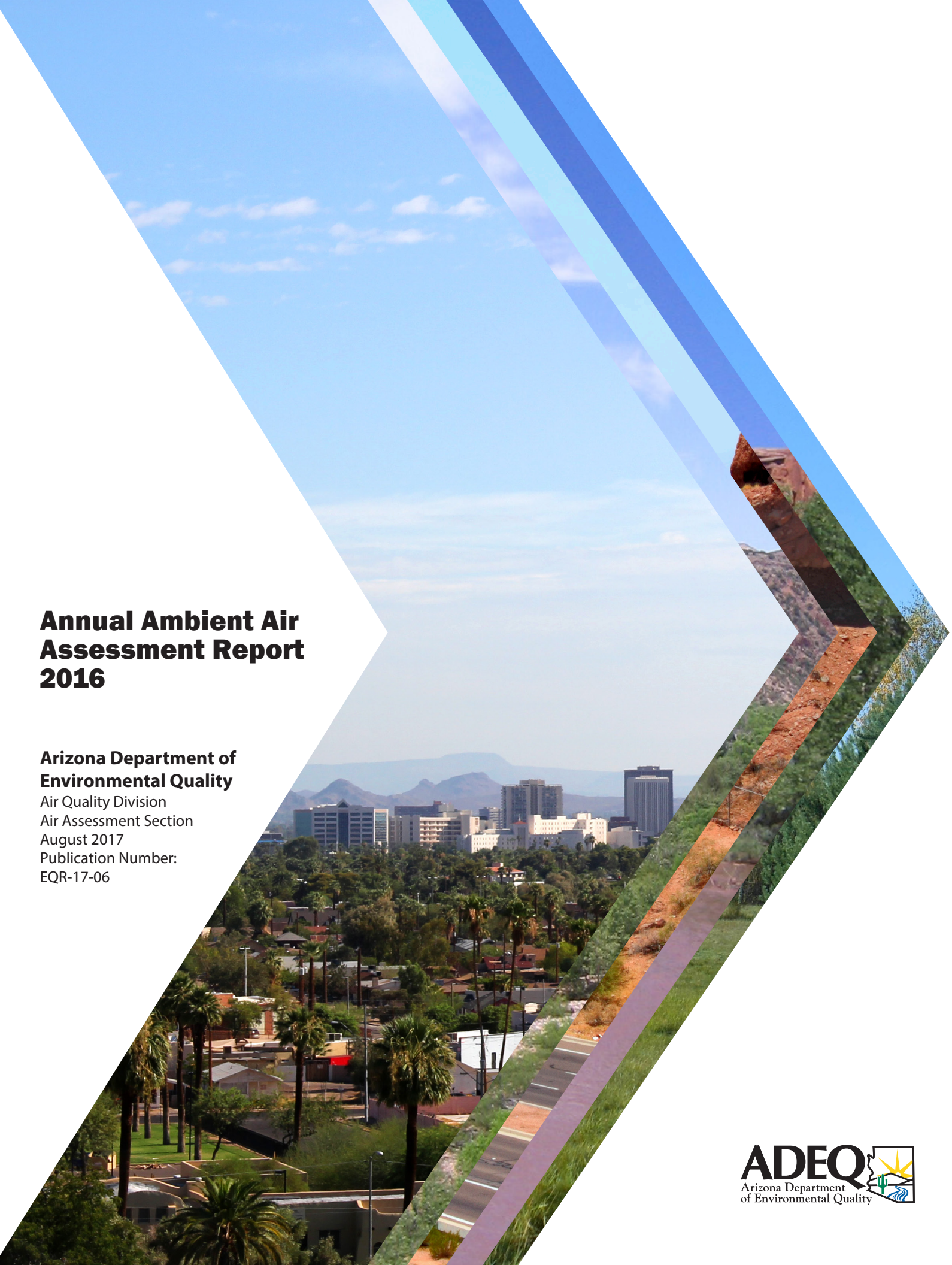

Annual Ambient Air Assessment Report 2016

Arizona Department of Environmental Quality
Air Quality Division
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Table of Contents

List of Figures

List of Tables

Executive Summary

The purpose of the Arizona Department of Environmental Quality (ADEQ) Annual Ambient Air Assessment Report is to serve as an informational and technical document for use within ADEQ, other state and local agencies, and health organizations such as the American Lung Association. This report summarizes the results of air quality monitoring conducted by ADEQ in 2016. Monitor locations, purpose of monitoring, and monitoring methods are discussed. Also included are area/monitor compliance values based on air monitoring conducted by ADEQ in 2016, an overview of long-term monitoring concentrations, and Air Quality Index (AQI) values.

Data were collected from 38 ADEQ air monitoring sites located throughout Arizona in 2016. Many of the sites have multiple instruments measuring a variety of gaseous, particulate, meteorological, and visibility parameters.

Criteria Pollutants

The majority of the ADEQ's air quality measurements are for criteria pollutants (carbon monoxide (CO), nitrogen dioxide (NO_2), ozone (O_3), sulfur dioxide (SO_2), particulate matter (PM_{10} and $PM_{2.5}$), and lead (Pb)) classified as State and Local Air Monitoring Stations (SLAMS) used for regulatory compliance. To show regulatory compliance, the U.S. Environmental Protection Agency (EPA) has established National Ambient Air Quality Standards (NAAQS). These standards are the concentrations at which each pollutant becomes harmful to human health and are unique to each pollutant.

Compliance statuses are presented in this document for informational purposes only and are considered preliminary. For each of the criteria pollutants the preliminary compliance status, along with the general trend and a 2016 AQI summary, are provided below:

- **CO**
  - In compliance with the NAAQS.
  - 81.9% decreasing trend for JLG Supersite from 1999-2016.
  - AQI values for 2016:

Site	"Good" Days	Missing Days
Alamo Lake*	122	0
JLG Supersite	244	122

*122 possible monitoring days.

- **NO_2**
  - In compliance with the NAAQS.
  - 40.3% decreasing trend for JLG Supersite from 1999-2016.
  - AQI values for 2016:

Site	"Good" Days	"Moderate" Days	Missing Days
Alamo Lake*	180	0	2
JLG Supersite	345	4	17

*182 possible monitoring days.

- **O_3**
  - Four sites in violation of the NAAQS: JLG Supersite, Queen Valley, Tonto National Monument, and Yuma Supersite.
  - 7.7% decreasing trend for Alamo Lake, JLG Supersite, Queen Valley, and Tonto National Monument from 2005-2016.
  - 3.7% decreasing trend for all O_3 sites from 2008-2016.
  - AQI values for 2016:

Site	"Good" Days	"Moderate" Days	"Unhealthy for Sensitive Groups" Days	Missing Days
Central/Southern Region* (averages)	270	82	6	9
Northern Region* (averages)	282	54	<1	30

*Specific sites are listed in Section 3.5.

- **SO_2**
  - Four sites in violation of the NAAQS: Hayden Old Jail, Miami Jones Ranch, Miami Ridgeline, and Miami Townsite.
  - 51.2% decreasing trend for JLG Supersite from 2005-2016; 92.4% decreasing trend for Hayden Old Jail from 1975-1991 and then 28.1% increasing trend from 1999-2016; 8.6% increasing trend for Miami Ridgeline from 1999-2016.
  - AQI values for 2016:

Site	"Good" Days	"Moderate" Days	"Unhealthy for Sensitive Groups" Days	"Unhealthy" Days	Missing Days
Alamo Lake*	82	0	0	0	0
JLG Supersite	353	0	0	0	12
Hayden Old Jail	132	100	91	27	16
Miami Area (averages)	267	50	21	<1	27

*82 possible monitoring days.

- **PM_{10}**
  - Three sites in violation of the NAAQS (preliminary, based on incomplete data): Douglas Red Cross, Paul Spur Chemical Lime Plant, and Yuma Supersite.
  - 7.0% average decreasing trend for southern region from 1998-2016; 4.5% average decreasing trend for northern region from 1997-2016; 3.4% average decreasing trend for the central region from 1999-2016.

- AQI values for 2016:

Site	"Good" Days	"Moderate" Days	"Unhealthy for Sensitive Groups" Days	Missing Days
Southern Region* (averages)	306	45	2	13
Central/ Northern Region* (averages)	341	14	<1	11

*Specific sites are listed in Section 5.5.

- **$PM_{2.5}$**
  - In compliance with the NAAQS.
  - 33.8% average decreasing trend for Douglas Red Cross, JLG Supersite, and Nogales Post Office from 1999-2016.
  - AQI values for 2016:

Site	"Good" Days	"Moderate" Days	"Unhealthy for Sensitive Groups" Days	"Unhealthy" Days	Missing Days
Southern Region* (averages)	298	43	1	<1	23
Central/ Northern Region* (averages)	319	30	0	<1	30

*Specific sites are listed in Section 6.5.

- **Pb**
  - Two sites in violation of the NAAQS: Globe Highway and Hillcrest.
  - Trends are not available since ADEQ began monitoring for Pb in 2011.
  - An AQI is not established for Pb.

Non-Criteria Pollutants

In addition to sampling for criteria pollutants, ADEQ conducts manual sampling of O_3 forming compounds, speciated particulate matter, and hazardous air pollutant sampling under the Photochemical Assessment Monitoring Stations (PAMS), Chemical Speciation Network (CSN), National Air Toxics Trends Stations (NATTS), and National Core (NCore) Monitoring Network. Brief summaries from the CSN, NATTS, and PAMS networks are provided below:

- **CSN**
  - The 2016 Annual Averages for Speciated $PM_{2.5}$ major elements at JLG Supersite included the following: 33% Other, 25% Organic Carbon, 19% Crustal Component, 9% Sulfate, 7% Nitrate, 6% Elemental Carbon, and 1% Ammonium.
  - Less than 1% variation in average annual $PM_{2.5}$ composition at JLG Supersite from 2000-2016.

- **NATTS**
  - Air toxics concentrations at JLG Supersite and South Phoenix continue to show decreasing trends.
  - Manganese may be of local concern as the 2016 average exceeded the 2014 national average by a factor of 2.5.
  - 69.1% decreasing trend in VOCs from 2001-2016 at JLG Supersite and 25.7% decreasing trend in VOCs from 2007-2016 at South Phoenix.
  - 30.0% decreasing trend in Aldehydes at JLG Supersite from 2003-2016.
  - 49.2% decreasing trend in Benzo[A]Pyrene and 15.7% decreasing trend in Naphthalene at JLG Supersite from 2007-2016.
- **PAMS**
  - 26.4% decreasing trend in the Total Non-Methane Organic Compound (TNMOC) concentrations at JLG Supersite from 2008-2016 and 4.7% decreasing trend in TNMOC at Queen Valley from 2007-2016.

Visibility

Further monitoring includes special continuous monitoring for the optical/visual characteristics of the atmosphere under the urban visibility network required by House Bill 2538 of the Forty-fifth AZ State Legislature. A description of the trends observed at each visibility instrument is provided below:

- **Phoenix Transmissometer**
  - 54% increase in the mean visual range (or 15.5 miles) for all hours from 1995-2016.
  - 44% increase in the mean visual range (or 12 miles) in the morning hours from 1995-2016.
  - Between 23% and 45% increase in the mean visual range for winter, spring, and fall from 2006-2016; 3% decrease in the summer months from 2006-2016.
- **Nephelometer**
  - 53% increase in the mean visual range (or 47.7 miles) for Vehicle Emissions Laboratory (VEL) from 2006-2016.
  - 33% increase in the mean visual range (or 35.8 miles) for Estrella from 2006-2016.
  - 19% increase in the mean visual range (or 24.2 miles) for Dysart from 2006-2016.

Additionally, ADEQ serves as an operator for the Interagency Monitoring of Protected Visual Environments (IMPROVE) which tracks visual conditions in and around national parks and monuments, as well as in some urban areas.

Conclusion

Overall, monitoring data collected by ADEQ in 2016 showed decreasing trends in many of the criteria pollutants, including CO, NO_2, O_3, $PM_{2.5}$, and PM_{10} monitors. There was a continued decreasing trend in SO_2 at the urban monitor, however, the other SO_2 monitors showed an increasing trend. There was a slight decreasing trend in O_3 concentrations since 2008. Trends in Pb concentrations will be further analyzed with additional years of data, however, exceedances of the three-month rolling average continue to be observed. The total average of the AQI values for monitors operated by ADEQ indicated that 83% of the days in 2016 were "Good" days. A summary of the percentage of "Good" days for each pollutant is listed below:

- 100% for the CO monitor at Alamo Lake;
- 67% for the CO monitor at JLG Supersite (low percentage due to missing three months of data);
- 99% for the NO_2 monitor at Alamo Lake;
- 94% for the NO_2 monitor at JLG Supersite;
- Between 87% and 93% for PM_{10} and $PM_{2.5}$ monitors in the Central/Northern Region;
- Between 82% and 84% for PM_{10} and $PM_{2.5}$ monitors in the Southern Region;
- Between 74% and 77% for O_3 monitors throughout the state;
- 97% for the SO_2 monitor at JLG Supersite;
- Approximately 73% for SO_2 monitors in the Miami area; and
- 36% for the SO_2 monitor at Hayden Old Jail.

Similar to the criteria pollutants, decreasing trends were also continued for non-criteria pollutants, including VOCs, Aldehydes, Benzo[A]Pyrene, Naphthalene, and TNMOC. With reductions in air pollutant concentrations over the years, visibility measurements made by ADEQ showed great improvements with increased visual range.

Section I – Introduction to ADEQ's Ambient Air Monitoring Program

1.0 Purpose and Background

The ADEQ Annual Ambient Air Assessment Report summarizes the air monitoring activities and the results of air quality monitoring conducted by the Arizona Department of Environmental Quality (ADEQ) for the calendar year 2016. This report shows monitor locations, purpose of monitoring, and monitoring methods. Also included is an overview of long-term monitoring concentrations, Air Quality Index (AQI) values, and area/monitor compliance values based on air monitoring conducted by ADEQ in 2016. The purpose of this report is to serve as an informational and technical document intended for use within ADEQ, other state and local agencies, and health organizations such as the American Lung Association.

Data from 38 sites located throughout Arizona are included in this report. Many of the sites have multiple instruments measuring a variety of gaseous, particulate, meteorological, and visibility parameters. The majority of the air quality measurements are for criteria pollutants (carbon monoxide (CO), nitrogen dioxide (NO_2), ozone (O_3), sulfur dioxide (SO_2), particulate matter (PM_{10} and $PM_{2.5}$), and lead (Pb)). The monitors used to measure these pollutants are classified as State and Local Air Monitoring Stations (SLAMS) used for regulatory compliance. Per requirements in the Clean Air Act, the U.S. Environmental Protection Agency (EPA) established the National Ambient Air Quality Standards (NAAQS) (40 CFR Part 50). These standards are the concentrations at which each criteria pollutant becomes harmful to human health and the environment, and are unique to each pollutant.

In addition to sampling for criteria pollutants, ADEQ performs special continuous monitoring for the optical/visual characteristics of the atmosphere under the urban visibility network required by House Bill 2538 of the Forty-fifth AZ State Legislature. Further monitoring includes manual sampling of O_3 forming compounds and other hazardous air pollutants, and speciated particulate matter sampling under the Photochemical Assessment Monitoring Stations (PAMS), Chemical Speciation Network (CSN), National Air Toxics Trends Stations (NATTS), and National Core (NCore) Monitoring Network. ADEQ also oversees industrial networks to determine the effects of their emissions on local air quality and how well pollution control technologies are working. Additionally, ADEQ serves as an operator for the Interagency Monitoring of Protected Visual Environments (IMPROVE) network which tracks visual conditions in and around national parks and monuments, as well as in some urban areas. Lastly, ADEQ operates a network of portable particulate monitors for public awareness to provide information regarding pollutant levels from wildfires and wood burning.

Air monitoring is commonly classified by networks based on individual pollutants or by a group of related pollutants. Monitoring networks for ambient air quality are established to sample pollution in a variety of settings representative of different populations and geographical areas, to assess health and welfare effects, and to assist in determining air pollution sources. The ambient monitoring networks cover both

urban and rural areas of the state and are composed of one or more monitoring sites whose data are compared to the NAAQS for compliance and statistically analyzed for trends analysis. ADEQ also tracks data recovery, quality control, and quality assurance parameters for the instruments operated at its various sites. Most of the sites within each network also measure meteorological variables. ADEQ networks monitor a wide variety of pollutant and atmospheric characteristics including urban, industrial, rural, transport, and background surveillance.

2.0 Standards and Guidelines

The Federal Clean Air Act (CAA) of 1970 requires the EPA to assist states and local agencies in establishing ambient air quality monitoring networks to characterize human health exposure and public welfare effects from criteria pollutants. The way public welfare is measured is by analyzing ambient air conditions using a variety of instruments specifically designed to measure a certain pollutant. These instruments show pollution concentrations for a given time period, and then the data is analyzed to identify certain concentrations which can affect human health. Because different concentrations of pollutants affect human health at different levels, an Air Quality Index (AQI) is used for showing when a specific concentration can be bad for human health.

For data completeness, EPA requires 75 percent valid data recovery over a set time period for values to be considered valid. Depending on the pollutant, this can apply to the scales of hourly, daily, quarterly, and yearly, for which each averaging period must be 75 percent complete. For regulatory purposes, if the data completeness is greater than 75 percent for the specified time period, then completeness criteria are met and data may be used for area designations.

2.1 Air Quality Index

The AQI is an index for reporting daily air quality to the general population. It indicates how clean or polluted the air is, and what associated health effects might be of concern for that day. The AQI focuses on health effects that may be experienced within a few hours or days after breathing polluted air. The EPA calculates the AQI for the criteria air pollutants regulated by the CAA: ground-level O_3, PM_{10}, $PM_{2.5}$, CO, SO_2, Pb, and NO_2. For each of these pollutants, EPA has established national air quality standards to protect public health. When the AQI reaches 100, this indicates that a concentration has exceeded the standard set forth by the EPA. Generally, ground-level O_3 and airborne PM are the two pollutant types that pose the greatest threat to human health in this country. EPA's AQI website AIRNow is found at www.airnow.gov.

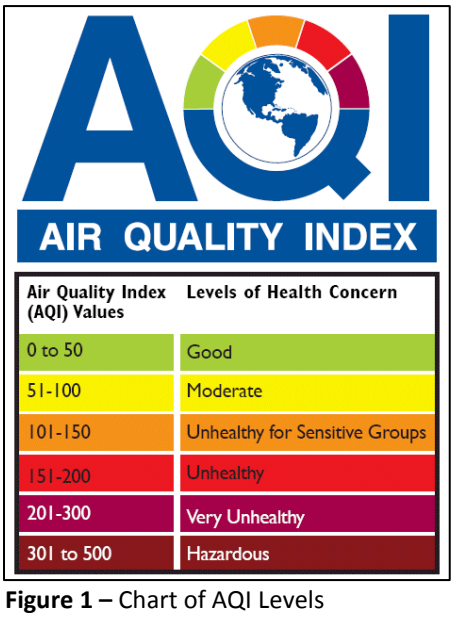


Figure 1 – Chart of AQI Levels

Each category in Figure 1 corresponds to a different level of health concern. The six levels of health concern are:

- "Good" AQI is 0 - 50. Air quality is considered satisfactory, and air pollution poses little or no risk to human health.
- "Moderate" AQI is 51 - 100. Air quality is acceptable; however, for some pollutants there may be a moderate health concern for a very small number of people. For example, people who are unusually sensitive to O_3 may experience respiratory symptoms.
- "Unhealthy for Sensitive Groups" AQI is 101 - 150. Although general public is not likely to be affected at this AQI range, people with lung disease, older adults, and children are at a greater risk from exposure to O_3, whereas persons with heart and lung disease, older adults, and children are at greater risk from the presence of particles in the air.
- "Unhealthy" AQI is 151 - 200. Everyone may begin to experience some adverse health effects, and members of the sensitive groups may experience more serious effects.
- "Very Unhealthy" AQI is 201 - 300. This would trigger a health alert signifying that everyone may experience more serious health effects.
- "Hazardous" AQI is greater than 300. This would trigger a health warning of emergency conditions. The entire population is more likely to be affected.

2.2 National Ambient Air Quality Standards

The NAAQS were first established by the EPA per the CAA in 1970 and are continuously evaluated and updated based on current scientific research on the effects of pollution exposure to the population. Focus is placed on those groups who are sensitive to air pollution. Table 1 shows the current NAAQS.

Table 1 – Current NAAQS
(Source: USEPA TTN NAAQS)

Pollutant		Primary/ Secondary	Averaging Time	Level	Form
Carbon Monoxide (CO)		primary	8-hour	9 ppm	Not to be exceeded more than once per year
			1-hour	35 ppm	
Lead (Pb)		primary and secondary	Rolling 3 month average	0.15 µg/m^3	Not to be exceeded
Nitrogen Dioxide (NO_2)		primary	1-hour	100 ppb	98th percentile, averaged over 3 years
		primary and secondary	Annual	53 ppb	Annual Mean
Ozone (O_3)		primary and secondary	8-hour	0.070 ppm	Annual fourth-highest daily maximum 8-hr concentration, averaged over 3 years
Particle Pollution	**$PM_{2.5}$**	primary	Annual	12 µg/m^3	annual mean, averaged over 3 years
		secondary	Annual	15 µg/m^3	annual mean, averaged over 3 years
		primary and secondary	24-hour	35 µg/m^3	98th percentile, averaged over 3 years
	PM_{10}	primary and secondary	24-hour	150 µg/m^3	Not to be exceeded more than once per year on average over 3 years
Sulfur Dioxide (SO_2)		primary	1-hour	75 ppb	99th percentile of 1-hour daily maximum concentrations, averaged over 3 years
		secondary	3-hour	0.5 ppm	Not to be exceeded more than once per year

Ambient concentrations to be compared to the NAAQS are defined under the “Form” column in Table 1 and are calculated based on the averaging time stated. For many of the pollutants, there is a primary standard and a secondary standard. Primary standards provide public health protection, including protecting the health of "sensitive" populations such as asthmatics, children, and the elderly. Secondary standards provide public welfare protection, including protection against decreased visibility and damage to animals, crops, vegetation, and buildings.

An area may be designated as nonattainment, attainment, or unclassifiable based on exceedances of the standards. Area designations occur after a revision to the NAAQS occurs, or at other times the EPA deems appropriate.

- A nonattainment area is one in which either the primary or secondary standard has been violated, and both the local agency and the EPA have acknowledged the area as being in nonattainment. The EPA can designate that area as nonattainment with certain sanctions or penalties being placed in order to bring that area into attainment. When EPA designates an area as nonattainment, a State Implementation Plan (SIP) is put in place. A SIP outlines the actions the state will take to improve air quality in the area. This can include instituting lower maximum pollutant allowances for industrial processes, paving of roads, replacing aging equipment, and other control strategies. If the controls outlined in the SIP do not achieve the standard or are inadequate, the EPA has the option to develop a Federal Implementation Plan (FIP) for the area.
- An attainment area is one which is achieving the standards and no additional measures are necessary.
- An unclassifiable area is an area for which data are incomplete and do not support a designation of attainment or nonattainment. Data may be incomplete due to lack of monitoring or completeness criteria for the year.

It is important to understand the difference between an exceedance and a violation of a standard in order to define area designation. An exceedance occurs when the pollutant concentration reaches a level where the AQI is at or above 100 for a given time period. This is above the acceptable level that is defined in the NAAQS, but does not necessarily indicate that the NAAQS have been violated.

> For example, the 24-hour $PM_{2.5}$ NAAQS level of exceedance is 35 micrograms per cubic meter ($\mu g/m^3$). If the concentration on a given day is above this level, an exceedance occurs, but a violation of standard does not necessarily occur. The form by which the $PM_{2.5}$ standard is calculated is the 98^{th} percentile of samples averaged over three years. If the 24-hour average for a day goes above the 35 $\mu g/m^3$ level, but the 98^{th} percentile averaged over three years is not above 35 $\mu g/m^3$, then there is an exceedance for that day, but there is no violation of the standard.

2.3 Monitoring Objectives

There are three basic monitoring objectives as outlined below, each containing multiple aspects and purposes: NAAQS comparison for regulatory compliance, research, and public information. There may be certain monitors which have more than one purpose due to crossover between different networks. For example, a NAAQS comparison monitor may also be used for research purposes in some circumstances.

A. NAAQS Comparison

The majority of ADEQ's monitoring falls under the NAAQS comparison category. This monitoring is governed by the CAA and is explained under the Code of Federal Regulations (CFR) 40 Part 58. This monitoring is required based on rules spelled out in the CFR, including: total emissions in an area, population of an area, attainment/nonattainment areas, population weighted emissions, traffic counts, and pollutant point sources. ADEQ designates these monitors as SLAMS. These are long term monitors that operate for the primary purpose of comparison to the NAAQS and are used for regulatory decision making. They may also support compliance with air quality standards and emissions strategy development, and provide air pollution data to the general public in a timely manner. The SLAMS network includes monitors at stations with network affiliations such as NCore, PAMS, or Speciation, but does not include Special Purpose Monitors (SPM) and other monitors used for non-regulatory or industrial monitoring purposes. Once monitoring occurs, EPA designates areas as attainment or nonattainment based on the comparison of observed concentrations with the NAAQS.

B. Research

ADEQ operates a range of monitors used mainly for research purposes. These instruments may not be regulated by the EPA as part of the NAAQS, but represent various precursor and toxic pollutants. The programs that fall under research include PAMS, NATTS, CSN, IMPROVE, urban air toxics monitoring program (UATMP), and NCore. PAMS, NATTS, CSN, and IMPROVE will be discussed at length in this report (Sections III and IV). These programs are required by the EPA as part of a national network of instruments, but many of the pollutants measured are not specifically regulated. Due to the cross over between NCore and criteria pollutants, a brief description of NCore is provided below. Crossover also exists between UATMP and NATTS and is also described below.

- **NCore** is a multi-pollutant network throughout the whole nation that integrates several advanced measurement systems for particles, pollutant gases, and meteorology. The stations are equipped with several measurement systems to monitor particulate matter ($PM_{2.5}$, PM_{10}, and $PM_{10\text{-}2.5}$), O_3, CO, SO_2, total reactive oxides of nitrogen (NO_y), and basic meteorological parameters (temperature, wind speed, wind direction, and relative humidity). The NCore stations should be perceived as developing a representative report card on air quality across the nation, capable of delineating differences among geographic and climatological regions. There are approximately 83 NCore stations nationwide. NCore meets a number of important data needs: improved flow and timely reporting of data to the public, including supporting air quality forecasting and information systems such as AIRNow; continued determination of NAAQS compliance; improved development of emissions control strategies; enhanced accountability for the effectiveness of emission control programs; and more complete information for scientific, public health, and ecosystem assessments.

Emphasis of NCore is placed on high sensitivity instruments with the capability to detect low levels of the precursor gases CO, SO_2, and NO_y. These gases play important roles in the formation of atmospheric O_3, air toxics, and PM, which are linked to human health issues. This interconnection among distinct air quality issues requires an integrated multiple pollutant air quality monitoring and management approach which NCore successfully incorporates. ADEQ supports the NCore network by monitoring all required pollutants at its Phoenix JLG Supersite. Concentration data will be shown and analyzed in Section II of this document.

- **UATMP** is a subset of the Air Toxics program, which includes NATTS, school air toxics monitoring initiative (SATMI), and community scale air toxics ambient monitoring (CSATAM) projects. All programs that are a part of Air Toxics utilize similar monitoring methods and are therefore directly comparable. All have similar monitoring objectives of characterizing toxics in an area of interest. UATMP specifically looks at toxics trends in urban areas. Concentration data will be shown and analyzed in Section III of this document.

C. Public Information

Data generated by ADEQ's SLAMS monitors for regulatory compliance are reported to AIRNow on an hourly basis to show real-time conditions to the public. AIRNow data are used to report the AQI only, not to show regulatory status of an area.

ADEQ also operates networks that do not have EPA approved monitoring techniques, for the purpose of providing public health and visibility information to the general public. Although these networks do not use approved monitoring techniques, they give the public a general understanding of current air quality in their area. These networks do not report data to AIRNow.

For public health, a network of temporary $PM_{2.5}$ monitors without an EPA method code are used to provide air quality conditions to the public in areas that do not require monitoring under the CAA or per the CFR. These areas are mainly located in the northeastern part of Arizona and are often impacted by summer wildfires. These monitors can be easily deployed around a wildfire to describe the impacts that it has on air pollution for the local population. There are also monitors located in areas where wood burning is the main source of heating in the winter. Wildfires and wood burning create small particulates that are harmful to human health. Information regarding these portable particulate monitors can be found at http://phoenixvis.net/PPMmain.aspx.

In the Phoenix metropolitan area, ADEQ operates a variety of instruments used to determine the visibility on a daily basis. Data and pictures for visibility will be shown and analyzed under Section IV of this document.

3.0 Quality Assurance

ADEQ sustains a quality system as required by EPA to ensure high quality data are produced that meet the users' needs. The EPA primarily specifies the quality assurance (QA) requirements for operating SLAMS, SPM, CSN, NCore, NATTS, PAMS, and prevention of significant deterioration (PSD) air monitors in *40 CFR Part 58 Appendix A*, the *Quality Assurance Handbook for Air Pollution Measurement Systems: Volume II: Ambient Air Quality Monitoring Program*, Technical Assistance Documents (TADs), and other supporting guidance documents. In response, ADEQ develops quality assurance plans for air monitoring networks, which provide detailed information regarding the specifics of each air monitoring network and how data will be managed. Components of ADEQ's quality system include, but are not limited to:

- ADEQ being established as the primary quality assurance organization (PQAO) for the criteria and non-criteria pollutant air monitoring data collected and reported to EPA's Air Quality System (AQS) database.

- An agency-level Quality Management Plan (QMP), which is an "umbrella" document that details, in broad terms, the strategies used to carry out QA/QC in environmental data collection activities.

- Division-level quality assurance program and project plans (QAPPs) for each major, ongoing air monitoring network. Each QAPP describes:

    - purpose for operating the monitoring station or network
    - data quality objectives (DQOs) and/or measurement quality objectives (MQOs) along with data quality indicators (DQIs) that specify the amount of tolerable error in the data using statistical metrics
    - variety of regularly occurring quality control (QC) checks along with pass/fail criteria
    - types of QA assessments and reports needed from the network
    - data validation processes and data reporting requirements

- Standard operating procedures (SOPs) that document procedures to assure that work products are reliable, reproducible, and consistent in quality. SOPs also serve to clearly communicate any process customizations in-use, providing a means of attesting that work products are credible, legally defensible, and meet or exceed our customers' and/or stakeholders' needs or requirements. Additional forms of standardization are used to document procedures for accuracy.

ADEQ uses a multi-tiered approach to data validation to ensure consistent quality. It requires all data to move through different levels of QA by separate reviewers. Data have five different levels associated with each tier level.

- Raw – Original unchanged data recorded by the sampler or produced by laboratory analysis.

- Level 1 – Data are reviewed programmatically and automatically using software written to flag data upon receipt to ADEQ's database. The data are flagged valid or invalid based on certain instrumentation parameters.
- Level 2 – Data are reviewed manually on a weekly basis by an initial data reviewer to flag any discrepancies found. This gives the data a preliminary validation decision and identifies outliers, anomalous data, and instrumentation/laboratory issues.
- Level 3 – Data are reviewed manually on a monthly basis by the final data reviewer by looking at the data spatially and temporally. QC measures are incorporated, environmental events are identified, and a final determination on the validity of data is made.
- Certified – Data are uploaded to AQS quarterly and are certified annually by ADEQ by ensuring compliance with programmatic goals of data completeness, data precision, and data bias.

Periodically, EPA publishes reports for some of the criteria pollutant networks, and potentially non-criteria pollutant networks, that rate and/or rank monitoring organizations' performance over a three- year period. The QA Team, as well as other personnel in the data management and quality assurance (DM&QA) unit, reviews these reports to gauge how well ADEQ's networks are performing with those across the nation. If needed, corrective actions are taken to ensure data of the highest quality possible are collected.

4.0 Monitoring Location Summary

Table 2 contains some of ADEQ's site associated metadata including the site number from EPA's AQS database, the city in which the site is located, the main monitoring objectives for the site, the site coordinate location, and which parameters were recorded at the site in 2016.

