Wisconsin Department of Natural Resources

2016 Wisconsin Air Quality Trends Report

Data from 2001 - 2015

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Acronyms and Abbreviations

TABLE 1. Acronyms and abbreviations used in this report

Term	Definition
CO	Carbon monoxide
DV	Design value
EPA	U.S. Environmental Protection Agency
hr	Hour
mo	Month
NAAQS	National Ambient Air Quality Standards
NO_2	Nitrogen dioxide
NO_x	Nitrogen oxides
$PM_{2.5}$	Fine particles (particles 2.5 micrometers or smaller in size)
PM_{10}	Inhalable particle (particles 10 micrometers or smaller in size)
ppb	Parts per billion
ppm	Parts per million
SO_2	Sulfur dioxide
TSP	Total suspended particles
$\mu g/m^3$	Microgram per cubic meter
µm	Micrometer
WDNR	Wisconsin Department of Natural Resources
yr	Year

Report Summary

Wisconsin Department of Natural Resources (WDNR) monitors ambient concentrations of several pollutants throughout the state, including ozone, particle pollution, sulfur dioxide, nitrogen dioxide, lead, carbon monoxide, and toxic compounds. With the exception of toxics, these comprise the set of principal pollutants, called criteria pollutants, which are regulated by the U.S. Environmental Protection Agency (EPA). Monitored levels of criteria pollutants are compared against the National Ambient Air Quality Standards (NAAQS) set by EPA to determine whether the standards are met.

This report presents trends in Wisconsin pollution monitoring data over the last 13 years (as data are available), though concentrations have been decreasing for decades. It addresses all six criteria pollutants regulated by EPA. The first section of the report provides an overview of the pollutants, the regulatory history of each (relative to the NAAQS), and Wisconsin's historical attainment status. The second section presents the monitoring data for each pollutant[1], and compares the data to the relevant NAAQS. For pollutants identified as regional in nature, monitoring data are grouped into broader regions to highlight geographic trends. County-level trends by pollutant follow in Appendix A. Tables comparing design values between the first and last years of the 13-year period are presented in Appendix B.

In general, concentrations of most criteria pollutants have been decreasing over the past decade in all regions of the state. In April 2014, three counties in southeastern Wisconsin that had been violating the fine-particle NAAQS were redesignated as attaining the standard because the monitors located in those counties measured concentrations below the NAAQS. The overall decrease in pollutant concentrations is encouraging and is the result of cooperative regulatory control programs reducing emissions from vehicles and stationary sources in Wisconsin and surrounding states.

As of the date of this report, Sheboygan County and a portion of Kenosha County are listed as nonattainment for the 2008 ozone NAAQS. Also, a small area around and including the city of Rhinelander in Oneida County is listed as nonattainment for the sulfur dioxide standard. WDNR is committed to working with partners in Wisconsin and other states to improve air quality in those areas.

Annual differences in meteorological conditions can lead to variability in measured concentrations. For example, relative to the summer of 2012, the summers of 2013, 2014 and 2015 were cooler and conditions were not as conducive to ozone formation. While annual data is important to consider, long-term trends in air quality guide decisions about management of air quality issues at federal and state levels.

[1] Data presented are design values which were downloaded from EPA's Design Value webpage (https://www.epa.gov/air-trends/air-quality-design-values).

Background

Federal Regulatory History

The Clean Air Act requires EPA to set NAAQS for pollutants considered harmful to public health and the environment. The technical basis for the NAAQS is provided through the independent recommendations of the Clean Air Scientific Advisory Committee as well as EPA staff evaluation.

There are two types of standards – primary and secondary. Primary standards are those set at a level meant to protect human health, especially for people with respiratory conditions or particular sensitivity to pollutant exposure. Secondary standards are intended to prevent impaired visibility, structural damage and vegetative/livestock injury. The current standards for the six criteria pollutants regulated by EPA are shown in Table 2 below.

TABLE 2. The EPA criteria pollutants and National Ambient Air Quality Standards*

Pollutant		Primary / secondary	Averaging time**	Level	Definition**
Carbon monoxide		primary	8-hr	9 ppm	not to be exceeded more than once per year
			1-hr	35 ppm	
Lead		primary and secondary	3-mo	0.15 µg/m^3	maximum 3-mo mean over 3 yr
Nitrogen dioxide		primary	1-hr	100 ppb	98th percentile value, averaged over 3 yr
		primary and secondary	annual	53 ppb	annual mean
Ozone		primary and secondary	8-hr	0.075 ppm	annual fourth-highest daily maximum 8-hr concentration, averaged over 3 yr
Particulate matter	$PM_{2.5}$	primary	annual	12 µg/m^3	annual mean, averaged over 3 yr
		secondary	annual	15 µg/m^3	annual mean, averaged over 3 yr
		primary and secondary	24-hr	35 µg/m^3	98th percentile value, averaged over 3 yr
	PM_{10}	primary and secondary	24-hr	150 µg/m^3	not to be exceeded more than once per year on average over 3 yr
Sulfur dioxide		primary	1-hr	75 ppb	99th percentile value of daily maximum 1-hr concentrations, averaged over 3 yr
		secondary	3-hr	0.5 ppm	not to be exceeded more than once per year

* Based on https://www.epa.gov/criteria-air-pollutants/naaqs-table.Please note that for the purpose of this report the table above reports the 2008 ozone standard. The 2015 ozone standard (currently linked on EPA's website) did not go into effect until December 28, 2015.

** hr = hour, mo = month, yr = year; 3-hr, 8-hr, and 3-mo averages are calculated as rolling averages; in contrast, annual averages are for the calendar year and 24-hr averages are for the calendar day (i.e., are not rolling)

Design Value Calculations

Design values are used to assess compliance with the NAAQS and are based on data collected over long periods. Usually, design values are averages of annual values to ensure they represent typical pollutant concentrations rather than isolated spikes in concentrations. The design values for criteria pollutants are

calculated using the method specified for each standard, as shown in the "Averaging time" and "Definition" columns of Table 2. The examples in the following paragraphs explain how ozone and fine-particle design values are calculated.

The metric used to determine compliance with the ozone NAAQS is the annual fourth-highest daily maximum eight-hour (8-hr) concentration, averaged over a period of three years (3 yr). Under the 2008 ozone standard[2], individual days are first divided into twenty-four 8-hr periods. Midnight to 8 AM, for example, would be the first period. The average ozone concentration during each period is calculated, and the highest of the 24 average values is determined (i.e., the maximum 8-hr value for the day). Figure 1 shows the highest 8-hr average value from each day at the Sheboygan – Kohler Andrae monitoring site during the 2015 ozone season. The fourth-highest value of the year is identified and then averaged with the fourth-highest value from two additional consecutive years to obtain the design value. For instance, the 2013-2015 design value was calculated by averaging the fourth-highest 8-hr maximum in 2015 with the fourth-highest values for 2014 and 2013. Note that even though the fourth-highest daily maximum 8-hr ozone value for 2015 was above the 2008 standard, ozone concentrations were below the standard for most days of the season (Fig. 1).

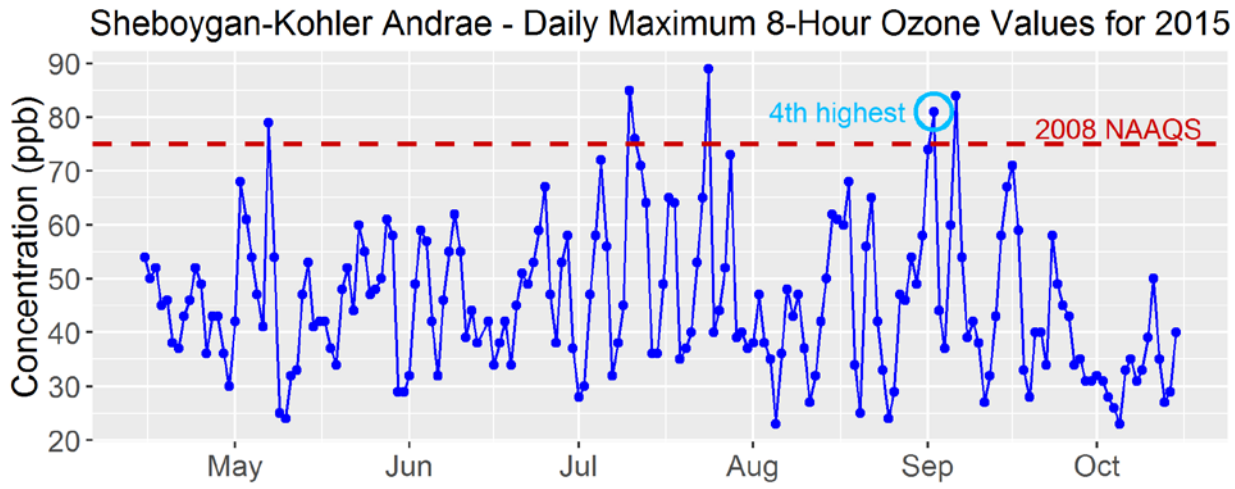


Figure 1. Example of fourth-highest yearly value identified for use in calculating the ozone design value.

For fine particles ($PM_{2.5}$), design values are calculated for comparison with the annual NAAQS and the 24-hr NAAQS. The annual design value for $PM_{2.5}$ is the average of the annual mean from three consecutive years, where each annual mean is the average of the four mean quarterly concentrations of that year. To obtain 24-hr design values, the observation representing the 98th percentile of 24-hr (calendar-day) average concentrations of fine particles is determined for each year (e.g., Fig. 2) and averaged over three consecutive years. The 98th percentile value is the observed concentration below which 98% of observations fall. Only 2% of observed concentrations are higher than this value. In the

[2] A new ozone standard went into effect on December 28, 2015. The 2015 rule also modified how the design value is calculated. This change, and design values calculated under the new 2015 rule, will be presented in next year's report. The current report presents and discusses design values calculated using the methods appropriate for comparison with the 1997 and 2008 eight-hour ozone NAAQS.

example, the calculated 98th percentile value for 2015 shown in Figure 2 is averaged with similar values from 2014 and 2013 to derive the official 2013-2015 design value.

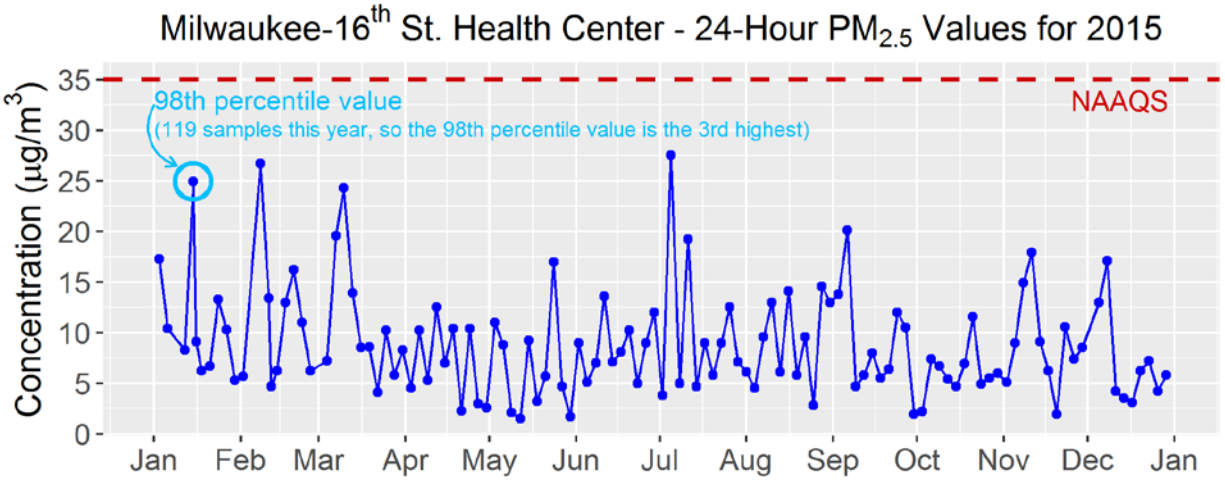


Figure 2. Example of 98th percentile identified for use in calculating the 24-hr $PM_{2.5}$ design value.

Design values in this report come from EPA's Design Value webpage (https://www.epa.gov/air-trends/air-quality-design-values). EPA publishes design values annually in August for data through the end of the previous year.

Ozone

Ozone is a naturally-occurring form of oxygen. While oxygen molecules predominantly found in the atmosphere contain two atoms, ozone molecules contain three. This molecular form of oxygen is unstable and is constantly forming and fragmenting through a variety of atmospheric reactions. Ozone is present in the Earth's upper atmosphere as well as at ground level. Ozone found at higher levels in the atmosphere (stratospheric ozone) filters out harmful ultraviolet rays, while ground-level (tropospheric) ozone can have an adverse impact on health. Monitored values of ozone found in this report represent ground-level ozone.

Ground-level ozone is not directly emitted into the air; rather it is created by photochemical reactions in the atmosphere. The highest measured ozone concentrations typically occur on hot sunny days with light winds, downwind of urban areas. Precursors of ozone can be transported long distances. Ozone concentrations in Wisconsin are significantly higher during the warmer months. The state's current ozone monitoring season is April 15 to October 15, with the exception of Kenosha County which has a season of April 1 to October 31. The 2015 ozone rule includes a change to the season start date for the state to March 1.

Ozone exposure can lead to numerous health issues including respiratory system irritation, reduced lung function, inflammation of and damage to cells in the lungs, aggravation of asthma and chronic lung diseases, increased lung susceptibility to infection, and potential for permanent lung damage. Children are at the greatest risk from exposure to ozone because their lungs are still developing. Also, research has shown that at certain levels, ozone can negatively affect vegetation and ecosystems. In Wisconsin,

ozone is measured using a network of continuously operating monitors which provide the basis for air-quality forecasting and real-time health advisories.

Regulatory History

In 1971, EPA issued a 1-hr standard of 0.08 ppm (effectively 84 ppb[3]) for "total photochemical oxidants", which included ozone. In 1979, EPA replaced this standard with a 1-hr standard for ozone set at a level of 0.12 ppm (effectively 124 ppb[2]). In July 1997, EPA replaced the 1-hr standard with an 8-hr standard of 0.08 ppm (effectively 84 ppb[3]) to protect the public against longer-term exposure. In March 2008, the 8-hr standard was lowered to 0.075 ppm (75 ppb). EPA further decreased the 8-hr standard to 0.070 ppm (70 ppb) on December 28, 2015. The new 2015 standard also reduced the number of 8-hr averages to be calculated per day[4] from 24 to 17. This change was designed to avoid double counting high early-morning values which under the 2008 guidelines could result in exceedances for two days (the current and the preceding day). The 2015 eight-hour standard is met when the calculated design value for a monitoring site is less than or equal to 70 ppb. Note that the 2008 standard of 75 ppb remains in effect until it is revoked by EPA.

Wisconsin Nonattainment History

As a result of EPA's 1971 one-hour standard for total photochemical oxidants, eighteen counties in Wisconsin were designated as "nonattainment", or non-compliant with the standard. In 1979, EPA designated twelve counties in Wisconsin as nonattainment with the 1-hr ozone standard. EPA completed a second round of designations under the 1-hr ozone standard in 1990 and designated eleven counties in eastern Wisconsin as nonattainment. When the 1-hr NAAQS was revoked in 2005, all counties except those in the six-county Milwaukee-Racine area (which included Ozaukee, Milwaukee, Racine, Kenosha, Washington, and Waukesha Counties) had been redesignated to attainment of the standard.

In 2004, ten counties in eastern Wisconsin were designated as nonattainment for the 1997 eight-hour ozone standard. Kewaunee County, Door County, Manitowoc County, and the six-county Milwaukee-Racine area were redesignated to attainment in 2008, 2010, 2010, and 2012, respectively. When the 1997 standard was revoked in 2015, Sheboygan County was still classified as nonattainment. In 2012, Sheboygan County and the eastern part of Kenosha County were also designated nonattainment for the 2008 ozone NAAQS. Nonattainment designations remain in effect for these two areas. In October of 2017, EPA is expected to make area designations for the 2015 standard.

Particulate Matter ($PM_{2.5}$ and PM_{10})

Particulate matter is not a single pollutant but rather a mixture of solid particles and liquid droplets distributed among numerous gases that interact with solid and liquid phases. Particles are classified

[3] Because older standards were set at the 0.01 ppm level, while the parameter was measured to the 0.001 ppm level, rounding conventions associated with attainment determination result in effective standards that appear to be slightly higher than the official published values. The official and effective standards are equivalent.

[4] Because the 2015 standard came into effect very late in 2015, design values presented and discussed in this report were calculated using the methods appropriate for comparison with the 1997 and 2008 eight-hour ozone NAAQS .

based on their diameter. There are three types of particles that are commonly of interest: fine particles (2.5 µm in diameter or smaller; $PM_{2.5}$), coarse particles (with diameters between 2.5 and 10 µm; PM_{crs}), and inhalable particles (10 µm in diameter or smaller; PM_{10}). Fine particles have different emission sources than the larger particles found in the coarse and inhalable particle categories, and behave much like gases in the atmosphere. Fine particles generally form in the atmosphere and have long atmospheric lifetimes. Coarse particles, which include larger particles, are primarily formed through mechanical processes such as crushing and grinding. Particles of different sizes have different atmospheric transport and fates once they become airborne. Fine particles have long lifetimes in the atmosphere (days to weeks), travel long distances (hundreds to thousands of kilometers), and are uniformly distributed over larger regions. National Ambient Air Quality Standards have been set for $PM_{2.5}$ and PM_{10} only (Table 2); there is not a separate NAAQS for PM_{crs}. Consequently, discussion in the remainder of the document will focus on $PM_{2.5}$ and PM_{10}.

Fine particles may be formed in one of two different ways. Primary particles are those emitted directly from combustion sources such as vehicles, fires, or smokestacks of combustion processes. Secondary particles are those that form when pollutants (e.g., sulfur oxides and nitrogen oxides) react in the atmosphere with ammonia and other gases. Secondary particles comprise the vast majority of fine particles.

While all inhalable particles pose a health risk according to EPA, fine particles pose the greatest risk because of their ability to penetrate deep into the respiratory tract. Very fine particles may also enter the bloodstream. Studies have shown an association between fine-particle exposure and premature death from heart or lung disease, as well as aggravated respiratory conditions such as asthma and airway irritation. Individuals most sensitive to fine-particle exposure include people with heart or lung disease, older adults, and children.

Regulatory History

EPA's original 1971 standard for particle pollution set a limit for total suspended particles (TSP), which included both $PM_{2.5}$ and PM_{10}, as well as coarser particles up to approximately 20 µm in diameter. In 1987, EPA discontinued the standard for TSP and replaced it with two PM_{10} standards: an annual limit of 50 µg/m^3 and a 24-hr (calendar-day) limit of 150 µg/m^3. Wisconsin retained its own 24-hr TSP standard until 2011. In 1997, EPA introduced a separate standard for $PM_{2.5}$. These separate standards are discussed further in the following sections.

$PM_{2.5}$

In 1997 the annual standard was set by EPA at 15.0 µg/m^3 based on a 3-yr average of the annual mean $PM_{2.5}$ concentration. The 24-hr (calendar-day) $PM_{2.5}$ standard was established the same year at 65 µg/m^3 for the 3-yr average of the annual 98th percentile concentrations. In 2006, the 24-hr standard was lowered to 35 µg/m^3, while in 2012, the annual standard was lowered to 12.0 µg/m^3, effective January 2014.

PM_{10}

In 2006, the 1987 annual PM_{10} standard of 50 µg/m^3 was revoked. The 24-hr standard of 150 µg/m^3 remains in effect today.

Wisconsin Nonattainment History ($PM_{2.5}$)

In 2009, EPA designated Milwaukee, Racine, and Waukesha Counties as nonattainment of the 2006 NAAQS for 24-hr $PM_{2.5}$ based on monitoring data from 2006 to 2008. In June 2012, the DNR submitted a request to EPA to redesignate these counties to attainment based on monitoring data collected between 2008 and 2011. Since that time, attainment levels of $PM_{2.5}$ have been consistently measured throughout the state. EPA proposed redesignation of the three counties to attainment, and the redesignation was finalized on April 22, 2014. As a result of this action, all counties in Wisconsin are in attainment for the annual and 24-hr $PM_{2.5}$ NAAQS.

Sulfur Dioxide (SO_2)

Sulfur dioxide (SO_2) is one of a group of highly reactive gases known as 'oxides of sulfur'. It is a product of combustion. The largest emission source of SO_2 is fossil fuel combustion at power plants and other industrial facilities.

Exposure to SO_2 has been shown to cause a range of adverse respiratory effects including bronchoconstriction and increased asthma symptoms. Further, emission sources that contribute to high concentrations of SO_2 also contribute to the formation of other oxides of sulfur. Some of these oxides can react with other compounds in the atmosphere to form fine particles, which can penetrate deep into the lungs.

Regulatory History

EPA first set standards for SO_2 in 1971. An annual primary standard was set at 30 ppb and a 24-hr primary standard was set at 140 ppb. A 3-hr secondary standard of 500 ppb was also set. In 1996, EPA reviewed the standards without revision.

In 2010, EPA changed the primary SO_2 standards by establishing a new 1-hr standard at 75 ppb. EPA revoked the existing annual and 24-hr primary standards because the 1-hr standard is more protective of public health. The 3-hr secondary standard remains in effect.

Wisconsin Nonattainment History

In 2013, EPA designated a portion of Oneida County as nonattainment for the 2010 primary SO_2 NAAQS. In July 2016, as part of its second round designations under the SO_2 Data Requirements Rule (DDR), EPA designated all of Columbia County as unclassifiable/attainment for this standard. Other areas may be designated attainment or nonattainment through future implementation of the SO_2 DDR.

Nitrogen Dioxide (NO_2)

Nitrogen dioxide (NO_2) is a reactive byproduct of combustion produced mainly by vehicles, resulting in concentrations that are highest immediately adjacent to roadways. Nitrogen dioxide and nitrogen oxide (NO), collectively referred to as NO_x, are important precursors of ozone, which is generated when NO_x reacts with volatile organic compounds in the presence of sunlight. In addition, these gases can also react with other pollutants to form airborne particles. Research indicates that direct exposure to NO_2 for short time periods can result in respiratory issues such as airway inflammation and aggravated asthma.

Longer-term exposure poses a risk of acute respiratory illness and inhibited lung development in children.

Regulatory History

In 1971, EPA set the original standard for NO_2 at 53 ppb based on an annual average. This standard is still in effect. In 2010, EPA established an additional 1-hr standard of 100 ppb and mandated the placement of NO_2 monitors near major roads in large urban areas. WDNR located a near-road NO_2 monitor in Milwaukee that became operational January 1, 2014. There have been no exceedances of NO_2 standards in Wisconsin, and consequently no NO_2 nonattainment areas.

Lead

Lead can be found in several places in the environment including the air, water and soil. Before unleaded gasoline was introduced in 1980, vehicle emissions were the primary source of airborne lead. Today, lead is emitted mainly from industrial metal processing sources, as well as the combustion of leaded aviation fuel.

People can be directly exposed to lead in the air. In addition, deposition onto soil or bodies of water may cause lead to accumulate in natural ecosystems and contaminate drinking water. Health effects of lead exposure in humans are numerous and well-documented. In general, neurological effects and developmental risks are the largest danger for children, whereas cardiovascular effects such as heart disease and high blood pressure commonly affect adults.

Regulatory History

The original lead standard, set by EPA in 1978, was 1.5 $\mu g/m^3$ on a calendar quarterly average basis. In 2008, this standard was replaced by a rolling 3-mo averaging period and lowered to 0.15 $\mu g/m^3$. In 2016, after an extensive review period, EPA decided to retain the existing 2008 standard. The design value for lead is determined using the maximum 3-mo average over a period of three years.

Wisconsin uses a collection technique that measures lead content as a subset of TSP samples as required by federal rule. During the past two decades, no areas in Wisconsin have had levels of lead that exceed the NAAQS.

Carbon Monoxide (CO)

Carbon monoxide (CO) is a toxic gas that is well known as a potential danger in indoor environments; however, it is also emitted into the ambient air primarily by mobile sources. Under certain conditions, it reacts to form ground-level ozone.

In the short term, carbon monoxide exposure can reduce people's respiratory efficiency. In extremely high concentrations, exposure can be fatal. People suffering from heart disease face increased risks from exposure to CO because their respiratory efficiency is already compromised.

Regulatory History

EPA originally set standards for CO in 1971: an 8-hr standard of 9 ppm and a 1-hr standard of 35 ppm. These standards were reviewed in 1994 and 2011, but were not changed.

Wisconsin Nonattainment History

In the past, Wisconsin had nonattainment areas for CO in portions of Milwaukee and Winnebago Counties. Both areas have since been redesignated to attainment.

Regional Pollutant Trends

The following section presents trends in Wisconsin monitoring data for all six criteria pollutants over roughly the last thirteen years (as data are available). Design values are plotted for each monitoring site and compared against the relevant NAAQS to show how the state's air quality has changed over time. The data for some pollutants are organized regionally to highlight geographic trends. Specifically, different areas of the state are prone to higher concentrations of ozone and fine particles – the main criteria pollutants of interest in Wisconsin.

The data presented are from currently-active ambient air monitoring sites operated by WDNR. For the trends data, sites were required to have a minimum of three consecutive valid design values (i.e., five consecutive years of valid data for 3-yr design values) to be included in the plots. For sites meeting this criterion, if data are not shown for a particular design-value year, it is because the design value was not valid, most often due to data-completeness issues. In contrast, maps for each pollutant include all currently-active WDNR sites; however, only sites with a valid design value for the most recent period (i.e., 2015 for 1-yr- design values and or 2013-2015 for 3-yr design values) will have values shown after the site name.

Typically, NAAQS attainment is assessed by county. Trends plots by county are shown in Appendix A. For counties with multiple monitors, the monitor with the highest design value is compared against the NAAQS.

Information on national air quality trends and how Wisconsin data compare to national averages can be found at https://gispub.epa.gov/air/trendsreport/2016/.

Ozone

Ozone in the lower atmosphere forms primarily as the result of reactions between volatile organic compounds and nitrogen oxides (NO_x, which consists of NO and NO_2). Ozone precursors that affect Wisconsin may originate in other states, particularly from the south. These precursors often react to form ozone over Lake Michigan. Ozone formation is greatest on hot, humid, sunny days with light southerly winds. On these days, temperature gradients from the shoreline to the lake often create pressure differences which cause an on-shore or lake breeze in the afternoon. Wisconsin counties along Lake Michigan experience the highest ozone concentrations on days with a southerly breeze, which transports ozone precursors north to Wisconsin. The southerly breeze, in combination with the lake breeze, pushes ozone formed over the lake onshore, causing ozone concentrations in Wisconsin to be closely correlated with distance from the Lake Michigan shoreline. For this reason, ozone design values are grouped based on their location in three distinct regions:

1) **Lakeshore -** counties bordering Lake Michigan extending from the Illinois border through Door County, WI
2) **Inland** - counties in central and western Wisconsin
3) **Far North** – counties in the northern part of the state including those near Lake Superior and the Upper Peninsula of Michigan

Figure 3 shows the most recently available ozone design values for all ozone monitors in the state. Only one of eleven monitoring sites in the Lakeshore region observed design values for these years that were greater than the 2008 ozone NAAQS of 75 ppb. No sites in the other two regions had design values exceeding the 2008 standard in 2013-2015. Sites in western and northern Wisconsin recorded the lowest ozone concentrations.

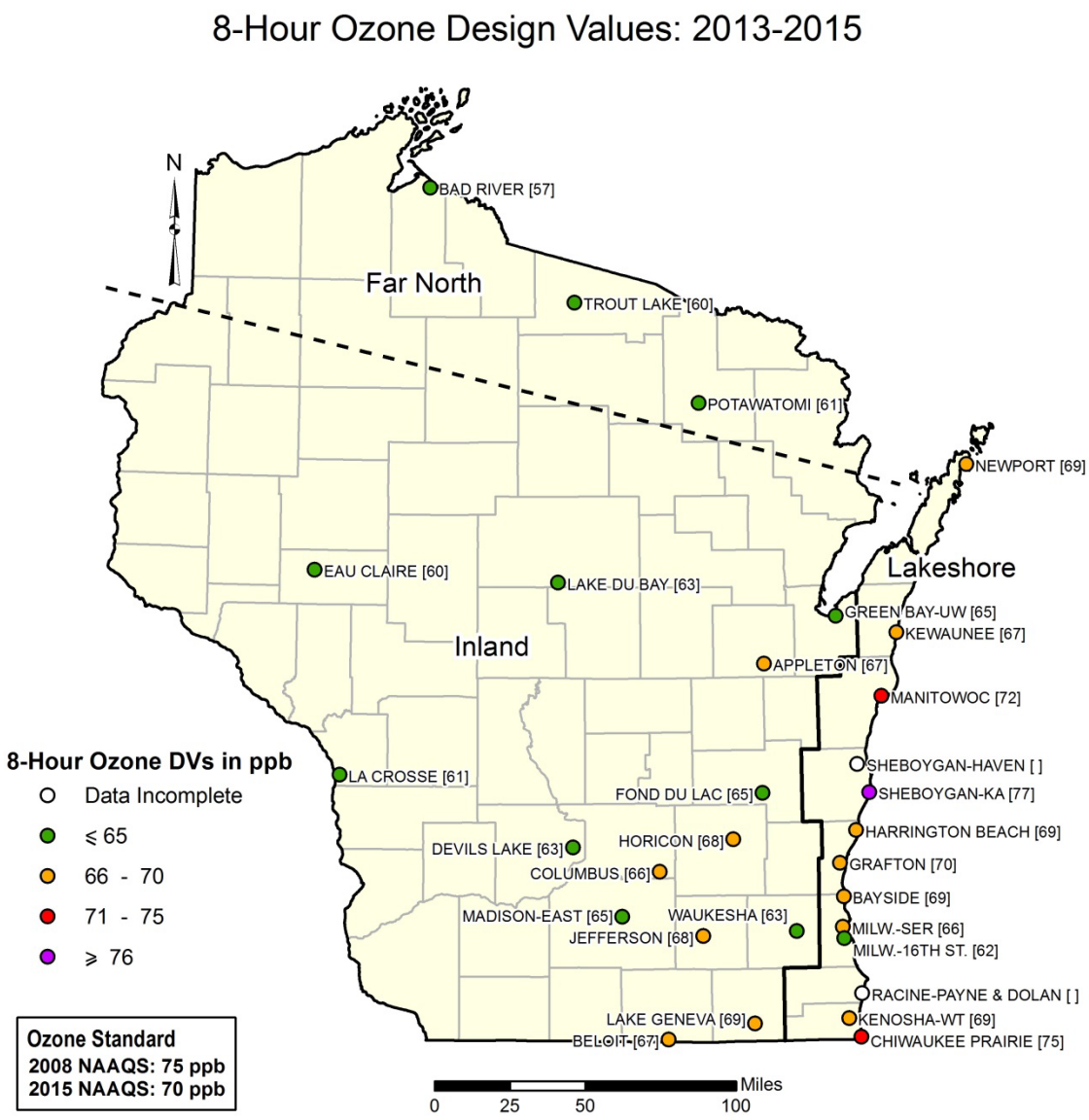


Figure 3. Ozone design values for each monitoring site for 2013-2015. Note that the Far North region includes the three sites shown, but its boundaries are not clearly defined. Full site names are found in Appendix C, Table C1.

Lakeshore Region

Figure 4 shows Lakeshore-region design values for ozone compared with the NAAQS. The Kenosha-WT site is not shown due to the short length of record at the site. The relationship between design values from different monitoring sites was generally consistent over time (e.g., the values from the Milwaukee-SER site were consistently greater than the values from the Milwaukee-16th St. site). Design values for

2010-2012 to 2012-2014 were higher than previous time periods due to the inclusion of data from 2012 which had an extraordinarily hot summer (with accordingly high ozone concentrations). Over the past eight years, the site located in Kohler-Andrae State Park in Sheboygan County (the Sheboygan-KA site) generally showed the highest design values in the region, and consistently exceeded the NAAQS. A number of other sites have also exceeded the 2008 NAAQS in some years (Fig. 4). The design values collectively demonstrated a downward trend between 2001-2003 and 2013-2015 with the lowest average values for the region recorded in 2013-2015. There was a 25% average reduction in design values in this region from 2001-2003 to 2013-2015 among sites with data available for the full period (Appendix B, Table B1).

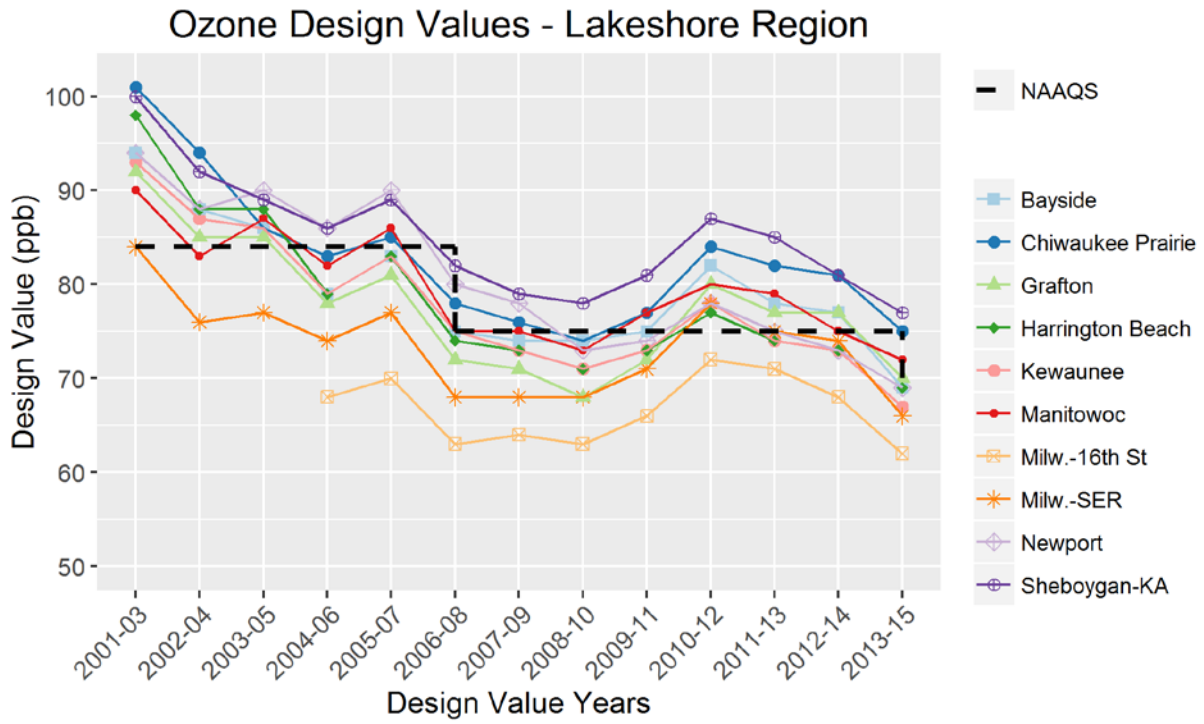


Figure 4. Ozone design values for the Lakeshore region. Note that the standard was lowered from 84 ppb to 75 ppb in 2008 and from 75 ppb to 70 ppb in 2015. Note also that the design value axis is truncated at 50 ppb (rather than going down to zero) to allow for a clearer view of the differences among sites. Full site names are found in Appendix C, Table C1.

Inland Region

Figure 5 shows Inland-region design values for ozone compared to the NAAQS. Once again, design values were higher for the 2010-2012 to 2012-2014 periods due to high ozone concentrations in 2012. Nonetheless, no design value in this region exceeded the NAAQS between 2001-2003 and 2013-2015. Like the Lakeshore region, the design values for each of these monitoring sites generally decreased over time. The lowest design value in this region, 60 ppb, was observed most recently at the Eau Claire site in 2013-2015. There was a 17% average reduction in design values in this region from 2001-2003 to 2013-2015 among sites with data available for the full period (Appendix B, Table B1).

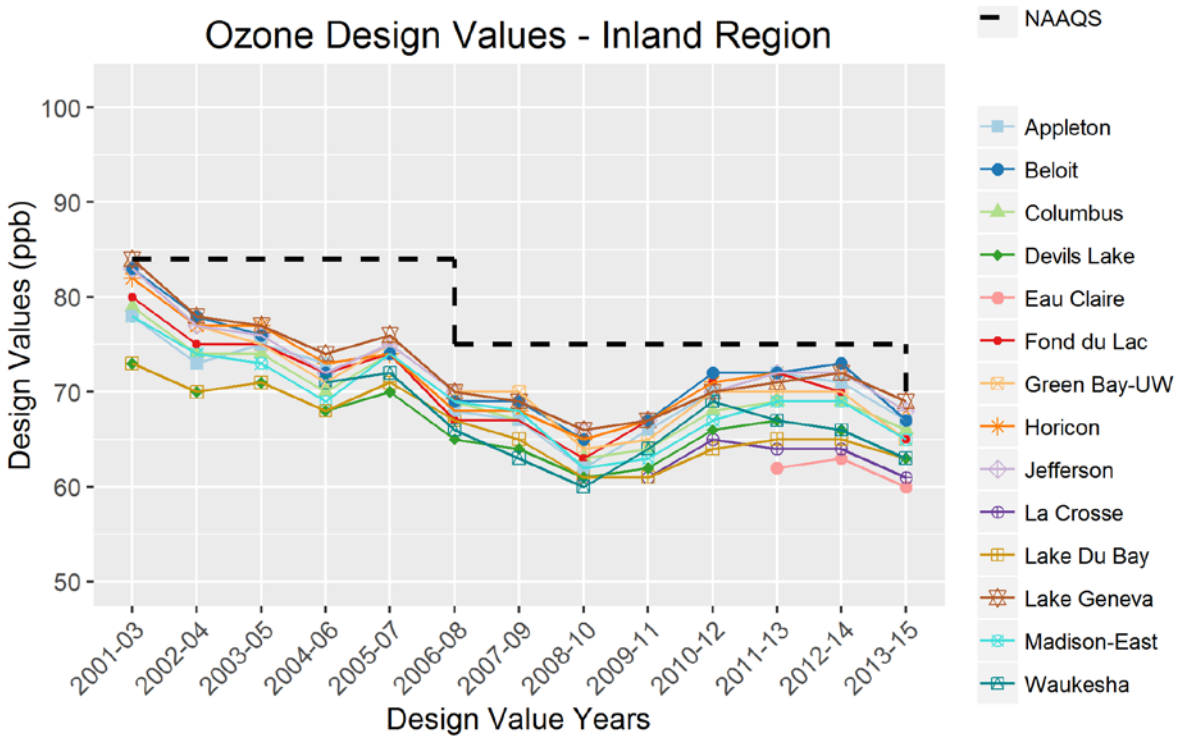


Figure 5. Ozone design values for the Inland region. Note that the standard was lowered from 84 ppb to 75 ppb in 2008 and from 75 ppb to 70 ppb in 2015. Note also that the design value axis is truncated at 50 ppb (rather than going down to zero) to allow for a clearer view of the differences among sites. Full site names are found in Appendix C, Table C1.

Overall, the design values in the Inland region were more similar among sites than those in the Lakeshore region. This finding suggests that while ozone concentrations are subject to variation at local scales in the Lakeshore region due to the impact of the lake breeze effect, Inland region concentrations are buffered from this effect because they are farther from the shoreline. Since onshore ozone transport is less of a factor at Inland locations, the ozone concentrations at the Inland sites were both more uniform throughout the region and generally lower than concentrations at the Lakeshore sites. In addition to having generally lower ozone concentrations, sites in the Inland region showed a smaller average reduction in design value compared to the Lakeshore sites (17% vs 25%) over the time period examined (Appendix B, Table B1).

Far North Region

Figure 6 shows Far-North-region design values for ozone compared to the NAAQS. All sites were consistently below the NAAQS and represented the overall lowest concentrations of ozone in the state. Minimum levels for the region were observed most recently in the 2013-2015. Concentrations were lowest among the three sites at the Bad River site.

