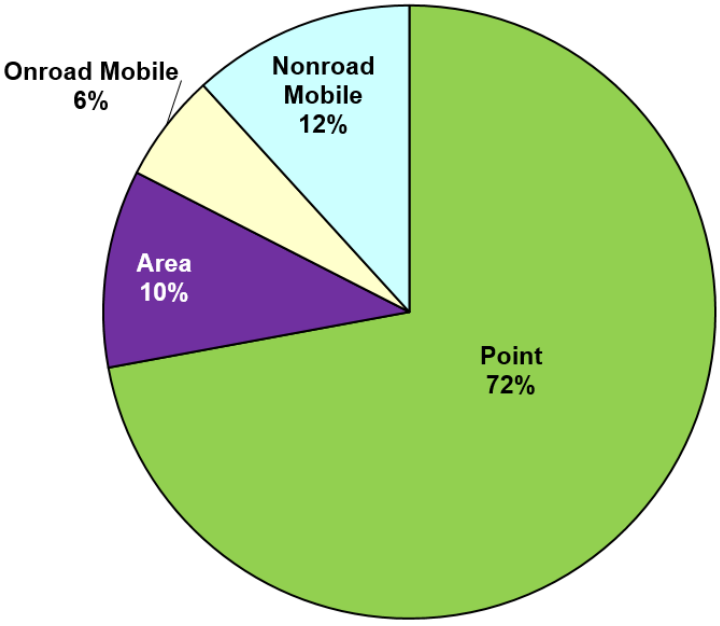
2016 Sulfur Dioxide Summary

New Jersey Department of Environmental Protection

SOURCES

Sulfur dioxide (SO_2) is a heavy, colorless gas with a suffocating odor, that easily dissolves in water to form sulfuric acid. SO_2 gases are formed when fuels containing sulfur (coal, oil, and gasoline) are burned, or when gasoline is extracted from oil. Most of the sulfur dioxide released into the air comes from fuel combustion in electric utilities, especially those that burn coal with a high sulfur content. Sulfur is found in raw materials such as crude oil, coal, and ores that contain metals. Industrial facilities that derive their products from these materials may also release SO_2. The pie chart in Figure 7-1 summarizes the primary sources of SO_2 in New Jersey in 2017.

Figure 7-1
2017 New Jersey SO_2 Projected Emissions



Inventory Source: MARAMA 2017 BETA2

HEALTH AND ENVIRONMENTAL EFFECTS

Sulfur dioxide causes irritation of the mucous membranes. This is probably the result of sulfurous acid forming when the highly soluble SO_2 gas dissolves at the surface of the membranes. Groups that are especially susceptible to the harmful health effects of SO_2 include children, the elderly, and people with heart or lung disorders such as asthma. When SO_2 concentrations in the air become elevated, people in these sensitive groups and those who are active outdoors may have trouble breathing.

Sulfur dioxide reacts with other gases and particles in the air to form sulfates, which also can be harmful to people and the environment. Sulfate particles are the major cause of reduced visibility in the eastern United States. SO_2 forms acids that fall to the earth in rain and snow. Better known as acid rain, this acidic precipitation can damage forests and crops, can make lakes and streams too acidic for fish, and can speed up the decay of building materials and paints.

AMBIENT AIR QUALITY STANDARDS

The current National Ambient Air Quality Standards (NAAQS) for SO_2 are shown in Table 7-1. Primary standards are set to 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. In June 2010 the United States Environmental Protection Agency (USEPA) established a new primary 1-hour NAAQS for SO_2 at a level of 75 parts per billion (ppb). At the same time, the old 24-hour and annual average NAAQS were revoked, and the 3-hour secondary NAAQS was retained.

Compliance with the 1-hour standard is determined by calculating the 99th percentile of 1-hour daily maximum concentrations for each monitoring site in the state each year, and then averaging each site's values for the three most recent years. This statistic is called the design value. Table 7-1 also shows New Jersey's ambient air quality standards for SO_2. The NJAAQS for SO_2 are expressed in micrograms per cubic meter ($\mu g/m^3$) instead of ppm, and are based on running averages (consecutive 12-month averages recorded during two years, and any consecutive 24-hours). The secondary 3-hour New Jersey standard is the same as the NAAQS.

