Letter Health Consultation

Analysis of Ambient Particulate Matter Data

OAK CREEK POWER PLANT
OAK CREEK, WISCONSIN

MARCH 16, 2017

U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES
Agency for Toxic Substances and Disease Registry
Division of Community Health Investigations
Atlanta, Georgia 30333

Health Consultation: A Note of Explanation

An ATSDR health consultation is a verbal or written response from ATSDR to a specific request for information about health risks related to a specific site, a chemical release, or the presence of hazardous material. In order to prevent or mitigate exposures, a consultation may lead to specific actions, such as restricting use of or replacing water supplies; intensifying environmental sampling; restricting site access; or removing the contaminated material.

In addition, consultations may recommend additional public health actions, such as conducting health surveillance activities to evaluate exposure or trends in adverse health outcomes; conducting biological indicators of exposure studies to assess exposure; and providing health education for health care providers and community members. This concludes the health consultation process for this site, unless additional information is obtained by ATSDR which, in the Agency's opinion, indicates a need to revise or append the conclusions previously issued.

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LETTER HEALTH CONSULTATION

Analysis of Ambient Particulate Matter Data

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OAK CREEK, WISCONSIN

Prepared By:

U.S. Department of Health and Human Services
Agency for Toxic Substances and Disease Registry
Division of Community Health Investigations
Science Support Branch

DEPARTMENT OF HEALTH & HUMAN SERVICES
Agency for Toxic Substances and Disease Registry

Ryan Wozniak
Wisconsin Department of Health Services
1 W. Wilson Street
Room 150
Madison, WI 53702

Re: Oak Creek Power Plant, Oak Creek, WI: Analysis of Ambient Particulate Matter Data

March 16, 2017

Dear Mr. Wozniak:

In November, 2016, the Wisconsin Department of Health Services (DHS) requested assistance from the Agency for Toxic Substances and Disease Registry (ATSDR) to analyze particulate matter data collected at an ambient monitoring location near the We Energies Oak Creek Power Plant in Oak Creek, WI. The purpose of the analysis is to determine whether the monitor is appropriately sited to quantify impacts from the facility stacks, coal storage pile, and/or train traffic to and from the facility and if the monitoring results indicate a potential public health hazard. This document presents the results of ATSDR's analysis of the available data.

Given the data ATSDR had to review, ATSDR concludes that the 2016 data indicate breathing total suspended particulate (TSP), particulate matter with aerodynamic diameter less than ten microns (PM_{10}), and particulate matter with aerodynamic diameter less than 2.5 microns ($PM_{2.5}$) near Oak Creek Power Plant is unlikely to harm people's health for either short-term or long term exposures, based on the siting of these monitors. However, the PM monitor may not have been sited in a location that captured worst case conditions from waste piles, stack emissions, and railroad sources.