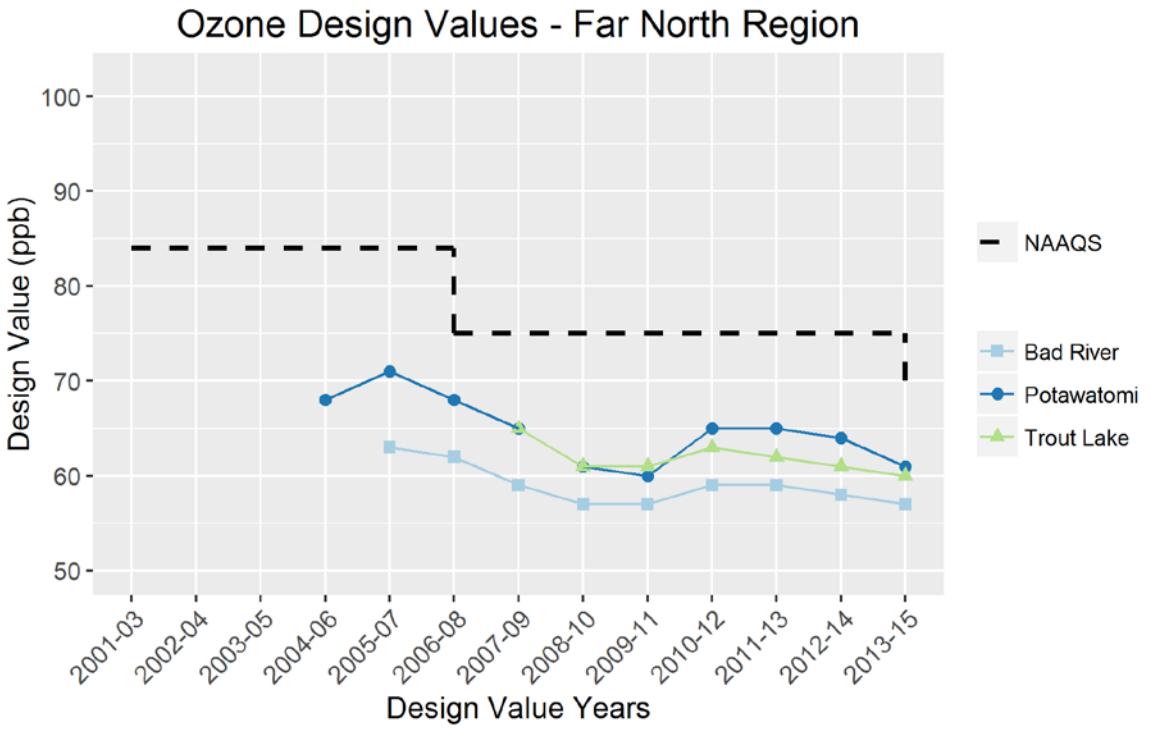


Figure 6. Ozone design values for Far North region. Note that the standard was lowered from 84 ppb to 75 ppb in 2008 and from 75 ppb to 70 ppb in 2015. Note also that the design value axis is truncated at 50 ppb (rather than going down to zero) to allow for a clearer view of the differences among sites. Full site names are found in Appendix C, Table C1.

Fine Particles ($PM_{2.5}$)

WDNR maintains a robust network of $PM_{2.5}$ monitoring sites throughout the state. Monitors at these sites use filter-based systems operating daily to once every 12 days to measure fine particles. This network currently measures attainment of the annual and 24-hr (calendar-day) standards at all sites. Fine particles may be transported long distances and are considered a regional pollutant. The pollutant's ambient concentrations are strongly influenced by weather and local topography. Specifically, low-lying areas may exhibit elevated fine-particle levels during a period of localized air stagnation.

To highlight geographic trends in fine-particle concentrations, design values are grouped by the following regions:

1) Southeast
2) Inland
3) Far North

Figure 7 shows the most recent annual $PM_{2.5}$ design values for sites in Wisconsin. Figure 8 shows 24-hr design values. For both sets of design values, the highest values were observed in the Milwaukee and Madison areas, although no sites exceeded either the annual (2012 NAAQS, 12 $\mu g/m^3$) or the 24-hr (2006 NAAQS, 35 $\mu g/m^3$) standard.

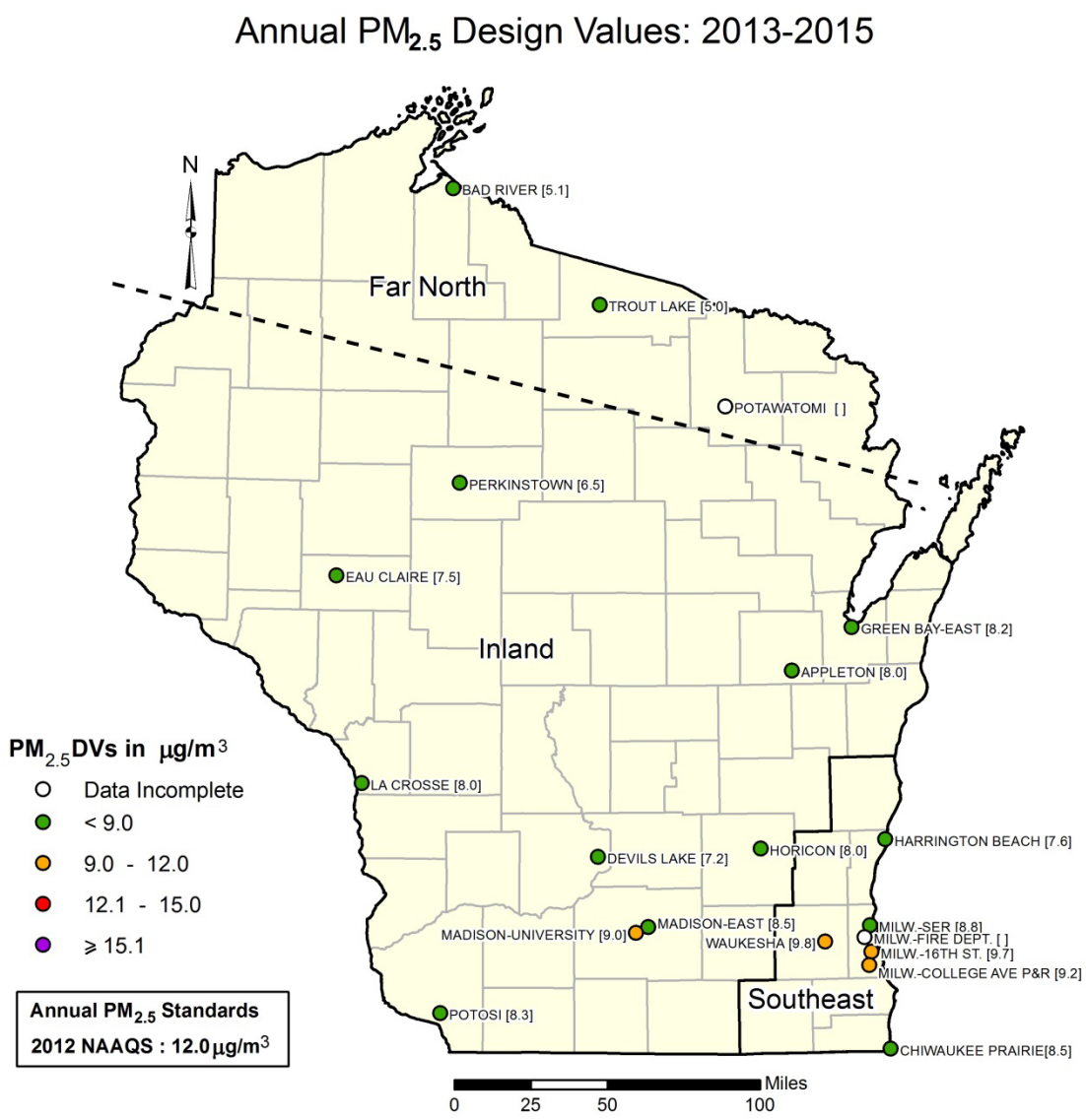


Figure 7. Annual $PM_{2.5}$ design values for each monitoring site for 2013-2015. Note that the Far North region includes the three sites shown, but its boundaries are not clearly defined. Full site names are found in Appendix C, Table C1.

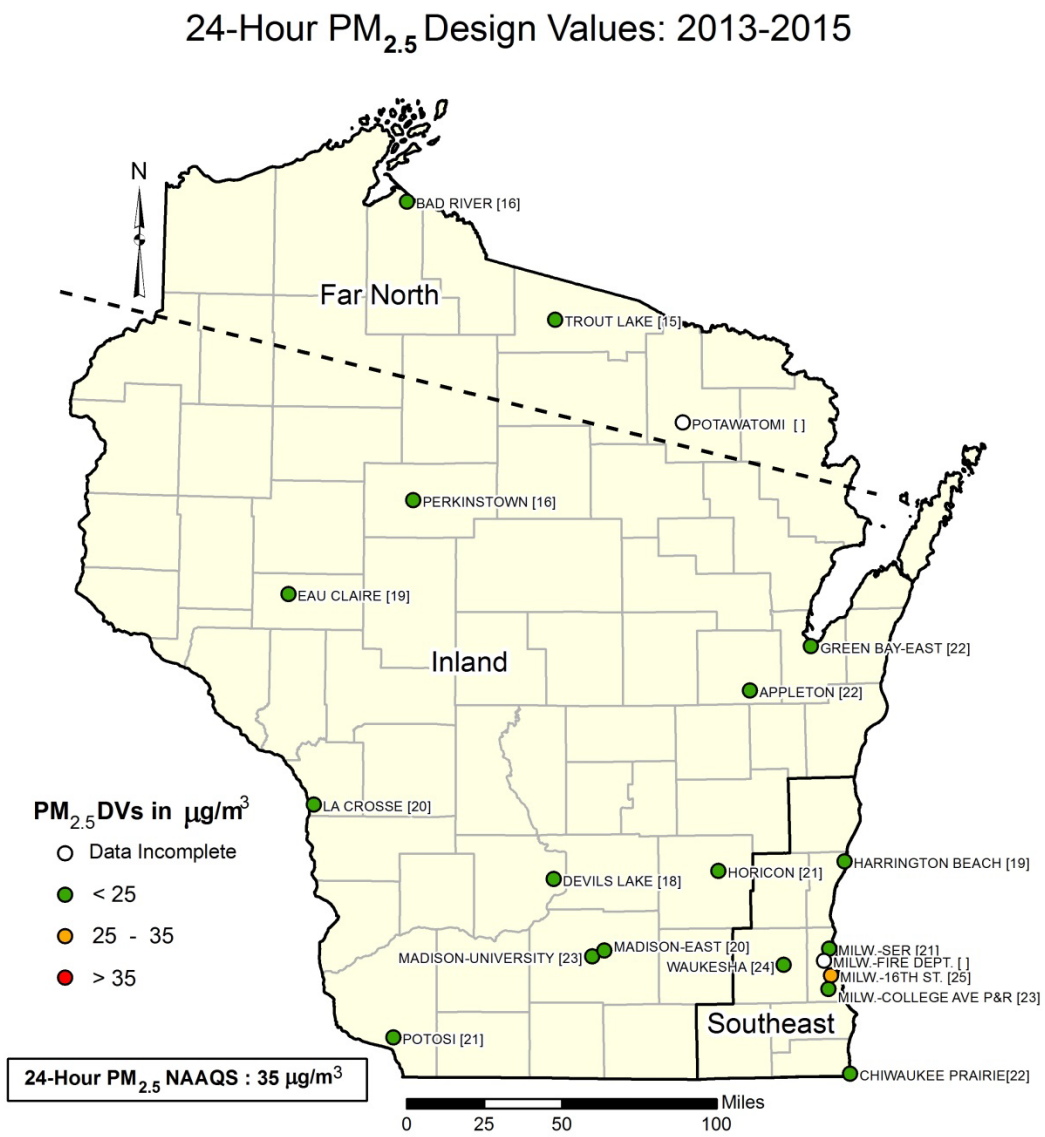


Figure 8. The 24-hr $PM_{2.5}$ design values for each monitoring site for 2013-2015. Note that the Far North region includes the three sites shown, but its boundaries are not clearly defined. Full site names are found in Appendix C, Table C1.

Southeast Region

Figure 9 shows annual and 24-hr design values for six of the seven monitoring sites in the Southeast region. The Milwaukee-College Avenue Park & Ride site is not shown due to the short length of record at the site.

The relationships between design values at different sites were relatively consistent for both the annual and 24-hr design values. For both metrics, monitoring sites generally measured a steady decrease in concentrations over the past eight years, reaching the lowest overall concentrations in 2013-2015. The Harrington Beach site had the lowest annual and 24-hr design values. The Waukesha and Milwaukee-

Fire Department sites generally recorded the highest annual values, while the Milwaukee-16th St. Health Center and Milwaukee Fire Department sites often measured the highest 24-hr design values.

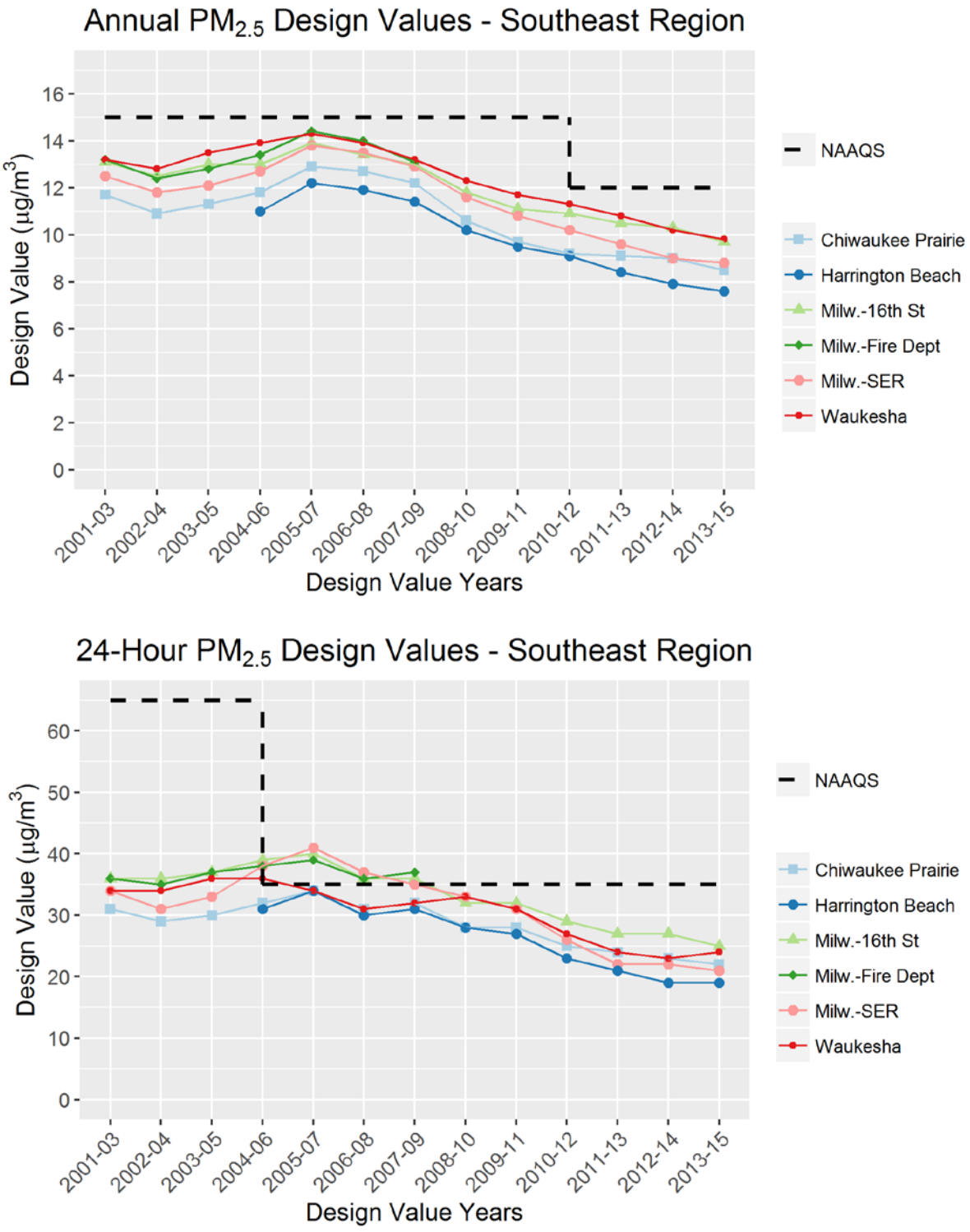


Figure 9. Annual (top) and 24-hr (bottom) $PM_{2.5}$ design values in the Southeast region. Note that the annual standard was lowered from 15.0 to 12.0 µg/m^3 in 2012, and the 24-hr standard was lowered from 65 to 35 µg/m^3 in 2006. Full site names are found in Appendix C, Table C1.

While none of the sites ever measured an annual design value exceeding the relevant NAAQS (the 2006 annual standard of 15 μg/m^3 or the 2012 annual standard of 12 μg/m^3), the decrease in the 24-hr standard from 65 to 35 μg/m^3 in 2006 resulted in design values at some sites exceeding the standard during subsequent years. Nonetheless, 24-hr design values for all sites in the region have been below the stricter 2006 NAAQS since 2008-2010. Design values have been reduced approximately 30% on average for the region between 2001-2003 and 2013-2015 (Appendix B, Tables B2-B3).

Inland Region

Figure 10 shows annual and 24-hr design values for the nine monitoring sites in the Inland region. Similar to the Southeast region, the relationship between annual design values at different sites in the Inland region were generally consistent over time. The annual design values decreased consistently at all sites after 2006-2008. The lowest annual design values in this region were observed at the Perkinstown site in Taylor County.

Trends over time were less consistent across sites for the 24-hr design values prior to 2008-2010; however, the values generally decreased after that time. Immediately after the lower standard went into effect in 2006, the Green Bay-East and Madison-University sites measured exceedances of the NAAQS, although no sites did in subsequent years. As with the Southeast region, Inland-region design values decreased approximately 30% between 2001-2003 and 2013-2015 (Appendix B, Tables B2-B3).

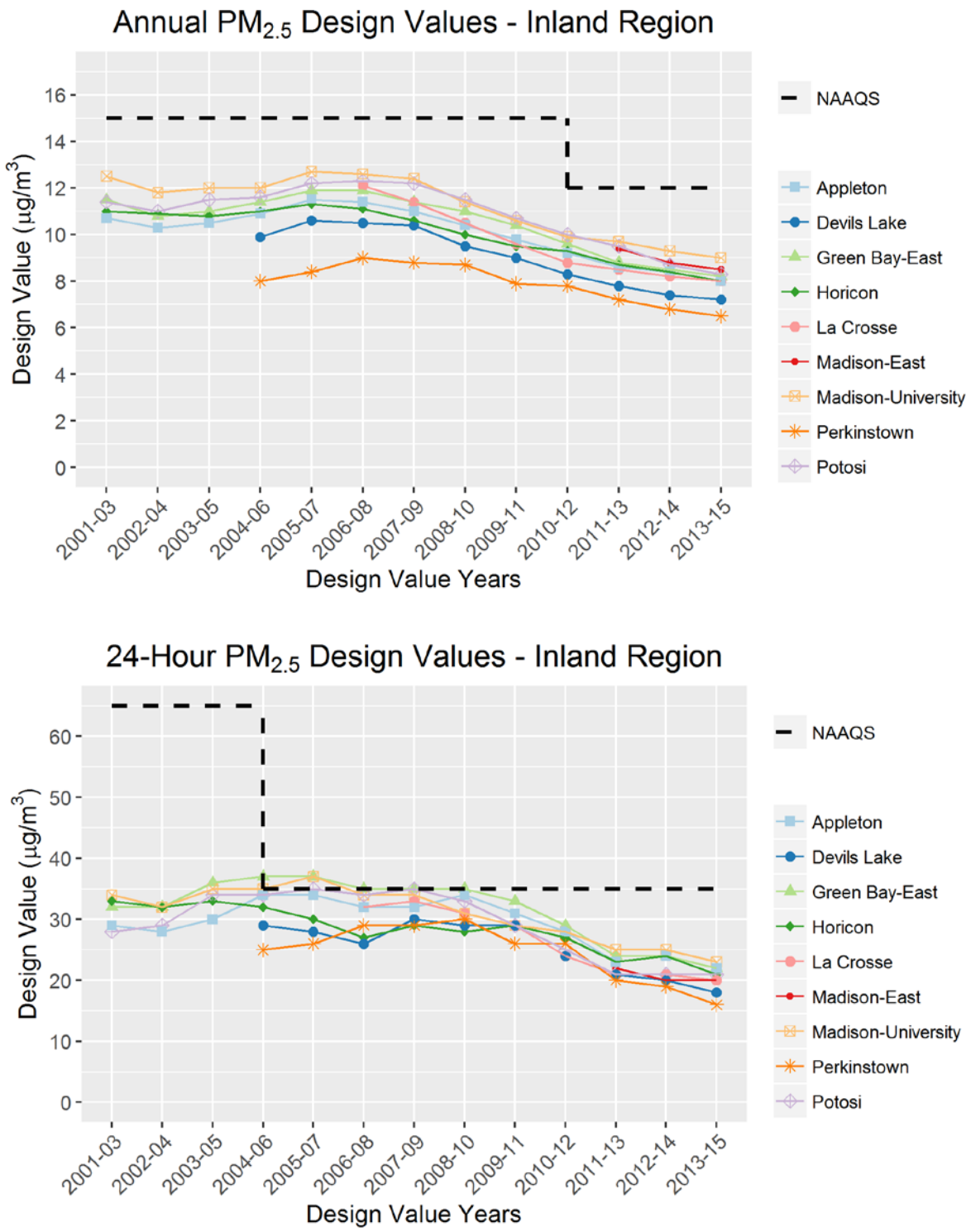


Figure 10. Annual (top) and 24-hr (bottom) $PM_{2.5}$ design values in the Inland region. Note that the annual standard was lowered from 15.0 to 12.0 µg/m^3 in 2012, and the 24-hr standard was lowered from 65 to 35 µg/m^3 in 2006. Full site names are found in Appendix C, Table C1.

Far North Region

Figure 11 shows annual and 24-hr design values for the three monitoring sites in the Far North region.

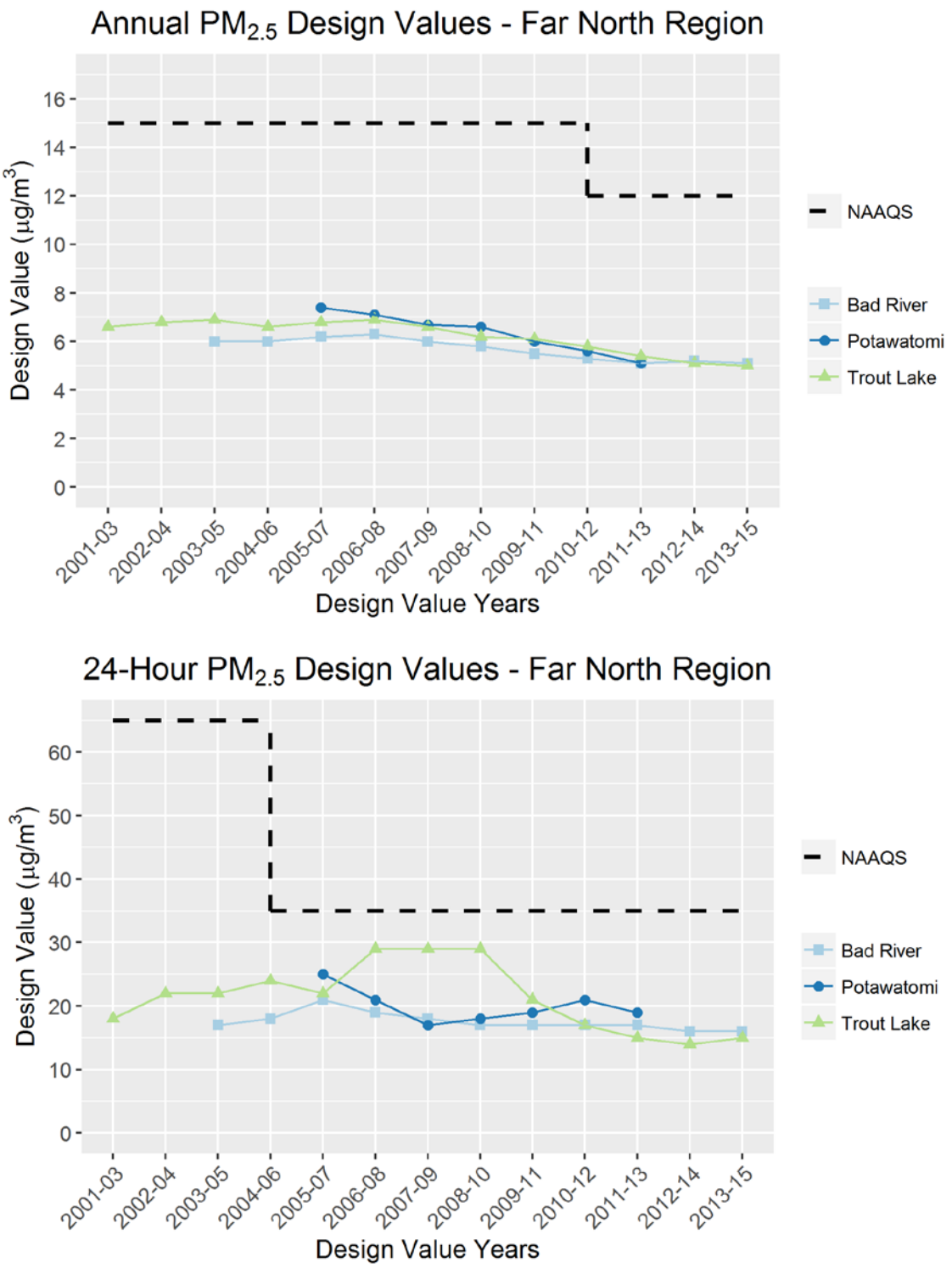


Figure 11. Annual (top) and 24-hr (bottom) $PM_{2.5}$ design values in the Far North region. Note that the annual standard was lowered from 15.0 to 12.0 µg/m^3 in 2012, and the 24-hr standard was lowered from 65 to 35 µg/m^3 in 2006. Full site names are found in Appendix C, Table C1.

Sites in this region showed the lowest concentrations of fine particles in the state. The annual design values decreased consistently after 2006-2008. Agreement between sites was much stronger for the annual design values than the 24-hr values.

Inhalable Particles (PM_{10})

Inhalable particles (PM_{10}) are monitored at seven sites in the WDNR network (Fig. 12) which use a combination of filter-based and continuous monitors. Values shown in the map below are the maximum 24-hr (calendar-day) averages measured from 2013-2015 which contribute to the determination of the PM_{10} design value. The highest PM_{10} concentrations are measured in urban areas.

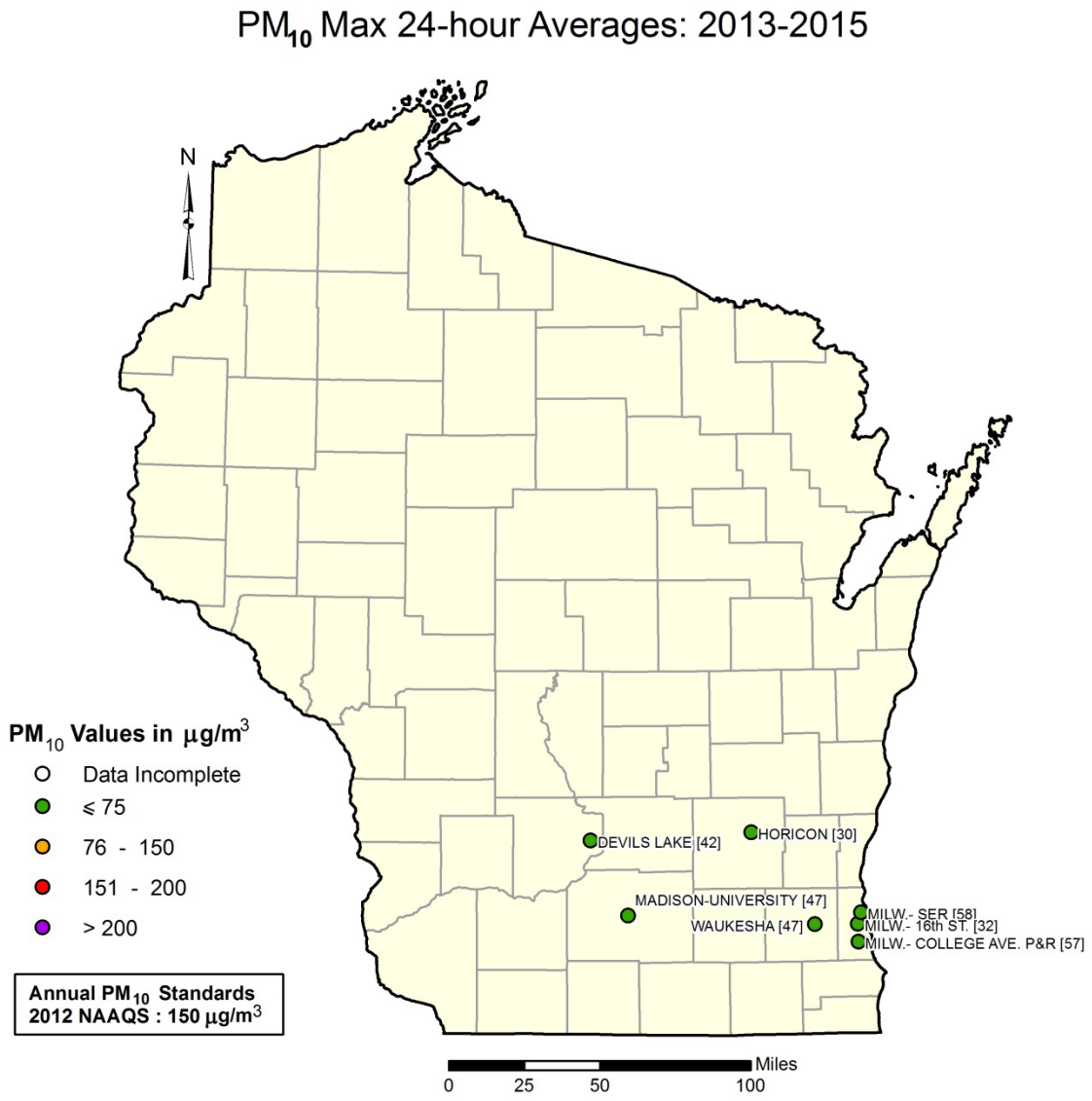


Figure 12. Maximum 24-hr averages of PM_{10} for 2013-2015. Full site names are found in Appendix C, Table C1.

Figure 13 shows the 3-yr maximum 24-hr averages for each PM_{10} monitoring site compared to the NAAQS. The Devils Lake site is not shown due to the short length of record at the site. If the 24-hr average PM_{10} values exceed the standard (150 $\mu g/m^3$) more than once per year on average over three years, the standard is violated.

The three-year 24-hr maxima for all sites fell well below the NAAQS. In addition, concentrations of PM_{10} generally decreased over time, although values were somewhat variable. For sites with three or more consecutive valid design values (i.e., five or more consecutive valid years of data), three-year 24-hr maxima decreased between 9% (Milw.-SER) and 52% (Horicon) between the first years of data and the most recent (2013-2015) values (Appendix B, Table B4).

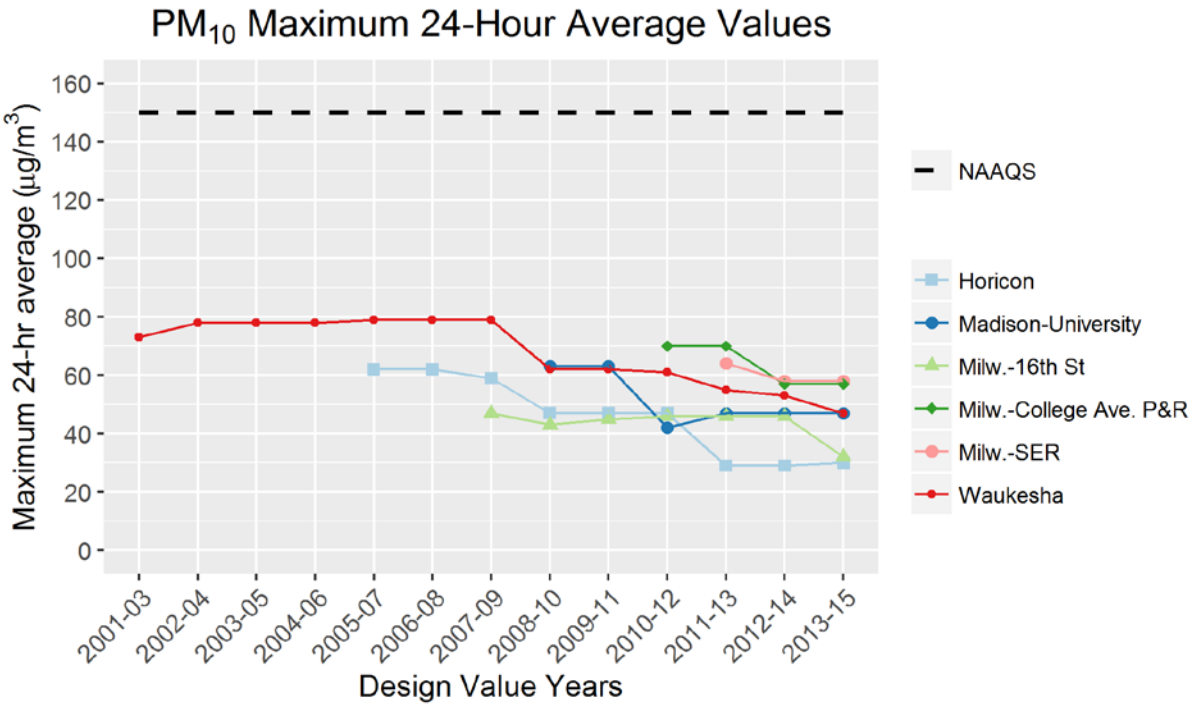


Figure 13. Maximum 24-hr averages of PM_{10} over each 3-yr period. Full site names are found in Appendix C, Table C1.

Some industrial sources in Wisconsin have a requirement in their permit to monitor for inhalable particles. The majority of these sources are industrial sand facilities monitoring for PM_{10}. WDNR quality assures these data and posts them quarterly on a webpage for viewing (http://dnr.wi.gov/topic/Mines/AQSandMap.html).

Sulfur Dioxide

Figure 14 shows WDNR SO_2 monitoring sites and their most recent 1-hr design values. These data are compared against the 2010 one-hour NAAQS of 75 ppb. In Wisconsin, most SO_2 is produced from combustion at power plants and industrial boilers. In addition, secondary sources include industrial processes such as pulp and paper production.

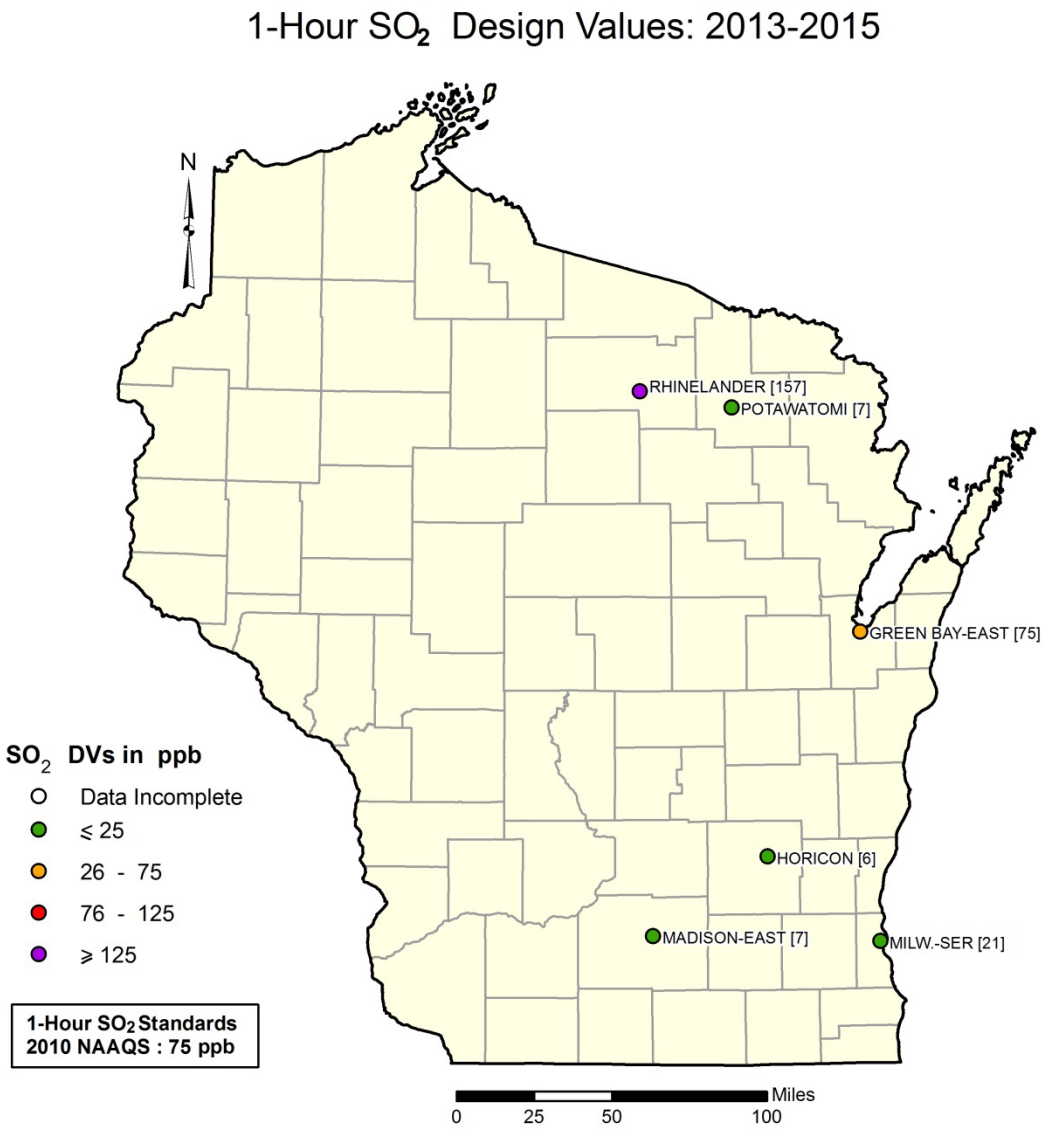


Figure 14. One-hour SO_2 design values for each monitoring site for 2013-2015. Full site names are found in Appendix C, Table C1.

Figure 15 shows 1-hr design values for SO_2 at five of the six monitoring sites. The Madison-East monitoring site is not shown due to the short length of record at the site. Note that SO_2 monitoring was paused at the Milwaukee-SER site from 2007 through 2010 so no design values are available for 2005-2007 through 2010-2012.

The annual and 24-hr SO_2 standards were replaced with a 1-hr standard in 2010. To provide a clearer picture of trends in SO_2 concentrations over time, 1-hr design values were calculated for years prior to 2010, even though the 1-hr design values preceding 2010 were not used to assess NAAQS compliance.

Very low concentrations of SO_2 were observed at the Horicon and Potawatomi sites. Low concentrations were also seen at the Milwaukee-SER site starting in 2011-2013. Design values from the Green Bay-East site were all close to the 2010 one-hour NAAQS and just exceeded the standard in 2012-2014 with a

design value of 76 ppb. Design values at the Rhinelander site have exceeded the NAAQS since the site was established. As a result, a portion of Oneida County is in nonattainment for the 2010 SO_2 standard.

Compared to design values from 2001-2003 (or later based on data availability), values from 2013-2015 increased modestly at two of the sites (5% and 12% for the Rhinelander and Green Bay-East sites, respectively) while decreasing at the remaining three sites. The largest reduction in SO_2 occurred at the Milwaukee-SER site, where design values decreased 69% since monitoring at the site began (Appendix B, Table B5).