Table 7-1
National and New Jersey Ambient Air Quality Standards for Sulfur Dioxide (SO_2)
Micrograms per Cubic Meter ($\mu g/m^3$)
Parts per Million (ppm)
Parts per Billion (ppb)

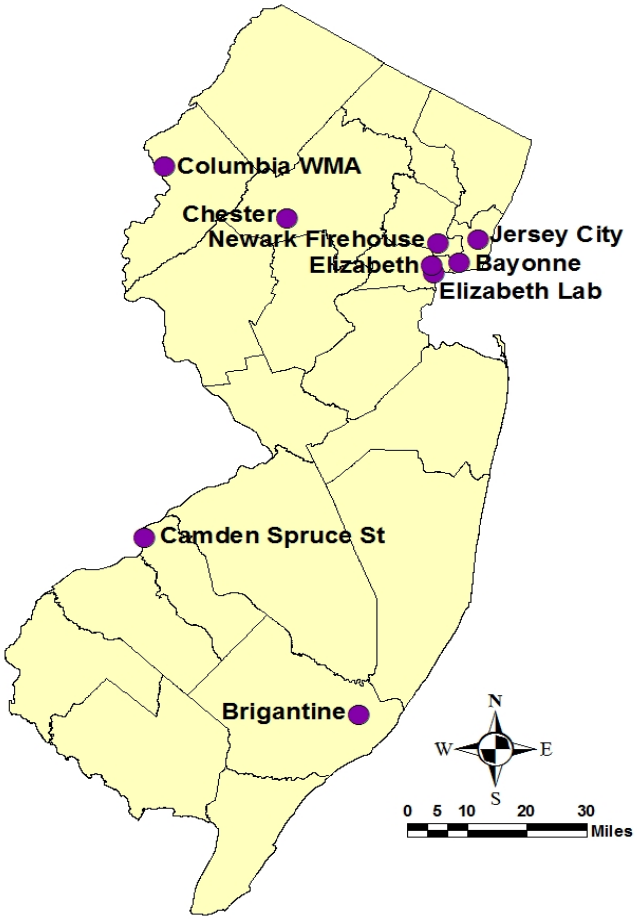
Averaging Period	Type	New Jersey	National
12–months [a]	Primary	80 $\mu g/m^3$ (0.03 ppm)	---
12–months [a]	Secondary	60 $\mu g/m^3$ (0.02 ppm)	---
24–hours [b]	Primary	365 $\mu g/m^3$ (0.14 ppm)	---
24–hours [b]	Secondary	260 $\mu g/m^3$ (0.10 ppm)	---
3–hours [b,c]	Secondary	1300 $\mu g/m^3$ (0.5 ppm)	0.5 ppm
1–hour [d]	Primary	---	75 ppb

[a] Based on rolling averages.
[b] Based on non-overlapping rolling averages.
[c] Not to be exceeded more than once per year.
[d] To meet this standard, the 3-year average of the 99th percentile of the daily maximum 1-hour averages at each monitor within the state must not exceed 75 ppb.

SO_2 MONITORING NETWORK

The New Jersey Department of Environmental Protection (NJDEP) monitored SO_2 levels at nine locations in 2016. These sites are shown in Figure 7-2. Two sites, Brigantine and Newark Firehouse, measure SO_2 concentrations at trace levels, down to a ten-thousandth part per million (0.0000 ppm). The other sites measure SO2 concentrations to the thousandth a part per million (0.000 ppm).

Figure 7-2
2016 Sulfur Dioxide
Monitoring Network



SO_2 Levels in 2016

In 2016, there were two exceedances of the 1-hour NAAQS of 75 ppb, recorded at Camden Spruce Street. These occurred on November 11 and November 21, and may have been caused by activity in the port nearby. However, the 99th-percentile value for the site, 11 ppb, fell below the NAAQS. This was the highest 99th-percentile value in the state. For 2016 Columbia still has the highest design value (the 3-year average of the 99th-percentile of the daily maximum 1-hour SO_2 concentration) at 30 ppb, because of high values recorded at the site in 2014.

No monitoring sites had exceedances of the 12-month or 24-hour New Jersey SO_2 standards during 2016. The maximum 12-month average concentration was 0.001 ppm, recorded at Elizabeth and Jersey City. The maximum 24-hour average concentration was 0.029 ppm, measured at the Camden Spruce Street site. The highest 3-hour average recorded was 0.126 ppm, also at the Camden Spruce Street site. This falls below the 3-hour secondary NAAQS of 0.5 ppm. Summaries of the 2016 data are provided in Tables 7-2, 7-3, 7-4, and 7-5, and Figures 7-3, 7-4 and 7-5.