Table 2– Site Index

Site Name	Air Quality System ID	Location	Monitoring Objective(s)	Lat. Long. (Deg.)	Parameters Recorded
ADEQ Building	None	Phoenix, AZ	Visibility	33.4483, -112.088	Digital High Resolution Image
Ajo	04-019-0001	Ajo, AZ	NAAQS Comparison	32.3820, -112.858	PM_{10}, Wind, Temp/RH
Alamo Lake	04-012-8000	Alamo Lake State Park, AZ	NAAQS Comparison	34.2439, -113.559	O_3, CO, PM_{10}, $PM_{2.5}$, NO_2
Banner Mesa Medical Center	None	Mesa, AZ	Visibility	33.4335, -111.843	Digital High Resolution Image
Bullhead City	04-015-1003	Bullhead City, AZ	NAAQS Comparison	35.1539, -114.566	PM_{10}
Douglas Red Cross	04-003-1005	Douglas, AZ	NAAQS Comparison	31.3492, -109.54	PM_{10}, $PM_{2.5}$, Temp/RH, Wind, IMPROVE
Dysart	04-013-4010	Surprise, AZ	Visibility	33.6370, -112.339	Bscat/$PM_{2.5}$, Temp/RH
Estrella	04-013-8005	Goodyear, AZ	Visibility	33.3833, -112.373	Bscat/$PM_{2.5}$, Temp/RH
Estrella Mountain Community College	None	Avondale, AZ	Visibility	33.4836, -112.350	Digital High Resolution Image
Flagstaff Middle School	04-005-1008	Flagstaff, AZ	NAAQS Comparison	35.2061, -111.653	O_3, $PM_{2.5}$ (EBAM)
Globe Highway	04-007-1002	Winkelman, AZ	NAAQS Comparison	33.002, -110.765	Pb, Temp/RH, Wind
Hayden Old Jail	04-007-1001	Hayden, AZ	NAAQS Comparison	33.0062, -110.786	SO_2, PM_{10}, Temp/RH, Wind
Hillcrest	04-007-1003	Hayden, AZ	NAQQS Comparison	33.0035 -110.7822	Pb
JLG Supersite	04-013-9997	Phoenix, AZ	NAAQS Comparison/ Research	33.5038, -112.096	CO, NO_2, NO_y, O_3, SO_2, Carbonyl, VOC, SVOC, Pb-PM_{10}, / PM_{10} metals speciation, PM_{10}, $PM_{10\text{-}2.5}$, $PM_{2.5}$, $PM_{2.5}$ speciation, Temp/RH, Wind, IMPROVE, Delta Temp, Horizontal Solar Radiation, Ultraviolet Solar Radiation
Meadview	04-015-9000	Meadview, AZ	Visibility	36.0193, -114.068	IMPROVE
Miami Golf Course	04-007-8000	Miami, AZ	NAAQS Comparison	33.4190, -110.83	Pb, PM_{10}, Temp/RH, Wind
Miami Jones Ranch	04-007-0011	Miami, AZ	NAAQS Comparison	33.3853, -110.867	SO_2
Miami Ridgeline	04-007-0009	Miami, AZ	NAAQS Comparison	33.3992, -110.859	SO_2
Miami Townsite	04-007-0012	Miami, AZ	NAAQS Comparison	33.3973, -110.874	SO_2
Nogales Post Office	04-023-0004	Nogales, AZ	NAAQS Comparison	31.3372, -110.937	PM_{10}, $PM_{2.5}$, Temp/RH, Wind, IMPROVE

Site Name	Air Quality System ID	Location	Monitoring Objective(s)	Lat. Long. (Deg.)	Parameters Recorded
North Mountain Summit	None	Phoenix, AZ	Visibility	33.5855, -112.072	Digital High Resolution Image
Organ Pipe National Monument	04-019-005	Ajo, AZ	Visibility	31.950, -112.80	IMPROVE
Paul Spur Chemical Lime Plant	04-003-0011	Paul Spur, AZ	NAAQS Comparison	31.366, -109.73	PM_{10}, Temp/RH, Wind
Payson Well Site	04-007-0008	Payson, AZ	NAAQS Comparison	34.230, -111.33	PM_{10}, $PM_{2.5}$ (EBAM), Temp/RH, Wind
Phoenix Transmissometer Receiver	None	Phoenix, AZ	Visibility	33.490, -112.08	Bext, Temp/RH
Phoenix Transmissometer Transmitter	None	Phoenix, AZ	Visibility	33.525, -112.10	Bext
Prescott College AQD	04-025-8033	Prescott, AZ	NAAQS Comparison	34.547, -112.48	O_3, $PM_{2.5}$ (EBAM)
Queen Valley	04-021-8001	Queen Valley, AZ	NAAQS Comparison	33.294, -111.29	O_3, NO_y, VOC, Temp/RH, Wind
Rillito	04-019-0020	Rillito, AZ	NAAQS Comparison	32.414, -111.16	PM_{10}, Temp/RH, Wind
Saguaro Nation Park West	04-019-9000	Tucson, AZ	Visibility	32.249, -111.22	IMPROVE (Protocol)
Sedona Fire Station AQD	None	Sedona, AZ	Public Information	34.868, -111.763	$PM_{2.5}$ (EBAM)
South Phoenix	04-013-4003	Phoenix, AZ	Research	33.403, -112.08	VOC
Tonto National Monument	04-007-0010	Roosevelt, AZ	NAAQS Comparison	33.655, -111.11	O_3, IMPROVE
Vehicle Emissions Laboratory	04-013-9998	Phoenix, AZ	Research	33.455, -111.10	Bscat/$PM_{2.5}$, Delta Temp, Horizontal Solar Radiation, Ultraviolet Solar Radiation, Temp/RH, Wind
Yuma Supersite	04-027-8011	Yuma, AZ	NAAQS Comparison	32.690, -114.62	O_3, PM_{10}, $PM_{2.5}$, Temp/RH, Wind

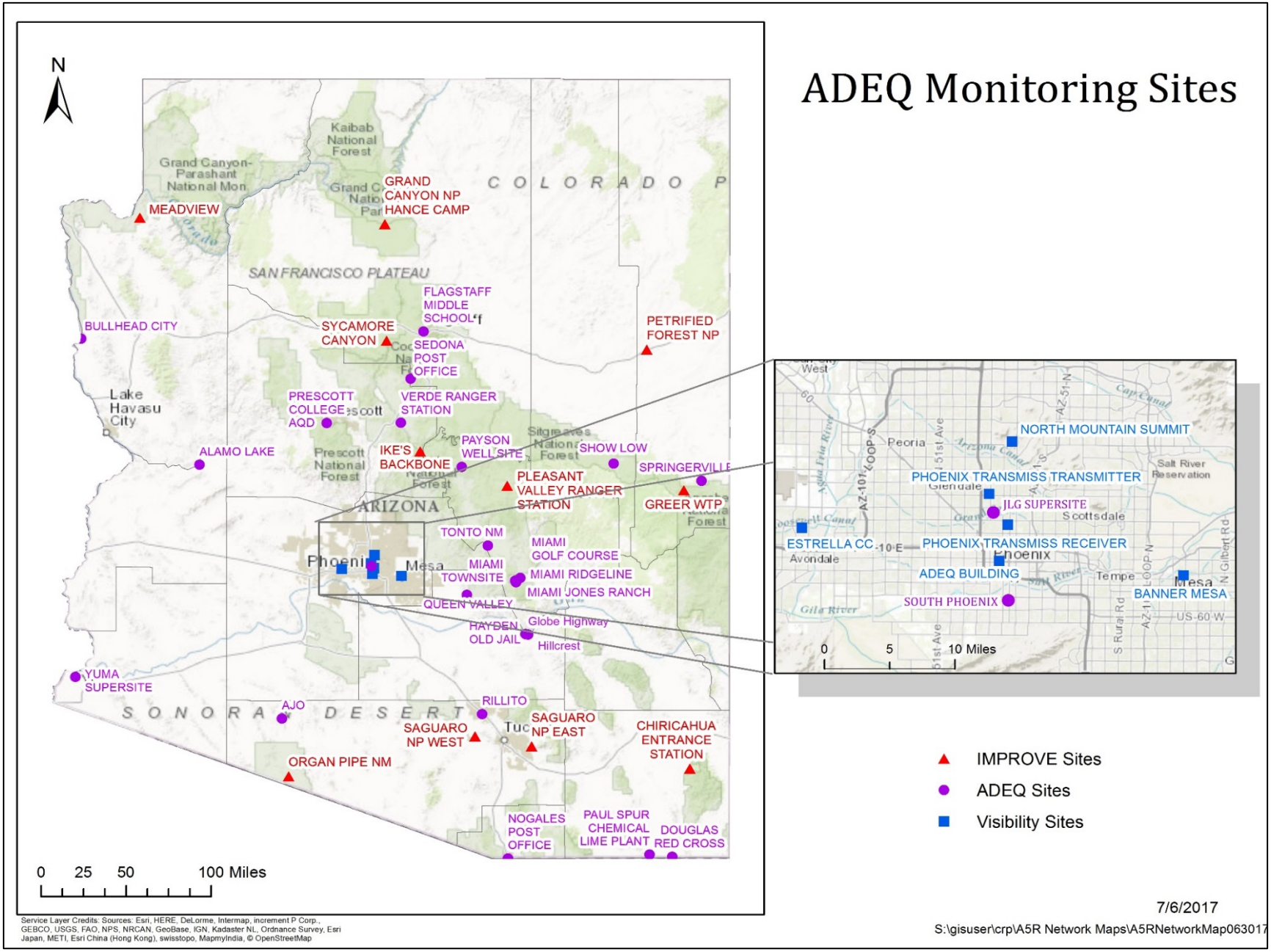


Figure 2 – The locations of ADEQ's monitoring sites. Sites from other monitoring organizations are not included.

Section II – Criteria Pollutants

The six criteria pollutants as outlined in the CAA are discussed at length in this Section. The health effects of each pollutant, the specific background of the pollutants in Arizona, and an explanation of current monitoring techniques are provided. Also included is a discussion of 2016 data which shows a history of the pollutant standards, compliance with the current standards, as well as data completeness for the year. Additionally, a length of record trend analysis provides a history of the monitors operating in Arizona in 2016. The trend analysis includes a qualitative summary of the trend and a quantitative increase/decrease of the pollutant over the years. Lastly, a summary of the AQI values in 2016 for each pollutant is presented.

1.0 Carbon Monoxide (CO)

Carbon Monoxide is a colorless, odorless, tasteless gas that is produced by the incomplete combustion of fuels. It has a variety of adverse health effects that arise from its ability to chemically bind to blood hemoglobin. Carbon Monoxide successfully competes with oxygen for binding with hemoglobin and thereby impairs oxygen transport. This impaired transport leads to several central nervous system effects, such as headache, fatigue, and dizziness. Chronic CO exposure also contributes to or exacerbates arteriosclerotic heart disease. Chronic exposure to low levels of CO can lead to depression, confusion, and memory loss.

1.1 Background

According to the 2014 National Emissions Inventory (NEI), in Arizona, 46 percent of CO emissions come from mobile sources including on-road motor vehicles, off-road motor vehicles, construction equipment, and lawn and garden equipment; 26 percent from biogenic sources; 20 percent from fires; 5 percent from miscellaneous sources; and 3 percent from fuel combustion. This pollutant has low background levels, with the highest concentrations next to busy streets, and elevated concentrations in locations with significant amounts of emissions transported from upwind areas. Concentrations peak from November to January because emissions are highest in cold weather. Automotive emissions of CO are greatest when engines operate in open loop. This occurs for longer periods of time in cold weather as the engine attempts to warm up and because the mixed layer of the atmosphere is most shallow in

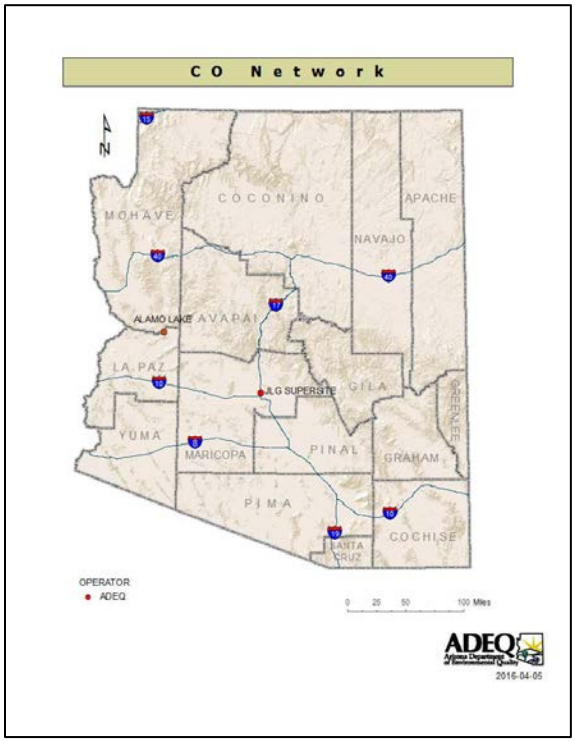


Figure 3 – Map of ADEQ's CO sites

wintertime due to decreased solar heating. Hourly concentrations tend to be at their maximum during the morning rush hour and between 6 p.m. and midnight.

Emission controls have reduced overall CO emissions, and the standards have been achieved in the metropolitan Phoenix area since 1996, in stark contrast to the first half of the 1980s when more than 100 exceedances were recorded each year. Similar improvements have occurred in Tucson, where the last eight-hour exceedances were recorded in 1988. Equipping vehicles with catalytic converters and electronic ignition systems was the most effective control, but significant reductions can also be attributed to the vehicle emissions inspection program (beginning in 1976) and oxygenated fuels (beginning in 1989). In the early 2000's, the EPA re-designated the Phoenix and Tucson metropolitan areas to attainment for the NAAQS for CO, and approved the attainment demonstration and maintenance plan. Each area is now in its second maintenance plan period.

ADEQ operated two CO monitors in 2016 at its NCore station and added a second in September at Alamo Lake as a background SPM monitor. Additional CO monitors are operated by other State and Local agencies as required, but will not be discussed in this report.

1.2 Monitoring Methods

Carbon Monoxide is monitored continuously with a nondispersive infrared (IR) instrument. The IR light passes through a gas filter correlation wheel that alternately uses a CO filled chamber and a chamber with no CO present. The light path travels through a sample cell following the correlation wheel and continues on toward an IR light detector which converts the light into an electrical signal. Carbon Monoxide absorbs a specific wavelength of IR light and the energy loss through the sample cell is compared with the zero reference provided by the gas filter correlation wheel to produce an electrical signal that is proportional to concentration. Raw data readings are retrieved by a data collection system and stored in a database. Readings are averaged into hourly, daily, monthly, quarterly, and yearly averages for data analysis.

1.3 Compliance/Summary of Design Values

On April 30, 1971, the EPA promulgated NAAQS for CO based on a criteria document published by the U.S. Department of Health, Education and Welfare in March 1970. Identical primary (health-based) and secondary (welfare-based) NAAQS for CO were set at 35 parts per million (ppm), one-hour average, and at 9 ppm, eight-hour average, neither to be exceeded more than once a year. After the most recent review of the CO NAAQS, on August 31, 2011, EPA proposed to retain the current primary standards. After review of the air quality criteria, EPA further concludes that no secondary standard should be set for CO at this time. Table 3 summarizes the history of the NAAQS for CO during the period 1971-2011. At present there are two primary standards for CO. The one-hour standard is 35 ppm and the eight-hour standard is 9 ppm.

Table 3 – History of the National Ambient Air Quality Standards for CO during the period 1971-2011
(*Source: USEPA TTN NAAQS)*

Final Rule	Primary/ Secondary	Indicator	Averaging Time	Level	Form
1971 36 FR 8186 Apr 30, 1971	Primary and Secondary	CO	1-hour period	35 ppm	Maximum, not to be exceeded more than once in a year
			8-hour period	9 ppm	Maximum, not to be exceeded more than once in a year*
1985 50 FR 37484 Sept 13, 1985	Primary standards retained, without revision; secondary standards revoked.				
1994 59 FR 38906 Aug 1, 1994	Primary standards retained, without revision.				
2011 76 FR 54294 Aug 31, 2011	Primary standards retained, without revision.				

**Second highest, non-overlapping 8-hour average concentration of 9 ppm*

According to 40 CFR Part 50, compliance for both standards is determined by having no more than one exceedance per year. EPA determines attainment of the standard by evaluating two calendar years of data from each site. The highest of the annual second-highest values in a two-year period must not exceed the standard of 35 ppm for the one-hour standard or 9 ppm for the eight-hour standard.

Table 4 and Table 5 below show the 1st maximum and 2nd maximum values for both the current primary standards for the years 2015 and 2016. No exceedances of the one-hour or eight-hour standards were recorded in 2015 and 2016. The CO monitor at Alamo Lake and JLG Supersite are considered to be in compliance for the year 2016. CO monitoring at Alamo Lake started in the year 2016, hence, no data is available for the year 2015.

Table 4 – CO One-Hour Compliance Summary

2015 to 2016 One-Hour CO Compliance Summary (in ppm) (NAAQS primary one-hour standard 35 ppm)					
Site Name	**2015**		**2016**		**Compliance Value**
	1st Max Value	**2nd Max Value**	**1st Max Value**	**2nd Max Value**	
La Paz County					
Alamo Lake[1]	N/A	N/A	0.5#	0.4#	N/A
Maricopa County					
JLG Supersite	2.4	2.2	2.3	2.2	2.3
Number of Sites in Violation of the NAAQS					0

[1]Monitor began operation in September 2016.
#Indicates the data do not satisfy EPA's summary criteria.
N/A-Data are not available.

Table 5 – CO Eight-Hour Compliance Summary

2015 to 2016 Eight-Hour CO Compliance Summary (in ppm) ***(NAAQS primary eight-hour standard 9 ppm)***					
Site Name	**2015**		**2016**		**Compliance Value**
	1st Max Value	**2nd Max Value**	**1st Max Value**	**2nd Max Value**	
La Paz County					
Alamo Lake[1]	N/A	N/A	0.3#	0.3#	N/A
Maricopa County					
JLG Supersite	1.9	1.8	1.9	1.6	1.9
Number of Sites in Violation of the NAAQS					0

[1]Monitor began operation in September 2016.
#Indicates the data do not satisfy EPA's summary criteria.
N/A-Data are not available.

1.4 Trends

Monitoring of CO throughout the state of Arizona contains the longest history of all the criteria pollutants. Most of this long-term monitoring was located in the highly urbanized areas of Phoenix and Tucson, and several of these CO sites contain monitoring records dating back to the 1970s. For the purpose of this report, the examination of CO trends will include the ADEQ monitors only. ADEQ has monitored CO at JLG Supersite since 1999. Figure 4 and Figure 5 show a decreasing trend in Phoenix for the primary one-hour and eight-hour CO standards respectively, both being under the NAAQS since monitoring started at the location. Most of the improvements can be attributed to emission control programs as stated in section 1.1. ADEQ started trace-level monitoring of CO in 2010 as part of the NCore program. Alamo Lake is not included in these graphs since monitoring at the site began in 2016.

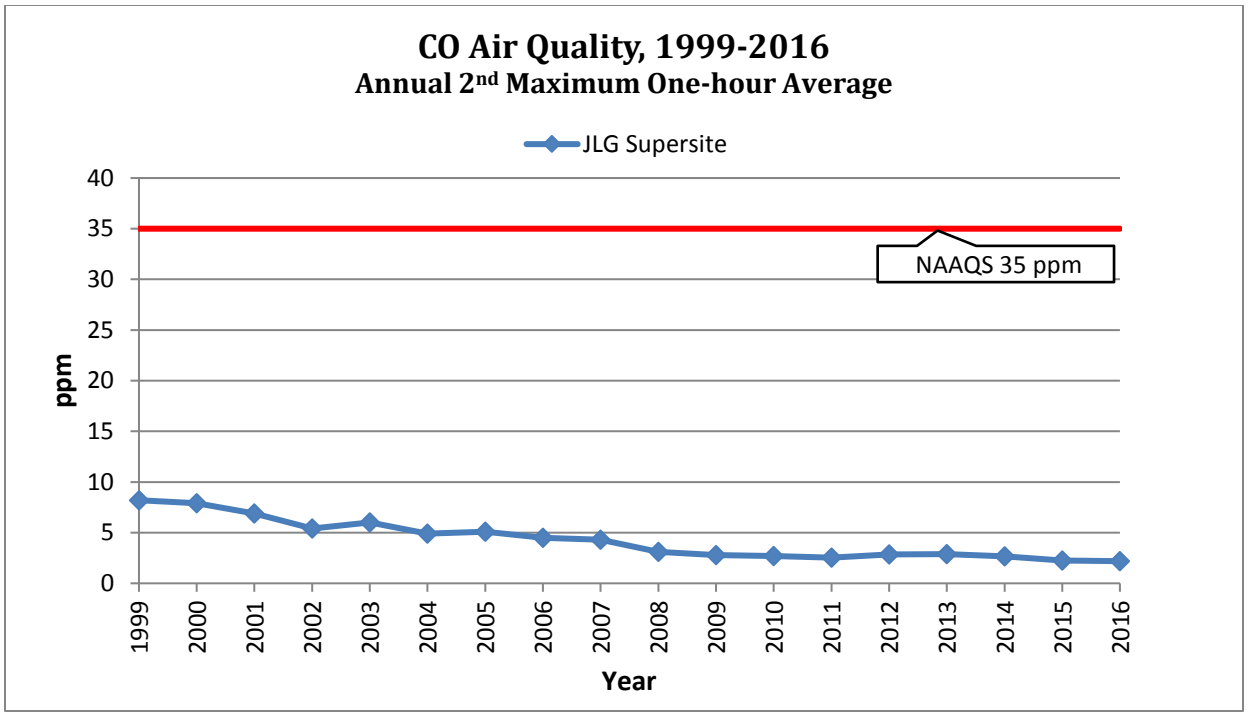


Figure 4 – CO One-Hour Average Trend
1999-2016: 81.9% decrease for JLG Supersite
***Note**: Some years might not satisfy completeness criteria.*

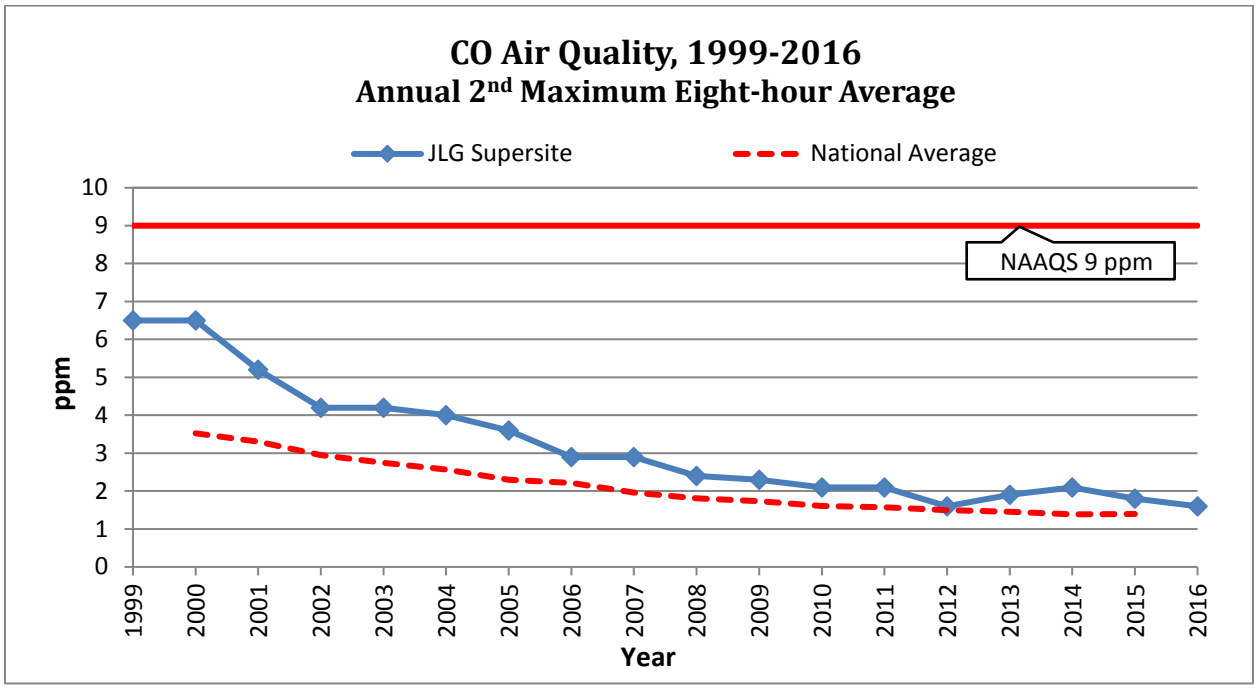


Figure 5 – CO Eight-Hour Average Trend
1999-2016: 84.8% decrease for JLG Supersite
2000-2015: 60% cumulative decrease in the National Average (https://www.epa.gov/air-trends/carbon-monoxide-trends). 2016 National Averages were not available.
***Note**: Some years might not satisfy completeness criteria*.

1.5 Air Quality Index (AQI)

The CO daily AQI values for 2016 are categorized into the different levels of health concerns shown in Table 6. Background levels of CO are near zero in areas without manmade sources. Levels of CO in more populous areas are low and stable due to significant emissions controls placed on mobile sources (cars, trucks, etc.). Emissions are highest in the winter months due to the increased time it takes engines to warm up. Wintertime meteorology in Arizona is typified by stable conditions, therefore increasing AQI values. A graphical representation of the CO Daily AQI values for 2016 is shown in Figure 6.

Table 6 – CO Daily AQI Count 2016

AQI Values	Levels of Health Concern	Number of Days	Number of Days
		JLG Supersite	**Alamo Lake***
0 - 50	Good	244	122
51 - 100	Moderate	0	0
101 - 150	Unhealthy for Sensitive Groups	0	0
151 - 200	Unhealthy	0	0
201 - 300	Very Unhealthy	0	0
301 - 500	Hazardous	0	0
	Missing	122	0
	Total Days	366	122*

*122 possible monitoring days.

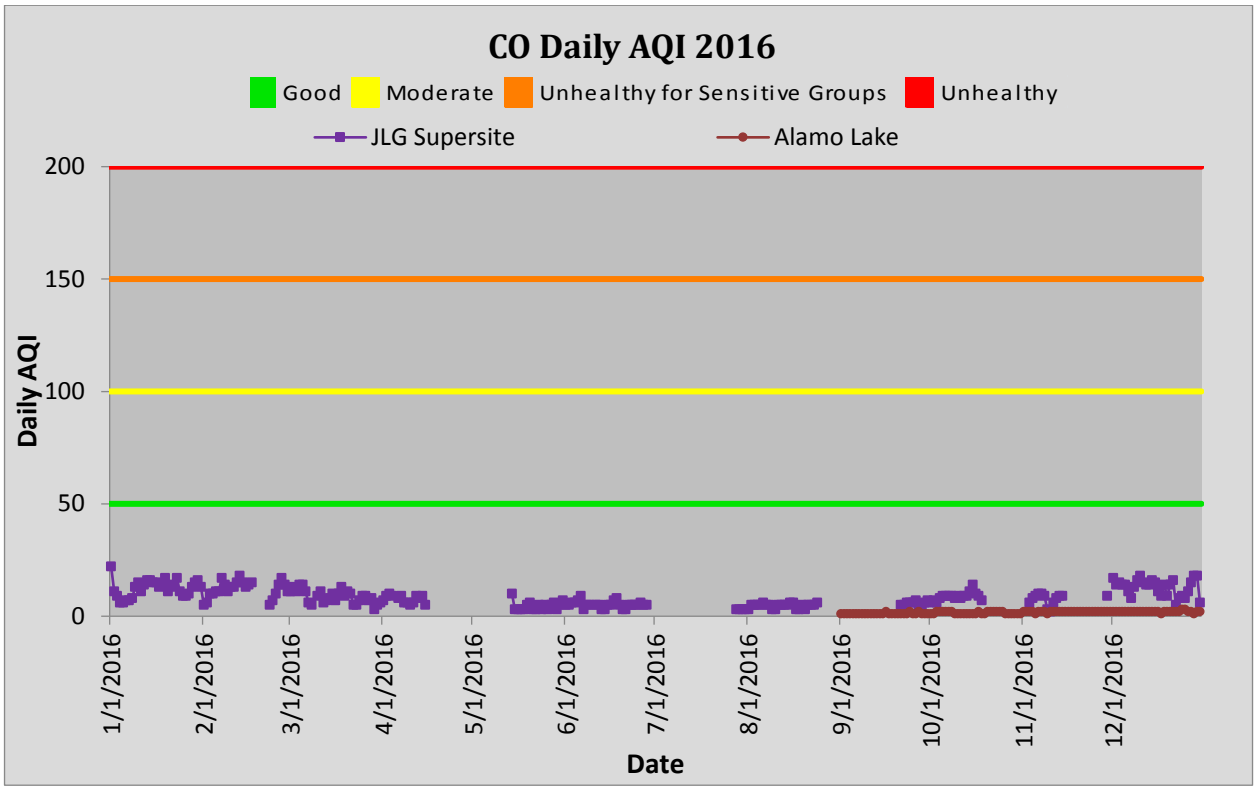


Figure 6 – CO Daily AQI 2016

***Note**: Data are the daily AQI values for 2016 obtained from https://www.epa.gov/outdoor-air-quality-data*

2.0 Nitrogen Dioxide (NO_2)

NO_2 is a reddish-brown gas that is formed by the oxidation of nitric oxide (NO) - a byproduct of combustion. Adverse health effects associated with NO_2 include the risk of respiratory illness in children and vary depending on the level of NO_2 and exposure time. Short exposure to low levels may result in changes to airway responsiveness and decreased lung function in individuals with pre-existing conditions. Irreversible changes may occur to lungs due to long-term exposure to higher levels. This pollutant is also of concern in its reduction of visibility and its contributory role in the photochemical formation of ground level O_3 and acid rain.

2.1 Background

Combustion emissions of nitrogen oxides (NO_x) are 95 percent NO and five percent NO_2. NO_2 concentrations often serve as the indicator for the larger group of nitrogen oxides since NO rapidly oxidizes to NO_2. In the 2014 NEI, Arizona NO_x emissions were led by the transportation sector with 68 percent of the emissions from mobile sources such as cars and trucks; 20 percent came from fuel combustion processes such as utility power plants; and 12 percent from other sources, including fires, biogenic emissions from soil, stationary combustion sources and other industrial processes. NO and NO_2 concentrations are highest near major roadways. NO concentrations decrease rapidly with distance from the roadway, whereas NO_2 concentrations are more evenly distributed because of their formation through oxidation and their subsequent transport. Concentrations of NO_2 are highest in the late afternoon and early evening of winter, when rush hour emissions of NO are converted to NO_2 under relatively stable atmospheric conditions. Because NO reacts rapidly with O_3, nocturnal O_3 concentrations in cities are often reduced to near zero levels, while concentrations at background sites remain higher.

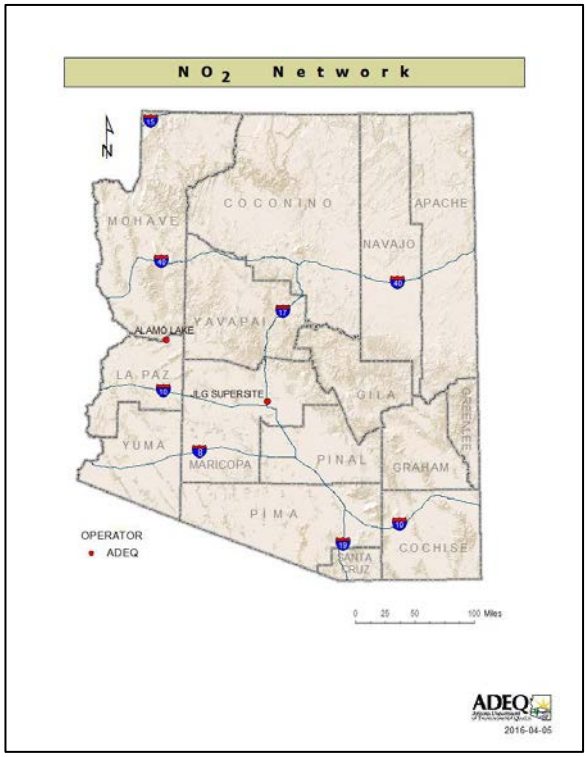


Figure 7 – Map of ADEQ's NO_2 sites

NO emissions have been reduced over time using several different techniques. NO emissions from motor vehicles have been reduced through retardation of spark timing, lowering the compression ratio, exhaust gas recirculation systems, diesel retrofits, Ozone Action Days, and three-way catalysts. Also, the vehicle inspection program's NO_x test for light-duty gasoline vehicles age 1981 and newer (in Phoenix only) has helped reduce emissions. Controls on electricity generating units include catalytic reductions and natural gas re-burn. Reformulated gasolines also decrease NO emissions: Federal Phase II gasoline, by 1.5 percent

for vehicular and 0.5 percent for off-road equipment; California Phase 2 gasoline, by 6.4 percent for vehicular and 7.7 percent for off-road equipment.

Two NO_2 monitors were operated by ADEQ in 2016. One is located in a local neighborhood which represents a typical Phoenix area community. This monitor is part of the PAMS network at JLG Supersite. The second NO_2 monitor was located at the Alamo Lake site and was removed at the end of June 2016. This monitor was used to obtain background data and was classified as a special purpose monitor (SPM). Additionally, two total NO_y monitors were operated by ADEQ. One was operated as part of the NCore station at JLG supersite, and the other at Queen Valley as part of the PAMS network. The NO_y monitor at Queen Valley was removed at the end of September 2016. However, NO_y is not a criteria pollutant and is not further evaluated in this section.

2.2 Monitoring Methods

NO_2 is monitored continuously with chemiluminescence instruments which operate on the principle that when two chemicals combine, a unique wavelength of light is emitted. This wavelength of light is detected using a light sensor, and the intensity of that light is a direct correlation to the concentration of the target chemical species (NO_2). An NO_2 analyzer is based on the chemiluminescence of an excited NO_2 molecule which determines NO and NO_x (the sum of NO_2 and NO) concentrations. Readings from all instruments are averaged into hourly, daily, monthly, quarterly, and yearly averages for data analysis. Readings are retrieved by a data collection system and stored in a database.

2.3 Compliance/Summary of Design Values

The NAAQS for NO_2 was reviewed in 2010 and the original 1971 primary NAAQS of 53 parts per billion (ppb) for the annual mean was retained. However, a new primary one-hour NO_2 standard of 100 ppb was added. The annual standard is attained when the annual arithmetic mean concentration in a calendar year is less than or equal to 53 ppb. The one-hour standard is attained when the three-year average of the 98th percentile of the yearly distribution of one-hour daily maximum NO_2 concentrations is below 100 ppb. A history of the NAAQS for NO_2 is provided in Table 7.

Table 7 – History of the National Ambient Air Quality Standards for NO_2 during the period 1971-2010 (*Source: USEPA TTN NAAQS*)

Final Rule	Primary/ Secondary	Indicator	Averaging Time	Level	Form
1971 36 FR 8186 Apr 30, 1971	Primary and Secondary	NO_2	Annual	53 ppb	Annual arithmetic average
1985 50 FR 25532 Jun 19, 1985	Primary and secondary NO_2 standards retained, without revision.				

Final Rule	Primary/ Secondary	Indicator	Averaging Time	Level	Form
1996 61 FR 52852 Oct 8, 1996	Primary and secondary NO_2 standards retained, without revision.				
2010 75 FR 6474 Feb 9, 2010	Primary	NO_2	1-hour	100 ppb	98th percentile, averaged over 3 years
		Primary annual NO_2 standard retained, without revision.			

Table 8 below shows the 2016 annual means for the 53 ppb primary standard. The annual means of both JLG Supersite and Alamo Lake are significantly below this primary standard, and are in compliance with the NAAQS.

Table 8 – NO_2 Annual Mean Compliance Summary

2016 NO_2 Annual Mean (in ppb) ***(NAAQS Annual Mean 53 ppb)***	
Site Name	**2016 Annual Mean**
Maricopa County	
JLG Supersite	13.26
La Paz County	
Alamo Lake	1.22*
Number of Sites in Violation of the NAAQS	0

*Preliminary Design Value since data completeness was not satisfied.

The NO_2 three-year average of the one-hour averages at the 98th percentile was approximately half of the 100 ppb standard at JLG Supersite and is in compliance with the NAAQS. ADEQ began monitoring NO_2 at Alamo Lake in July of 2014 and removed the instrument at the end of June 2016; therefore, the three-year average is based on incomplete data in 2014 and 2015. Refer to Table 9 for the 2016 three-year averages.

Table 9 – NO_2 One-Hour Compliance Summary

2014 to 2016 One-Hour Average NO_2 Compliance (in ppb) ***(NAAQS One-Hour Average 100 ppb)***				
Site Name	**98th Percentile Samples**			**Three-Year Average**
	2014	**2015**	**2016**	
Maricopa County				
JLG Supersite	52.0	50.0#	51.2	51*
La Paz County				
Alamo Lake[1]	6.3#	4.8	3.4#	5*
Number of Sites in Violation of the NAAQS				0

[1]Monitor began operation in July 2014 and was removed in June 2016.

#Indicates the data do not satisfy EPA's summary criteria.

*Preliminary Design Value since data completeness was not satisfied.

2.4 Trends

ADEQ began monitoring for NO_2 in Phoenix at JLG Supersite in 1993. However, data are not readily available in AQS prior to 1999. As a result, the assessment of trends in NO_2 uses a period of eighteen years from 1999 to 2016. Figures 8 and 9 illustrate the temporal variability of JLG Supersite over the 1999 to 2016 period in the form of annual means and one-hour averages at the 98th percentile. The NO_2 trend can be described as decreasing over this eighteen-year period. Alamo Lake is not included in these graphs since there is only one complete year of data available for 2015 and partial years for 2014 and 2016.