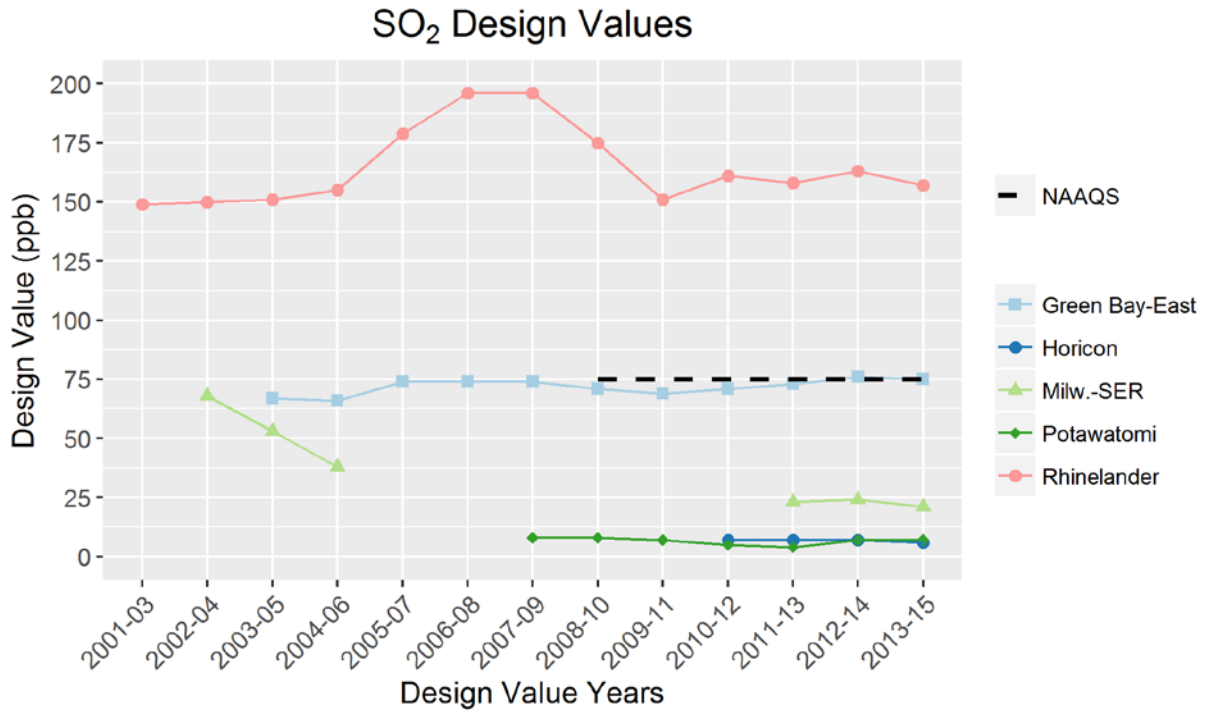


Figure 15. One-hour SO_2 design values. Note that the 75 ppb 1-hr NAAQS was established in 2010, replacing the annual and 24-hr standards. Full site names are found in Appendix C, Table C1.

Nitrogen Dioxide

Three sites measure NO_2 in the WDNR network. Nitrogen dioxide has an annual and a 1-hr NAAQS. The annual design value is based on one year of data, while the 1-hr design value is based on three years of data. Figures 16 and 17 show monitoring sites for NO_2 along with annual and 1-hr design values. Nitrogen dioxide is emitted by all combustion sources, including vehicles, home and commercial heating systems, and power plants.

WDNR also monitors NO_2 at the Manitowoc site during the summer months (June-August) as part of the Photochemical Assessment Monitoring Stations (PAMS) network. However, due to the shorter monitoring period, these values cannot be used to determine compliance with the NAAQS and are not included in this document.

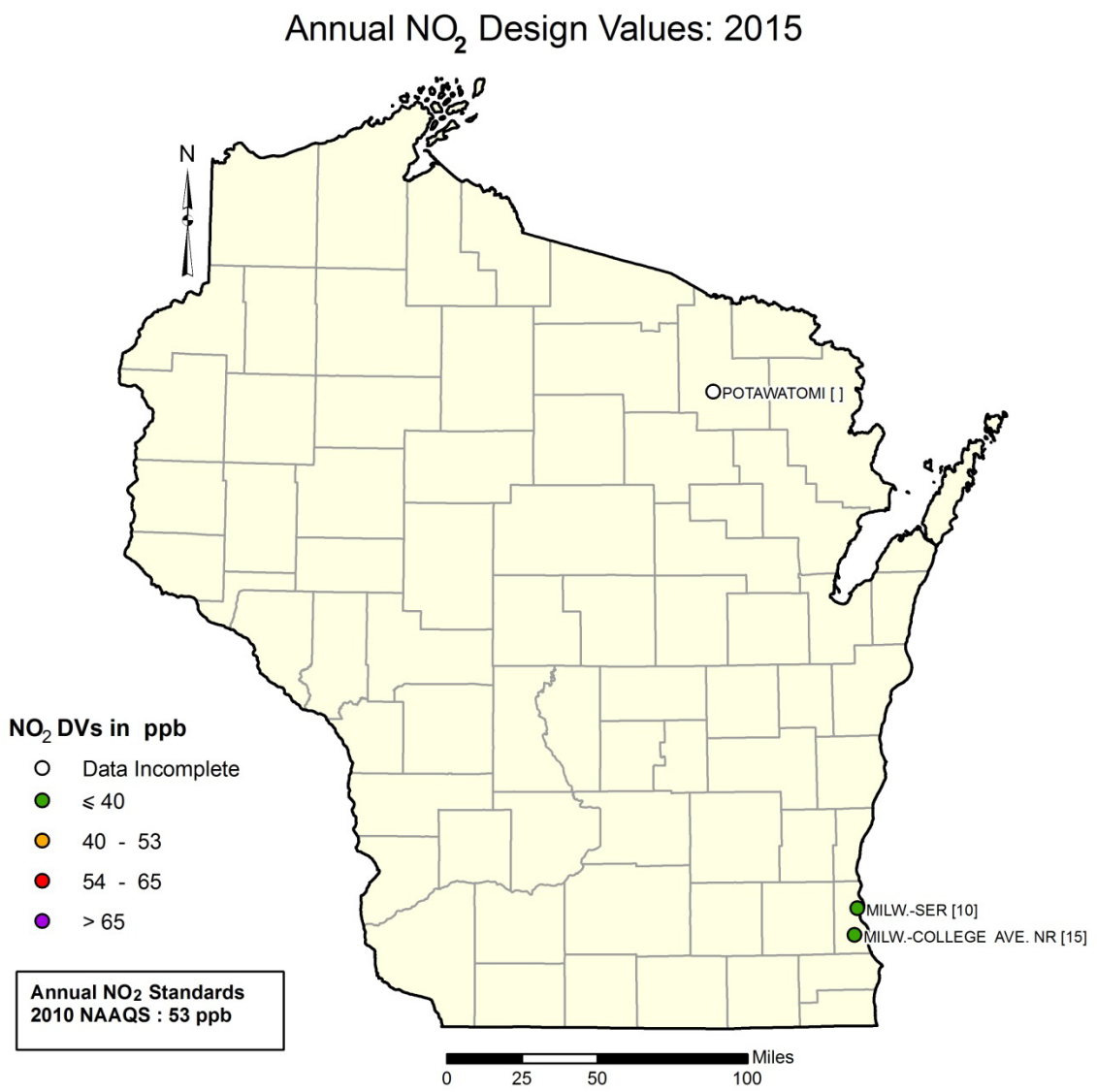


Figure 16. Annual NO_2 design values for each monitoring site for 2015. Full site names are found in Appendix C, Table C1.

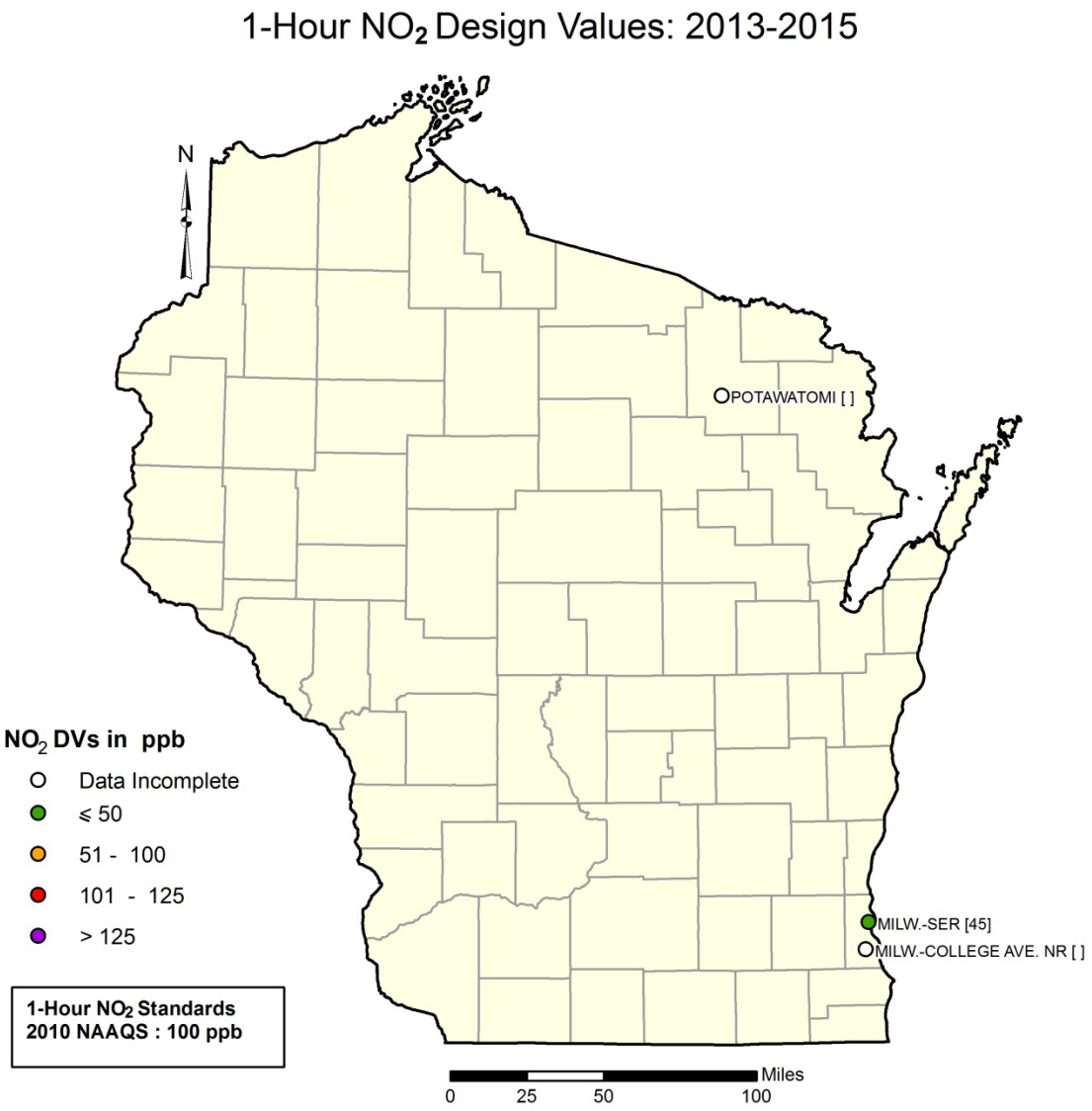


Figure 17. One-hour NO_2 design values for each monitoring site for 2013- 2015. Full site names are found in Appendix C, Table C1.

Figure 18 shows annual and 1-hr NO_2 design values. The Milwaukee-College Avenue Near Road site is not shown due to the short length of record at the site; however, recent trends and additional information about this site can be found at http://dnr.wi.gov/topic/airquality/monitor.html.

Overall, monitored levels of NO_2 were very low. The annual design values at the Milwaukee-SER site decreased over time, showing a reduction of 33% between 2006 and 2015 (Appendix B, Table B6). One-hour design values at the Milwaukee-SER site have begun to decline again after remaining steady for the previous few years. The 1-hr design values decreased 13% between 2004-2006 and 2013-2015 (Appendix B, Table B7).

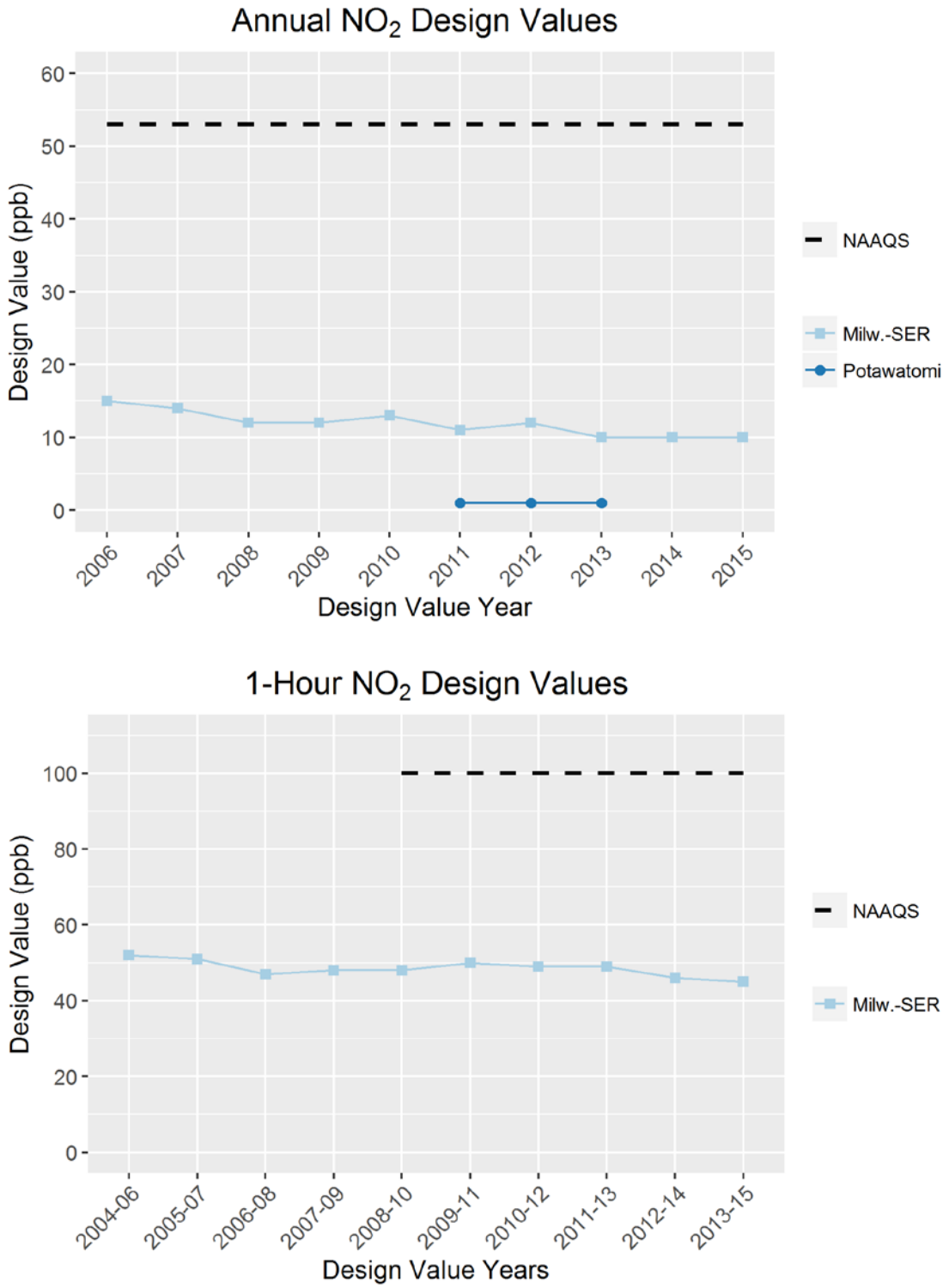


Figure 18. Annual (top) and 1-hr (bottom) design values for NO_2. Full site names are found in Appendix C, Table C1.

Lead

Lead is measured for comparison to the NAAQS at a monitoring site in the town of Kohler (Fig. 19) using two filter-based monitors operating at frequencies of 1-in-6 days and 1-in-12 days. Lead is emitted primarily as the result of industrial processes such as metallic processing, power production, and waste incineration. The NAAQS is based on a rolling 3-mo average, which is not to exceed 0.15 μg/m^3. The design value is expressed as the maximum 3-mo average over a 3-yr period. All 3-mo average values at the Kohler site meet the lead NAAQS. While the design value for the Kohler site could be computed for 2012-2014 and 2013-2015 (Fig. 19), values from previous years were not valid. As a result, we do not show a trend line for this site.

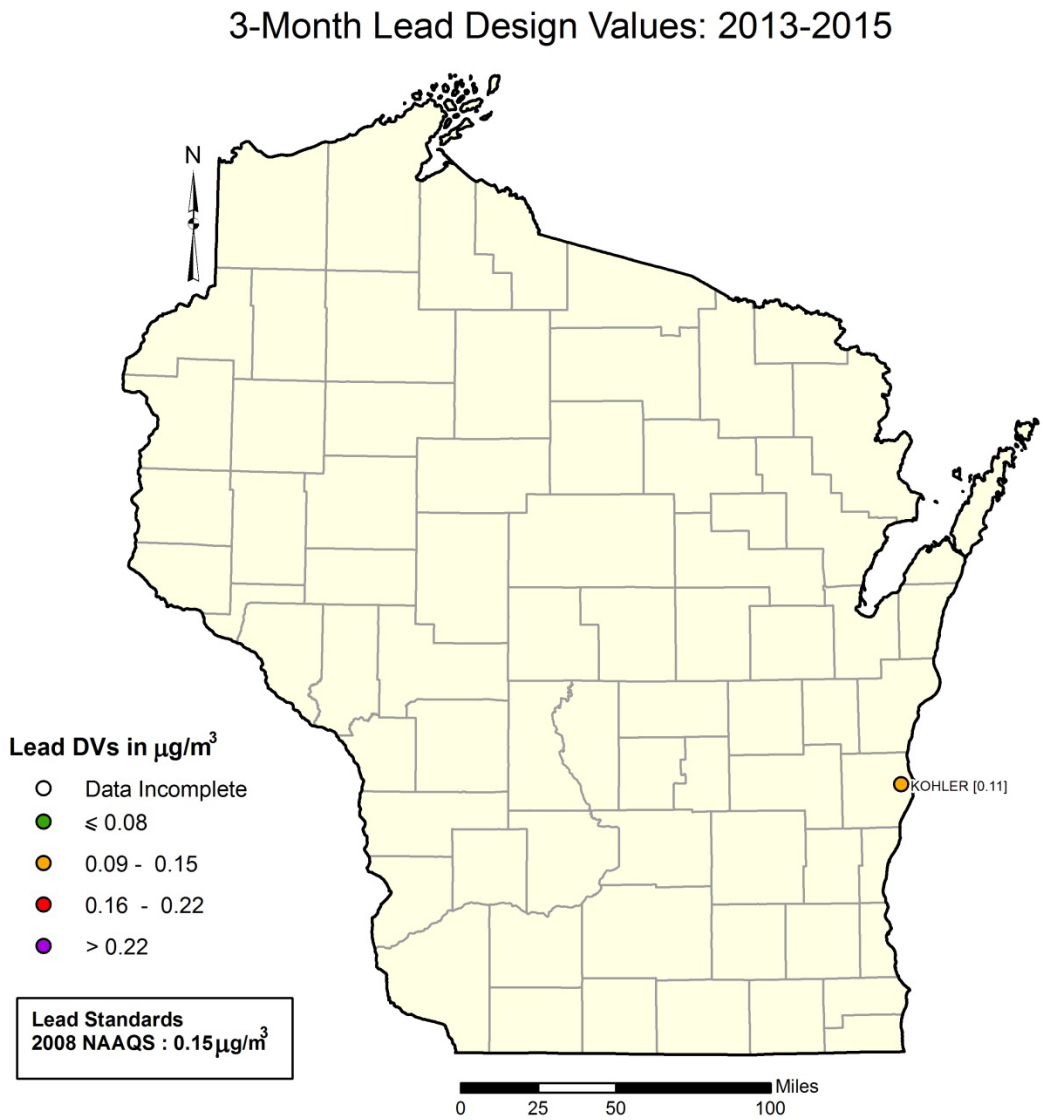


Figure 19. Three-month lead design values for each monitoring site for 2013-2015. Full site names are found in Appendix C, Table C1.

WDNR also monitors lead at the Horicon and Milwaukee-16th St. sites as part of the National Air Toxics Trends Stations (NATTS) network and Urban Air Toxics program, respectively. The fraction of particles

monitored for lead at these sites (i.e., PM_{10}), however, differs from that required for lead criteria pollutant monitoring (i.e., TSP). As a result of this difference, the lead data from the Horicon and Milwaukee-16th St. sites cannot be used to determine compliance with the NAAQS and are not included in this document.

Carbon Monoxide

Carbon monoxide is monitored at two sites in the WDNR network. Design values are compared against an 8-hr and a 1-hr NAAQS (Fig.s 20 and 21, respectively). Both design values are based on one year of data.

The main source of CO is motor vehicle emissions. As a result, higher concentrations will be observed in urban areas. Nationwide, levels of this pollutant have decreased over the past two decades with the help of emission control technologies. Consequently, no areas currently violate federal standards.

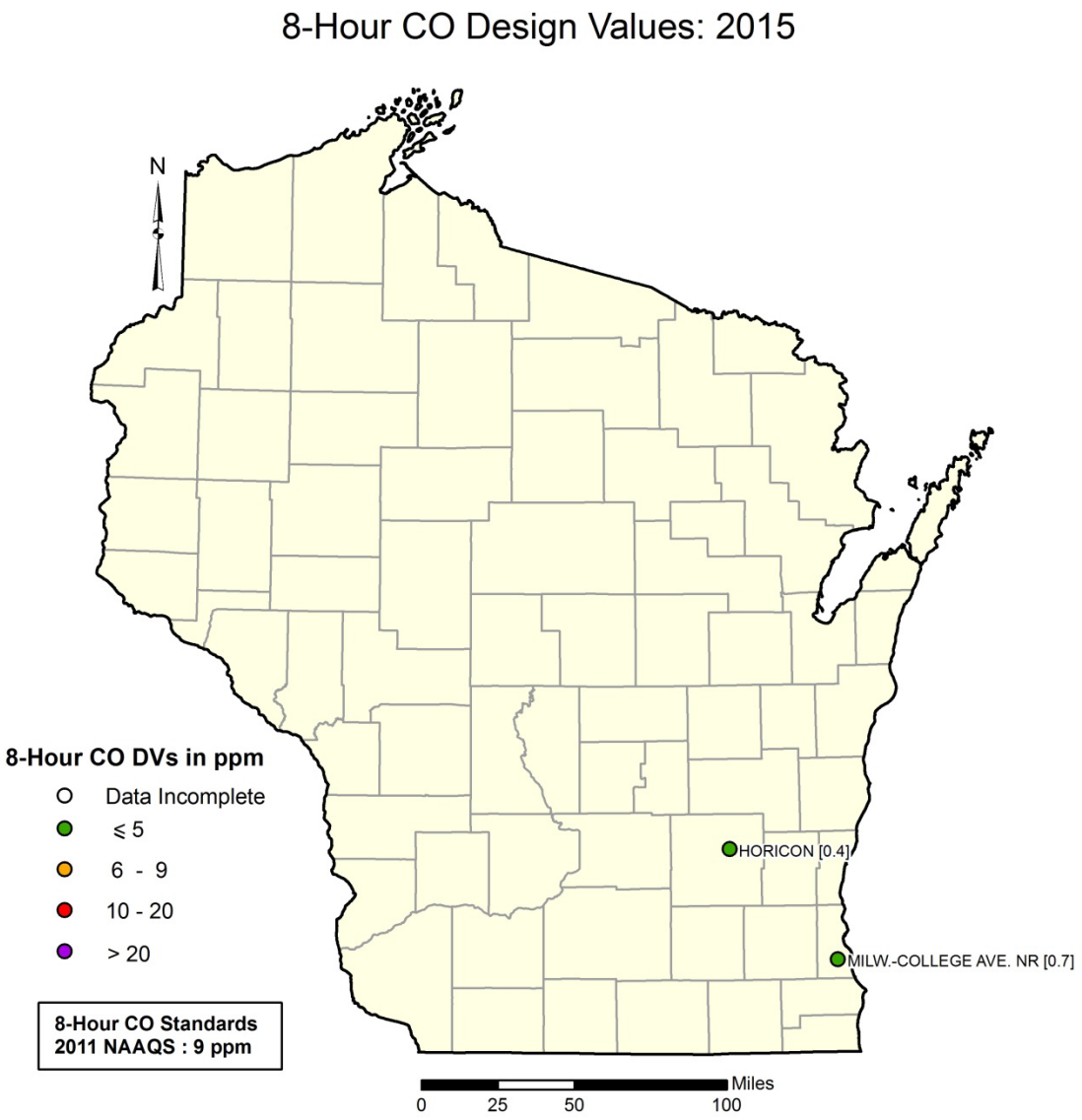


Figure 20. Eight-hour CO design values for each monitoring site for 2015. Full site names are found in Appendix C, Table C1.

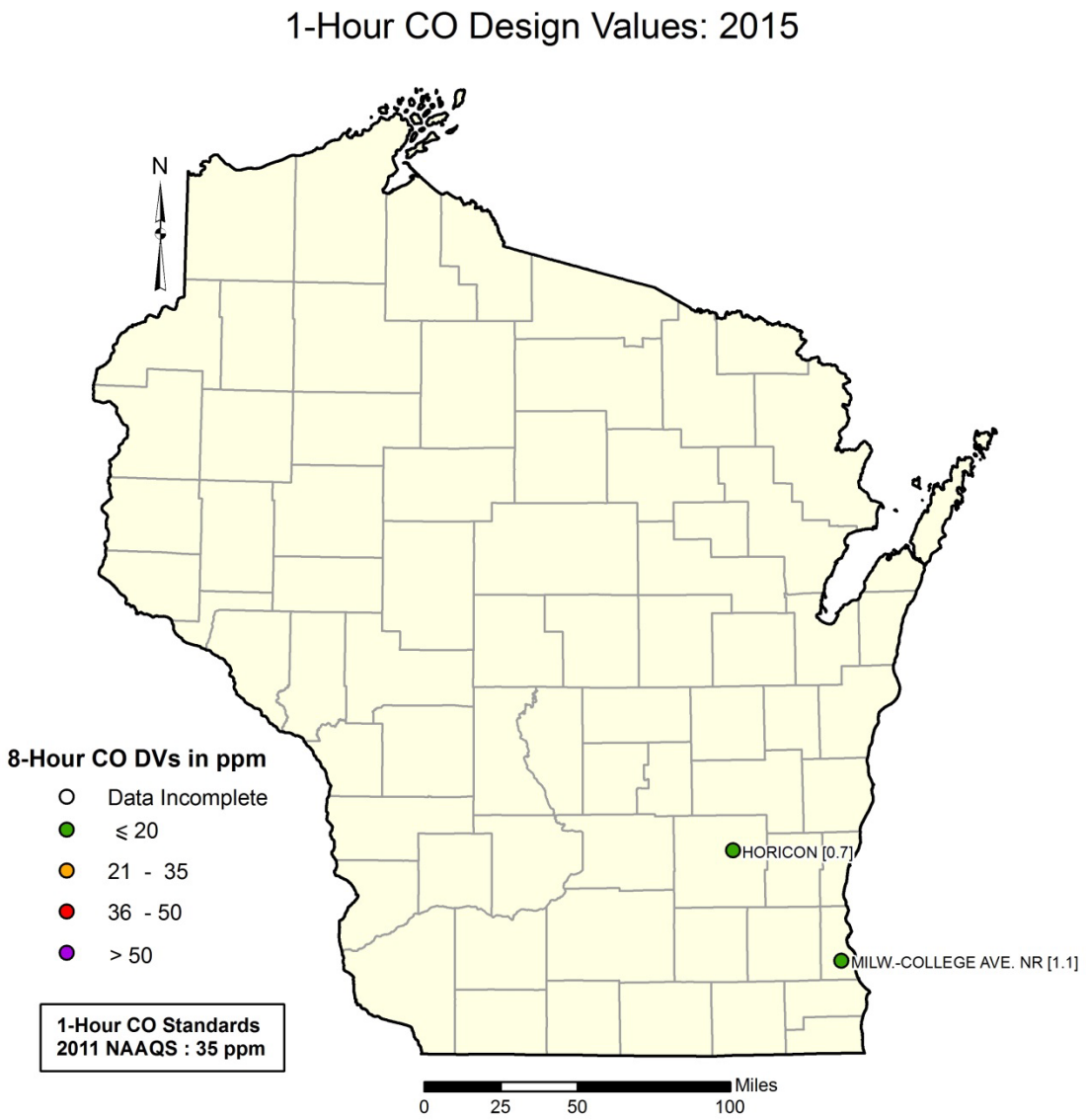


Figure 21. One-hour CO design values for each monitoring site for 2015. Full site names are found in Appendix C, Table C1.

Figure 22 shows 8-hr and 1-hr CO design values at the Horicon site. The Milwaukee-College Avenue Near Road site is not shown due to the short length of record at the site. Values at Horicon were extremely low, almost indistinguishable from zero (Appendix B, Table B8).

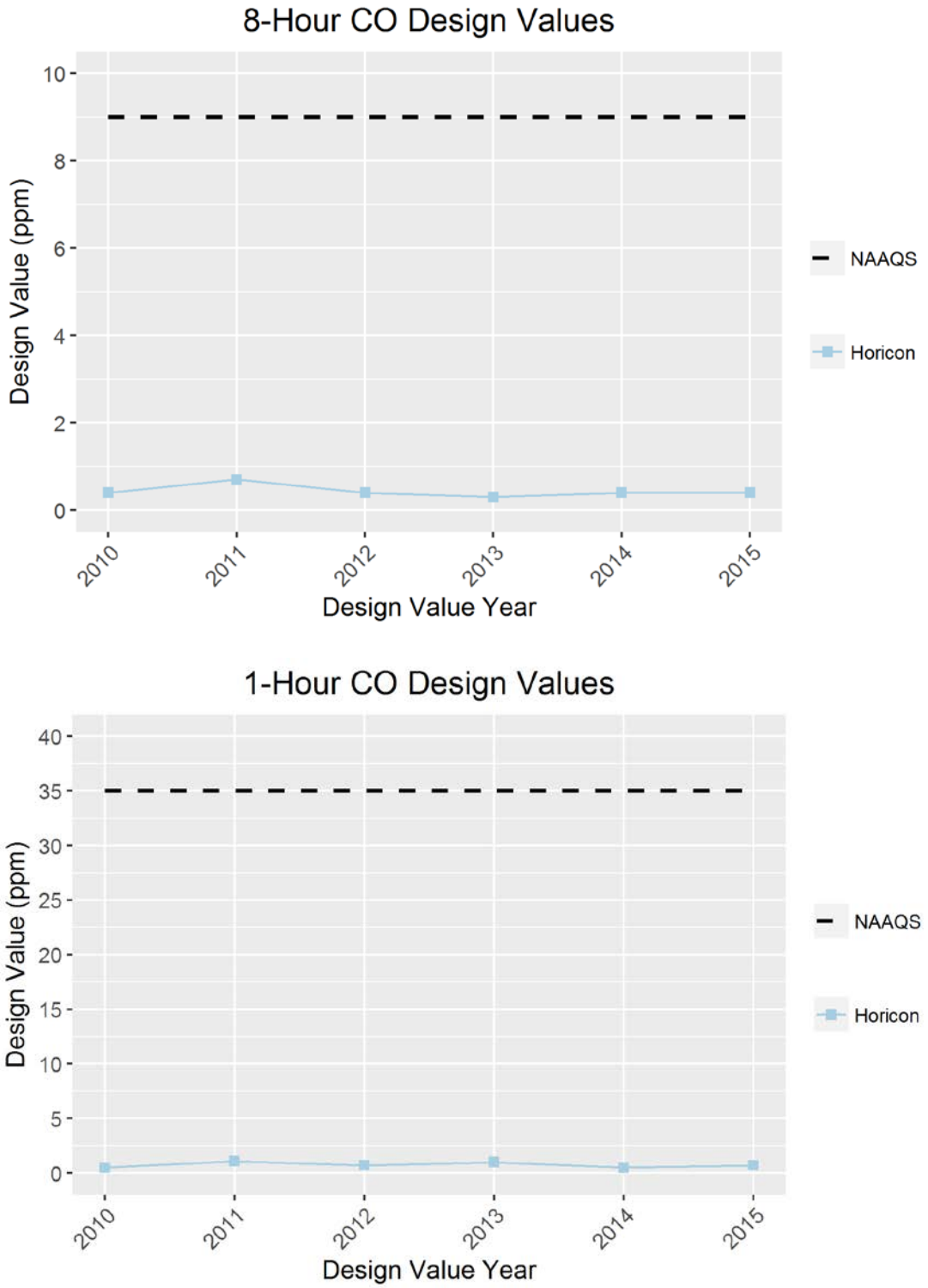
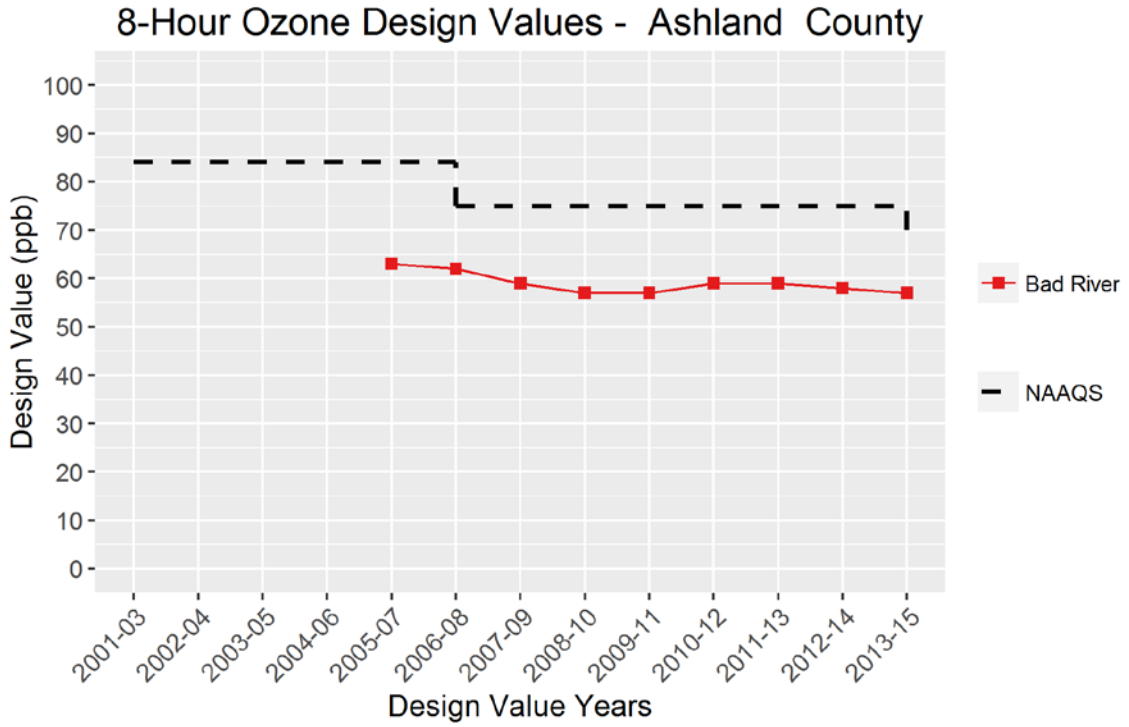


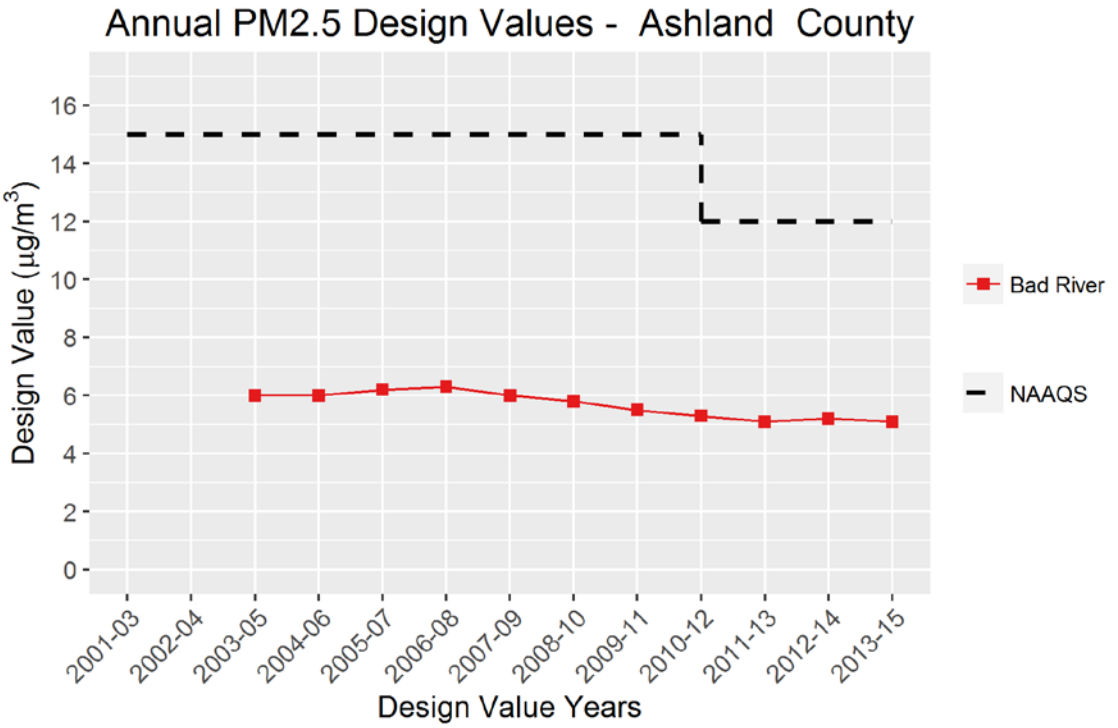
Figure 22. Eight-hour (top) and 1-hr (bottom) design values for CO at Horicon. Full site names are found in Appendix C, Table C1.

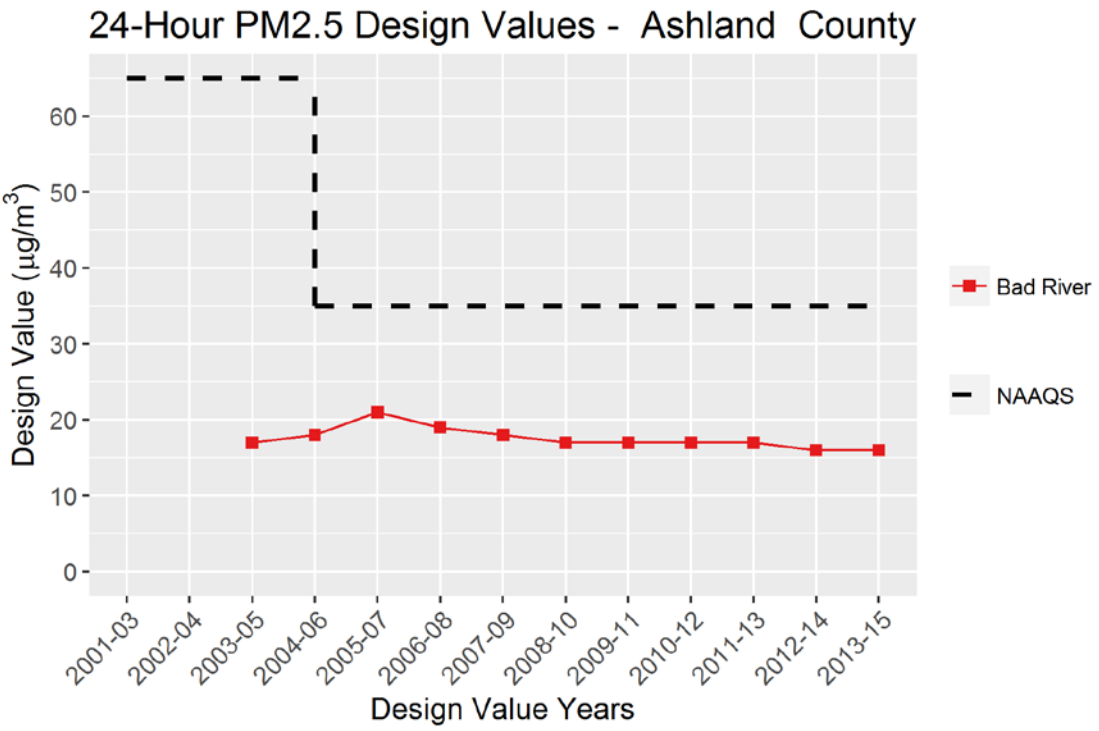
Appendix A. – Air Quality by County

Ashland County

Sampling for ozone and $PM_{2.5}$ is conducted at the Bad River Tribal School which is located at 10 Birch Street in Odanah.

