Oklahoma Department of Environmental Quality
Air Quality Division
Five-year Network Assessment

Oklahoma Department of Environmental Quality
707 N. Robinson
P.O. Box 1677
Oklahoma City, OK 73101-1677

Table of Contents

I. Abstract

The U.S. Environmental Protection Agency (EPA) requires each state, or where applicable, local monitoring agencies to conduct network assessments once every five years [40 CFR Part 58.10(d)]. Oklahoma is a rural state with only two major urban areas (Oklahoma City and Tulsa), and is currently in attainment with all National Ambient Air Quality Standards (NAAQS), therefore DEQ monitoring program staff believe that a detailed analysis is unnecessary. DEQ will take the straightforward approach toward meeting the requirements posed by 40 CFR Part 58.10(d).

II. Climate

The climate of Oklahoma is continental. Warm, moist air moving northward from the Gulf of Mexico often exerts much influence, particularly over the southern and eastern portions of the state where humidity, cloudiness, and precipitation are resultantly greater than in western and northern sections. Summers are long and usually quite hot, while winters are shorter and less rigorous than those of the more northern Plains states. Periods of extreme cold are infrequent, and those lasting more than a few days are rare.

i. Temperature

The mean annual temperature over the state ranges from 62 ºF along the Red River to about 58 ºF along the northern border. Temperatures then decrease westward to 56 ºF in Cimarron County. Temperatures of 90 ºF or greater occur, on average, about 60 to 65 days per year in the western panhandle and the northeast corner of the state, 115 days in the southwest, and 85 days in the southeast. Temperatures of 100 ºF or higher occur frequently between May and September and very rarely in April or October. The western half of the state (excluding most of the panhandle) averages 15 or more days with temperatures greater than or equal to 100 ºF, and ranges from about 35 days on average in the southwest corner to 25 days on average in the northwest. The eastern half of the state and most of the panhandle average less than 15 such days. Years without 100 ºF temperatures are rare, ranging from about one of every seven years in the eastern half of the state to somewhat rarer in the west. The highest temperature ever recorded in the state was 120 ºF. Temperatures of 32 ºF or less occur, on average, about 60 days per year in the southeast. This value increases to approximately 110 days per year where the panhandle joins the rest of the state and expands to 140 days per year in the western panhandle.

ii. Precipitation

The dominant feature of the spatial distribution of rainfall is a sharp decrease in rainfall from east to west. Although precipitation is quite variable on a year-to-year basis, average annual precipitation ranges from about 17 inches in the far western panhandle to about 56 inches in the far southeast. The climatological maximum for precipitation comes in late spring for almost all of the state east of the panhandle. On average, May brings more precipitation than any other month across 90% of Oklahoma. The frequency of days with measurable precipitation follows the same gradient as the annual accumulation, increasing from 45 days per year in western Oklahoma to 115 near the Arkansas border. On average, more precipitation falls during the nighttime hours, while greatest rainfall intensities occur during late afternoon.

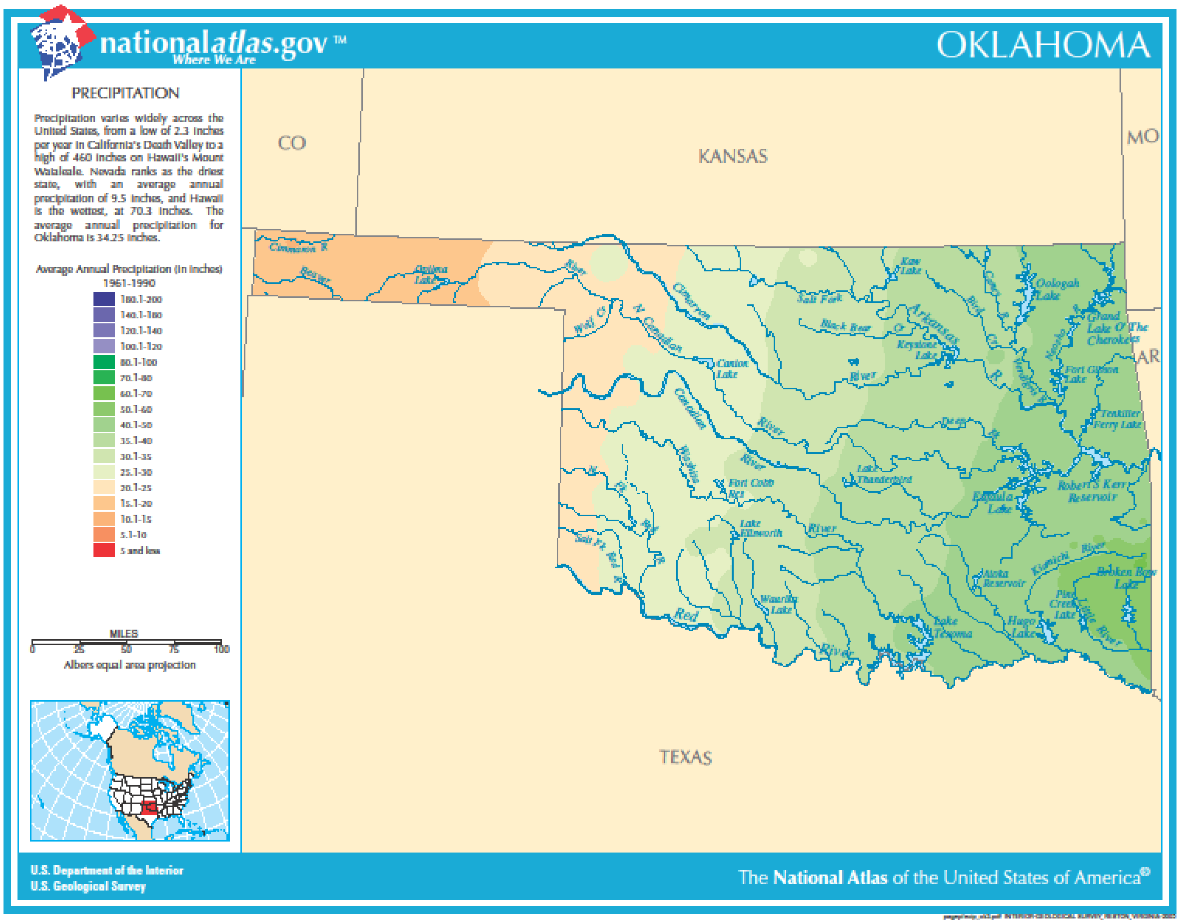


Figure 1: Average annual precipitation in Oklahoma from 1961-1990. (US Department of Interior)

iii. Floods

Floods of major rivers and tributaries may occur during any season, but they occur with greatest frequency during those spring and autumn months associated with greatest rainfall. Such floods cost many lives and caused property damage in the first 50 years of statehood, but flood prevention programs have reduced the frequency and severity of such events. Autumn floods are often associated with widespread heavy rains north of a stalled cold front or the interaction between a surface front and remnants of a tropical storm. Springtime floods usually occur in the warm sector of a slow-moving cyclone. Flash flooding of creeks and minor streams remains a serious threat, especially in urban and suburban areas, where development and removal of vegetation have increased runoff.

iv. Drought

Drought is a recurring part of Oklahoma’s climate cycle, as characterized in all the Plains states. Almost all of Oklahoma’s usable surface water comes from precipitation that falls within the state’s borders. The influence of upstream events on drought is very small, therefore drought in Oklahoma is almost entirely tied to local rainfall patterns. Precipitation in western Oklahoma tends to be more variable percentage-wise and marginal for dry-land farm applications lending the area to be slightly more susceptible to drought.

Drought episodes can last from a few months to several years. Those that last a few months or more can elevate wildfire danger and impact municipal water use. Seasonal droughts can occur at any time of the year, and those that resonate with crop production cycles can cause billions of dollars of damage to the farm economy. Multi-season and multi-year episodes can severely impact large reservoirs, stream flow, and ground water.

The agricultural impact of drought is increasingly mitigated on a farm-by-farm and year-by-year basis through irrigation of crops, mostly with fossil water. This practice is widespread in much of the panhandle and portions of western Oklahoma.

OCS's Climate Trends graphics show the evolution of Oklahoma's climate history with regards to precipitation since the modern record began in 1895.

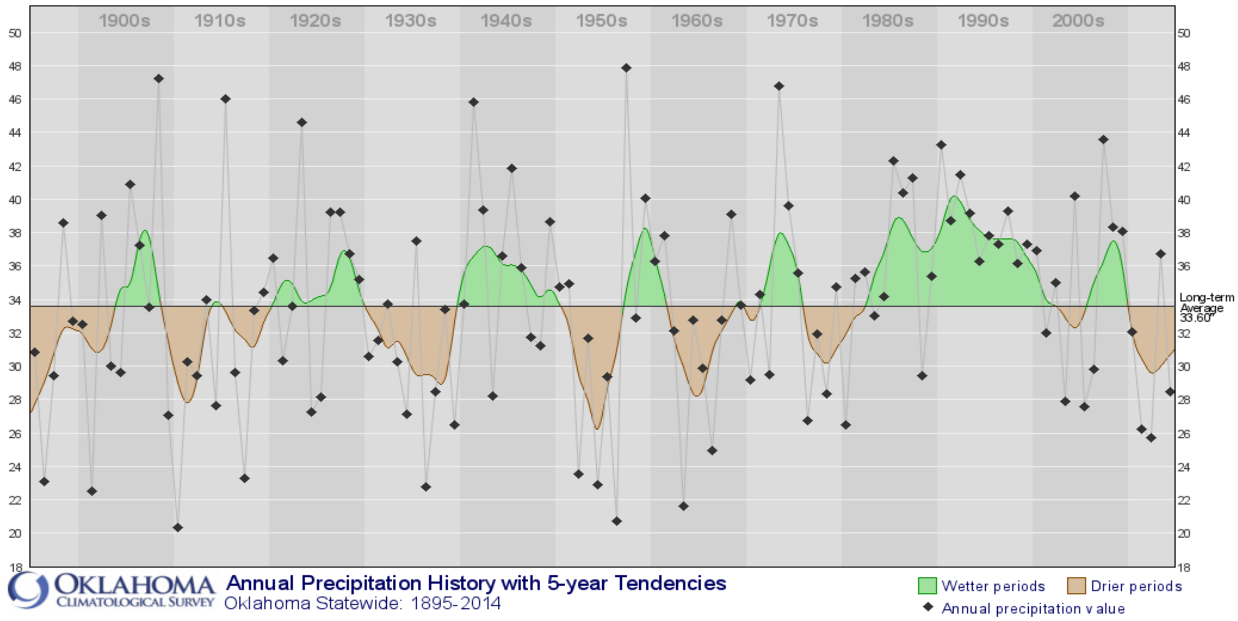


Figure 2: Annual Precipitation History with 5-year Tendencies in Oklahoma from 1895-2014. (Survey)

v. Relative Humidity

Annual average relative humidity ranges from about 60% in the panhandle to just over 70% in the east and southeast. The average statewide dew point temperature ranges from 27 ºF in January to 68 ºF in July.

