Exploratory Data Analysis for the
Filling Ozone Gaps in Region 6 (FOGIR6) 2002 Study

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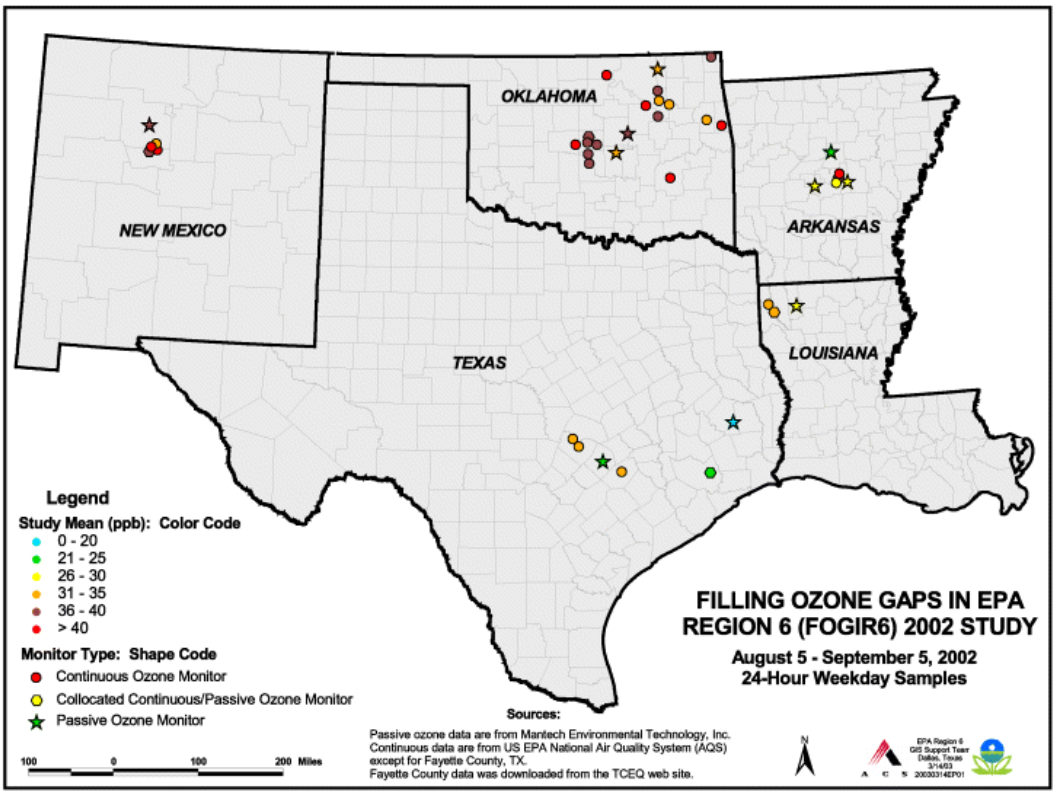
Executive Summary

In 2002 the U.S. EPA Region 6 received funding from the U.S. EPA Office of Air Quality Planning and Standards (OAQPS) for a first time regional daily passive ozone monitoring project. Region 6 had earlier collaborated with the EPA Office of Research and Development (ORD) and the contractor Mantech in an important passive ozone monitoring study during the summers of 1998 and 1999 in the greater Dallas-Fort Worth area called the Passive Ozone Network of Dallas (POND). The passive sampling devices for ozone in POND produced excellent correlations with conventional continuous ozone samplers (r = 0.95-0.97 for 24-hour samples). Excellent correlation between passive and continuous ozone samplers was also found in the FOGIR6 2002 study, with the correlation coefficient r ranging from 0.84-0.97 for 24-hour samples at five collocated sites, and of these five sites three had r values equal to 0.97 and one site had an r value equal to 0.94.

The FOGIR6 2002 study was initiated to provide additional ozone data beyond that collected by Federal reference monitors in order to gather important gap filling ozone air quality information in key areas in Region 6. Like the previous POND studies, the FOGIR6 2002 study provided an opportunity for direct community involvement, and provided a considerably less expensive method for collecting credible ozone screening data to supplement the existing regional ozone monitoring network. Twenty-four hour sampling was conducted on weekdays from August 5, 2002 – September 5, 2002 at 15 sites (five collocated with continuous monitors) throughout Texas, Louisiana, Arkansas, Oklahoma, and New Mexico. Ozone concentrations during this period were generally low, especially at the Texas sites (please reference the study mean map below in Figure 1). Above average Gulf Coast precipitation during the study period helped to greatly depress the ozone concentrations in the Houston, Beaumont and southern Louisiana areas during the month of August. Thus, it is not surprising that the highest 24-hour ozone concentrations recorded during FOGIR6 2002 were recorded at some sites in the northern part of Region 6 (i.e. at some sites in New Mexico, Oklahoma, and Arkansas). In Tulsa, Oklahoma, during FOGIR6 2002 there were two days (August 6 and 8, 2002) with at least one continuous ozone site recording a daily 8-hour maximum ozone concentration greater than the 8-hour ozone standard (i.e. greater than 84 ppb). Detailed exploratory data analyses for each FOGIR6 2002 study area appear below. A follow-up study to FOGIR6 2002 incorporating more sites is scheduled for mid-July to the end of August, 2003 to compare to the generally low ozone summer of 2002.

Figure 1. FOGIR6 2002 Site Locations and Study Arithmetic Means.



Highlights of the FOGIR6 2002 Study

1. The FOGIR6 2002 study expanded the previous successful 1998 and 1999 Passive Ozone Network of Dallas (POND) studies to a first time regional daily passive ozone monitoring project.

2. Excellent correlations between passive ozone sampling devices and continuous federal reference method ozone monitors for 24-hour samples seen in previous studies was also seen in the FOGIR6 2002 study.

3. Above average precipitation during August, 2002, in Houston probably contributed to low ozone concentrations at the Polk County tribal land passive ozone site, and the Bastrop County passive ozone site in the Austin area.

4. The Webster Parish, Louisiana passive ozone site was mainly upwind of the Shreveport core area during the 2002 study with lower ozone concentrations recorded compared to the Bossier and Caddo continuous ozone sites.

5. For the Little Rock MSA ozone concentrations were highest in Pulaski County and lower in the surrounding three counties, with the lowest ozone concentrations recorded at the passive ozone sites in Saline and Faulkner Counties.

6. The Jemez tribal land passive ozone site in Sandoval County, New Mexico, was downwind of the Albuquerque ozone plume for much of the summer study. No 8-hour ozone exceedances were recorded at the highest Albuquerque continuous ozone sites and no 8-hour ozone exceedances were probable at the Jemez passive ozone site.

7. There were two 8-hour ozone exceedance days in the Tulsa area on August 6 and 8, 2002, but detailed contour analyses suggested that additional 8-hour ozone exceedances at passive ozone gap-filling sites in Pottawatomie, Lincoln, and Washington Counties were not probable on those two days.

Austin, Texas Area

In the Austin area, a passive ozone monitoring sensor was deployed at Bastrop State Park in central Bastrop County for five weeks of the ozone season. This county represents a portion of the Austin Metropolitan Statistical Area (MSA) which has no current or historical ozone air monitoring data. The other four counties in the Austin MSA (Travis, Williamson, Caldwell, and Hays) all have either current or historical continuous ozone air monitoring data recorded in, or close to, the county boundaries.[1] The Bastrop County passive ozone monitoring site was located approximately 33 miles southeast from continuous ozone site #48-453-0014, and approximately 41 miles southeast from continuous ozone site #48-453-0020, both in neighboring Travis County. For the 20 sampling days during the study period (weekdays from August 5, 2002 to September 5, 2002), the Bastrop passive ozone monitoring site was rarely downwind of the two Travis County continuous ozone monitors. As seen in Table 1, easterly wind directions dominated at 71% from site #48-453-0014 and 72% from site #48-453-0020.

Table 1. Breakdown by Sector of Resultant Wind Directions at the Two Travis County Ozone Monitoring Sites; Weekdays August 5, 2002 – September 5, 2002; 7 AM Local Standard Time (LST) - 7 AM LST.

Site	sector	% of time rwd from sector	mean rwd from sector
#48-453-0014	NE	22%	52 deg.
	SE	49%	144 deg.
	SW	19%	198 deg.
	NW	10%	311 deg.
#48-453-0020	NE	27%	57 deg.
	SE	45%	144 deg.
	SW	21%	205 deg.
	NW	7%	315 deg.