Table 7-2
2016 Sulfur Dioxide Concentrations in New Jersey
Daily Maximums and 99th Percentile 1-Hour Averages
Parts per Billion (ppb)

Monitoring Site	1-Hour Average (ppb)			2014-2016 Design Value[a]
	Highest Daily Maximum	2nd-Highest Daily Maximum	99th %-ile Daily Maximum	
Bayonne	12	9	4	6
Brigantine	8.1	6.3	5.3	6
Camden Spruce St.	167	81	11	12
Chester	8	5	5	8
Columbia	8	8	8	30
Elizabeth	6	5	4	5
Elizabeth Lab	25	13	7	12
Jersey City	5	5	4	6
Newark Firehouse	6.5	5.5	3.8	6

[a] 3-Year (2014-2016) average of the 99th %-ile 1-hour daily maximum concentrations.

Figure 7-3
New Jersey Sulfur Dioxide Design Values for 2014-2016
3-Year Average of the 99th Percentile of the 1-Hour Daily Maximum Concentrations
Parts per Billion (ppb)

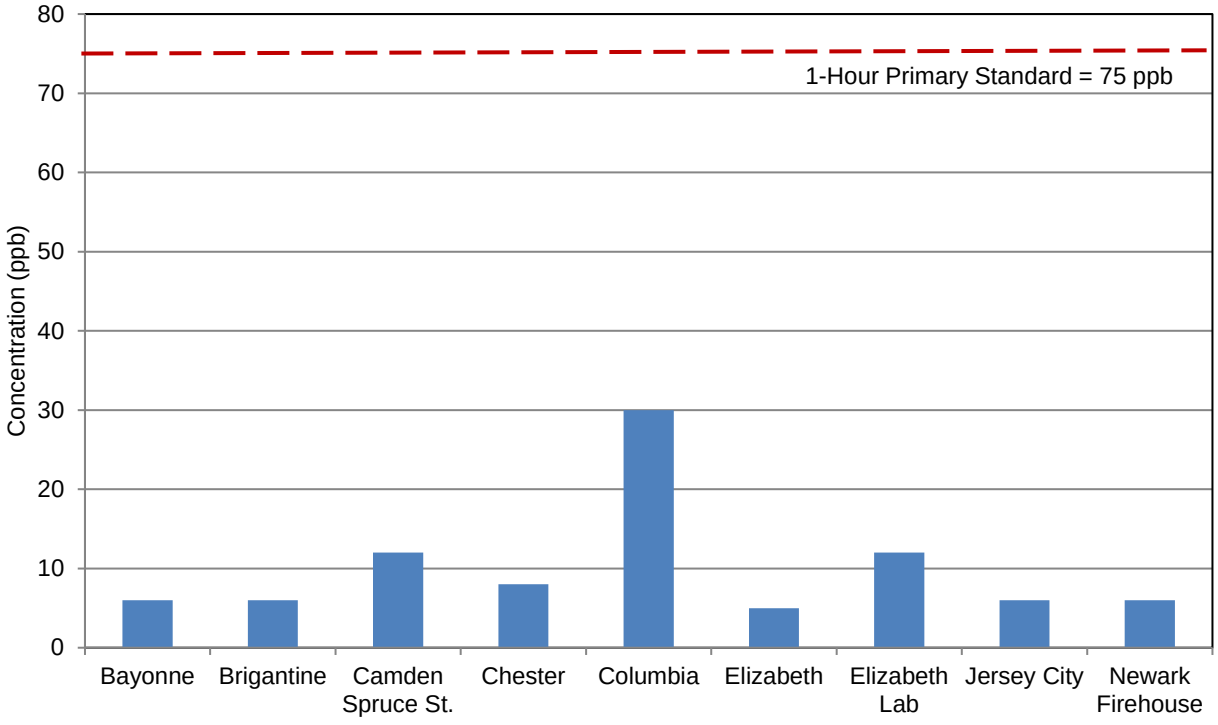


Table 7-3
2016 Sulfur Dioxide Concentrations in New Jersey
3-Hour Averages
Parts per Million (ppm)

Monitoring Site	3-Hour Average	
	Maximum	2nd Highest
Bayonne	0.0040	0.0030
Brigantine	0.0054	0.0045
Camden Spruce St.	0.1260	0.0670
Chester	0.0050	0.0040
Columbia	0.0060	0.0060
Elizabeth	0.0050	0.0040
Elizabeth Lab	0.0140	0.0090
Jersey City	0.0050	0.0040
Newark Firehouse	0.0046	0.0044

[a] Based on non-overlapping 3–hour rolling averages.