vi. Prevailing Winds

Prevailing winds are southerly to southeasterly throughout most of the state during the spring through autumn months. These prevailing winds veer to south-to-southwest in far western Oklahoma, including the panhandle. The winter wind regime is bimodal, with roughly equal split between northerly and southerly winds. In a diurnal sense, prevailing winds tend to oscillate from southeast to southwest to southeast from sunrise to sunset to sunrise. In the panhandle, the daytime swing is more dramatic with westerly winds prevailing. March and April are the windiest months while July, August, and September are the calmest.

vii. Thunderstorms/Severe Weather

Thunderstorms occur, on average, about 55 days per year in the east, decreasing to about 45 days per year in the southwest. The general gradient relaxes in northwestern Oklahoma, where annual thunderstorm days number about 50. The annual rate increases to near 60 in the extreme western panhandle. Late spring and early summer are the peak seasons for thunderstorms, averaging about eight thunderstorms per month per location during these seasons. For the southeastern two-thirds of the state, thunderstorms occur most often in May. June is the peak month for much of the remainder of the state, while the western panhandle observes the most thunderstorms in July. December and January, on average, feature the fewest thunderstorms, at a rate of less than one per month per location.

Frequent frontal invasions and dry line development combined with favorable upper-level support make springtime the preferred season for violent thunderstorms, although they can occur at any time of year. Severe weather threats during spring are squall lines, mesoscale convective systems, and totaling supercells that can produce very large hail, damaging winds and tornadoes. Autumn marks a secondary severe weather season, but the relative frequency of supercellular activity is much lower than during spring. General thunderstorms are quite common in the summer, but tend to be less organized storms of relatively short duration. These storms can produce locally heavy rain and some hail. Severe weather events during summer are predominantly mesoscale convective systems, these events tend to be nocturnal in nature.

Severe weather can occur at any time of day, but the maximum frequency for severe weather is from mid-afternoon to sunset. This maximum shifts from afternoon hours in western Oklahoma to late afternoon and early evening in eastern Oklahoma, because severe weather is often associated with surface boundaries that move west to east during the afternoon. Diurnally, precipitation shows a maximum during the overnight hours. This can be attributed to the nocturnal nature of heavy rain associated with summertime events and heavy rains associated with the continuance of squall lines into eastern Oklahoma.

Tornadoes are a prevalent hazard with the frequency of occurrence per unit area among the greatest in the world. Since 1950, an average of 54 tornadoes has been observed annually within the state's borders. Tornadoes can occur at any time of year, but are most frequent during springtime. April, May, and June represent the months of peak occurrence; these three months account for approximately three-fourths of the observations. May's average of 20 tornado observations per month is the greatest.

viii. Climate's Effect on Air Pollution

Air pollution concentrations are greatly influenced by climate. Prevailing south southeast winds occasionally bring ozone and ozone precursors from the south causing unhealthy concentrations of ozone into the southern half of the state. Inhalable particulates may also reach unhealthy concentrations when wildfires occur during the dry months of February and March.

Pollution events caused by air stagnation occur frequently throughout the summer although mostly during the months of July through August. These events, along with ozone transport events, are among the easiest to predict in terms of warning the public through the Ozone Watch program. Staff meteorologists consult daily weather models and EPA's AIRNOW forecast models in making these determinations. While Ozone Watch predictions are not 100% accurate, the ability to make scientifically sound decisions in forecasting is improving as model accuracy improves.

While heavy rainfall events tend to clear out pollution for short periods of time ranging from one to a few days, there appears to be no correlation between statewide pollution concentrations which increase from west to east, and statewide average annual rainfall amounts which increase from west to east. Frontal passages also affect pollution concentrations, specifically ozone, sometimes concentrating high values along those boundaries between warm moist air and cool dry air that are often found moving through the state. It is difficult if not impossible to predict these types of ozone events in terms of where they will occur and how long they will last. Several instances of localized high ozone concentrations have been observed as a result of this phenomenon where one or two local monitoring sites register unusually high values and the remainder of ozone sites in the area does not. Frontal passages which commonly move through the state from northwest to southeast also bring clean air masses through the state for a few days at a time.

Wind roses for Oklahoma City, Tulsa, and Lawton Metropolitan Statistical Areas (MSAs) are included to verify prevailing wind directions which often affect pollutant concentrations:

Wind Rose for Oklahoma City MSA – 1994-2010
Oklahoma Mesonet – Spencer, OK (SPEN)

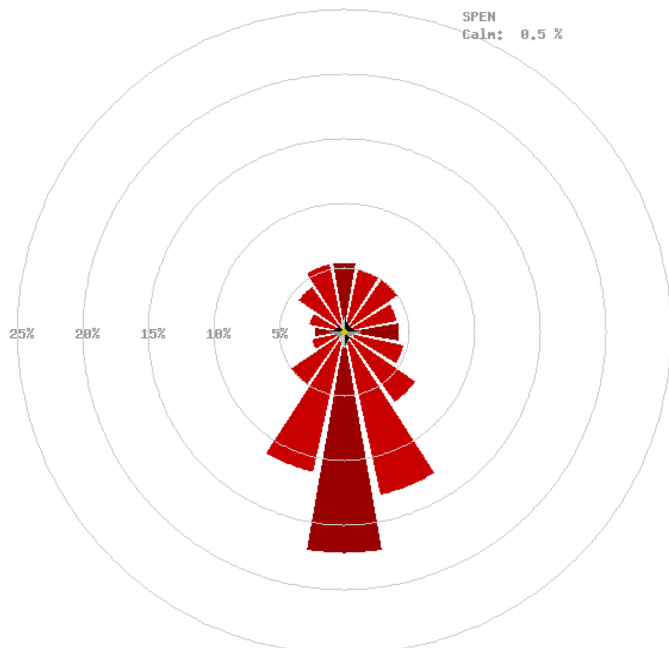


Figure 3: Wind rose for Oklahoma City MSA from 1994-2010

Wind Rose for Tulsa MSA – 1994-2010
Oklahoma Mesonet -- Bixby, OK (BIXB)

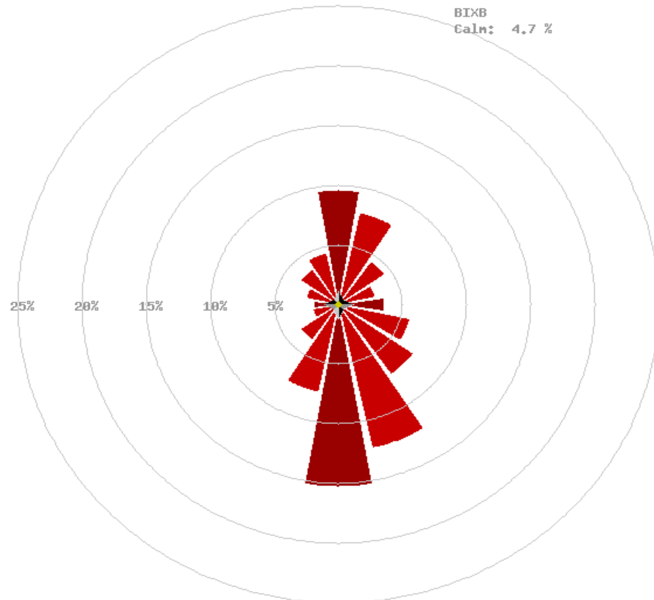


Figure 4: Wind rose for Tulsa MSA from 1994-2010

Wind Rose for Lawton MSA – 1994-2010
Oklahoma Mesonet – Medicine Park, OK (MEDI)

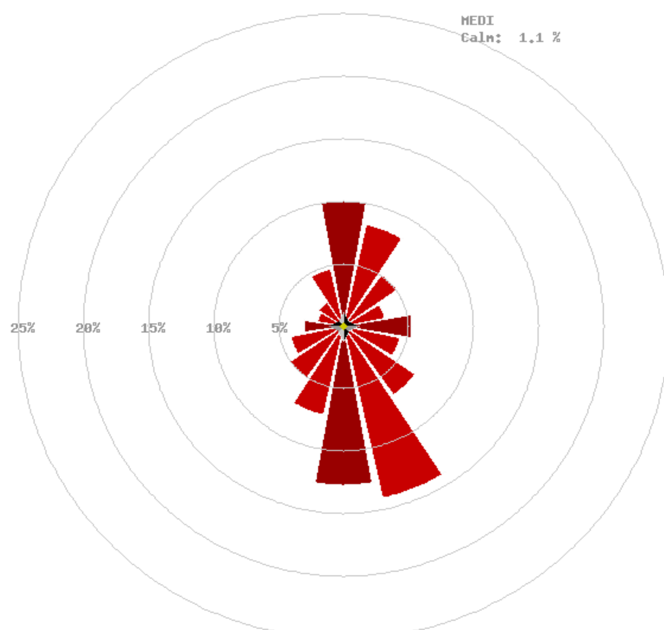


Figure 5: Wind rose for Lawton MSA from 1994-2010.

III. Topography

Oklahoma is located in the southern Great Plains. Of the 50 states, Oklahoma ranks 20th in size, with an area of 69,903 square miles, about 1,224 of which are covered by water. The northern boundary of Oklahoma is about 465 miles in length while its southern boundary is 315 miles long. The greatest distance from north to south is 222 miles.