Concerning ozone concentrations, the Bastrop site recorded a study mean of only 21 ppb, 10 ppb below each of the two continuous ozone sites in Travis County. As discussed above, the Bastrop site was not usually downwind of the Austin area during the sampling period. There were no 8-hour ozone concentrations recorded by the Travis County sites that exceeded the standard of 84 ppb during the study period. The highest 8-hour ozone concentration recorded in Travis County during the study period was 70 ppb at site #48-453-0014 on the first sampling day of FOGIR6 2002, August 5, 2002. The accompanying 24-hour ozone value (7 AM – 7 AM LST) was 42 ppb. The Bastrop County passive ozone site recorded the lowest 24-hour ozone concentrations on all days of the study except for the last day, and on that day its 31 ppb 24-hour average was the same as site #48-453-0020 and just one ppb above site #48-453-0014. The two highest 24-hour ozone concentrations recorded at the Bastrop passive site were 36 ppb on August 7, 2002, and 43 ppb on August 29, 2002. Higher 24-hour concentrations were recorded at the two Travis County sites for both of these dates as seen in the spreadsheet file titled "txpo2002.wk4", but the maximum 8-hour ozone concentrations at the Travis County sites for these two days were well below the standard at 63 ppb on August 7, 2002, and 69 ppb on August 29, 2002 (both from site #48-453-0014). On both of these days the dominant resultant wind direction was from the northeast and the average resultant wind speeds were low at 5 mph for August 7, 2002, and 4 mph for August 29, 2002. Back trajectory analyses (24-hour) for these two days corroborate the surface weather data as seen below in Figures 2 and 3. Both trajectories were produced using the National Oceanic and Atmospheric Administration (NOAA) Hysplit transport and dispersion model on the web.[2] The back trajectories were computed for heights of 10 (red line), 100 (blue line), and 500 (green line) meters above ground level.

[1]Travis County contains the two current continuous ozone sites #48-453-0014 and #48-453-0020 (U.S. EPA Air Quality System (AQS) database tracking numbers). Both of these sites are located in north Travis County close to Williamson County. Site #48-453-0014 in north-central Travis County is currently recording ambient ozone concentrations over the new 8-hour ozone standard (84 ppb), with a 2000-2002 three year average of the annual 4th highest values at 85 ppb. From 1998-2001, a continuous ozone monitoring site operated at the San Marcos Airport in Caldwell County close to the Hays County line. The San Marcos site was meeting the 8-hour ozone standard from 1998-2001. The annual 4th highest 8-hour ozone maxima at this site were 84 ppb in 1998 (3 exceedances of the standard), 79 ppb in 1999 (1 exceedance of the standard), 84 ppb in 2000 (3 exceedances of the standard), and 75 ppb in 2001 (no exceedances of the standard).

[2]The Hysplit model is available by registration on the NOAA web site at http://www.arl.noaa.gov/ready/

Figure 2. Bastrop State Park 24-hour Back Trajectory Ending 0700 LST 8/8/02.

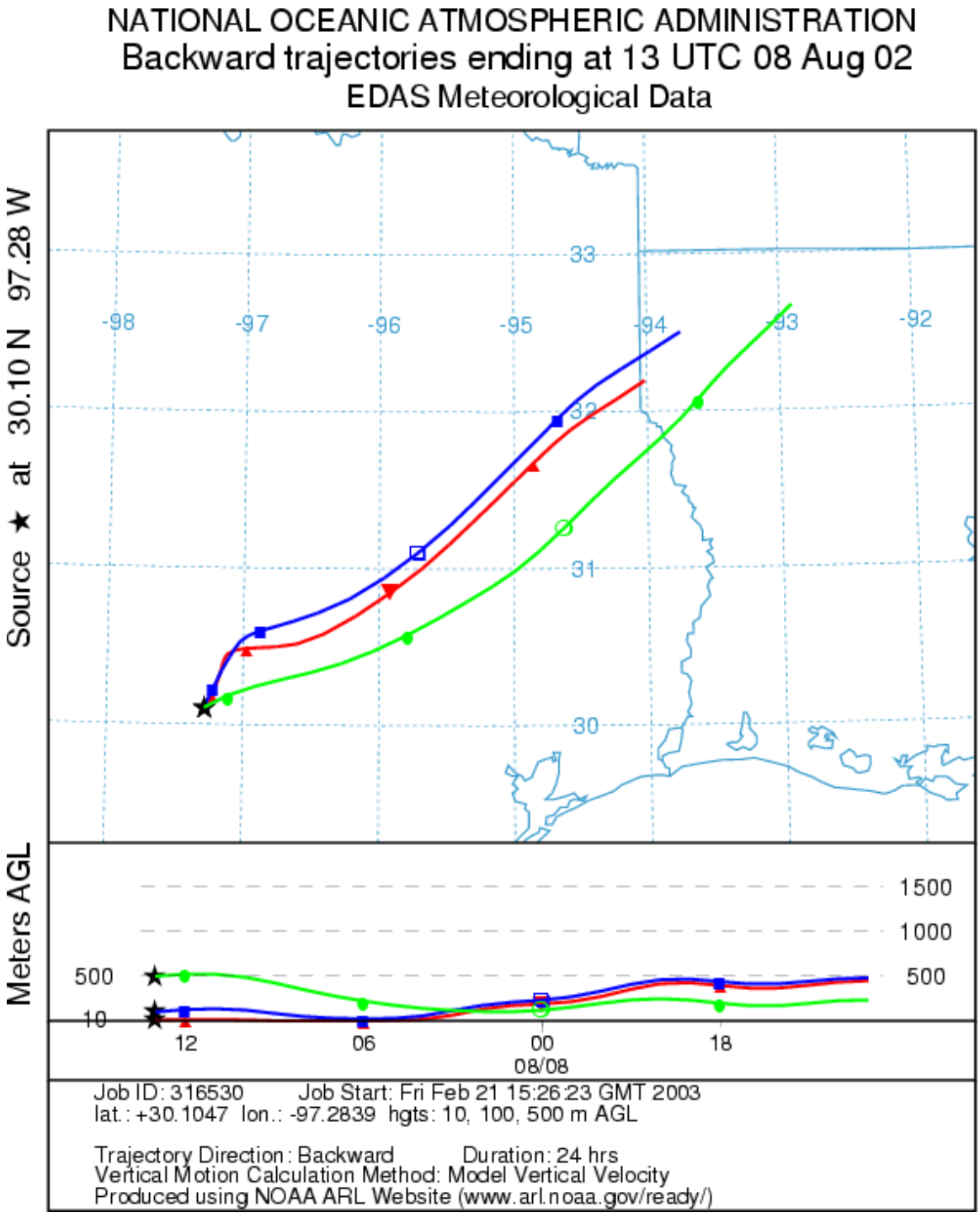
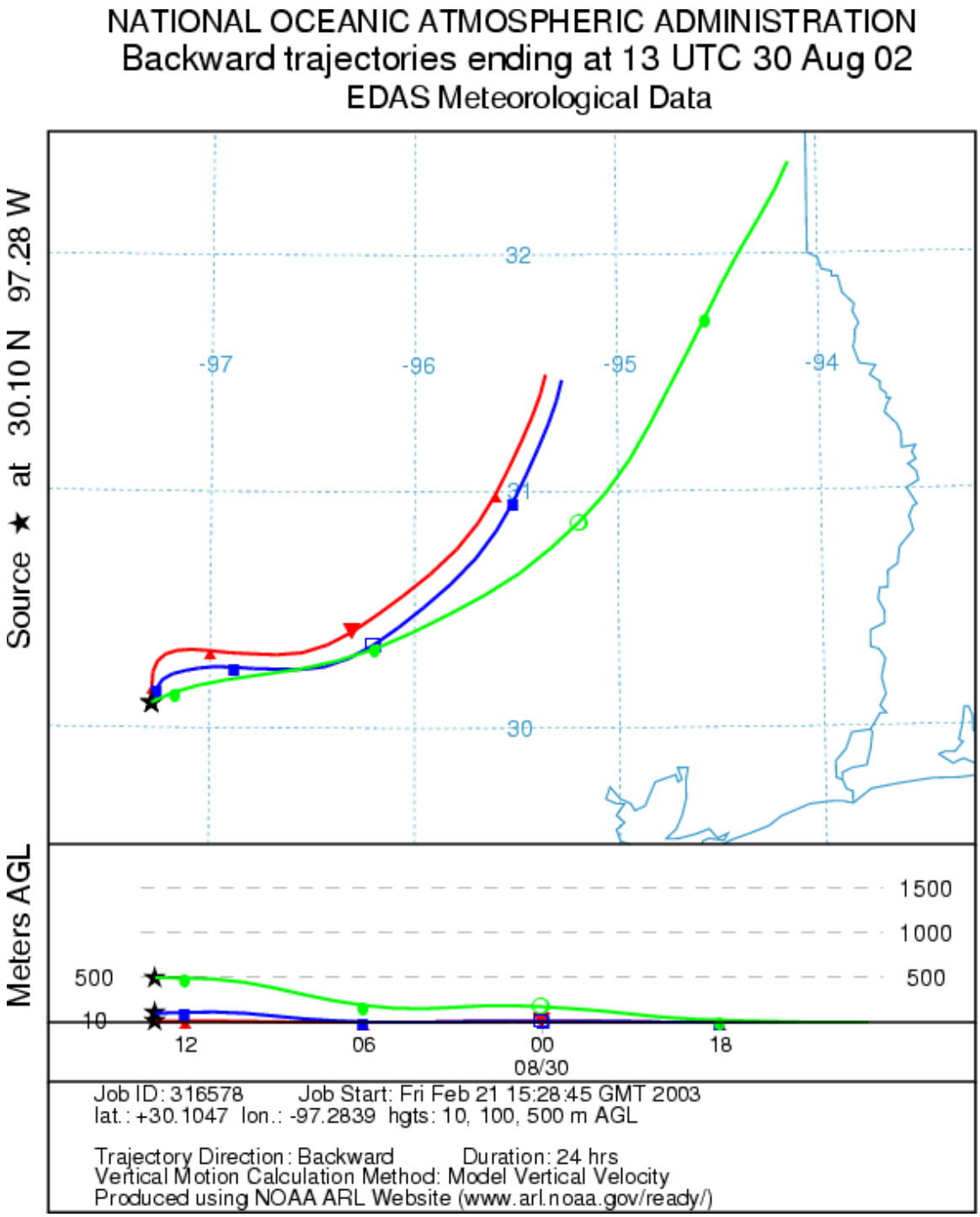
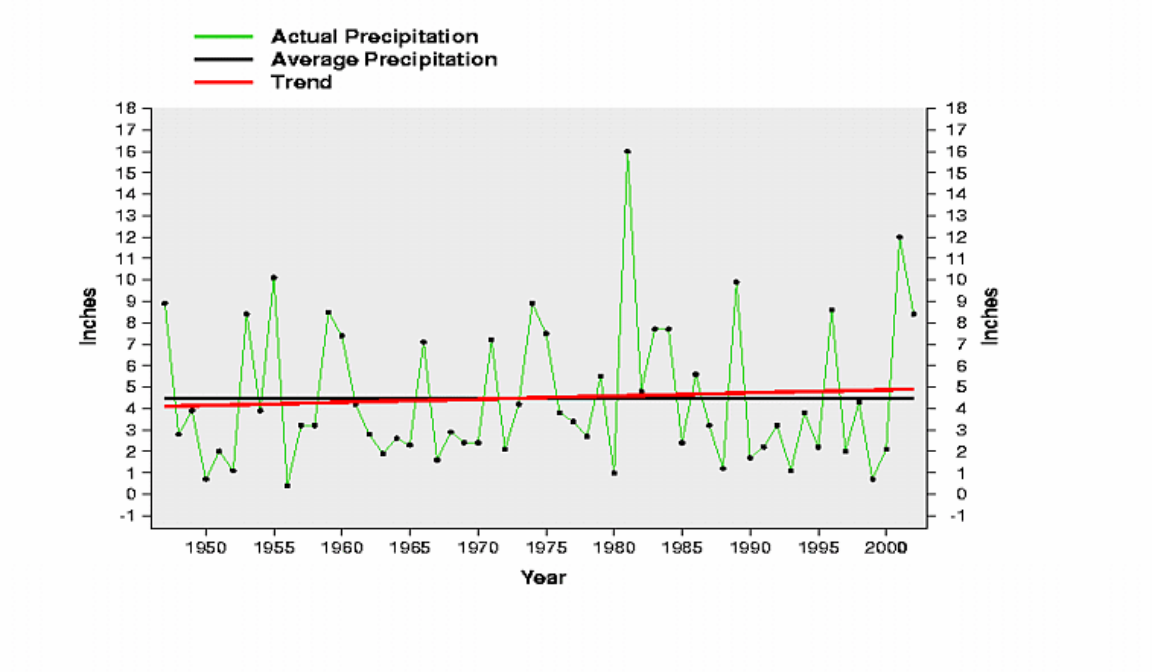