Figure 7-4
2016 Sulfur Dioxide Concentrations in New Jersey
2nd Highest 3-Hour Running Averages
Parts per Million (ppm)

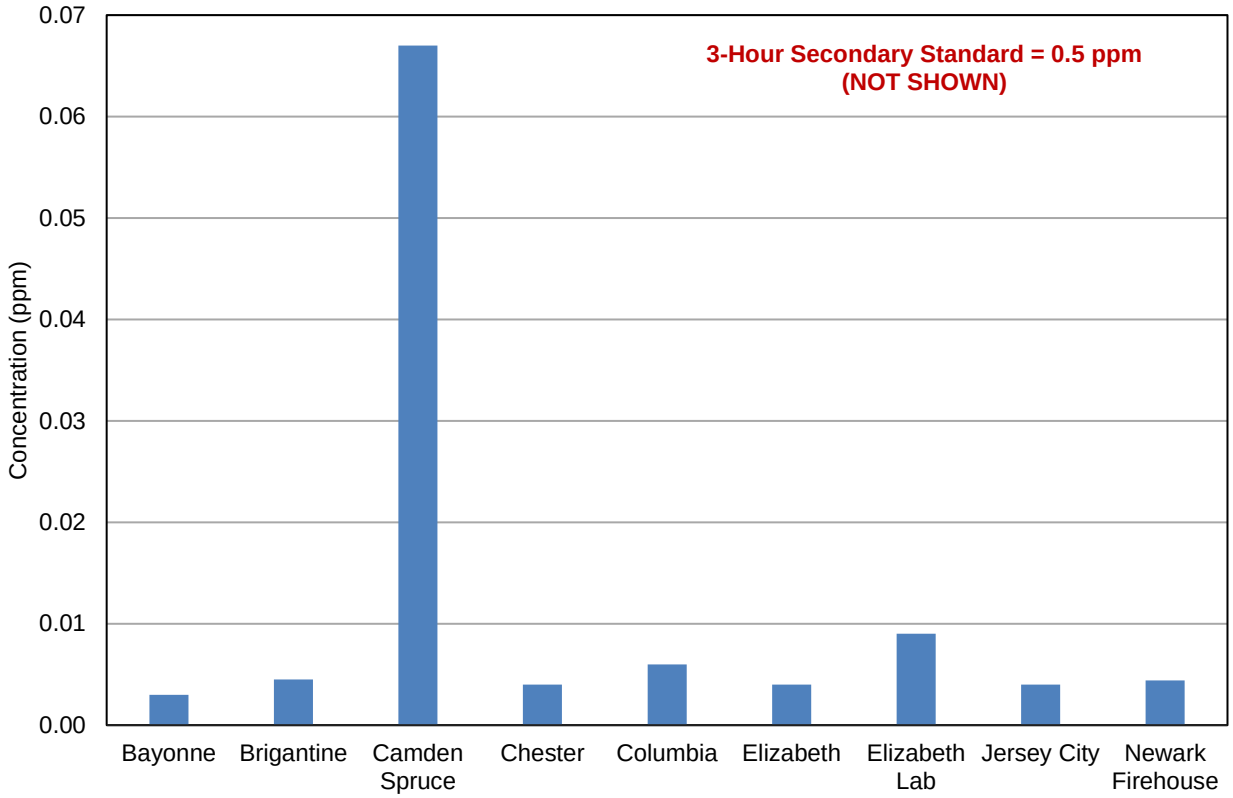


Table 7-4
2016 Sulfur Dioxide Concentrations in New Jersey
24-Hour and Daily Averages
Parts per Million (ppm)

Monitoring Site	24-Hour Average [a]		Daily Average [b]	
	Maximum	2nd-Highest	Maximum	2nd Highest
Bayonne	0.001	0.001	0.002	0.001
Brigantine	0.0017	0.0014	0.0017	0.0011
Camden Spruce St.	0.029	0.013	0.030	0.006
Chester	0.002	0.002	0.003	0.002
Columbia	0.003	0.002	0.003	0.002
Elizabeth	0.003	0.003	0.004	0.003
Elizabeth Lab	0.003	0.003	0.003	0.003
Jersey City	0.003	0.003	0.004	0.003
Newark Firehouse	0.0031	0.0023	0.0031	0.0021

[a] Based on non-overlapping 24–hour rolling averages.
[b] Based on daily 24-hour block averages, midnight to midnight.