The terrain is mostly plains, varying from nearly flat in the west to rolling in the central and near east, with a general slope upward from east to west. The plains are broken by scattered hilly areas where most points are 600 feet or less above the adjacent countryside. These hilly areas include the Wichita Mountains in the southwest, and the Arbuckle Mountains in the south-central. The Ouachita Mountains dominate much of the southeast, with peaks that rise as much as 2,000 feet above their base. Extreme east central Oklahoma features the mountains of the Arkansas River Valley, which rise several hundred feet above the plains. The extreme northeastern counties are part of the Ozark Plateau, which is marked by steep, rocky, river valleys between large areas of hills and rolling plains. The western tip of the panhandle features part of the Black Mesa complex, a fractured terrain featuring large mesas overlooking seasonal creeks and riverbeds. Elevations range from 287 feet above sea level where the Little River exits in southeastern Oklahoma to 4,973 feet on Black Mesa near the border with New Mexico.

Oklahoma lies entirely within the drainage basin of the Mississippi River. The two main rivers in the state are the Arkansas River, which drains the northern two-thirds of the state, and the Red

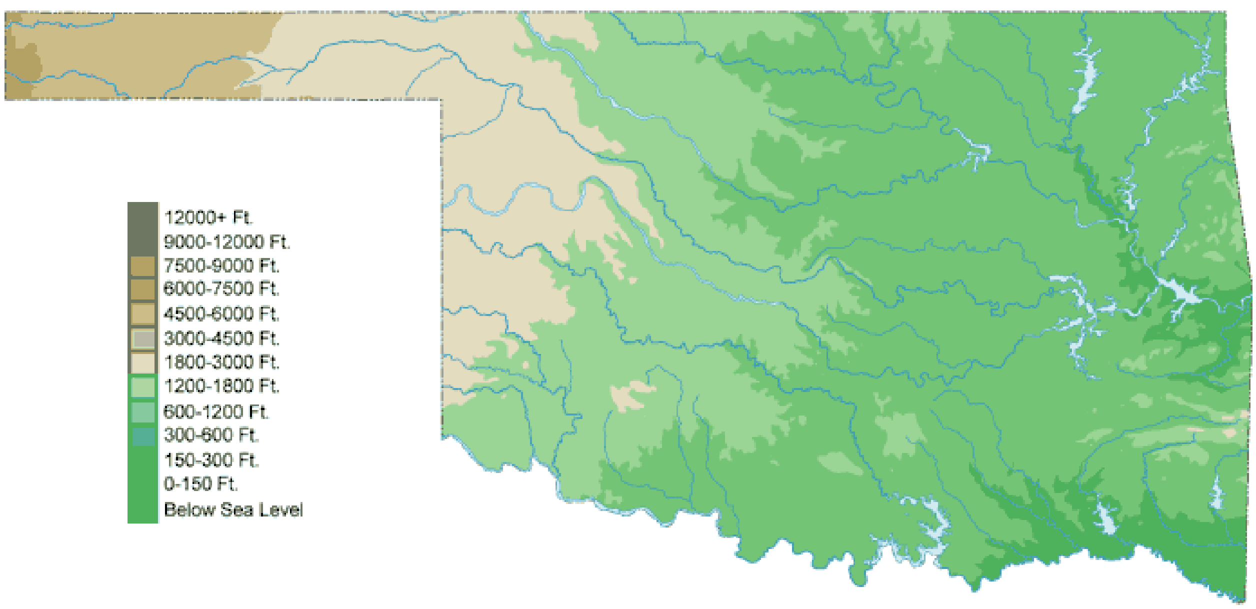


Figure 6: Oklahoma elevation map. (Cole)

River, which drains the southern third, and serves as the state's southern border. Principal tributaries of the Arkansas River are the Verdigris, Grand (Neosho), Illinois, Cimarron, Canadian and North Canadian. The Washita and Kiamichi serve as the Red River's principal tributaries in Oklahoma, with the Little River flowing into the Red River after it crosses into Arkansas.

There are relatively few deep river basins or valleys in Oklahoma, which serve to trap air pollution for any extended period of time. Therefore, ozone episodes tend to be of short duration. Because of the relatively flat terrain and prevailing south winds, Oklahoma City, Tulsa and Lawton areas (see wind roses above) can be influenced by ozone transport from the Dallas/Ft. Worth (DFW) area during transport events lasting for only a day or a few days at a time. On a more localized scale, the Arkansas River valley west of Tulsa winds through an area of small hills, which are capable of funneling ozone and precursors toward the Keystone Lake area on days when the wind is from the east. These transport events are rare and usually last only a day. Transport events differ from stagnation events in the wind speeds. Transport events occur when winds bring ozone and ozone precursors from outside of Oklahoma, like DFW, into the state.

Stagnation events occur when high ozone levels are sensed due to low or no wind conditions for extended periods. The ozone that is created in this scenario is due to pre-cursors emitted from the local area. Stagnation events lasting more than a week occur about once every ten years or so, usually during the middle of summer when high pressure in the atmosphere causes clear skies, heat and calm conditions. During those stagnation events, the ozone levels at all monitoring sites in an MSA can reach unhealthy levels. Regional-scale particulate pollution is highest in the lower elevations of eastern Oklahoma, and gradually decreases to very low levels as you move west to higher elevations. High concentrations of fine particulate values in eastern Oklahoma seem to be mostly related to secondary sulfates that originate from the mid-western United States.

IV. Population

Oklahoma is a rural state of just over 3.7 million people. There are three MSAs:

1. Oklahoma City: approximately1.25 million people with an estimate of 1.31million for 2014.
2. Tulsa: approximately 937 thousand people with an estimate of 969 thousand for 2014.
3. Lawton: approximately 130 thousand people with an estimate of 131 thousand for 2014. (Bureau, n.d.)

i. Demographic Trends

No demographic trends have been identified which would increase the current design of our network. The "air quality characterization, in terms of NAAQS comparable values, for areas with relatively high populations of susceptible individuals" has not changed. In other words, concerning our largest population areas, air quality design value trends have not increased, and in fact have decreased, for all NAAQS pollutants in recent years.

V. MAJOR EMISSION SOURCES

Oklahoma has a diverse industrial base that dates back to the oil boom era of the early twentieth century. Although many refineries have sprung up, only four remain with all of them located in the eastern half of the state. Their emissions have declined greatly in the last ten years. There are several oil storage facilities in the state with the largest located in Cushing in east central Oklahoma. With an abundance of natural gas, generation is split between gas- and coal-fired facilities. There are six coal-fired power plants located in the eastern half of Oklahoma. Six power plants, three coal-fired and three natural gas-fired, were required to reduce NOx emissions, and three were required to reduce SO_2 emissions by the Oklahoma's EPA Regional Haze State Implementation Plan (SIP) Revision and the Federal Implementation Plan (FIP). Some of the power plants have already installed low NOx burners to comply with the emission requirements in the Regional Haze SIP and FIP. The number of major sources has gone from just under 400 in 2003 to around 325 for the last five-year period. Emissions from the major sources that are still operating have declined in the last ten years. An increase in major criteria or precursor pollutants does not appear likely for the next five years as the shift to a service- based economy continues.

Emission trends graphs will be included in pollutant specific discussions later within this document.

VI. Oklahoma Air Monitoring Network

Oklahoma has no designated nonattainment areas for any of the NAAQS.

i. Lead/TSP

Lead monitoring began in 1958 with one Total Suspended Particulate (TSP) monitor in Oklahoma City. After the TSP and lead NAAQS were promulgated in 1971, the network grew and samples were taken at many locations throughout Oklahoma. TSP and lead were measured by the same type of monitors and filter media. After the filter media was weighed for TSP, it was analyzed for lead. Lead monitoring was discontinued as was TSP after 1999 when TSP transitioned to PM10 and the lead monitoring network requirements were relaxed nationally to require only one population-based site per EPA region and source-oriented sites for facilities emitting greater than five tons per year. Before this monitoring rule was put in place, several years of samples showed concentrations below detectable limits. Area source lead concentrations in ambient air trended downward drastically throughout the nation following the ban on leaded gasoline in the early 1970s.

DEQ installed and operated two lead sites as a result of the 2010 lead NAAQS rule. The Tulsa NCore site (#40-143-1127) has a required lead site and the Savanna site (#40-121-0416) was placed into operation to meet the current source monitoring requirement for the McAlester Army Ammunition Plant. The Tulsa NCore site remains in operation with very low concentrations being monitored. There has been some speculation from EPA that the rule requiring an NCore lead site may be rescinded. Based on the values DEQ is currently collecting, the NCore lead site would be terminated if this should occur. Operation of the Savanna (#40-121-0416) site was discontinued at the end of 2013 following three years of measured concentrations below or very near the minimum detectable limit, except for two sample values. These two values stood out from three years of sampling values because they were much greater than routinely measured at the site, but they were well below the NAAQS. Further investigation, documented these higher lead concentrations as attributable to a city project where old lead paint was being removed from a nearby water tower, when there were northeast winds. Lead values on those days could not have been attributable to any activities originating from the McAlester Army Ammunition Plant.

In light of the data collected during these three years, DEQ is requesting a renewal of the waiver of operation for Savanna (#40-121-0416) from the Region 6 Administrator. The request is also based on new modeling that was performed in early 2016.

Monitoring

DEQ believes the data from the table below demonstrates that the McAlester Army Ammunition Plant source near Savanna (#40-121-0416) will not contribute to a maximum lead concentration in ambient air in excess of 50 percent of the NAAQS. Refer to Table 1 for data from the Tulsa NCore site.

AQS Site ID#	***City***	***Year***	***Maximum 3 Month Average***
40-121-0416	Savanna	2011	0
		2012	0
		2013	0.06
		2014	0
40-143-1127	Tulsa	2011	0.01
		2012	0.01
		2013	0.01
		2014	0

Table 1: Lead data collected from Tulsa NCore site.

According to Part 58 Appendix D 4.5 (ii); The Regional Administrator may waive the requirement in paragraph 4.5(a) for monitoring near lead (Pb) sources if the

State or, where appropriate, local agency can demonstrate the lead (Pb) source will not contribute to a maximum lead (Pb) concentration in ambient air in excess of 50 percent of the NAAQS (based on historical monitoring data, modeling, or other means). The waiver must be renewed once every 5 years as part of the network assessment required under §58.10(d).

The original monitoring waiver for this site was granted in the response to the 2013 annual network review plan based on data from 2011 to 2013. DEQ requests that this waiver be renewed and submits the attached modeling files to support this request. Table 2, as seen below, contains additional information regarding facility emissions from the McAlester Army Ammunition Plant since 2009.