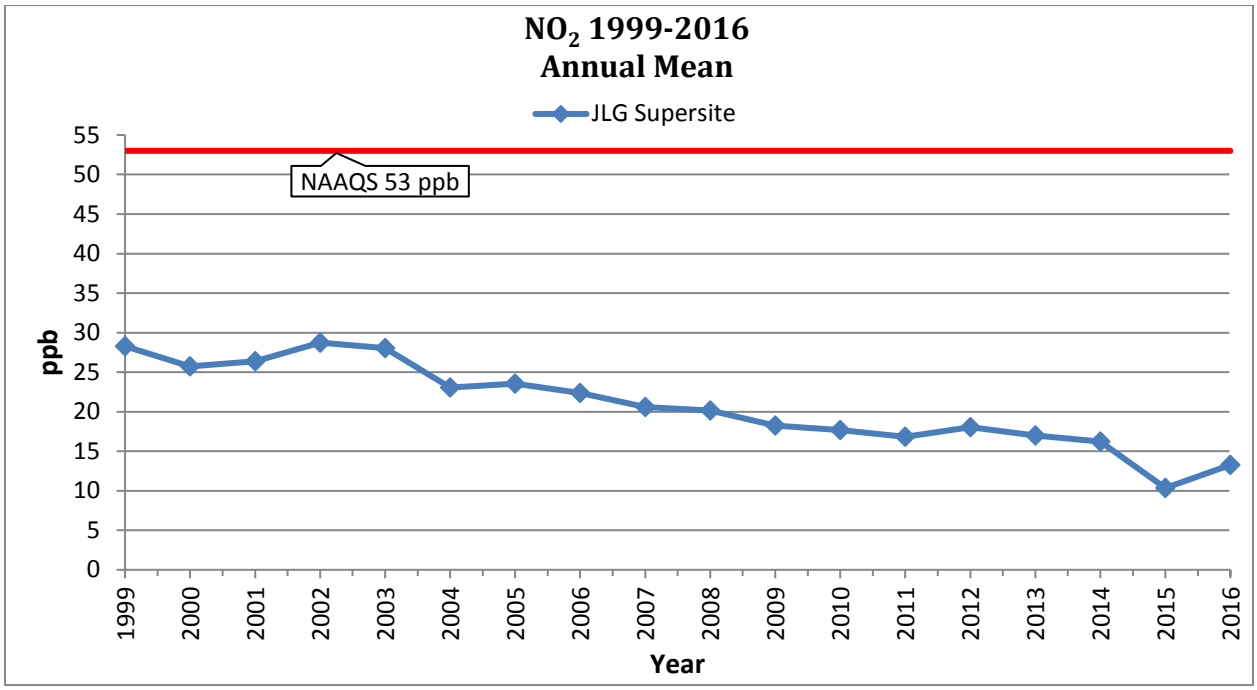


Figure 8 – NO_2 Annual Mean Trend
1999-2016: 57.4% decrease for JLG Supersite
Note: *Some years might not satisfy completeness criteria*

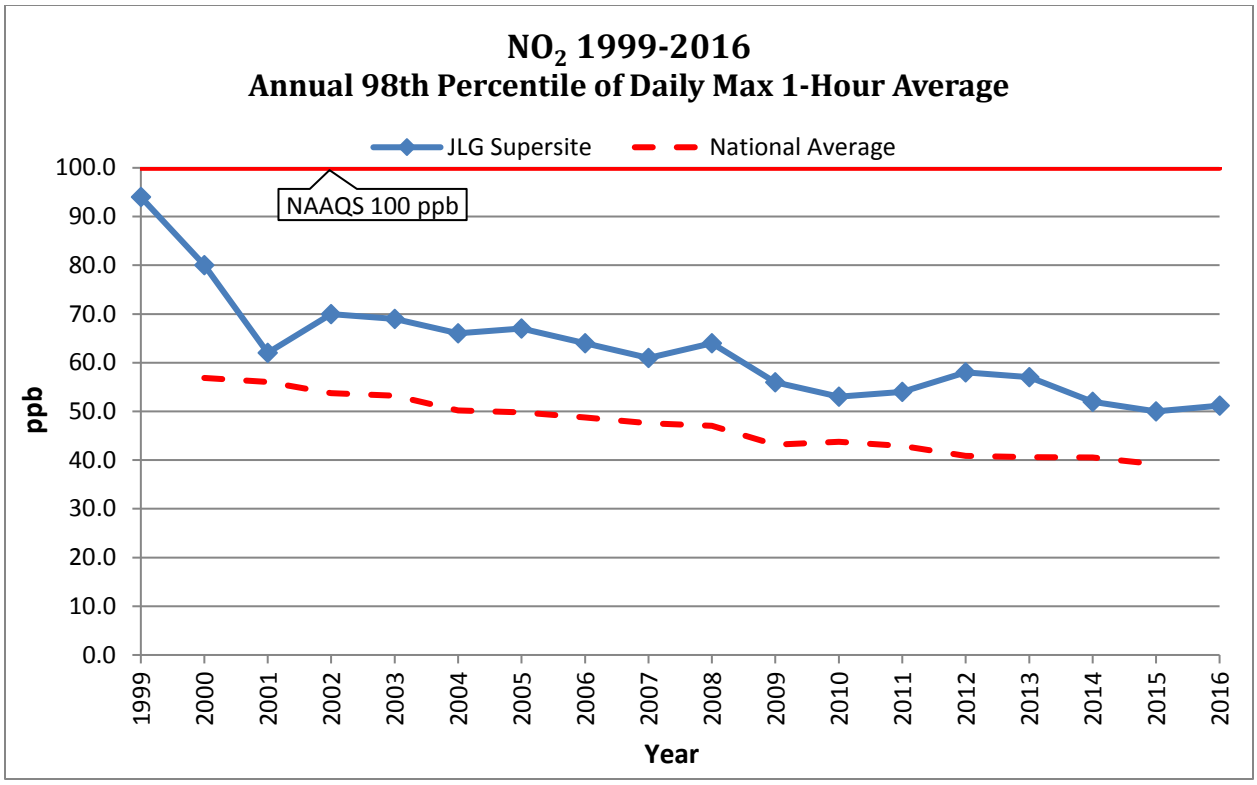


Figure 9 – NO_2 One-Hour Average Trend
1999-2016: 40.3% decrease for JLG Supersite
2000-2015: 31.0% cumulative decrease in the National Average (www.epa.gov/air-trends/nitrogen-dioxide-trends). 2016 National Averages were not available.
Note: *Some years might not satisfy completeness criteria*.

2.5 Air Quality Index (AQI)

The NO_2 daily AQI values for 2016 are categorized into the different levels of health concerns in Table 10. Background levels of NO_2 are near zero in areas without manmade sources. Levels of NO_2 in more populous areas are low and stable due to significant emissions controls placed on mobile sources (cars, trucks, etc.). Emissions are highest in the winter months due to the NO_2 from mobile sources in stable atmospheric conditions, which can elevate AQI values. A graphical representation of the NO_2 Daily AQI values for 2016 is shown in Figure 10.

Table 10 – NO_2 Daily AQI Count 2016

AQI Values	Levels of Health Concern	Number of Days	
		Alamo Lake*	JLG Supersite
0 - 50	Good	180	345
51 - 100	Moderate	0	4
101 - 150	Unhealthy for Sensitive Groups	0	0
151 - 200	Unhealthy	0	0
201 - 300	Very Unhealthy	0	0
301 - 500	Hazardous	0	0
	Missing	2	17
	Total Days	182	366

*182 possible monitoring days.

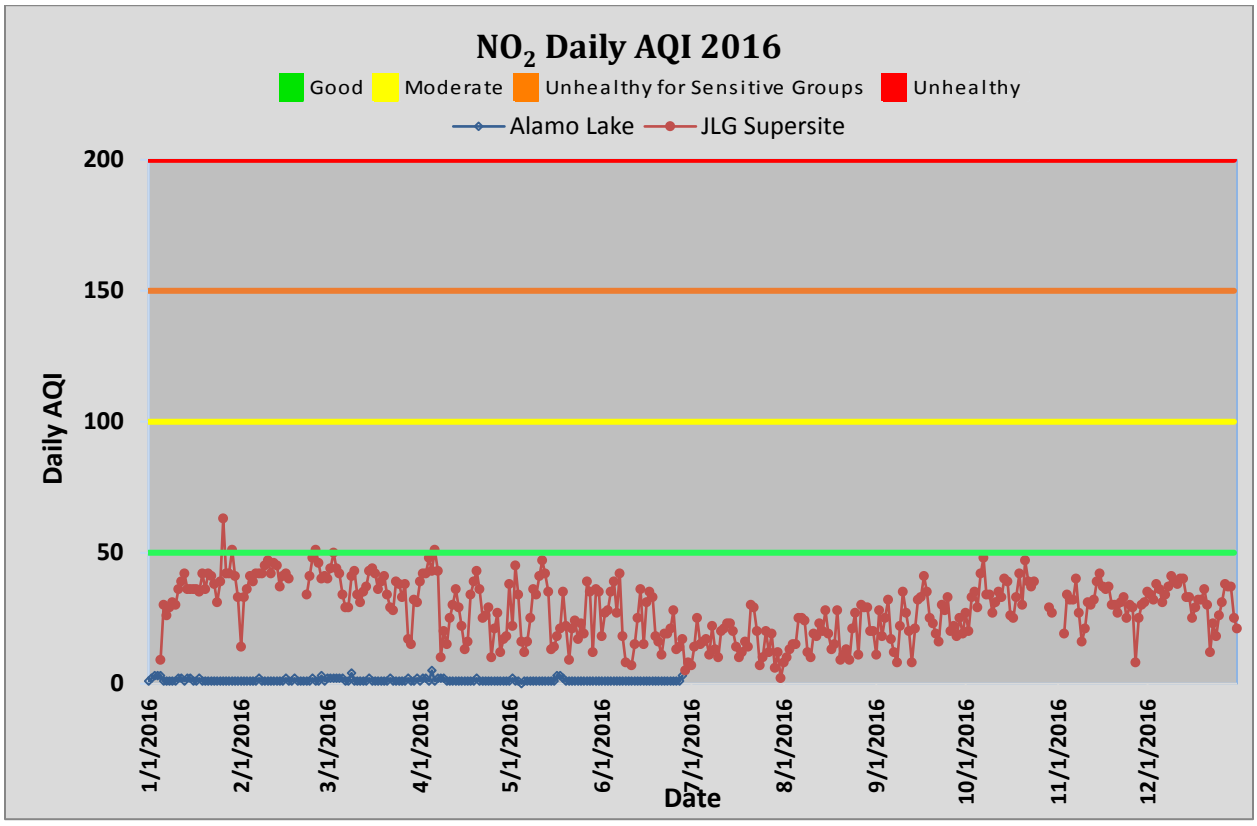


Figure 10 – NO_2 Daily AQI 2016

***Note**: Data are the daily AQI values for 2016 obtained from https://www.epa.gov/outdoor-air-quality-data*

3.0 Ozone (O_3)

Ozone is a colorless, slightly odorous gas that is both a natural component of the upper atmosphere and a key air contaminant in the lower atmosphere. In the stratosphere, O_3 blocks harmful ultraviolet radiation. In the lower atmosphere, its photochemical formation by the reaction of volatile organic compounds (VOC), hydrocarbons (HC), and Nitrogen Oxides (NO_x), leads to concentrations harmful to people, animals, plants, and materials (plastics, tires, o-rings). In both animals and humans, O_3 causes significant physiological and pathological changes at concentrations present in many urban environments. Short-term (one to two hours) exposure to concentrations in the range of 100 ppb to 400 ppb induce changes in lung function, including increased respiratory rates, increased pulmonary resistance, decreased volume of air, and changes in lung mechanics. Symptomatic responses in exercising adults include throat dryness, chest tightness, substernal pain, coughing, wheezing, pain on deep inspiration, shortness of breath, and headache. These symptoms also have been observed at lower concentrations for longer exposure times. Evidence suggests that O_3 exposure makes the respiratory airways more susceptible to other bronchoconstrictive challenges and interferes with or inhibits the immune system. Ozone at ambient concentrations also injures the stomata of plants, which are the cells that regulate plant respiration, resulting in flecks on the upper leaf surfaces of dichotomous plants and the death of the tips of coniferous needles. Plant scientists consider O_3 to be the most important of all of the phytotoxic air pollutants, causing over 90 percent of all plant injury from air pollution on a global basis.

3.1 Background

High O_3 concentrations are a phenomenon caused when sunlight, emissions from plant life, and evaporating fuel emissions peak. Fuel emissions consist of VOCs and NO_x and are two of the main components of O_3 formation. According to the 2014 NEI, VOC emissions in Arizona are: 89 percent biogenic emissions (grass, shrubs, trees); 3 percent fires (wildfire and wood burning); 3 percent mobile sources (cars and trucks, off-road vehicles and equipment such as lawn mowers); 3 percent industrial solvent processes; and 1 percent miscellaneous. Nitrogen oxides are: 68 percent mobile sources; 20 percent fuel combustion (power plants, industrial processes); 7 percent biogenic emissions; 2 percent industrial processes; 2 percent fires; and 1 percent miscellaneous. Ozone has relatively high background levels, with the daily maximum in remote areas being about one-half to three-quarters of the daily maximum in urban areas. In these areas, the highest O_3 concentrations tend to occur on the downwind edge, although high concentrations do occur less frequently in the central city. Urban

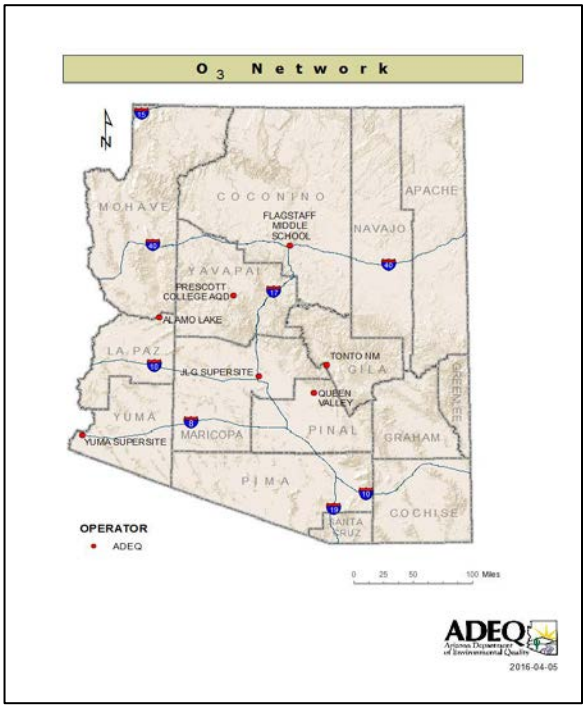


Figure 11 – Map of ADEQ's O_3 sites

O_3 concentrations are low to near zero at night and rise rapidly through the morning and peak in the afternoon.

Controls to reduce the precursors of O_3, VOC, and NO_x have been successfully implemented for years. Nitrogen oxides and VOC from vehicular exhaust have been reduced through engine modifications and three-way catalytic converters. Reformulated gasoline standards, ethanol blends, ozone education days, and alternative fuel programs all help reduce VOC emission. Evaporative HC from vehicles have been reduced through better engineered fuel tanks and auxiliary plumbing combined with carbon absorption canisters. Additional reductions of vehicular VOCs have come through ADEQ's vehicle emissions inspection program, which tests all gasoline fueled vehicles for HC (in Phoenix and Tucson), through vapor capturing equipment for gasoline tankers, vapor recovery systems at retail gas stations (Phoenix area only), and cleaner burning gasoline (Phoenix area only). Stationary sources of HC have been reduced through a variety of better control equipment required by stricter regulations. Despite these efforts, the continued population growth in Arizona combined with the high natural background O_3, may make achieving the eight-hour standard difficult.

In 2016, ADEQ operated a network of seven O_3 monitors to support a variety of monitoring objectives; chief among them is for NAAQS compliance. Other monitoring objectives include support for the NCore station, PAMS, and to show O_3 transport coming from across Arizona's borders.

3.2 Monitoring Methods

Continuous monitoring for O_3 is done with an ultraviolet absorption instrument. A specific ultraviolet wavelength of light which O_3 absorbs is passed through a sample cell. A drop in light intensity is detected by a light sensor and that drop is a direct correlation to the concentration of O_3 in the sample cell. This results in accurate readings of O_3 concentrations continuously. Readings are averaged into hourly, daily, monthly, quarterly, and yearly averages for data analysis. Readings are retrieved by a data collection system and stored in a database.

3.3 Compliance/Summary of Design Values

On Oct. 1, 2015, the U.S. Environmental Protection Agency (EPA) strengthened the National Ambient Air Quality Standards (NAAQS) for ground-level ozone based on EPA's review of the air quality criteria for ozone (O_3) and related photochemical oxidants and for O_3. Further, based on extensive scientific evidence about ozone's effects on public health and welfare, EPA revised the primary and secondary ozone standard levels to 0.070 parts per million (ppm), and retained their indicators (O_3), forms (fourth-highest daily maximum, averaged across three consecutive years) and averaging times (eight hours). The designation rule finalized the nonattainment area boundaries for areas that do not meet the 0.070 ppm standard. The standard is met when the 4^{th} highest rolling eight-hour average for the year, averaged over three years is less than the 0.070 ppm standard. Thus, an exceedance above the 0.070 ppm standard for a given year may not cause a violation of the standard, if the three-year average is still below 0.070 ppm.

The designations are based on air quality monitoring data and the history of the NAAQS for O_3 is provided in Table 11 below.

Table 11 – History of the National Ambient Air Quality Standards for O_3 during the period 1971-2015
(Source: USEPA TTN NAAQS)

Final Rule/Decision	Primary/ Secondary	Indicator	Averaging Time	Level	Form
1971 36 FR 8186 Apr 30, 1971	Primary and Secondary	Total photochemical oxidants	1 hour	0.08 ppm	Not to be exceeded more than one hour per year
1979 44 FR 8202 Feb 8, 1979	Primary and Secondary	O_3	1 hour	0.12 ppm	Attainment is defined when the expected number of days per calendar year, with maximum hourly average concentration greater than 0.12 ppm, is equal to or less than 1
1993 58 FR 13008 Mar 9, 1993	EPA decided that revisions to the standards were not warranted at the time				
1997 62 FR 38856 Jul 18, 1997	Primary and Secondary	O_3	8 hours	0.08 ppm	Annual fourth-highest daily maximum 8-hr concentration, averaged over 3 years
2008 73 FR 16483 Mar 27, 2008	Primary and Secondary	O_3	8 hours	0.075 ppm	Annual fourth-highest daily maximum 8-hr concentration, averaged over 3 years
2015 80 FR 65292 Oct 26, 2015	Primary and Secondary	O_3	8 hours	0.070 ppm	Annual fourth-highest daily maximum 8 hour average concentration, averaged over 3 years

The data in Table 12 are from the sites in operation from 2014 to 2016 and have been evaluated based on the 2015 O_3 standard (0.070 ppm). Three sites met the revised standard: Flagstaff Middle School, Alamo Lake and Prescott College AQD. The other four sites were in violation of the current 0.070 ppm O_3 NAAQS.

Table 12– O_3 Compliance Summary

2014 to 2016 Eight-Hour O_3 Compliance (in ppm) ***(NAAQS eight-hour 0.070 ppm)***				
Site Name	**Fourth-Highest Value**			**Three-Year Average**
	2014	**2015**	**2016**	
Coconino County				
Flagstaff Middle School[1]	0.073	0.070	0.064	0.069
Gila County				
Tonto NM[1]	0.072	0.073	0.070	**0.071**
La Paz County				
Alamo Lake[1]	0.071	0.070	0.067	0.069
Maricopa County				
JLG Supersite	0.077	0.075	0.075	**0.075**
Pinal County				
Queen Valley[1]	0.068	0.074	0.072	**0.071**
Yavapai County				
Prescott College AQD[1]	0.077	0.067	0.064	0.069
Yuma County				
Yuma Supersite[1]	0.078	0.077	0.067	**0.074**
Number of Sites in Violation of the NAAQS				**4**

[1]Seasonal monitor in 2014 and 2015, operational during March 1st to December 31st.

Bold denotes exceedance of the 2015 NAAQS of 0.070 ppm for the time period of 2014-2016.

3.4 Trends

Monitoring for O_3 has occurred for many years in Arizona, mainly in the urbanized centers of Phoenix and Tucson. Figure 12 illustrates the temporal variability in the O_3 Eight-Hour Averages for the period of twelve years from 2005 to 2016. The examination of O_3 trends includes the monitors that have been run by ADEQ only for the years 2005 to 2016, which includes Alamo Lake, JLG Supersite, Queen Valley, and Tonto National Park. Additionally, trends were analyzed for the years 2008 to 2016 for all O_3 sites, which includes the aforementioned sites, as well as Flagstaff Middle School, Prescott College, and Yuma Supersite. The O_3 trend of Eight-Hour Averages can be described as decreasing over the 2005 to 2016 period for Alamo Lake, JLG Supersite, Queen Valley, and Tonto National Park. In 2008, the Yuma instrument was moved from the Yuma Game & Fish site to the Yuma Supersite. The annual values of both sites met the completeness criteria and were averaged for the purpose of the trends graph. The trends for all O_3 sites from 2008 to 2016 show a slight average decrease.

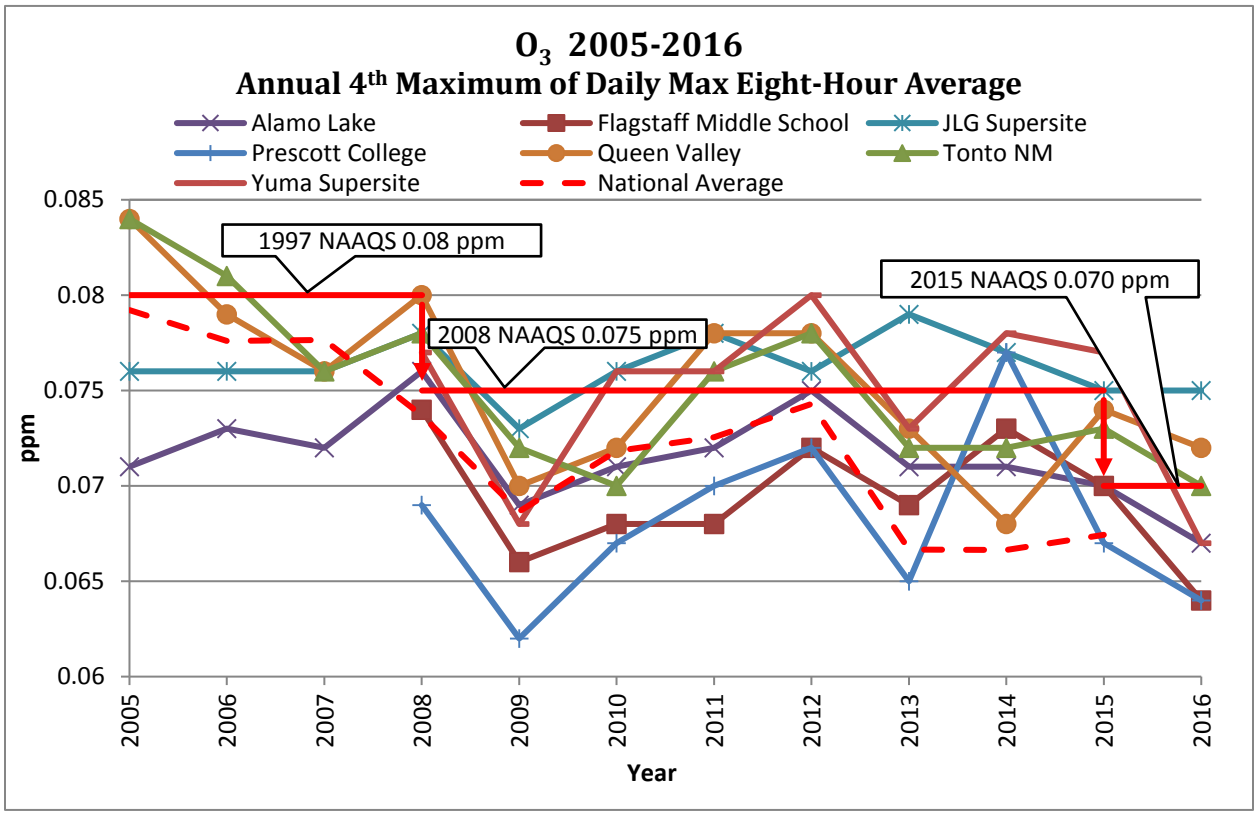


Figure 12 – O_3 Eight-Hour Average Trend

2005-2016: 7.7% decrease for Alamo Lake, JLG Supersite, Queen Valley, and Tonto National Monument
2008-2016: 3.7% decrease for all O_3 sites
2005-2015: 15% cumulative decrease in the National Average (https://www.epa.gov/air-trends/ozone-trends). 2016 National Averages were not available.
Note: *Some years might not satisfy completeness criteria. From 2005-2016 Alamo Lake, JLG Supersite, Queen Valley, and Tonto National Monument O_3 sites were averaged to calculate a best-fit straight line, which was used to determine the average percent change. An additional average percent change was calculated in the same manner for all O_3 sites from 2008-2016. In order to reduce bias in averaging, all sites must have at least seven consecutive years of data and the same number of consecutive years.*

3.5 Air Quality Index (AQI)

The O_3 daily AQI values for 2016 are categorized into the different levels of health concerns in Table 13. Background levels of O_3 in Arizona are typically elevated in areas without manmade sources due to regional transport. Higher O_3 levels typically occur in the summer months when the sun angle is higher than during the winter months. Graphical representations of the O_3 Daily AQI values for 2016 are shown in Figures 13 and 14.

Table 13 – O_3 Daily AQI Count 2016

AQI Values	Levels of Health Concern	Number of Days						
		Alamo Lake	Flagstaff Middle School	JLG Supersite	Prescott College	Queen Valley	Tonto National Monument	Yuma Supersite
0 - 50	Good	236	315	250	294	237	277	316
51 - 100	Moderate	64	49	79	49	116	85	47
101 - 150	Unhealthy for Sensitive Groups	1	0	12	0	6	2	2
151 - 200	Unhealthy	0	0	0	0	0	0	0
201 - 300	Very Unhealthy	0	0	0	0	0	0	0
301 - 500	Hazardous	0	0	0	0	0	0	0
	Missing	65	2	25	23	7	2	1
	Total Days	366	366	366	366	366	366	366

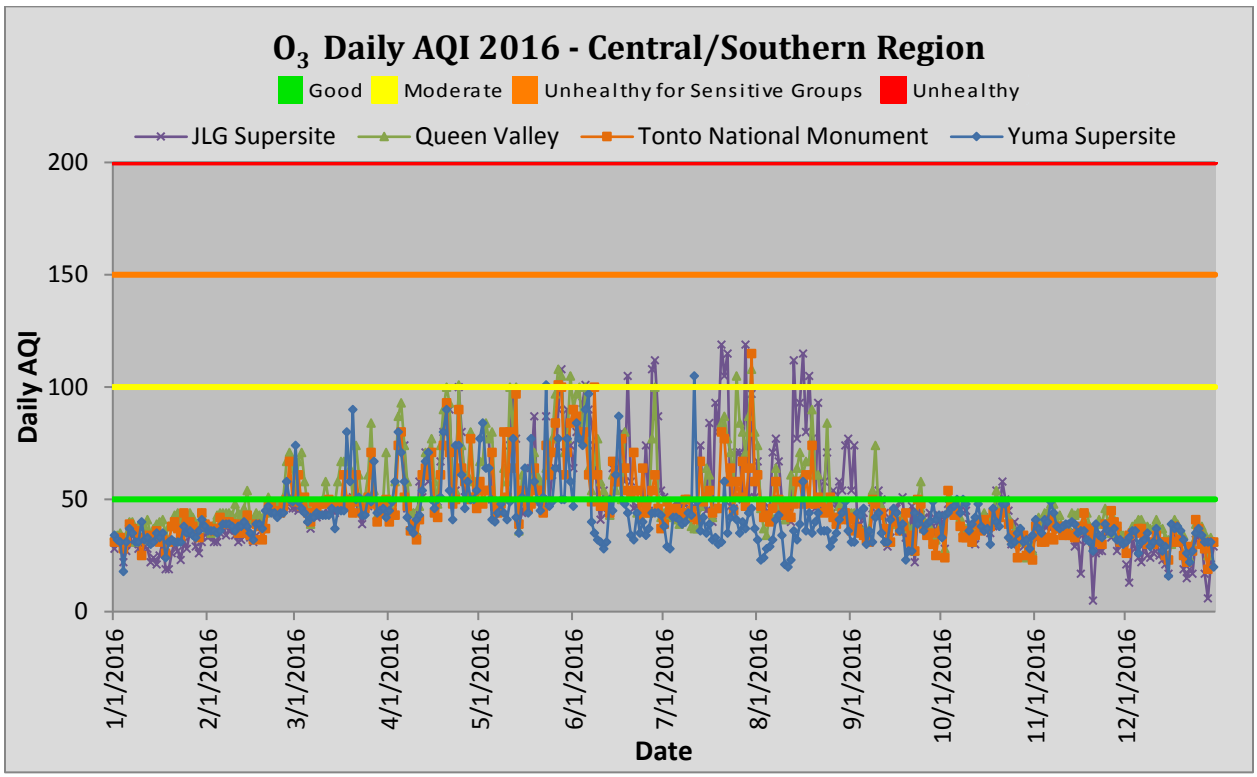


Figure 13 – O_3 Daily AQI 2016 – Central/Southern Region

***Note**: Data are the daily AQI values for 2016 obtained from https://www.epa.gov/outdoor-air-quality-data*

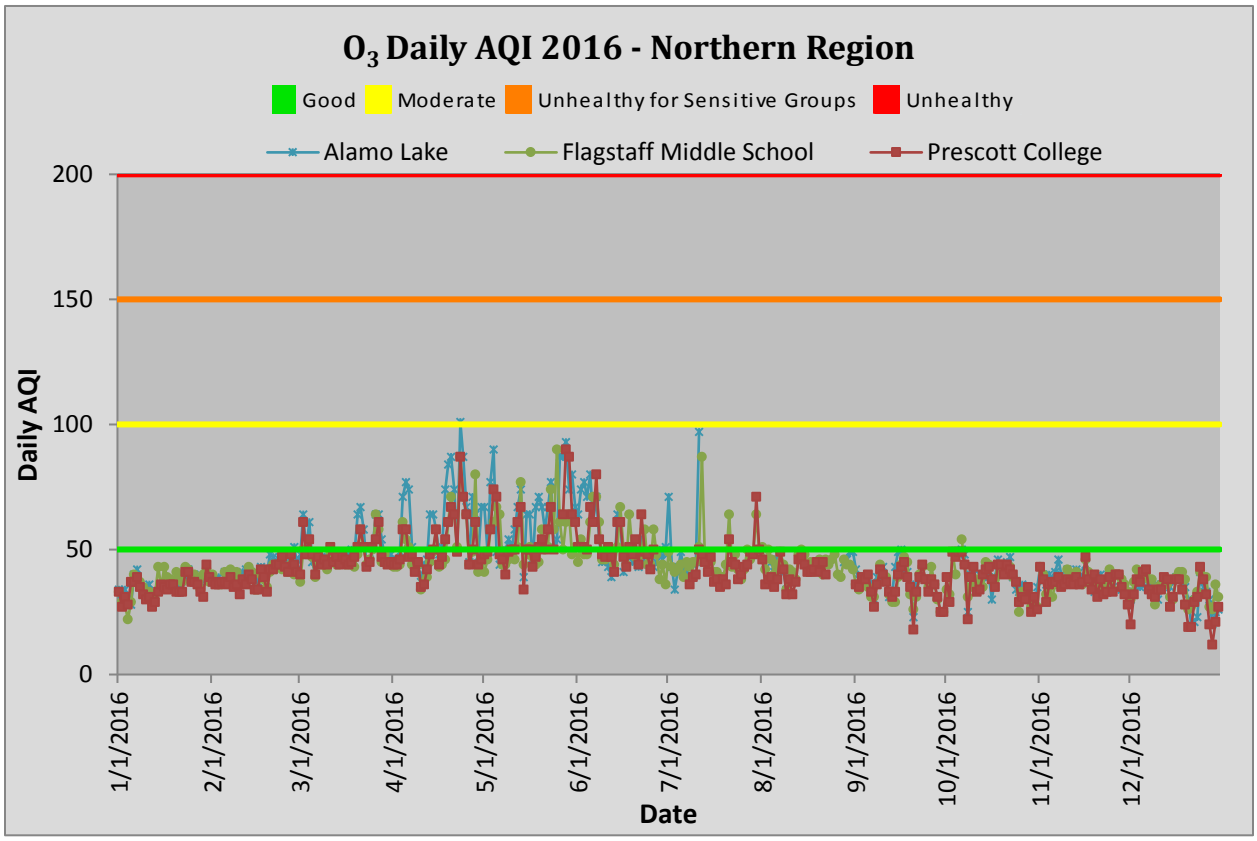


Figure 14 – O_3 Daily AQI 2016 – Northern Region

***Note**: Data are the daily AQI values for 2016 obtained from https://www.epa.gov/outdoor-air-quality-data*

4.0 Sulfur Dioxide (SO_2)

Sulfur Dioxide is a colorless gas with a pungent, irritating odor at elevated concentrations. It mainly alters the mechanical function of the upper airway, including increasing the nasal flow resistance and decreasing the nasal mucus flow rate. Current scientific evidence links short-term exposures to SO_2, ranging from five minutes to 24 hours, with an array of adverse respiratory effects, including bronchoconstriction and increased asthma symptoms. These effects are particularly significant for asthmatics at elevated ventilation rates. Studies have shown a connection between short-term exposure and increased visits to emergency departments and hospital admissions for respiratory illnesses, particularly in at-risk populations including children, the elderly, and asthmatics.

4.1 Background

Sulfur Dioxide is removed from the atmosphere through dry deposition on plants and is converted to sulfuric acid and eventually to sulfate. Sulfur Dioxide has extremely low background levels, with elevated concentrations found downwind of large point sources. Concentrations in urban areas are low and are homogeneously distributed. In Arizona, the principal source of SO_2 emissions has been the smelting of sulfide copper ore. Most fuels contain trace quantities of sulfur and their combustion releases both gaseous SO_2 and particulate sulfate. In the 2014 NEI, Arizona showed 52 percent of SO_2 emissions came from industrial point sources including smelting; 38 percent from fuel combustion; 5 percent from fires; 3 percent from mobile sources, such as off-road vehicles and on-road motor vehicles; and 1 percent miscellaneous.

Figure 15 – Map of ADEQ's SO_2 sites

Major controls were installed in Arizona's copper smelters in the 1980s, which reduced SO_2 emissions substantially. Vehicular emissions of SO_2 and sulfate have been reduced through lowering the sulfur content in diesel fuel and gasoline.

Controls have reduced SO_2 emissions throughout the state in recent years, but there are still two significant point sources which are affecting nearby air quality. Copper smelting operations have caused the areas in Miami, AZ and Hayden, AZ to be designated by the EPA as nonattainment areas for the 2010 standard. Compliance with the new NAAQS standard is being achieved throughout the state besides in these two areas. Historically, there were six copper smelters in operation in AZ. Concentrations and emission of SO_2 have been reduced since four of those major sources were removed.

ADEQ operated four source oriented monitors in 2016. Three are located in and around the Miami, AZ area and one is located in Hayden, AZ. One additional monitor was operated at JLG supersite as part of the NCore station. Additionally, ADEQ started monitoring SO_2 at Alamo Lake in 2014 for background data. This monitor was classified as a special purpose monitor (SPM).

4.2 Monitoring Methods

Continuous monitoring for SO_2 is done with pulsed fluorescence instruments. Sulfur Dioxide absorbs a specific wavelength of ultraviolet light. Absorption of light at this wavelength results in the fluorescent emission of light at a different wavelength. This second wavelength of light is detected by a light sensor and is directly proportional to the SO_2 concentration in the sample. Readings are averaged into hourly, daily, monthly, quarterly, and yearly averages for data analysis and can be retrieved by a data collection system and stored in a database.