Figure 3. Bastrop State Park 24-hour Back Trajectory Ending 0700 LST 8/30/02.



In summary, the Bastrop County passive ozone site, rarely downwind of the Austin area, recorded low 24-hour ozone concentrations for much of the 5-week study period, with no probable exceedances of the new 8-hour ozone standard. The two continuous AQS sites in Travis County did not record any exceedances of the new 8-hour ozone standard (70 ppb 8-hour maximum), and a non-AQS continuous ozone site in Fayette County, just to the southeast of Bastrop County, also did not record any exceedances of the 8-hour ozone standard during the FOGIR6 2002 study period (76 ppb 8-hour maximum with an accompanying 24-hour average of 50 ppb). It is recommended that a minimum of one or two more years of data be collected at the Bastrop County site to compare to the low ozone year of 2002. Southeasterly flow dominated during the study period in 2002, but the air from this sector may have been cleaner than usual due to above average rainfall recorded along the Texas Gulf Coast during this time as indicated below by Houston data in Figure 4.

Figure 4. August Precipitation Trends, Houston, Texas, 1947-2002; August average = 4.49 inches, Data from National Climatic Data Center web page http://www.ncdc.noaa.gov/oa/climate/research/cag3/cag3.html



Northeast of Houston, Texas Area

There are presently no continuous federal reference method ozone monitoring sites northeast of the Houston MSA. Thus, to help fill in an ozone data gap in the FOGIR6 2002 summer study, a passive ozone monitoring site was located on Alabama-Coushatta Tribal land in Polk County. A collocated passive/continuous site was also operated at the Texas Commission on Environmental Quality (TCEQ) Sheldon site in eastern Harris County, just northeast of the Houston downtown core. The collocated site produced an excellent correlation with r = 0.94 even though summer study mean values for this site were very low (16 ppb for the passive monitor and 23 ppb for the continuous monitor).

The Polk County passive site northeast of Houston also recorded a very low study mean of just 19 ppb. Please reference the spreadsheet titled "tx2po2002.wk4" for all of the 24-hour ozone data from these sites. The highest 8-hour ozone concentration recorded at the collocated Sheldon site was 66 ppb on August 26, 2002. For all of the Houston and Beaumont areas during the study, there were only 8-hour ozone exceedances on August 5-6 and August 28-29, and all of these exceedances were confined to the south of these areas in either Brazoria County southwest of Houston, south Houston, or south Beaumont. Due to the above-average rainfall and low ozone concentrations recorded in the Houston and Beaumont areas during the study period, it is recommended that a minimum of one or two more years of data be collected at the Alabama-Coushatta Tribal land site in Polk County to compare to the low ozone year of 2002.

Shreveport, Louisiana Area

For the Shreveport area, a passive ozone monitoring sensor was deployed in Webster Parish. This parish is the only one of three in the Shreveport MSA (Caddo and Bossier comprising the other two) without any current or historical ozone air monitoring data. The Webster Parish passive ozone monitoring site was located approximately 25 miles northeast of the Bossier Parish continuous ozone monitoring site (AQS #22-015-0008) and approximately 25 miles east of the Caddo Parish continuous ozone monitoring site (AQS #22-017-0001). The two continuous sites in Bossier and Caddo Parish did not have meteorological equipment, so meteorological data were analyzed from the nearby Harrison County, Texas continuous ozone site (AQS #48-203-0002), approximately 10 miles to the west of the Caddo Parish continuous ozone monitoring site. As seen for the Bastrop passive ozone monitoring site in the Austin, Texas, area, for the 20 days during the study period (weekdays from August 5, 2002 to September 5, 2002), the Webster Parish passive ozone monitoring sensor was rarely downwind of the continuous ozone sensors in Bossier and Caddo Parishes. As shown in Table 2, easterly wind directions dominated at 68% according to the nearby Harrison County, Texas site.

Table 2. Breakdown by Sector of Resultant Wind Directions at the Harrison County, Texas Ozone Monitoring Site; Weekdays August 5, 2002 – September 5, 2002; 7 AM LST-7 AM LST.

site	sector	% of time rwd from sector	mean rwd from sector
#48-203-0002	NE	43%	53 deg.
	SE	25%	146 deg.
	SW	17%	209 deg.
	NW	15%	319 deg.

Regarding ozone concentrations, the Webster Parish passive ozone sensor recorded a study mean of 29 ppb, just a few ppb below the study means recorded at the Bossier continuous site (33 ppb) and the Caddo continuous site (32 ppb). An excellent correlation was obtained at the Bossier collocated passive/continuous site ($r = 0.97$). Please reference the spreadsheet titled "lapo2002.wk4" for all of the 24-hour ozone data. There were no 8-hour ozone concentrations recorded in the Shreveport MSA that

exceeded the new standard during the study period, with the highest 8-hour ozone concentration recorded at the Caddo site on August 29, 2002 at 73 ppb (46 ppb accompanying 24-hour average). The highest 24-hour average concentrations at all three sites were recorded on August 8, 2002 (59 ppb at the Bossier site, 61 ppb at the Caddo site, and 60 ppb at the Webster site). The peak 8-hour ozone concentration on this day, though, was only 68 ppb. Back trajectory analysis for August 8 and 29, 2002 (depicted below in Figures 5 and 6), corroborated by also looking at the Harrison site surface meteorological data, showed northeasterly flow dominating the area with low mean resultant wind speeds (4 mph mean on August 8 and 3 mph mean on August 29). Interestingly, the Harrison site, being downwind of Shreveport on these two days, recorded the highest 8-hour ozone concentrations of the area monitors, with a maximum 8-hour value of 81 ppb on August 8 and a maximum 8-hour value of 88 ppb (over the standard) on August 29. It is recommended that at a minimum an additional year or two of data be collected at the Webster Parish site to see if this site continues being primarily an upwind site in the Shreveport MSA during the peak summer season.