Facility Emissions and Changes

	2009	*2010*	*2011*	*2012*	*2013*	*2014*
Emissions (tons/year)	0.091	0.198	0.325	0.621	0.166	3.489

Table 2: McAlester Army Ammunition Plant lead emissions since2009

Modeling

Although not located in the maximum modeled concentration area of the original model, the lead site for this source was sited so as to measure population exposure in the small town of Savanna just east of the facility property boundary. DEQ felt this was a more appropriate location than the maximum concentration location, which is a sparsely populated area with very few options to obtain electricity posed other logistical and security concerns.

Assessment

There are relatively few lead sources in Oklahoma; however, the 2014 state emission inventory identified one new source whose emissions exceeded the emission threshold of 0.5 tons per year for required monitoring. DEQ has installed a new primary and co-located lead monitor near the Ardaugh Glass facility in Sapulpa, Oklahoma, which began collecting data on January 1, 2016. No other sources are expected to be added within the next five-year period; however, DEQ will evaluate the emission inventory data annually to ensure compliance with source-related network requirements.

Sites are operated using standard high-volume sampler technology (TSP samplers) and filters are analyzed by a private lab using Federal Reference or Equivalent analysis methods. DEQ chose not to use the EPA national contract for lead analysis.

ii. Particulate Matter < 10µm (PM_{10})

The first Oklahoma TSP site was opened in Tulsa in 1972. In 1987, the TSP NAAQS was replaced by a PM_{10} NAAQS. Originally, PM_{10} samplers in Oklahoma City and Tulsa were operated by the City/County Health Departments. Responsibility for these monitors was transferred to DEQ in the mid-1990s. Over the years, Oklahoma has operated more than twenty different sites collecting these data. With the exception of one source-oriented PM_{10} site near Muskogee, DEQ has collected no PM_{10} values, which would indicate that more than the minimum number of required samplers is necessary in any of our Oklahoma MSAs. Currently, the Oklahoma PM_{10} network consists of three continuous samplers and one filter-based sampler.

Assessment

The long running Muskogee sampler has a history of higher than normal values due to its proximity to several area sources. The sampler is located in the Muskogee Industrial Park area and during periods of dry, windy weather, values tend to rise during the midday hours. Heavy truck traffic in the area during normal working hours tends to increase the PM_{10} values.

Oklahoma City and Weatherford PM_{10} monitors are relatively new and were added in order to sample the occasional dust storms that frequently occur in western and central Oklahoma.

The filter-based FEM sampler near downtown Oklahoma City is a long-term trends site located at the Oklahoma Fire Department #1 site (#40-109-0035). The remaining three continuous sites are used to determine statewide geographical patterns and supplement the Air Quality Health Advisory Program. DEQ recently added one continuous PM_{10} monitor in western Oklahoma (Weatherford) to identify and track the occasional dust storms that accompany high wind events. At this time, DEQ feels these four sites are adequate to determine PM_{10} trends and geographical distribution and does not intend to expand its PM10 network in the foreseeable future. The PM_{10} network will likely continue, as is, for the next five years unless network requirements are changed in an upcoming NAAQS review.

iii. Particulate Matter $< 2.5\mu m$ ($PM_{2.5}$)

Monitoring for $PM_{2.5}$ began with promulgation of the $PM_{2.5}$ NAAQS in 1996. DEQ was tasked with installing 23 sites for the initial $PM_{2.5}$ network. Sampling began in 1997, but FRM quality control issues delayed collection of valid data until 1999. No violation of the $PM_{2.5}$ NAAQS has been monitored in Oklahoma at this point at any monitoring location. As a result, the size of the FRM network has been reduced incrementally over the years. Conversely, DEQ has increased the number of continuous samplers in order to enhance the Air Quality Health Advisory Program. This transition from a predominantly manual sampling network to continuous samplers is represented in the chart below and shows DEQ’s efforts to make higher resolution $PM_{2.5}$ data more readily available to the public in near real-time fashion.

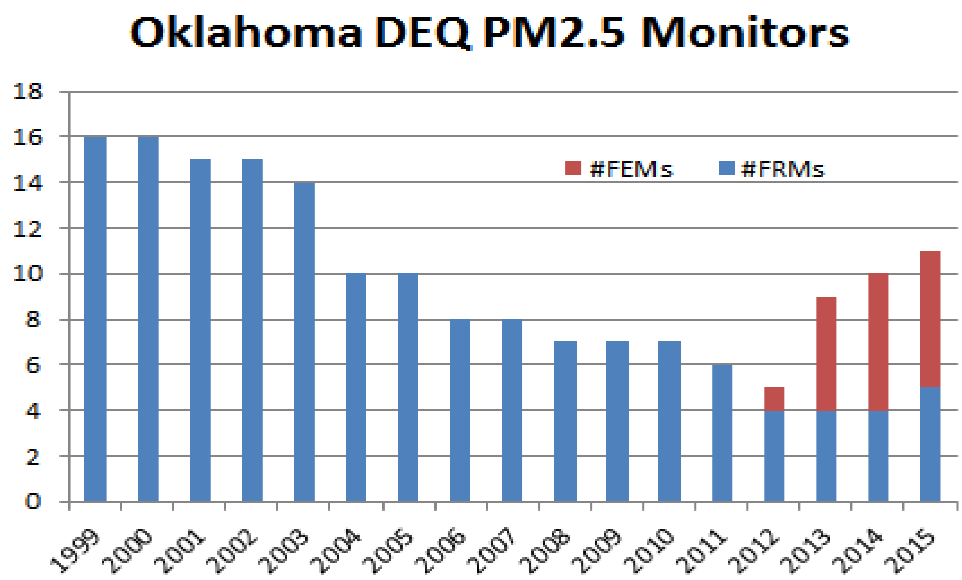


Figure 7: Oklahoma DEQ PM2.5 monitor count, FEM vs. FRM.

The continuous network has transitioned from the TEI (formerly R&P) TEOM/FDMS monitors to a network of SHARP Model 5030 monitors. This portion of the network supports the Agency's daily AQI reporting and Health Advisory Program. These monitors have recently been designated by the EPA as a Federal Equivalent Method for $PM_{2.5}$; however, two years of data must be collected from each site to determine if the samplers are meeting data quality objectives. Only two of these FEMs have met the criteria to be designated as SLAMS: Ponca City and McAlester.

Of the nine SHARP monitors now operating throughout Oklahoma, three are collocated with FRMs. DEQ is evaluating the performance of these new instruments to determine if they can be relied upon to collect high quality data as FEM monitors. Should the FEMs prove capable of collecting the required quality of data as defined by EPA guidance and assessment tools, DEQ would have the option of deactivating all but one FRM monitor in the coming years, if DEQ chooses to do so. This transition would offer a significant cost savings to the Agency. Early evaluations of the data collected by the SHARP samplers show a significant improvement over the TEOM/FDMS technology used previously, but have indicated data completeness issues. Further reduction of the filter-based FRM samplers currently in place will be predicated on the continued evaluation of the data collected by the SHARP samplers.

Refer to Figure 8 for the spatial distribution of all $PM_{2.5}$ monitors (FRM/FEM/Continuous) in the Oklahoma DEQ network.

PM2.5 Monitor Location vs. Oklahoma Population Density

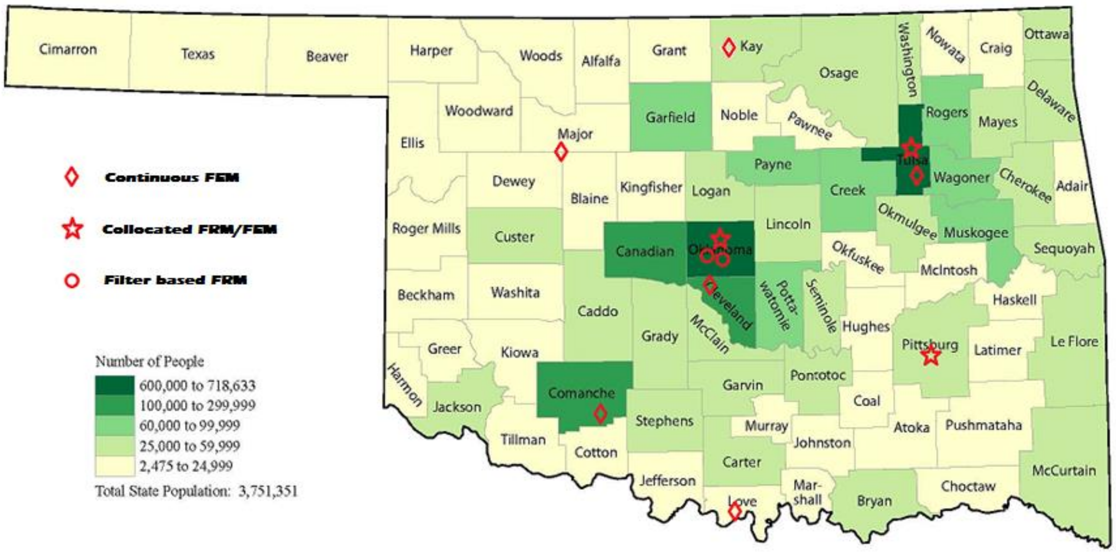


Figure 8: Monitor location and type compared to Oklahoma Population Density.

The number of NAAQS-comparable $PM_{2.5}$ monitoring sites as described in DEQ's FY16 Annual Network Review meets minimum requirements for the Oklahoma network. The network consists of two monitoring sites each in Oklahoma City and Tulsa, and a background site in McAlester. All of these sites are less than 85% below the annual standard of 12 micrograms per cubic meter and the daily standard of 35 micrograms per cubic meter. The minimum number of monitors required for Oklahoma City is two, and for Tulsa, it is one. $PM_{2.5}$ values at our Tulsa NCore site (#40-143-1127) for 2012-2014 can be found in Table 3.

AQS Site #	*2011-14 (Annual) Values in µg/m³*	*2011-14 (Daily-98th percentile) Values in µg/m³*	*2012-14 (Annual) Values in µg/m³*	*2012-14 (Daily-98th percentile) Values in µg/m³*
40-143-1127			9.45	21
40-109-0035	9.5	20.5		
40-109-1037	9.2	21		

Table 3: $PM_{2.5}$ values for Oklahoma City sites (#40-109-0035 and #40-109-1037) and the NCore site (#40-143-1127).

