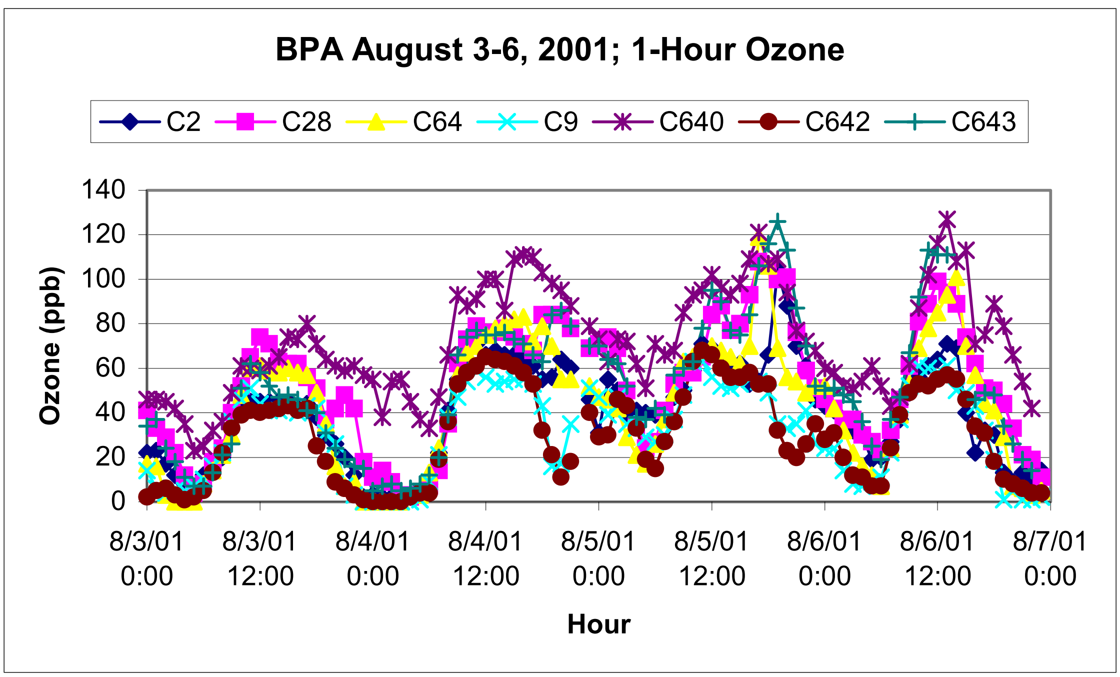

Figure 5-14. Time series of observed 1-hour ozone concentrations in BPA for August 3-6, 2001.