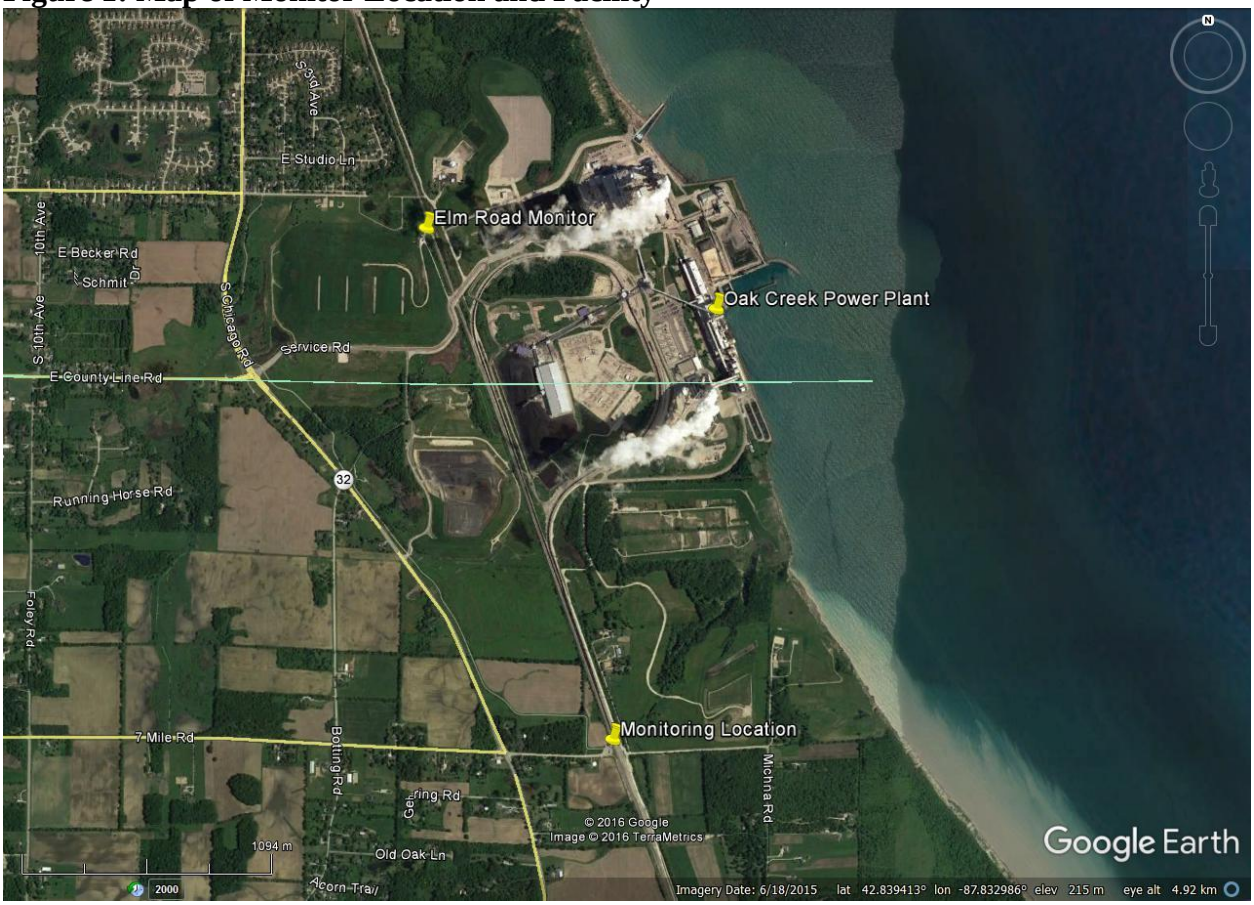
Background

The Oak Creek Power Plant is a coal fired generation facility operated by We Energies in Oak Creek, WI. The plant consists of four active steam turbine generating units with a total capacity of 1,135 megawatts (We Energies 2014). The facility occupies 1,000 acres on the western shore of Lake Michigan and uses 6,000-6,200 tons of coal per day (We Energies 2014). Ambient air quality monitoring was previously conducted from January 2009 through September 2013 at a location just to the northwest of the facility on Elm Road. At the time, the Environmental Protection Agency (EPA) concluded that the measured concentrations were in compliance with applicable air quality standards. The Wisconsin DHS has received several complaints about air quality and noise from residents to the south of the facility. In order to address these complaints, ambient air quality monitoring was initiated in January 2016 at a location south of the facility and immediately to the west of the rail line that services the power plant. Hourly measurements of TSP, PM_{10}, and $PM_{2.5}$ are available from mid-January through the end of December 2016.

Data

A beta attenuation monitor (BAM) was used to collect particulate matter data on an hourly basis starting on January 21, 2016 with data available until December 30, 2016. In addition to hourly concentrations of TSP, PM_{10}, and $PM_{2.5}$, meteorological data were collected including wind speed, wind direction, temperature, and atmospheric pressure. There are three periods with extended missing data during this interval, a zero test from August 3 through August 9, 2016 (missing for all particle sizes), a tape break from October 5 through October 9, 2016 ($PM_{2.5}$ data missing), and a tape break from October 16 through October 17, 2016 ($PM_{2.5}$ data missing). One hour of TSP data (3/17/16 10:00 am) was removed from the analysis because it was a one hour spike in TSP during a time period that did not show a similar increase in PM_{10} or $PM_{2.5}$. A map of the area showing the locations of the EPA (Elm Road) and state monitors as well as the Oak Creek Power Plant is shown in Figure 1.

Figure 1: Map of Monitor Location and Facility



Measured concentrations of particulate matter were compared to the appropriate EPA air quality standards, as well as to guidelines published by the World Health Organization (WHO). Temporal and spatial patterns in the data were also examined. The following sections provide results of these comparisons and analyses.

Average Concentrations

Average concentrations of TSP, PM_{10}, and $PM_{2.5}$, as well as available screening values, are shown in Table 1 for the approximately 12-month monitoring period. The average concentration of $PM_{2.5}$ was 6.8 micrograms per cubic meter ($\mu g/m^3$), which is below both the annual $PM_{2.5}$ National Ambient Air Quality Standard (NAAQS) (EPA 2013) and the WHO $PM_{2.5}$ air quality guideline (WHO 2006) for chronic exposure, 12 and 10 $\mu g/m^3$, respectively. The average concentration of PM_{10} was 14.7$\mu g/m^3$, which is below the WHO PM_{10} air quality guideline (WHO 2006) for chronic exposure (20 $\mu g/m^3$). There is no NAAQS for chronic exposure to PM_{10}. The average concentration of TSP was 16.7 $\mu g/m^3$. While there are no current standards for chronic TSP exposure, this concentration is below the WHO guideline for chronic PM_{10} exposure. Thus, TSP concentrations are unlikely to present a chronic public health hazard at this location.

Table 1: Average Concentrations

Species	Average Measured Concentration ($\mu g/m^3$)	Annual NAAQS* ($\mu g/m^3$)	Chronic WHO† Guideline ($\mu g/m^3$)
$PM_{2.5}$	6.8	12	10
PM_{10}	14.7	NA	20
TSP	16.7	NA	NA

$PM_{2.5}$: particulate matter with aerodynamic diameter less than 2.5 microns
PM_{10}: particulate matter with aerodynamic diameter less than 10 microns
TSP: total suspended particulate
$\mu g/m^3$: micrograms per cubic meter
NAAQS: National Ambient Air Quality Standard
WHO: World Health Organization
* EPA 2013
† WHO 2006

ATSDR also reviewed the data previously collected from the site on Elm Road to the northwest and determined that all annual averages of $PM_{2.5}$ and PM_{10} were below the current NAAQS (EPA 2013) and WHO guidelines (WHO 2006) for each year for which data were available (2009 through 2013). Maximum annual averages (reported in PDF form and not independently calculated from raw data by ATSDR) were 9.43 $\mu g/m^3$ for $PM_{2.5}$ and 14.4 $\mu g/m^3$ for PM_{10}. Annual averages were not reported for TSP.

It is unlikely that ambient concentrations of particulate matter will harm people's health since all of the average PM concentrations are below the applicable standards or guidelines.

Maximum Concentrations

Maximum measured 24-hour average concentrations of TSP, PM_{10}, and $PM_{2.5}$, as well as available comparison values are shown in Table 2. The maximum 24-hour concentration of $PM_{2.5}$ was 23.1 $\mu g/m^3$. This concentration corresponds to an EPA Air Quality Index (AQI) of

74 (Moderate) (EPA 2016) The AQI is discussed in more detail in the Health Implications section. Over the one year monitoring period, 45 days had $PM_{2.5}$ AQI in the moderate range (51-100). All 24-hour averages are below both the NAAQS (35 µg/m^3 [EPA 2013]) and the WHO 24-hour guideline (25 µg/m^3 [WHO 2006]). Since all 24-hour averages are below both the NAAQS (regulatory) and WHO (health-based) guideline, it is unlikely that concentrations of $PM_{2.5}$ will harm people's health.