In both Oklahoma City and Tulsa one of the $PM_{2.5}$ monitors is located near the city center and the other at some distance to the north. In terms of annual mean concentrations, the DEQ background monitor in McAlester is about the same concentration as our Tulsa monitors and slightly more than the Oklahoma City monitors. This would seem to indicate that most of the $PM_{2.5}$ measured is coming from regional or even national sources and not locally generated.

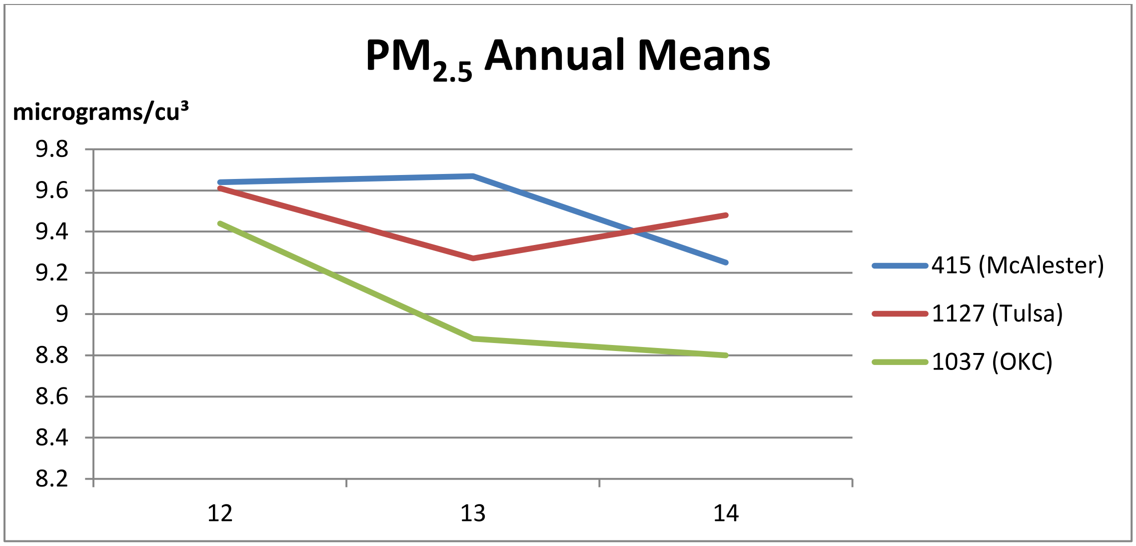


Figure 9: $PM_{2.5}$ annual means.

The map below shows only the continuous $PM_{2.5}$ sites. The state maintains good spatial and geographical distribution of its $PM_{2.5}$ sites, which results in collection of good, near real-time data for the Air Quality Health Advisory program.

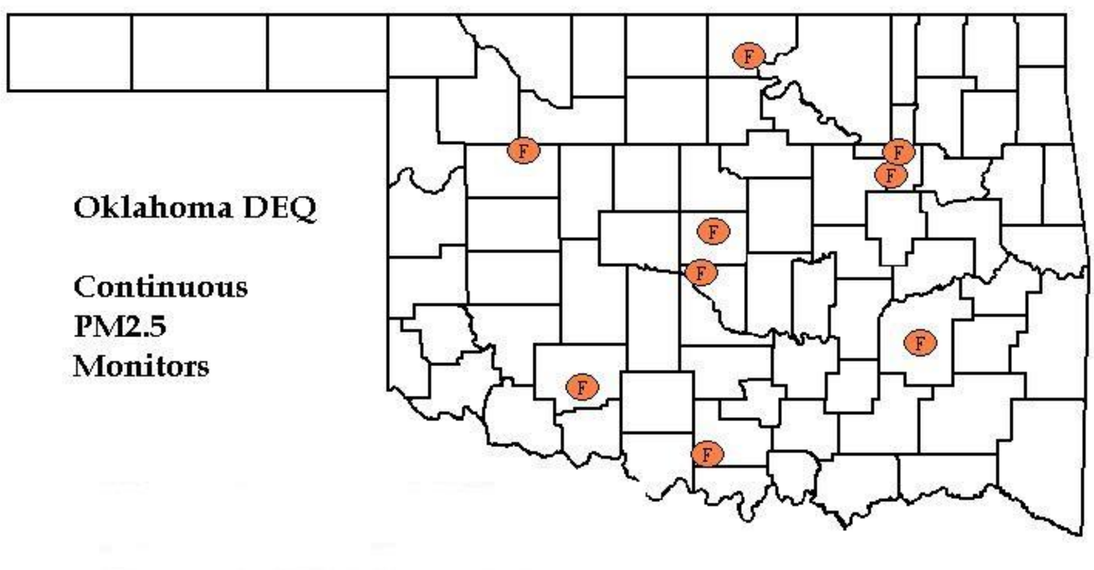


Figure 10: Location of all continuous $PM_{2.5}$ monitors in Oklahoma.

These monitors have been particularly useful during the springtime burn season. While some fires are local in size, the continuous network works well for larger fires such as the burning that occurs in the Flint Hills annually. As mentioned previously, an additional special purpose monitor (SPM) is being added in Washington County to gather data on the springtime Flint Hills burning. Oklahoma's daily $PM_{2.5}$ high values appear to stem almost exclusively from large seasonal agricultural burns. Those burns consist of a mix between "prescribed burns" and "wildfires".

DEQ continues to try to realize the advantages of continuous monitors which are as follows:

- Less travel required for operation and maintenance
- Higher resolution (hourly) of data when samplers are operating properly
- No lab cost involved for data collection
- Real-time data access to notify the public when concentrations reach unhealthy levels

Assessment:

DEQ's current $PM_{2.5}$ network meets minimum requirements and is more than adequate to protect the health of the citizens of Oklahoma from $PM_{2.5}$. The network will likely not be expanded beyond the current size, with the exception of potential special projects that are being considered to monitor fire emissions. DEQ plans to maintain its non-required continuous network for its Health Advisory Program.

While DEQ's monitoring staff acknowledges the benefits of continuous technology, they believe an increase of quality control on the manufacturing end of these instruments should be performed at the factory before releasing them to the states, locals, and tribes for use. Efforts to work with the vendors to improve data quality and completeness are ongoing even though they have not been very fruitful to date due to constant software and hardware problems.

DEQ's past experience with both the TEOM/FDMS technology and the SHARP monitors seems to be as beta testers of the equipment which is detrimental to the data capture rates and data quality. Both instruments perform poorly in seasonally humid environments common in Oklahoma and have design limitations that frequently affect data completeness. DEQ's monitoring staff will continue to search for consistent, reliable continuous methods to use in the network for $PM_{2.5}$ monitoring and to provide quality data for NAAQS compliance, AQI, and the Health Advisory Program.

iv. Ozone

The Oklahoma ozone monitoring network began operating in the early 1970s. A portion of the original sites are still in operation and are situated upwind and downwind of the prevailing wind direction (SSE) in the two major metropolitan areas, Oklahoma City and Tulsa. There are 6 ozone sites in the Oklahoma City MSA, which are included on the map below:

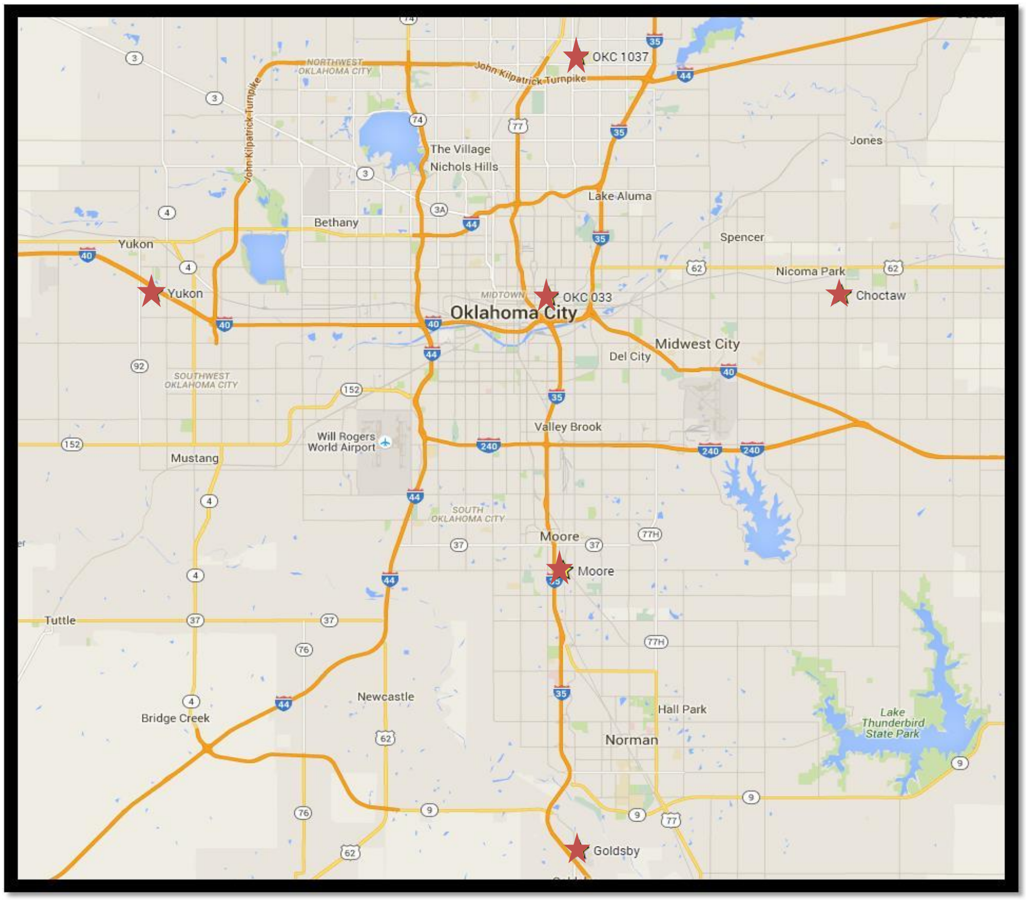


Figure 11: Each star denotes the location of an ozone monitor in Oklahoma City.