4.3 Compliance/Summary of Design Values

On April 30, 1971, the EPA promulgated primary and secondary NAAQS for sulfur oxides, measured as SO_2 under section 109 of the Clean Air Act (36 FR 8186). After periodic reviews of additional scientific information, EPA announced first in 1986 and then in 1996, its decision not to revise the NAAQS for SO_2. In 2010, EPA replaced both the 24-hour and annual standards with a new short-term standard based on the three-year average of the 99th percentile of the yearly distribution of one-hour daily maximum SO_2 concentrations. EPA set the level of this new standard at 75 ppb. The one-hour SO_2 standard added in 2010 is a primary standard. The revision of the SO_2 NAAQS in 2010 did not address the secondary standard, which remains a three-hour standard with a level of 0.5 ppm. Table 14 summarizes the history of the NAAQS for oxides of sulfur during the period of 1971-2010.

Table 14 – History of the National Ambient Air Quality Standards for SO_2 during the period 1971-2010
(Source: USEPA TTN NAAQS)

Final Rule	Primary/ Secondary	Indicator	Averaging Time	Level	Form
1971 36 FR 8186 Apr 30, 1971	Primary	SO_2	24-Hour	0.14 ppm	Not to be exceeded more than once per year
			Annual	0.03 ppm	Annual arithmetic average
	Secondary		3-Hour	0.5 ppm	Not to be exceeded more than once per year
			Annual	0.02 ppm	Annual arithmetic average
1973 38 FR 25678 Sept 14, 1973	Secondary	Secondary 3-hour SO_2 standard retained, without revision; secondary annual SO_2 standard revoked.			
1996 61 FR 25566 May 22, 1996	Primary	Existing primary SO_2 standards retained, without revision.			

Final Rule	Primary/ Secondary	Indicator	Averaging Time	Level	Form
Final Rule	**Primary/ Secondary**	**Indicator**	**Averaging Time**	**Level**	**Form**
2010 75 FR 35520 Jun 22, 2010	Primary	SO_2	1-hour	75 ppb	99th percentile, averaged over 3 years
		Primary annual and 24-hour SO_2 standards revoked.			

Table 15 summarizes the status for the annual 99th percentile of one-hour daily maximum for SO_2 for the years 2014 to 2016. Miami Jones Ranch, Miami Townsite, Hayden Old Jail and Miami Ridgeline are sites in violation of the 2010 NAAQS of 75 ppb.

Table 15 – SO_2 One-Hour Compliance Summary

2014 to 2016 Annual 99th % of One-Hour daily max. SO_2 Compliance (in ppb) (NAAQS primary one-hour 75 ppb)				
Site Name	**2014**	**2015**	**2016**	**Three-Year Average**
Gila County				
Hayden Old Jail	236	246	359	**280**
Miami Jones Ranch	207	242	150	**200**
Miami Ridgeline	147	171	120	**146**
Miami Townsite	240	231	110#	**194***
La Paz County				
Alamo Lake[1]	2#	3	3	2*
Maricopa County				
JLG Supersite	5	5	5#	5*
Number of sites in violation of NAAQS				**4**

#Indicates the data do not satisfy EPA's summary criteria.

*Preliminary Design Value since data completeness was not satisfied.

[1]Stopped monitoring at Alamo Lake in March 2016.

N/A-Data are not available.

Bold denotes exceedances and sites in violation of the 2010 NAAQS of 75 ppb.

4.4 Trends

In Arizona, SO_2 monitoring began in the late 1960s and early 1970s. These early sites were predominantly located near facilities where smelting of sulfide copper ore occurred. Monitoring SO_2 at several of these smelting facilities no longer occurs due to the termination of smelting operations in certain areas. However, a long SO_2 monitoring record does exist for the Hayden and Miami areas due to continued smelting operations in these areas. Only monitors operated by ADEQ are used for the purpose of assessing SO_2 trends in this report. For the period of 1975-2016, two sites were used to assess trends in SO_2 as shown in Figure 16. These sites are Hayden Old Jail and Miami Ridgeline. Figure 16 does not reflect the trends from Miami Jones Ranch and Miami Townsite as ADEQ started monitoring at these locations in 2013, at Alamo Lake in 2014, and JLG Supersite in 2005.

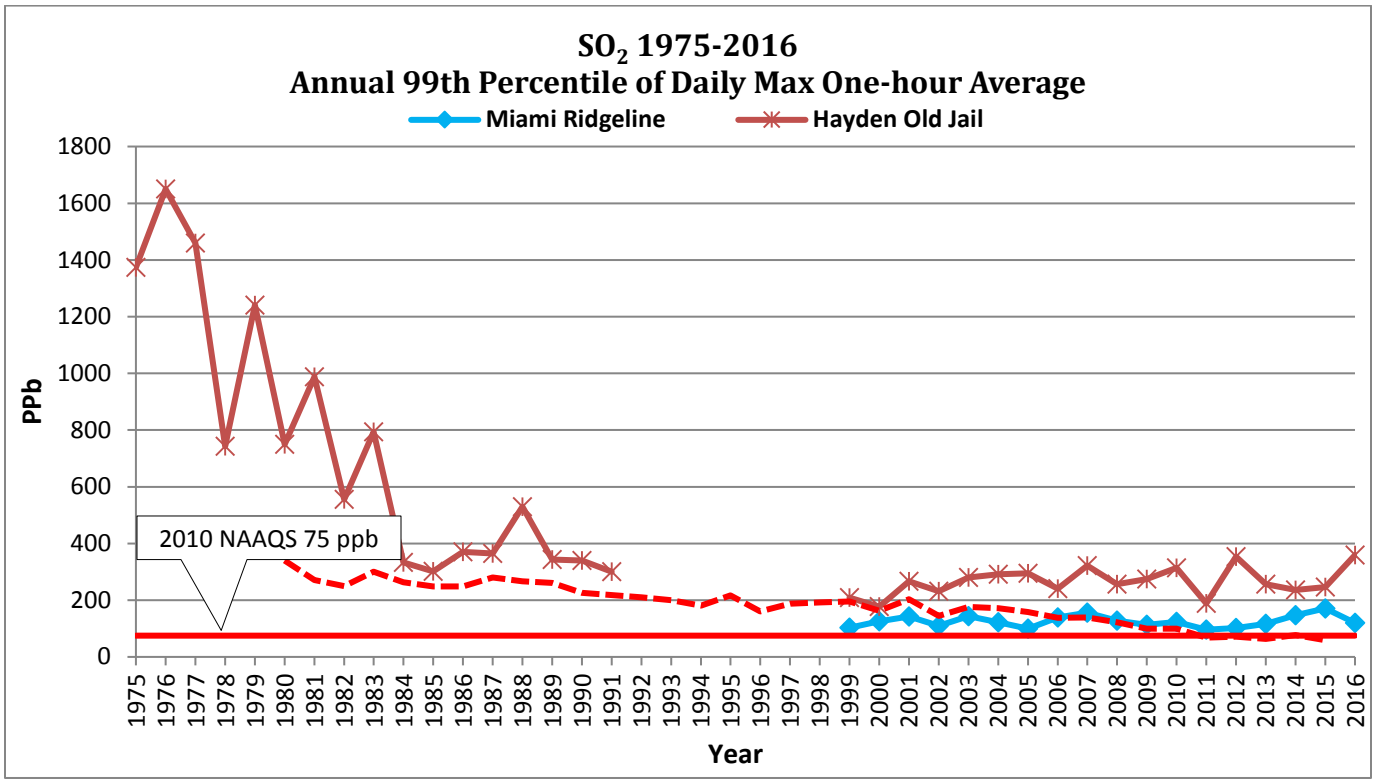


Figure 16 – SO_2 One-Hour Average Trend for Miami and Hayden Areas
1975-1991: 92.4% decrease for Hayden Old Jail
1999-2016: 8.6% increase for Miami Ridgeline
1999-2016: 28.1% increase for Hayden Old Jail
1980-2015: 84% cumulative decrease in the National Average (https://www.epa.gov/air-trends/sulfur-dioxide-trends). 2016 National Averages were not available.
***Note**: Some years might not satisfy completeness criteria.*

Beginning in 2011, trace-level SO_2 monitoring began in the Phoenix area as part of EPA's NCore program. The sensitivity of this monitor is far greater than the monitors used earlier, and low concentrations of SO_2 in the urban environments can be assessed with greater confidence; therefore, a separate trend is shown in Figure 17.

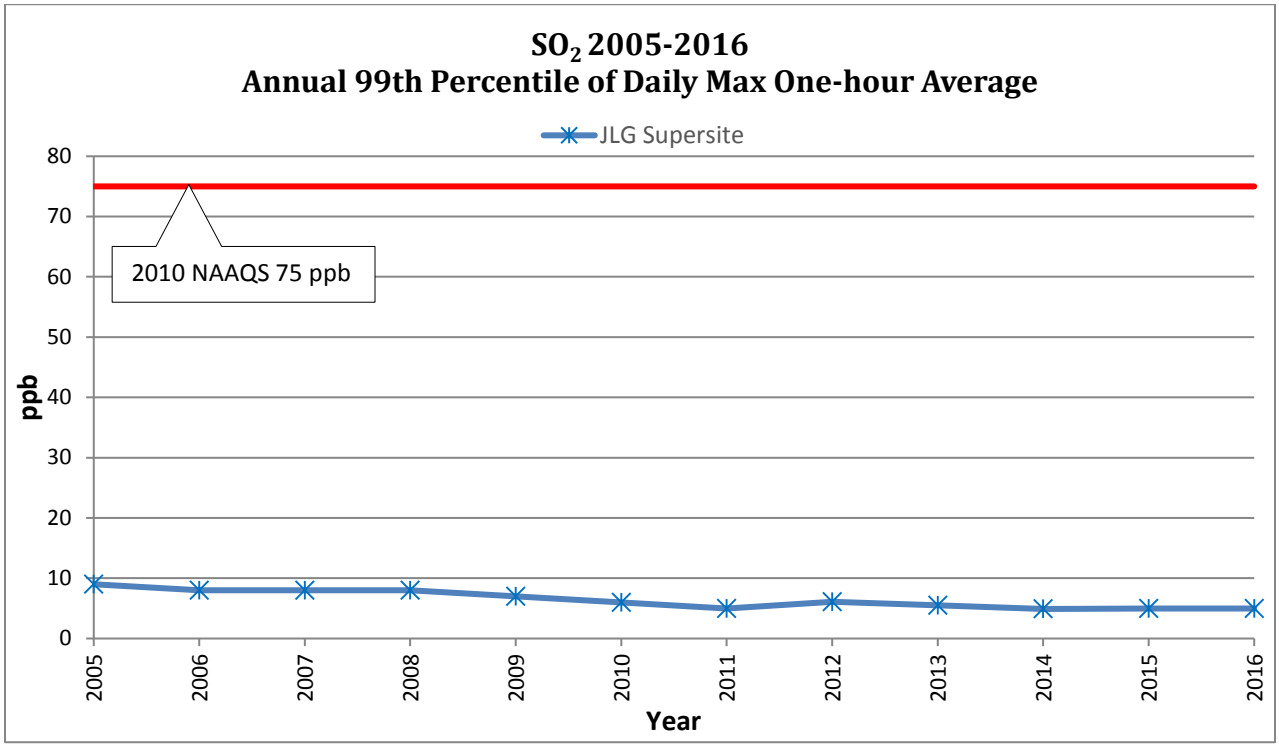


Figure 17 – SO_2 One-Hour Average Trend for JLG Supersite
2005-2016: 51.2% decrease for JLG Supersite
***Note**: Some years might not satisfy completeness criteria.*

The annual average trend for Hayden Old Jail and Miami Ridgeline is shown below in Figure 18, which indicates that total output of the sources has decreased somewhat over the past seventeen years. However, the increase in the daily max one-hour average trend from 1999-2016 , as shown previously in Figure 16, indicates that the one-hour averages have increased. This means that the highs are higher, and the lows are lower.

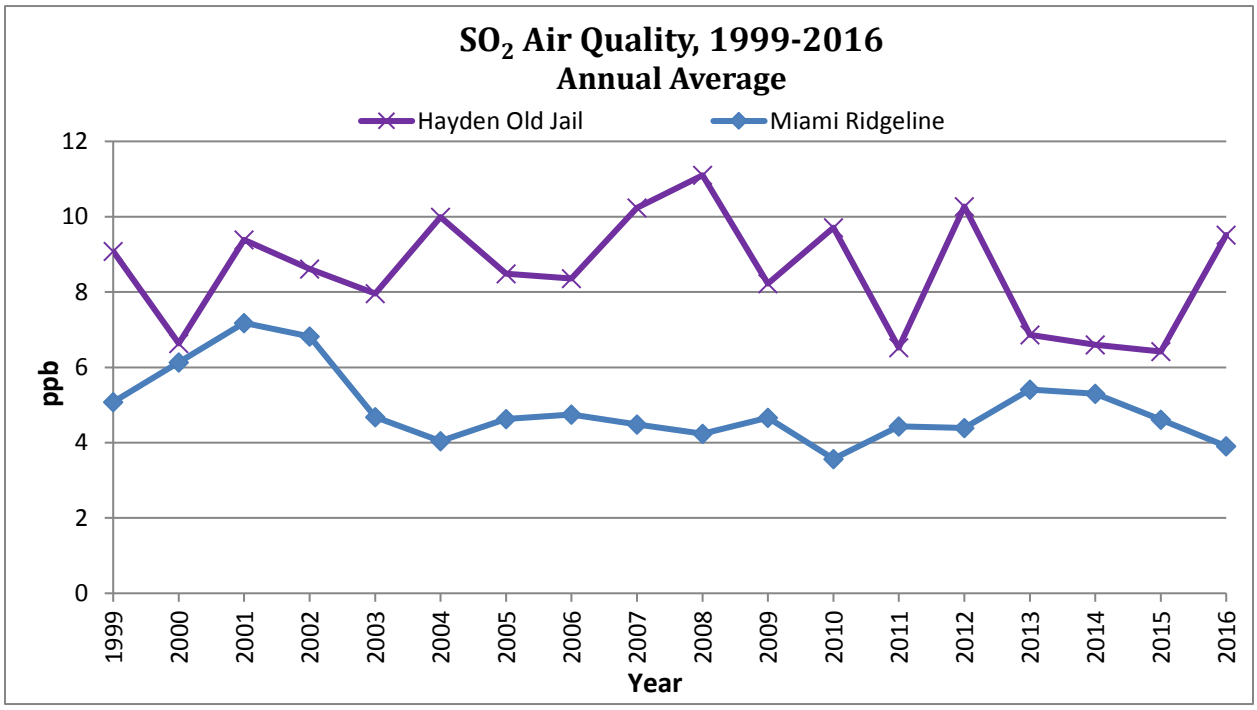


Figure 18 – SO_2 Annual Average Trend
1999-2016: 10.0% decrease for Hayden Old Jail
1999-2016: 28.4% decrease for Miami Ridgeline
***Note**: Some years might not satisfy completeness criteria.*

4.5 Air Quality Index (AQI)

The SO_2 daily AQI values for 2016 are categorized into the different levels of health concerns in Table 16. Background levels of SO_2 are near zero in areas without manmade sources. Levels of SO_2 are at a maximum near industrial sources where SO_2 is directly related to production activity. Graphical representations of the SO_2 Daily AQI values for 2016 are shown in Figures 19 and 20.

Table 16 – SO_2 Daily AQI Count 2016

AQI Values	Levels of Health Concern	Number of Days					
		Alamo Lake	Hayden Old Jail	JLG Supersite	Miami Jones Ranch	Miami Ridgeline	Miami Townsite
0 - 50	Good	82	132	317	259	273	270
51 - 100	Moderate	0	100	0	59	52	38
101 - 150	Unhealthy for Sensitive Groups	0	91	0	27	15	22
151 - 200	Unhealthy	0	27	0	1	0	0
201 - 300	Very Unhealthy	0	0	0	0	0	0
301 - 500	Hazardous	0	0	0	0	0	0
	Missing	0	16	49	20	26	36
	Total Days	82	366	366	366	366	366

*82 possible monitoring days.

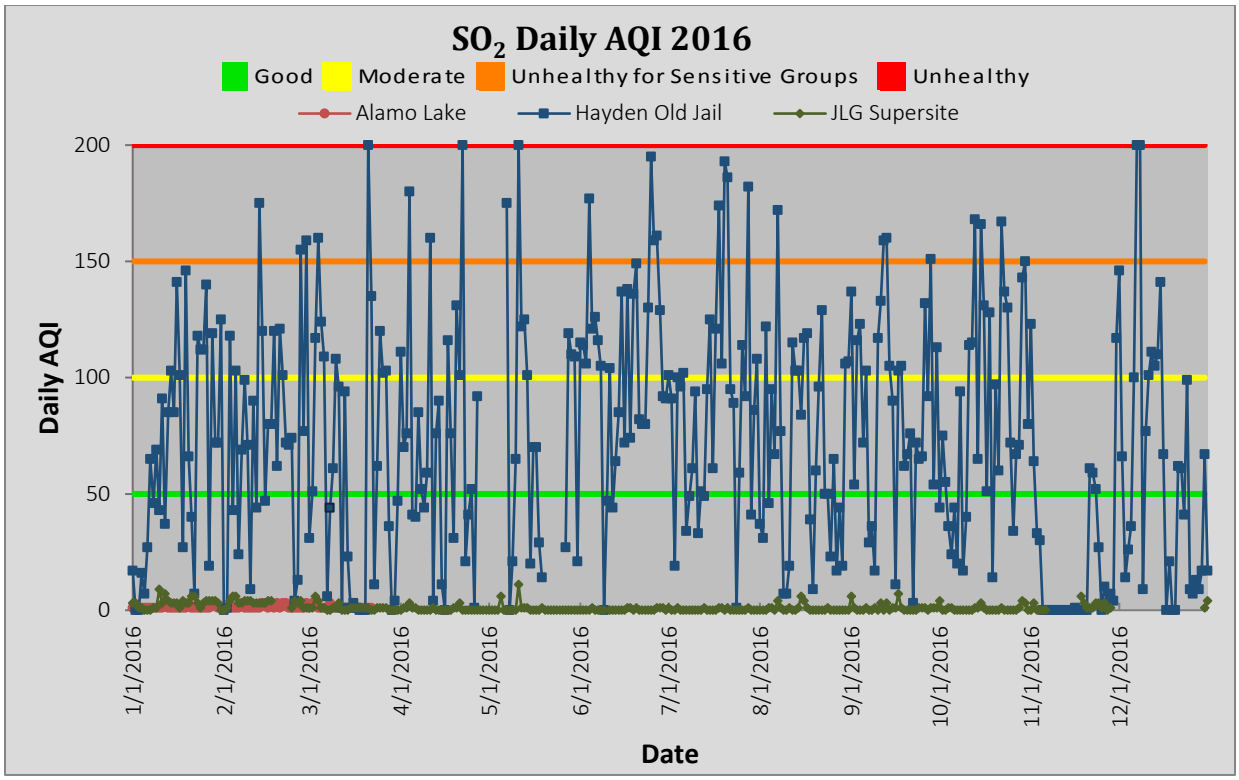


Figure 19 – SO_2 Daily AQI 2016

***Note**: Data are the daily AQI values for 2016 obtained from [https://www.epa.gov/outdoor-air-quality-data.](https://www.epa.gov/outdoor-air-quality-data) The 2010 Final Rule for the Primary National Ambient Air Quality Standard for Sulfur Dioxide does not give breakpoints for the higher end of the AQI scale (from 200-500). Thus, an AQI of 200 is reported when concentrations are greater than 305 ppb.*

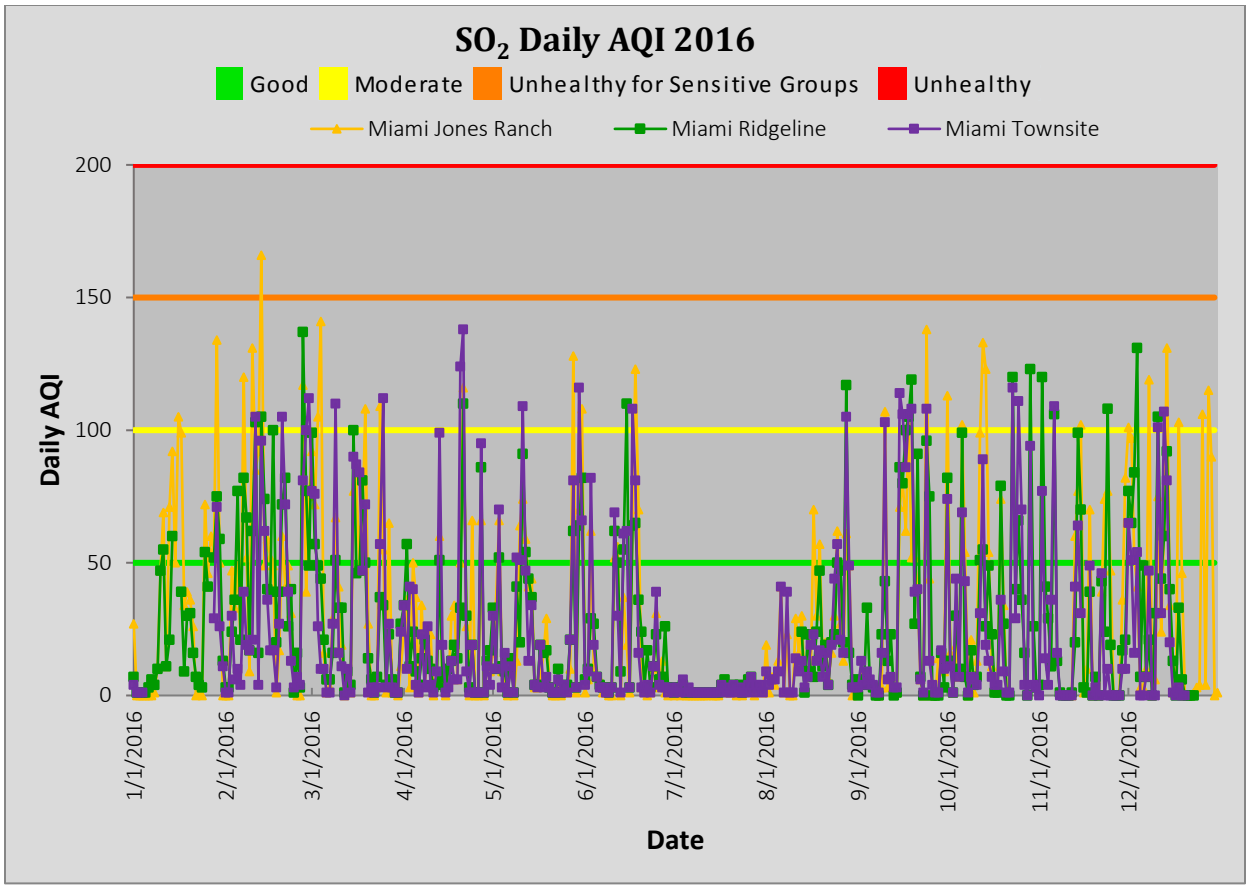


Figure 20 – SO_2 Daily AQI 2016 - Miami Area

***Note**: Data are the daily AQI values for 2016 obtained from https://www.epa.gov/outdoor-air-quality-data*

5.0 Particulate Matter Smaller Than 10 Microns (PM_{10})

Particulate matter is a collective term describing very small solid or liquid particles that vary considerably in size, geometry, chemical composition, and physical properties. PM_{10} describes particles that are less than 10 microns in diameter. Produced by natural processes (pollen and wind erosion) and by human activity (soot, fly ash, and dust from paved and unpaved roads), particulates contribute to visibility reduction, pose a threat to public health, and cause economic damage through soil disturbances. The size, shape, and chemical composition of particulates determine their health effects. Particles from 2.5 to 10 microns are inhaled and deposited in the upper parts of the respiratory system. Epidemiological studies have shown causal relationships between particulates and excess mortality, aggravation of bronchitis, and small reversible changes in pulmonary function in children.

5.1 Background

PM_{10} emissions in Arizona are mostly geological in origin and are dominated by dust from three activities: the constant grinding (re-entraining) of dust from paved roads, driving on unpaved roads, and earth moving associated with construction. On days with winds in excess of 15 miles per hour, wind erosion of soil may contribute to this loading. According the 2014 NEI, 53 percent of all PM_{10} emissions come from dust; 22 percent from industrial processes; 10 percent from wildfires and wood burning; 7 percent from agriculture; 3 percent from mobile sources, including diesel trucks and off highway vehicles; 3 percent miscellaneous; and 2 percent from fuel combustion.

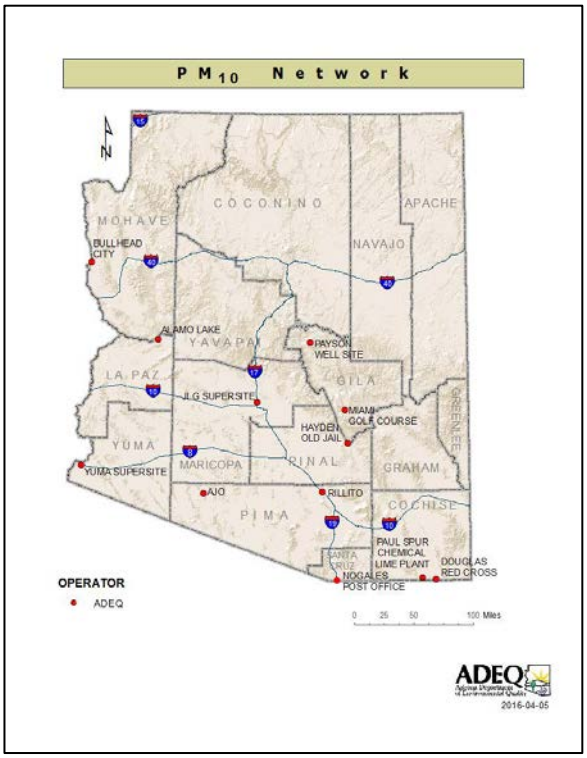


Figure 21 – Map of ADEQ's PM_{10} sites

PM_{10} concentrations are not spatially distributed evenly across Arizona because each monitoring site is strongly influenced by the degree of localized emissions of particulates. PM_{10} maximum concentrations can occur in any season, provided nearby sources of coarse particulates are present or when strong and gusty winds suspend soil disturbed by human activities. Hourly concentrations of particulates tend to peak during those hours of the worst distribution, which is from sunset to midmorning.

Controls to reduce particulates in Arizona have been in place for decades, beginning in the 1960s with a Pima County ordinance that required watering to reduce dust from construction. Maricopa County's umbrella dust abatement rules, Rule 310 and 310.01, have been revised many times through the years and now regulates construction dust, trackout dust (accumulation on tires of vehicles) from construction

sites, and dust from unpaved parking and vacant lots. Efforts to reduce dust re-suspended from paved roads have concentrated on eliminating trackout from construction sites, curbing and stabilizing road shoulders, and investigating more efficient street sweepers. In Maricopa County, the Governor's Agricultural Best Management Practices Committee developed a rule containing best management practices for agricultural activities (AgBMP) to reduce particulate emissions from tilling and harvesting activities of cropland and non-cropland. In a recent PM_{10} SIP, the Maricopa Association of Governments (MAG) committed to implement 77 new measures including enhanced enforcement of the county's dust rules, implementation of AgBMP, diesel engine replacement and retirement programs, and requirements for cleaner burning fireplaces.

Controls on PM_{10} have been successful in limiting anthropogenic emissions in recent years. Due to natural sources of PM_{10} in Arizona, areas of the state as shown in Appendix III- 2016 Area Designations, are in nonattainment for PM_{10} for the 1987 standard. PM_{10} is one of the major pollutants affecting the health of the people of Arizona and as such is a major part of ADEQ's ambient air monitoring. In 2016, ADEQ operated a network of 12 monitors throughout the state.

5.2 Monitoring Methods

ADEQ is utilizing several methods for measuring PM_{10}. The two general types are filter based and continuous instruments.

Particulates can be monitored using a weighing and filter based method. This is done by pulling ambient air through a filter for 24 hours every sixth day (or as designated for the monitor per the CFR), weighing the filter before and after sampling and measuring the volume of air sampled. Pollutant concentrations are measured by the weight of pollutant within a standard volume of air, for example micrograms per cubic meter ($\mu g/m^3$) or milligrams per cubic meter (mg/m^3). Weight and volume of air sampled are calculated to give a daily concentration. Weight is determined from an automated weighing system in ADEQ's air filter lab. The 24-hour monitoring instruments are fitted with different aerodynamic devices (inlets) to segregate particle size fractions. The particles can be segregated into two size ranges (less than 10 microns and less than 2.5 microns). This method provides one 24-hour concentration.

Particulates can also be monitored continuously with a tapered element oscillating microbalance (TEOM) instrument which utilizes the same inlets as the filter instruments to segregate particle sizes. PM particles are deposited onto an oscillating filter, which changes its frequency of oscillation based on the weight of particles deposited. This change in frequency is a direct correlation to the concentration of PM in ambient air based on the volume of air sampled in a given time period. This change is recorded by the instrument every hour to get an hourly PM concentration.

Another type of instrument called a beta attenuation mass monitor (BAM), utilizes the same inlets as filter instruments to segregate particles. This method of detection utilizes a radioactive beta source to measure the particles through a paper tape. The rate that a beta source decomposes is a known constant; therefore a sensor similar to a Geiger counter can detect this rate of radiation. Any changes to that rate can be recorded and this change in readings is a direct correlation to the concentration of PM. Particulate

matter blocks or interferes with the beta radiation by absorbing or causing the beta radiation to change. Readings on a blank part of the paper tape are taken before sampling, then an airflow rate of 16.7 liters per minute deposits particles on the paper tape for about one hour. Afterward, a reading is taken on the tape where the particles are deposited to determine the concentration of PM. The volume of air sampled is also used to determine the concentration.

Readings from continuous types of instruments (TEOM and BAM) are averaged into hourly, daily, monthly, quarterly, and yearly averages for data analysis. Readings are retrieved by a data collection system and stored in a database. Filter data are stored by air filter lab weighing equipment and uploaded to the database.

5.3 Compliance/Summary of Design Values

In 2012, EPA revised the suite of standards for PM. EPA retained the 24-hour PM_{10} standard of 150 $\mu g/m^3$ which has been in place since 1987 and revoked the annual PM_{10} standard. The 24-hour PM_{10} standard is met when the 24-hour average (rounded to the nearest 10 $\mu g/m^3$) does not exceed 150 $\mu g/m^3$ more than once per year on average over a three-year period. A history of the NAAQS for PM_{10} is provided in Table 17 below.

Table 17 – History of the National Ambient Air Quality Standards for PM_{10} during the period 1971-2012 (*Source: USEPA TTN NAAQS)*

Final Rule	Primary/ Secondary	Indicator	Averaging Time	Level	Form
1971 36 FR 8186 Apr 30, 1971	Primary	TSP	24-hour	260 $\mu g/m^3$	Not to be exceeded more than once per year
			Annual	75 $\mu g/m^3$	Annual Average
	Secondary	TSP	24-hour	150 $\mu g/m^3$	Not to be exceeded more than once per year
1987 52 FR 24634 Jul 1, 1987	Primary and Secondary	PM_{10}	24-hour	150 $\mu g/m^3$	Not to be exceeded more than once per year on average over a 3-year period
			Annual	50 $\mu g/m^3$	Annual arithmetic mean, averaged over 3 years
1997 62 FR 38652 Jul 18, 1997	Primary and Secondary	PM_{10}	24-hour	150 $\mu g/m^3$	Initially promulgated 99th percentile, averaged over 3 years; when 1997 standards for PM_{10} were vacated, the form of 1987 standards remained in place (not to be exceeded more than once per year on average over a 3-year period)
			Annual	50 $\mu g/m^3$	Annual arithmetic mean, averaged over 3 years

Final Rule	Primary/ Secondary	Indicator	Averaging Time	Level	Form
2006 71 FR 61144 Oct 17, 2006	Primary and Secondary	PM_{10}	24-hour	150 µg/m^3	Not to be exceeded more than once per year on average over a 3-year period
2012	Primary and Secondary	PM_{10}	24-hour	150 µg/m^3	Not to be exceeded more than once per year on average over a 3-year period

Table 18 presents the 2014 to 2016 expected exceedance rates for the PM_{10} sites in Arizona, along with the annual maximum 24-hour concentration. The 24-hour primary PM_{10} NAAQS of 150 µg/m^3 has been exceeded at several sites in the 2014 to 2016 time period. Parts of the following counties are currently designated nonattainment with the 1987 PM_{10} NAAQS of 150 µg/m^3: Cochise, Pima, Santa Cruz, and Yuma. See Appendix III for the nonattainment area map.

Table 18 – PM_{10} Compliance Summary

2014 to 2016 Maximum 24-Hour Average PM_{10} Compliance (in µg/m³) **Bold** denotes value above the standard. ***(NAAQS 24-hour Average 150 µg/m³)***							
Site Name	**2014**		**2015**		**2016**		**Three-Year Avg Exp. Rate of Exc.**
	Max 24-Hr Avg	**Exp. Exceed.**	**Max 24-Hr Avg**	**Exp. Exceed.**	**Max 24-Hr Avg**	**Exp. Exceed**	
Cochise County							
Douglas Red Cross[1]	**197**	**3.0**	89	0	**236**[#]	1.1	**1.4***
Paul Spur Chemical Lime Plant[1]	**228**[#]	**3.8**	69	0	77	0	**1.3**
La Paz County							
Alamo Lake[1,2]	92	0	73	0	90	0	0
Gila County							
Hayden Old Jail[1]	131	0	128	0	115	0	0
Miami Golf Course[1]	123	0	46[#]	0	73	0	0*
Payson Well Site[3]	67	0	62	0	58		0
Maricopa County							
JLG Supersite[1]	**193**	**1.0**	85	0	**223**	**1.0**	0.7
Mohave County							
Bullhead City[1]	108	0	69	0	119	0	0
Pima County							
Ajo[1]	134	0	67	0	141	0	0
Rillito[1]	**169**	**1.0**	144[#]	0	**192**	**2.0**	1.0*
Santa Cruz County							
Nogales Post Office[1]	**221**	**2.0**	107[#]	0	**180**	**1.0**	1.0*
Yuma County							
Yuma Supersite[1]	**413**	**9.0**	**400**	**5**	**523**	**9.7**	**7.9**
Preliminary Number of Sites in Violation of the NAAQS							**3**

[1]Samples collected every day - 365 sample days in non-leap years.
[2]Installed in 2014.
[3]Switched from filter-based sampler to continuous monitor in 2014.
[#]Indicates the data do not satisfy EPA's summary criteria, usually meaning less than 75 percent valid data recovery available in one or more calendar quarters.
*Preliminary Design Value since data completeness was not satisfied.

5.4 Trends

The analysis of trends in PM_{10} concentrations were divided into three different regions of Arizona: Southern Region, Northern Region, and Central Region. The division into regions helps to group sites that have similar PM_{10} sources and characteristics.

PM_{10} Southern Region

Sites evaluated in the southern region of Arizona include Ajo, Douglas Red Cross, Nogales Post Office, Paul Spur Chemical Lime Plant, Rillito, and Yuma. The site identified as "Yuma Area" included records from Yuma Courthouse for the years 2008 and 2009 and from Yuma Supersite for the years 2010 to 2016. Figure 22 illustrates the temporal variability of PM_{10} in the southern region over the 1987 to 2016 period in the form of annual means. The PM_{10} trend in this region can be described as having a significant decrease over the 1987 to 1997 period and a slight decrease over the 1998 to 2016 period.