Figure 7-5
2016 Sulfur Dioxide Concentrations in New Jersey
Highest and 2nd-Highest 24-Hour Averages
Parts per Million (ppm)

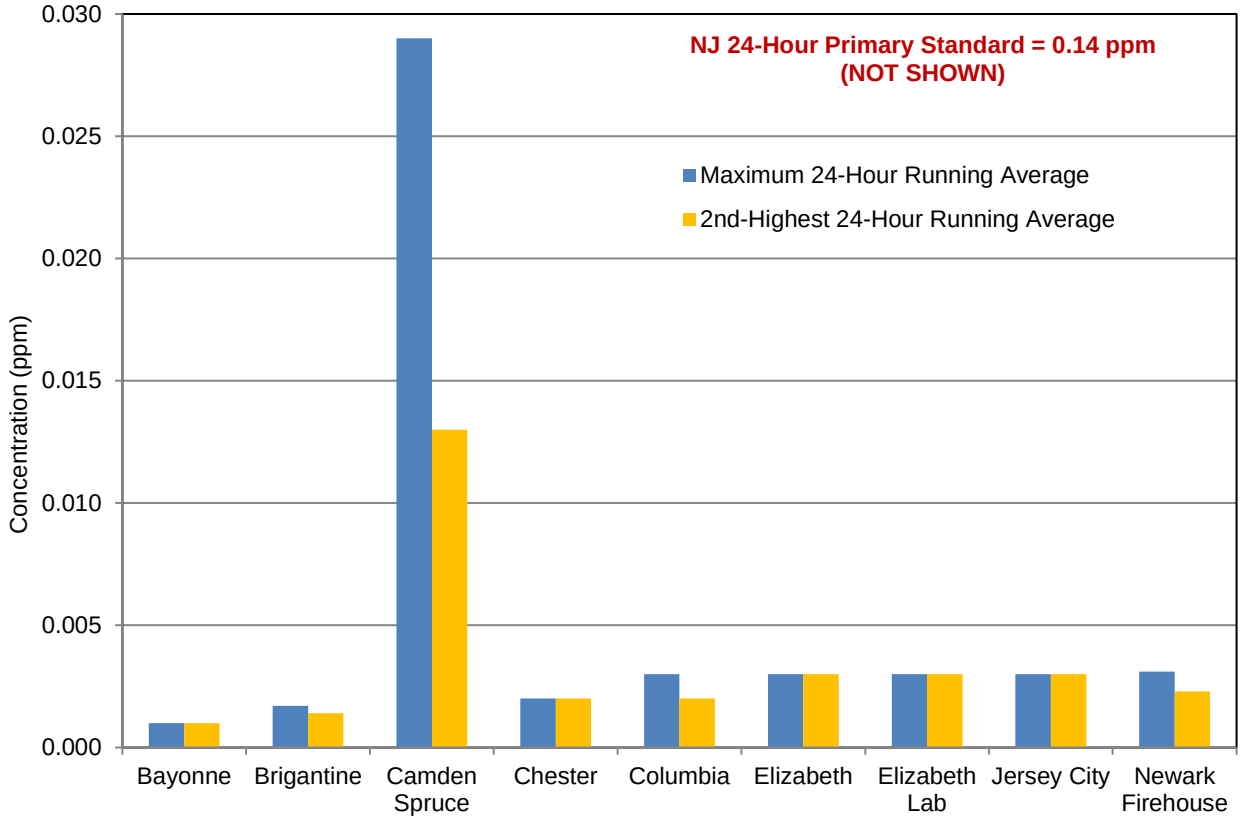


Table 7-5
2016 Sulfur Dioxide Concentrations in New Jersey
12-Month* and Annual Averages
Parts per Million (ppm)

Monitoring Site	12-Month Maximum Average*	Annual Average
Bayonne	0.000	0.000
Brigantine	0.0002	0.0002
Camden Spruce St.	0.000	0.000
Chester	0.000	0.000
Columbia	0.000	0.000
Elizabeth	0.001	0.000
Elizabeth Lab	0.000	0.000
Jersey City	0.001	0.001
Newark Firehouse	0.0005	0.0003

*Running average

SO_2 TRENDS

Sulfur dioxide concentrations across the country have decreased significantly since the first NAAQS were set in 1971. Figure 7-6 shows the second-highest daily average concentrations of SO_2 recorded in New Jersey each year since 1975. In addition to capturing emissions at sources, nationwide reduction efforts have focused on sulfur in fuels. Regulations passed in 2000 reduced the sulfur content of gasoline by up to 90 percent, and enabled the use of new emission control technologies in cars, sport utility vehicles (SUVs), minivans, vans and pick-up trucks (beginning with model year 2004). Even more stringent gasoline and emissions controls for sulfur went into effect in 2017. And in New Jersey, limits on sulfur in commercial fuel oil were implemented beginning in 2014.