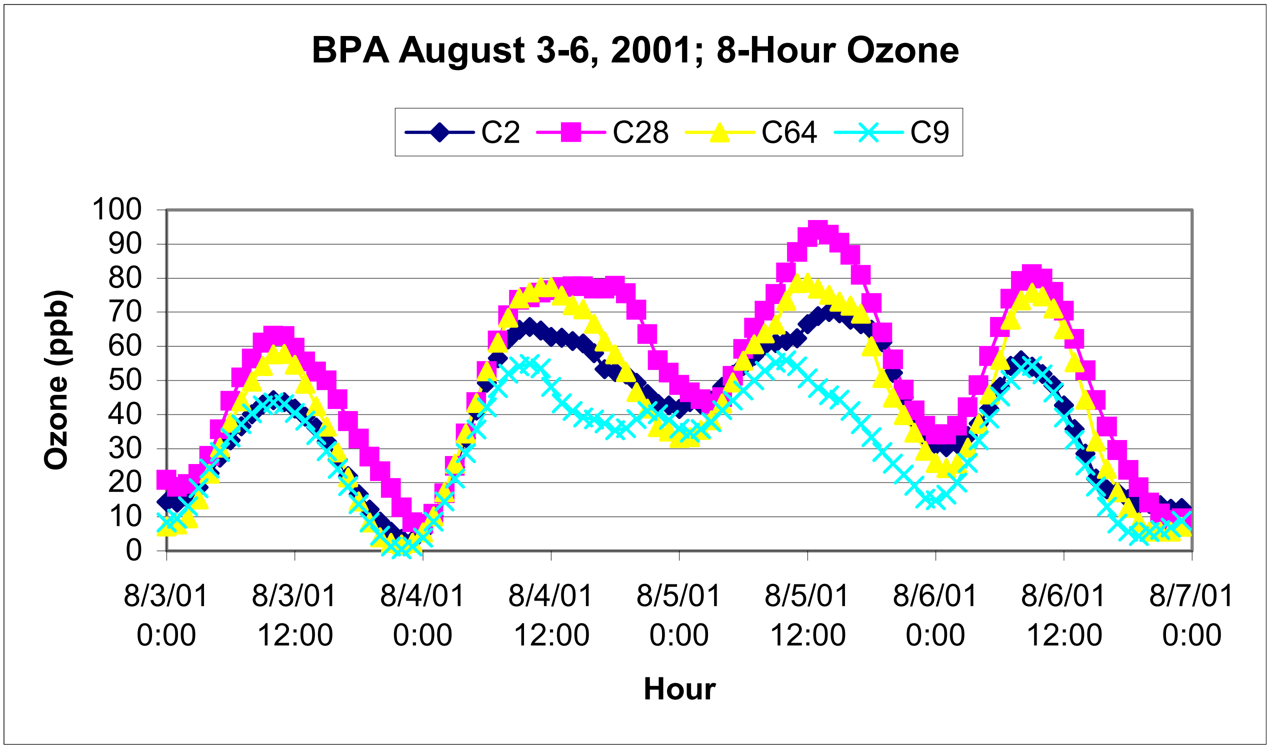

Figure 5-15. Time series of observed 8-hour ozone concentrations in BPA for August 3-6, 2001.

Recommended Episodes

Based on the analyses conducted as part of the development of the conceptual model of ozone formation in the Beaumont/Port Arthur nonattainment area, a candidate episodes is identified for the 1-hour and 8-hour ozone attainment demonstration air quality modeling in BPA. The candidate episodes is August 29-Septemeber 2, 2000. The primary reasons for selection of this episode are as follows:

- The episode occurs during the seasonal peak ozone period of August/September;
- The episode represents the primary trajectory directions, transport from east/southeast and north/northeast;
- The episode has multiple 1-hour and 8-hour ozone exceedances in Beaumont/Port Arthur;
- The episode is supported by robust air quality and meteorological data; and,
- The episode occurs during the last 3 years.

In order to further illuminate the complex situation occurring in the BPA area during this episode, it would be beneficial to conduct additional surface trajectory analyses similar to those presented in Section 4.

If there is a desire to augment this episode with additional episodes that represent other transport directions and/or modeling years then the August 3-6, 2001 and August 10-14, 2000, represent possible additional candidate episodes. The analyses of these episodes would also benefit from additional surface trajectory analyses.

REFERENCES

ENVIRON. 2002. Review of the Current Conceptual Model for Beaumont/Port Arthur. Prepared for the Texas Commission on Environmental Quality. Prepared by ENVIRON International Corporation. September 30, 2002.

ENVIRON. 2001. Area and Mobile Source Emission Inventory Technical Support Project—1990-2010 Emission Inventory Trends and Projections. Prepared for the Texas Natural Resource Conservation Commission. Prepared by ENVIRON International Corporation, August 31, 2001.

EPA. 2002. Midcourse Review Guidance for the 1-Hour Ozone Nonattainment Areas that Rely on Weight-of-Evidence for Attainment Demonstration. Memorandum from Lydia Wegman and David Mobley dated March 28, 2002.

EPA. 2000. National Air Quality and Emissions Trends Report, 2000. Appendix A. U.S. Environmental Protection Agency, 2000.

EPA. 1999. Draft Guidance on the Use of Models and Other Analyses in Attainment Demonstrations for the 8-Hour Ozone NAAQS, EPA-454/R-99-004, Office of Air Quality, Planning and Standards, USEPA. May 1999.

EPA. 1997. Guidance on Use of Modeled Results to Demonstrate Attainment of the Ozone NAAQS, Office of Air Quality, Planning and Standards, USEPA. 1997.

EPA. 1991. "Guideline for Regulatory Application of the Urban Airshed Model," EPA-450/4-91-013, U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Research Triangle Park, NC 27711. July 1991.

TCEQ. 2002a. Modeling Protocol for the Mid-Course Review of the Beaumont-Port Arthur Area Attainment Demonstration SIP Revision, Air Modeling and Data Analysis Section, Technical Analysis Division, Office of Environmental Policy, Analysis, and Assessment, Texas Commission on Environmental Quality, May 2002.

TCEQ. 2002b. Conceptual Model for Ozone in Beaumont-Port Arthur Area, presentation by Zhaohua Fang, Technical Analysis Division, TCEQ, May 2002.

TCEQ. 2002c. Technical Support Document, TNRCC, Technical Analysis Division, Air Modeling and Data Analysis Section, June 5, 2002.

TCEQ. 2002d. Conceptual Model for Ozone Formation in the Houston-Galveston Area, Appendix A to Technical Support Document, TNRCC, Technical Analysis Division, Air Modeling and Data Analysis Section, June 5, 2002.