Figure 5. Bossier Parish 24-hour Back Trajectory Ending 0700 LST 8/9/02.

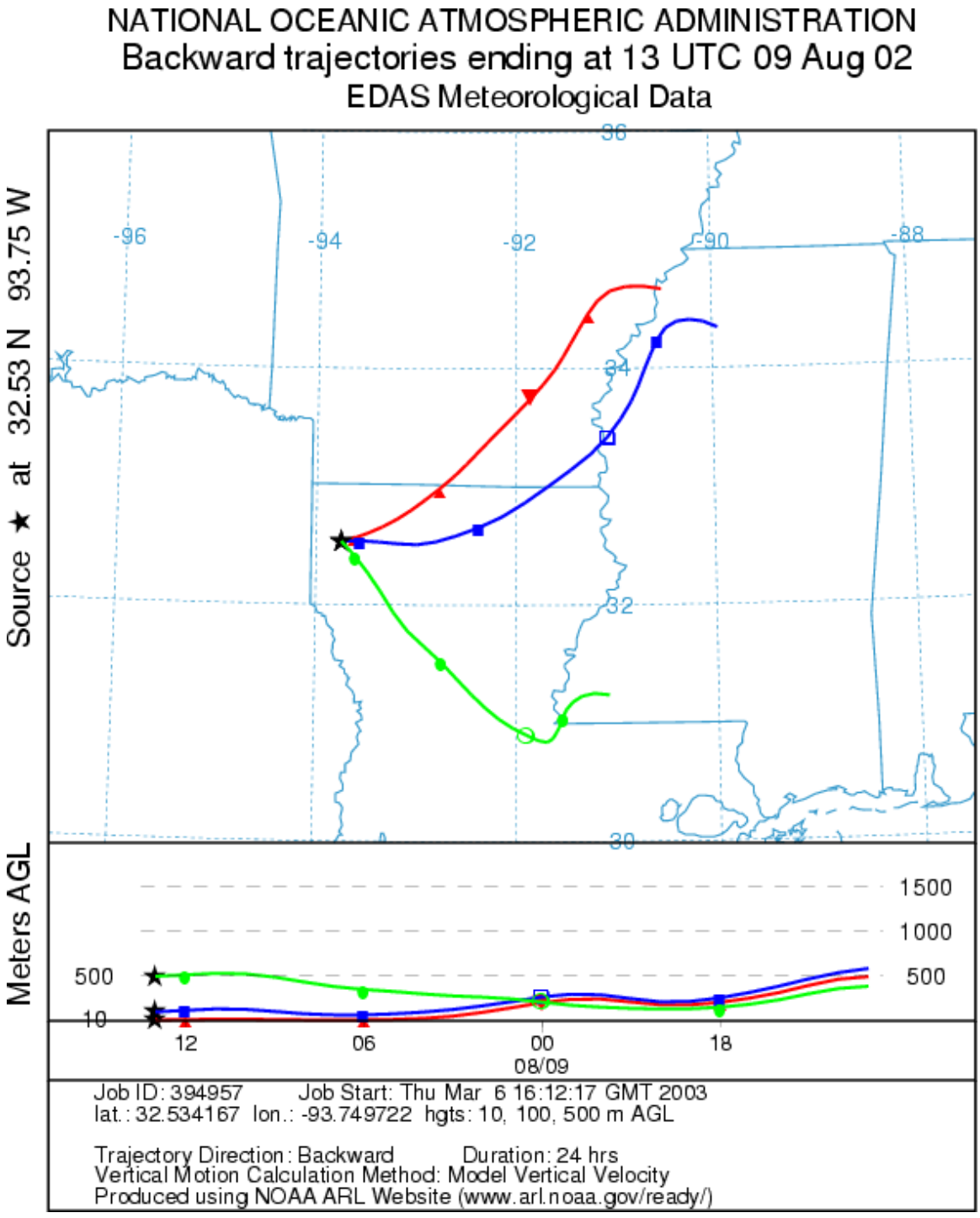
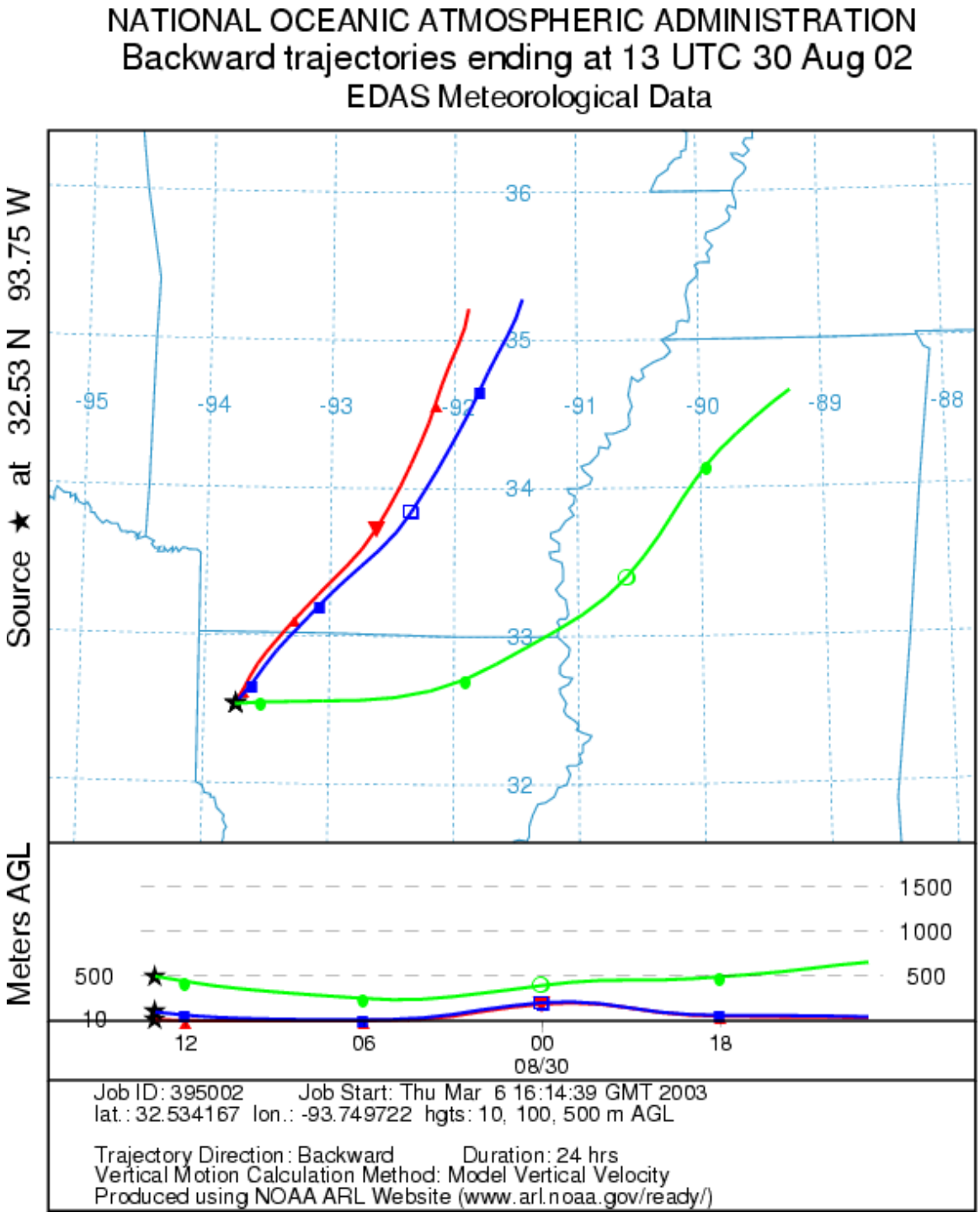