DEQ feels that the current configuration has been very beneficial and necessary for supplementing EPA's ozone mapping program, giving DEQ the ability to alert the public of harmful concentrations in near real time on high ozone days via Air Quality Health Advisories.

There are five ozone sites in the Tulsa MSA, shown as stars on the map below:

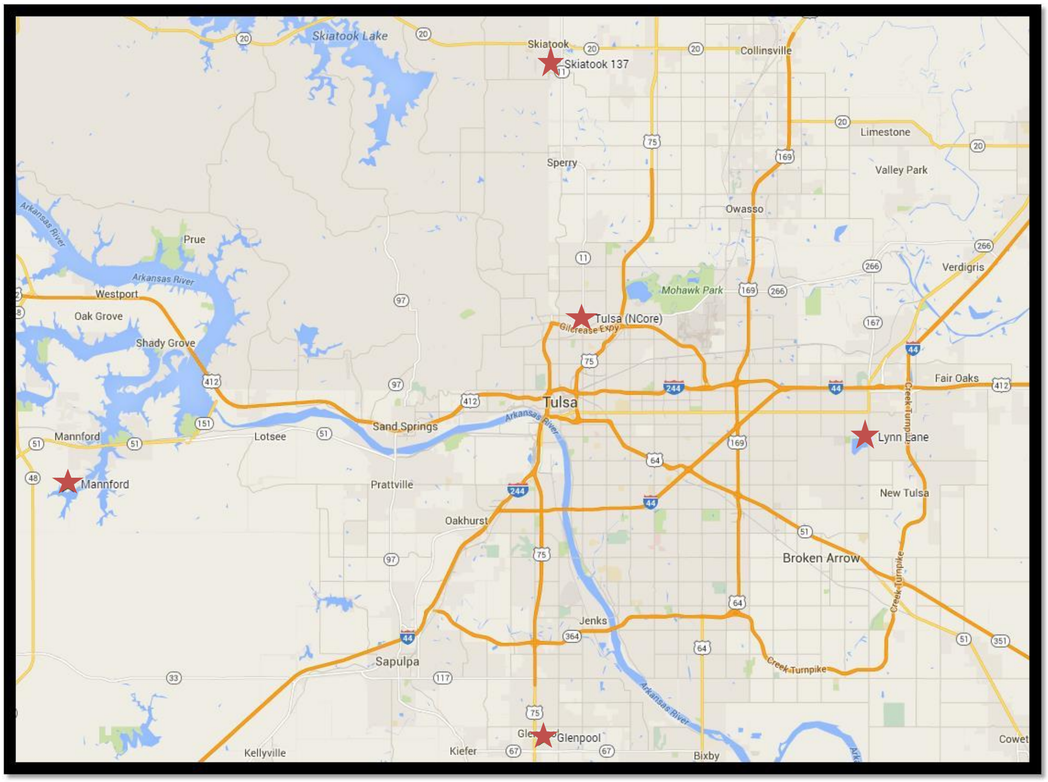


Figure 12: Each star denotes the location of an ozone monitor in Tulsa.

The Edmond (#40-109-1037) and Skiatook (#40-143-0137) sites are both located in ideal positions to monitor the maximum downwind ozone concentrations from Oklahoma City and Tulsa, while the Moore (#40-027-0049) and Glenpool (#40-143-0174) sites are located upwind of the prevailing wind direction and, as such, tend to measure lower concentrations.

The central Oklahoma City (#40-109-0033) and central Tulsa (#40-143-1127) sites are located in the downtown areas of OKC and Tulsa and are population oriented.

The ozone monitoring network has consisted of 16 to 17 sites in any given year for the past several years. Of those sites, 14 are permanent (SLAMS) sites, and data collected at these sites are comparable to the NAAQS. Of these, 11 sites are situated in and around the two major metropolitan areas of the state, Oklahoma City and Tulsa, with four of the 11 monitors sited to the west and east of the Oklahoma City and Tulsa downtown areas. Oklahoma City has an additional background site on the south side of the MSA near the town of Goldsby.

The Lawton MSA is the third largest populated area of the state and contains one ozone monitor. The additional ozone sites are at McAlester, located in southeast Oklahoma, and Seiling, located in northwest Oklahoma. The sites in Seiling and McAlester were chosen to fill the large geographical gaps that existed in their respective parts of the state and to determine rural background concentrations. Both are regional in scale. They also enhance DEQ's ability to provide a robust advisory program because they provide a broad geographic distribution.

Special Purpose Monitors (SPMs) are located at the Tishomingo, Waurika, and the newly established Healdton sites as part of the Red River ozone study. These sites will alternate with the Burneyville, Durant and Walters sites approximately every two years. The data collected has been very useful in determining interstate ozone transport and for enhancement of ozone mapping. Transport of ozone and ozone precursors from the Dallas/Ft. Worth metropolitan area occurs frequently in areas served by these monitors. Though sparsely populated, the people of southern Oklahoma have benefitted from the data collected by these monitors. Near real-time email notifications of high concentrations of ozone, known as ozone events, are available to these residents by subscription to the DEQ Air Quality Health Advisory Program.

Assessment

During the months of March and April, prairie grass is often burned in order to spur growth of native vegetation for cattle production and to control invasive plant species such as Eastern Red Cedar and other woody plants. This practice has occurred for many years but could threaten the attainment status of Oklahoma, Kansas, Nebraska, and other surrounding states as the ozone NAAQS continues to be tightened. Due to this seasonal burning occurring in the Flint Hills and Tall Grass Prairie, plans are being made to expand the ozone network to Washington County. Monitors may be added for this project if needed. This additional monitor will be co-located within the Washington County $PM_{2.5}$ monitor mentioned in the previous section of this document.

DEQ supports a very robust ozone network that is more than adequate to protect the citizens of Oklahoma, meet program objectives, and satisfy 40 CFR Part 58 requirements. It is not likely that the core network will be expanded or reduced in the coming five-year period unless resources diminish.

After assessing data collected from the Red River sites, DEQ believes that resources used to maintain these sites are well spent and should be continued into the foreseeable future.

v. Sulfur Dioxide (SO_2)

The SO_2 monitoring network was originally developed using a source specific strategy, later expanding to include a population exposure aspect. Currently, two monitors within the network are source-specific, one monitor is population-based, and four monitors are a combination of both. The monitor in Oklahoma City (#40-109-1037) is population-based and retained to assist with determination of background levels for the Prevent Significant Deterioration (PSD) program. The monitor in Ponca City (#40-071-0602) is in an area of large SO_2 sources and will be retained as long as resources are available. Muskogee (#40-101-0167) is source-based, monitoring a large coal-fired power plant. Three monitors in Tulsa (#40-143-0175, #40-143-0179, and #40-143-0235) are both source- and population-based. One of those is in an area that has historically had numerous complaints from area citizens. The remaining Tulsa SO_2 monitor is a trace level monitor (#40-143-1127), which is a requirement of NCore.

The graphs below show oxides of sulfur (SO_x) in tons per year and the location of current SO_2 monitors. The graph includes all point, nonpoint, non-road, on-road, and event sources.

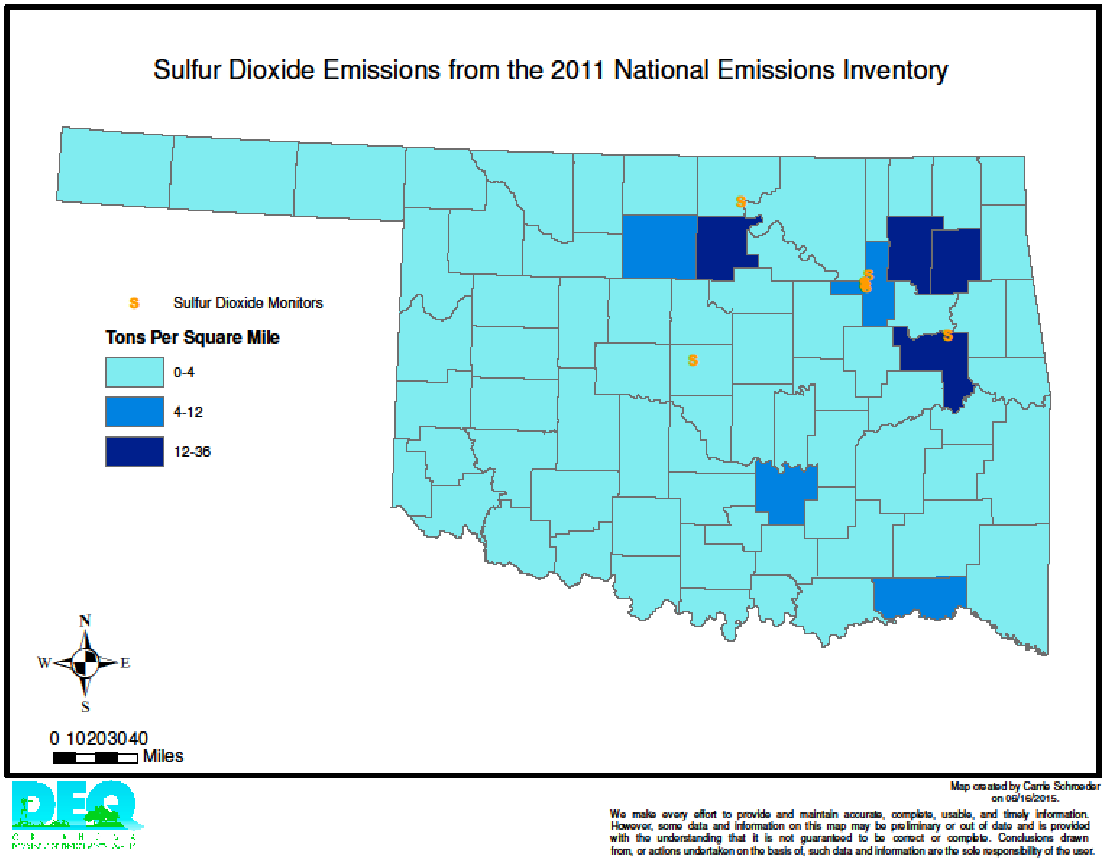


Figure 13: SO_2 emissions from the 2011 National Emissions Inventory compared to the location of DEQ's SO_2 monitoring locations.