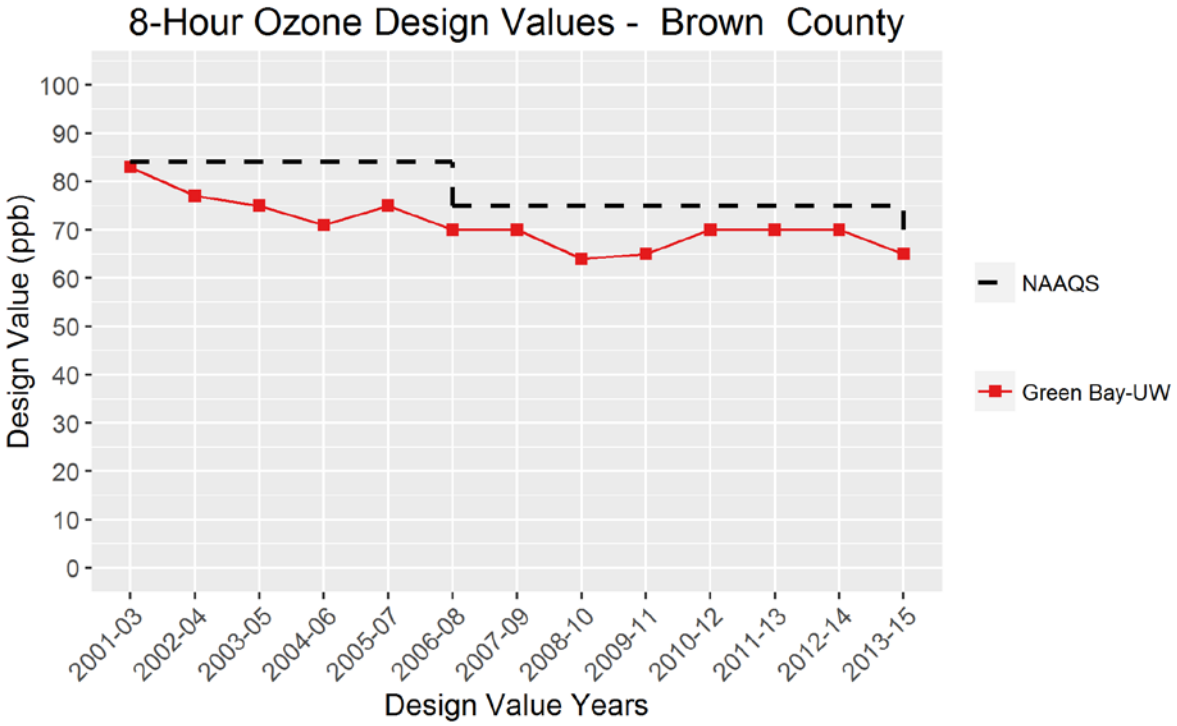


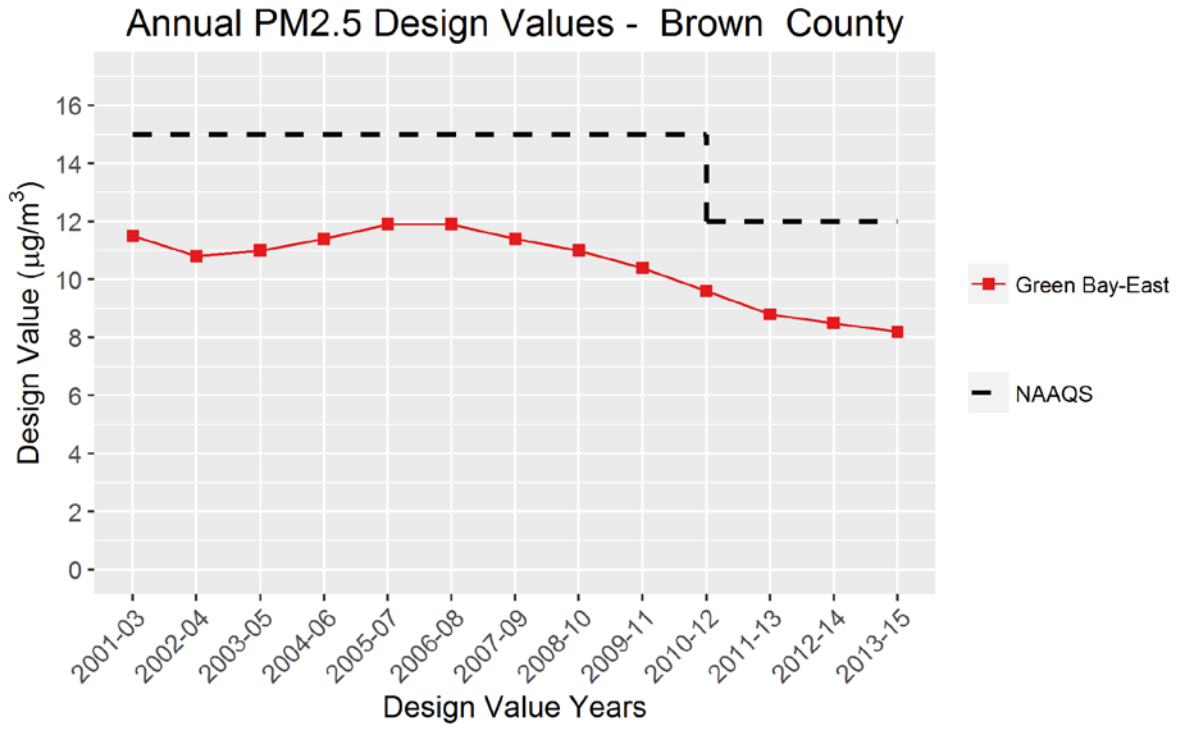


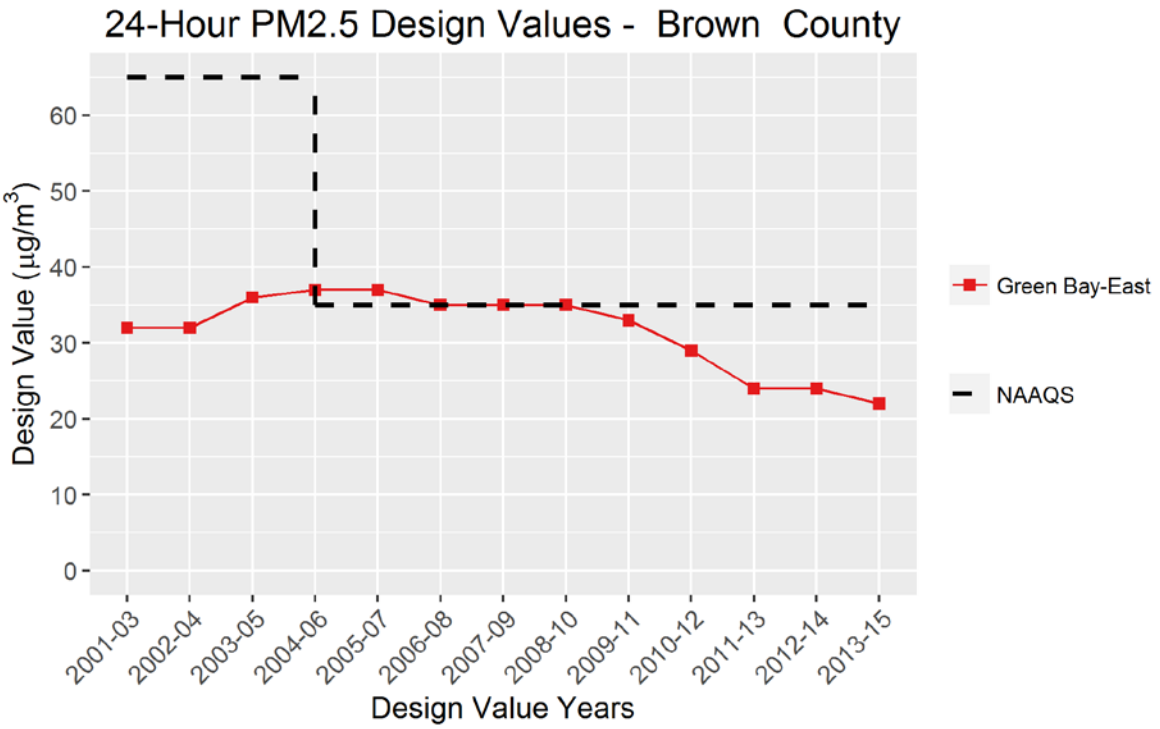

24-Hour PM2.5 Design Values - Ashland County
Design Value (µg/m3)
60
50
40
30
20
10
0
2001-03
2002-04
2003-05
2004-06
2005-07
2006-08
2007-09
2008-10
2009-11
2010-12
2011-13
2012-14
2013-15
Design Value Years
Bad River
NAAQS

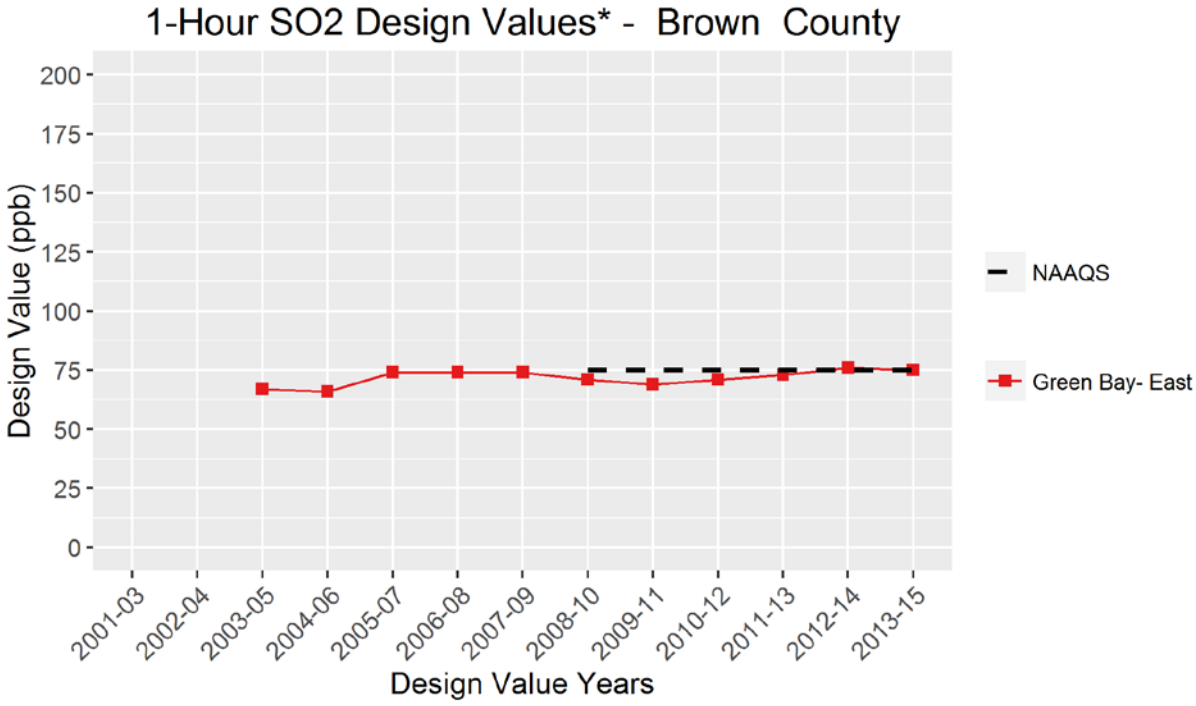
Brown County

Ozone monitoring in Brown County takes place north of Highways 54 & 57 east of the University of Wisconsin–Green Bay campus. Sampling for $PM_{2.5}$ and SO_2 is conducted at Green Bay East High School, located at 1415 East Walnut Street.





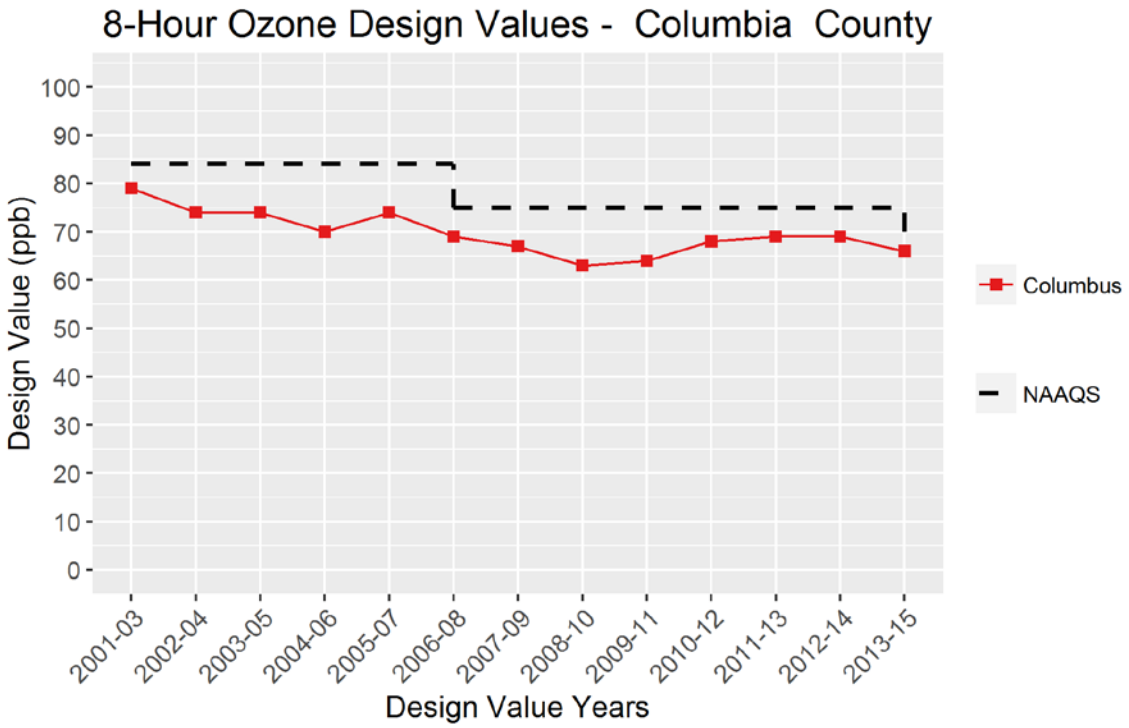




*In 2010, EPA established a 1-hr SO_2 standard that replaced the previous annual and 24-hr standards.

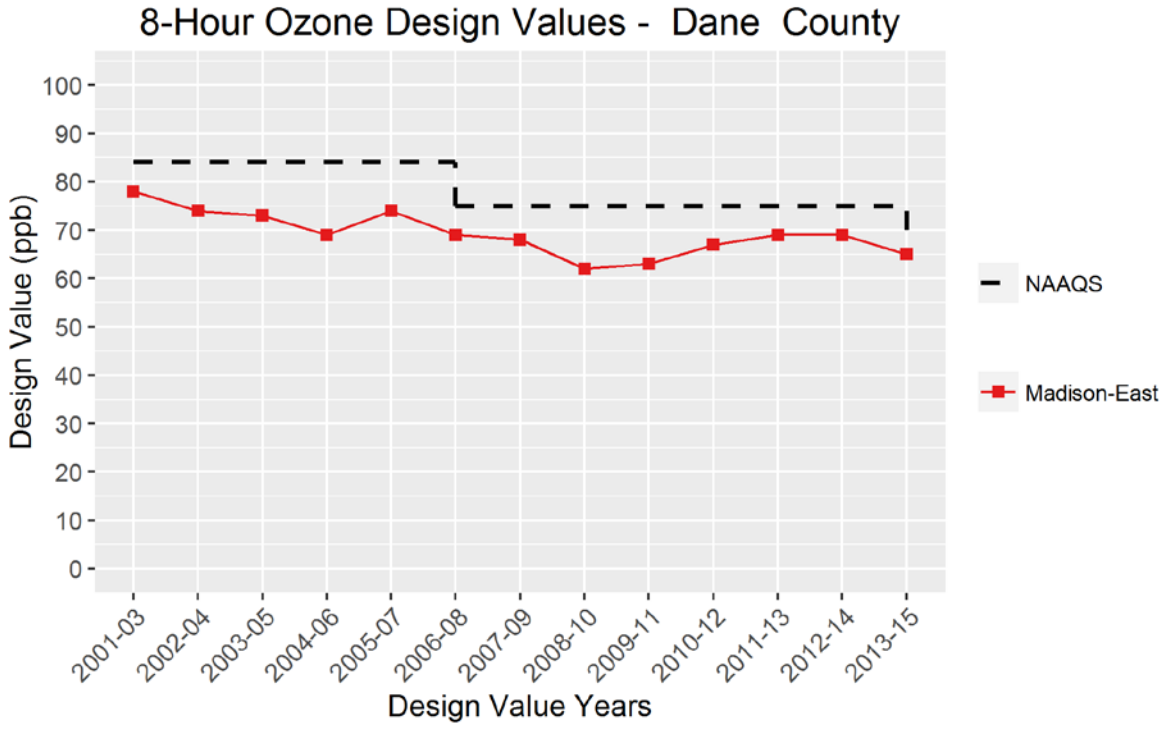
Columbia County

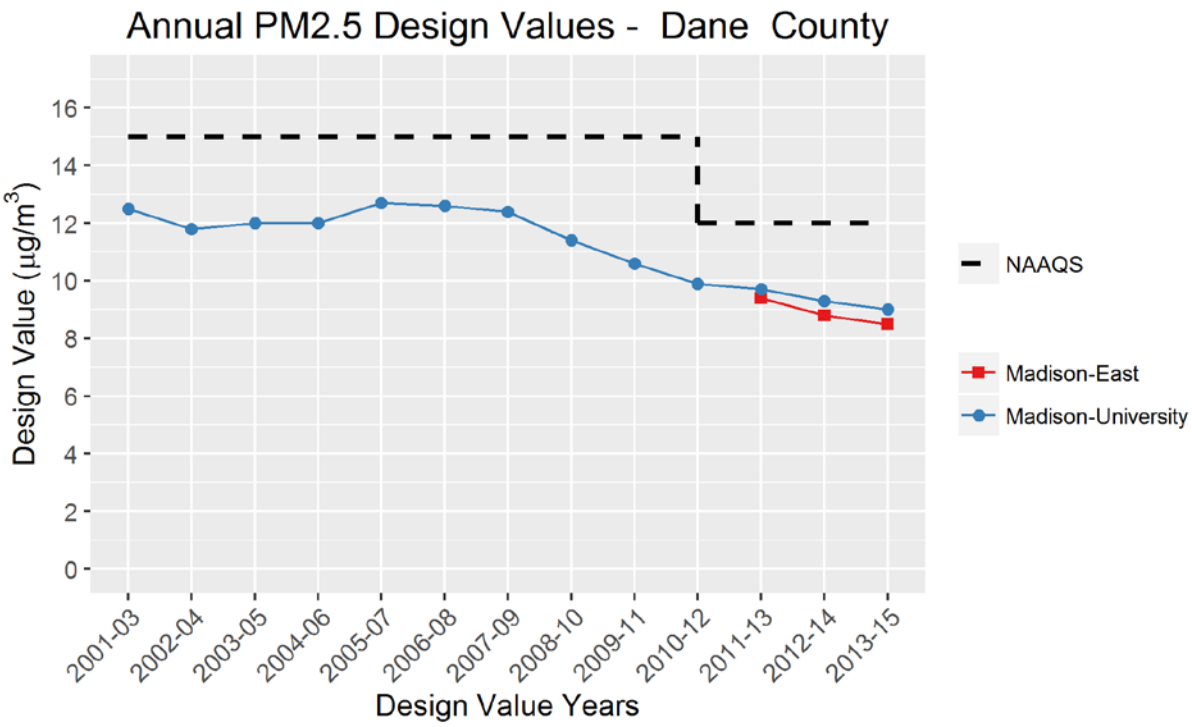
Ozone monitoring in Columbia County takes place at N 1045 Wendt Road, a rural location in Columbus Township. The ozone monitor serves as the downwind ozone instrument in the Madison Core Based Statistical Area.

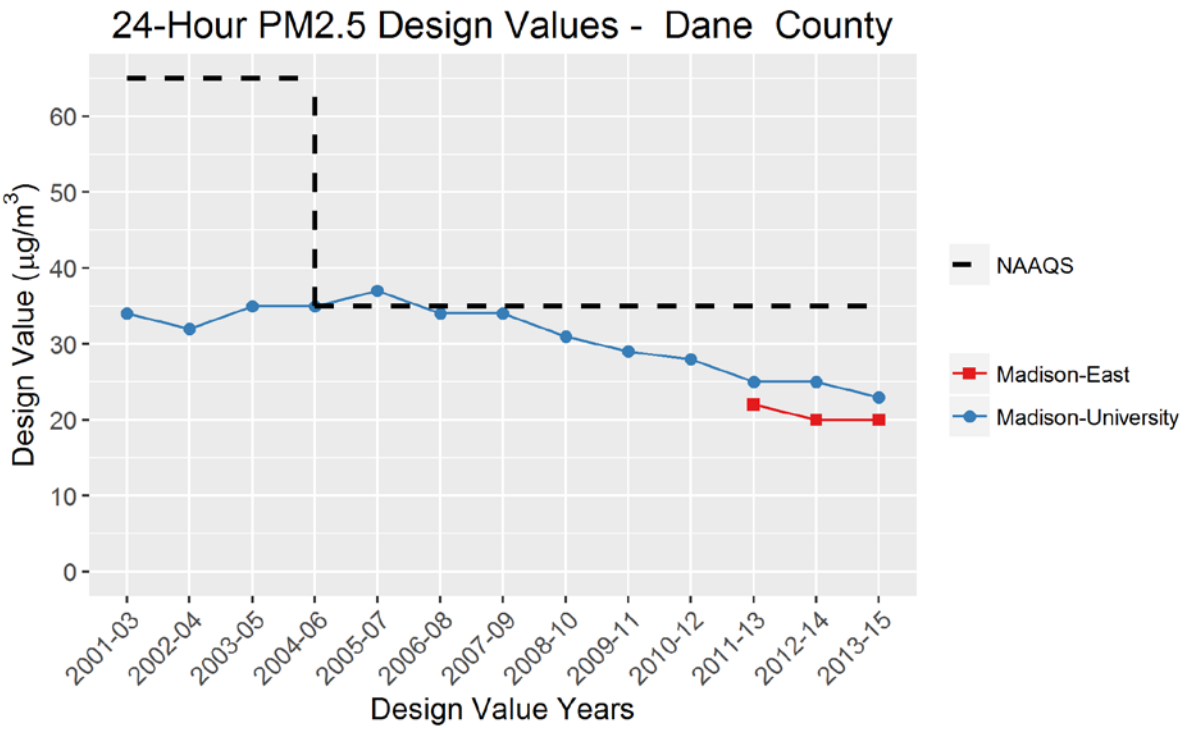


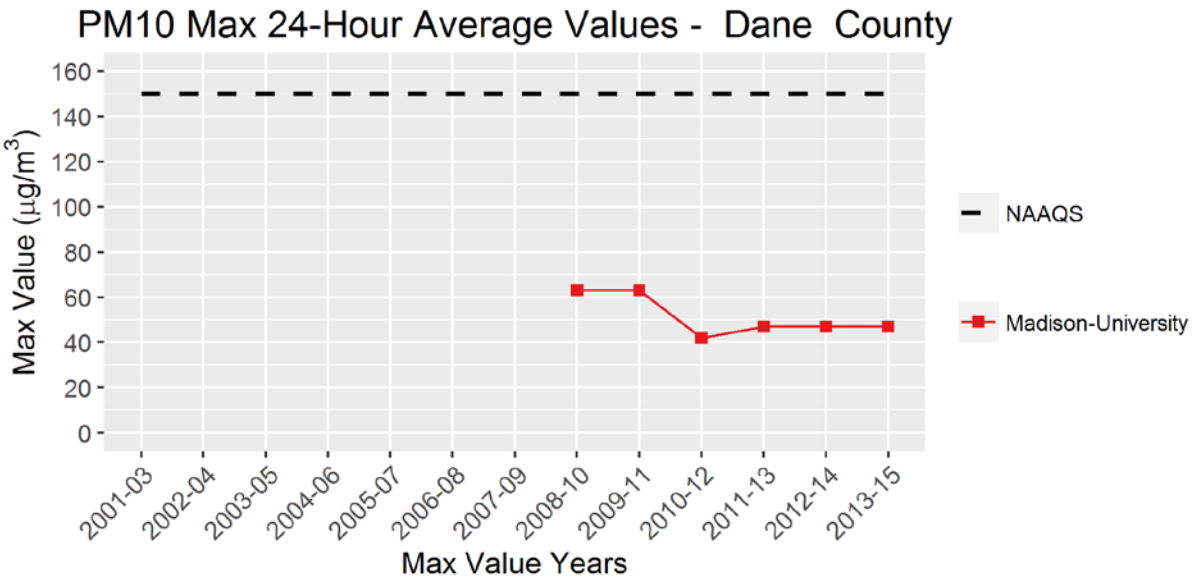
Dane County

Ozone monitoring in Dane County takes place at Madison East High School located at 2302 North Hoard Street next to the Madison East High School sports field. Fine particles are monitored at both the Madison-East site and the Madison-University Avenue site located at 2757 University Avenue. Monitoring of PM_{10} takes place at the Madison-University Avenue site only. Sulfur-dioxide monitoring restarted at the Madison-East site in 2013. Due to the short record, a graph for SO_2 is not included.



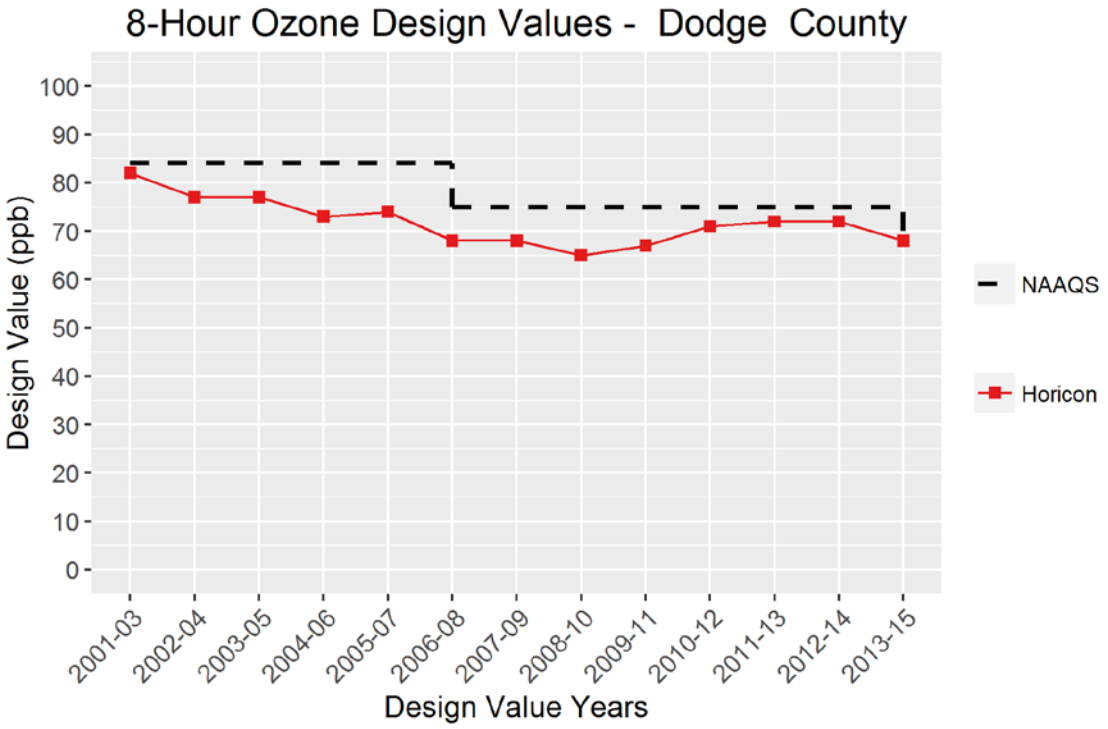


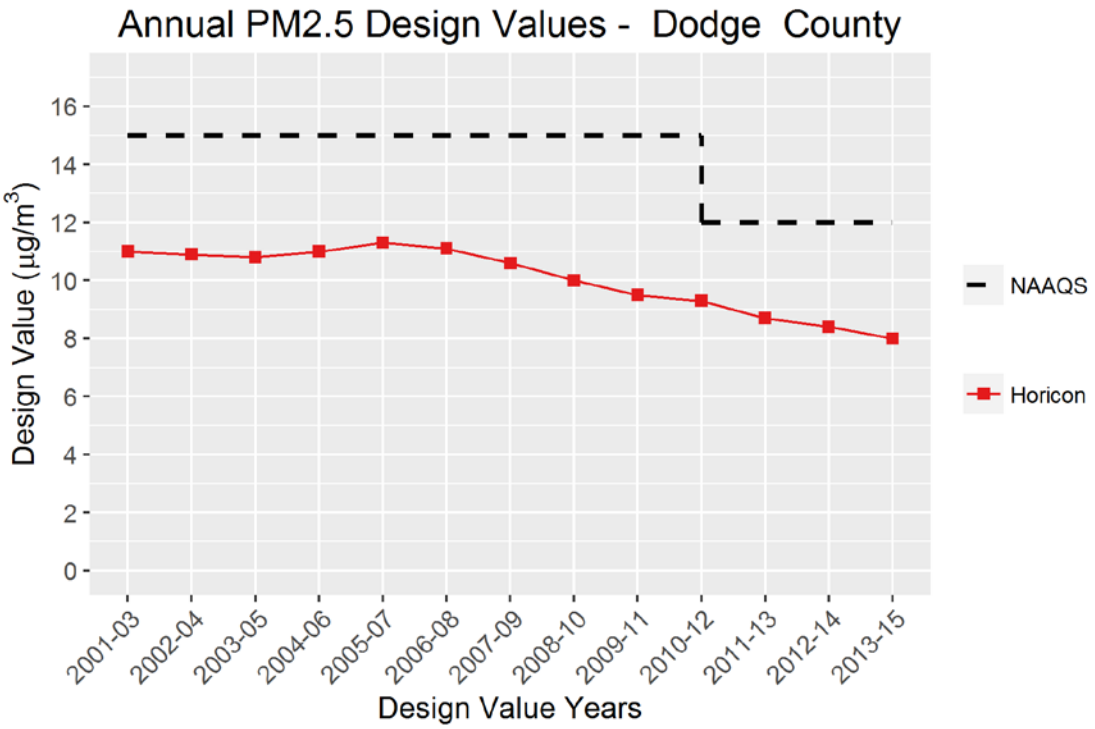

24-Hour PM2.5 Design Values - Dane County
Design Value (µg/m3)
0
10
20
30
40
50
60
2001-03
2002-04
2003-05
2004-06
2005-07
2006-08
2007-09
2008-10
2009-11
2010-12
2011-13
2012-14
2013-15
Design Value Years
NAAQS
Madison-East
Madison-University

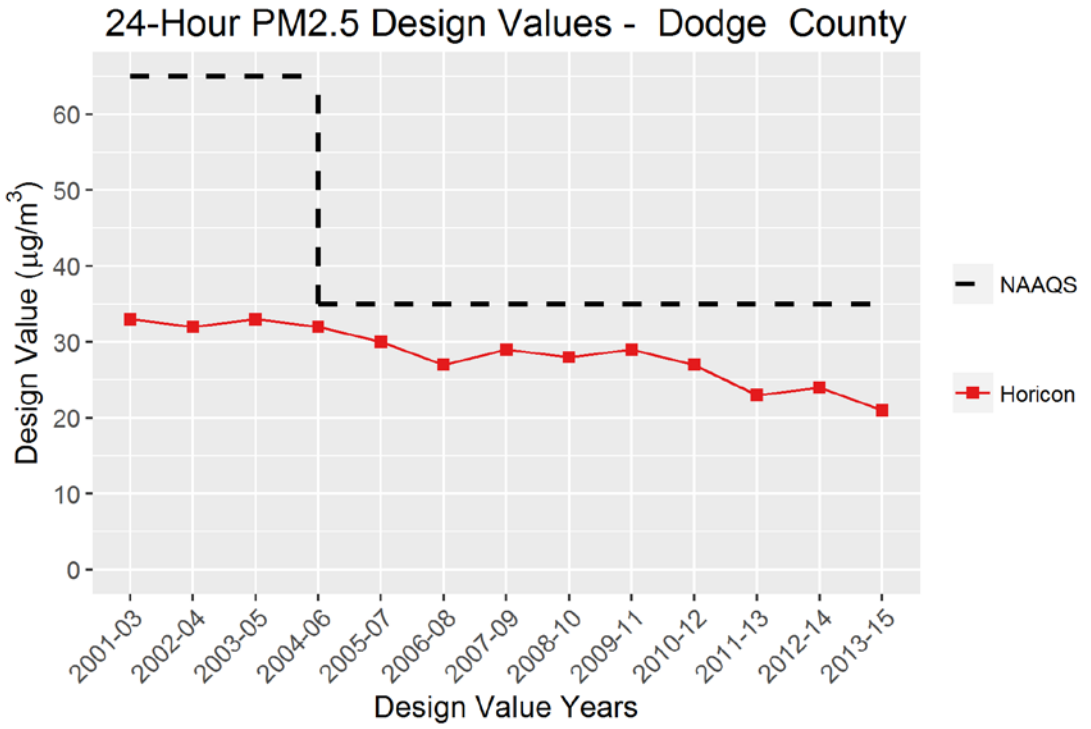

PM10 Max 24-Hour Average Values - Dane County
Max Value (µg/m3)
0
20
40
60
80
100
120
140
160
2001-03
2002-04
2003-05
2004-06
2005-07
2006-08
2007-09
2008-10
2009-11
2010-12
2011-13
2012-14
2013-15
Max Value Years
NAAQS
Madison-University

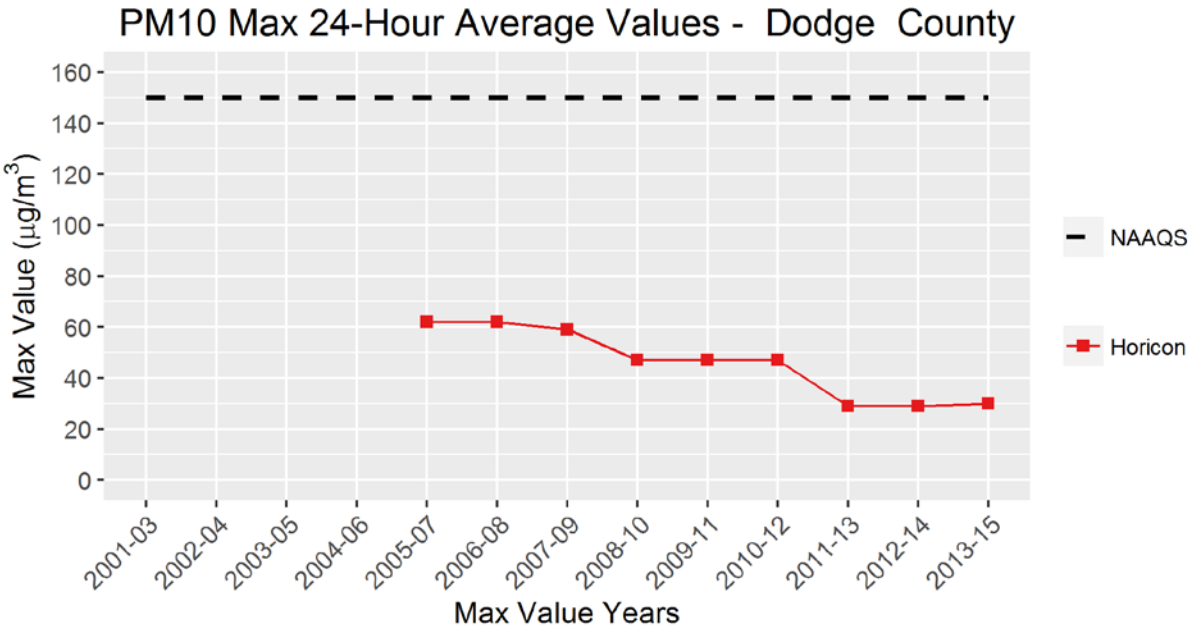
Dodge County

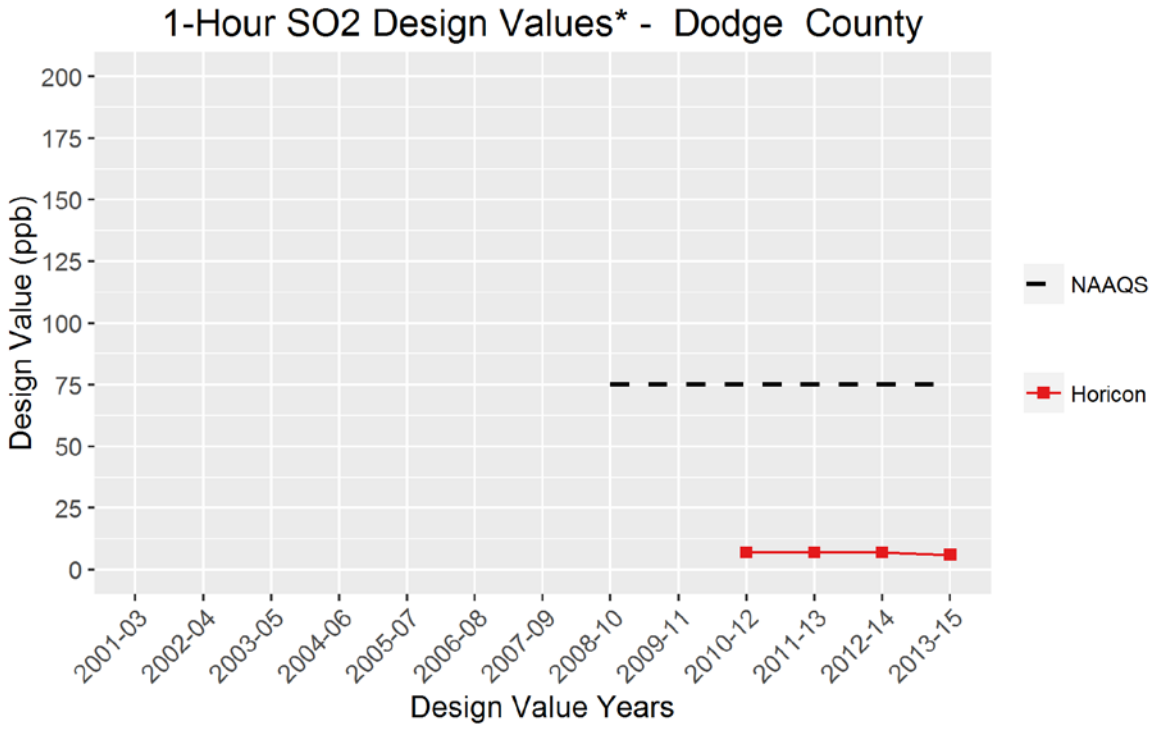
Monitoring for ozone, $PM_{2.5}$, PM_{10}, SO_2, and CO in Dodge County is conducted at the Horicon Wildlife Area located at 1210 North Palmatory Street. The Horicon site began sampling for ozone on January 22, 2010 and for 24-hr $PM_{2.5}$ on December 18, 2009. Prior to these dates, sampling in Dodge County was performed at a site near Mayville. Data from both sites are used to calculate design values for 2008-2010, 2009-2011, and 2010-2012.