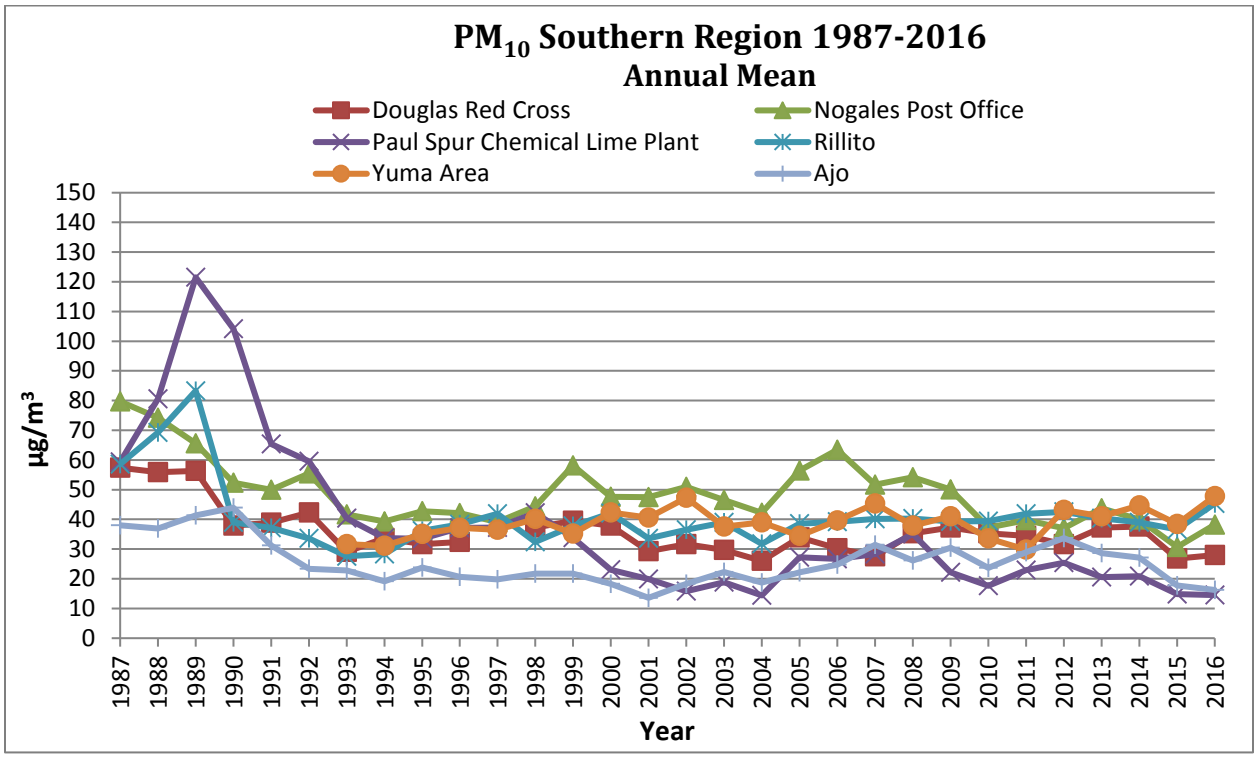


Figure 22 – PM_{10} Annual Mean Average for the Southern Region
1987-1996: 61.1% decrease for the Southern Region Average, excluding Yuma Area
1998-2016: 7.0% decrease for the Southern Region Average
Note: *Some years might not satisfy completeness criteria. All PM_{10} Southern Region sites were averaged to calculate a best-fit straight line, which was used to determine the average percent change. In order to reduce bias in averaging, all sites must have at least 7 consecutive years of data and the same number of consecutive years.*

PM_{10} Northern Region

Sites evaluated in the northern region of Arizona include Bullhead City and Payson Well Site. Figure 23 illustrates the temporal variability of PM_{10} in the northern region over the 1992 to 2016 period in the form of annual means. The PM_{10} trend in this region can be described as having a slight decrease over this period.

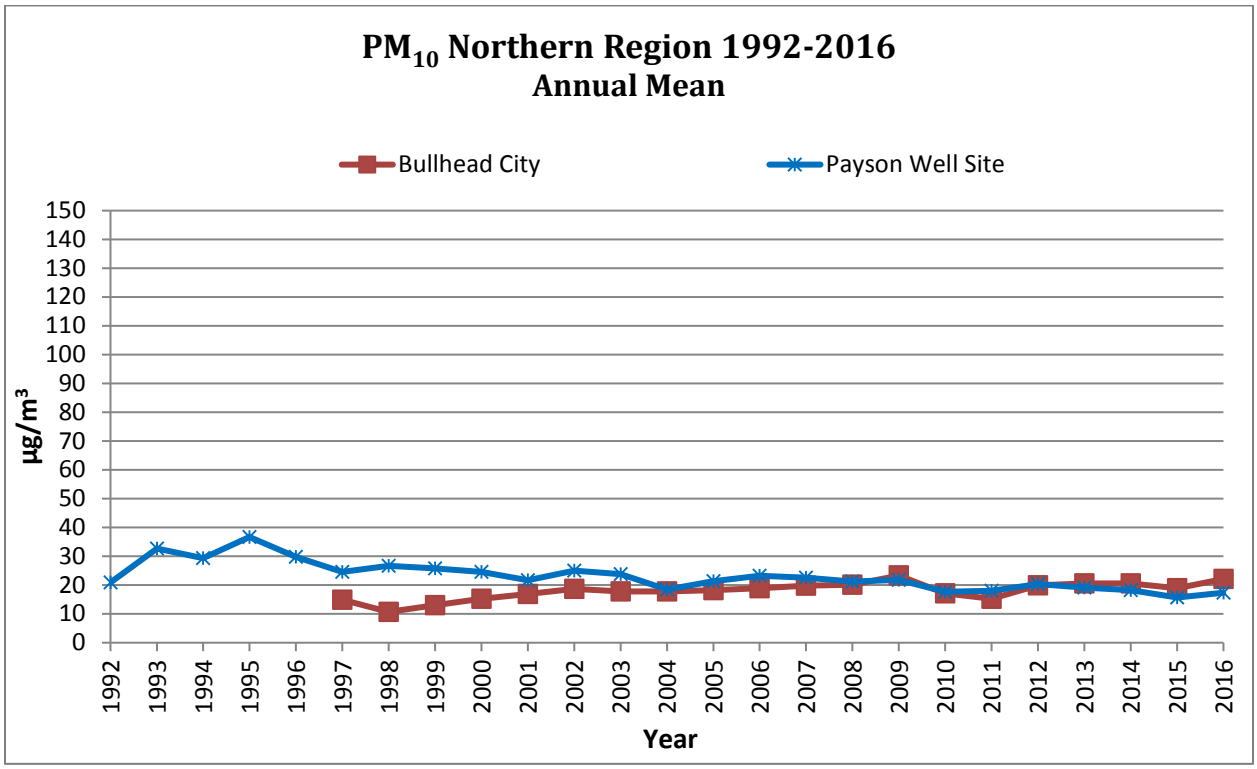


Figure 23 – PM_{10} Annual Mean Average for the Northern Region
1997-2016: 4.5% decrease for the Northern Region Average
Note: *Some years might not satisfy completeness criteria. All PM_{10} Northern Region sites were averaged to calculate a best-fit straight line, which was used to determine the average percent change. In order to reduce bias in averaging, all sites must have at least 7 consecutive years of data and the same number of consecutive years.*

PM_{10} Central Region

Sites evaluated in the central region of Arizona include Hayden Old Jail, JLG Supersite, and Miami Golf Course. Figure 24 illustrates the temporal variability of PM_{10} in the central region over the 1991 to 2016 period in the form of annual means. The PM_{10} trend in this region can be described as fairly constant, with no significant changes for Hayden Old Jail and JLG Supersite, over the 1999 to 2016 period.

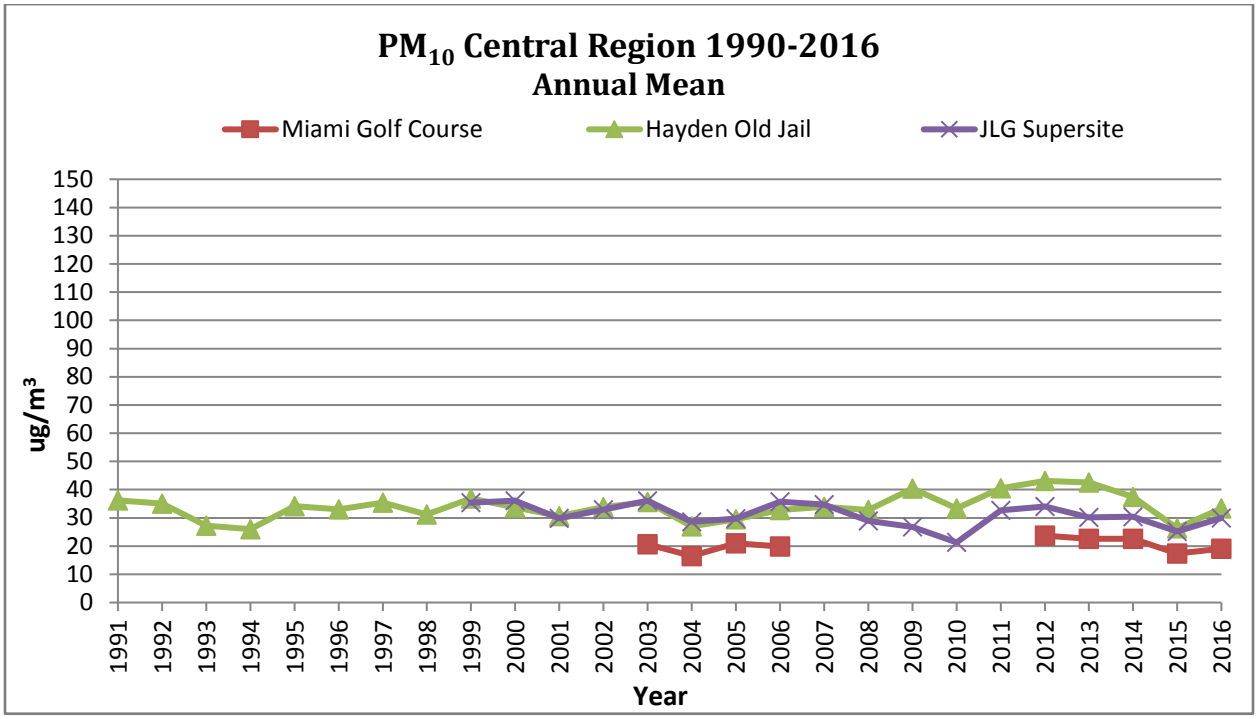


Figure 24 – PM_{10} Annual Mean Average for the Central Region
1999-2016: 3.4% decrease for Hayden Old Jail and JLG Supersite
Note: *Some years might not satisfy completeness criteria. Hayden Old Jail and JLG Supersite PM_{10} sites were averaged to calculate a best-fit straight line, which was used to determine the average percent change. In order to reduce bias in averaging, all sites must have at least 7 consecutive years of data and the same number of consecutive years.*

5.5 Air Quality Index (AQI)

Similar to the analysis of trends in PM_{10} concentrations, the representation of the AQI daily values for 2016 was divided into three different regions of Arizona: Southern Region (divided into South/Central and Southeastern Regions) and a combined Northern and Central Region.

Background levels of PM_{10} are very low in areas without manmade sources, but can be slightly elevated due to windblown particulates. High PM_{10} levels are influenced by localized emissions (disturbed soil, unpaved roads, and high wind events). High levels can occur during any season when particulates are picked up by strong and gusty winds. The highest PM_{10} AQI values occur when large dust storms form over central and southern Arizona. Wintertime AQI values can be elevated due to woodstove burning and stable atmospheric conditions.

PM_{10} Southern Region

The PM_{10} daily AQI values for 2016 are categorized into the different levels of health concerns in Table 19. Graphical representations of the PM_{10} Daily AQI values for 2016 are shown in Figures 25 and 26.

Table 19 – PM_{10} Daily AQI Count 2016 - Southern Region

AQI Values	Levels of Health Concern	Number of Days					
		Ajo	**Douglas Red Cross**	**Nogales Post Office**	**Paul Spur Chemical Lime Plant**	**Rillito**	**Yuma Supersite**
0 - 50	Good	352	306	291	361	276	250
51 - 100	Moderate	10	18	70	1	86	84
101 - 150	Unhealthy for Sensitive Groups	0	1	1	0	2	8
151 - 200	Unhealthy	0	0	0	0	0	0
201 - 300	Very Unhealthy	0	0	0	0	0	0
301 - 500	Hazardous	0	0	0	0	0	1
	Missing	4	41	4	4	4	23
Total Days		366	366	366	366	366	366

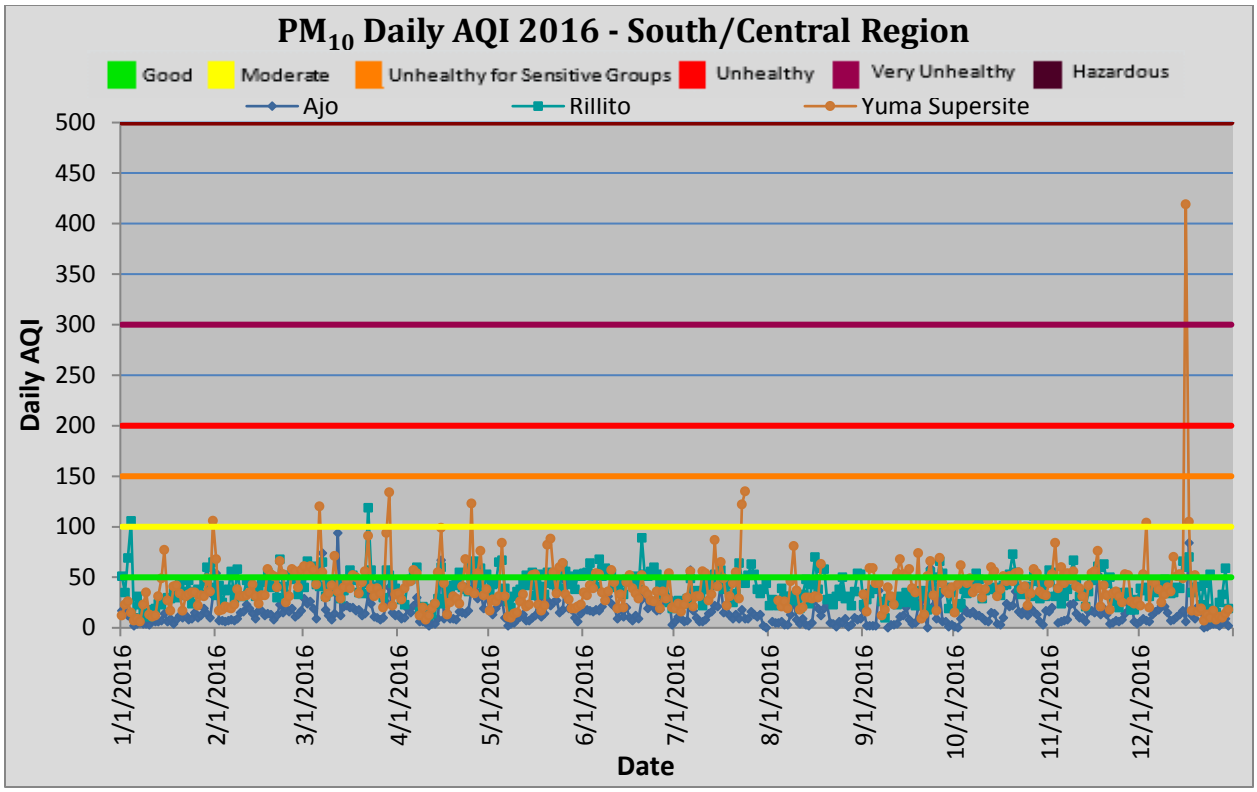


Figure 25 – PM_{10} Daily AQI 2016- South/Central Region

***Note**: Data are the daily AQI values for 2016 obtained from https://www.epa.gov/outdoor-air-quality-data and include Exceptional Events.*

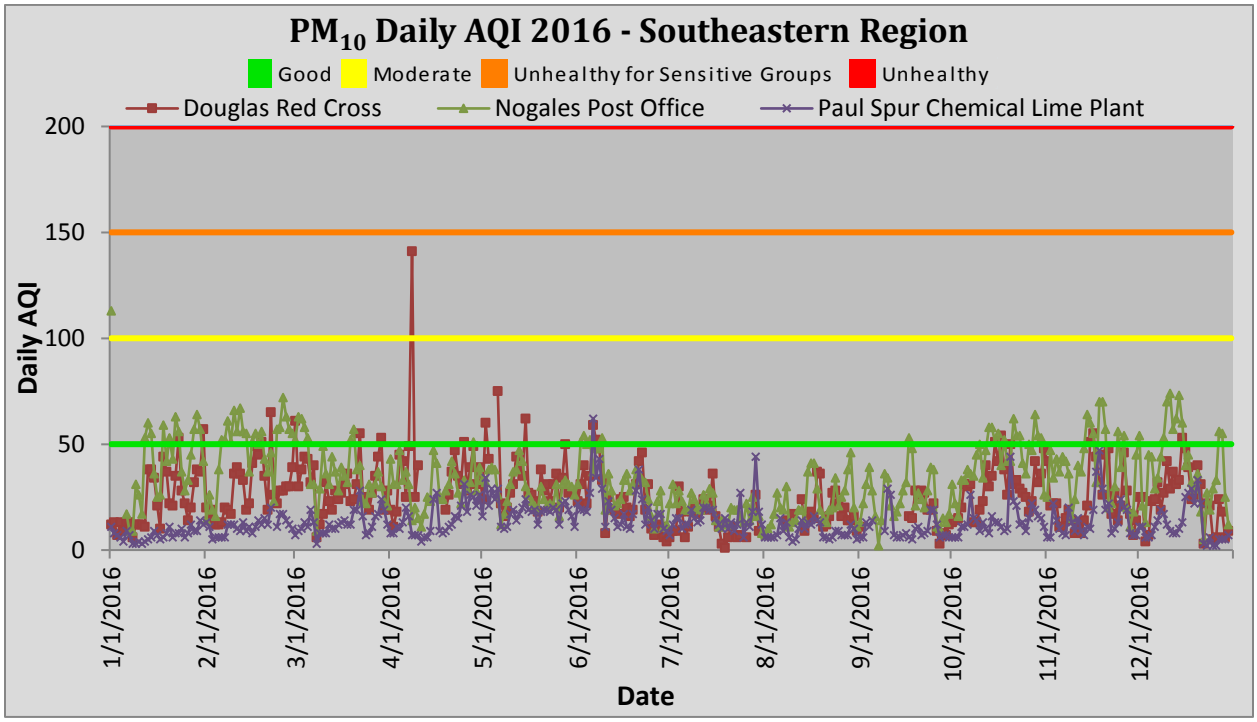


Figure 26 – PM_{10} Daily AQI 2016- Southeastern Region

***Note**: Data are the daily AQI values for 2016 obtained from https://www.epa.gov/outdoor-air-quality-data and include Exceptional Events.*

PM_{10} Northern and Central Region

The PM_{10} daily AQI values for 2016 are categorized into the different levels of health concerns in Table 20. Graphical representations of the PM_{10} Daily AQI values for 2016 are shown in Figures 27 and 28.

Table 20– PM_{10} Daily AQI Count 2016 - Northern and Central Region

AQI Values	Levels of Health Concern	Number of Days					
		Alamo Lake	Bullhead City	Hayden Old Jail	JLG Supersite	Miami Golf Course	Payson Well Site
0 - 50	Good	357	333	289	343	363	361
51 - 100	Moderate	8	19	37	15	3	3
101 - 150	Unhealthy for Sensitive Groups	0	0	0	1	0	0
151 - 200	Unhealthy	0	0	0	0	0	0
201 - 300	Very Unhealthy	0	0	0	0	0	0
301 - 500	Hazardous	0	0	0	0	0	0
	Missing	1	14	40	7	0	2
	Total Days	366	366	366	366	366	366

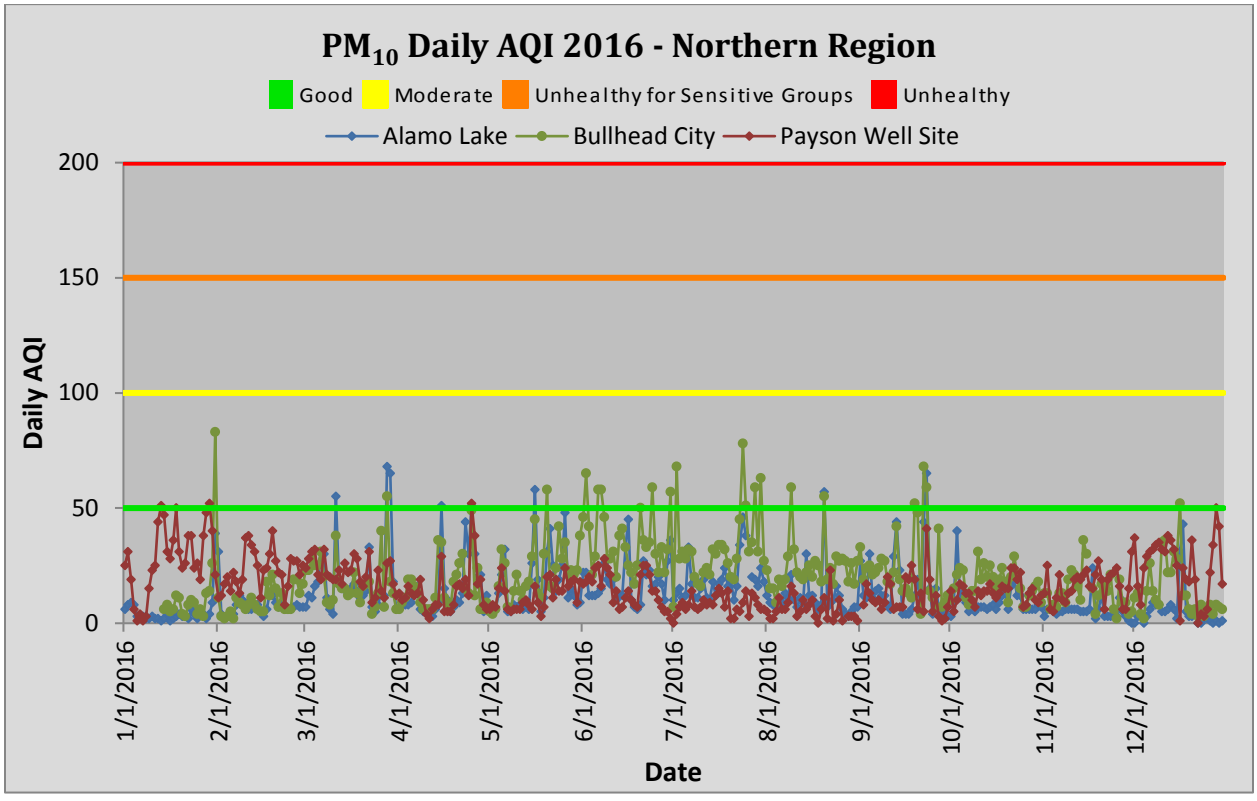


Figure 27 – PM_{10} Daily AQI 2016 - Northern Region

***Note**: Data are the daily AQI values for 2016 obtained from https://www.epa.gov/outdoor-air-quality-data and include Exceptional Events.*

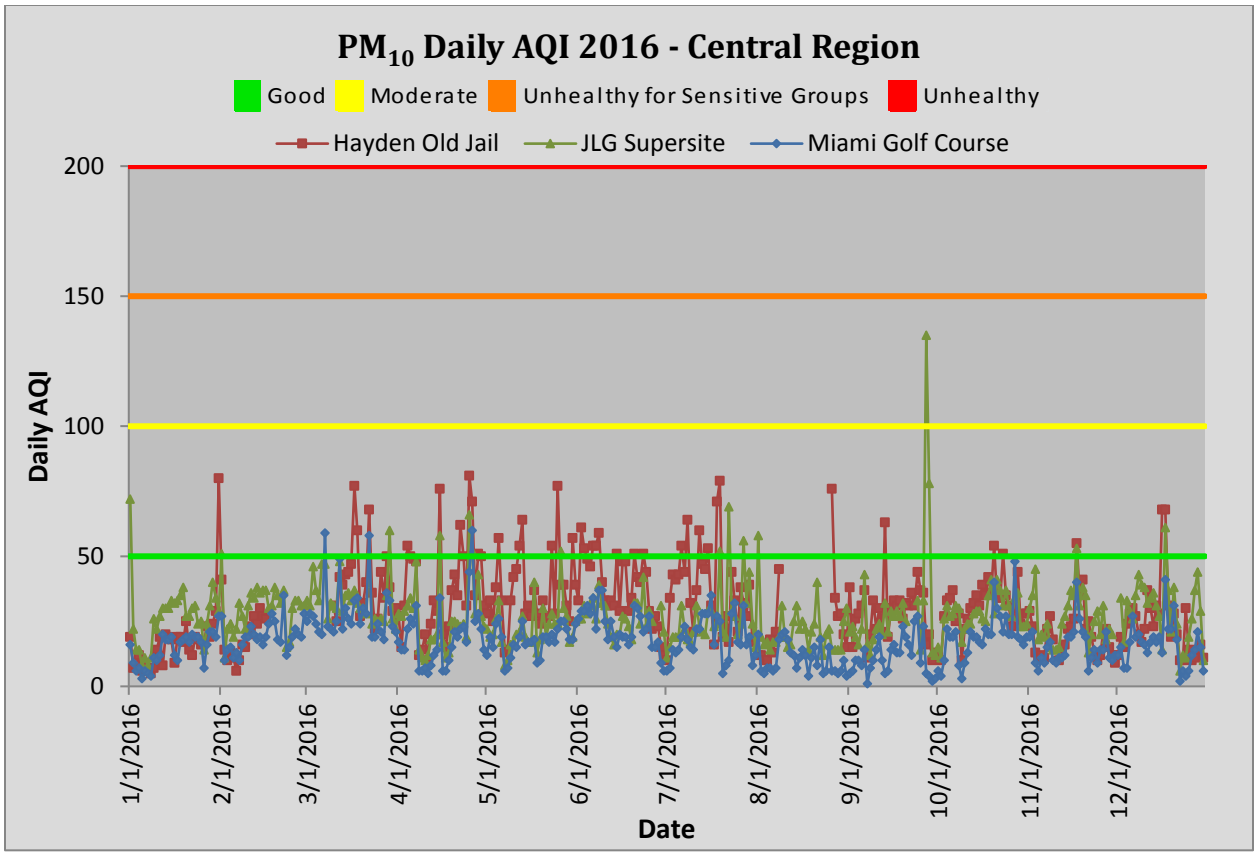


Figure 28 – PM_{10} Daily AQI 2016 - Central Region

***Note**: Data are the daily AQI values for 2016 obtained from https://www.epa.gov/outdoor-air-quality-data and include Exceptional Events.*

6.0 Particulate Matter Smaller Than 2.5 Microns ($PM_{2.5}$)

Particulate matter smaller than 2.5 microns ($PM_{2.5}$) describes particles that are less than 2.5 microns in diameter. These fine particulates are formed by the condensation of vapors or by their subsequent growth through coagulation or agglomeration. Others are emitted directly from sources, either by combustion or from mechanical grinding of soils. Fine particulates are classified as: primary - produced within and emitted from a source with little subsequent change; or secondary - formed in the atmosphere from gaseous emissions. For example, secondary particulate nitrates and sulfates form in the atmosphere from the oxidation of gaseous SO_2 and NO_2. In contrast, most atmospheric particulate carbon is primary, having been emitted directly from combustion sources, although some of the organic carbon in aerosols is secondary, having been formed by the complex photochemistry of gaseous VOCs.

For particulate matter, the primary route of entry into the body is inhalation. Particles smaller than 2.5 microns are respired and enter the pulmonary tissues where they are deposited. Particles in the size range of 0.1 to 2.5 microns are most efficiently deposited in the alveoli, where their effective toxicity is greater than larger particles because of the higher relative content of toxic heavy metals, sulfates, and nitrates. Health studies have shown a significant association between exposure to fine particles and premature death from heart or lung disease. Fine particles can aggravate heart and lung diseases and have been linked to effects such as: cardiovascular symptoms, cardiac arrhythmias, heart attacks, respiratory symptoms, asthma attacks, and bronchitis. Individuals that may be particularly sensitive to fine particle exposure include people with heart or lung disease, older adults, and children.

6.1 Background

With a more diverse chemical composition, fine particulate emissions are distributed among a larger number of sources. According the 2014 NEI, 33 percent of all $PM_{2.5}$ emissions come from wildfires and wood burning; 23 percent from dust; 13 percent from industrial processes; 10 percent from miscellaneous sources; 8 percent from mobile sources including diesel trucks and off highway vehicles; 8 percent from fuel combustion; and 5 percent from agriculture.

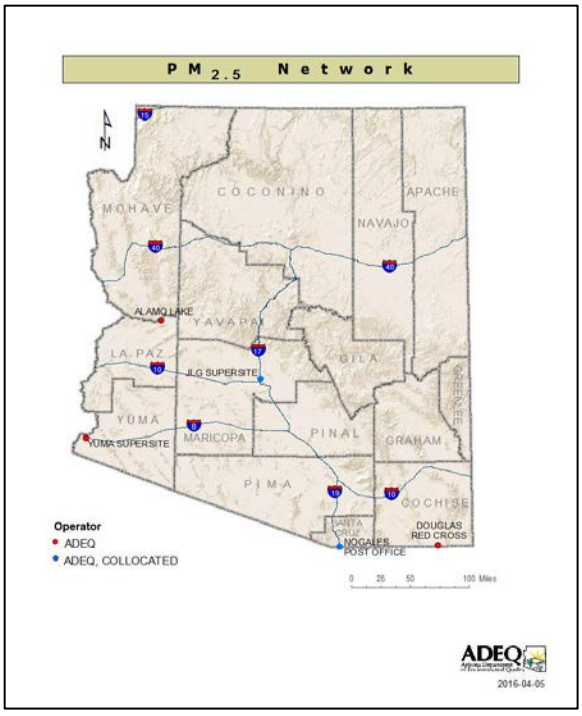


Figure 29 – Map of ADEQ's $PM_{2.5}$ sites

Concentrations of $PM_{2.5}$ tend to be at their highest in the central portions of urban areas, diminishing to background levels at the urban fringe. Background concentrations of $PM_{2.5}$ are about 5 $\mu g/m^3$, in contrast to the urban maximum of 12 to 15 $\mu g/m^3$. Concentrations of fine particulates tend to be higher in the late fall and winter, when atmospheric dispersion is at a seasonal low, which traps the particulates and allows for a build-up in the ambient air.

Controls to reduce particulates in Arizona have been in place for decades, beginning in the 1960s with a Pima County ordinance that required watering to reduce dust from construction. Secondary fine particulates have been reduced by vehicle emission controls, which reduce precursor gases. For example, reducing gaseous HC emissions has led to reductions in ambient concentrations of secondary organic carbon. Additionally, techniques have been implemented that are similar to PM_{10} controls for $PM_{2.5}$ reduction such as paving of streets, chip sealing, and graveling alleyways.

Due to the successful nature of the controls on $PM_{2.5}$, most of Arizona is in attainment for both of the 2012 primary $PM_{2.5}$ NAAQS. Areas in nonattainment are shown in Appendix III- 2016 Area Designations. Since fires and blowing dust make up the majority of $PM_{2.5}$ in Arizona, levels can be elevated above the 24-hour standard and are beyond controls on anthropogenic sources.

6.2 Monitoring Methods

Monitors measuring $PM_{2.5}$ operate using the same methods as PM_{10} instruments. The instruments are also the same, using BAMs, and filter-based samplers for monitoring. The difference being that the instruments are fitted with different aerodynamic devices to segregate particle size fractions. See section 5.2 of this document.

Figure 30 – Nogales Post Office monitoring station

6.3 Compliance/Summary of Design Values

Effective December 14, 2012 the EPA changed the annual primary $PM_{2.5}$ NAAQS from 15.0 $\mu g/m^3$ (set in 1997) to 12.0 $\mu g/m^3$, thereby strengthening this annual health standard. The annual $PM_{2.5}$ standard is met when the three-year average (rounded to the nearest 0.1 $\mu g/m^3$) of annual means is less than or equal to 12.0 $\mu g/m^3$. This three-year average is determined by calculating the quarterly averages for each year to determine the calendar year average and then averaging the three years together.

The 24-hour primary $PM_{2.5}$ NAAQS of 35 $\mu g/m^3$ was retained in December 2012. EPA originally issued this 24-hour standard in 2006 when they changed it from 65 $\mu g/m^3$ to 35 $\mu g/m^3$. The 24-hour standard is met when the three-year average (rounded to the nearest 1 $\mu g/m^3$) of the yearly 98th percentile value is less than or equal to 35 $\mu g/m^3$. A history of the NAAQS for $PM_{2.5}$ is provided in Table 21 below.

Table 21 – History of the National Ambient Air Quality Standards for $PM_{2.5}$ during the period 1997-2012
(Source: USEPA TTN NAAQS)

Final Rule	Primary/ Secondary	Indicator	Averaging Time	Level	Form
1997 62 FR 38652 Jul 18, 1997	Primary and Secondary	$PM_{2.5}$	24-hour	65 µg/m^3	98th percentile, averaged over 3 years
			Annual	15.0 µg/m^3	Annual arithmetic mean, averaged over 3 years
2006 71 FR 61144 Oct 17, 2006	Primary and Secondary	$PM_{2.5}$	24-hour	35 µg/m^3	98th percentile, averaged over 3 years
			Annual	15.0 µg/m^3	Annual arithmetic mean, averaged over 3 years
2012	Primary	$PM_{2.5}$	Annual	12.0 µg/m^3	Annual arithmetic mean, averaged over 3 years
	Secondary		Annual	15.0 µg/m^3	Annual arithmetic mean, averaged over 3 years
	Primary and Secondary		24-hour	35 µg/m^3	98th percentile, averaged over 3 years

The annual primary $PM_{2.5}$ NAAQS of 12.0 µg/m^3 was met in 2016 by all five sites operated by ADEQ. See Table 22 for a summary of the annual three-year averages at these sites. In order to calculate the three-year average, there must be a designation of a primary monitor at each site. In the 2014 to 2016 time period, all primary monitors were continuous monitors, with samples collected every day (365 sample days in non-leap years).

Table 22 – $PM_{2.5}$ Annual Average Compliance Summary

2014 to 2016 Annual Average $PM_{2.5}$ Compliance (in µg/m^3)
Federal Reference Methods and Federal Equivalent Methods
Bold denotes a value above the standard.
(NAAQS Annual Average 12 µg/m^3)

Site Name	2014	2015	2016	Three-Year Average
La Paz County				
Alamo Lake	2.0	1.1#	2.4	1.8*
Cochise County				
Douglas Red Cross	7.2	5.2	3.8#	5.4*
Maricopa County				
JLG Supersite	7.0	7.7	7.9	7.6
Santa Cruz County				
Nogales Post Office	9.5	9.0	9.8	9.4
Yuma Count				
Yuma Supersite	6.3	5.6#	8.3	6.7*
Number of Sites in Violation of the NAAQS				0

#Indicates the data do not satisfy EPA's summary criteria, usually meaning less than 75 percent valid data recovery available in one or more calendar quarters.
*Preliminary Design Value since data completeness was not satisfied.

In 2016, all five sites operated by ADEQ were in compliance with the 24-hour primary $PM_{2.5}$ NAAQS of 35 µg/m^3. See Table 23 for a summary of the 24-hour three-year averages at these sites. Design calculations for this standard were also based on the designated primary monitor, as they were for the annual standard discussed above.