The maximum 24-hour concentration of PM_{10} was 44.9 µg/m^3. This concentration corresponds to an EPA AQI of 41 (Good) (EPA 2016). At this AQI, EPA does not recommend any actions, even for sensitive groups (EPA 2016). All 24-hour averages were below both the NAAQS (150 µg/m^3 [EPA 2013]) and the WHO 24-hour guideline (50 µg/m^3 [WHO 2006]). Since all 24-hour averages are below both the NAAQS (regulatory) and WHO (health-based) guideline, concentrations of PM_{10} are unlikely to harm people's health.

The maximum 24-hour concentration of TSP was 73.0 µg/m^3. While there are no current standards for acute exposure to TSP, all 24-hour averages are below the 24-hour NAAQS for PM_{10}.

Table 2: Maximum Concentrations

Species	Maximum 24-Hour Concentration (µg/m^3)	24-Hour NAAQS* (µg/m^3)	24-Hour WHO† Guideline (µg/m^3)
$PM_{2.5}$	23.1	35	25
PM_{10}	44.9	150	50
TSP	73.0	NA	NA

$PM_{2.5}$: particulate matter with aerodynamic diameter less than 2.5 microns
PM_{10}: particulate matter with aerodynamic diameter less than 10 microns
TSP: total suspended particulate
µg/m^3: micrograms per cubic meter
NAAQS: National Ambient Air Quality Standard
WHO: World Health Organization
* EPA 2013
† WHO 2006

ATSDR also reviewed the data previously collected from the site on Elm Road to the northwest and determined that all 24-hour averages of PM_{10} were below the current NAAQS (EPA 2013) and WHO guidelines (WHO 2006) for each day for which data were available. One measured 24-hour average $PM_{2.5}$ concentration did slightly exceed the nominal 24-hour $PM_{2.5}$ NAAQS (maximum concentration of 35.21 µg/m^3 compared to current NAAQS of 35 µg/m^3). This maximum concentration corresponds to an EPA AQI of 100 (Moderate) (EPA 2016), the same category as the maximum from the monitoring to the south. There were six days with 24-hour measured concentrations greater than the current WHO $PM_{2.5}$ guideline (WHO 2006) over the approximately five years of data available from the Elm Road site. All days with measured concentrations of $PM_{2.5}$ in excess of 25 µg/m^3 occurred between July and September. ATSDR generally concurs with EPA's original assessment of the measured

concentrations at the Elm Road site but notes that measured concentrations did exceed the current nominal NAAQS on one occasion and infrequently exceeded the WHO $PM_{2.5}$ guideline at this monitoring location. There were 229 days, over approximately five years, with measured concentrations in the moderate AQI range at the Elm Road monitor.

It is unlikely that ambient concentrations of particulate matter will harm people's health since all of the 24-hour PM concentrations are at or below the applicable regulatory standards and health-based guidelines.

Temporal Analysis

Available data were analyzed using the openair package in R (Carslaw and Ropkins 2012). Time series of TSP, PM_{10}, and $PM_{2.5}$ are shown in Figure 2, Figure 3, and Figure 4 respectively. TSP and PM_{10} show a change in mid-April with higher concentrations occurring periodically after this time, with a return to lower concentrations in mid-November. $PM_{2.5}$ shows a slight decrease over the first two months of data collected with increasing frequency of negative reported concentrations (small negative reported concentrations are possible with this instrument and indicate actual concentrations are very low) over the course of the monitoring. $PM_{2.5}$ concentrations then increase slightly in mid-October and remain higher through the end of the monitoring period. The change in TSP and PM_{10} could be due to changes in weather (e.g. thawing of exposed piles of material allowing scouring by wind) or operational changes at a source.

Time variation plots of TSP, PM_{10}, and $PM_{2.5}$ are shown in Figure 5, Figure 6, and Figure 7 respectively. TSP and PM_{10} again show similar patterns with higher concentrations during the day and lower concentrations at night. There is also a monthly pattern with higher concentrations from approximately April through August and October through November as well as a weekly pattern with the lowest concentrations on Thursdays and highest concentrations on Sundays and Mondays. $PM_{2.5}$ data show different diurnal and monthly patterns with lower concentrations during the day and higher concentrations in January, October, November, and December. There is a weekly pattern with lower concentrations Wednesday through Friday. The weekly patterns may indicate operational factors at a nearby source impacting the particulate concentrations. The $PM_{2.5}$ concentrations are very low and sometimes register negative values. After a zero check in early August concentrations increased slightly. The negative trend in $PM_{2.5}$ combined with this change after the zero check suggests that there may have been a slight baseline drift, or slight changes in the accuracy of the equipment's lower detection limit, occurring during the early months of monitoring.

While there are some trends in the particulate data, concentrations on all time scales and for all months are below applicable screening levels.