A coal-burning power plant across the Delaware River in Pennsylvania had for many years been suspected of causing high SO_2 levels in New Jersey. Air dispersion modeling carried out by NJDEP showed that the facility was causing likely violations of the SO_2 NAAQS. New Jersey petitioned the USEPA under Section 126 of the Clean Air Act to take action against the Portland Power Plant. In support of the petition, NJDEP established an SO_2 monitoring station at the Columbia Wildlife Management Area in Knowlton Township, Warren County, in September 2010. The dramatic increase in the monitored SO_2 concentration in 2010 (shown in Figure 7-7) is the result of measurements taken at the Columbia site. In October 2011, USEPA finalized a rule to grant New Jersey's petition. This final rule required the Portland Power Plant to reduce its SO_2 emissions such that the plant's contribution to predicted air quality standard violations would be lowered within one year, and completely eliminated within three years. The power plant stopped operating in mid-2014. Recent monitoring data have shown that Warren County and its vicinity are now able to meet the 1-hour SO_2 NAAQS.

Figure 7-7 shows the trend in one-hour concentrations of SO_2 since 2000. The graph uses the 99th percentile of the daily maximum 1-hour concentrations. Figure 7-8 shows the trend in the design value, the value that determines compliance with the NAAQS. The design value for the 1-hour NAAQS is the 3-year average of the 99th percentile of the daily maximum 1-hour concentrations.

Figure 7-6
Sulfur Dioxide Concentrations in New Jersey, 1975-2016
Second-Highest 24-Hour Averages
Parts per Million (ppm)

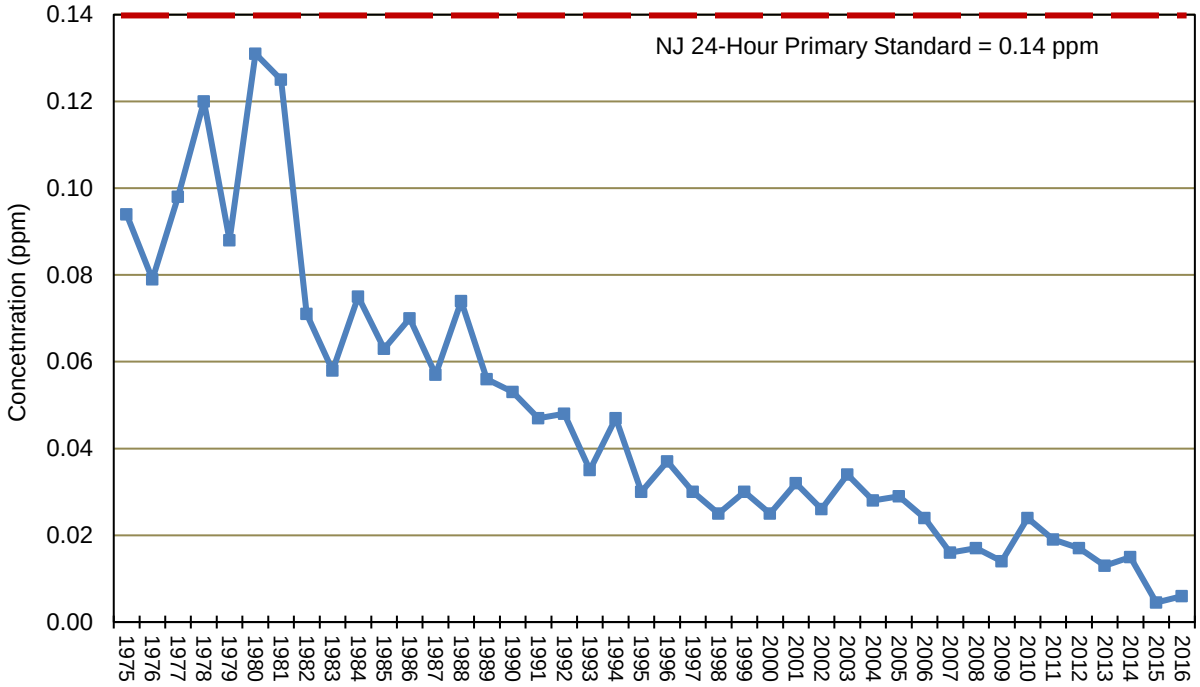


Figure 7-7
Sulfur Dioxide Concentrations in New Jersey, 2000-2016
99th Percentile of the Daily Maximum 1-Hour Concentrations
Parts per Million (ppm)