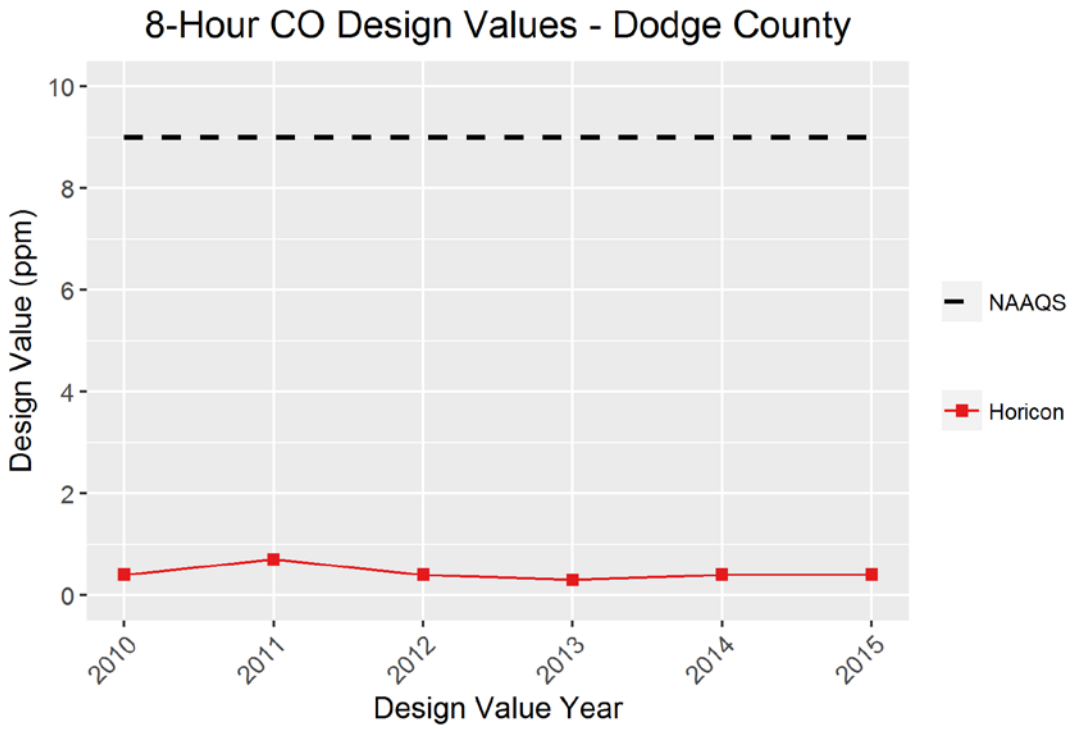

Annual PM2.5 Design Values - Dodge County
Design Value (µg/m3)
16
14
12
10
8
6
4
2
0
2001-03
2002-04
2003-05
2004-06
2005-07
2006-08
2007-09
2008-10
2009-11
2010-12
2011-13
2012-14
2013-15
Design Value Years
NAAQS
Horicon

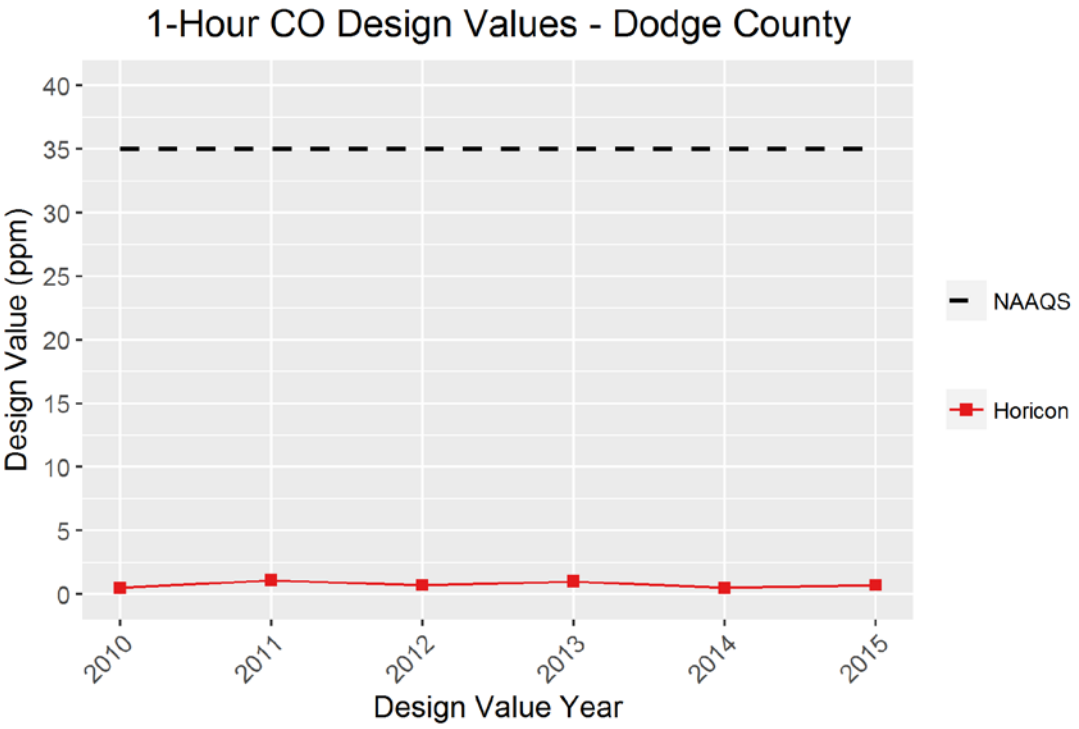

24-Hour PM2.5 Design Values - Dodge County
Design Value (µg/m3)
60
50
40
30
20
10
0
2001-03
2002-04
2003-05
2004-06
2005-07
2006-08
2007-09
2008-10
2009-11
2010-12
2011-13
2012-14
2013-15
Design Value Years
NAAQS
Horicon





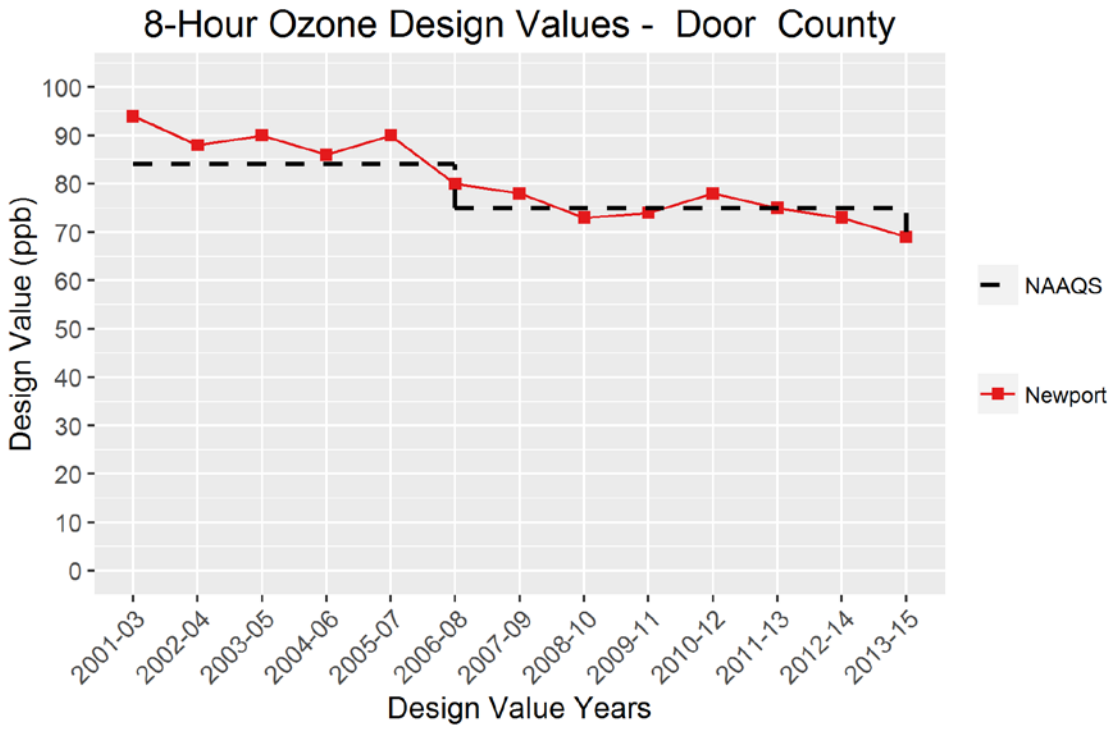
*In 2010, EPA established a 1-hr SO_2 standard that replaced the previous annual and 24-hr standards.


8-Hour CO Design Values - Dodge County
Design Value (ppm)
10
8
6
4
2
0
2010
2011
2012
2013
2014
2015
Design Value Year
NAAQS
Horicon


1-Hour CO Design Values - Dodge County
Design Value (ppm)
40
35
30
25
20
15
10
5
0
2010
2011
2012
2013
2014
2015
Design Value Year
NAAQS
Horicon

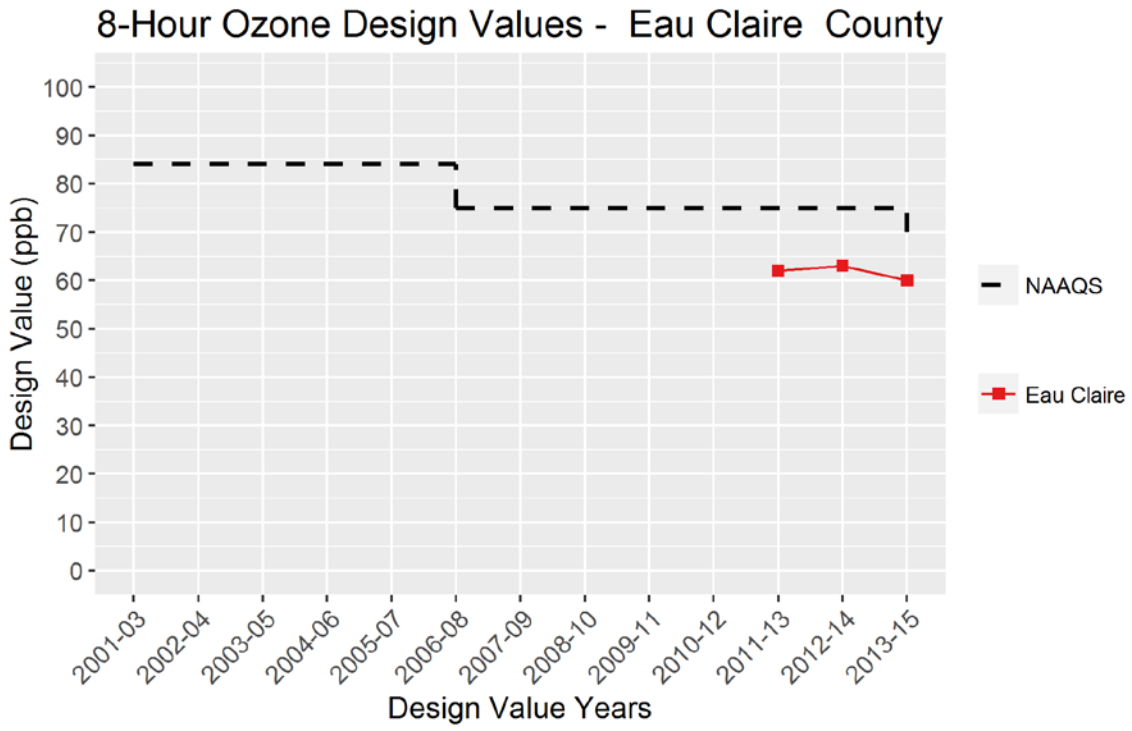
Door County

Ozone monitoring in Door County takes place at Newport State Park at 475 County Trunk Highway NP in Ellison Bay. The site is located inside the state park.



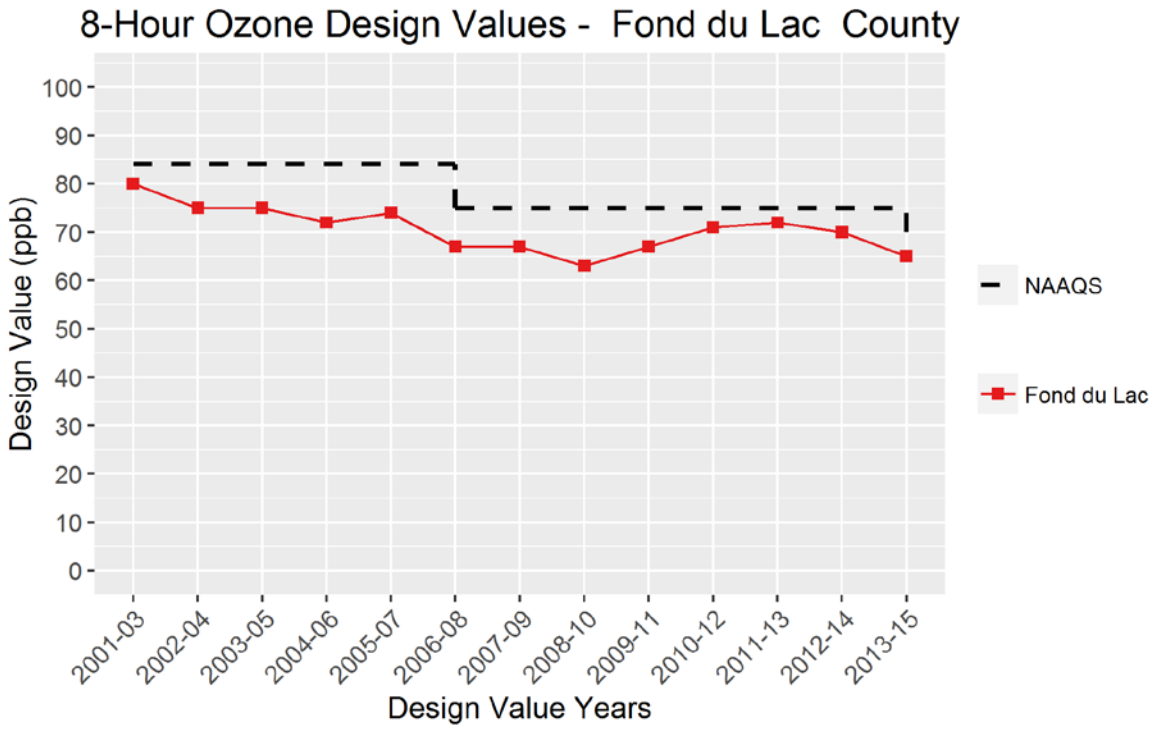
Eau Claire County

Ozone and $PM_{2.5}$ monitoring in Eau Claire County take place in a grassy clearing near the Department of Transportation Sign Shop located at 5509 Highway 53 South on the outskirts of Eau Claire. Monitoring at this site began April 1, 2011. Because the ozone monitoring season for 2011 started on April 15th, there was a complete season of data for ozone , resulting in sufficient data to meet the minimum criteria to create a graph. In contrast, the $PM_{2.5}$ monitoring season for 2011 began on January 1, resulting in incomplete data for the year and insufficient data to produce a graph for fine particles.



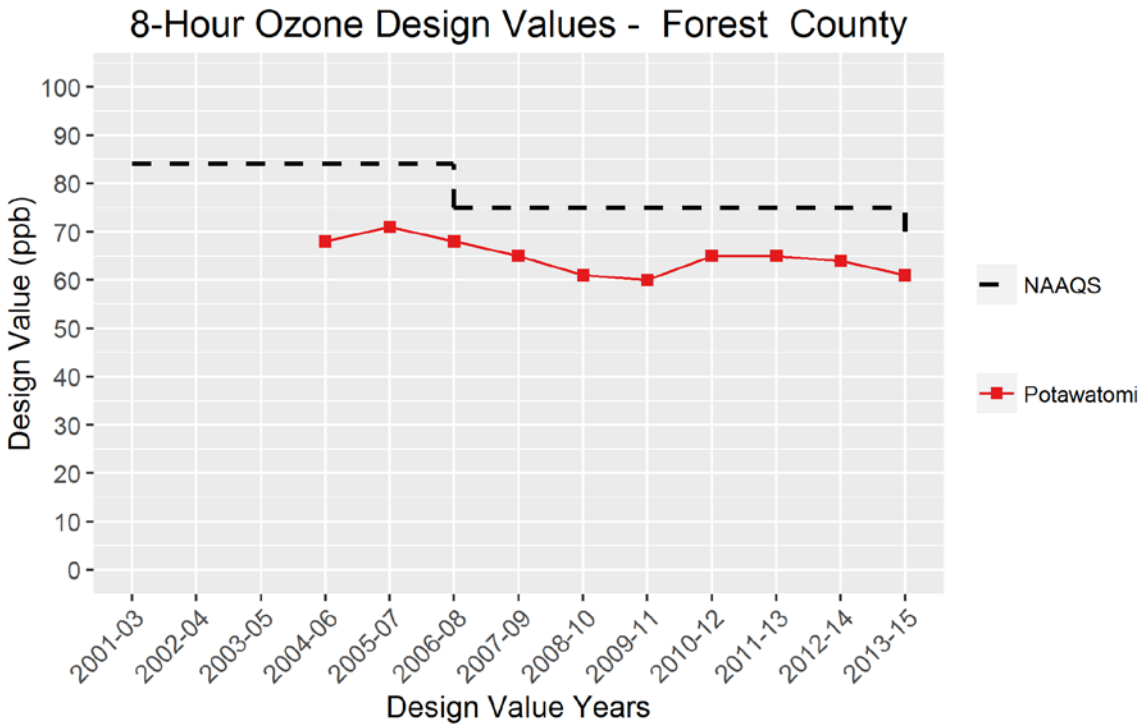
Fond du Lac County

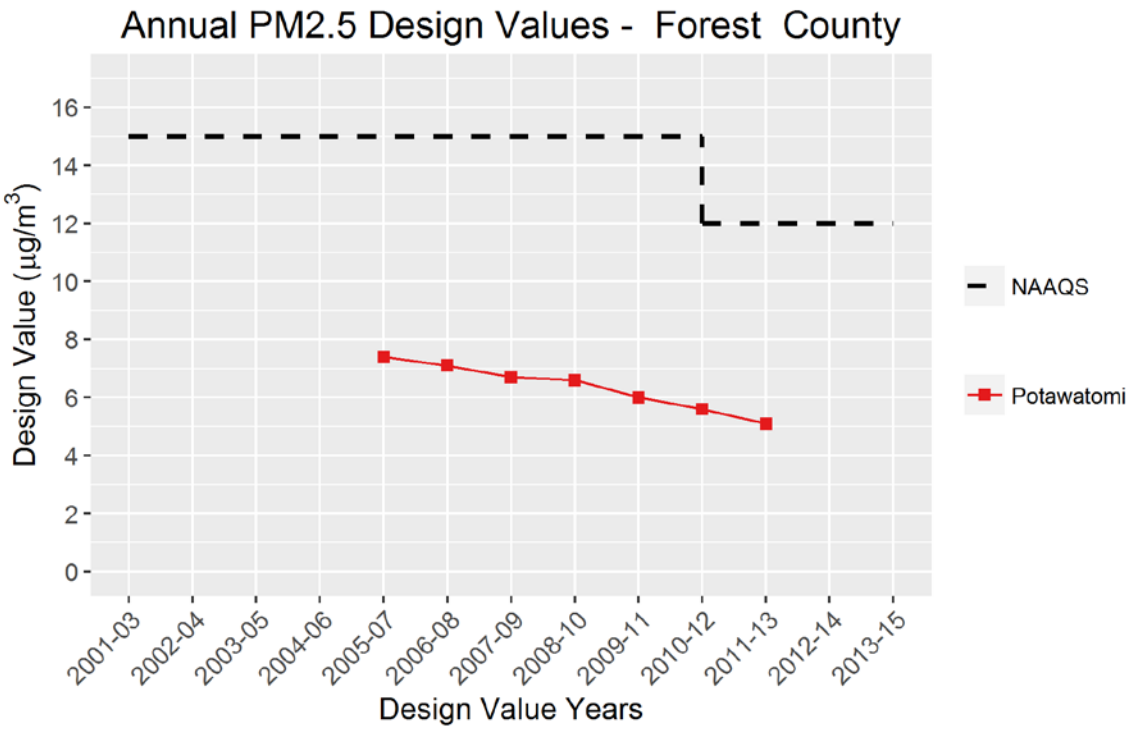
Ozone monitoring in Fond du Lac County is performed at N3996 Kelly Road in the Town of Byron. The site is located at the edge of a farm field.

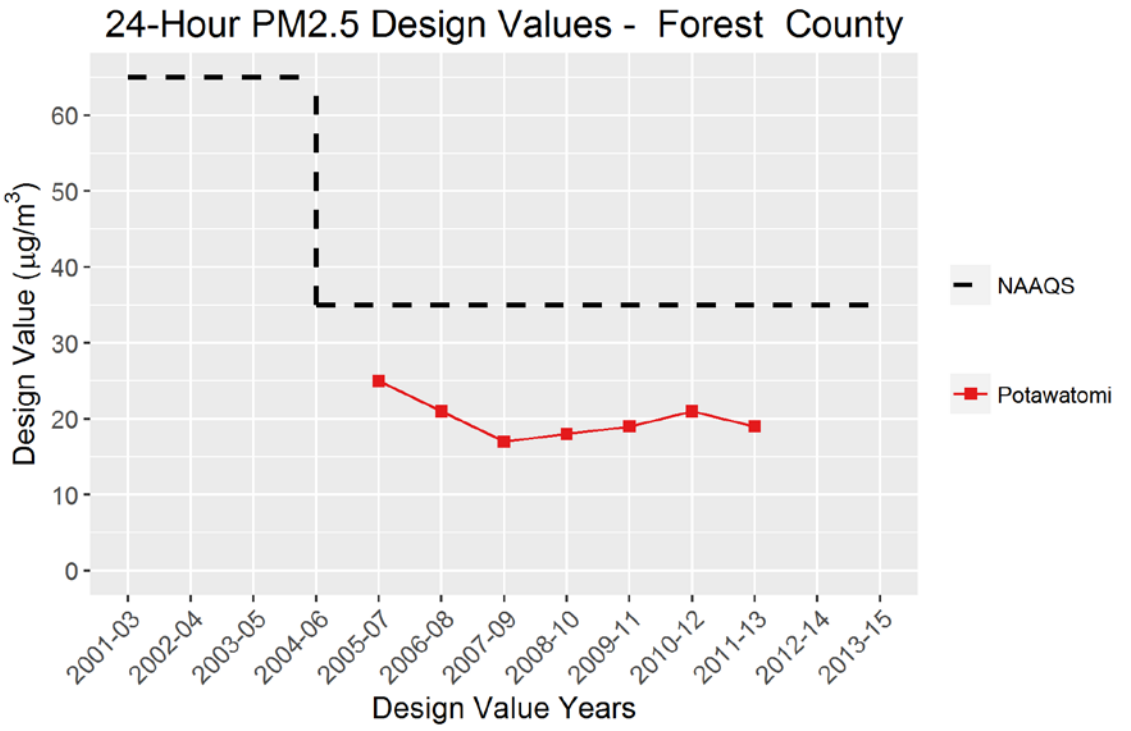


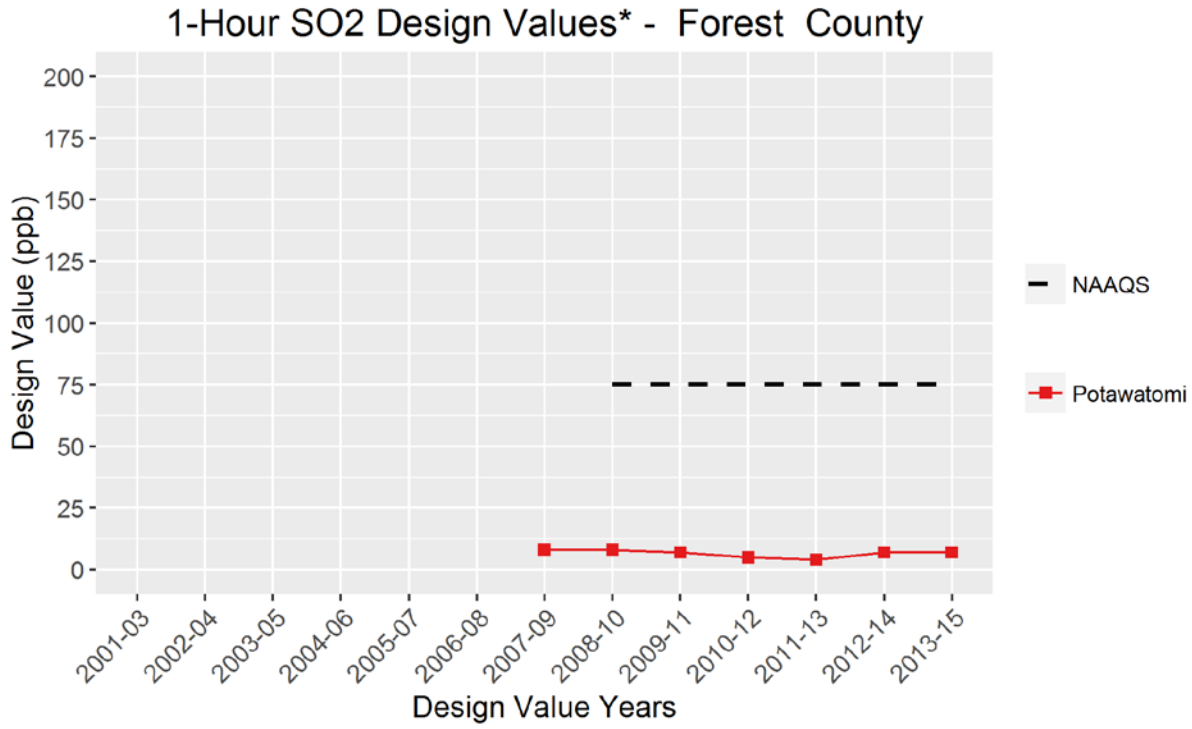
Forest County

Monitoring for ozone, $PM_{2.5}$, SO_2, and NO_2 is conducted by the Forest County Potawatomi Tribe along Fire Tower Road in Crandon. The site does not have enough data to meet the criteria for the 1-hr NO_2 design value calculation.

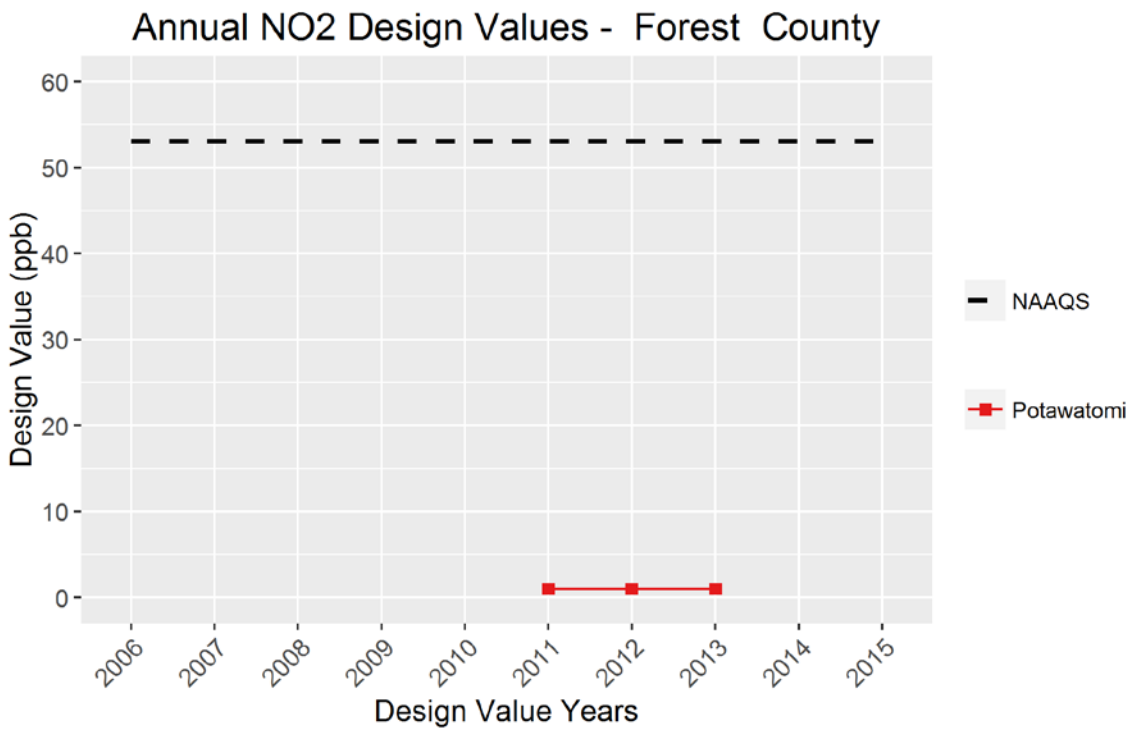






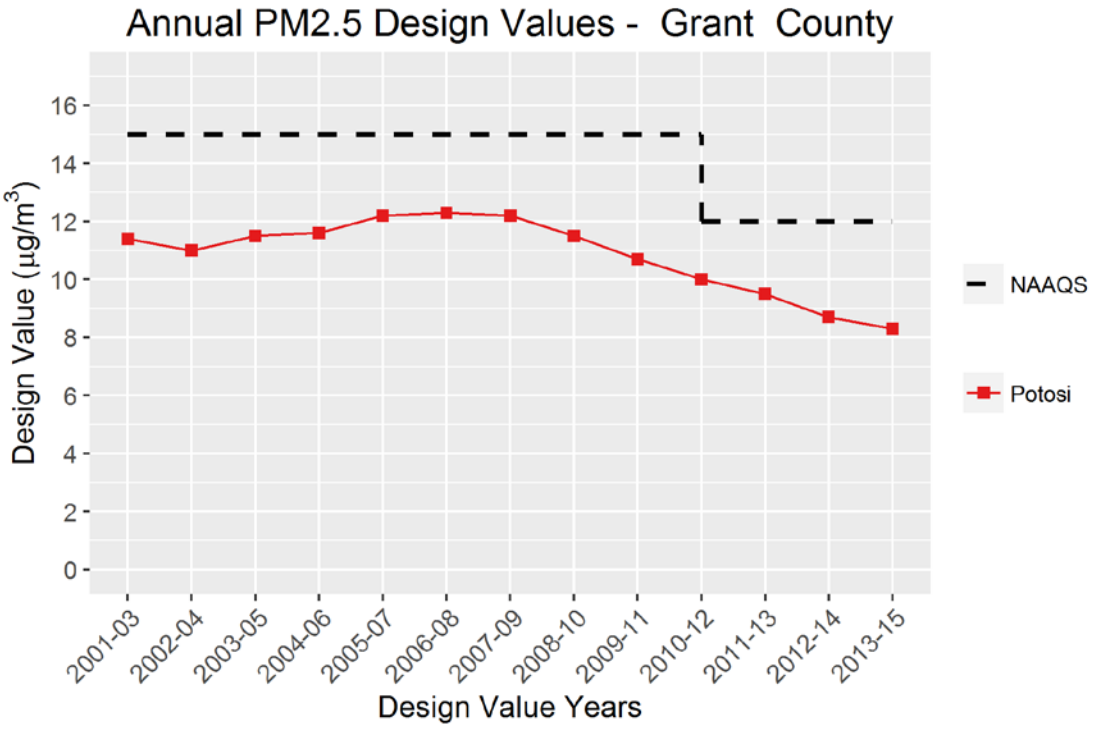


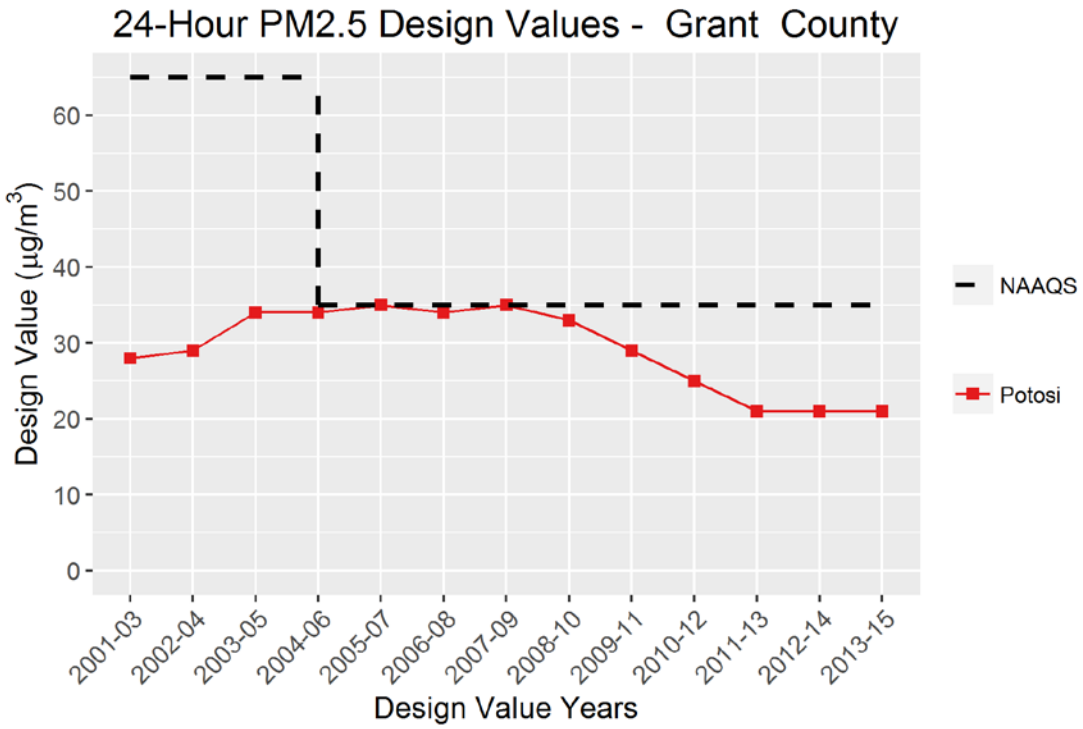
*In 2010, EPA established a 1-hr SO_2 standard that replaced the previous annual and 24-hr standards.


Annual NO2 Design Values - Forest County
Design Value (ppb)
60
50
40
30
20
10
0
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
Design Value Years
NAAQS
Potawatomi

Grant County

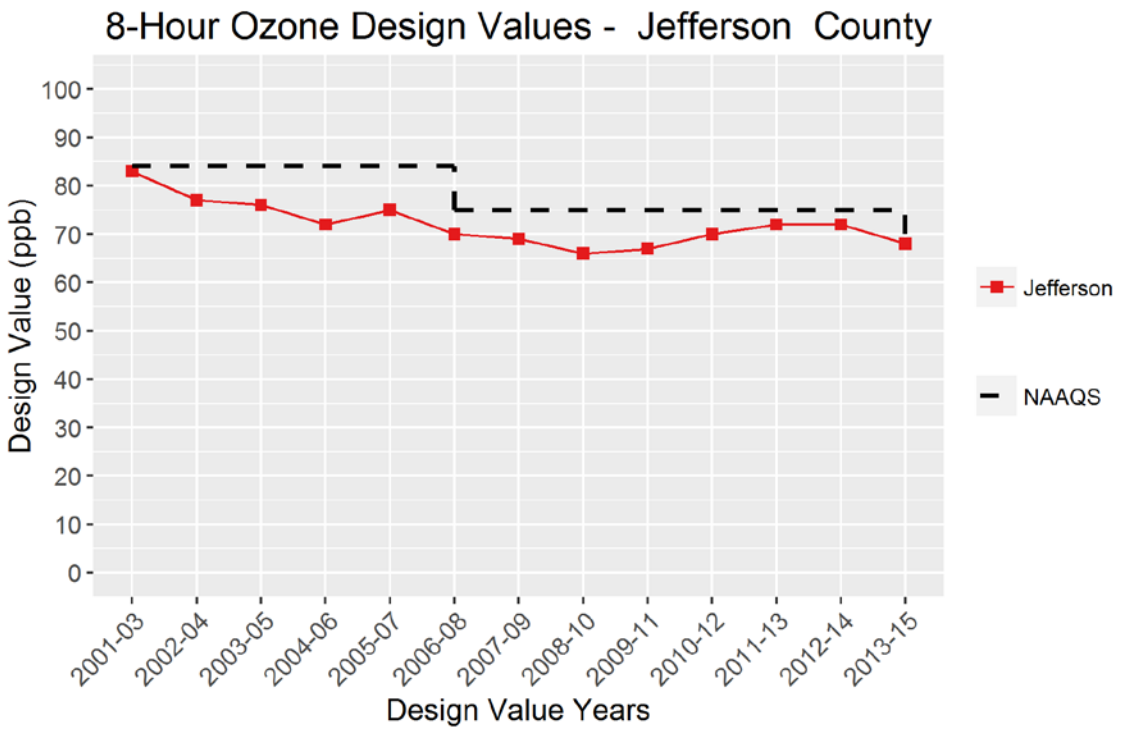
Monitoring for $PM_{2.5}$ in Grant County takes place at 128 Highway 61 on Potosi High School property.





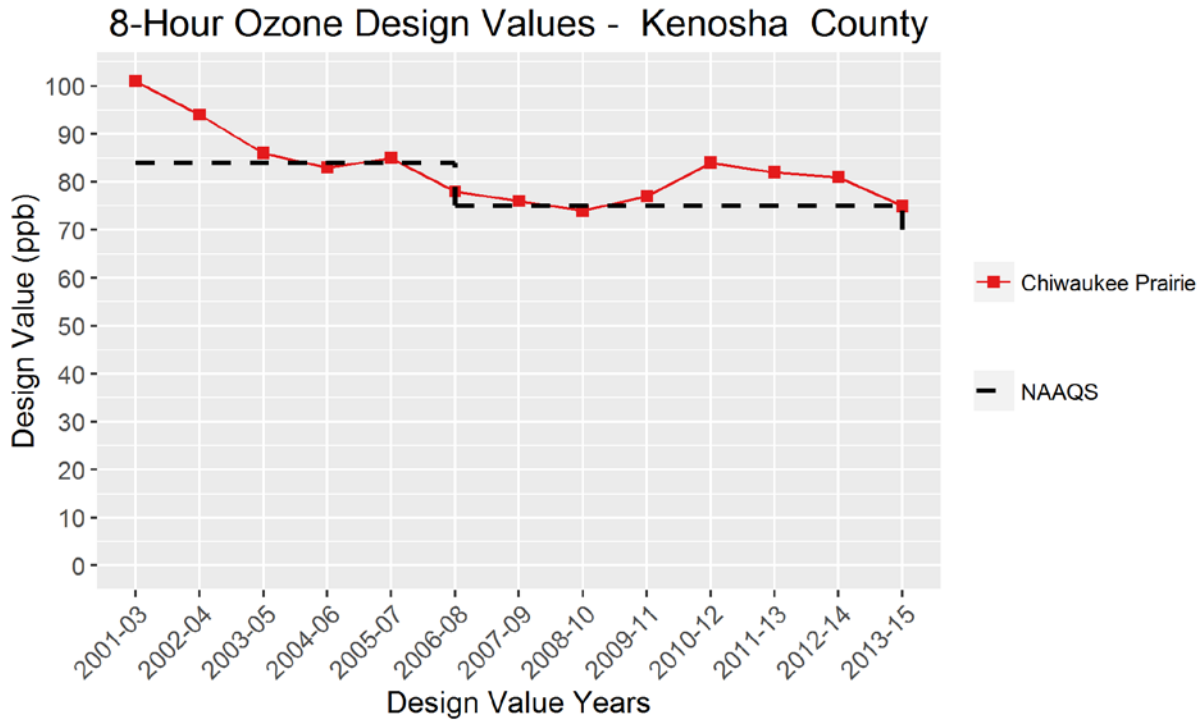
Jefferson County

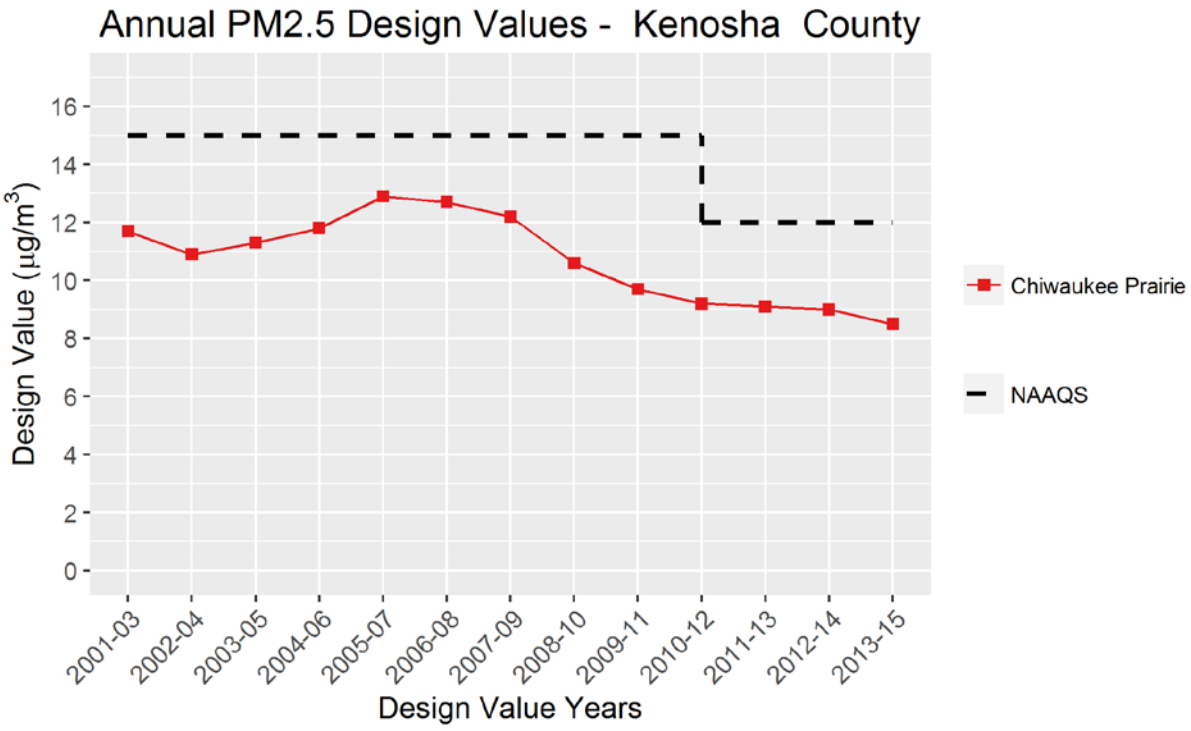
Ozone monitoring in Jefferson County was previously conducted at Jefferson High School next to the sports field grounds at 634 West Linden Drive. For the 2013 ozone season, the monitoring site was moved near the elementary school grounds at N4440 Laatsch Lane in the city of Jefferson. This is approximately ¾ mile from the previous site. Data from both sites are used to calculate design values for 2011-2013, and 2012-2014.