Table 23 – $PM_{2.5}$ 24-Hour Average Compliance Summary

2014 to 2016 24-Hour Average $PM_{2.5}$ Compliance (in µg/m^3) Federal Reference Methods and Federal Equivalent Methods **Bold** denotes a vale above the standard. ***(NAAQS 24-hour Average 35 µg/m^3)***				
Site Name	**98th Percentile Samples**			**Three-Year Average**
	2014	**2015**	**2016**	
La Paz County				
Alamo Lake	8.2	6.8#	10.2	8*
Cochise County				
Douglas Red Cross	15.9	10.5	9.1#	12*
Maricopa County				
JLG Supersite	22.5	23.2	19.4	22
Santa Cruz County				
Nogales Post Office	29.0	27.2	26.0	27
Yuma County				
Yuma Supersite	22.9	14.7#	23.0	20*
Number of Sites in Violation of the NAAQS				0

#Indicates the data do not satisfy EPA's summary criteria, usually meaning less than 75 percent valid data recovery available in one or more calendar quarters.

*Preliminary Design Value since data completeness was not satisfied.

6.4 Trends

For this trends assessment, data from Douglas Red Cross, JLG Supersite, and Nogales Post Office were evaluated for a period of eighteen years from 1999 to 2016. A shorter length of record for the Yuma area site was evaluated for a period of nine years from 2008 to 2016. This site identified as "Yuma area" included records from Yuma Courthouse for the years 2008 and 2009 and from Yuma Supersite for the years 2010 to 2016.

Figures 31 and 32 illustrate the temporal variability of $PM_{2.5}$ over the 1999 to 2016 period in the form of annual means and the 24-hour averages at the 98th percentile. The $PM_{2.5}$ trend of annual means can be described as decreasing over the 1999 to 2016 period. The overall trend of the 24-hour averages at the 98th percentile is also decreasing over the 1999 to 2016 period; however, it is important to note that the period of 2008 to 2016 does not show the same magnitude of $PM_{2.5}$ concentration reductions.

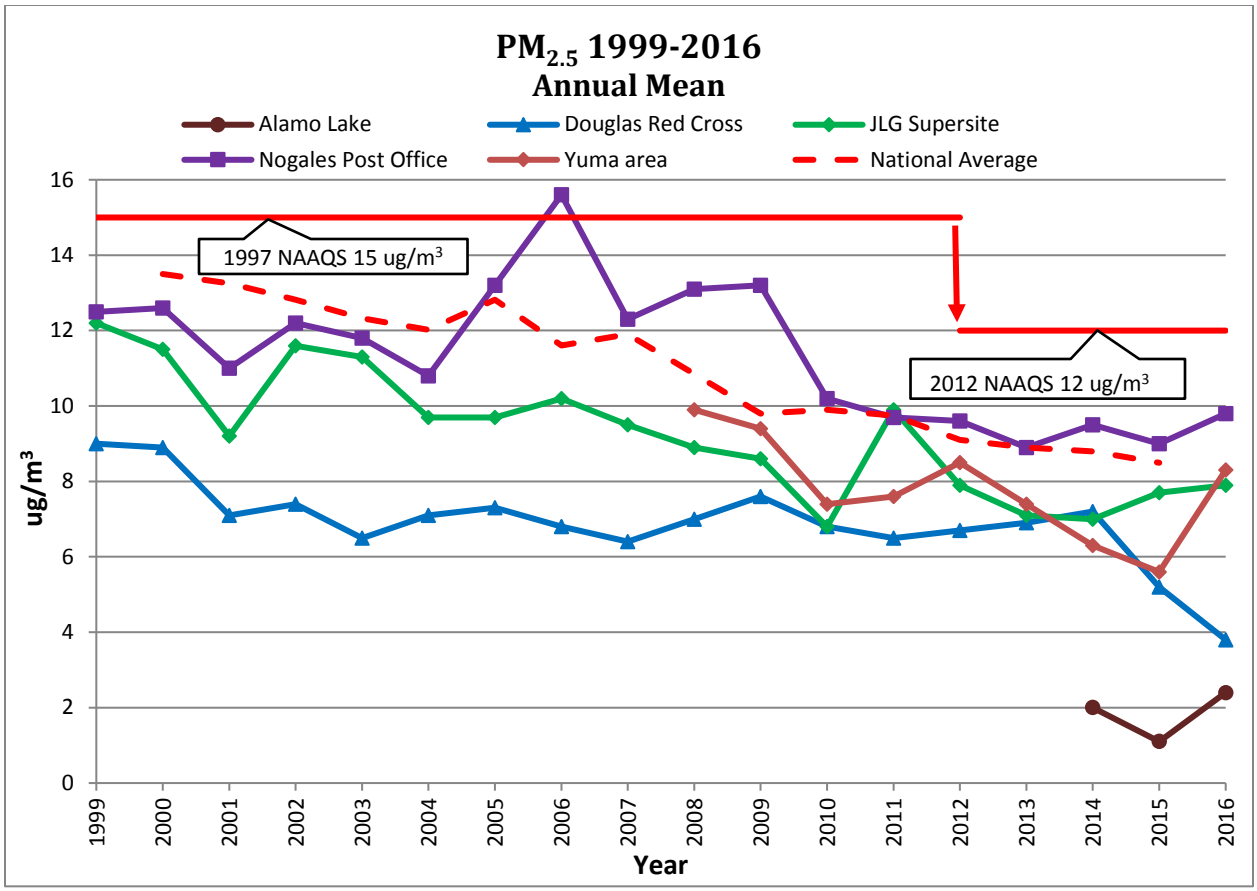


Figure 31 – $PM_{2.5}$ Annual Mean Trend

1999-2016: 33.8% decrease for Douglas Red Cross, JLG Supersite, and Nogales Post Office
2008-2016: 29.4% decrease for Douglas Red Cross, JLG Supersite, Nogales Post Office, and Yuma
2000-2015: 37% cumulative decrease in the National Average (https://www.epa.gov/air-trends/particulate-matter-pm25-trends). 2016 National Averages were not available.

Note: *Some years might not satisfy completeness criteria. Douglas Red Cross, JLG Supersite, and Nogales Post Office $PM_{2.5}$ sites were averaged to calculate a best-fit straight line, which was used to determine the average percent change. An additional average percent change was calculated in the same manner for all $PM_{2.5}$ sites (except Alamo Lake) from 2008-2016. In order to reduce bias in averaging, all sites must have at least 7 consecutive years of data and the same number of consecutive years.*

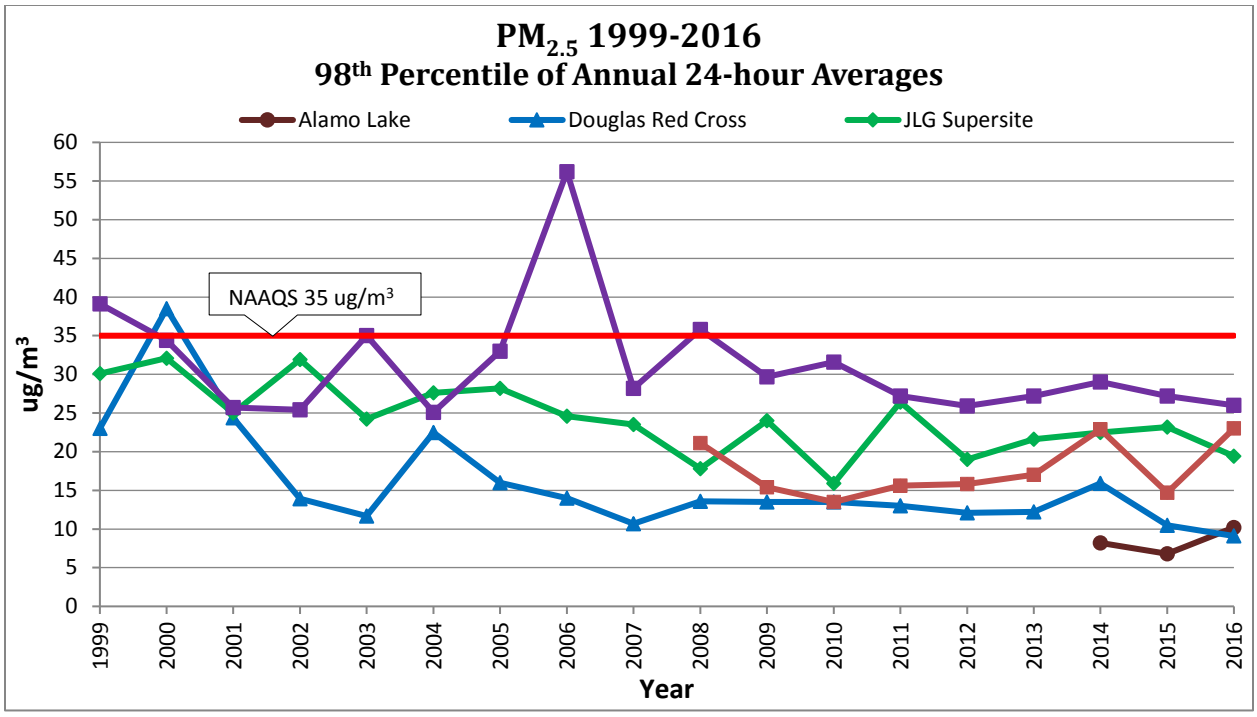


Figure 32 – $PM_{2.5}$ 24-Hour Average Trend

1999-2016: 38.5% decrease for Douglas Red Cross, JLG Supersite, and Nogales Post Office

2008-2016: 5.9% decrease for Douglas Red Cross, JLG Supersite, Nogales Post Office, and Yuma

Note: *Some years might not satisfy completeness criteria. Douglas Red Cross, JLG Supersite, and Nogales Post Office $PM_{2.5}$ sites were averaged to calculate a best-fit straight line, which was used to determine the average percent change. An additional average percent change was calculated in the same manner for all $PM_{2.5}$ sites (except Alamo Lake) from 2008-2016. In order to reduce bias in averaging, all sites must have at least 7 consecutive years of data and the same number of consecutive years.*

6.5 Air Quality Index (AQI)

The $PM_{2.5}$ daily AQI values for 2016 are categorized into the different levels of health concerns in Table 24. Background levels of $PM_{2.5}$ are very low in areas without manmade sources. Urban background levels are elevated some due to industrial and mobile sources. Wintertime AQI values can be higher due to woodstove burning and stable atmospheric conditions. The highest $PM_{2.5}$ AQI values occur when large dust storms form over central and southern Arizona and also when forest fires occur in the northern areas of Arizona. Graphical representations of the $PM_{2.5}$ Daily AQI values for 2016 are shown in Figures 33 and 34.

Table 24 – $PM_{2.5}$ Daily AQI Count 2016

AQI Values	Levels of Health Concern	Number of Days				
		Alamo Lake	Douglas Red Cross	JLG Supersite	Nogales Post Office	Yuma Supersite
0 - 50	Good	355	330	282	263	301
51 - 100	Moderate	4	1	55	83	46
101 - 150	Unhealthy for Sensitive Groups	0	0	0	0	3
151 - 200	Unhealthy	0	0	1	1	0
201 - 300	Very Unhealthy	0	0	0	0	0
301 - 500	Hazardous	0	0	0	0	0
	Missing	7	35	28	19	16
	Total Days	366	366	366	366	366

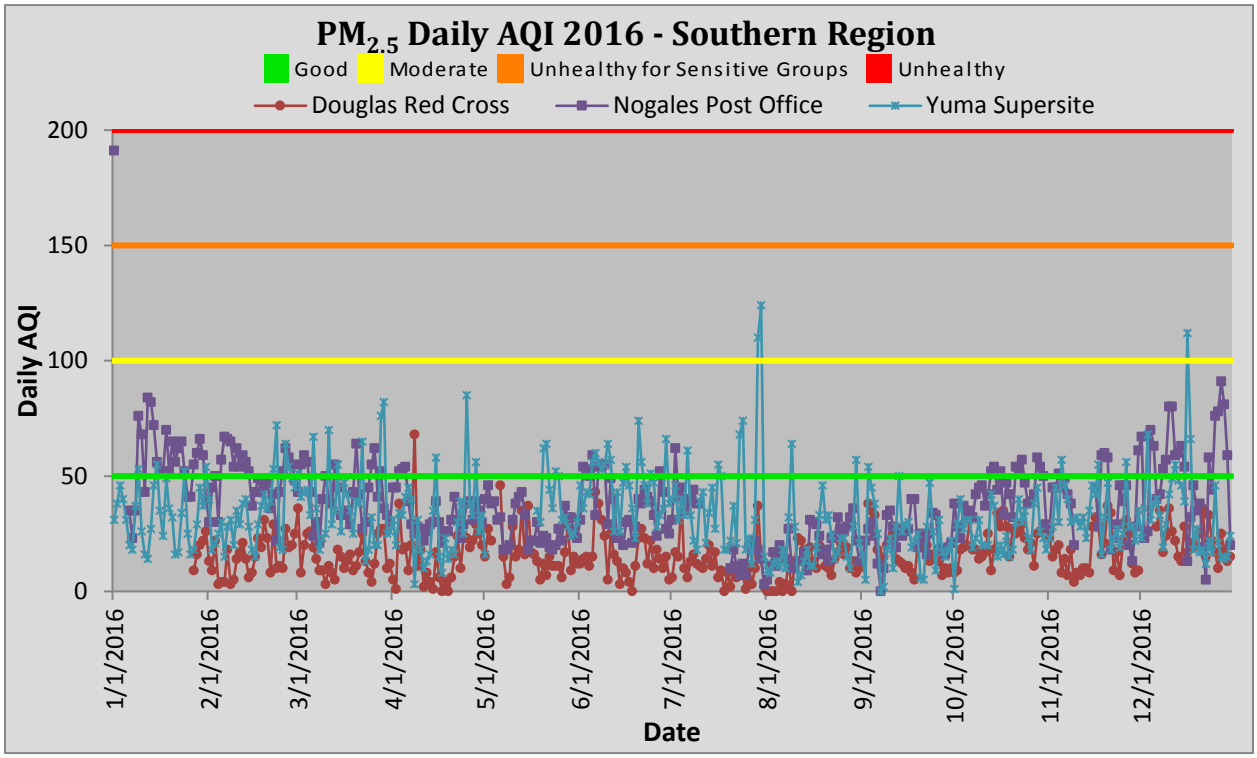


Figure 33 – $PM_{2.5}$ Daily AQI 2016 - Southern Region

***Note**: Data are the daily AQI values for 2016 obtained from https://www.epa.gov/outdoor-air-quality-data and include Exceptional Events.*

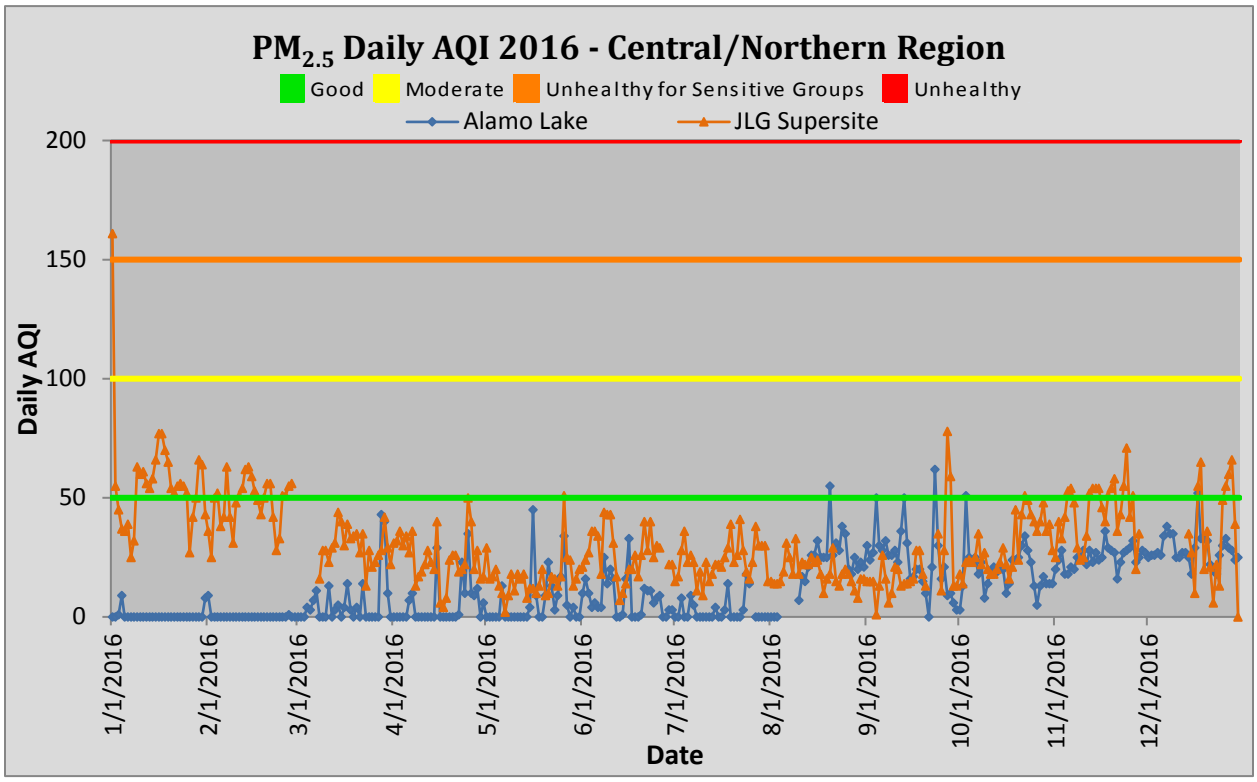


Figure 34 – $PM_{2.5}$ Daily AQI 2016 - Central/Northern Region

***Note**: Data are the daily AQI values for 2016 obtained from https://www.epa.gov/outdoor-air-quality-data and include Exceptional Events.*

7.0 Lead (Pb)

Lead is a metal found naturally in the earth and a key element in the composition of many rocks and soils. It is a very dense metal that is used in a variety of industrial processes in many forms. It can be used as anodes in car batteries or as ballast in boats or in scuba diving. Lead as defined in terms of air quality, is a component of air particulates that can be inhaled into the lungs. Lead found in car batteries for instance is not considered an air pollutant. Today, the major sources of Pb emissions that pertain to air quality are ore and metals processing and piston-engine aircraft operating on leaded aviation gasoline. The highest ambient air concentrations of Pb in Arizona are usually found near copper smelters.

In addition to exposure to Pb in air, other major exposure pathways include ingestion of Pb in drinking water and Pb-contaminated food as well as incidental ingestion of Pb-contaminated soil and dust. Lead-based paint remains a major exposure pathway in older homes. However, data from these other exposure pathways are not measured by ADEQ Air Quality Division. Once taken into the body in any form, Pb distributes throughout the body in the blood and is accumulated in the bones. Depending on the level of exposure, Pb can adversely affect the nervous system, kidney function, immune system, reproductive and developmental systems, and the cardiovascular system. Lead exposure also affects the oxygen carrying capacity of the blood. The Pb effects most commonly encountered in current populations are neurological effects in children and cardiovascular effects in adults. Infants and young children are especially sensitive to even low levels of Pb, which may contribute to behavioral problems, learning deficits, and lowered IQ.

7.1 Background

Lead emissions in Arizona are made up of two main sources: mobile sources including piston-engine aircraft and other older engines which use leaded gasoline, and copper and metals smelting. According to the 2014 NEI, mobile sources contribute to about 65 percent of Pb emissions in Arizona, smelting and other industrial processes contribute about 27 percent, and all other sources including fuel combustion contribute about 8 percent.

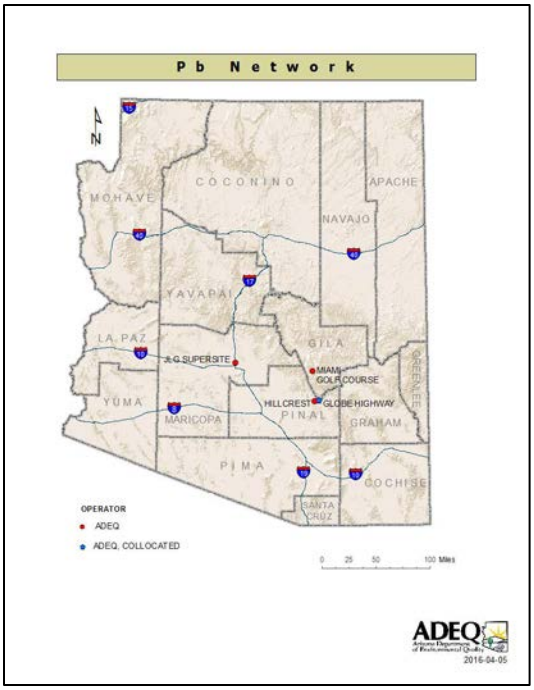


Figure 35 – Map of ADEQ's Pb sites

Lead has historically been used in paints, as an additive to fuel, in electronics, and in various other industrial applications. U.S. Regulations have eliminated the use of Pb in almost all of these applications due to its toxicity.

Mobile sources are spread out over the state. There are around 100 small airports that still have some airplanes that require leaded-fuel, but since this is spread out over the whole state, no single airport contributes to a high concentration of Pb at a time. The only other large sources of Pb are due to metals

smelting. Since Arizona has large copper smelting operations, Pb continues to be a concern in the areas surrounding these sources.

Controls to reduce Pb have been in place since its removal from gasoline in the 1970's. The controls that are being implemented to control the major Pb sources at the smelting operations include various fugitive dust control measures.

7.2 Monitoring Methods

Figure 36 – Hillcrest monitoring station

Lead is monitored using two different sampling techniques. The first uses the same manual filter instruments that are used for PM_{10} sampling as described in Section II.5. The same PM_{10} inlet is used, and this method for using the PM_{10} sampler is approved by the EPA as Pb-PM_{10}. The difference between sampling for Pb and sampling for PM_{10} is that the filters are not pre-weighed or post weighed; the filters are analyzed by an independent laboratory for Pb content using an EPA approved method involving the digestion or dissolving of other contaminants and the isolation of Pb on the filter. Once the Pb is isolated, it can be weighed using a precise scale. Based on the total flow of the sample and the weight, a concentration is calculated.

The second method of lead sampling uses a total suspended particulates (TSP) sampler that does not have an inlet attached. All particles in the air are captured by the sampler on a large filter using a high flow rate. Once the 24-hour sampling period is over, the filter is cut, digested, and Pb is isolated in the same way as with the Pb-PM_{10} sample filter.

Readings from all the types of instruments are averaged into daily, monthly, quarterly, and yearly averages for data analysis. Readings are retrieved on the samplers manually and by weighing equipment, then stored in a database.

7.3 Compliance/Summary of Design Values

In 2008, the Pb standard was revised from the 1978 rule. This lowered the three-month rolling average from 1.5 $\mu g/m^3$ to 0.15 $\mu g/m^3$. The rule also set forth a monitoring requirement based on an emissions threshold for each source. This threshold states that sources require monitoring if they are above 0.5 tons per year, based on their most recent emissions inventory. Lead concentrations in Arizona generally do not exceed this standard since leaded fuels were banned in the U.S. starting in 1996. Due to the 2008 rule change, ADEQ operated three source oriented monitors in 2016 around two copper smelters in Miami and Hayden. ADEQ also operated one Pb monitor at JLG Supersite as part of NCore. A history of the NAAQS for Pb is provided in Table 25 below:

Table 25 – History of the National Ambient Air Quality Standards for Pb during the period 1978-2008
(Source: USEPA TTN NAAQS)

Final Rule	Primary/ Secondary	Indicator	Averaging Time	Level	Form
1978 43 FR 46246 Oct 5, 1978	Primary and Secondary	Pb-TSP	Calendar Quarter	1.5 µg/m^3	Not to be exceeded
Feb 21, 1991 – Agency released multimedia "Strategy for Reducing Lead Exposures"					
2008 73 FR 66964 Nov 12, 2008	Primary and Secondary	Pb-TSP	3-month period	0.15 µg/m^3	Not to be exceeded

Table 26 summarizes the maximum three-month rolling average Pb concentrations for the year from 2014 to 2016. Globe Highway did not meet the 2008 NAAQS of 0.15 µg/m^3 with a 2016 Three-Year Design Value of 0.17 µg/m^3. In comparison, the Three-Year Design Value for Miami Golf Course for 2016 was 0.05 µg/m^3 and JLG Supersite was 0.0094 µg/m^3. The Hillcrest site began monitoring in 2016. The site was specifically located for Pb maximum concentration determination and chosen in response to elevated readings from an EPA Superfund monitor. There is no Three-Year Design Value for the Hillcrest site due to there only being one year of data available. However, the maximum three-month rolling average for 2016 exceeded the 0.15 µg/m^3 NAAQS, which will cause a violation of the 2018 Three-Year Design Value.

Table 26 – Pb Compliance Summary

2014 to 2016 Maximum 3 - Month Average Pb-TSP Compliance (in µg/m^3) **Bold** denotes value above the standard. ***(NAAQS 3-Month Rolling Average 0.15 µg/m^3)***				
Site Name	**Max 3-Month Rolling 24-Hr Avg**			**Three-Year Design Value**
	2014	**2015**	**2016**	
Gila County				
Globe Highway	**0.17**	0.12	0.14	**0.17**
Hillcrest	N/A	N/A	**0.22**	N/A
Miami Golf Course	0.05	0.03	0.04	0.05
Maricopa County				
JLG Supersite	0.0056	0.0094	0.0056	0.0094
Number of Sites in Violation of the NAAQS				**2**

7.4 Trends

ADEQ began monitoring for Pb in 2011. A trends analysis was not performed on the Pb data as there were not at least seven consecutive years of data available. However, the Annual Maximum Rolling 3-Month Average for 2011-2016 is shown below in Figure 36.

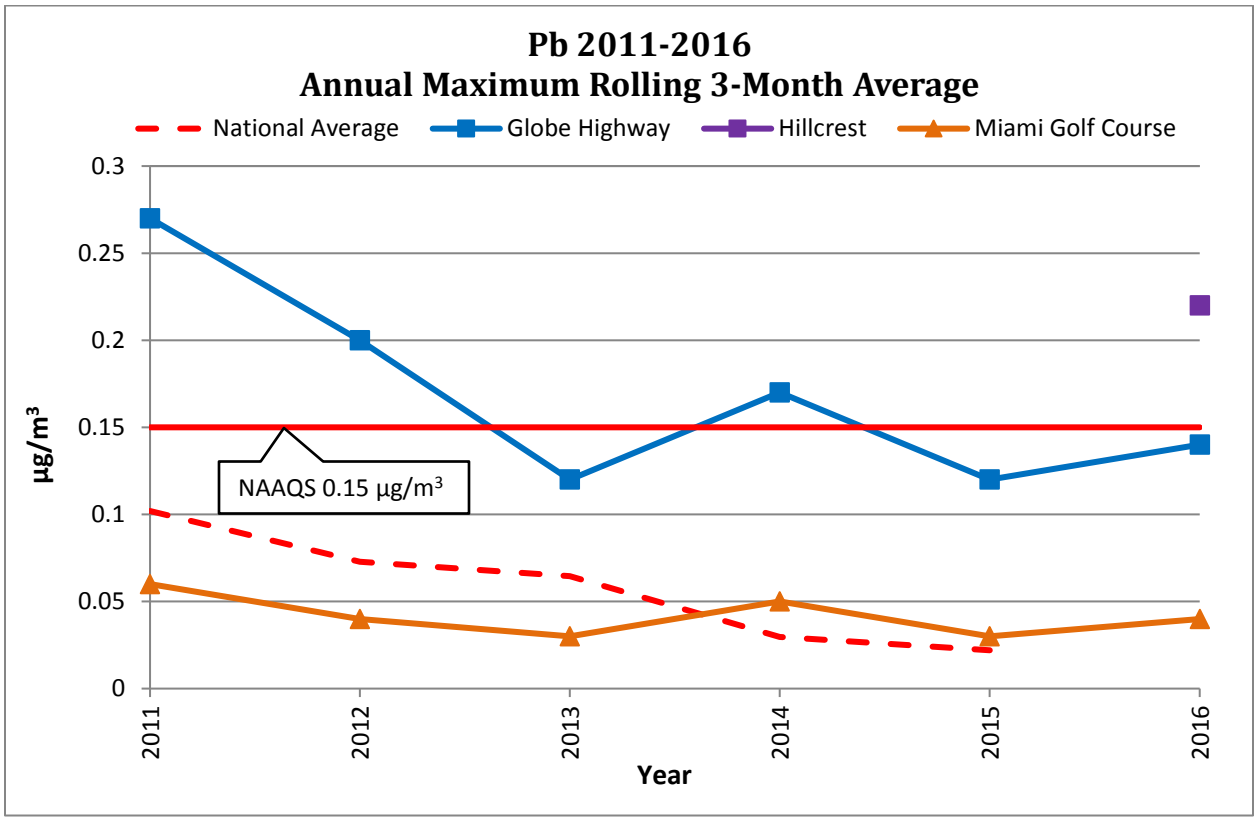


Figure 37 – Pb Three-Month Average

Note: *Some years might not satisfy completeness criteria. The National Averages are based on data from EPA on 35 sites. (https://www.epa.gov/air-trends/lead-trends). 2016 National Averages were not available.*

7.5 Air Quality Index (AQI)

The AQI scale is not established by EPA for Pb; therefore, there were no AQI values reported for Pb in 2016.

Section III – Non-Criteria Pollutants

This section covers the non–criteria pollutant networks monitored by ADEQ. Non-Criteria pollutants are those that do not have specific standards under the CAA but which can still pose a health threat. There are hundreds of air pollutants classified as non-criteria that are measured under different national programs. These include, but are not limited to, hazardous air pollutants (HAPs) sometimes referred to as air toxics, volatile organic compounds (VOC), heavy metal pollutants, particulate speciation, and many other contaminants and carcinogens. The following sections will discuss the Chemical Speciation Network (CSN), the National Air Toxics Trends Stations (NATTS), and the Photochemical Assessment Monitoring Station (PAMS) programs. Each subsection will provide a background for each program and a synopsis of current monitoring techniques. There will be a discussion of 2016 data and trend analysis on certain pollutants for the length of record for each program.

1.0 Chemical Speciation Network (CSN)

$PM_{2.5}$, as described previously, are particles with a diameter less than 2.5 microns and are associated with respiratory and other health-related problems. These negative effects have been correlated to the total mass concentration in ambient air, but whether these negative effects are more correlated to total mass concentration or to the concentration of specific chemical species is not fully understood. To better understand and manage $PM_{2.5}$, EPA commissioned a companion network in 1997 called the CSN, in addition to the NAAQS $PM_{2.5}$ network, to ascertain the chemical composition of fine particulates. Chemical speciation includes the identification and quantification of individual chemical elements, compounds, or classes of compounds that make up $PM_{2.5}$ aerosols. The $PM_{2.5}$ CSN targets analytes or species that are of particular interest to health officials, epidemiological researchers, and other interested parties.

1.1 Background

ADEQ supports the CSN network by serving as the operator and QA organization for a CSN site in Arizona at JLG Supersite.

The program objectives for the CSN are:

- to characterize annual and seasonal spatial characterization of aerosols
- air quality trends analysis
- tracking progress of control programs
- to compare the chemical speciation data set to the data collected from the IMPROVE network
- development of emission control strategies

The data generated from this network are not used for regulatory decisions concerning the $PM_{2.5}$ NAAQS, but may be used to supplement the $PM_{2.5}$ program.

1.2 Monitoring Methods

CSN instruments operate using the same principles as PM filter-based samplers. A filter is sampled on a specific date for a period of 24-hours, after which the sample is collected and sent to an EPA contracted lab for speciation analysis. EPA sets the schedule so that every CSN site in the U.S. is sampling on the same day. Currently, two different types of speciation samplers produce three 24-hour $PM_{2.5}$ filter samples every three days at JLG Supersite. Samples are collected on three different filter types: Teflon, nylon, and quartz. Polytetrafluoroethylene (PTFE, commonly known as Teflon) filters are used to determine trace elements/crustal constituents that include metals, metalloids, and non-metals. Samples collected on nylon filters are used to determine the cations (sodium, potassium, and ammonium) and the anions (nitrate and sulfate). Samples collected on quartz filters are used to determine elemental and organic carbons.

1.3 Graphs

$PM_{2.5}$ CSN characterization summaries for JLG Supersite are shown in Figures 38 and 39. Major elements show seasonal shifts, but organic carbon emerges as the dominant element throughout the year. Sulfates are more abundant during the spring and summer months because warmer temperatures favor the formation of particulate sulfate by the photochemical oxidation of SO_2. Nitrates are greater during the cooler months because cooler temperatures favor the formation of particulate nitrate by the gas-to-particle conversion of ammonium nitrate (NH_4NO_3). The crustal component of $PM_{2.5}$ tends to increase during the months of April, May, and June. This is likely because these months are the driest months for Arizona, leaving soil very dry and ready to become airborne with winds. Elemental carbon tends to be in higher abundance during the cooler months of year, most likely due to increased burning of biofuels for heat generation. Unidentified constituents are classified as “Other” and tend to increase in cooler months as well. This category exists because the analytical tests do not yield results for all possible species of $PM_{2.5}$ aerosol. Analyzing for all species in $PM_{2.5}$ would be impractical; however, the analytes selected are carefully chosen and often serve as indicators of other species. As more information concerning the chemical composition of fine particulates becomes available to researchers and regulators, the selected analytes may change as they did in early 2009 as explained in the following section.