SO_2 monitoring is required at all NCore multi-pollutant sites and where Population Weighted Emission Index (PWEI) values dictate. The only Core-Based Statistical Area (CBSA) required to operate a source-oriented SO_2 sampler is Tulsa, with a PWEI value of 23,811.36. DEQ operates three source-oriented monitoring sites in west Tulsa (#40-143-0175, #40-143-0179, and #40-143-0235) exceeding the SO_2 CBSA requirement. Due to emissions from local SO_2 sources and a history of complaints from residents in the west Tulsa refinery area, DEQ has determined these sites should remain operational for the foreseeable future. With a

PWEI of 2,076.12 in the Oklahoma City CBSA, there is no requirement for SO_2 monitoring. See Table 4 for PWEI numbers. DEQ also maintains one site at Oklahoma Christian University (#40-109-1037) to provide background data for modeling.

CBSA	***Population***	***2011 NEI Total***	***PWEI***
Oklahoma City	1,278,053	1624.44	2076.12
Tulsa	946,962	25,145	23,811.36

Table 4: PWEI numbers for Oklahoma City and Tulsa.

<u>Assessment</u>

DEQ's monitoring network exceeds the minimum SO_2 network requirements; however the Agency deemed it necessary to expend state resources for the additional sites in the west Tulsa area where complaints continue to occur. DEQ also plans to review the PWEI values annually for the Tulsa and Oklahoma City MSAs but does not anticipate that a network expansion will be necessary as a result of increased emissions.

Emissions for SO_x in the Oklahoma City MSA initially showed an upward trend from 2009 to 2010 before steadily falling until 2013. While not falling to pre-2009 levels, levels are still considered low. Emissions for SO_x in the Tulsa MSA continue to trend downward from 2009 to 2012 before slightly increasing from 2012 to 2013.

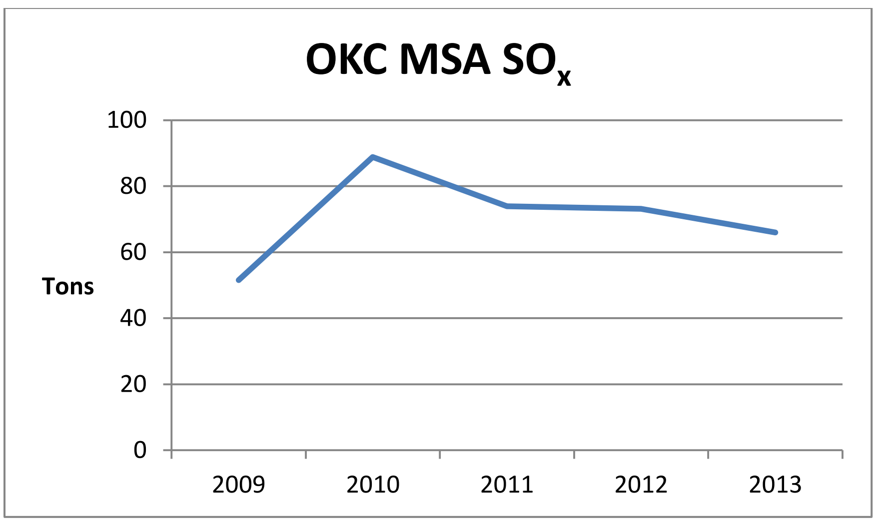


Figure 14: Oklahoma City MSA SO_x emissions in tons per year.

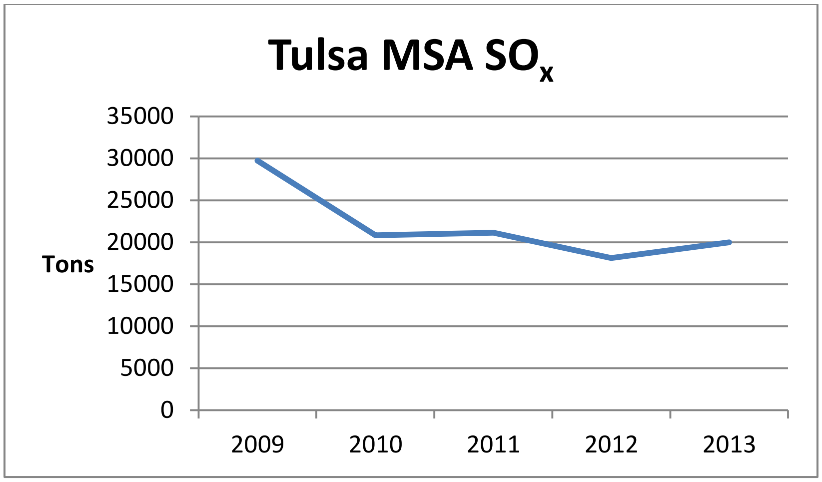


Figure 15: Tulsa MSA SO_x emissions in tons per year.

vi. Nitrogen Dioxide (NO_2)

The NO_2 monitoring network was set up to collect data for NAAQS comparison under Part 58 monitoring regulations and is a valuable supplement to the ozone network. Data is also used for determination of background concentrations in the PSD program. At its peak in the mid-1970s, the NO_2 network consisted of over 20 sites. Over the years, that network has been reduced dramatically. Only four NO_2 sites currently comprise the entire network. This includes one added Near-road NO_2 site (#40-109-0097), which is a recent requirement of the NO2 NAAQS update.

A required population site is located in central Oklahoma City (#40-109-0033), while a downwind maximum concentration site is located in North Oklahoma City (#40-109-1037). The third site is located in Tulsa, a requirement for the NCore site (#40-143-1127). Low annual mean concentrations were collected throughout recent years from all sites compared to the 0.053ppm NAAQS requirement for NO_2, the network has been reduced to four sites.

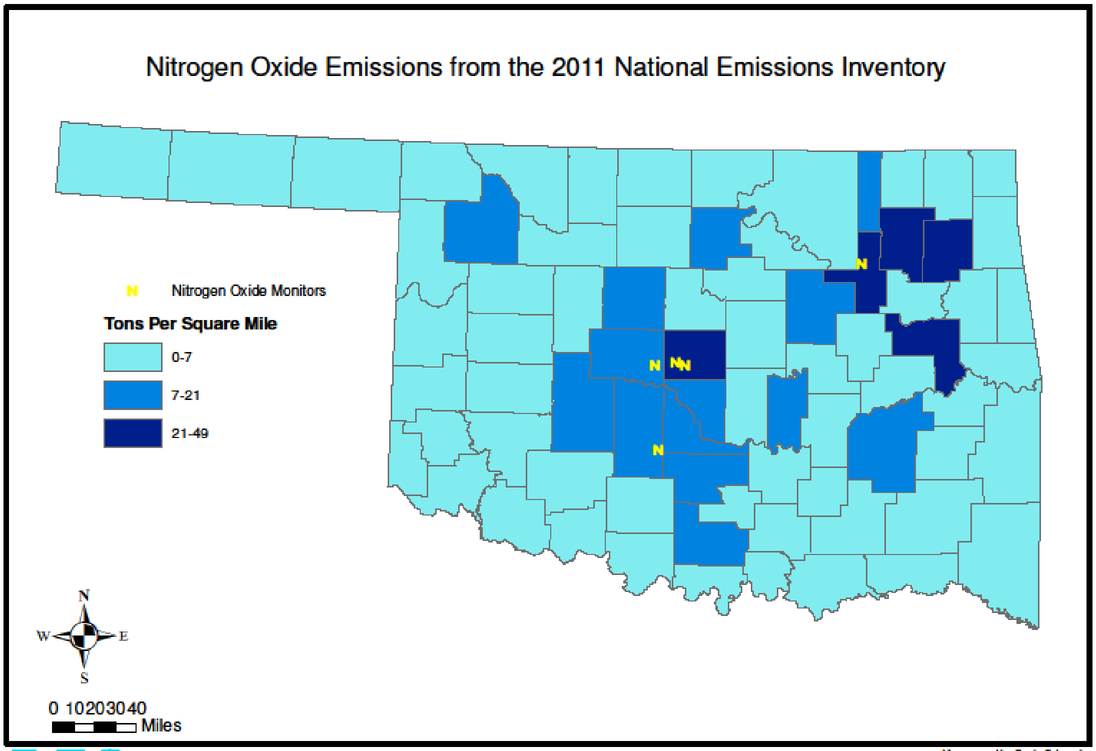
<u>Assessment</u>

DEQ installed its first required Near-road NO_2 site located in Will Rogers Park near I-44, which began operation in 2015. The second phase of the Near-road rule requires an additional site in CBSAs having a population of between 500,000 and 1,000,000 by January 1, 2017. Revisions to the NO_2 Near-road rule are being proposed that would remove the requirement for a latter phase; therefore, DEQ is not planning to devote any further resources to this project.

With only four sites in the entire network, and only three of those being required, DEQ is not making any long-term plans to reduce this portion of the network. Furthermore, concentrations being seen recently in the population sites of the network do not indicate a need for expansion of the network.

Figure 16 indicates oxides of nitrogen (NO_x) in tons per year along with locations of DEQ monitors. These graphs also indicate no need for additional source monitors in the foreseeable future.

Figures 17 and 18 indicate both Oklahoma City and Tulsa areas have shown a downward trend for all major point sources of NOx.



Map created by Carrie Schroeder on 06/16/2015.

We make every effort to provide and maintain accurate, complete, usable, and timely information. However, some data and information on this map may be preliminary or out of date and is provided with the understanding that it is not guaranteed to be correct or complete. Conclusions drawn from, or actions undertaken on the basis of, such data and information are the sole responsibility of the user.

Figure 16: NO_x emissions for Oklahoma from the 2011 National Emissions Inventory compared to location of NO_x monitoring sites.