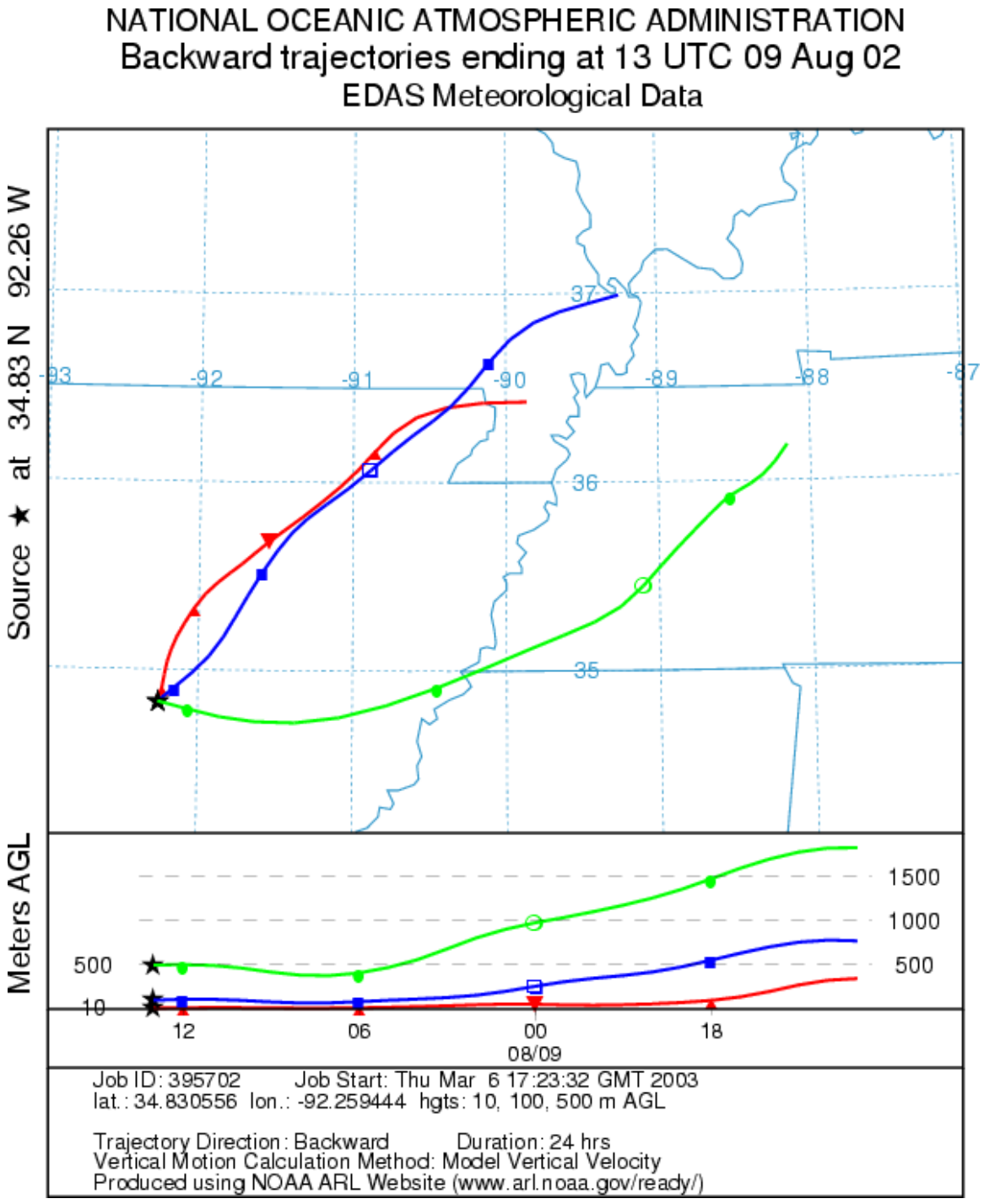
Figure 6. Bossier Parish 24-hour Back Trajectory Ending 0700 LST 8/30/02.



Little Rock, Arkansas Area

Previous to the FOGIR6 2002 summer study, ambient ozone monitoring had occurred in only one county of the four county Little Rock MSA (Pulaski, which currently has three operating continuous ozone monitors). For FOGIR6 2002 passive ozone monitoring devices were placed at one site apiece in Lonoke, Saline, and Faulkner Counties surrounding Pulaski County. The Lonoke site was closest to Pulaski County at around 10 miles to the east of the closest Pulaski County continuous ozone monitoring site. The Saline and Faulkner sites were located about 25 miles to the west and the north, respectively, of the nearest Pulaski County continuous ozone air monitoring site. Meteorological data were provided by the Arkansas Department of Environmental Quality for the collocated passive/continuous ozone site in central Pulaski County (site #15 for FOGIR6 2002 and AQS #05-119-0007). The average wind speed for the study period was 3 mph and wind direction was generally spread out equally between four sectors (NE=25%, SE=22%, SW=34%, and NW=19%). Ozone concentrations were highest at the North Little Rock Airport site, the northernmost monitor of the three in Pulaski County. The study mean at this site was 45 ppb with a maximum 24-hour value of 69 ppb and a maximum 8-hour value of 81 ppb. Ozone concentrations decreased in Pulaski from north to south as the central collocated site (site #15) recorded a study mean of 36 ppb and the south lab site recorded a study mean of 30 ppb. The central Pulaski County collocated site (site #15) produced an excellent correlation coefficient r of 0.97. The three surrounding county passive ozone sites were generally lower in ozone concentrations compared to the Pulaski County sites, with the Lonoke site recording a 30 ppb study mean, the Saline site reporting a 27 ppb study mean, and the Faulkner site recording the lowest study mean in the area at 25 ppb. Please reference the spreadsheet file titled “arpo2002.wk4” for all of the Little Rock data. No 8-hour ozone exceedance days occurred during the study period, but the North Little Rock Airport site monitor recorded a close call maximum 8-hour ozone concentration (81 ppb) on August 8, 2002. As seen previously for Austin and Shreveport this day had low wind speeds (4 mph average) and dominant northeasterly winds (please see the back trajectory below in Figure 7). It is recommended that future ozone studies in the area consider a more northern location for the Lonoke County site in order to place a sensor downwind of Little Rock with southwesterly winds.

Figure 7. North Little Rock Airport 24-hour Back Trajectory Ending 0700 LST 8/9/02.



Albuquerque, New Mexico Area

For the Albuquerque MSA a passive ozone monitoring sensor was operated by the Jemez Tribe in Central Sandoval County, about 25 miles north of the northernmost continuous ozone monitors in Albuquerque. A collocated passive/continuous ozone site in the City of Albuquerque (AQS #35-001-0027 and FOGIR6 2002 site #4) produced a good correlation with r = 0.84. The five-week study meteorological profile at the collocated site differed markedly from the other areas in FOGIR6 2002, with 84% southerly flow (NE=4%, SE=47%, SW=37%, NW=12%). Wind speeds were similar to the other areas with a study mean of 3 mph. Although the Jemez site recorded 24-hour average ozone concentrations of 47 ppb on August 27, 2002, and 50 ppb on September 4, 2002, 8-hour ozone exceedances were not probable because the highest Albuquerque 8-hour readings on those dates were just 73 ppb and 67 ppb, respectively, with accompanying 24-hour high readings of 60 ppb and 52 ppb. Please reference the spreadsheet titled "nmpo2002.wk4" for all of the 24-hour ozone data. It is recommended that follow-up data be collected at the Jemez site to more thoroughly study the apparent strong downwind impact of the Albuquerque ozone plume on this site. As seen below in the back trajectories in Figures 8 and 9, the two highest 24-hour ozone concentrations recorded at the Jemez site occurred with light winds (4 mph average at site #4) from the south. Note that the 50 ppb reading at the Jemez site on September 4, 2002 occurred under very stagnant conditions.

Figure 8. Jemez, NM 24-hour Back Trajectory Ending 0800 LST 8/28/02.