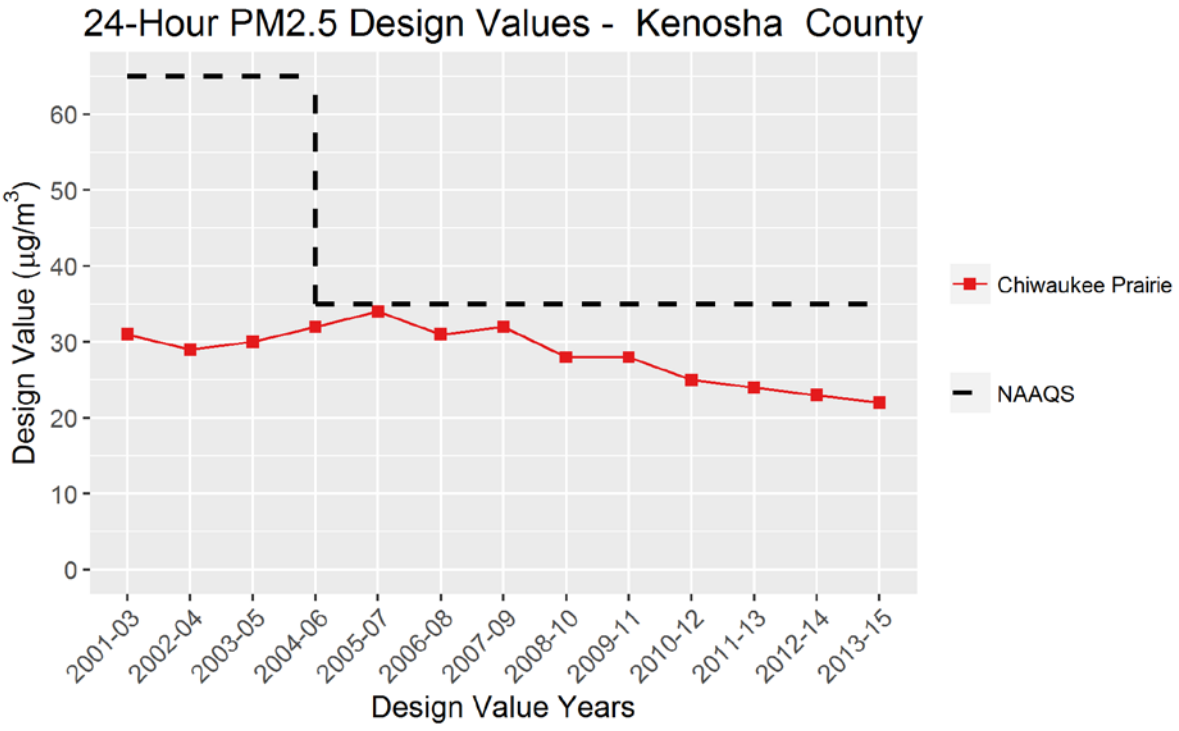


Kenosha County

Ozone and $PM_{2.5}$ monitoring for Kenosha County are performed at 11838 First Court in the Chiwaukee Prairie which is a rural area near the Wisconsin – Illinois border. A second ozone monitoring site in Kenosha County (Kenosha-WT) was added in 2013 at the water tower located at 4504 64th St. in Kenosha. The Kenosha-WT site is designated as a special purpose monitor. This report only shows design values from the Chiwaukee Prairie site because of the short length of record at the Kenosha-WT site.

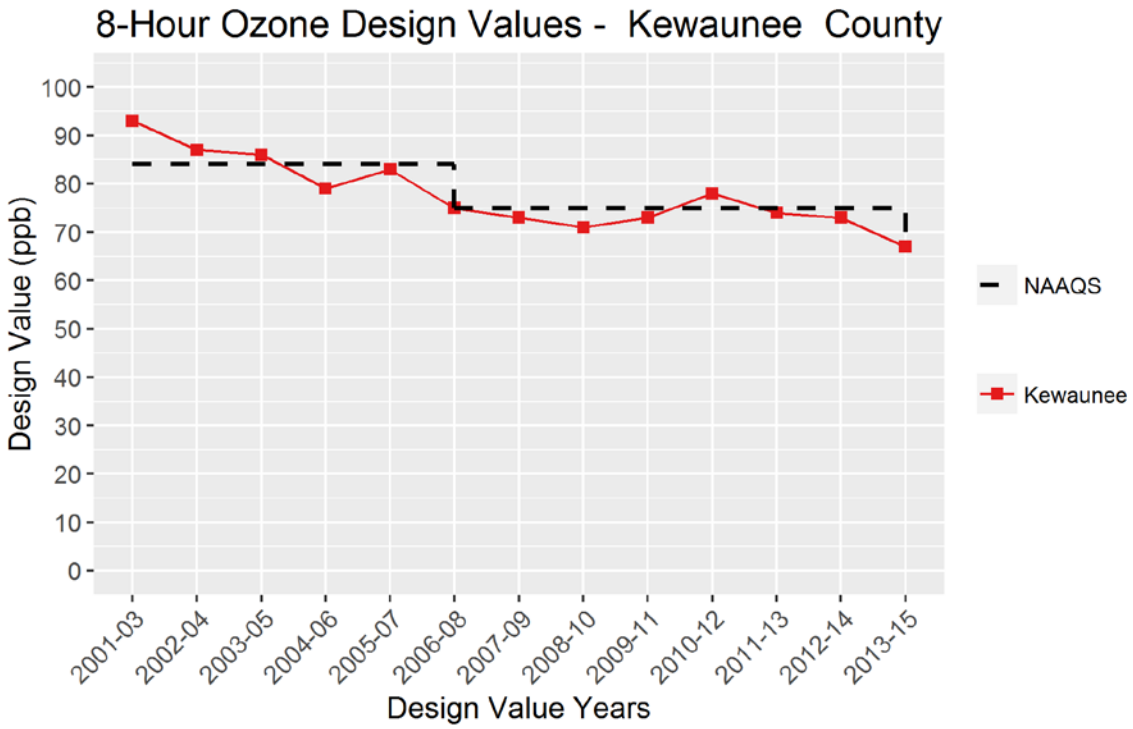



Annual PM2.5 Design Values - Kenosha County
Design Value (µg/m3)
0
2
4
6
8
10
12
14
16
2001-03
2002-04
2003-05
2004-06
2005-07
2006-08
2007-09
2008-10
2009-11
2010-12
2011-13
2012-14
2013-15
Design Value Years
Chiwaukee Prairie
NAAQS


24-Hour PM2.5 Design Values - Kenosha County
Design Value (µg/m3)
0
10
20
30
40
50
60
2001-03
2002-04
2003-05
2004-06
2005-07
2006-08
2007-09
2008-10
2009-11
2010-12
2011-13
2012-14
2013-15
Design Value Years
Chiwaukee Prairie
NAAQS

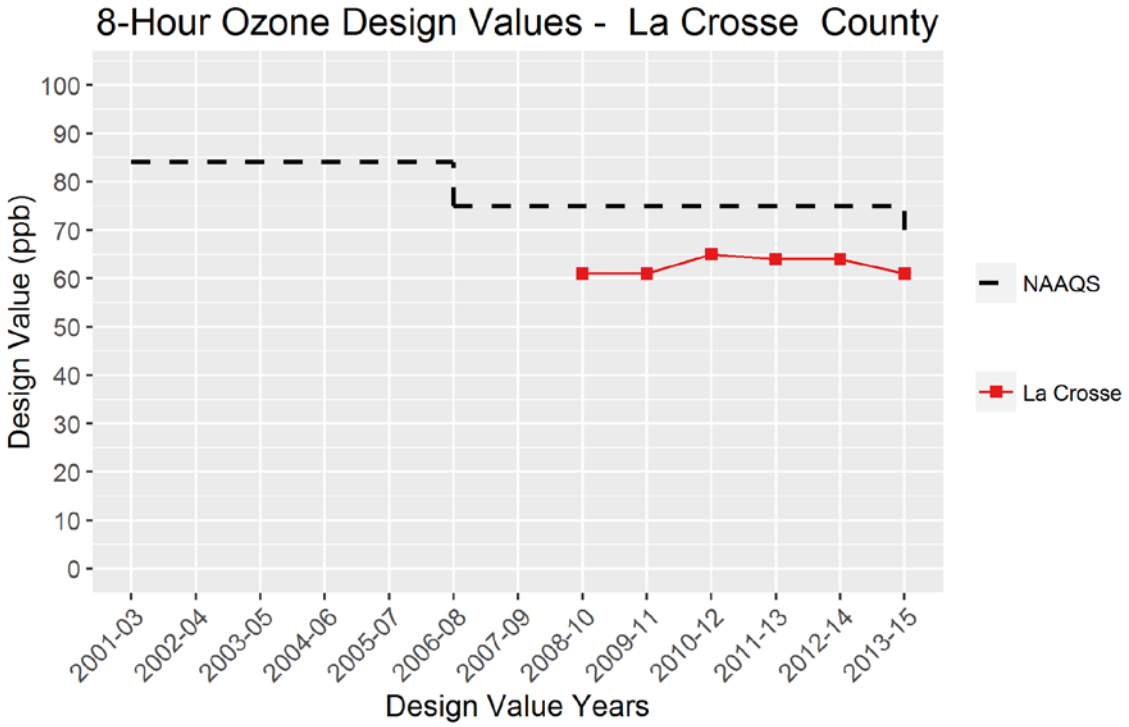
Kewaunee County

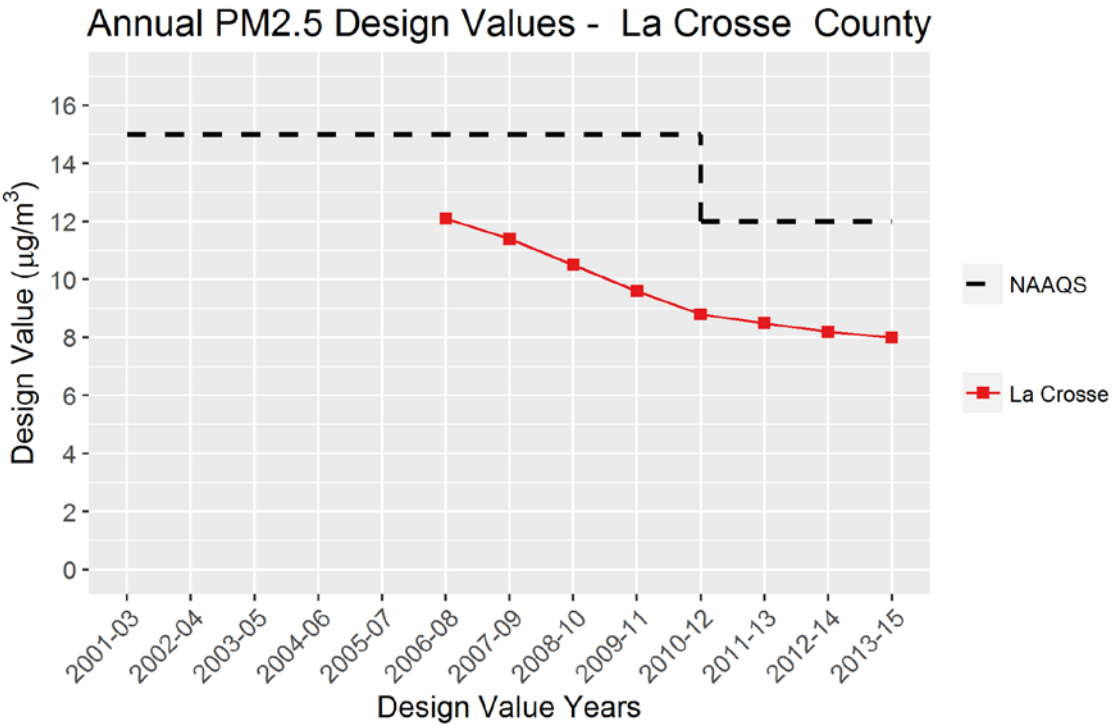
Ozone monitoring in Kewaunee County takes place at Rural Route 1, Highway 42 on a bluff over Lake Michigan.

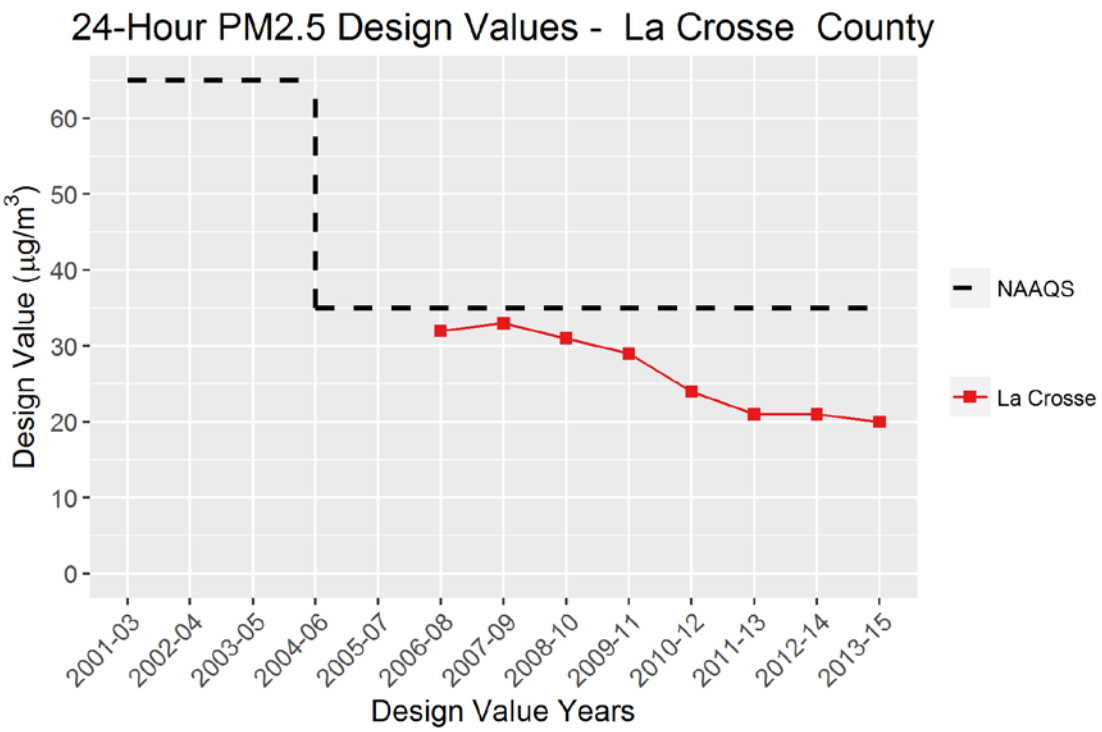


La Crosse County

Ozone and $PM_{2.5}$ monitoring for La Crosse County are conducted at the Department of Transportation office located at 3350 Mormon Coulee Road in La Crosse.

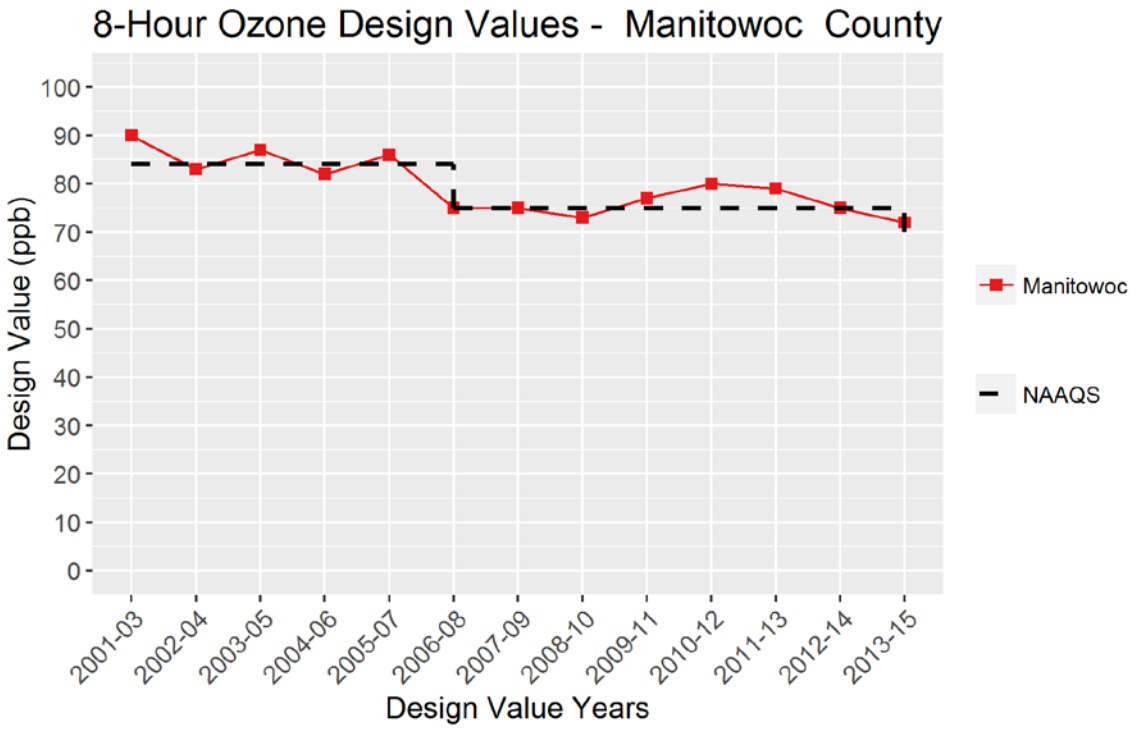





24-Hour PM2.5 Design Values - La Crosse County
Design Value (µg/m3)
60
50
40
30
20
10
0
2001-03
2002-04
2003-05
2004-06
2005-07
2006-08
2007-09
2008-10
2009-11
2010-12
2011-13
2012-14
2013-15
Design Value Years
NAAQS
La Crosse

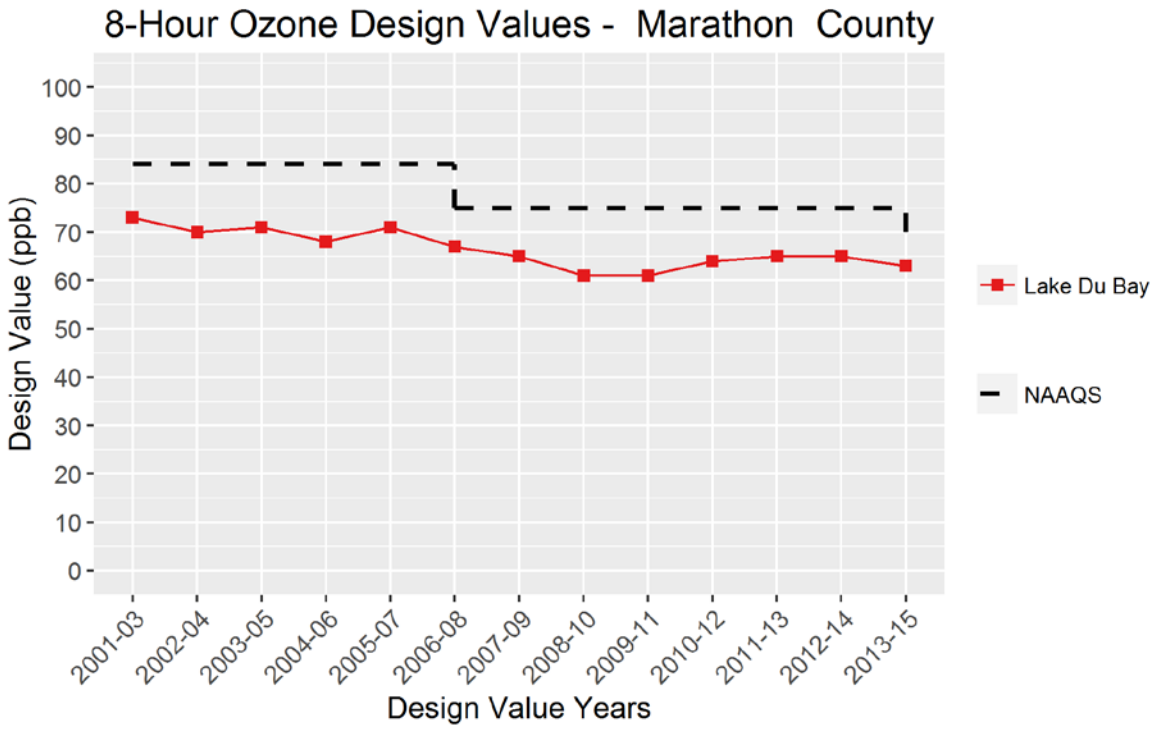
Manitowoc County

Ozone monitoring for Manitowoc County is performed at 2315 Goodwin Road in Two Rivers at the Woodland Dunes Nature Center and Preserve.



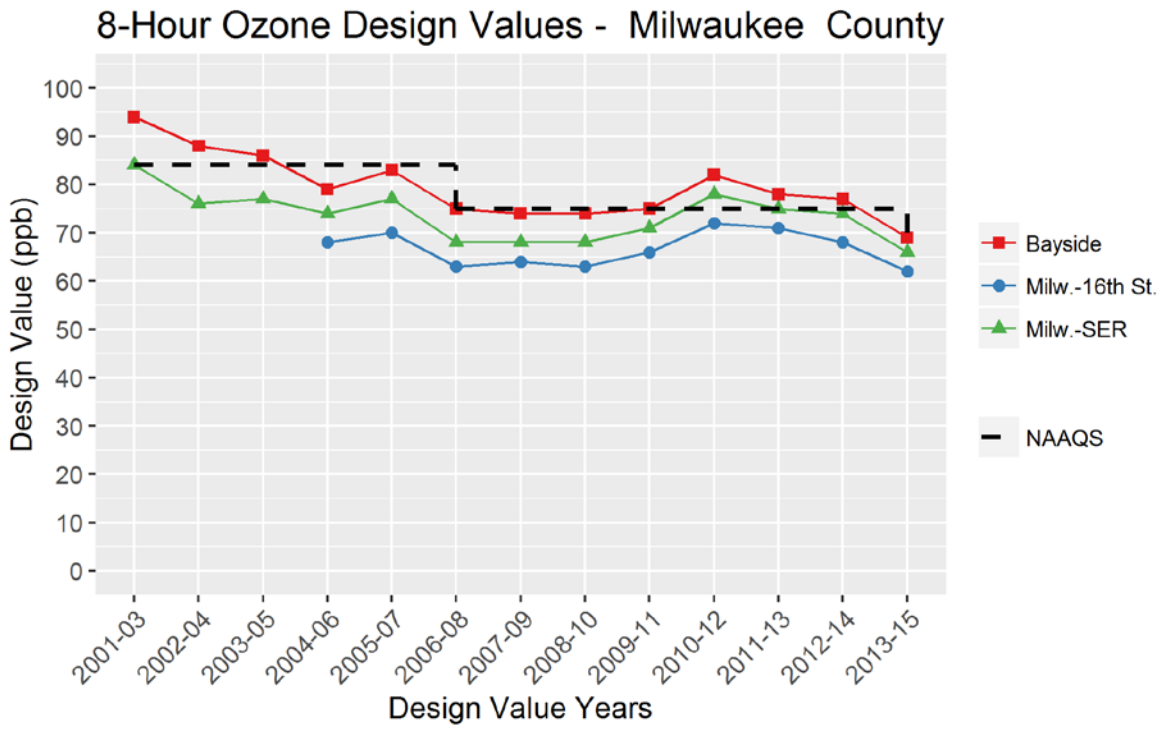
Marathon County

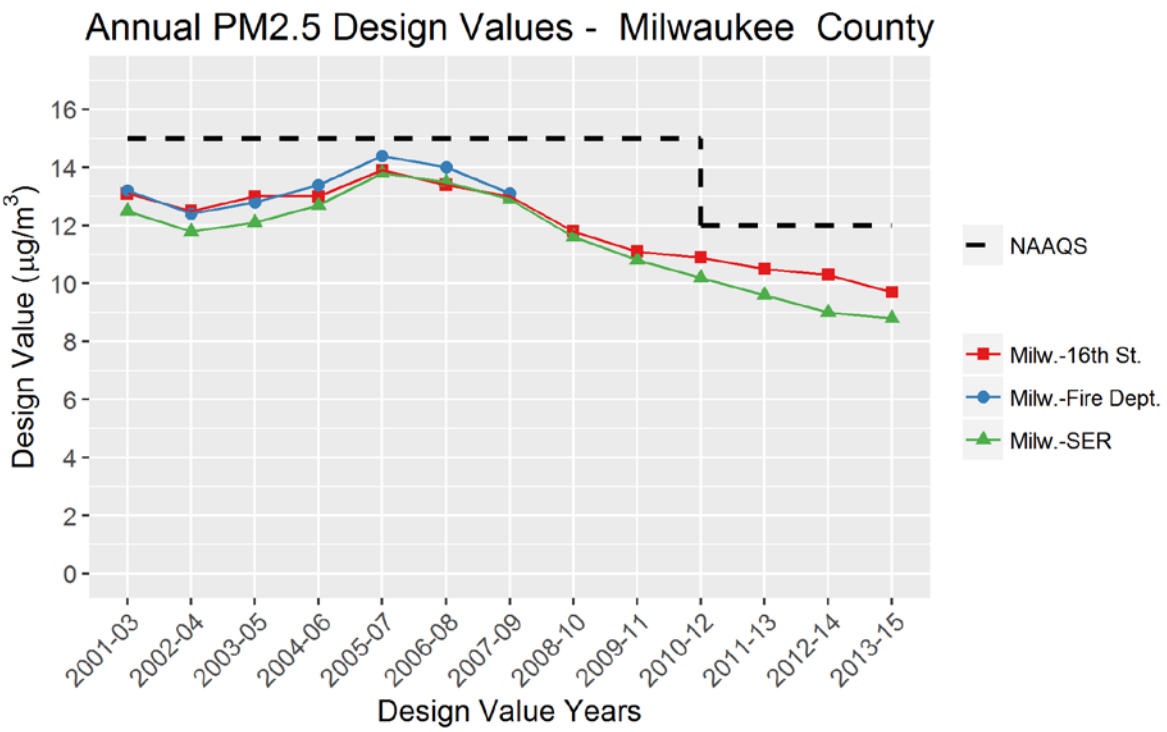
Ozone monitoring in Marathon County is conducted at a rural location at 1780 Bergen Road near Lake Du Bay, in Bergen Township.

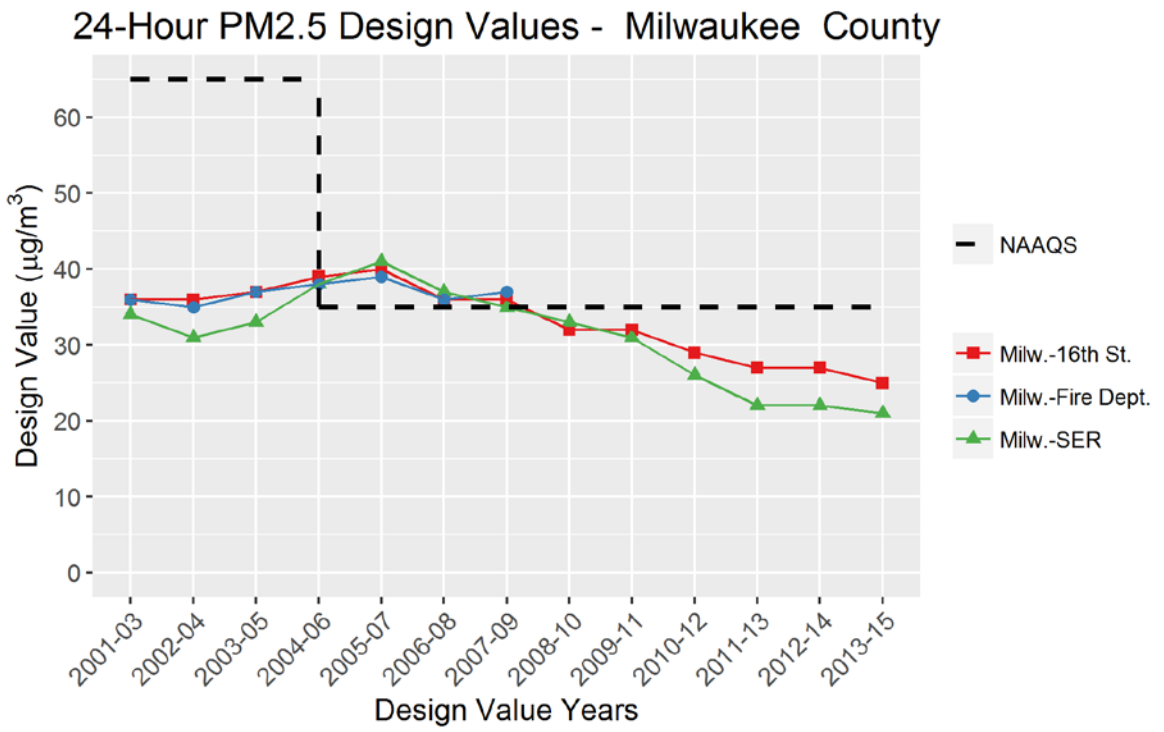


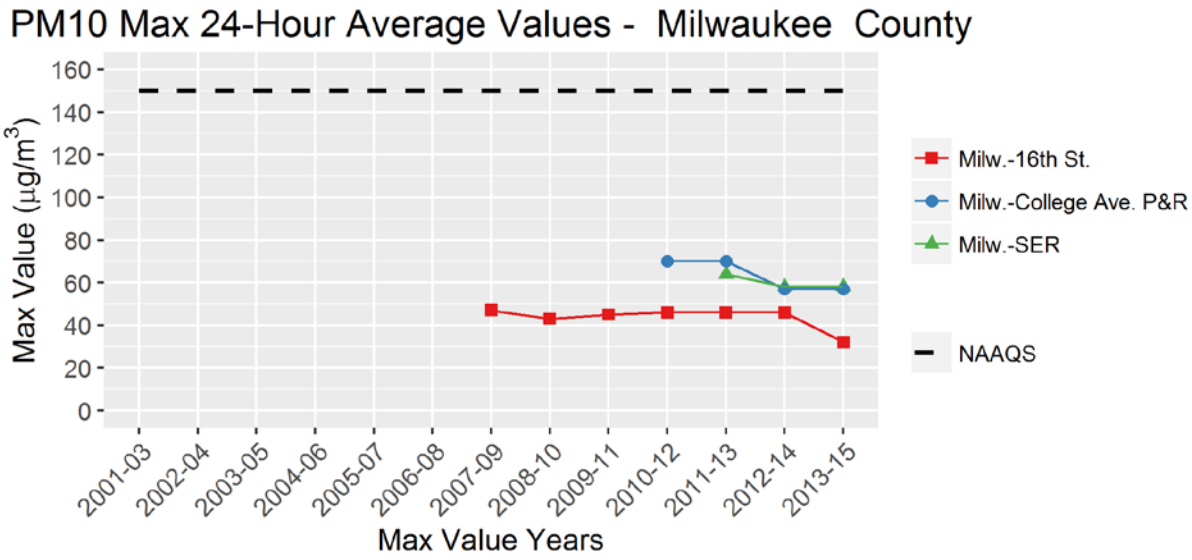
Milwaukee County

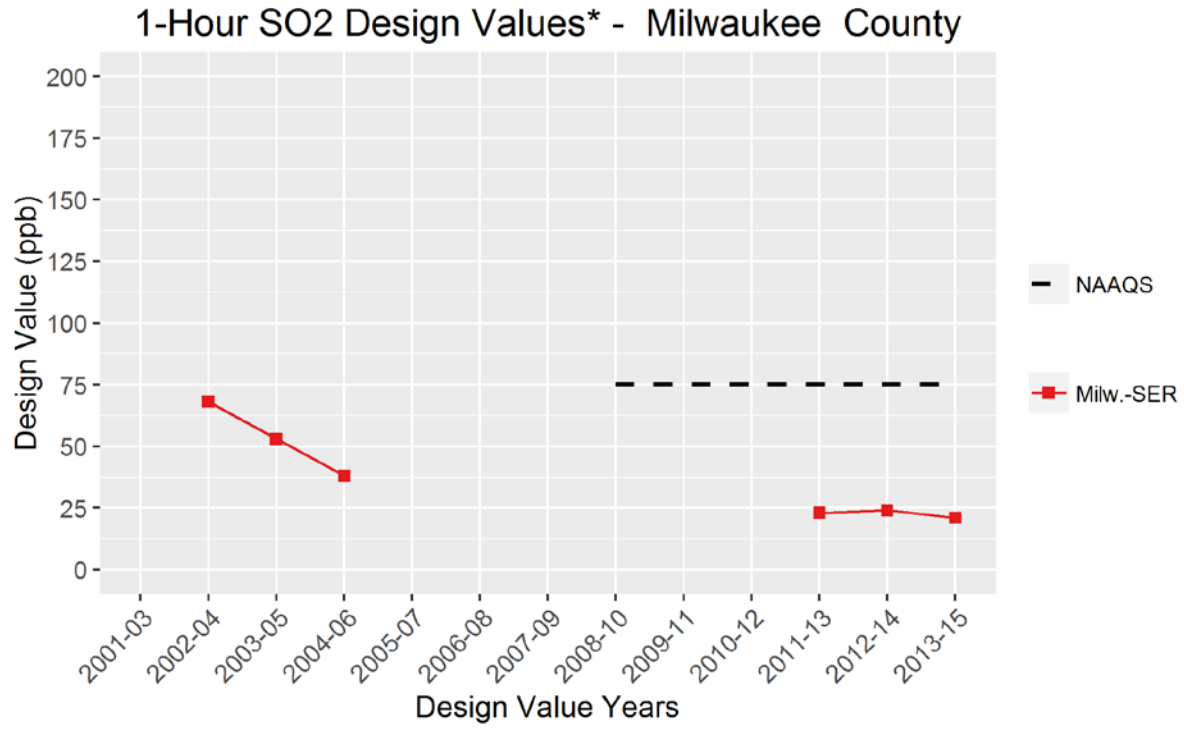
Monitoring for ozone, $PM_{2.5}$, and PM_{10} in Milwaukee County takes place at multiple sites which are shown together in graphs below for comparison. Sites include Bayside (601 E Ellsworth Lane in Bayside), Milwaukee-16th St. (1337 S Cesar E Chavez Dr at the Health Center Buidling), Milwaukee-SER (2300 N. Dr. Martin Luther King Jr. Drive at the DNR Southeast Region Headquarters office) , Milwaukee-Fire Department (711 W. Wells St, on top of a fire deparment) and Milwaukee-College Avenue Park & Ride (1550 W. College Avenue in the park and ride area). Fine-particle data are not shown for the Milwaukee-College Avenue Park & Ride site due to invalid design values for some years and no data from 2010 and 2011 when monitoring at the site was paused. Sulfur dioxide is measured only at the Milwaukee-SER site; monitoring at this site was paused from 2007 to 2010. Nitrogen dioxide is monitored at the Milwaukee-SER site as well as at the Milwaukee-College Avenue Near Road site which was established in October 2013 also at 1550 W. College Avenue but adjacent to the highway. Only data from the Milwaukee-SER site are shown for NO_2 due to the short record at the Milwaukee-College Avenue Near Road site. Monitoring for CO (started in 2014) takes place only at the Milwaukee-College Avenue Near Road site. Due to the short record, a graph for CO is not included.