Figure 2: Time Series of Total Suspended Particulate Data

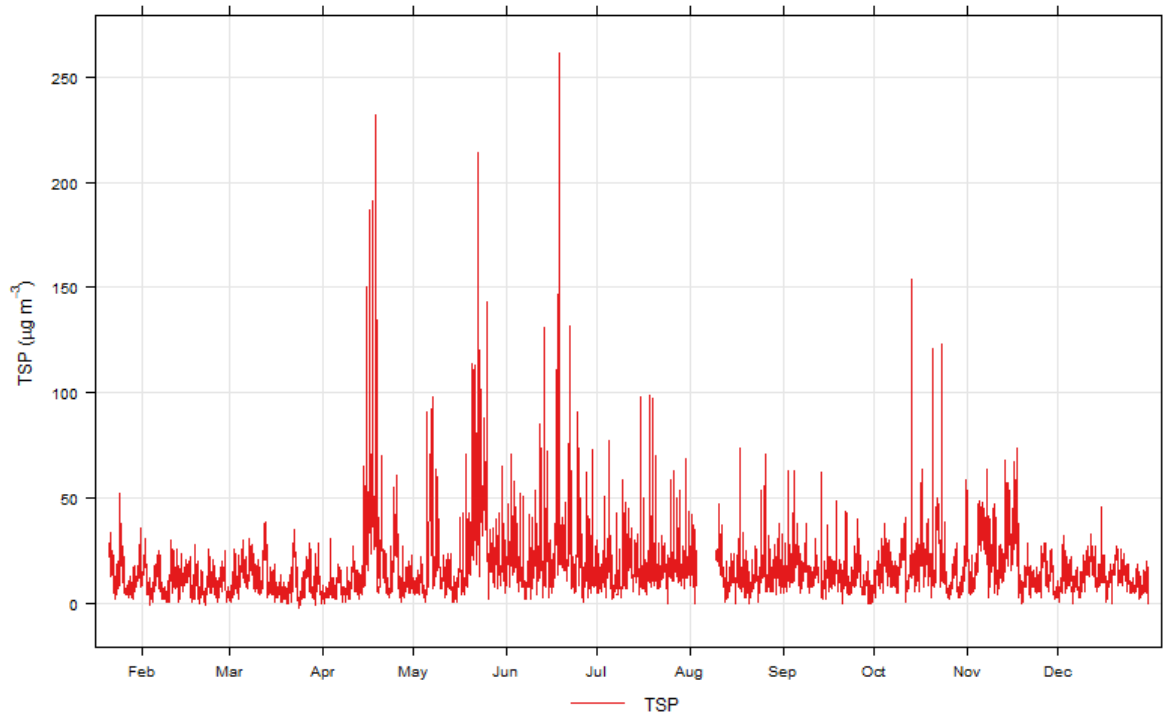


Figure 3: Time Series of PM_{10} Data

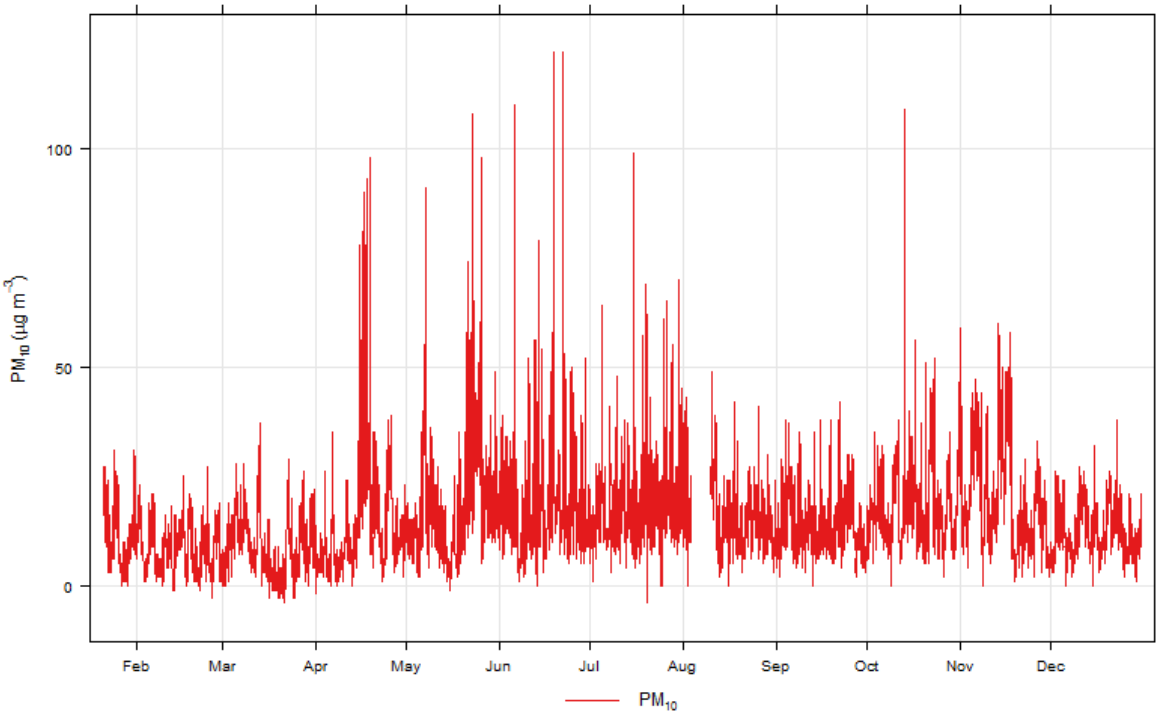


Figure 4: Time Series of $PM_{2.5}$ Data

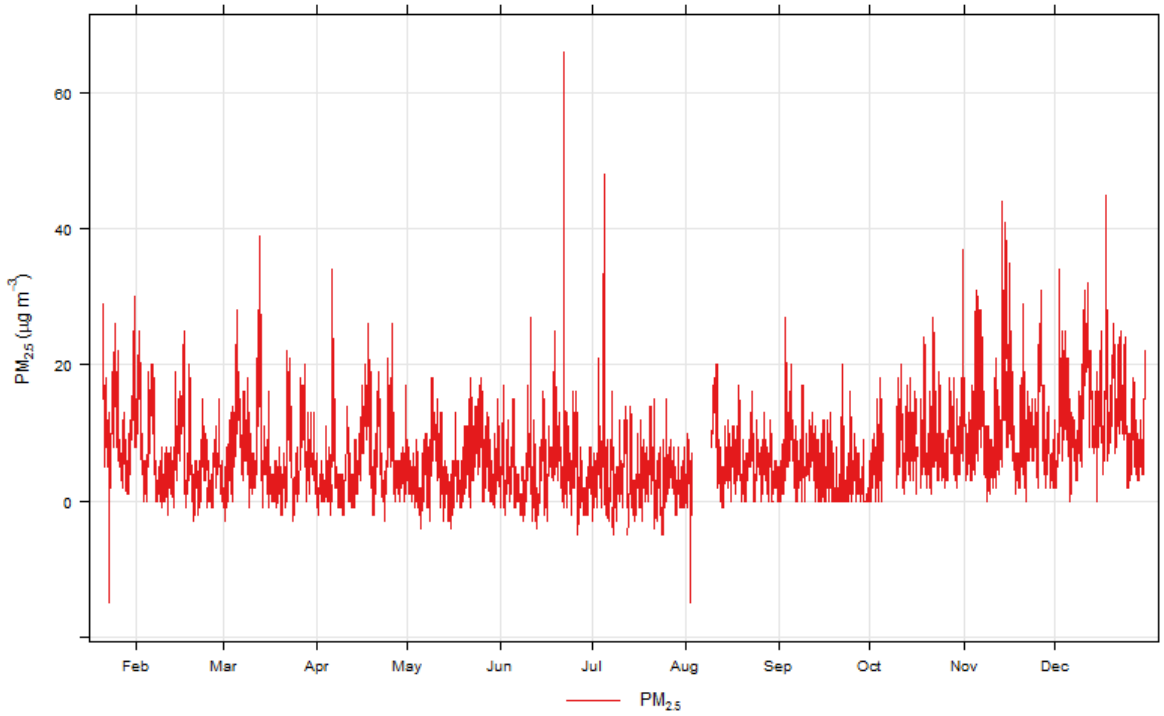


Figure 5: Time Variation of Total Suspended Particulate Data

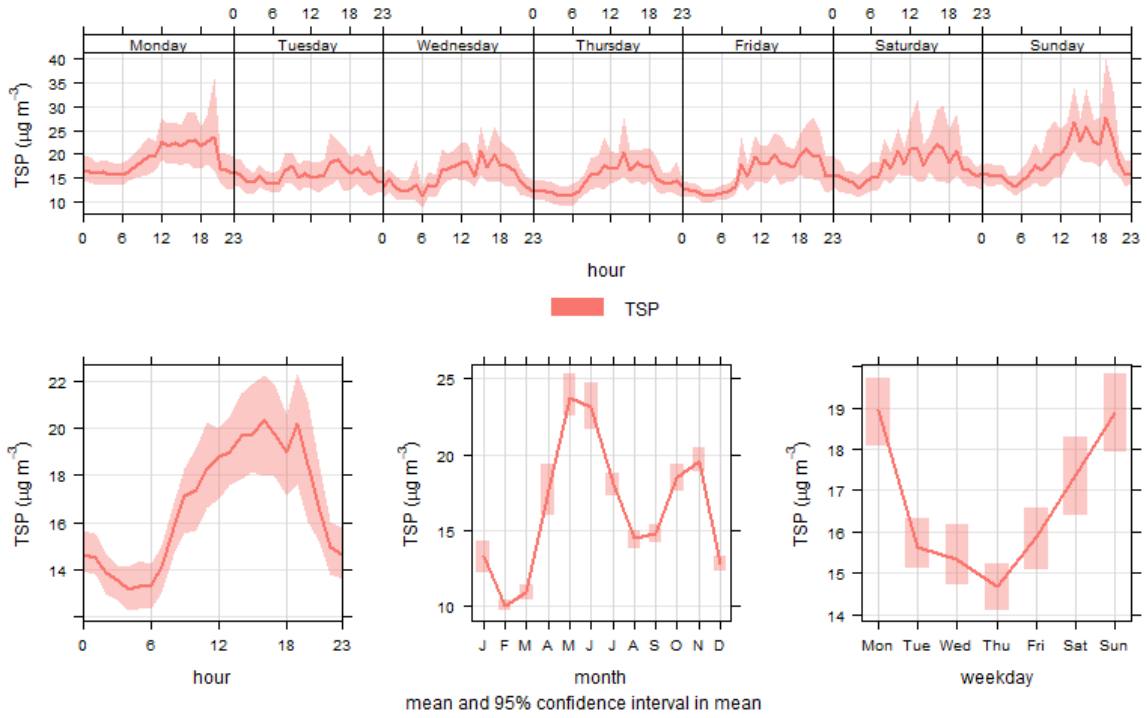


Figure 6: Time Variation of PM_{10} Data

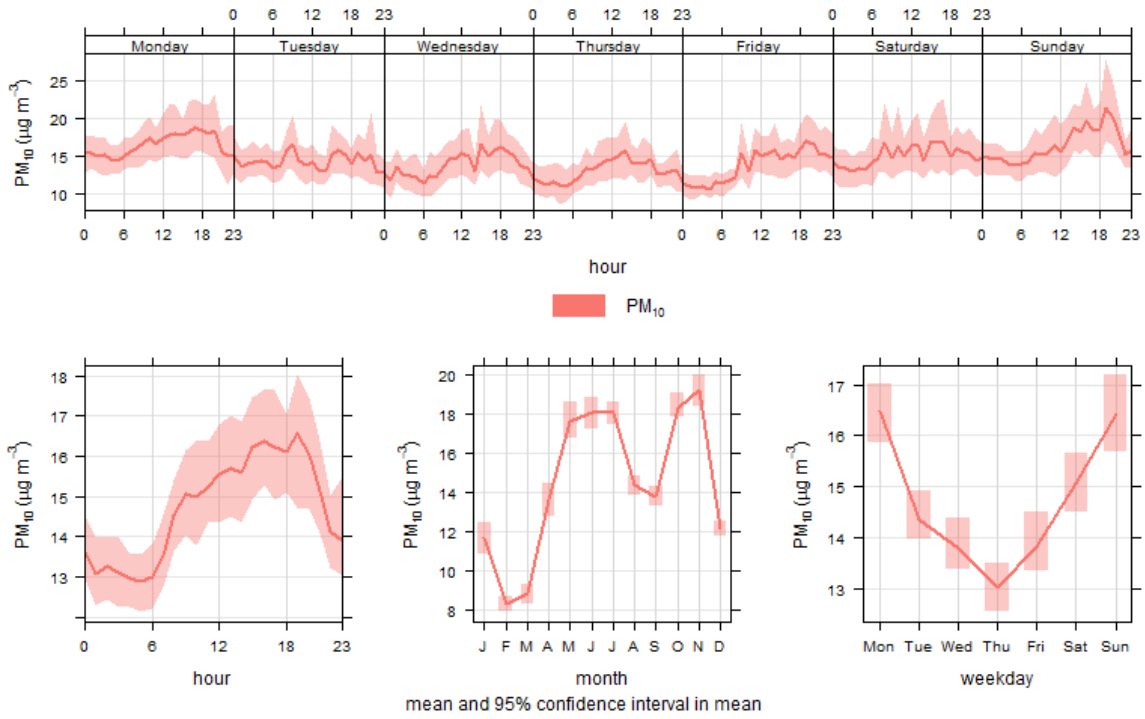
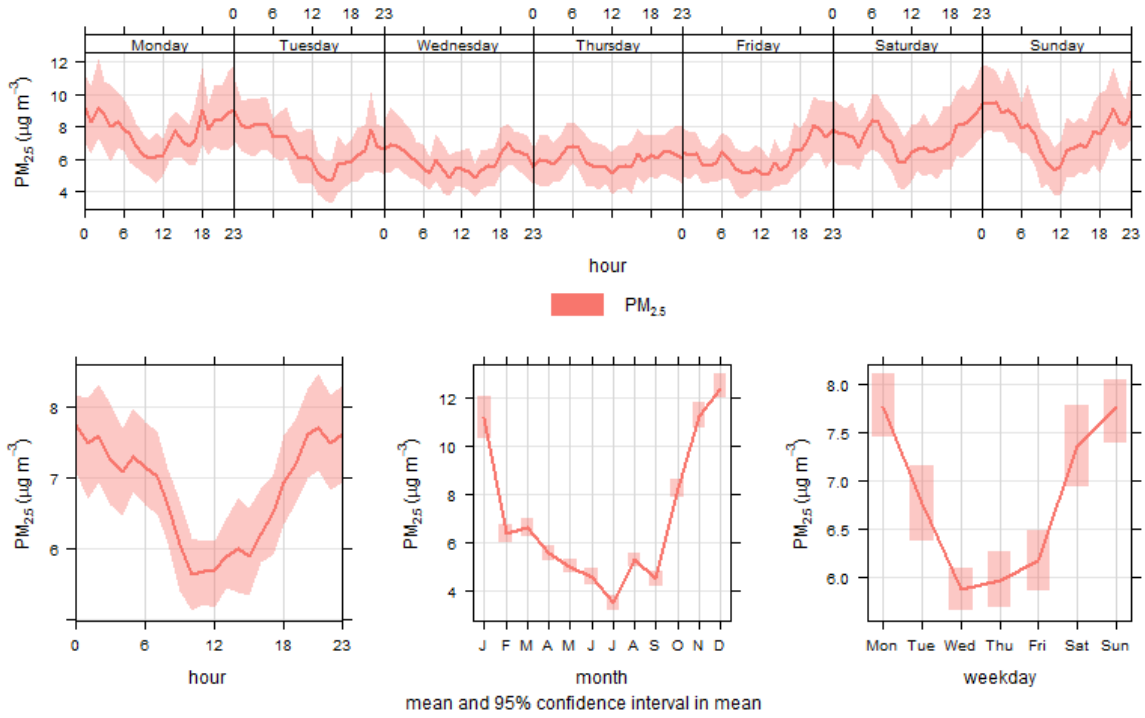


Figure 7: Time Variation of $PM_{2.5}$ Data



Spatial Analysis

The power plant is to the north and northeast of the monitoring location while the rail line runs from NNW to SSE and passes just to the east of the monitor (Figure 1). Polar plots showing the measured concentrations with wind speed and wind direction are shown in Figure 8 (TSP), Figure 9 (PM_{10}), and Figure 10 ($PM_{2.5}$). The high concentration data for TSP and PM_{10} associated with strong southwesterly winds are due to a two day period in October 2016. Unfortunately, this period corresponds with the time when the $PM_{2.5}$ monitor was not collecting data due to a broken tape so it is not possible to determine if these elevated concentrations are just in the larger size range or for all particles. Regardless, winds from the southwest are unlikely to be transporting material from any of the potential sources associated with the power plant to the monitoring location. TSP data show elevated concentrations with light to moderate winds from the northeast. PM_{10} data show a similar pattern, but concentrations are also increased with stronger winds from the north as well as all winds from the southeast. Concentrations of $PM_{2.5}$ are highest with strong winds from the east and southeast but show no indication of increases when winds are from the northeast or north.