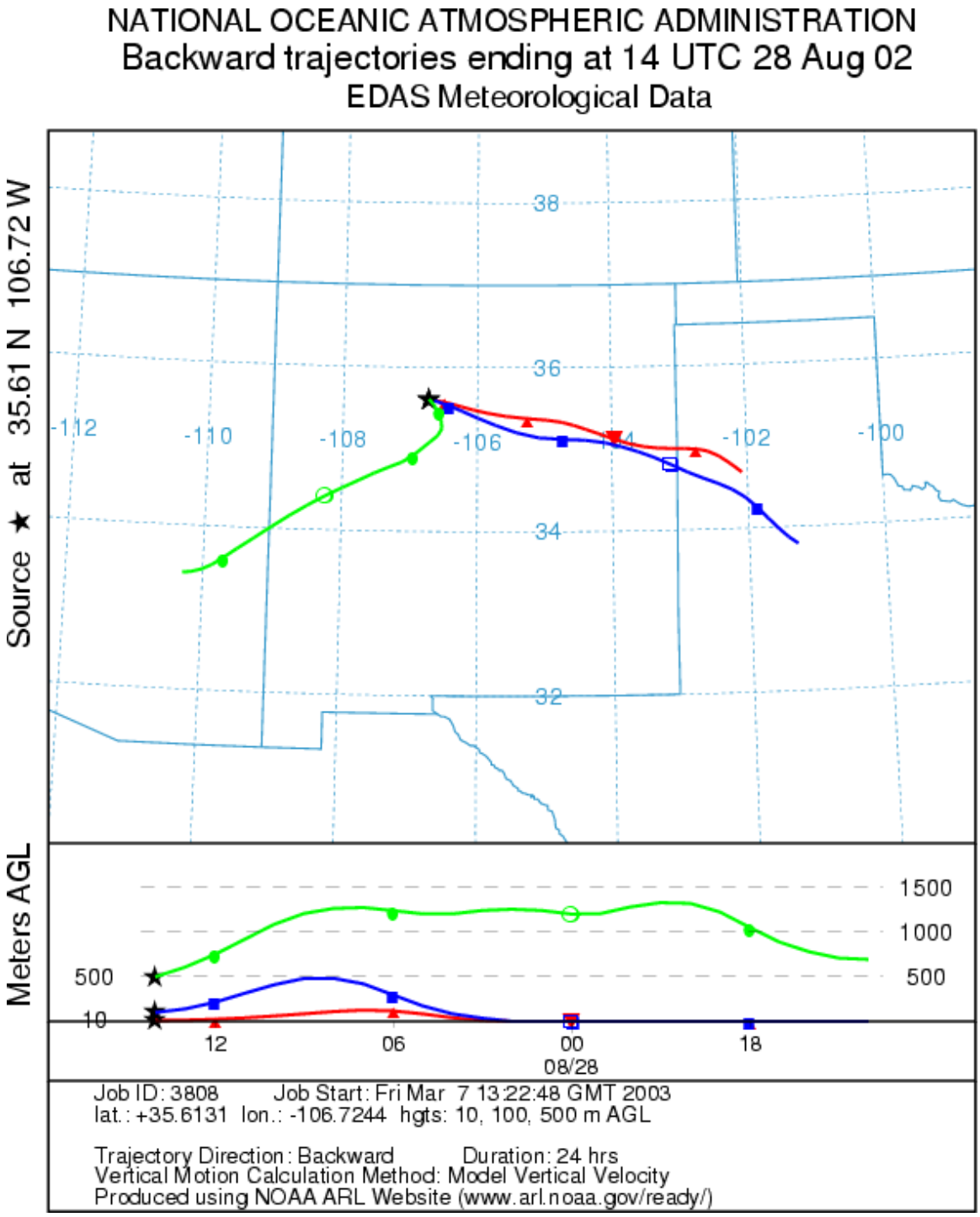
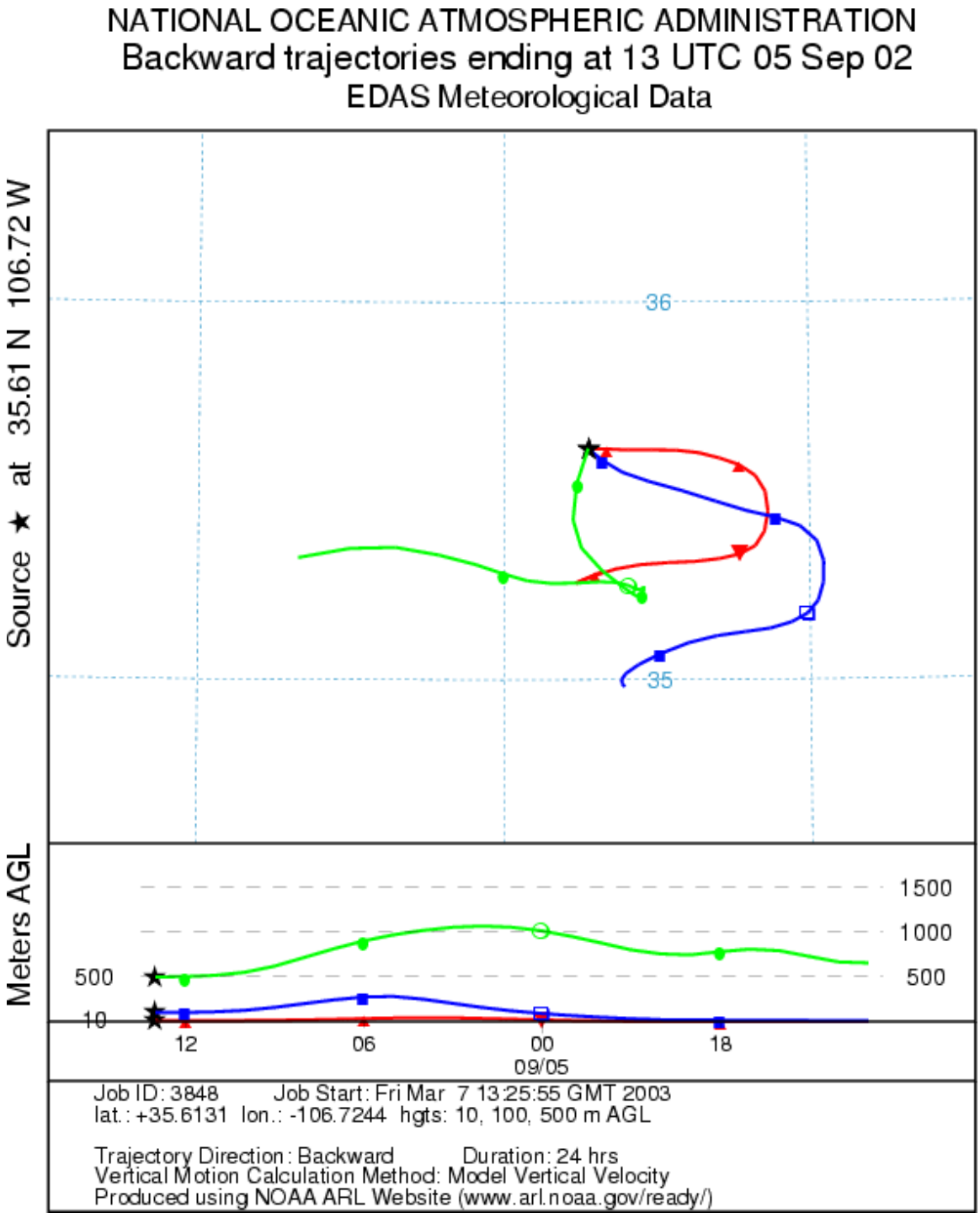


Figure 9. Jemez, NM 24-hour Back Trajectory Ending 0700 LST 9/5/02.



Central and Northeast Oklahoma

Passive ozone sensors were placed in three locations to help fill in ozone data gaps around Oklahoma City and Tulsa. One sensor was located in Pottawatomie County in the eastern portion of the Oklahoma City MSA, another sensor was placed roughly halfway between the Oklahoma City and Tulsa MSAs in Lincoln County on Sac & Fox Tribal Land, and the final passive ozone sensor was placed north of the Tulsa MSA in Washington County on Eastern Delaware Tribal Land. As seen on the map in Figure 1, the study means at these passive sites were not the highest in the State, although the Lincoln County site mean (37 ppb) was close to the 40 ppb means shared by four of the six Oklahoma City sites. The 24-hour ozone data for each of the 19 sampling sites in central and northeastern Oklahoma is found in the spreadsheet titled "okpo2002.wk4". The collocated passive/continuous ozone site in Oklahoma City (AQS #40-109-1037 and FOGIR6 2002 site #9) produced an excellent correlation with r = 0.97. There were two 8-hour ozone exceedance days in the Tulsa area during the study period on August 6 and August 8, 2002. Both of these days were analyzed in detail by constructing 24-hour ozone pollutant concentration contour maps and 24-hour Hysplit back trajectories (Figures 10-14). Surface meteorological data for resultant wind speed and resultant wind direction were obtained from the Oklahoma Department of Environmental Quality for the collocated passive/continuous ozone monitoring site (AQS #40-109-1037). The contour map is one valuable tool in studying the possibility of whether a passive ozone site is recording ozone concentrations over or close to the 8-hour standard on an 8-hour ozone exceedance day. On August 6, 2002, an 8-hour ozone exceedance was recorded at the Tulsa Keystone site in west Tulsa County (AQS site #40-143-0177, 88 ppb maximum 8-hour ozone concentration and an accompanying 6 AM – 6 AM 24-hour ozone concentration of 52 ppb). This was the only continuous site in central and northeast Oklahoma that recorded an 8-hour ozone exceedance on August 6. The next highest 8-hour ozone concentrations were quite a bit lower (72 ppb) in Oklahoma City and McAlester, even though the accompanying 24-hour ozone averages were also around 50 ppb. Thus, the three passive ozone sites on this day (August 6, 2002) probably did not record maximum 8-hour ozone concentrations close to the standard since their 24-hour concentrations were significantly lower than the peak 24-hour concentrations in Tulsa and Oklahoma City.