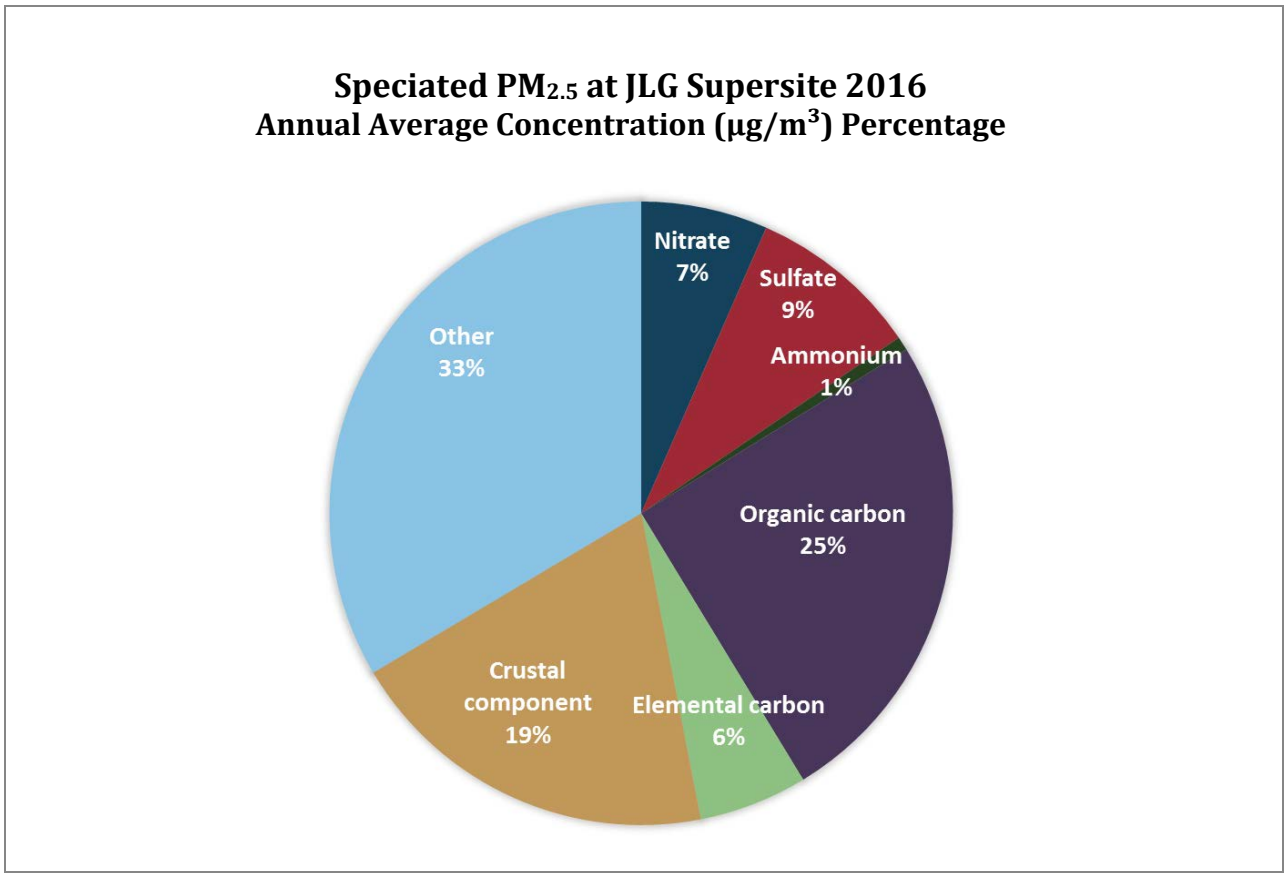
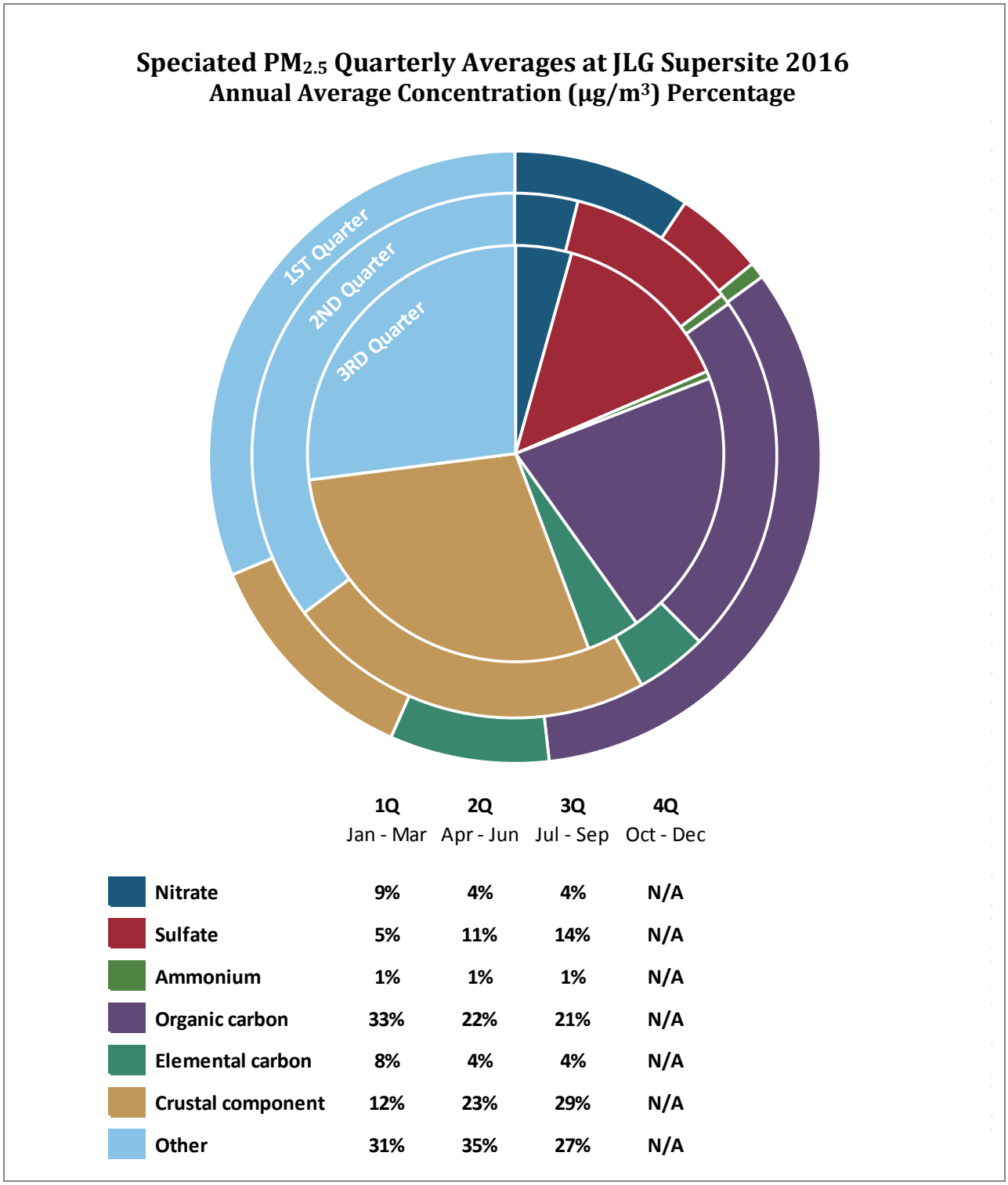


Figure 38 – 2016 Annual Averages for Speciated $PM_{2.5}$ major elements expressed as percentages of the total $PM_{2.5}$ concentration ($\mu g/m^3$) at JLG Supersite

Note: *2016 Fourth Quarter data unavailable at time of publication, therefore, 2016 Annual Averages do not include October through December concentrations*



	1Q Jan - Mar	2Q Apr - Jun	3Q Jul - Sep	4Q Oct - Dec
Nitrate	9%	4%	4%	N/A
Sulfate	5%	11%	14%	N/A
Ammonium	1%	1%	1%	N/A
Organic carbon	33%	22%	21%	N/A
Elemental carbon	8%	4%	4%	N/A
Crustal component	12%	23%	29%	N/A
Other	31%	35%	27%	N/A

Figure 39 – 2016 Quarterly Averages for Speciated $PM_{2.5}$ major elements as percentages of the total $PM_{2.5}$ concentration (µg/m^3) at JLG Supersite in 2016

Note: *2016 Fourth Quarter averages unavailable at time of publication*

1.4 Trends

In order to improve data comparability, in 2009 the EPA switched the sampling and analytical methods for organic carbon and elemental carbon nationwide. The organic carbon, elemental carbon, and "Other" concentrations reported from 2010 to 2016 are slightly more accurate and more comparable to national data than those reported prior to 2010. Due to the change in sampling and analytical methods, there was a noticeable decrease in the average organic carbon concentrations beginning in 2016. The decrease in the total average organic carbon concentrations did not, however, impact the percentage of organic carbon as compared to the other species. The percentages of each species compared to the total $PM_{2.5}$ concentration, had a negligible change from 2000 to 2016 at JLG Supersite (Figure 40). This indicates that the annual average composition of $PM_{2.5}$ at JLG Supersite has shown no significant changes during the time period.

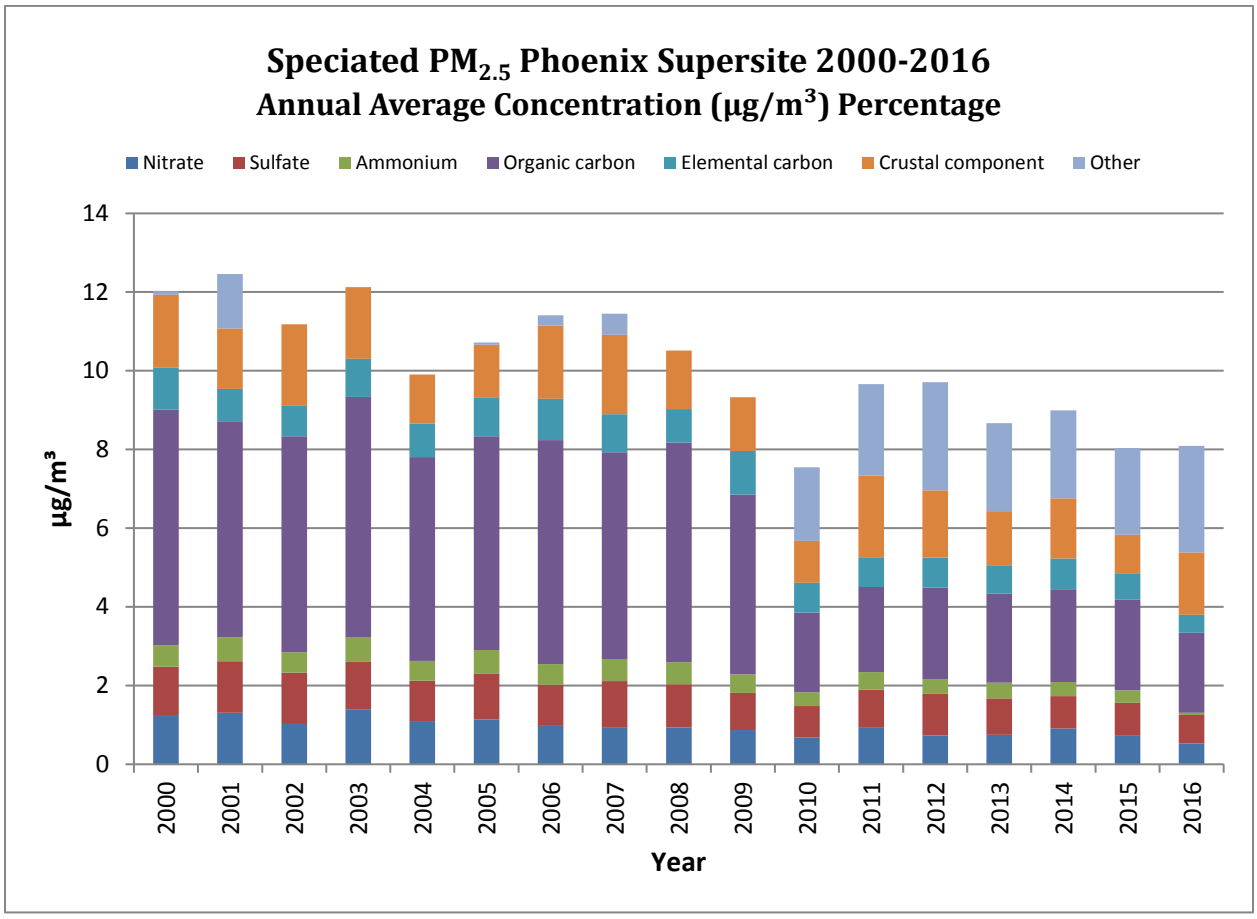


Figure 40 – Speciated $PM_{2.5}$ Annual Average Trend
2000-2016: Less than 1% variation in average Annual $PM_{2.5}$ composition at JLG Supersite
Note: *2016 Fourth Quarter data unavailable at time of publication, therefore, 2016 Annual Averages do not include October through December concentrations*

2.0 National Air Toxics Trends Stations (NATTS)

Air toxics, also known as HAPs, are compounds or elements known or suspected to cause cancer or other serious health effects, such as reproductive, neurological, birth defects, or adverse environmental effects. There are currently 189 HAPs regulated under the CAA. Examples of HAPs include benzene, which is found in gasoline; perchlorethlyene, which is emitted from some dry cleaning facilities; and methylene chloride, which is used as a solvent and paint stripper by a number of industries. Examples of other known air toxics include chloroform, formaldehyde, and metals such as cadmium, chromium, and Pb compounds.

2.1 Background

ADEQ monitors many HAPs including VOCs, carbonyls, and PM_{10} metals at JLG Supersite as part of the NATTS program. NATTS is a national network of 27 monitors that was developed to fulfill the need for long-term, high-quality toxics data to estimate national toxics averages. The principle purpose of the NATTS program is tracking toxics trends to assess progress towards emission and risk reduction. The goal is to reduce air toxics emissions by 75% from 1993 levels to significantly reduce the potential for human health risk. ADEQ entered the NATTS program in 2003 but had been monitoring some of the toxics in prior years. With the minimum pollutants monitored being met, ADEQ monitors a total of 104 HAPs.

The UATMP monitoring program began in 1987 to characterize the magnitude and composition of urban air pollution through monitoring in various cities across the U.S. Urban air pollution consists of many components from a wide range of industrial, motor vehicle, and biogenic and natural sources, some of which are toxics. ADEQ monitored VOCs at the South Phoenix site as part of the EPA's UATMP from 2001-2003 and started monitoring again in 2007. As stated earlier in this report, UATMP data are directly comparable to NATTS data as the monitoring methods and selected analytes are identical, and many of the program objectives overlap.

2.2 Monitoring Methods

To monitor VOCs, ambient air is captured in special evacuated canisters at a constant flow rate for a 24-hour period every sixth day in accordance with the EPA monitoring schedule. The canisters are collected and sent to a laboratory for analysis by a standard procedure (TO-15) appropriate for VOCs, and the results are reported to ADEQ for review before submittal to EPA.

For carbonyls, ambient air is drawn through small cartridges at a constant flow rate for a 24-hour period every sixth day in accordance with the EPA monitoring schedule. The cartridges are made from a high purity silica adsorbent coated with 2,4-dinitrophenylhydrazine (DNPH) which traps carbonyls (e.g. formaldehyde). The cartridges are sent to a laboratory for analysis using a standard procedure (TO-11A) appropriate for carbonyls analysis. The results are reviewed by ADEQ before submittal to EPA.

PM_{10} metals are collected by drawing ambient air through a standard 47mm filter at a 16.7 LPM for 24-hours, as is done for PM measurements discussed in Section II of this report, every sixth day in accordance with the EPA monitoring schedule. The filters are sent to a laboratory and processed using a standard procedure (TO-3.5) that is appropriate for metals analysis. The results are reviewed by ADEQ before submittal to EPA.

To sample polycyclic aromatic hydrocarbons (PAH), ambient air is drawn at a high-volume flow rate through a filter and sorbent cartridges containing polyurethane foam (PUF). PUF absorbs PAHs at a high collection efficiency. Approximately 300 m^3 of air is drawn through in a 24-hour sample run. Runs occur every sixth day in accordance with the EPA monitoring schedule. The filter and cartridge are sent to a lab for analysis by a standard procedure (TO-13A) appropriate for PAHs. PAHs are analyzed via a Gas Chromatograph and Mass Spectrometer. Using the total air sampled, the concentrations of PAHs in the air sample are found and reported to ADEQ before submittal to EPA.

2.3 Tables

The EPA has not issued monitoring compliance criteria for air toxics (as it has for O_3, for example). Instead it addresses control issues through rules covering emissions from industrial sources such as chemical plants as well as smaller sources, such as dry cleaners and chromium electroplating facilities. As can be seen in Tables 27 and 28, air toxics concentrations at JLG Supersite and South Phoenix are comparable to national averages with some values being higher, and some lower, but none with extreme differences. For the pollutants that are in common between the two sites (i.e., VOCs), the summary data are very similar, which is an indication that the sites do a reasonable job of representing ambient air and are not significantly affected by nearby sources. These data also indicate that in comparison to the 2014 National Averages, manganese may be of local concern as the 2016 annual average exceeds the 2014 national average by a factor of 2.5. Air Toxics is a relatively new field within ambient air monitoring, and these data will continue to be collected to provide more information about urban air pollution.

Table 27 – Air Toxics Data for JLG Supersite

2016 Air Toxics data for JLG Supersite						
Pollutant	**Quarterly Average**					
	Q1	**Q2**	**Q3**	**Q4**	**Annual**	**National (2014)**
VOC (ppb)						
1,3-Butadiene	0.15	0.05	0.04	0.16	0.10	0.05
Acrolein	0.67	0.67	0.53	0.61	0.62	0.34
Benzene	0.44	0.21	0.19	0.56	0.35	0.23
Carbon Tetrachloride	0.09	0.11	0.09	0.10	0.10	0.10
Chloroform	0.07	0.08	0.07	0.08	0.07	0.04
Tetrachloroethylene	0.05	0.02	0.03	0.07	0.04	0.02
Trichloroethylene	0.00	0.00	0.00	0.00	0.00	0.01
Aldehydes (ppb)						
Acetaldehyde	1.54	1.48	1.14	1.92	1.53	1.00
Formaldehyde	2.63	3.52	2.91	3.38	3.10	2.30
PAH(ng/m^3)						
Benzo[A]Pyrene (Tsp) Stp	0.15	0.01	0.01	0.15	0.12	0.11
Naphthalene (Tsp) Stp	78.55	52.06	31.35	109.73	85.57	66.5
PM_{10} Metals (ng/m^3)						
Arsenic	0.83	0.44	0.57	1.01	0.71	0.61
Beryllium	0.03	0.03	0.05	0.03	0.04	0.01
Cadmium	0.16	0.06	0.07	0.17	0.11	0.20
Chromium	2.78	1.55	1.62	2.74	2.18	4.86
Lead	4.48	1.96	2.55	5.63	3.67	2.93
Manganese	17.49	14.48	27.64	20.35	19.95	8.02
Nickel	1.41	1.17	1.53	2.29	1.60	1.11

Table 28 – Air Toxics Data for South Phoenix

2016 Air Toxics data for South Phoenix site						
Pollutant	**Quarterly Average VOC (ppb)**					
	Q1	**Q2**	**Q3**	**Q4**	**Annual**	**National (2014)**
1,3-Butadiene	0.24	0.06	0.03	0.16	0.12	0.05
Acrolein	0.47	0.51	0.43	0.44	0.47	0.34
Benzene	0.60	0.25	0.21	0.57	0.42	0.23
Carbon Tetrachloride	0.10	0.11	0.10	0.10	0.10	0.10
Chloroform	0.04	0.04	0.04	0.05	0.04	0.04
Tetrachloroethylene	0.03	0.02	0.01	0.04	0.03	0.02
Trichloroethylene	0.00	0.00	0.00	0.01	0.00	0.01

2.4 Trends

The VOC trends include data from the JLG Supersite and South Phoenix (SP) sites. Seven chemical species were used to calculate the VOC trends data shown in Figures 41 and 42. These species were chosen due to their high frequency of detections in Arizona and nationwide. South Phoenix VOC concentrations are unavailable from 2005-2006 because ADEQ did not monitor for the UATMP during that time period. ADEQ began monitoring for Acrolein at JLG Supersite and South Phoenix in 2007, so Acrolein was not used in the 2001 to 2006 average concentration calculations for JLG Supersite. At JLG Supersite and South Phoenix, there was an overall decrease in the average annual concentrations of the seven species selected for trends data from 2001 to 2016.

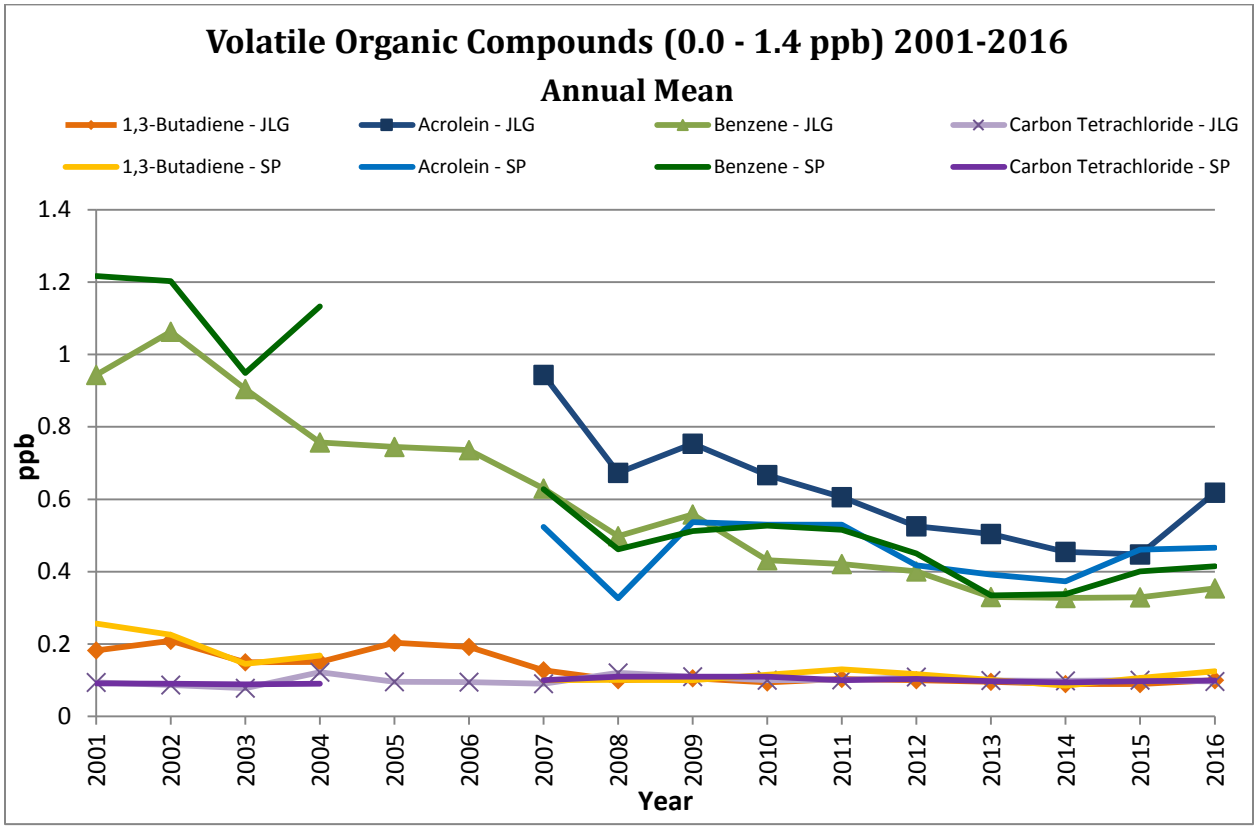


Figure 41 – VOC Annual Mean Trend (0.0-1.4 ppb)
2001-2016: 69.1% decrease at JLG Supersite
2007-2016: 46.41% decrease in Acrolein at JLG Supersite
2007-2016: 25.7% decrease at South Phoenix
***Note**: Some years might not satisfy completeness criteria. Seven species were averaged to calculate a best-fit straight line, which was used to determine the average percent change. In order to reduce bias in averaging, all species must have at least seven consecutive years of data and the same number of consecutive years.*

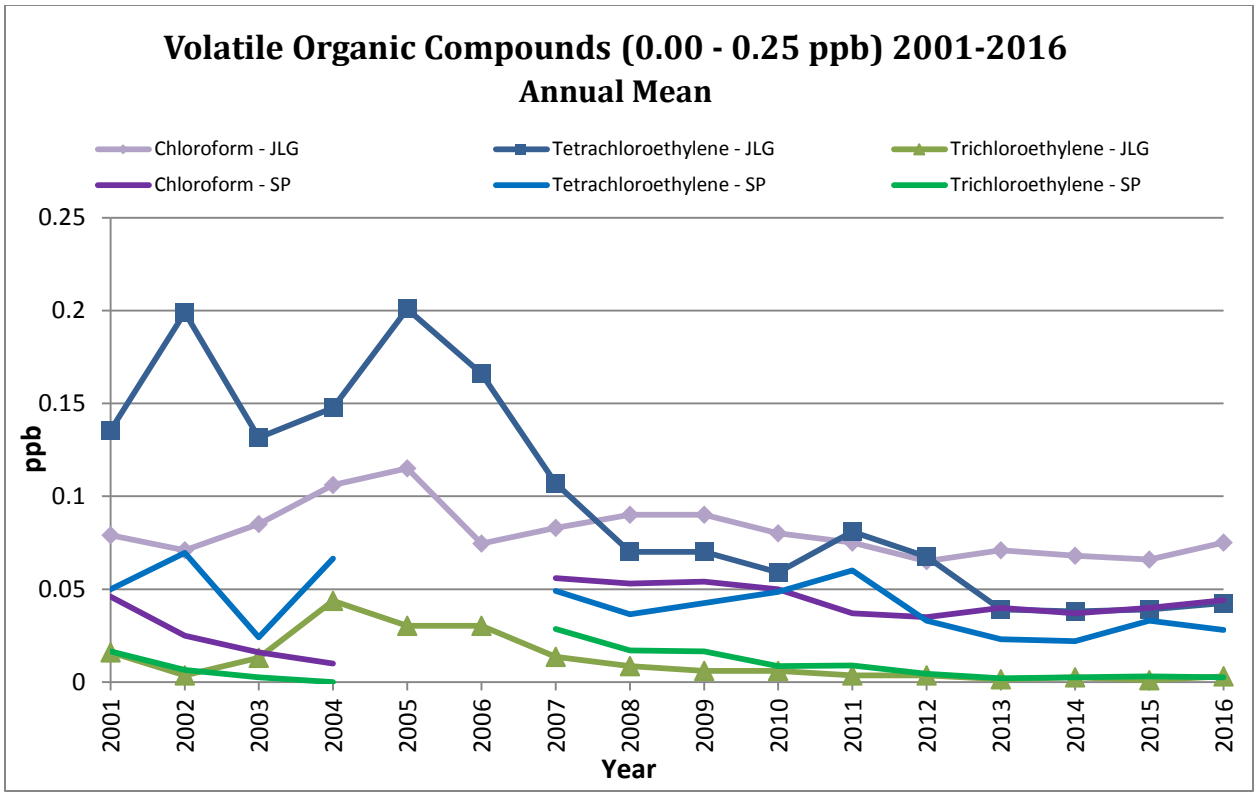


Figure 42 – VOC Annual Mean Trend (0.00-0.25 ppb)
2001-2016: 69.1% decrease at JLG Supersite
2007-2016: 25.7% decrease at South Phoenix
***Note**: Some years might not satisfy completeness criteria. Seven species were averaged to calculate a best-fit straight line, which was used to determine the average percent change. In order to reduce bias in averaging, all species must have at least seven consecutive years of data and the same number of consecutive years.*

The aldehydes and polycyclic aromatic hydrocarbon (PAH) trends data were taken from JLG Supersite. There was a decrease in the average annual concentrations of both aldehydes (acetaldehyde and formaldehyde) from 2003 to 2016 (Figure 43). There was also a decrease in the PAH benzo[A]pyrene and the PAH naphthalene from 2007 to 2016 (Figures 44 and 45).

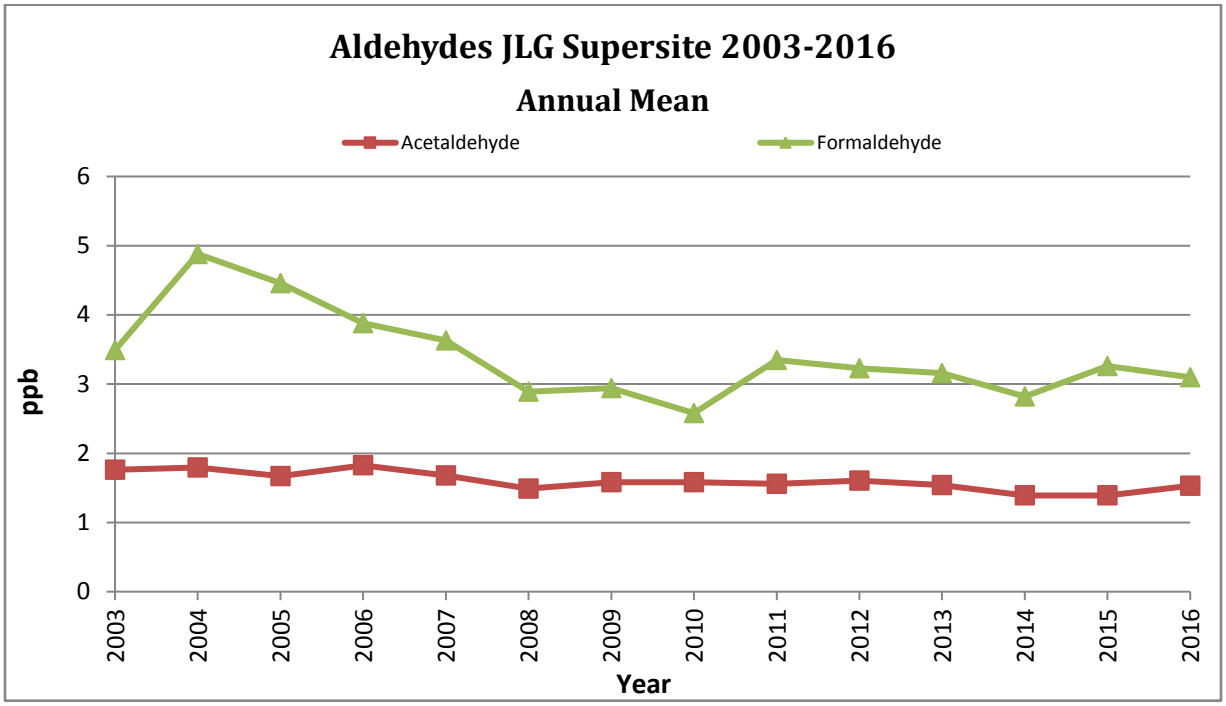


Figure 43 – Aldehydes Annual Mean Trend
2003-2016: 30.0% decrease at JLG Supersite
Note: *Some years might not satisfy completeness criteria*.

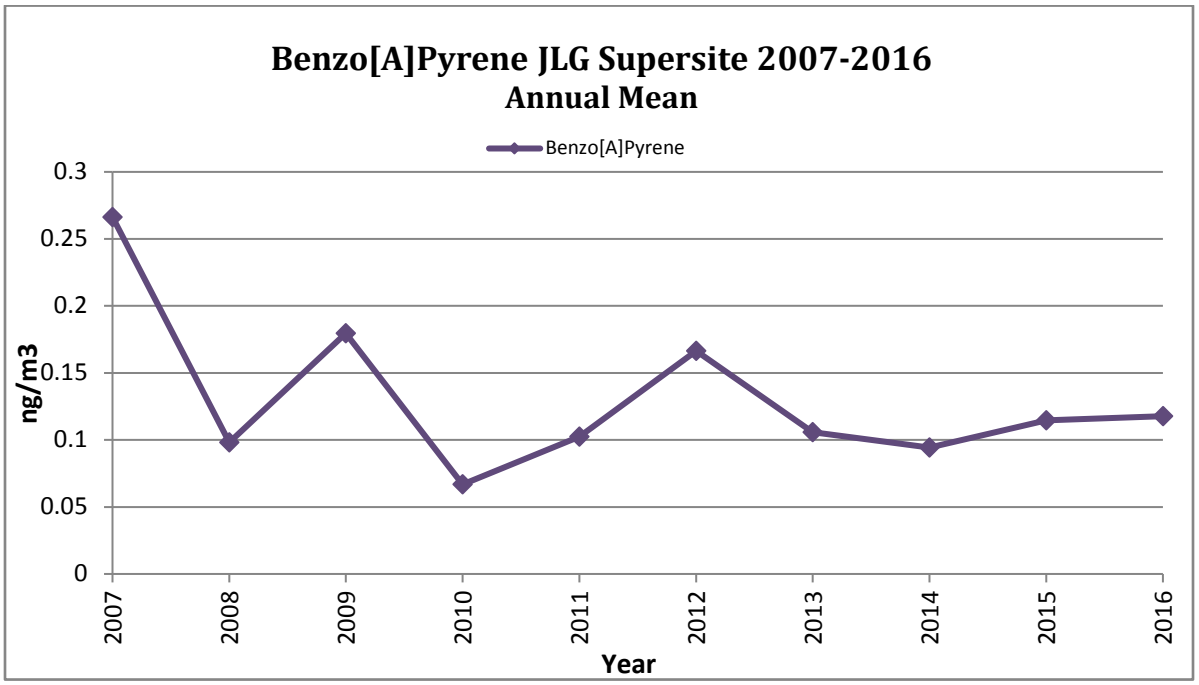


Figure 44 – Benzo[A]Pyrene Annual Mean Trend
2007-2016: 49.2% decrease at JLG Supersite
Note: *Some years might not satisfy completeness criteria.*

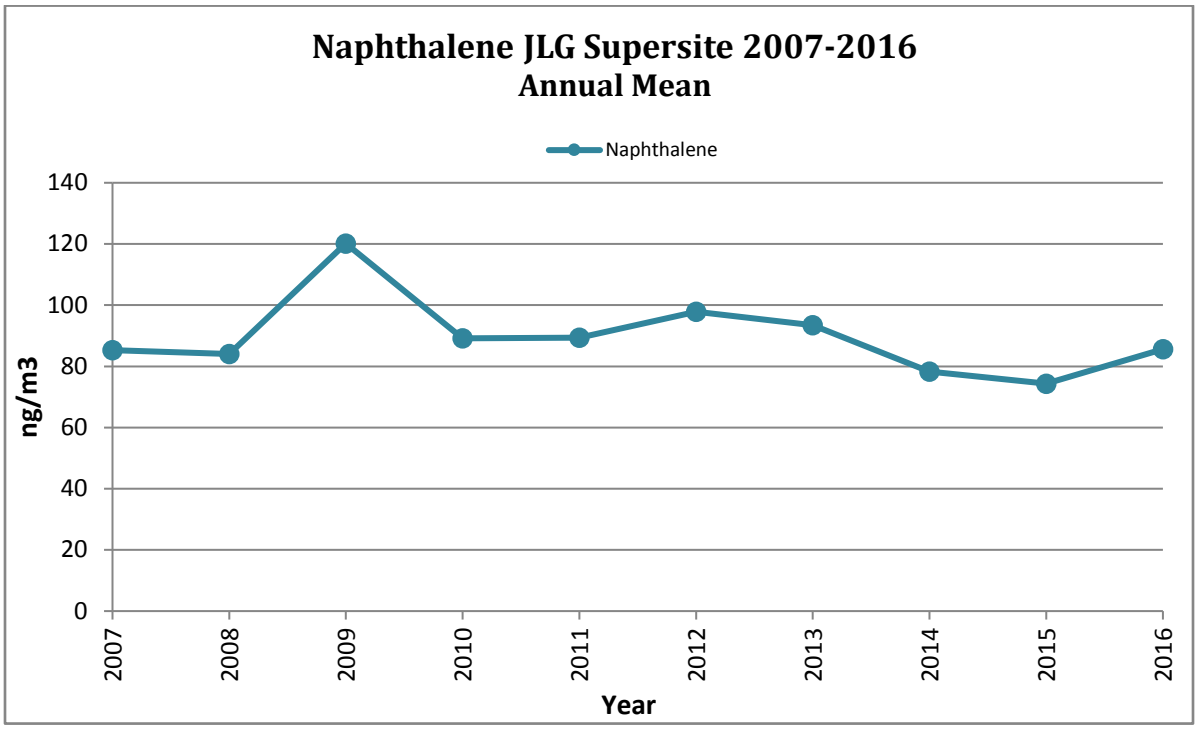


Figure 45 – Naphthalene Annual Mean Trend
2007-2016: 15.7% decrease at JLG Supersite
Note: *Some years might not satisfy completeness criteria.*

3.0 Photochemical Assessment Monitoring Stations (PAMS)

The PAMS are a collection of nationwide monitoring stations that are used to obtain comprehensive and representative data on O_3 air pollution. Section 182(c)(1) of the 1990 Clean Air Act (CAA) Amendments requires the Administrator to promulgate rules for enhanced monitoring of O3 that includes concurrent monitoring of O_3, oxides of nitrogen (NO_x), total reactive nitrogen (NO_y), speciated volatile organic compounds (VOC), carbonyls, CO, and meteorology. The principal reasons for requiring the collection of additional ambient air pollutants and meteorological data are the widespread nonattainment of the O_3 NAAQS and the need for a more comprehensive air quality database for O_3 and its precursors. EPA issued a final rule for a reengineering of the PAMS program in October 2015 as part of the 2015 O_3 NAAQS Revision. In 2016, ADEQ operated under the original PAMS program at JLG Supersite and Queen Valley sites. 2016 was the final year of operating PAMS at Queen Valley. ADEQ will continue to operate a PAMS program under this new rule at JLG Supersite, which is collocated with the JLG Supersite NCore site as required.