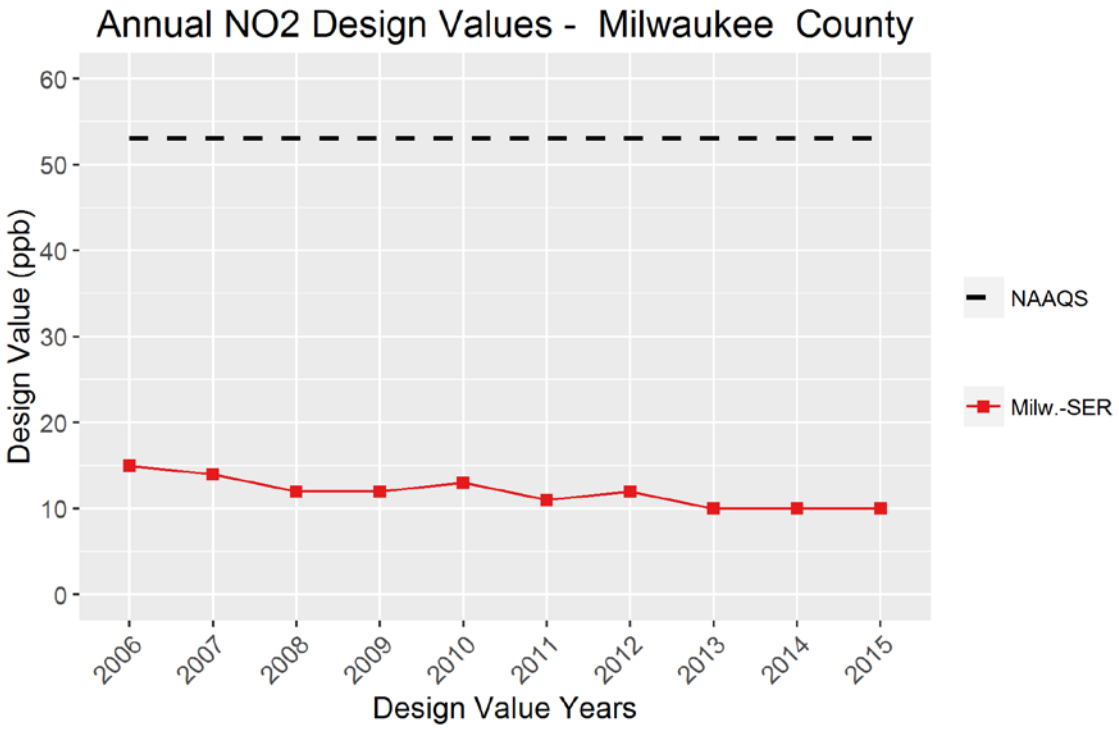

Annual PM2.5 Design Values - Milwaukee County
Design Value (µg/m3)
16
14
12
10
8
6
4
2
0
2001-03
2002-04
2003-05
2004-06
2005-07
2006-08
2007-09
2008-10
2009-11
2010-12
2011-13
2012-14
2013-15
Design Value Years
NAAQS
Milw.-16th St.
Milw.-Fire Dept.
Milw.-SER

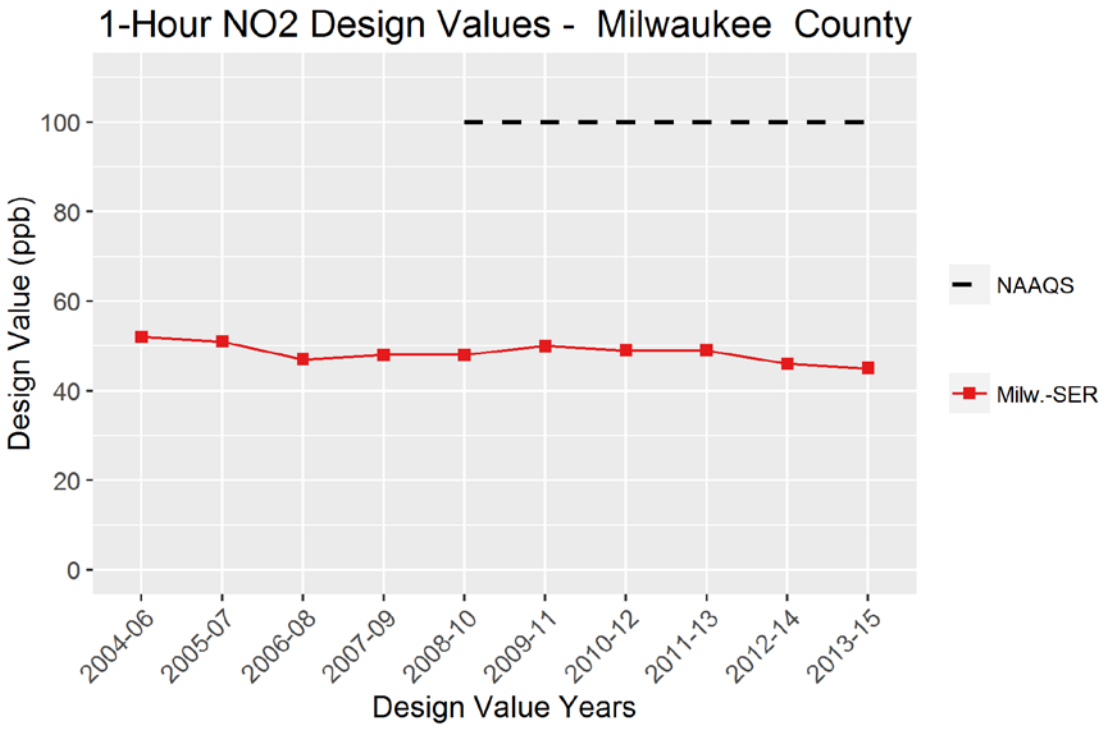

24-Hour PM2.5 Design Values - Milwaukee County
Design Value (µg/m3)
60
50
40
30
20
10
0
2001-03
2002-04
2003-05
2004-06
2005-07
2006-08
2007-09
2008-10
2009-11
2010-12
2011-13
2012-14
2013-15
Design Value Years
NAAQS
Milw.-16th St.
Milw.-Fire Dept.
Milw.-SER





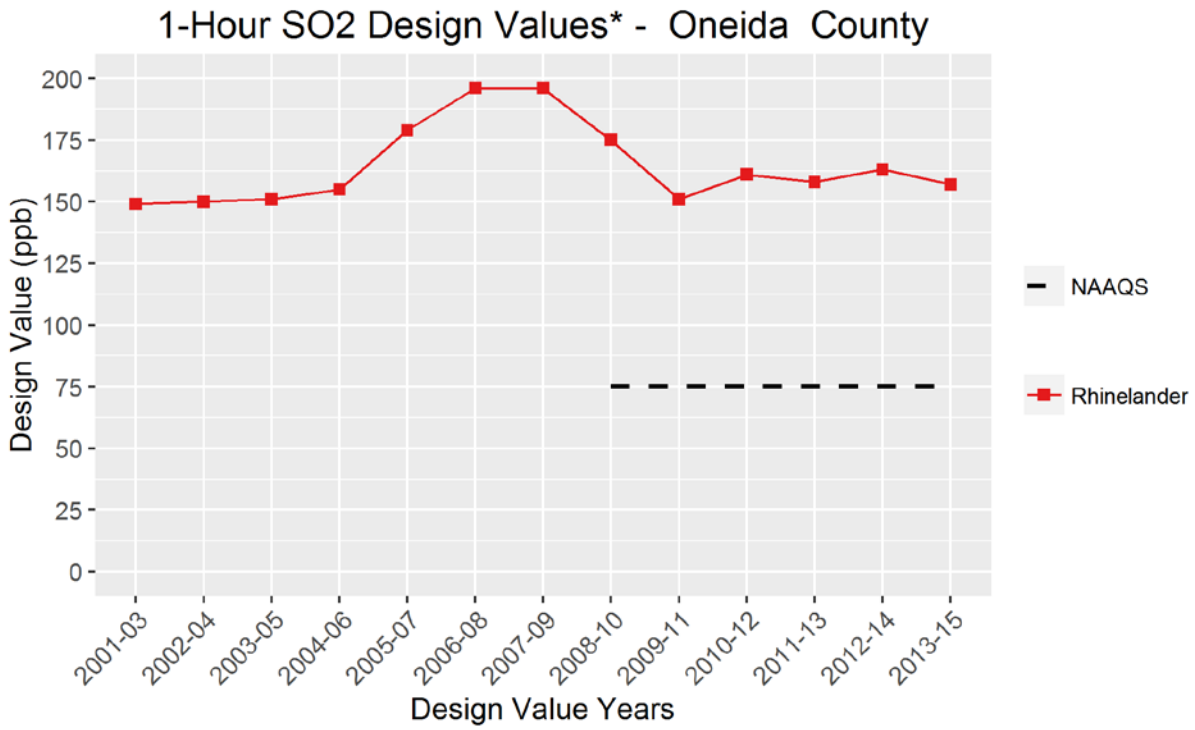
*In 2010, EPA established a 1-hr SO_2 standard that replaced the previous 24-hr and annual standards.


Annual NO2 Design Values - Milwaukee County
Design Value (ppb)
60
50
40
30
20
10
0
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
Design Value Years
NAAQS
Milw.-SER


1-Hour NO2 Design Values - Milwaukee County
Design Value (ppb)
100
80
60
40
20
0
2004-06
2005-07
2006-08
2007-09
2008-10
2009-11
2010-12
2011-13
2012-14
2013-15
Design Value Years
NAAQS
Milw.-SER

Oneida County

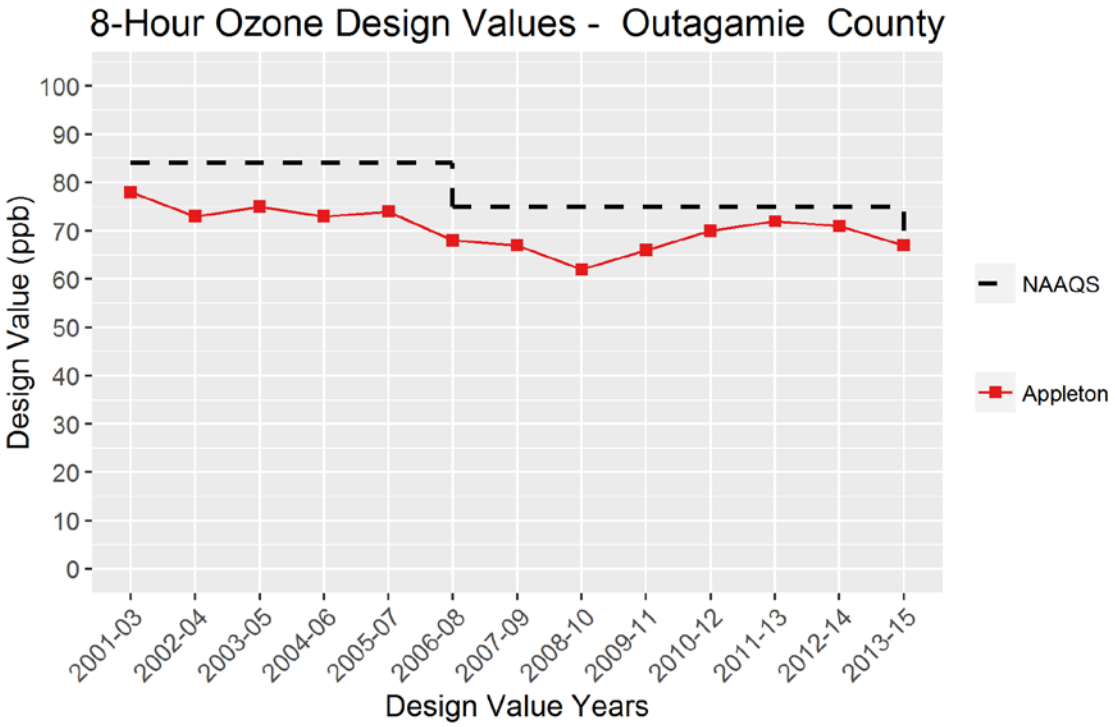
Monitoring for SO_2 in Oneida County takes place at 434 High Street next to the Rhinelander water tower. This site is source-oriented and is sited to assess compliance with the SO_2 NAAQS. Note that the design values from this site are out of compliance with the 2010 one-hour standard. WDNR has submitted an SO_2 NAAQS attainment demonstration that establishes permanent and enforceable SO_2 requirements through Administrative Order AM-01-15 entered between the WDNR and the facility primarily responsible for the monitored values. EPA has found the attainment demonstration to be complete, and the facility completed construction to implement the requirements by September 2016.

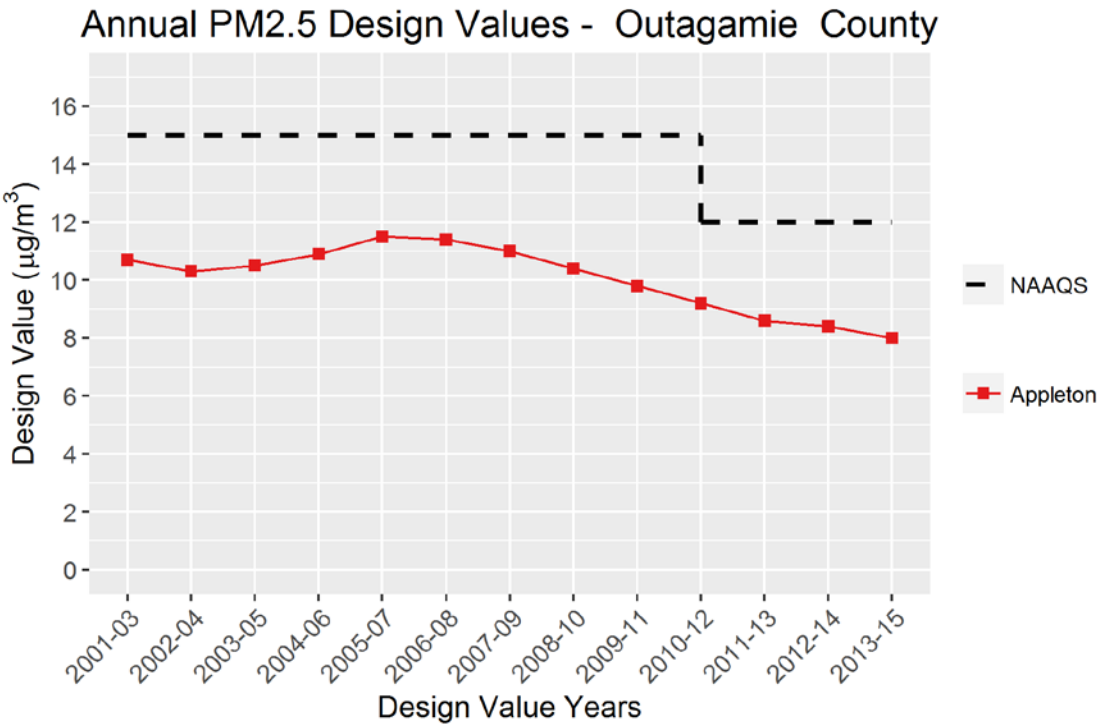


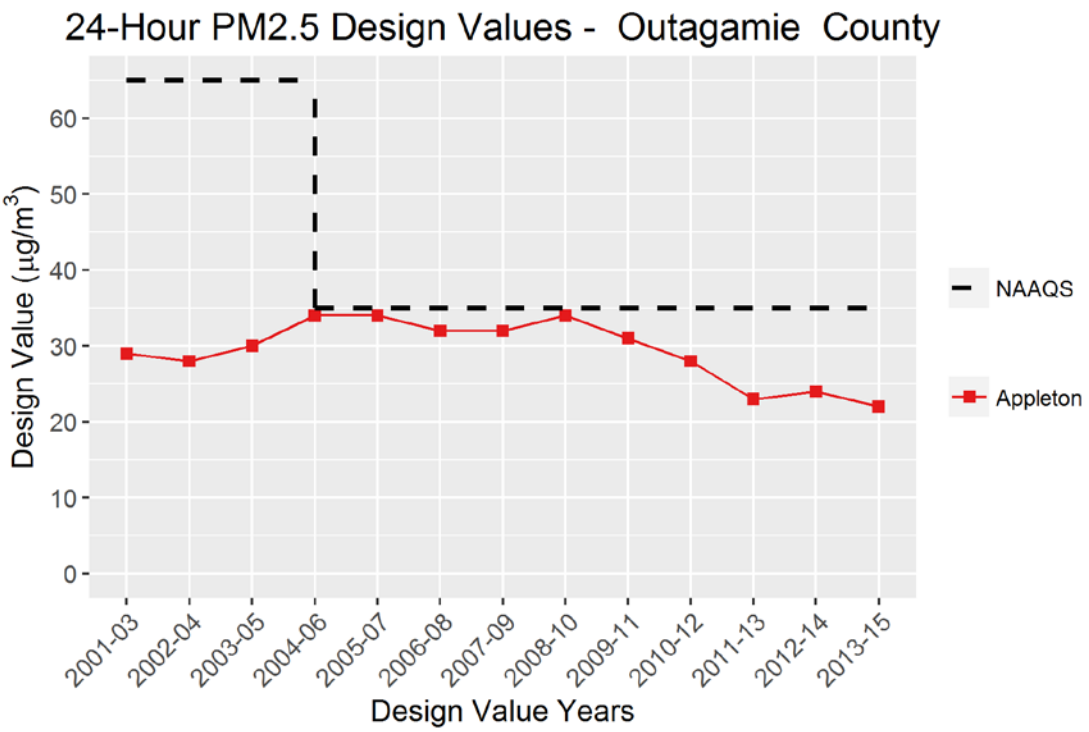
*In 2010, EPA established a 1-hr SO_2 standard that replaced the previous annual and 24-hr standards.

Outagamie County

Ozone and $PM_{2.5}$ monitoring in Outagamie County are performed at 4432 North Meade Street in Appleton near a residential area.

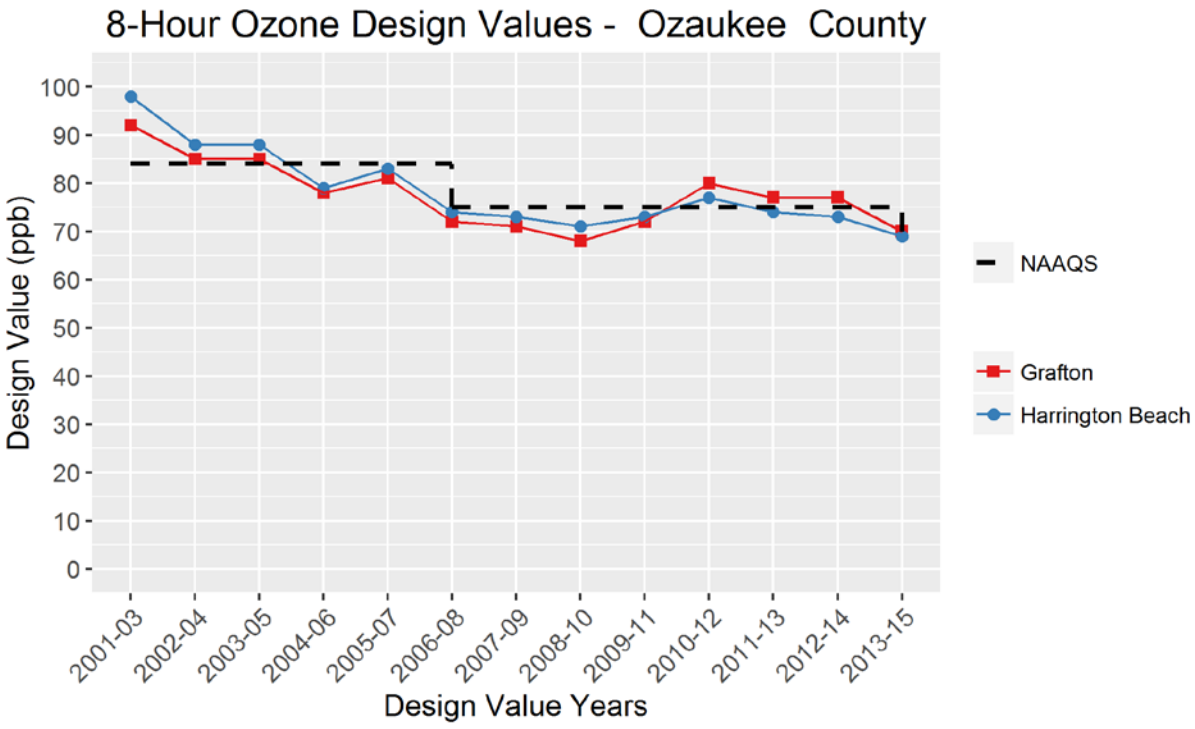


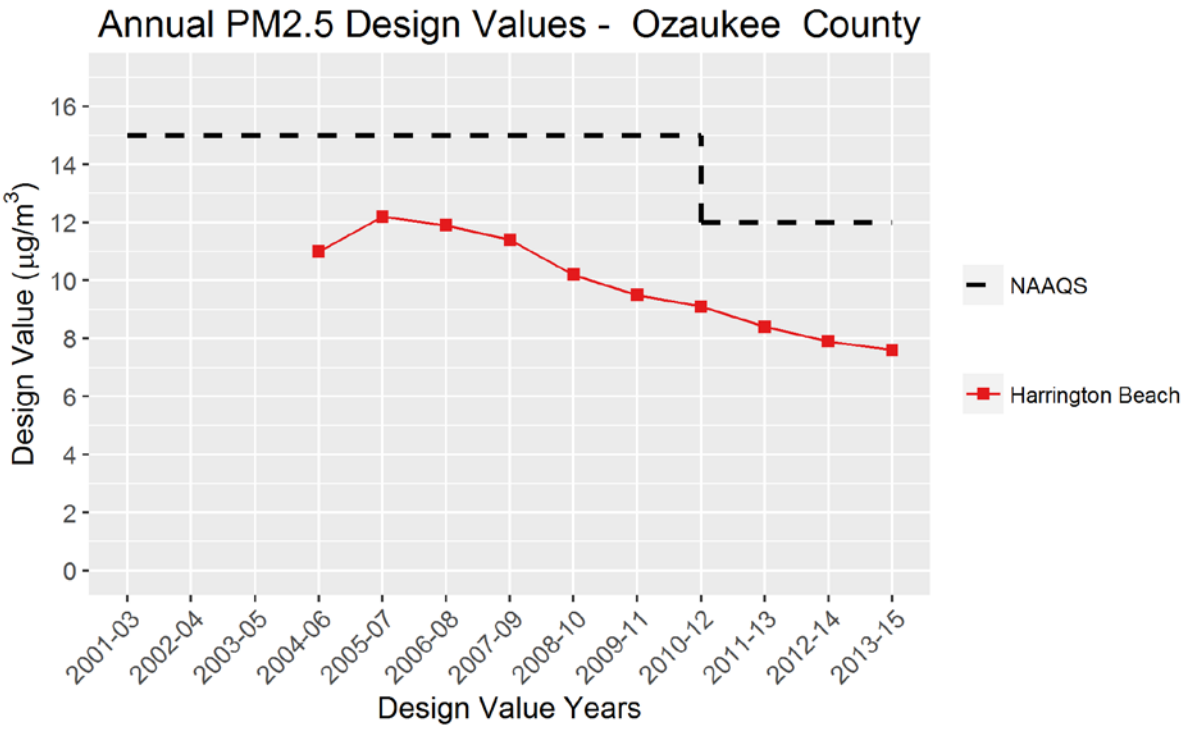


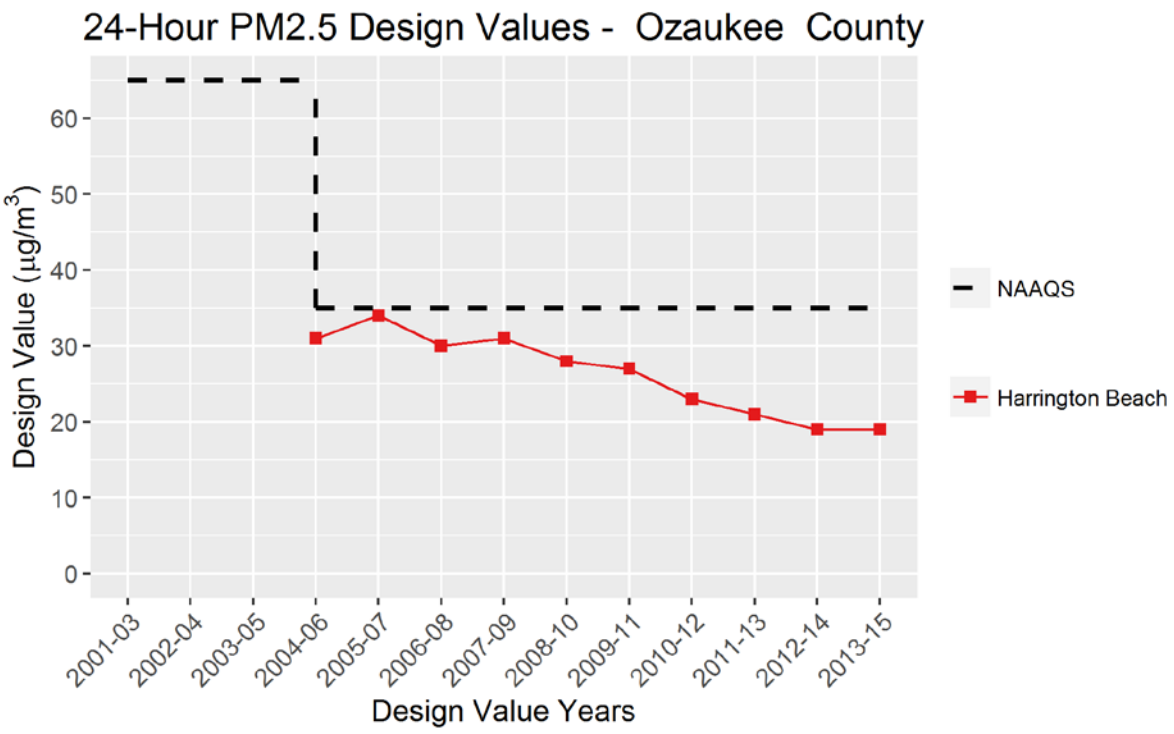

24-Hour PM2.5 Design Values - Outagamie County
Design Value (µg/m3)
60
50
40
30
20
10
0
2001-03
2002-04
2003-05
2004-06
2005-07
2006-08
2007-09
2008-10
2009-11
2010-12
2011-13
2012-14
2013-15
Design Value Years
NAAQS
Appleton

Ozaukee County

Ozone monitoring in Ozaukee County takes place at the intersection of Highway 57 and Interstate 43 in Grafton and at Harrington Beach State Park, located at 531 Highway D. Monitoring for $PM_{2.5}$ takes place only at the Harrington Beach site.





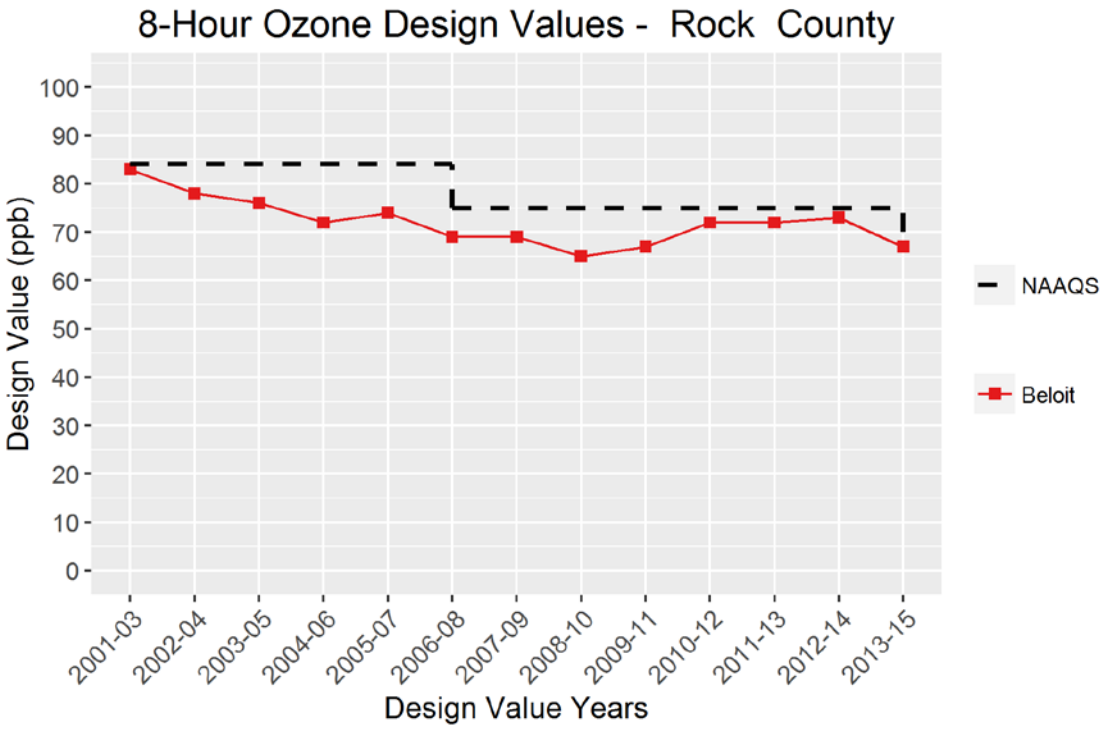

24-Hour PM2.5 Design Values - Ozaukee County
Design Value (µg/m3)
60
50
40
30
20
10
0
2001-03
2002-04
2003-05
2004-06
2005-07
2006-08
2007-09
2008-10
2009-11
2010-12
2011-13
2012-14
2013-15
Design Value Years
NAAQS
Harrington Beach

Racine County

Ozone monitoring in Racine County is conducted at 4227 Charles Street in a farm field in the rural village of Caledonia (Racine-Payne & Dolan site). Sampling began at this site on April 3, 2015. Prior to this date, sampling for ozone in Racine County was performed at 1519 Washington Avenue inside a local business in the downtown area of the city of Racine. This site shut down at the end of 2013. Data from the old and new sites will not be combined. Because sampling at the new site began after 2013, no design values for this site are currently available.

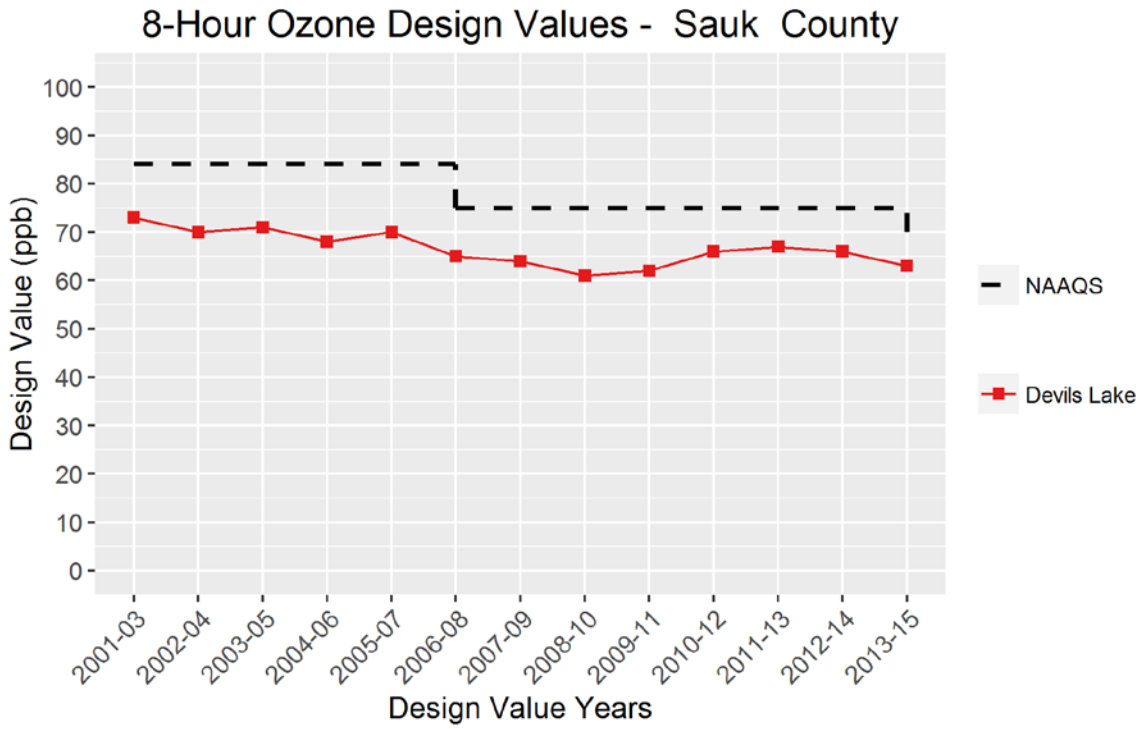
Rock County

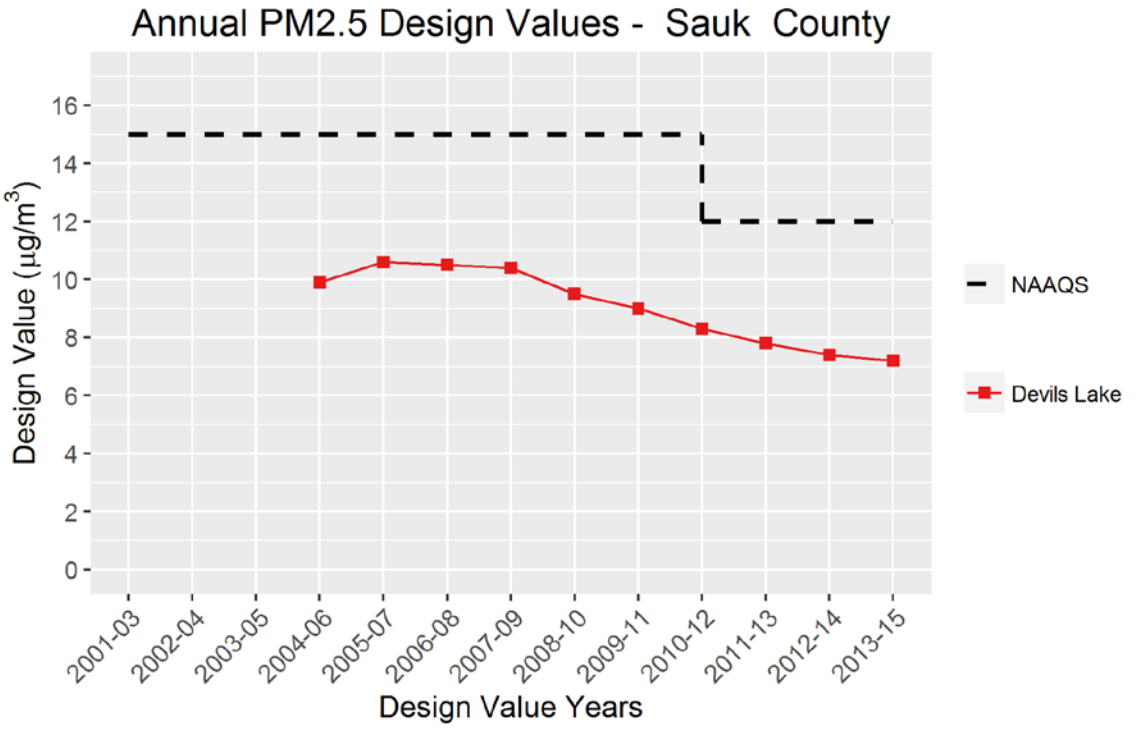
Ozone monitoring in Rock County is conducted at 1948 Merrill Street in Beloit. The site is located in a fenced area at the Cunningham School.

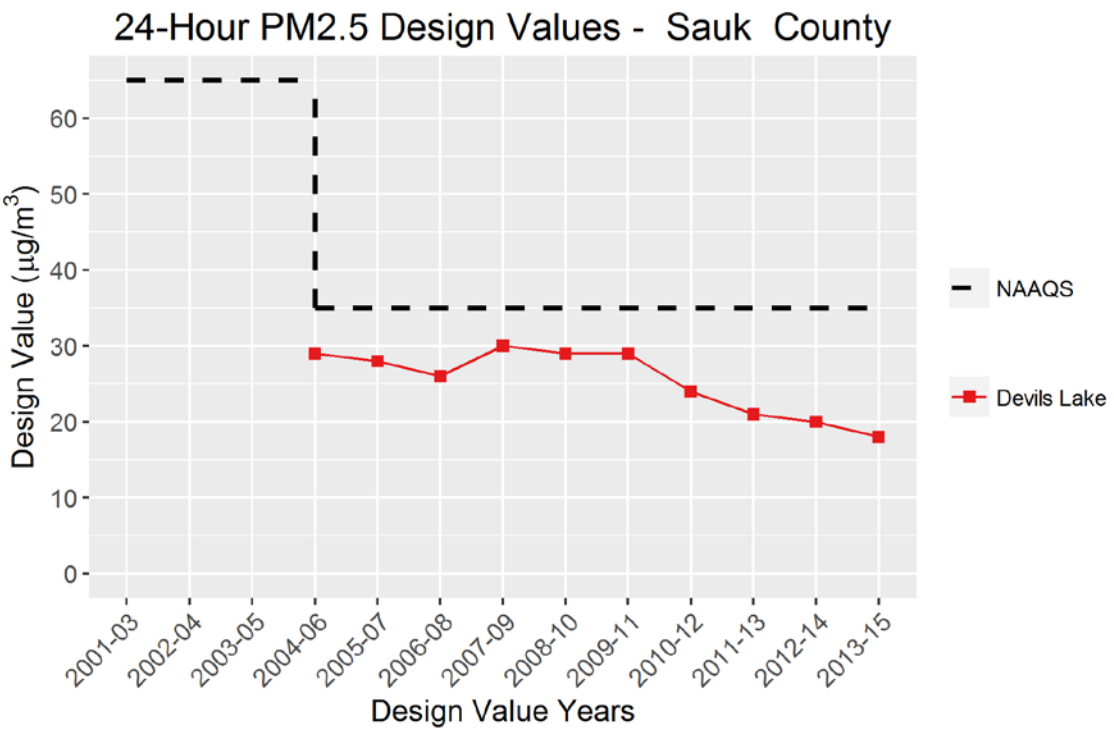


Sauk County

Ozone, $PM_{2.5}$, and PM_{10} monitoring in Sauk County take place at Devils Lake State Park at E12886 Tower Road in Baraboo. Monitoring for PM_{10} began in November 2011. Due to the short record, a graph for PM_{10} is not included.

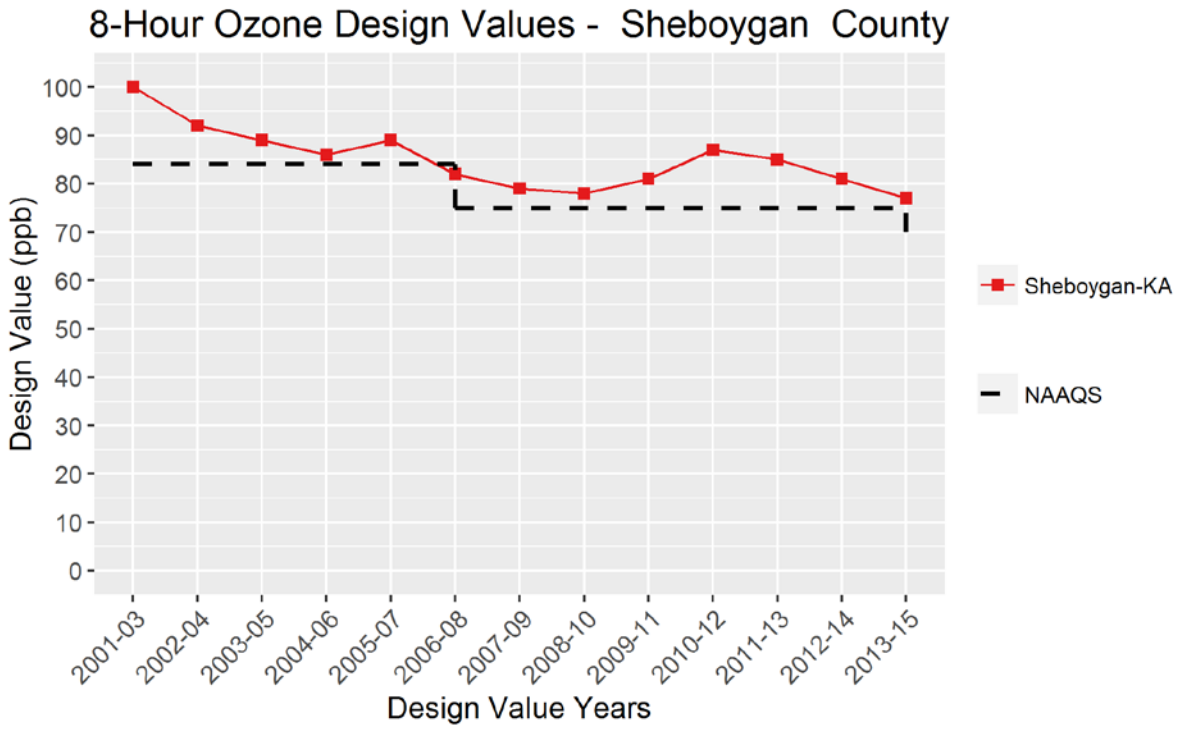





24-Hour PM2.5 Design Values - Sauk County
Design Value (µg/m3)
60
50
40
30
20
10
0
2001-03
2002-04
2003-05
2004-06
2005-07
2006-08
2007-09
2008-10
2009-11
2010-12
2011-13
2012-14
2013-15
Design Value Years
NAAQS
Devils Lake

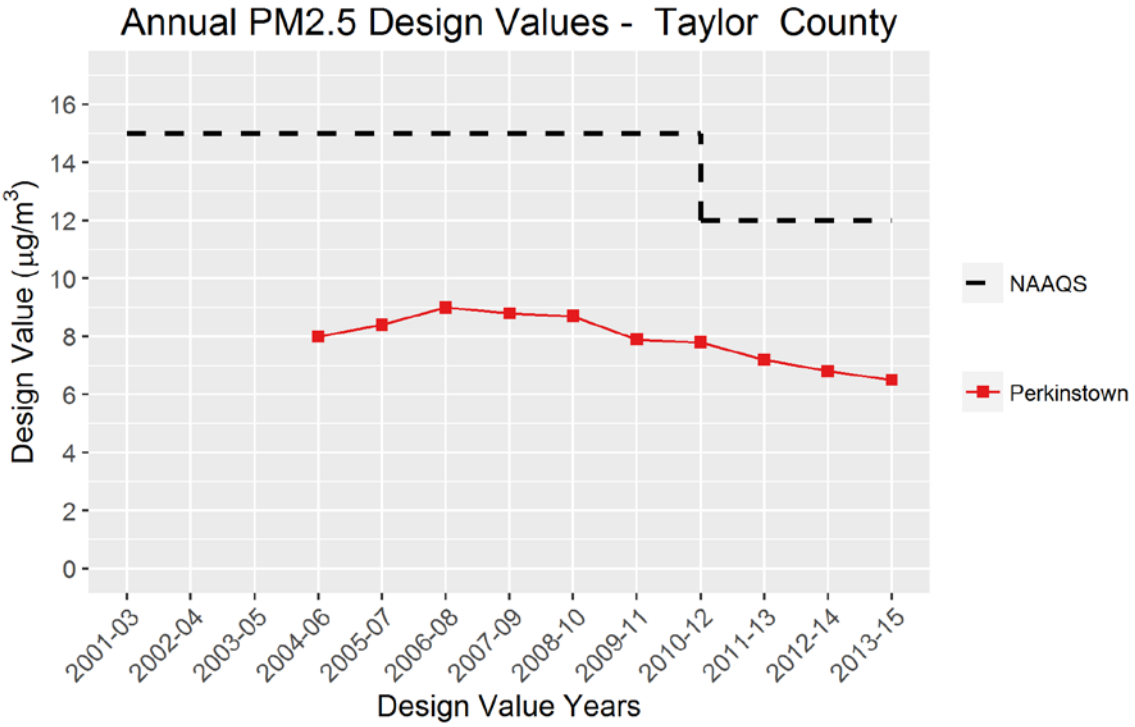
Sheboygan County

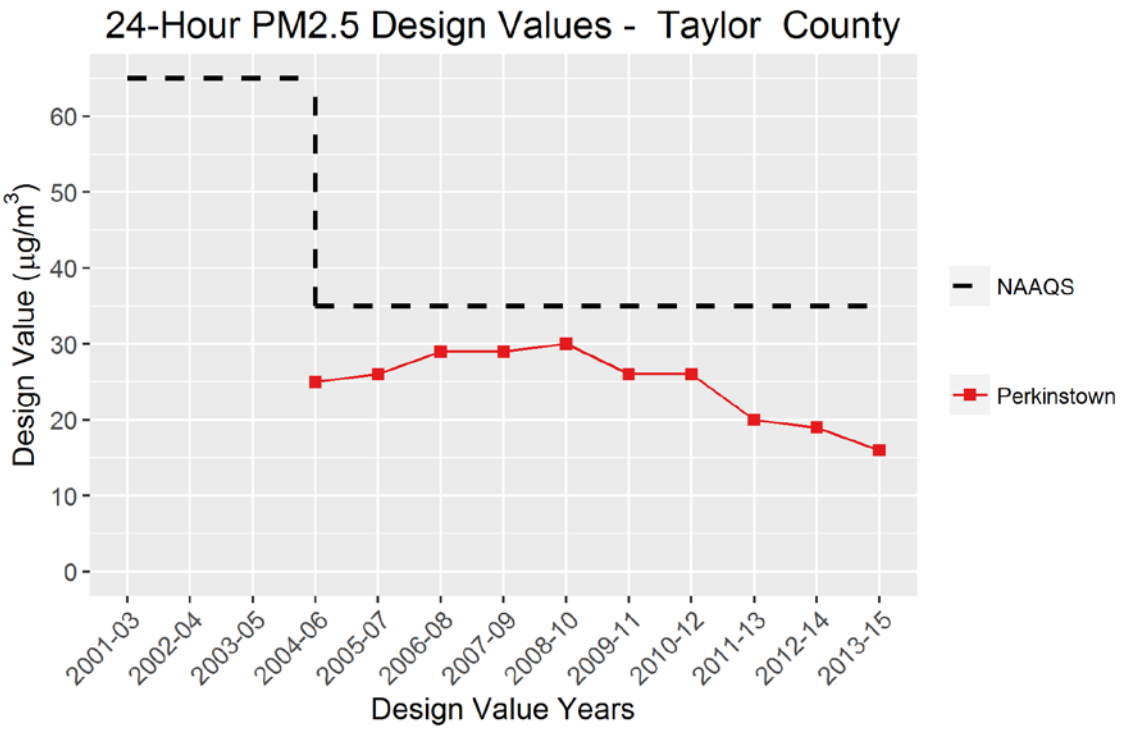
Ozone monitoring in Sheboygan County is performed inside the nature center at Kohler-Andrae State Park. This Lake Michigan shoreline site is located at 1520 Beach Park Road. A second special-purpose ozone monitoring site was added during the 2014 ozone season (Sheboygan-Haven). The special-purpose site is located at N7563 Highway 42 near the intersection with County Road JJ. This report only shows design values from the Sheboygan-KA site due to the short length of record at the Sheboygan-Haven site. Lead monitoring in Sheboygan County began in December 2009 at the Kohler site. This source-oriented site is located at 444 Highland Drive at the Kohler Company fence line. Due to a short record at the site and invalid design values during the early years of monitoring, no graph is included below for lead.