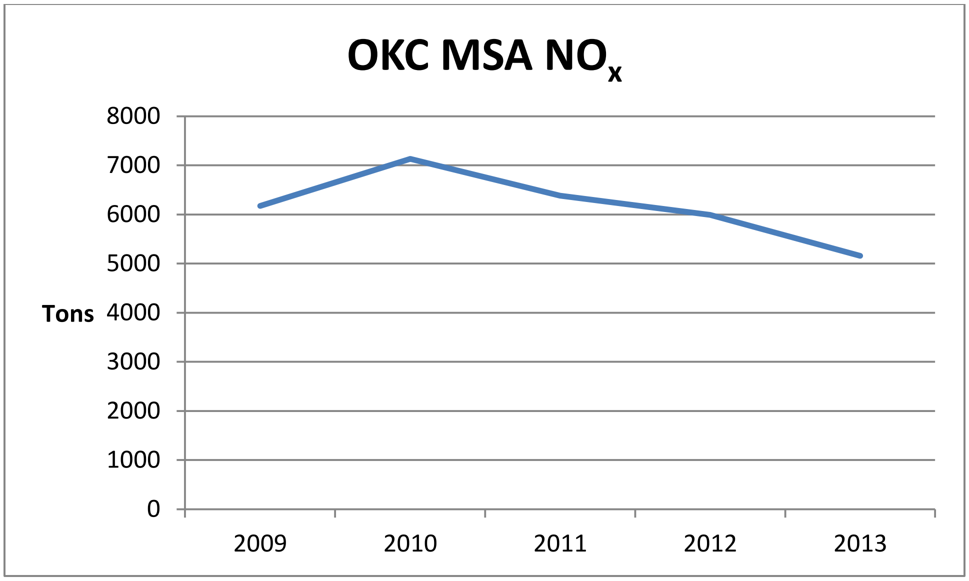


Figure 17: Oklahoma City MSA NO_x emissions in tons per year.

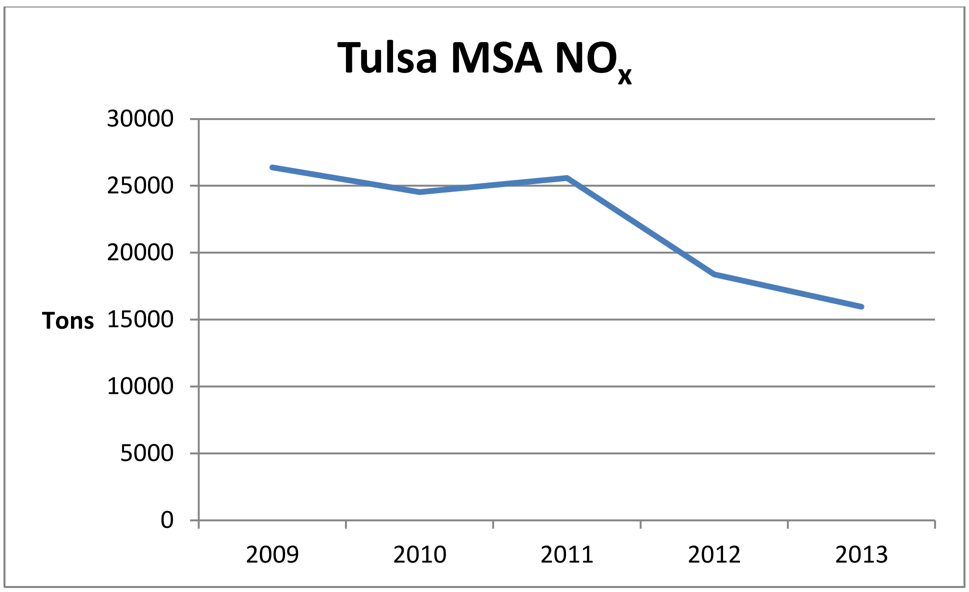


Figure 18: Tulsa MSA NO_x emissions in tons per year.

vii. Carbon Monoxide (CO)

The CO monitoring network was historically designed to assess population exposure. Attainment of the CO NAAQS was achieved in the late 1980s after automobile controls improved and the older more polluting models of the fleet (public automobiles) were removed from service. There were more carbon monoxide monitors during that time, some of which were situated using microscale site location criteria (i.e. close to neighborhoods and busy automobile traffic areas). Microscale CO sites are no longer required for state or local networks; however, there is a requirement for co-location of a CO monitor at required Near-road NO_2 sites in cities with populations larger than 1,000,000. DEQ meets this minimum requirement at the Near-road NO_2 site in Oklahoma City (#40-109-0097).

Aside from the Near-road requirement, two sites are currently operational in Oklahoma City (#40-109-1037) and Tulsa (#40-143-1127). These two sites are NAAQS comparable but not required. They remain useful for ongoing trend analysis in our largest MSAs. Since microscale siting requirements were eliminated in 2006 with changes in the monitoring rule, reductions in the CO network resulted in the current configuration of these three sites.

Assessment

DEQ does not foresee a reduction or expansion of the current network but will work with the EPA regional office under the "Regional Administrator Required Monitoring" provision of the rule should additional CO monitoring be required.

Due to the geographical location of the sites in this small network and local scale behavior as a pollutant, site redundancy is a non-issue. Also, DEQ is aware of no new technologies for CO monitoring that should be considered for network deployment in the next few years.

With regard to major sources of CO, both of the large MSAs, Oklahoma City and Tulsa, are experiencing downward trends for CO from Title V sources.

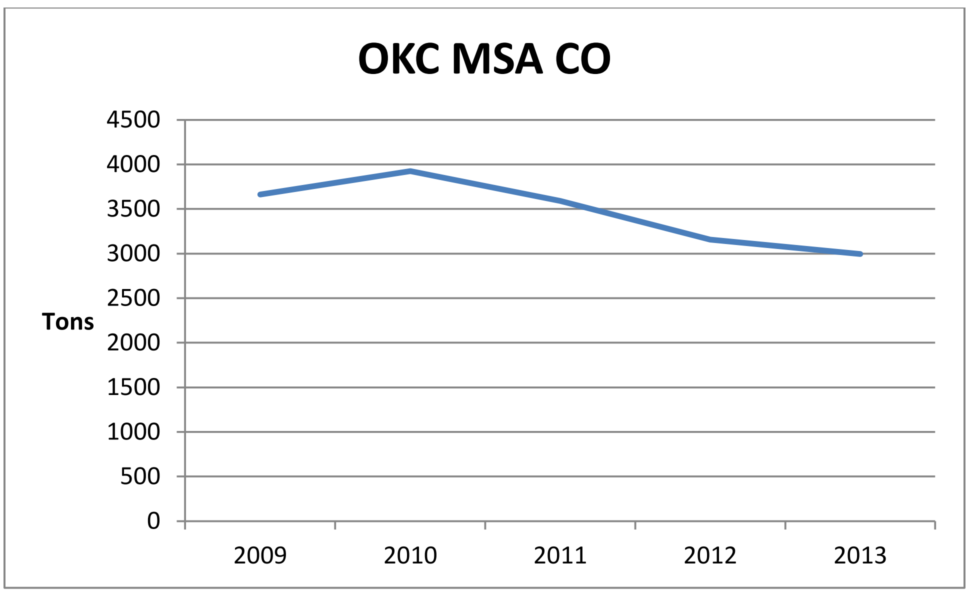


Figure 19: OKC MSA CO emissions in tons per year.

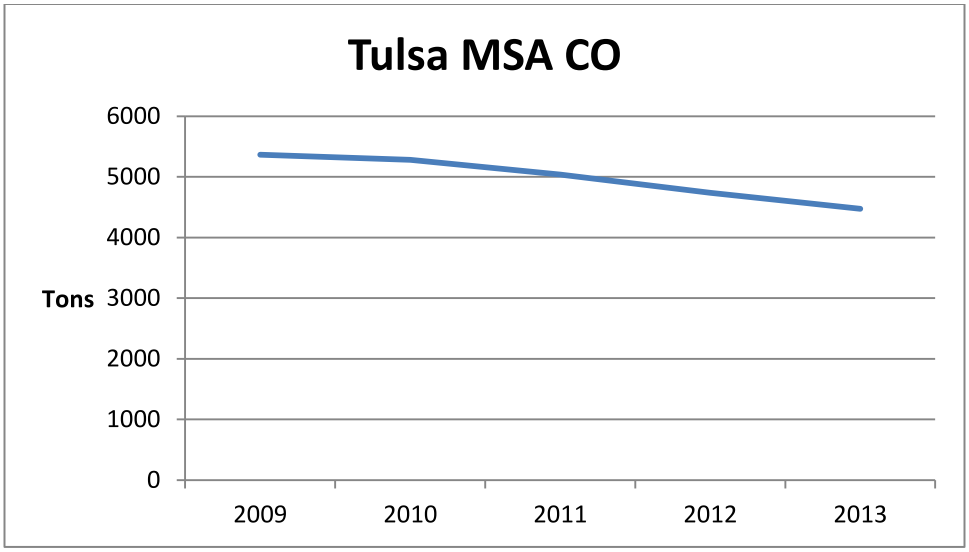


Figure 20: Tulsa MSA CO emissions in tons per year.

VII. Summary and Conclusions for the Assessment:

DEQ will continue to enhance our current network with special study areas in the northeastern portions of the state to determine ozone and particulate effects of the Kansas Flint Hills during the agricultural burning season. The Red River's Special Purpose Monitors continue to provide invaluable information regarding ozone transport. While DEQ does need to identify higher quality continuous instrumentation for the $PM_{2.5}$ network, efforts are continuing to be made to improve this portion of the network, working alongside instrument manufacturers to solve the problem of data incompleteness using the current instrumentation. Despite this setback, DEQ has and will continue with its robust network of PM 2.5 and ozone sites near the state's three largest MSAs to provide a solid infrastructure for the required AQI.

Overall, the DEQ monitoring network is efficient and effective in meeting both state and federal goals for air monitoring. Using up-to-date technology in all aspects of its network, including monitoring, data collection, and data analysis, DEQ is able provide useful, quality data to the citizens of Oklahoma through the Air Quality Health Advisory Program.

Bibliography

Bureau, U. C. (n.d.). *Quickfacts*. Retrieved from www.census.gov

Cole, B. (n.d.). *Oklahoma Map Collection*. Retrieved from Geology.com: Geoscience News and Information: http://geology.com/state-map/oklahoma.shtml

Survey, O. C. (n.d.). *Precipitation History; Annual, Statewide*. Retrieved from Oklahoma Climate: http://climate.ok.gov/index.php/climate/climate_trends/precipitation_history_annual_statewide/CD00/prcp/Annual/oklahoma_climate

US Department of Interior, U. (n.d.). *National Atlas*. Retrieved from National Atlas: Nationalatlas.gov