On August 8, 2002, higher ozone concentrations were recorded in Oklahoma with three sites in Tulsa recording maximum 8-hour ozone concentrations over the standard: (1) the Keystone site again (AQS #40-143-0177; maximum 8-hour concentration = 92 ppb; accompanying 24-hour concentration = 64 ppb); (2) the north Tulsa County site (AQS #40-143-0137; maximum 8-hour concentration = 86 ppb; accompanying 24-hour concentration = 54 ppb); and (3) the central Tulsa County site (AQS #40-143-1127; maximum 8-hour concentration = 87 ppb; accompanying 24-hour concentration = 47 ppb). No other continuous ozone sites in the State recorded 8-hour ozone exceedances on August 8, but maximum 8-hour ozone concentrations approached 80 ppb at the Canadian County site in the Oklahoma City MSA (AQS #40-017-0101; maximum 8-hour concentration = 77 ppb; accompanying 24-hour concentration = 60 ppb), at the McAlester site in Pittsburg County (AQS #40-121-0415; maximum 8-hour concentration

= 76 ppb; accompanying 24-hour concentration = 62 ppb), and at the Adair County site (AQS #40-001-9009; maximum 8-hour concentration = 79 ppb; accompanying 24-hour concentration = 66 ppb). Taking this and the meteorological data into account the three passive ozone sites on this day (August 8, 2002) again probably did not record maximum 8-hour ozone concentrations over the standard since their 24-hour concentrations were again significantly lower than the highest concentration continuous sites. Additional interesting information gleaned from the August 8, 2002 contour map are the strong ozone concentration gradients between the Adair County and Cherokee County sites, and between the western and eastern Tulsa County sites.

For the upcoming FOGIR6 2003 summer study additional ozone data gaps in Oklahoma will be filled in by new sites in Logan County (north of Oklahoma City), Payne County (west of Tulsa), Caddo County (southwest of Oklahoma City), Okmulgee County (south of Tulsa), and McCurtain County (far southeastern Oklahoma). Four of these five additional sites in Oklahoma will be operated on Tribal land.

Figure 10. Central and Northeast Oklahoma Continuous/Passive Ozone Site Locations for the FOGIR6 2002 study.

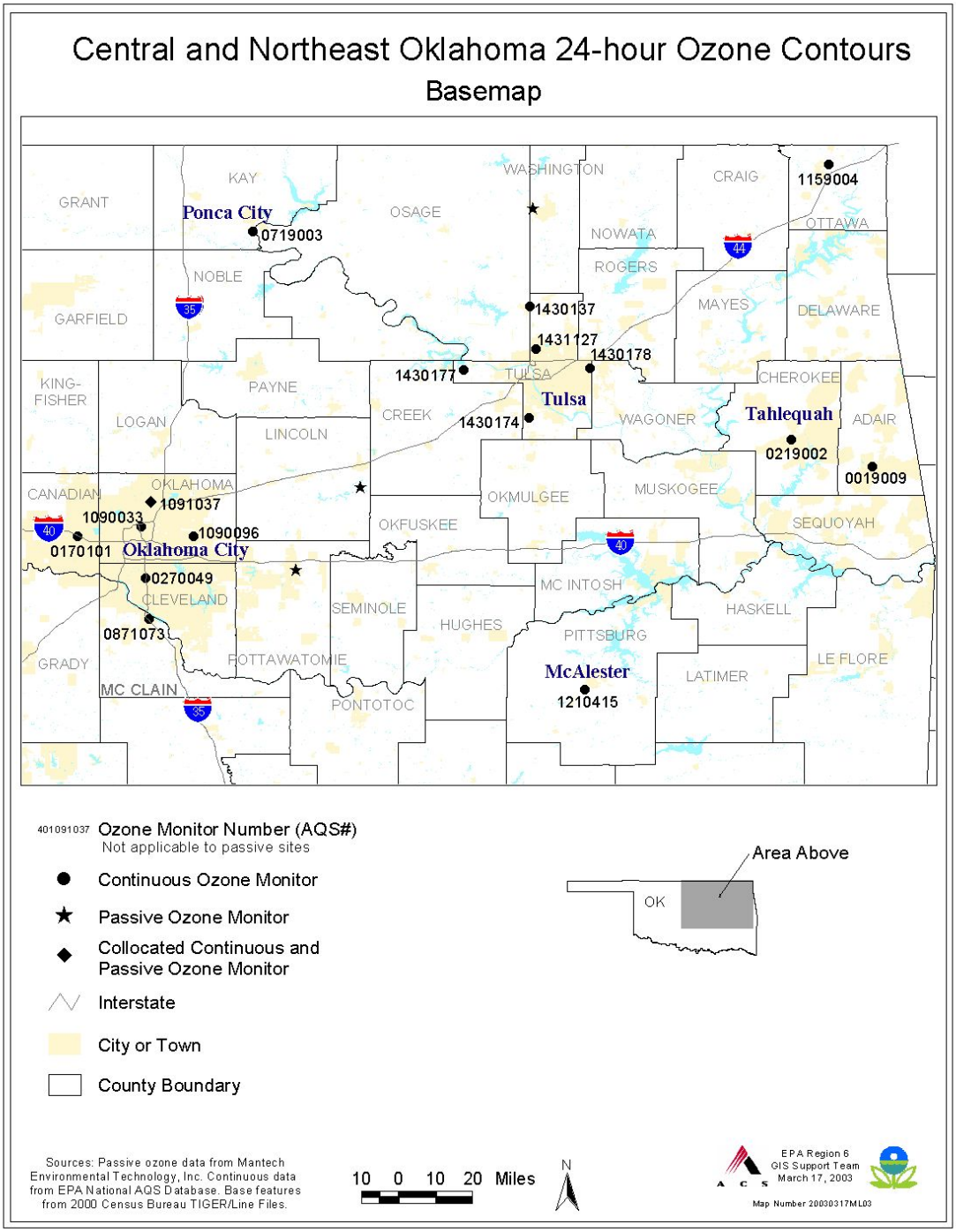


Figure 11. 8/6/02 24-hour O3 Contour Analyses for Central/NE Oklahoma.

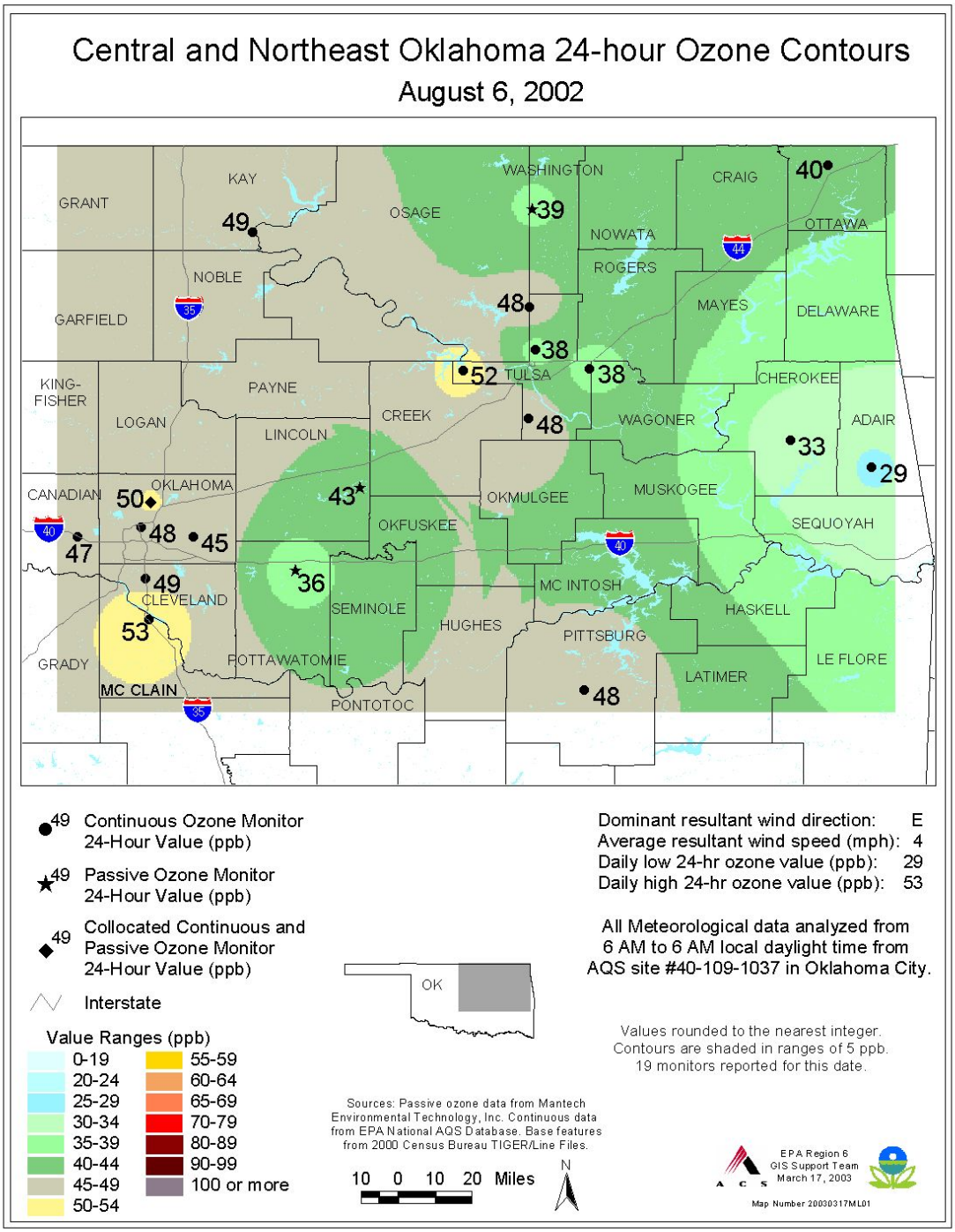


Figure 12. Tulsa (Keystone site) 24-hour Back Trajectory Ending 0500 LST 8/7/02.