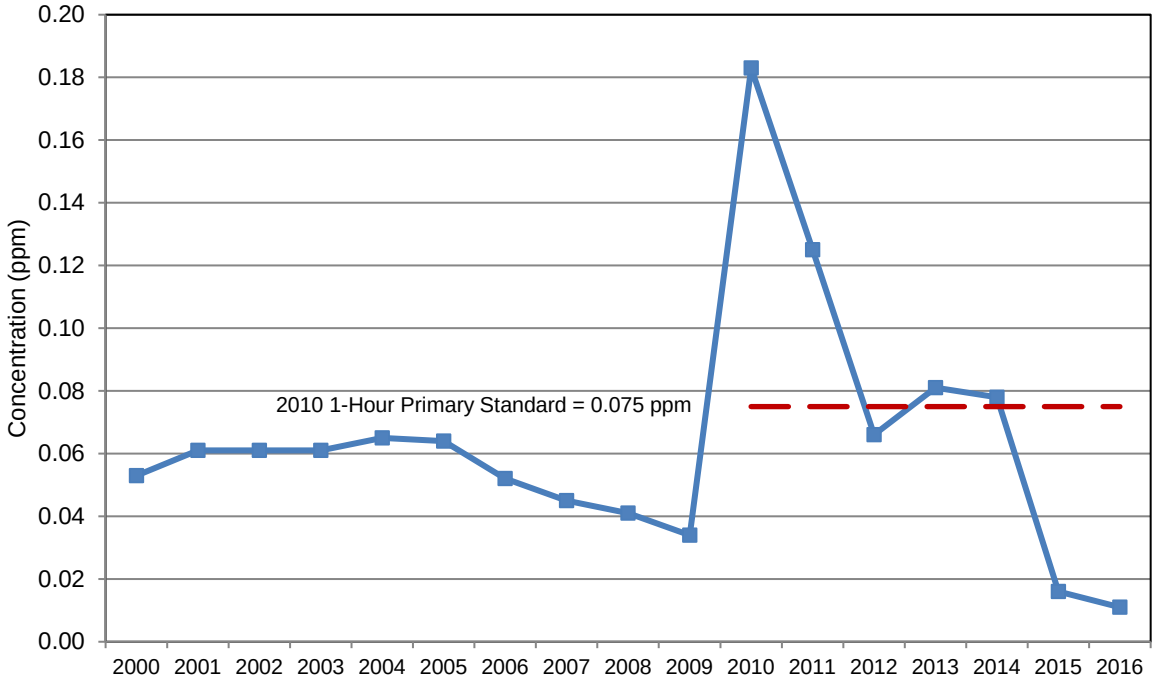
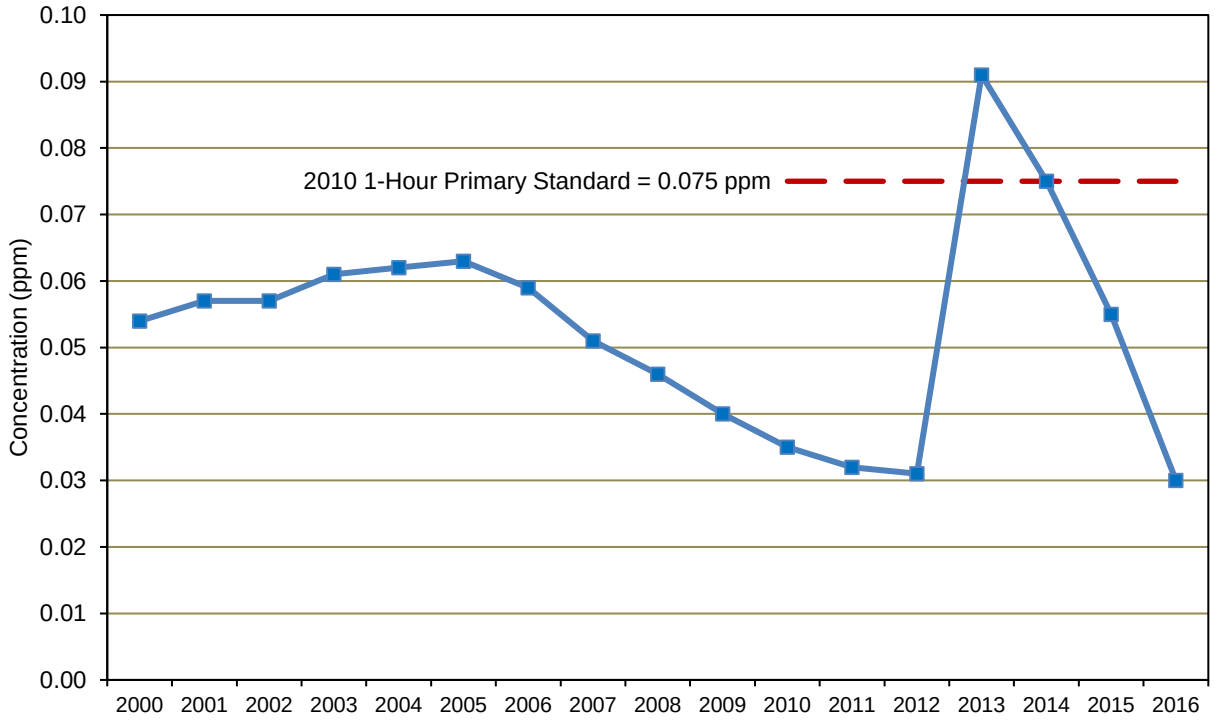