Figure 8: Polar Plot of Total Suspended Particulate Data (µg/m^3)

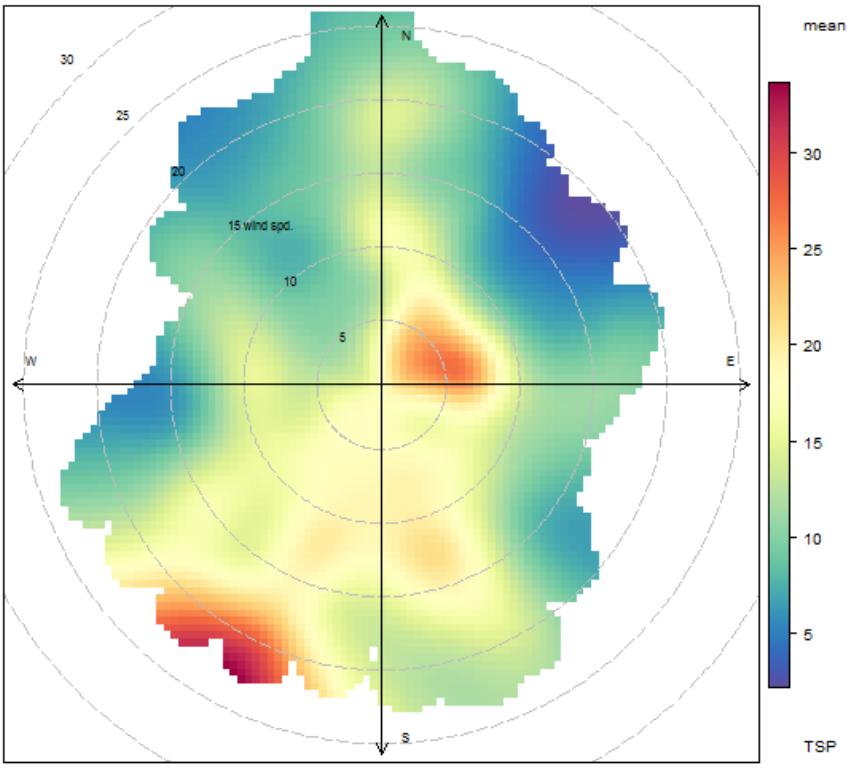


Figure 9: Polar Plot of PM_{10} Data ($\mu g/m^3$)

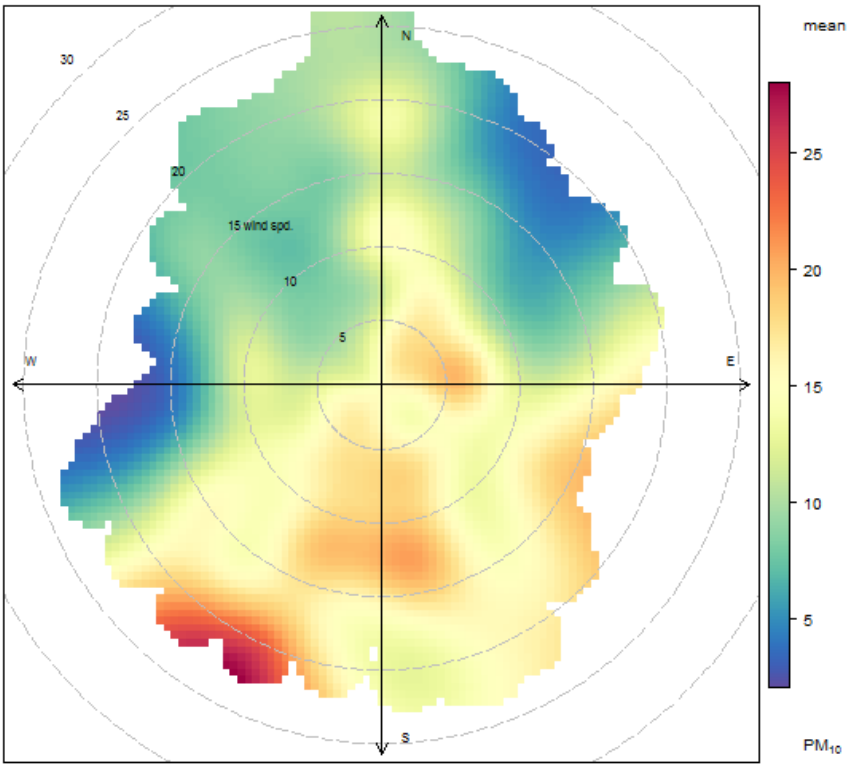
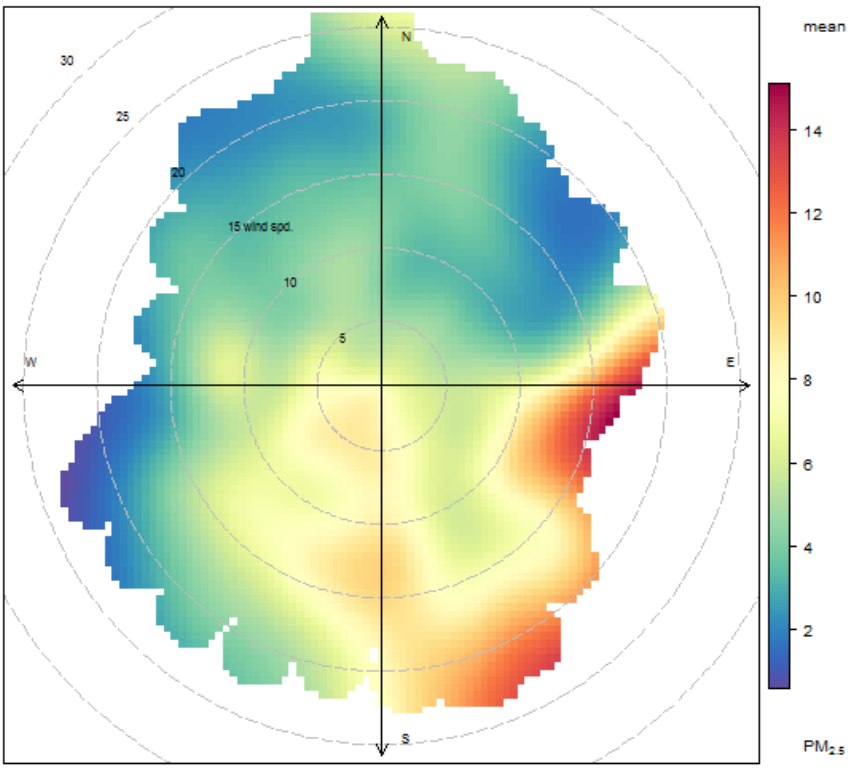