Taylor County

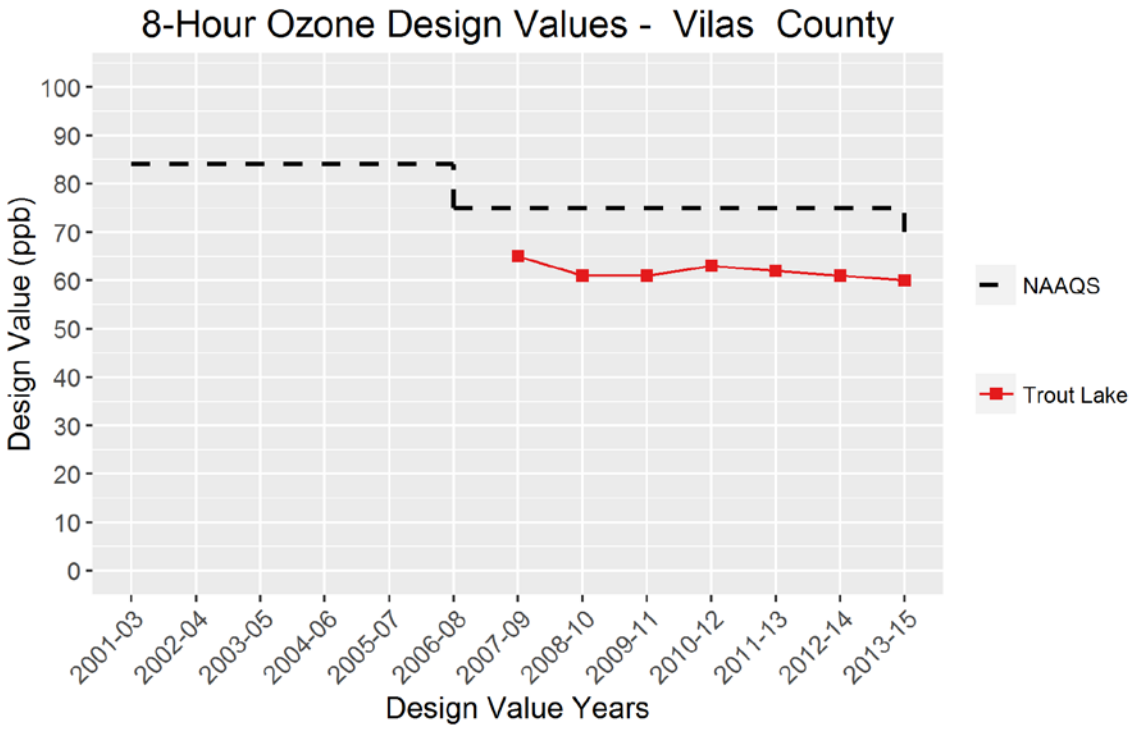
Monitoring for $PM_{2.5}$ in Taylor County takes place at W10746 County Highway M, a rural site one mile east of Perkinstown.

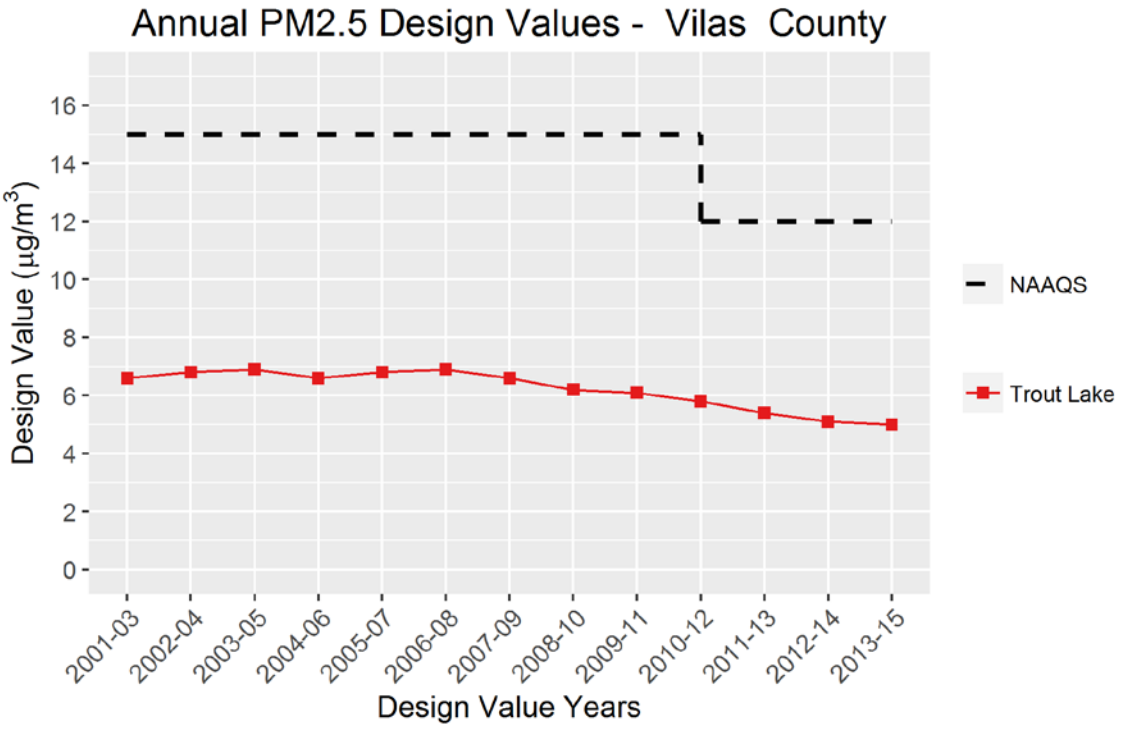


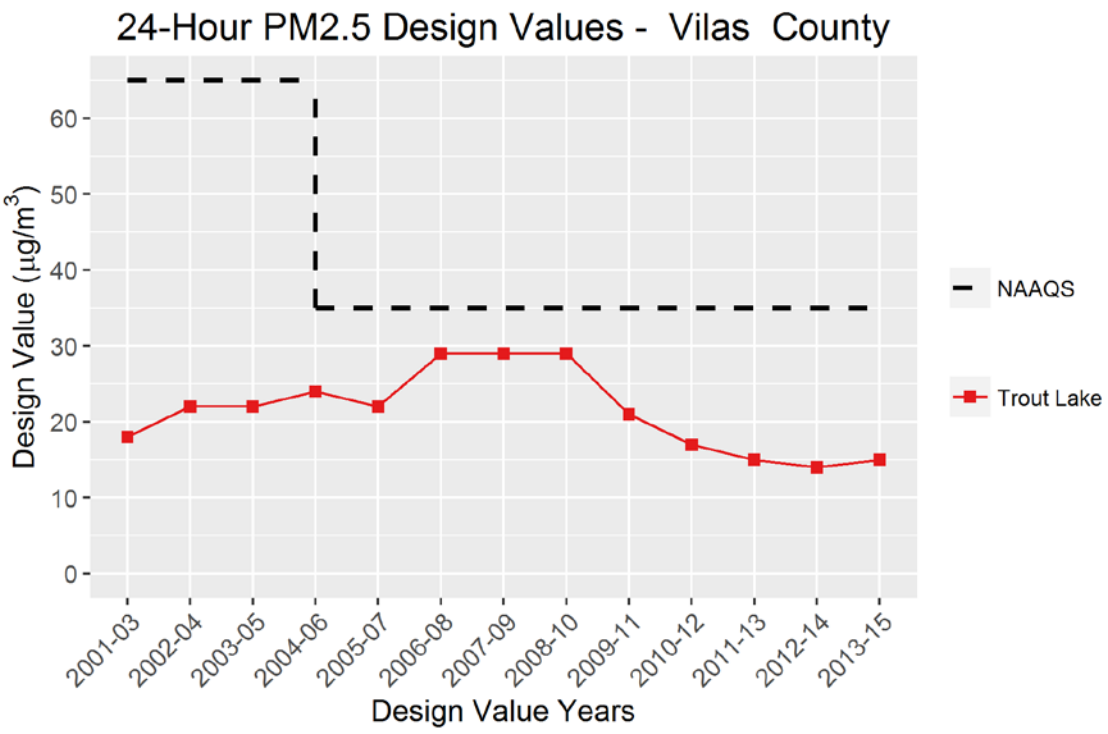


Vilas County

Ozone and $PM_{2.5}$ monitoring in Vilas County are conducted in a field at the WDNR-University of Wisconsin Trout Lake Station at 10810 County Highway M in Boulder Junction.

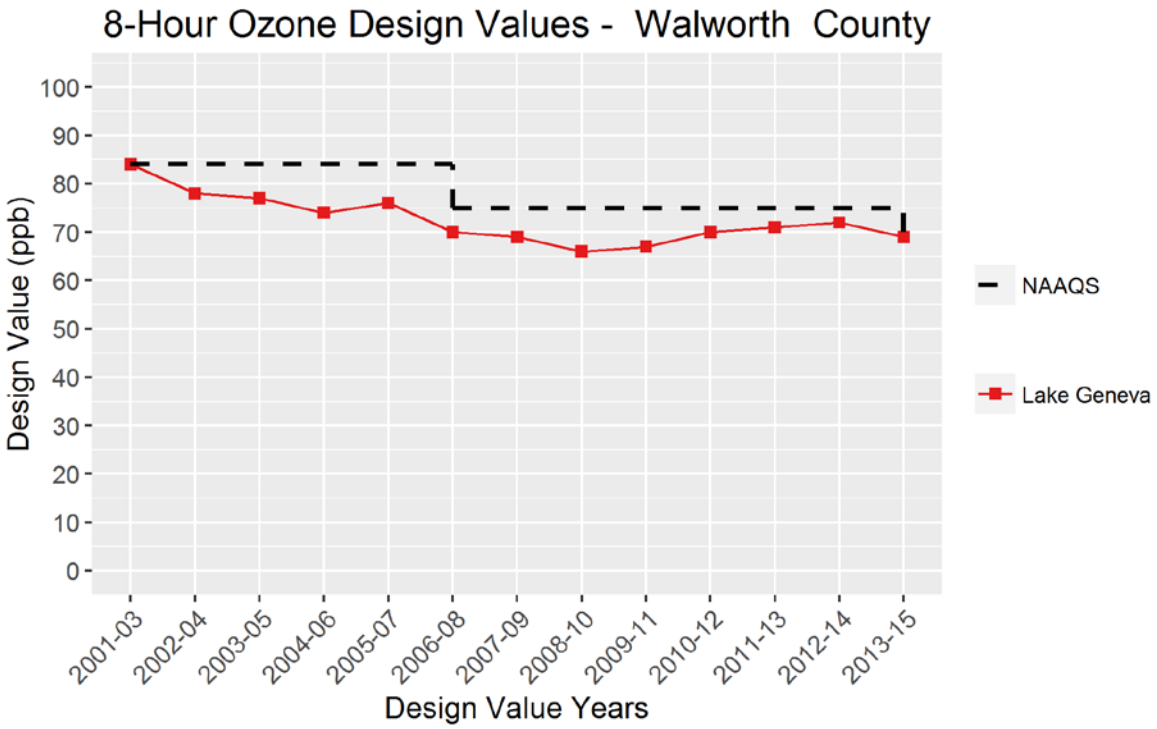





24-Hour PM2.5 Design Values - Vilas County
Design Value (µg/m3)
60
50
40
30
20
10
0
2001-03
2002-04
2003-05
2004-06
2005-07
2006-08
2007-09
2008-10
2009-11
2010-12
2011-13
2012-14
2013-15
Design Value Years
NAAQS
Trout Lake

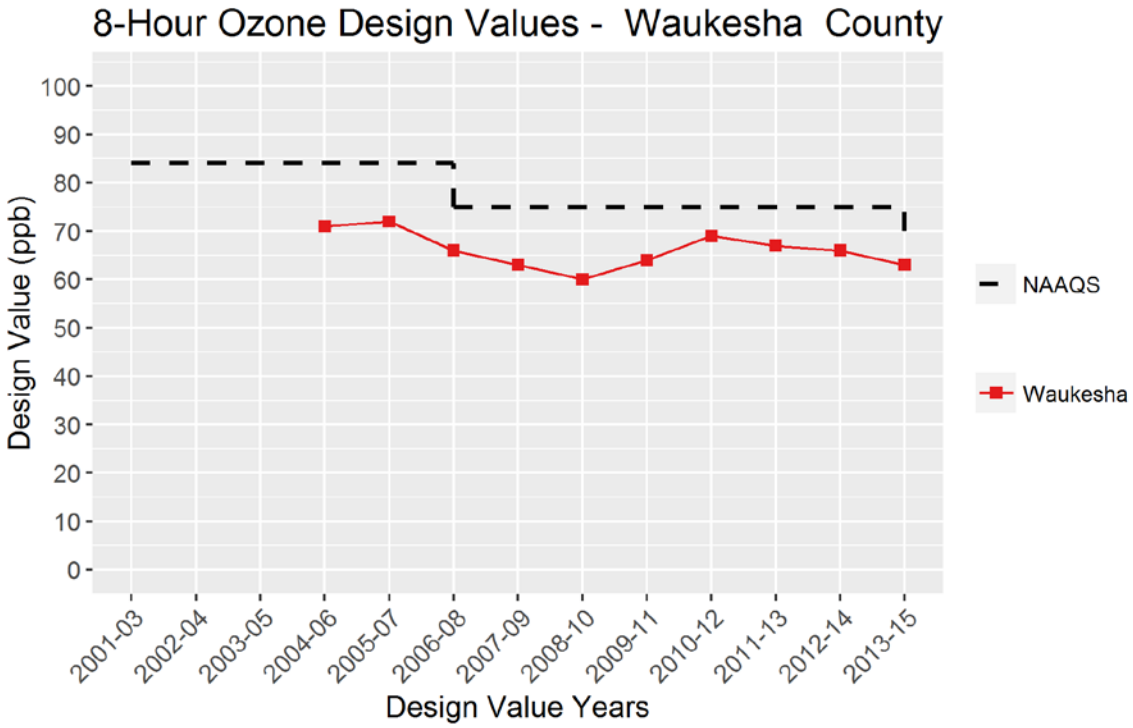
Walworth County

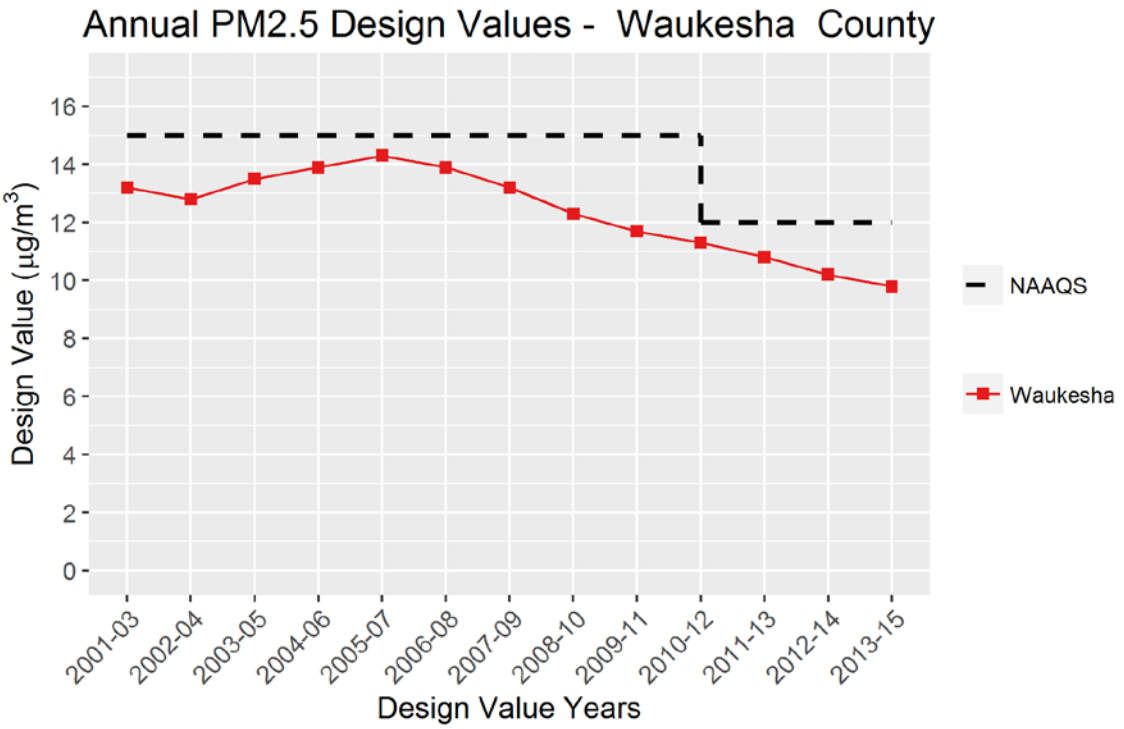
Ozone monitoring in Walworth County is performed at a rural site on the outskirts of the city of Lake Geneva. The address for the site is Rural Route 4 Elgin Club Road.

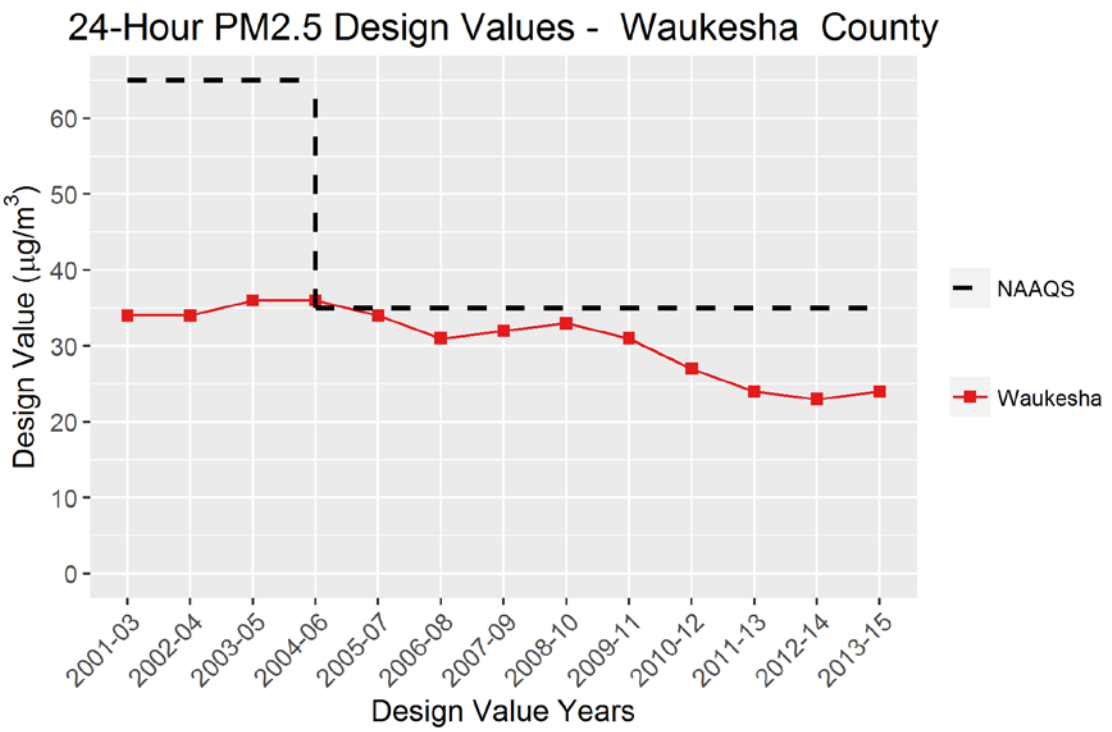


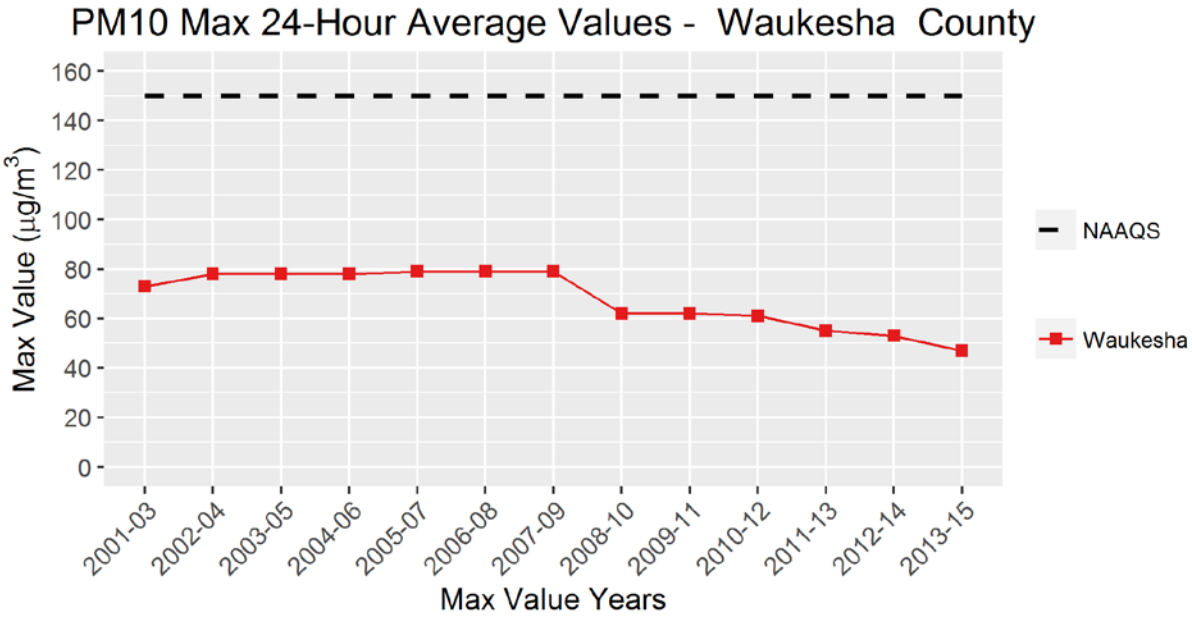
Waukesha County

Ozone, $PM_{2.5}$ and PM_{10} monitoring in Waukesha County are conducted at 1310 Cleveland Avenue in the city of Waukesha. Sampling for concentrations of ozone and $PM_{2.5}$ began on April 29, 2004 and January 22, 2004, respectively. Prior to these dates, sampling for ozone in Waukesha County was performed at a Carroll College site.






24-Hour PM2.5 Design Values - Waukesha County
Design Value (µg/m3)
60
50
40
30
20
10
0
2001-03
2002-04
2003-05
2004-06
2005-07
2006-08
2007-09
2008-10
2009-11
2010-12
2011-13
2012-14
2013-15
Design Value Years
NAAQS
Waukesha


PM10 Max 24-Hour Average Values - Waukesha County
Max Value (µg/m3)
160
140
120
100
80
60
40
20
0
2001-03
2002-04
2003-05
2004-06
2005-07
2006-08
2007-09
2008-10
2009-11
2010-12
2011-13
2012-14
2013-15
Max Value Years
NAAQS
Waukesha

Appendix B. – Change in Design Values 2001-2003 to 2013-2015

TABLE B1. Change in design values for ozone between the 2001-2003 and 2013-2015. Only monitors with valid design values for both beginning and ending periods are included. Note that none of the Far North monitors operated in 2001-2003.

Site name	County	Site ID	8-hr design values^ (ppb)		Change (2001-03 to 2013-15)	
			2001-2003	2013-2015	ppb	%
Appleton	Outagamie	55-087-0009	78	67	-11	-14%
Bayside	Milwaukee	55-079-0085	94	69	-25	-27%
Beloit*	Rock	55-105-0030	83	67	-16	-19%
Chiwaukee Prairie	Kenosha	55-059-0019	101	75	-26	-26%
Columbus	Columbia	55-021-0015	79	66	-13	-16%
Devils Lake	Sauk	55-111-0007	73	63	-10	-14%
Fond du Lac	Fond du Lac	55-039-0006	80	65	-15	-19%
Grafton	Ozaukee	55-089-0008	92	70	-22	-24%
Green Bay-UW	Brown	55-009-0026	83	65	-18	-22%
Harrington Beach	Ozaukee	55-089-0009	98	69	-29	-30%
Horicon*	Dodge	55-027-0001	82	68	-14	-17%
Jefferson*	Jefferson	55-055-0009	83	68	-15	-18%
Kewaunee	Kewaunee	55-06-10002	93	67	-26	-28%
Lake Du Bay	Marathon	55-07-30012	73	63	-10	-14%
Lake Geneva	Walworth	55-127-0005	84	69	-15	-18%
Madison-East	Dane	55-025-0041	78	65	-13	-17%
Manitowoc	Manitowoc	55-07-10007	90	72	-18	-20%
Milw.-SER	Milwaukee	55-079-0026	84	66	-18	-21%
Newport	Door	55-029-0004	94	69	-25	-27%
Sheboygan-KA	Sheboygan	55-117-0006	100	77	-23	-23%
Lakeshore region** average					-24	-25%
Inland region** average					-14	-17%

* The "Horicon" monitor combines records from the Mayville monitor (55-027-0007), which shut down after 2009, and Horicon, which replaced it. The "Jefferson" monitor combines records from the Jefferson H.S. monitor (55-055-0002), which shut down after 2012, and the Jefferson-Laatsch monitor that replaced it. The "Beloit" monitor combines records from the Beloit-Cunningham monitor (55-105-0024), which shut down in 2013, and the Beloit-Converse monitor that replaced it.

** See Figure 3 and associated text for definition of these regions.

^The 2001-2003 design values would be compared against the 1997 eight-hour ozone NAAQS of 84 ppb; the 2013-2015 design values would be compared against the 2008 eight-hour ozone NAAQS of 75 ppb.

TABLE B2. Change in annual design values for $PM_{2.5}$ between the 2001-2003 and 2013-2015. Only monitors with valid design values for both beginning and ending periods are included.

Site name	County	Site ID	Annual design values^ (µg/m³)		Change (2001-03 to 2013-15)	
			2001-2003	2013-2015	(µg/m³)	%
Appleton	Outagamie	55-087-0009	10.7	8	-2.7	-25%
Chiwaukee Prairie	Kenosha	55-059-0019	11.7	8.5	-3.2	-27%
Green Bay-East	Brown	55-009-0005	11.5	8.2	-3.3	-29%
Horicon*	Dodge	55-027-0001	11	8	-3.0	-27%
Madison-University	Dane	55-025-0047	12.5	9	-3.5	-28%
Milw.-16th St.	Milwaukee	55-079-0010	13.1	9.7	-3.4	-26%
Milw.-SER	Milwaukee	55-079-0026	12.5	8.8	-3.7	-30%
Potosi	Grant	55-043-0009	11.4	8.3	-3.1	-27%
Trout Lake**	Vilas	55-125-0001	6.6	5	-1.6	-24%
Waukesha	Waukesha	55-133-0027	13.2	9.8	-3.4	-26%
Southeast region† average					-3.43	-27%
Inland region† average					-3.12	-27%

* The "Horicon" monitor combines records from the Mayville monitor (55-027-0007), which shut down after 2009, and Horicon, which replaced it.

** The only Far North monitor operating in 2001-03 was Trout Lake so no average is shown.

† See Figure 7 and associated text for definition of these regions.

^ The 2001-2003 design values would be compared against the 1997 annual $PM_{2.5}$ NAAQS of 15.0 µg/m³; the 2013-2015 design values would be compared against the 2012 annual $PM_{2.5}$ NAAQS of 12.0 µg/m³.

TABLE B3. Change in 24-hr design values for $PM_{2.5}$ between the 2001-2003 and 2013-2015. Only monitors with valid design values for both beginning and ending periods are included.

Site name	County	Site ID	24-hr design values^ (µg/m³)		Change (2001-03 to 2013-15)	
			2001-2003	2013-2015	(µg/m³)	%
Appleton	Outagamie	55-087-0009	29	22	-7	-24%
Chiwaukee Prairie	Kenosha	55-059-0019	31	22	-9	-29%
Green Bay-East	Brown	55-009-0005	32	22	-10	-31%
Horicon*	Dodge	55-027-0001	33	21	-12	-36%
Madison-University	Dane	55-025-0047	34	23	-11	-32%
Milw.-16th St.	Milwaukee	55-079-0010	36	25	-11	-31%
Milw.-SER	Milwaukee	55-079-0026	34	21	-13	-38%
Potosi	Grant	55-043-0009	28	21	-7	-25%
Trout Lake**	Vilas	55-125-0001	18	15	-3	-17%
Waukesha	Waukesha	55-133-0027	34	24	-10	-29%
Southeast region^ average					-10.75	-32%
Inland region^ average					-9.40	-30%

*The "Horicon" monitor combines records from the Mayville monitor (55-027-0007), which shut down after 2009, and Horicon, which replaced it.

**The only far north monitor operating in 2001-03 was Trout Lake so no average is shown.

^ See Figure 8 and associated text for definition of these regions.

^The 2001-2003 design values would be compared against the 1997 twenty-four-hour $PM_{2.5}$ NAAQS of 65 µg/m³; the 2013-2015 design values would be compared against the 2006 twenty-four-hour $PM_{2.5}$ NAAQS of 35 µg/m³.

TABLE B4. Change in three-year maximum 24-hr average for PM_{10} between the start of monitoring (date variable) and 2013-2015. Annual maximum values over three years contribute to the determination of the PM_{10} design value.

Site name	County	Site ID	First years of data	3-yr maximum 24-hr average^ (ppb)		Change (first years to 2013-15)	
				First years	2013-2015	ppb	%
Devils Lake	Sauk	55-111-0007	2012-14	41	42	+1	+2%
Horicon*	Dodge	55-027-0001	2005-07	62	30	-32	-52%
Madison-University	Dane	55-025-0047	2008-10	63	47	-16	-25%
Milw.-16th St.	Milwaukee	550-790-010	2007-09	47	32	-15	-32%
Milw.-College Ave. P&R	Milwaukee	55-079-0058	2010-12	70	57	-13	-19%
Milw.-SER	Milwaukee	55-079-0026	2011-13	64	58	-6	-9%
Waukesha	Waukesha	55-133-0027	2001-03	73	47	-26	-36%

*The "Horicon" monitor combines records from the Mayville monitor (55-027-0007), which shut down after 2009, and Horicon, which replaced it.

^All design values would be compared against the 1987 twenty-four-hour PM_{10} NAAQS of 150 µg/m³, which is not to be exceeded more than once per year on average over 3 yr.

TABLE B5. Change in 1-hr design values for SO_2 between the start of monitoring (date variable) and 2013-2015. Only one monitor (Rhinelander) had valid design values for the entire 2001-2003 to 2013-2015 period. Madison-East only had one valid design value so is not included in the table.

Site name	County	Site ID	First years of data	1-hr design values^ (ppb)		Change (first years to 2013-15)	
				First years	2013-2015	ppb	%
Green Bay-East	Brown	55-009-0005	2003-05	67	75	+8	+12%
Horicon	Dodge	55-027-0001	2010-12	7	6	-1	-14%
Milw.-SER	Milwaukee	55-079-0026	2002-04	68	21	-47	-69%
Potawatomi	Forest	55-041-0007	2007-09	8	7	-1	-13%
Rhinelander	Oneida	55-085-0996	2001-03	149	157	+8	+5%

^Design values from 2010-2012 to 2013-2015 would be compared against the 2010 one-hour SO_2 NAAQS of 75 ppb. There was not a 1-hr standard in effect prior to 2010; rather there were annual and 24-hr standards of 30 ppb and 140 ppb, respectively.

TABLE B6. Change in annual design values for NO_2 between 2006 and 2015. Only monitors with valid design values for both beginning and ending periods are included.

Site name	County	Site ID	Annual design values^ (ppb)		Change (2006 to 2015)	
			2006	2015	ppb	%
Milw.-SER	Milwaukee	55-079-0026	15	10	-5	-33%

^All design values would be compared against the 1971 annual NO_2 NAAQS of 53 ppb.

TABLE B7. Change in 1-hr design values for NO_2 between 2004-2006 and 2013-2015. Only monitors with valid design values for both beginning and ending periods are included.

Site name	County	Site ID	1-hr design values^ (ppb)		Change (2004-06 to 2013-15)	
			2004-2006	2013-2015	ppb	%
Milw.-SER	Milwaukee	55-079-0026	52	45	-7	-13%

^Design values from 2013-2015 would be compared against the 2010 one-hour NO_2 NAAQS of 100 ppb. There was not a 1-hr standard in effect prior to 2010; rather there was an annual standard of 53 ppb as noted in Table B6 above.

TABLE B8. Change in 8-hr and 1-hr design values for CO between 2010 and 2015. Only monitors with valid design values for both beginning and ending periods are included. The percentage change between years is not shown because it is not meaningful when measurements are close to zero.

Site name	County	Site ID	8-hr design values^ (ppm)		1-hr design values^ (ppm)	
			2010	2015	2010	2015
Horicon	Dodge	55-027-0001	0.5	0.7	0.4	0.4

^All 8-hr design values would be compared against the 1971 eight-hour CO NAAQS of 9 ppm and all 1-hr design values would be compared against the 1971 one-hour NAAQS of 35 ppm.

Appendix C. – Full Site Names

TABLE C1. Full site names corresponding to shorter names used in the text, tables and figures.

Site Name	County	Site ID	Full site name
Appleton	Outagamie	55-087-0009	Appleton - AAL
Bad River	Ashland	55-003-0010	Bad River Tribal School - Odanah
Bayside	Milwaukee	55-079-0085	Bayside
Beloit*	Rock	55-105-0030	Beloit - Converse
Chiwaukee	Kenosha	55-059-0019	Chiwaukee Prairie Stateline
Columbus	Columbia	55-021-0015	Columbus
Devils Lake	Sauk	55-111-0007	Devils Lake Park
Eau Claire	Eau Claire	55-035-0014	Eau Claire - DOT Sign Shop
Fond du Lac	Fond du Lac	55-039-0006	Fond du Lac
Grafton	Ozaukee	55-089-0008	Grafton
Green Bay-East	Brown	55-009-0005	Green Bay - East High
Green Bay-UW	Brown	55-009-0026	Green Bay - UW
Harrington Beach	Ozaukee	55-089-0009	Harrington Beach Park
Horicon*	Dodge	55-027-0001	Horicon Wildlife Area
Jefferson*	Jefferson	55-055-0009	Jefferson - Laatsch
Kenosha-WT	Kenosha	55-059-0025	Kenosha-Water Tower
Kewaunee	Kewaunee	55-061-0002	Kewaunee
Kohler	Sheboygan	55-117-0008	Kohler
La Crosse	La Crosse	55-063-0012	Lacrosse - DOT Building
Lake Du Bay	Marathon	55-073-0012	Lake Du Bay
Lake Geneva	Walworth	55-127-0005	Lake Geneva
Madison-East	Dane	55-025-0041	Madison - East
Madison-University	Dane	55-025-0047	Madison – University Ave. Well #6
Manitowoc	Manitowoc	55-071-0007	Manitowoc - Wdlnd Dunes
Milw.-16th St.	Milwaukee	55-079-0010	Milwaukee - Sixteenth St. Health Center
Milw.-College Ave. NR	Milwaukee	55-079-0056	Milwaukee – College Ave. Near Road
Milw.-College Ave. P&R	Milwaukee	55-079-0058	Milwaukee – College Ave. Park & Ride
Milw.-Fire Dept.	Milwaukee	55-079-0099	Milwaukee – Fire Dept. HQ.
Milw.-SER	Milwaukee	55-079-0026	Milwaukee - SER DNR Hdqrs.
Newport	Door	55-029-0004	Newport Park
Perkinstown	Taylor	55-119-8001	Perkinstown
Potawatomi	Forest	55-041-0007	Potawatomi
Potosi	Grant	55-043-0009	Potosi
Racine-Payne & Dolan	Racine	55-101-0020	Racine-Payne & Dolan
Rhinelander	Oneida	55-085-0996	Rhinelander Tower
Sheboygan-Haven	Sheboygan	55-117-0009	Sheboygan - Haven
Sheboygan - KA	Sheboygan	55-117-0006	Sheboygan - Kohler Andrae
Trout Lake	Vilas	55-125-0001	Trout Lake
Waukesha	Waukesha	55-133-0027	Waukesha - Cleveland Ave.

*The "Horicon" monitor combines records from the Mayville monitor (55-027-0007), which shut down after 2009, and Horicon, which replaced it. The "Jefferson" monitor combines records from the Jefferson H.S. monitor (55-055-0002), which shut down after 2012, and the Jefferson-Laatsch monitor that replaced it. The "Beloit" monitor combines records from the Beloit-Cunningham monitor (55-105-0024), which shut down in 2013, and the Beloit-Converse monitor that replaced it.