Figure 7-8
Sulfur Dioxide Design Value Trend in New Jersey, 2000-2016
3-Year Average of the 99th Percentile Daily Maximum 1-Hour Concentrations
Parts per Million (ppm)



REFERENCES

Agency for Toxic Substances and Disease Registry. *ToxFAQs for Sulfur Dioxide*. June 1999. www.atsdr.cdc.gov/toxfaqs/tf.asp?id=252&tid=46. Accessed 9/7/17.

"Revisions to Final Response to Petition from New Jersey Regarding SO2; Direct Final Rule." 76 Federal Register 79541 (December 22, 2011), pp. 79574-79578. www.federalregister.gov/documents/2011/12/22/2011-32652/revisions-to-final-response-to-petition-from-new-jersey-regarding-so2.

New Jersey Department of Environmental Protection (NJDEP) Bureau of Evaluation and Planning. *Petitions Pursuant to Section 126 of the Clean Air Act.* www.state.nj.us/dep/baqp/petition/126petition.htm. Accessed 8/17/17.

NJDEP Bureau of Evaluation and Planning. 2017 New Jersey Projected Emissions Inventory. 11/29/2017.

NJDEP. New Jersey Administrative Code, Title 7, Chapter 27, Subchapter 7 (N.J.A.C. 7:27-7). Sulfur. www.state.nj.us/dep/aqm/2017/Sub7_083117.pdf . Accessed 9/7/17.

NJDEP. N.J.A.C. 7:27-9. Sulfur in Fuels. www.state.nj.us/dep/aqm/2017/Sub9%20_083117.pdf . Accessed 9/7/17.

NJDEP. N.J.A.C. 7:27-10. Sulfur in Solid Fuels. www.state.nj.us/dep/aqm/2017/Sub10_083117.pdf . Accessed 9/7/17.

U.S. Environmental Protection Agency (USEPA). *Air Trends. Sulfur Dioxide Trends*. www.epa.gov/air-trends/sulfur-dioxide-trends. Accessed 8/17/17.

USEPA. Gasoline Standards – Gasoline Sulfur. www.epa.gov/gasoline-standards/gasoline-sulfur. Accessed 8/31/17.

USEPA. Our Nation's Air. https://gispub.epa.gov/air/trendsreport/2017/. Accessed 8/2/17.

USEPA. *Sulfur Dioxide (SO2) Pollution*. www.epa.gov/so2-pollution. Accessed 8/17/17.

USEPA. *Table of Historical Sulfur Dioxide National Ambient Air Quality Standards (NAAQS)*. www.epa.gov/so2-pollution/table-historical-sulfur-dioxide-national-ambient-air-quality-standards-naaqs. Accessed 8/17/17.

USEPA. What is Acid Rain? www.epa.gov/acidrain/what-acid-rain. Accessed 8/17/17.