Figure 10: Polar Plot of $PM_{2.5}$ Data ($\mu g/m^3$)



The spatial patterns in the data suggest that the power plant, and associated activities, are not contributing significantly to $PM_{2.5}$ at the monitoring location. There is an indication that sources to the north and northeast of the monitor (the direction of the power plant and rail line) do contribute to higher measured PM_{10} concentrations. For TSP, the highest measured concentrations are associated with winds from the northeast (possibly associated with the rail line) and southwest (likely not due to any power plant source). Wind-blown PM_{10} from material on trains and from the coal pile at the facility may be reaching the monitoring location. TSP from material on trains may be reaching the monitoring location but the spatial analysis using wind direction data indicates that TSP from within the facility boundary is not frequently being transported to the monitoring location. The larger TSP particles are only transported a short distance by the wind so it makes sense that the closer rail line shows a potential impact while the coal pile that is further away does not.

There are some residences to the north of the monitoring site on the east side of the rail line. These homes are closer to the facility (and the coal pile) so if the coal pile is the source of PM_{10} it is possible that concentrations at these residences may be higher than those measured at the monitoring location. It is not possible to determine how much higher concentrations might be at these homes with the currently available data.

Health Implications

The predominant health effects of breathing particulate matter are related to the respiratory and cardiovascular systems. ATSDR has not developed independent risk levels for particulate matter species but relies on published values from other organizations such as EPA and WHO to assess risk.

The EPA NAAQS are regulatory standards set to provide public health protection, including protecting the health of sensitive populations such as asthmatics, children, and the elderly (EPA 2013). EPA also uses the AQI as an index for daily air quality with AQI air quality conditions ranging from good to hazardous (EPA 2016). Air concentrations at the NAAQS correspond to an AQI of 100 (the upper end of the moderate range) with higher concentrations classified as unhealthy for sensitive groups, unhealthy, very unhealthy, or hazardous. Below the NAAQS, AQI can be either good or moderate. With AQI in the good range (0-50) air quality is considered satisfactory and air pollution poses little or no risk (EPA 2016). In the moderate range (51-100), air quality is acceptable but there may be a moderate health concern for a very small number of people who are unusually sensitive to air pollution (EPA 2016).

The WHO air quality guidelines are non-regulatory values recommended to protect public health in different contexts (WHO 2006). They are based on a variety of health measures and acknowledge that research has not identified thresholds below which adverse effects do not occur. The WHO guidelines are generally more conservative than the EPA NAAQS and are health-based guidelines below which ATSDR considers public health hazards to be unlikely.

Conclusions

- Measured concentrations of TSP, PM_{10}, and $PM_{2.5}$ south of the Oak Creek Power Plant are unlikely to harm people's health for either short-term or long-term exposure. It is possible that other, unsampled locations could have higher air concentrations of particulate matter.
- Temporal analysis shows higher concentrations of TSP and PM_{10} from late spring through autumn compared to winter. Measured concentrations are lowest on Thursdays and highest on Sundays and Mondays indicating that there may be sources that operate on set weekly schedules.
- Polar plots indicate that the Oak Creek Power Plant is unlikely to be contributing significantly to the $PM_{2.5}$ burden at the monitoring location, but that the rail line (TSP and PM_{10}) and coal pile (PM_{10}) may contribute to the concentrations of larger particles measured at the site. Homes closer to the site than the monitoring location may experience higher concentrations than those measured.
- Given the meteorology of the area and the locations of the possible sources of PM_{10} and TSP (railroad tracks and coal pile), the area with the potential for the highest air concentrations would be south of the coal pile and to the east of the railroad tracks. There are some residences in this area that might experience higher concentrations than at the monitoring location.

Data previously collected by EPA (2009 – 2013) to the northwest of the facility show slightly higher concentrations than the data analyzed here, but those measured concentrations were below chronic screening levels and only infrequently above 24-hour screening levels for $PM_{2.5}$ (and never above 24-hour screening levels for PM_{10}).

Please feel free to contact me at 770-488-3795 if you have questions or wish to discuss further.

Sincerely,

Brad Goodwin, PhD
Lieutenant, US Public Health Service Commissioned Corps
Agency for Toxic Substances and Disease Registry
Division of Community Health Investigations
Science Support Branch

CC:
Ethan Chatfield, USEPA Region 5
Mark Johnson, ATSDR Region 5
Michelle Colledge, ATSDR Region 5
Rob Thiboldeaux, Wisconsin DHS

References

Carslaw, D. C. and K. Ropkins. 2012. openair – an R package for air quality data analysis. Environmental Modelling & Software. Volume 27-28, 52-61.

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[WHO] World Health Organization. 2006. WHO Air quality guidelines for particulate matter, ozone, nitrogen dioxide and sulfur dioxide. http://apps.who.int/iris/bitstream/10665/69477/1/WHO_SDE_PHE_OEH_06.02_eng.pdf. Geneva, Switzerland.