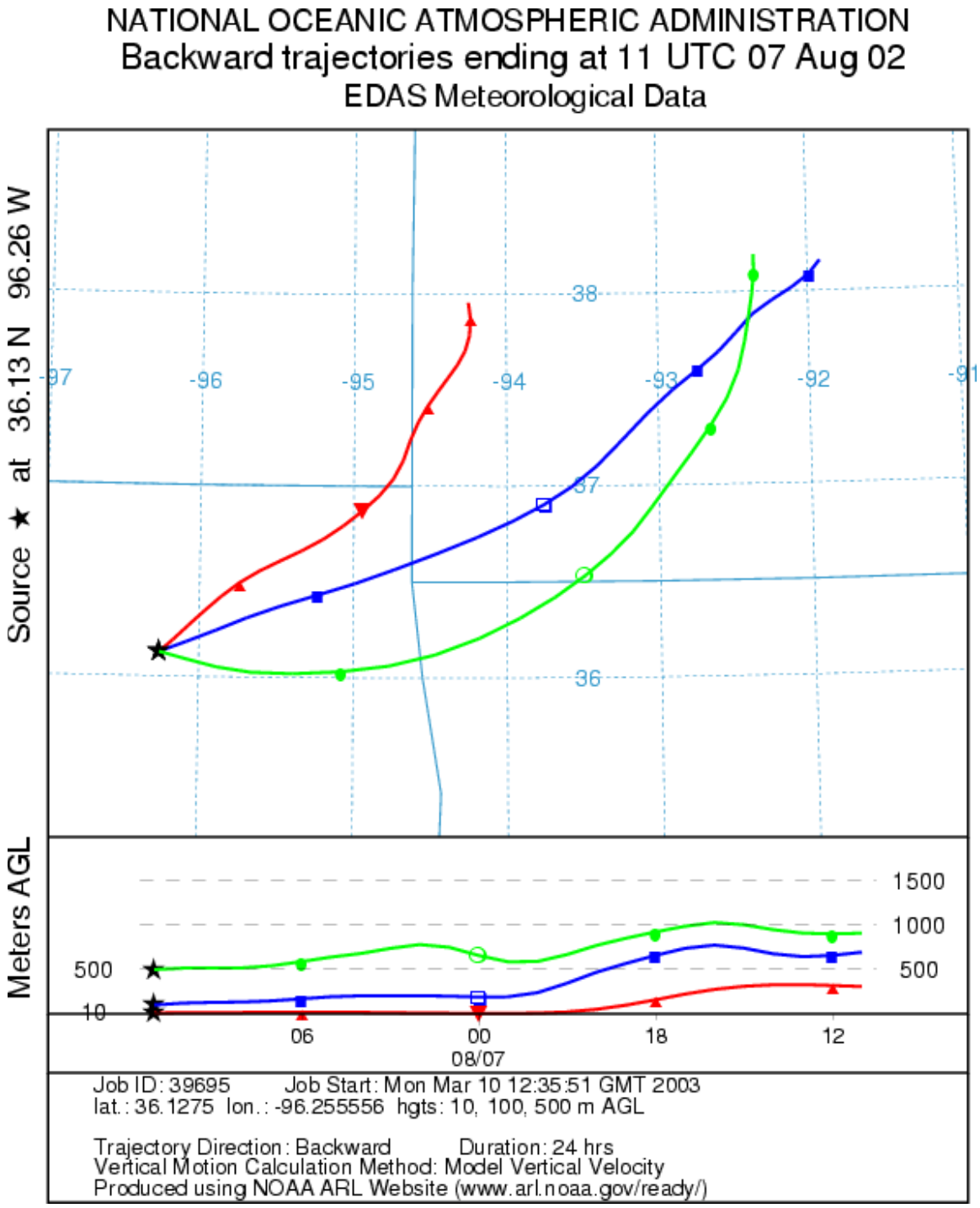


Figure 13. 8/8/02 24-hour O3 Contour Analyses for Central/NE Oklahoma.

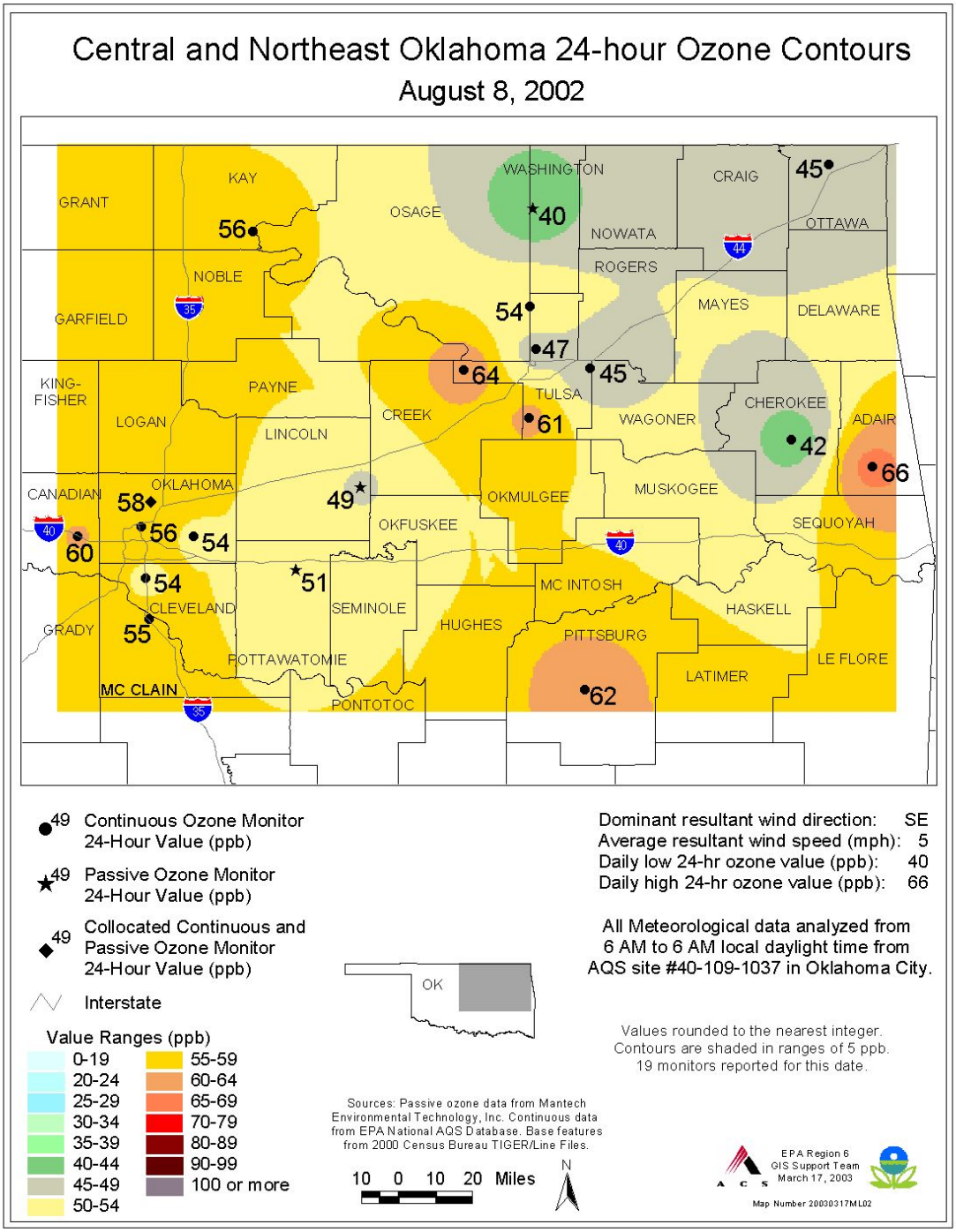


Figure 14. Tulsa (Keystone site) 24-hour Back Trajectory Ending 0500 LST 8/9/02.