3.1 Background

High O_3 concentrations are caused when sunlight and precursor pollutants react in the lower atmosphere. Higher O_3 levels typically occur in the summer months when the sun angle is higher than during the winter months. This is partially due to the sun being out for a longer period during the summer than the winter. The onset of the ozone season in Arizona is usually observed during early spring. The PAMS monitoring season is during this high concentration time from June-August, which requires many more samples to be taken in order to characterize peak levels of O_3 and O_3 precursor pollutants. The sources for O_3 precursor pollutants include combustion vehicles, biogenics from plants, industrial processes, and electric power plants. Ozone conditions and typical concentrations in Arizona are described in more detail in Section II of this report.

ADEQ maintains the PAMS network in the metropolitan statistical area (MSA) of Phoenix-Mesa-Scottsdale. This MSA was classified as serious nonattainment for the one-hour O_3 standard in 1979 and is therefore subject to PAMS monitoring. This MSA has since been designated as marginal nonattainment for the 2008 eight-hour O_3 standards as stated in Section II of this report.

ADEQ operates a Type 2 station and a Type 3 station to support the PAMS network. The Type 2 site is JLG Supersite. The Pollutants monitored are VOCs, Carbonyls, NO_x, CO, O_3, and surface meteorology. JLG Supersite is used to monitor the magnitude and type of precursor emissions in the area and is representative of the MSA. It is located near the boundary and downwind of the central business district of downtown Phoenix and downwind of many industrial sources of precursor emissions in the Phoenix MSA. The Type 3 site is Queen Valley. The pollutants monitored are VOCs, NO_y, O_3, and surface meteorology. The Queen Valley location is designed to capture maximum O_3 concentrations. Typical Type 3 sites are located 10-30 miles from the fringe of the urban area. Queen Valley is located 30 miles from downtown Mesa.

In 2016, ADEQ also measured upper air meteorology at the Vehicle Emissions Laboratory and JLG Supersite which is representative of the Phoenix-Mesa-Scottsdale MSA. Measurements at that site included Solar Radiation, UV radiation, and Delta Temperature. These upper air measurements are not included in this report.

3.2 Monitoring Methods

Methods for monitoring pollutants that are part of PAMS are the same as with other networks. PAMS O_3 is monitored using the same instruments and ultraviolet absorption method as described in Section II of this report.

VOCs and Carbonyls use the same instruments and methods as the air toxics network. In addition to a 24-hour sample, three three-hour samples are collected for analysis during the morning and early afternoon in order to better characterize precursor pollutant concentrations during the day. Peak levels generally occur during the morning rush hour; therefore, samples of both VOCs and Carbonyls are collected in three three-hour blocks from 5:00 am to 8:00 am, 8:00 am to 11:00 am, and 11:00 am to 2:00 pm during PAMS season.

Nitrogen oxides and NO_y monitoring use the same chemiluminescence instruments and methods as the NO_2 network. Reactive nitrogen oxides differ from NO_x due to the sampling height. Since O_3 is a scavenger of some oxides of nitrogen, the sample inlet is located above ground level O_3 (~10 m). The reactive forms of nitrogen that are normally scavenged by O_3 are measured at this elevated height to give a better representative value of the total nitrogen precursor pollutants.

PAMS CO is monitored using the same nondispersive infrared instruments and methods as described in Section II of this report.

All readings from continuous gas analyzers are averaged into hourly, daily, quarterly, and yearly averages for data analysis. Readings are retrieved by a data collection system and stored in a database. Readings from sample monitors (VOCs and Carbonyls) are sent to ADEQ by the analysis lab and are also averaged for data analysis.

3.3 Trends

Total Non-Methane Organic Compounds (TNMOC) are defined in the PAMS TAD as the unspeciated total concentration of VOC (C2 through C12) in ambient air as determined by "summation of peaks" from GC/FID analysis, expressed in parts per billion carbon (ppbC). Parts per billion carbon is the concentration (in ppb) of the compounds multiplied by the number of carbon molecules in the compound. This unit is useful as it gives the concentration of the individual carbon molecules available to react to form O_3. TNMOC are a precursor to O_3 and emission sources include fossil fuel burning, landfills, and solvents. The annual means used for trend analysis were calculated from 24-hour samples taken during the June 1st through August 31st PAMS sampling season of each year. TNMOC data from 2007 at JLG Supersite were unavailable, so only 2008 through 2015 data were used in the trend analysis. There was a decrease in the average TNMOC concentrations at JLG Supersite and Queen Valley from 2008 to 2016 (Figure 46).

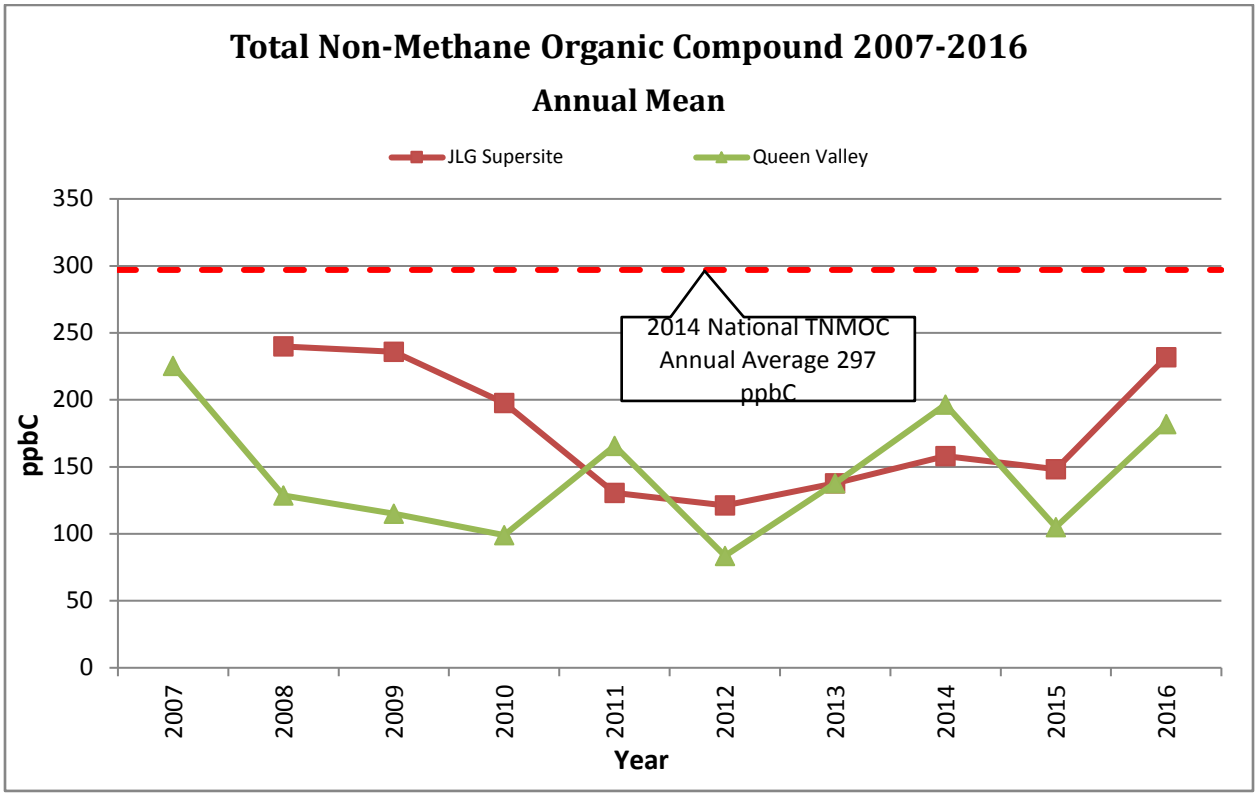


Figure 46 – TNMOC Annual Mean Trend
2008-2016: 26.4% decrease at JLG Supersite
2007-2016: 4.7% decrease at Queen Valley
Note: *Some years might not satisfy completeness criteria.*

Section IV – Visibility

Visibility has historically been defined as the maximum distance that a human eye can view a contrasting object. This is a technical definition that also can include other quantitative measurements. Defining visibility does not always lend itself to the quantitative measures that many instruments can produce. Visibility can also be based on the judgments of an observer viewing a beautiful vista. It is the combination of both the technical and the judgmental definition that most closely describes visibility.

Figure 47 – Pleasant Valley monitoring station.

Visibility and haze are two terms that are closely related, as haze is the form of air pollution that degrades visibility. Haze is caused when sunlight encounters tiny particles in the air, which reduces the color and clarity of what is seen. Since 1988, the U.S. EPA, States, and Federal land management agencies have conducted monitoring of air pollution and visibility impairment at a number of national parks and wilderness areas across the U.S. In 1999, the EPA announced a major effort to improve air quality in national parks and wilderness areas. The Regional Haze Rule (RHR) calls for the improvement of visibility in 156 Class I national parks and wilderness areas throughout the U.S. (formally known as mandatory Federal Class I areas). The RHR outlines the requirements for states to follow in order to address haze impairing pollutants. . States are required to demonstrate reasonable progress towards the national visibility goal established in 1977 by the CAA (Section 169A and 169B): "The prevention of any future, and the remedying of any existing impairment of visibility in mandatory Class I Federal areas which impairment results from man-made air pollution." ADEQ submitted its Regional Haze SIP in 2011 which satisfies the planning portion of the RHR with an emphasis on the human-caused sources of haze producing pollutants.

1.0 Urban Haze

Haze not only affects natural vistas, but can also affect urban skylines. Reducing urban haze mirrors the objectives of the RHR in improving visibility in the urban environment by reducing emissions that directly contribute to haze. House Bill 2538 of the Forty-fifth AZ State Legislature states that ADEQ “shall establish a daily visibility index to be used in evaluating and reporting current visibility conditions and progress toward visibility improvement goals.” Pursuant to this bill, ADEQ has established an urban visibility network in the Phoenix area.

1.1 Program Background

ADEQ operates a network of urban visibility instruments that are designed to characterize different optical phenomena in the Phoenix metropolitan area. This network measures the amount of visibility impairing haze using different optical measurements which show the amount of light scattered from one point to another. ADEQ operates several instruments as part of its Urban Haze program including one transmissometer located in downtown Phoenix, three nephelometers located in the in the west valley and near central Phoenix, and five high resolution digital cameras in various locations throughout the Phoenix metropolitan area.

1.2 Monitoring Methods

The transmissometer is used to assess visibility impairment by measuring the amount of light lost over a known distance. The instrument consists of a light source (transmitter) and light detector (receiver) which are generally located on an elevated surface, such as a tall building, and are separated by a distance of 1-3 miles. The Phoenix transmitter is located on the roof of the Phoenix Baptist Hospital and the receiver is 2.96 miles away on the roof of the Holiday Inn on the corner of Osborn and 3rd Avenue in downtown Phoenix. The transmitter emits a uniform light beam of constant intensity that is carefully aimed at the receiver. The amount of light transmitted and received is precisely measured. The receiver includes a telescope that gathers the transmitter's light and a computer that compares the measured light intensity with the known transmitter light intensity to calculate the transmission of the intervening atmosphere. The measured transmission can be related to the light lost along the path due to scattering and absorption.

The nephelometer is used to assess visibility impairment by estimating the particle scattering coefficient at a point location. The nephelometer provides a direct measurement of the light scattered by aerosols and gases in a sampled air volume. It employs a light source and a detector set to the side of the source. Light is scattered by particles over a large range of scattering angles, in a defined band of visible wavelengths. The detector picks up the specific wavelengths of scattered light to the side. These wavelengths are particular to a certain type of particle, $PM_{2.5}$. Because the total light scattered out of a path is the same as the reduction of light along a path due to scattering, the integrating nephelometer gives a direct estimate of the particle scattering coefficient and hence impaired visibility.

Photographic documentation is an important aspect of evaluating visibility. Photography is an effective way to document events and trends on a media that is easily interpreted. ADEQ uses high-resolution digital images from locations around Phoenix to document visibility conditions. The digital images are readily available for viewing at www.phoenixvis.net and can be conveniently distributed via the Internet, easily stored, managed, and duplicated without degradation. Each site consists of a high-resolution digital camera housed in a weatherproof, environmental enclosure, and a supporting image capture computer. Digital images are captured every 5 minutes, stored on the system's internal hard drive, and uploaded to the Web site every 15 minutes.

1.3 Trends

Visibility data from these monitors can be expressed by several different measurement units: deciview, inverse megameters, and visual range. An inverse megameter (Mm^{-1}) (units used by ADEQ) is a representation of the ratio between how much light is not received by a sensor compared to the amount of light that leaves a source. Higher numbers mean worse visibility. As an Mm^{-1} is an uncommon unit of measure, the visual range will be reported.

Optical measurements of urban visibility have been made continuously in Phoenix since 1994. Light extinction, the degree to which light is reduced by its interaction with particles and gases in the atmosphere, is measured continuously with transmissometers. The units of measurement are Mm^{-1}: the higher the light extinction value in Mm^{-1}, the more visibility is reduced. In Figure 47, these light extinction data have been plotted as a yearly average and converted to the preferred units of visual range in miles.

In Phoenix, when taking into consideration all hours of the day, transmissometer data indicate a steady trend toward clearer air for the mean, cleanest 20%, and the dirtiest 20% categories over the past 20 years (Figure 48). The data trends have shown that the morning hours visual range (Figure 49) have increased less when compared with the all hours visual range. This indicates that the overall increasing trend of visual range has been influenced by the other parts of the day more than the morning hours. Visual range peaked during the year 2010, which was an above average year for rainfall.

The trend in downtown Phoenix has an increase which shows an increase in visual range of approximately 15.5 miles over the past 20 years. Haze and visibility in the Phoenix downtown area have improved steadily.

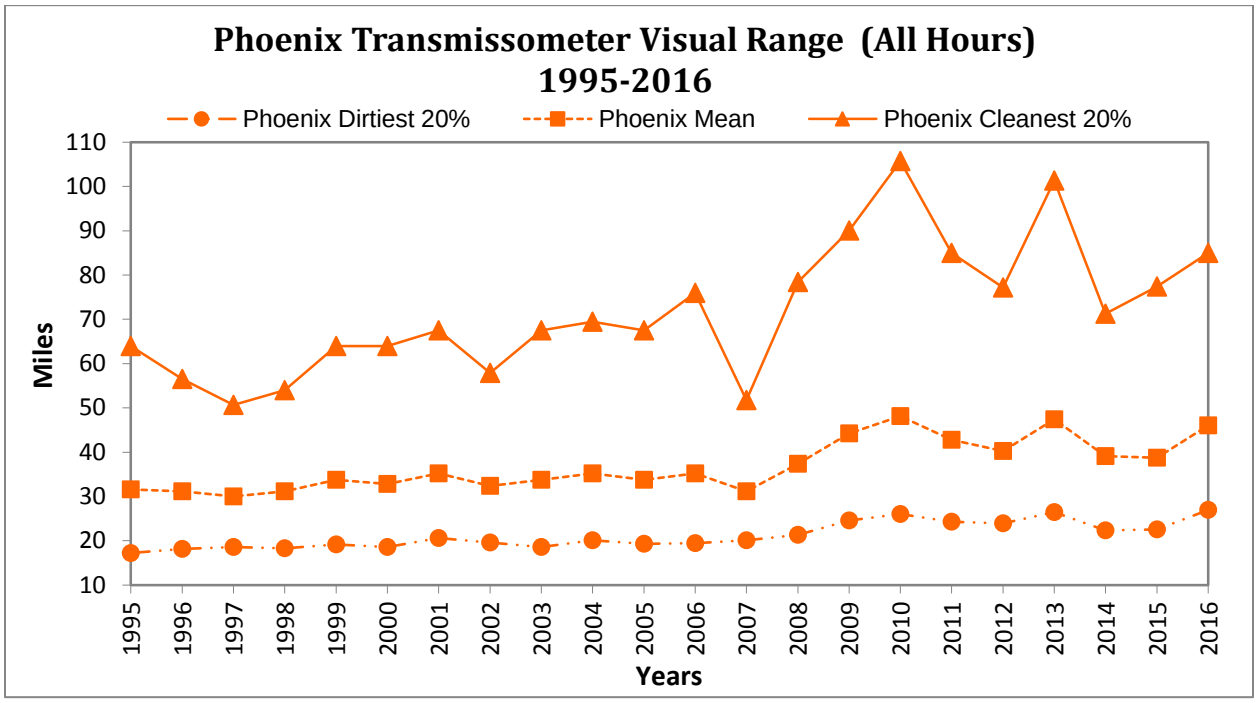


Figure 48 – Transmissometer Visual Range (All Hours) Trend
1995-2016: 54% increase in the mean visual range or 15.5 miles
67% increase in the 20% Cleanest times
52% increase in the 20% Dirtiest times

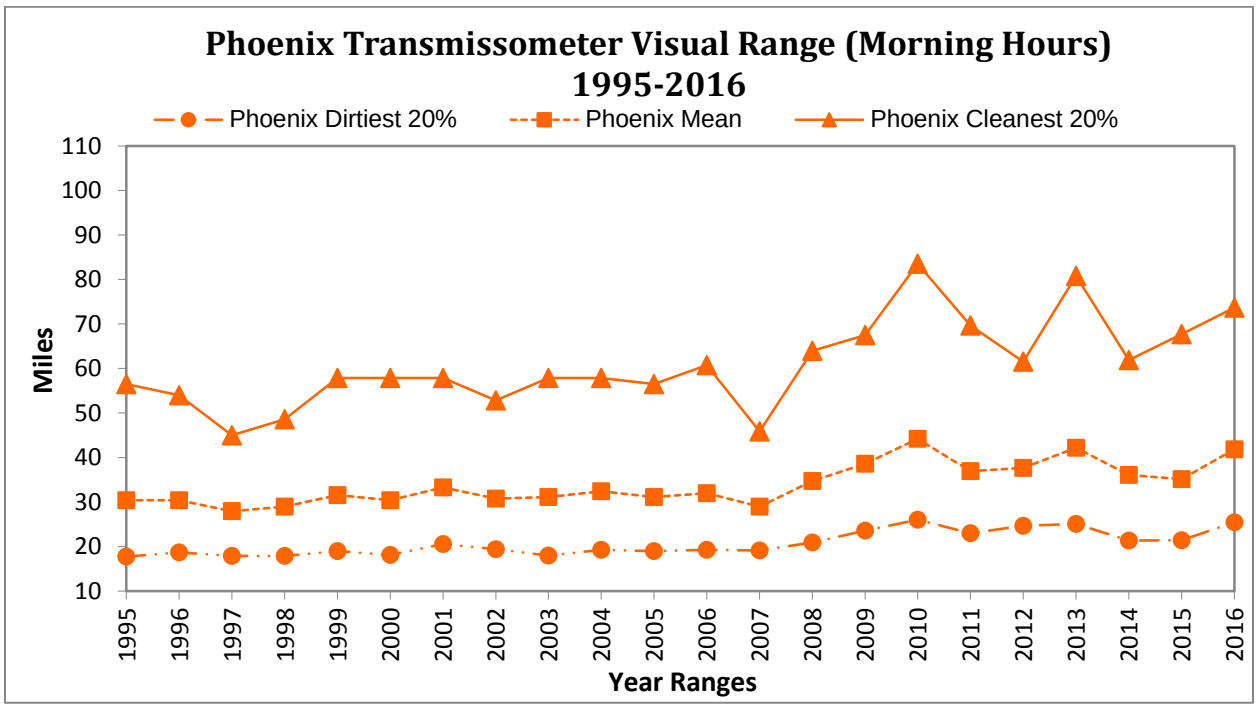


Figure 49 – Transmissometer Visual Range (Morning Hours) Trend
1995-2016: 44% increase in the mean visual range trend in the morning hours or 12 miles
49% increase in the 20% Cleanest times
44% increase in the 20% Dirtiest times

Transmissometer seasonal variability shows which seasons have higher visual range (Figure 50). The seasons shown are Winter (Jan-Mar), Spring (Apr-June), Summer (July-Sept), and Fall (Oct-Dec). Data for seasonal variability is currently available for the years 2006-2016. The visual range is greater during the spring and summer months than during the fall and winter months. Visual range peaked during the year 2010 in the summer months at around 77 miles. A contributing factor for this was that 2010 was an above normal year for precipitation. Rainfall cleans the air, improving visual range. The overall visual range trend has increased over the past eleven years.

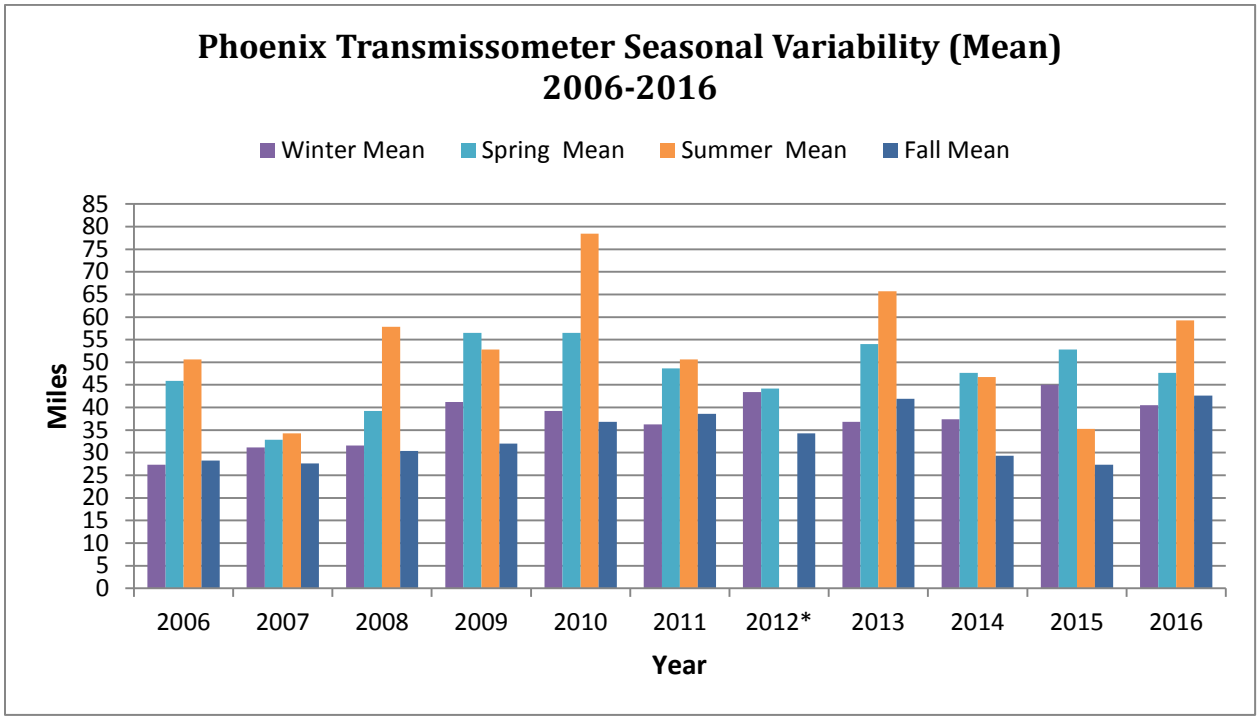


Figure 50 – Transmissometer Seasonal Average Trend

2006-2016: 23% increase in the Transmissometer Mean visual range trend in the spring months
3% decrease in the summer months
29% increase in the fall months
45% increase in the winter months

***Note**: Data did not meet completeness criteria for the summer of 2012; therefore, it was excluded from analysis.*

Nephelometer visual range also shows an increasing trend over the years 2006-2016 (Figure 51). Spatial variation shows sites increase in visual range at different rates, with the greatest improvement at the Vehicle Emissions Laboratory site, close to downtown Phoenix. While there is steady improvement at Estrella Mountain Park, Dysart has shown the least improvement. The biggest increases have been in the downtown area. Possible causes for this can be that decreases in vehicle pollution have increased visual range. Whereas in the areas where vehicle density is lower, the increases come from other pollutant controls which are less substantial.

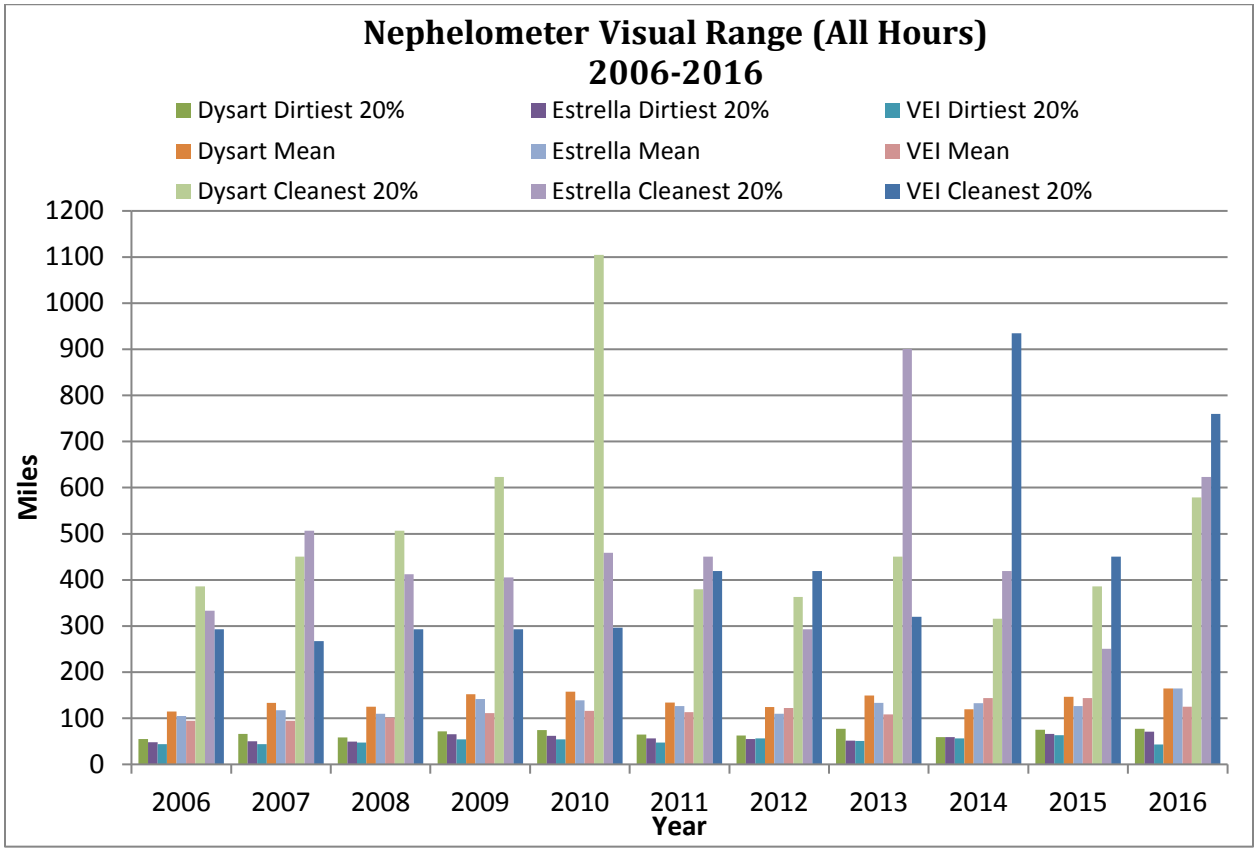


Figure 51 – Nephelometer Visual Range Trend

2006-2016: 53% increase in the nephelometer mean visual range trend or 47.7 miles for VEI
33% increase in the nephelometer mean visual range or 35.8 miles for Estrella
19% increase in the nephelometer mean visual range or 24.2 miles for Dysart

***Note**: Data for Dysart and Estrella are based on data collected from January through June of 2016. Monitoring at both these sites was discontinued with the removal of the instruments in July 2016. Data from VEI is based on data collected from January through April of 2016. This instrument was removed in April 2016 and relocated to JLG Supersite.*

Examples of photographic visibility conditions are shown in Figure 52. As visibility decreases, the clarity and resolution of the mountains and downtown area decreases and a milky appearance covers the vista. On poor visibility days, the mountain ridgeline and most of the downtown area are no longer visible.

Figure 52 – Examples of Visual Condition in Phoenix. Excellent to Very Poor visibility days taken from the high resolution digital picture. All are images of South Mountain were taken from the camera located at North Mountain. Center-Excellent, Top left-Good, Top right-Fair, Bottom left-Poor, Bottom right-Very Poor.

2.0 IMPROVE

The IMPROVE program is the main supporter of the RHR across the nation. It uses monitors specific to the objectives to increase visibility and decrease haze in the national parks and wilderness areas. The program objectives of IMPROVE are:

- to establish current visibility and aerosol conditions in mandatory Class I areas;
- to identify chemical species and emission sources responsible for existing man-made visibility impairment;
- to document long-term trends for assessing progress towards the national visibility goal; and,
- with the enactment of the RHR, to provide regional haze monitoring representing all visibility-protected Federal Class I areas where practical.

The IMPROVE monitors are closely related to those in the CSN in that they use different types of sample filters to measure the amount of speciated pollutants in the air. Ambient air is drawn into the sampler, where the pollutants are deposited onto the sample filters. There are four different sample filters that are run on the same day, each collecting different types of pollutants. Different aerosols and particulates contribute to haze more than others: therefore, the monitors are designed to capture these specific pollutants.

The IMPROVE network in Arizona has 16 samplers in 12 Class I areas. This program is governed by a steering committee composed of representatives from federal and regional/state organizations. This network was established in 1985 to aid the creation of federal and state implementation plans. ADEQ supports the IMPROVE network by performing filter sample changes at JLG Supersite, Queen Valley, and Douglas Red Cross sites, and by conducting performance audits on protocol samplers in Arizona. ADEQ is one of the many government agencies involved in the IMPROVE network. Users of these data include, but are not limited to, the EPA, visibility researchers, and land management agencies.

More information of the IMPROVE program and data can be accessed at the following website: http://vista.cira.colostate.edu/improve/.

Appendix I – Abbreviations

ADEQ	Arizona Department of Environmental Quality
AgBMP	Best Management Practices for Agricultural Activities
AQD	Air Quality Division
AQI	Air Quality Index
AQS	Air Quality System (EPA database)
BAM	Beta Attenuation Monitor
Bext	Total Light Extinction
Bscat	Light Scattering
CAA	Clean Air Act
CFR	Code of Federal Regulations
CO	Carbon Monoxide
CSATAM	Community Scale Toxics Ambient Monitoring
CSN	Chemical Speciation Network
DM&QA	Data Management & Quality Assurance Unit
DNPH	2,4-dinitrophenylhydrazine
DQI	Data Quality Indicator
DQO	Data Quality Objective
EPA	Environmental Protection Agency
FIP	Federal Implementation Plan
FMMI	Freeport McMoRan Copper and Gold Inc.
GC/FID	Gas Chromatography with Flame Ionization Detector
HAP	Hazardous Air Pollutant
HC	Hydrocarbons
IMPROVE	Interagency Monitoring of PROtected Visual Environments
IR	Infrared
LPM	Liters per Minute
MAG	Maricopa Association of Governments
MQO	Measurement Quality Objective
MSA	Metropolitan Statistical Area
Mm^{-1}	Inverse Megameter
mg/m^3	Milligrams per Cubic Meter
$\mu g/m^3$	Micrograms per Cubic Meter
NAAQS	National Ambient Air Quality Standard
NATTS	National Air Toxics Trends Station
NCore	National Core multipollutant monitoring stations
NEI	National Emissions Inventory
NH_4NO_3	Ammonium Nitrate
NM	National Monument
NO	Nitric Oxide
NO_2	Nitrogen Dioxide
NOx	Nitrogen Oxides
NOy	Total Reactive Oxides of Nitrogen
O_3	Ozone
PAH	Polycyclic Aromatic Hydrocarbon

PAMS	Photochemical Assessment Monitoring Station
Pb	Lead
PM	Particulate Matter
PM_{10}	Particulate Matter ≤ 10 microns
$PM_{10-2.5}$	Coarse Particulate Matter between 2.5 to 10 micrometers aerodynamic diameter, may also be denoted as PM_{coarse}
$PM_{2.5}$	Particulate Matter ≤ 2.5 microns
ppb	Parts Per Billion
ppm	Parts Per Million
PQAO	Primary Quality Assurance Organization
PSD	Prevention of Significant Deterioration
PTFE	Polytetrafluoroethylene
QA	Quality Assurance
QAPP	Quality Assurance Program Plan
QC	Quality Control
QMP	Quality Management Plan
RH	Relative Humidity
RHR	Regional Haze Rule
SATMI	School Air Toxics Monitoring Initiative
SIP	State Implementation Plan
SLAMS	State and Local Air Monitoring Stations
SO_2	Sulfur Dioxide
SOP	Standard Operating Procedure
SPM	Special Purpose Monitor
STP	Standard Temperature Pressure
SVOC	Semi-Volatile Organic Compound
TAD	Technical Assistance Document
TEOM	Tapered Element Oscillating Microbalance
TNMOC	Total Non-Methane Organic Compound
TSP	Total Suspended Particle
UATMP	Urban Air Toxics Monitoring Program
USG	Unhealthy for Sensitive Groups
UV	Ultraviolet
VEI	Vehicle Emissions Inspection
VEL	Vehicle Emissions Laboratory
VOC	Volatile Organic Compound

Appendix II – References

http://www.airnow.gov/ - AQI Forecast

http://www.ecy.wa.gov/programs/air/sips/pollutants/naaqs.htm - National and State Ambient Air Quality Standards, Department of Ecology, State of Washington

https://www.epa.gov/criteria-air-pollutants/naaqs-table - National Ambient Air Quality Standards (NAAQS)

http://www.epa.gov/airquality/carbonmonoxide/health.html - Carbon Monoxide Health Effects

https://www.epa.gov/ozone-pollution - Ozone (O_3) Health Effects

https://www.epa.gov/air-trends - National Trends.

http://www.epa.gov/ttn/naaqs/standards/co/s_co_history.html - Carbon Monoxide (CO) Standards - Table of Historical CO NAAQS

http://www.epa.gov/ttn/naaqs/standards/nox/s_nox_history.html - Nitrogen Dioxide (NO_2) Standards - Table of Historical NO_2 NAAQS

https://www.epa.gov/ozone-pollution/table-historical-ozone-national-ambient-air-quality-standards-naaqs - Ozone (O_3) Standards - Table of Historical O_3 NAAQS

http://www.epa.gov/ttn/naaqs/standards/pb/s_pb_history.html - Lead (Pb) Standards - Table of Historical Pb NAAQS

http://www.epa.gov/ttn/naaqs/standards/pm/s_pm_history.html - Particulate Matter (PM) Standards - Table of Historical PM NAAQS

http://www.epa.gov/ttn/naaqs/standards/so2/data/so2final.pdf - National Ambient Air Quality Standards for Sulfur Oxides (Sulfur Dioxide)—Final Decision

http://www.epa.gov/ttn/naaqs/standards/so2/s_so2_history.html - Sulfur Dioxide (SO_2) Primary Standards - Table of Historical SO_2 NAAQS

http://www.phoenixvis.net/PPMmain.aspx - Non-Regulatory Portable Particulate Monitors

https://www.epa.gov/aqs - EPA's Air Quality System

https://www3.epa.gov/ttnamti1/uatm.html - 2014 National Monitoring Programs Annual Report (UATMP, NATTS, and CSATAM)

Appendix III – 2016 Area Designations Map