Public Comments & DNR Response
Variance Request Procedures for Industrial Sources Subject to NR415.075 (4), Wis. Adm. Code

WDNR received a total of five comments on the ambient monitoring variance request procedures document. Three were in support of the variance procedures document and were supplied by one industrial sand facility and two trade groups. Two comments were not in support of the variance request procedures document and were supplied by citizens. Finally, during an internal review of the document, it was discovered that the process for requesting a variance was not explicitly clear. The comments are summarized here, with associated response.

The comment from Fairmount Santrol was in support of the variance request procedures document, but noted that the guidance documents should be considered a step toward future rulemaking. Fairmount Santrol's comment is noted and will not result in any changes to the guidance document.

The comment from Wisconsin Manufacturers and Commerce (WMC) was also in support of the variance request procedures document. The comment letter noted that the guidance "provides additional transparency and clarity for industrial sand mining companies, whether existing sources or new…". WMC also noted that the variance procedures are "justified from an air quality protection standpoint" by referencing a report summarizing a PM4 study conducted by Dr. John Richards that found PM4 ambient concentrations near four Wisconsin industrial sand facilities were consistent with background levels. The WMC comments regarding variance procedures are in support and will not result in any changes to the guidance document.

The comment from the Wisconsin Transportation Builders Association (WTBA) mentions the variance request procedures document and is generally in support of that document, as well as other documents released by the air program at the same time. The WTBA comments are supportive and will not result in any changes to the variance procedures document.

The comment from Patricia Hammel does not appear to be in support of the variance request procedures guidance, but does not point to any specific change desired in the procedures. The comment is included here:

Comment:
Finally we have the "Variance Request Procedure under NR415.075(4)", which will allow industrial sand mining facilities who may have been doing some dust emission monitoring to stop doing any monitoring. Given that the Draft Guidance for including PM2.5 in applications has "concluded" that industrial sand mining just cannot produce PM2.5 fugitive dust and the DNR will not look for it, and the statements in the preamble of the variance request document's emphasis on the absence of any legal duty to notify the public of a variance request, the outcome of most variance requests is not difficult to predict.

Response:
The variance request procedures document does not require the discontinuation of monitoring at industrial sand facilities. Rather, the document serves to provide a process

for variance requests that is transparent to both industry and the public. WDNR will not be making any changes to the variance request procedures document in light of the Hammel comment.

The comment from Patricia Popple addresses the PM2.5 strategy document in more detail, but did seem to relate to the variance document in some instances. The comment is written as follows.

Comment:
I would like to know the source of information that brought the State of Wisconsin and the DNR to the conclusion that it was not necessary to monitor nor to be no longer concerned about respirable crystalline silica, PM2.5's , and the dangers inherent in the type of product being mined for use in the oil and gas industry.

Response:
Respirable crystalline silica is not regulated by the department because there is not a federal ambient air quality standard. PM2.5 is not a primary component of industrial sand emissions because the process is mechanical and PM10 is the size fraction expected. Further, the department is not making a conclusion that it is not necessary to be concerned about pollutants, simply that variance requests may be granted if the facility requesting the variance meets certain criteria as identified in the process. WDNR will not be making changes to the variance document as a result of the comment made by the commenter.

As noted, an internal review of the document noted that the process for requesting a variance was not explicitly clear. To address this, language was added under the "Variance Tracking" portion of the document. Specifically, the first bullet in the aforementioned section, which read "Variance requests are to be sent to the facility's assigned WDNR compliance inspector." now reads as follows: "Variance requests are to be sent to the facility's assigned WDNR compliance inspector via letter, which can be mailed or emailed." Similar language will be included in a fact sheet developed for the variance process to make this step clear to a facility requesting a variance.

FairmountSantrol

Ms. Kristin Hart

Wisconsin Department of Natural Resources

1010 South Webster Street

Madison, WI 53703

Re: Comments on $PM_{2.5}$ and Air Dispersion Modeling Draft Guidance Documents

Dear Ms. Hart:

Fairmount Santrol has been operating responsibly in the state of Wisconsin for decades. As a member of the WDNR Green Tier Program, Fairmount strives to collaborate with other responsible industry members, and with the WDNR. In fact, we were the first mining facility to be awarded the Green Tier certification. A key part of Fairmount Santrol's operating philosophy is to continuously look for ways to reduce our footprint, and ensure the protection of our environment, the health and safety of our workers, and the well-being of our neighbors in the communities where we operate.

Through coordination with the DNR, and with data collected through private studies that Fairmount has conducted, we promote transparent communication between industry and the Department, on air-related subjects. Fairmount appreciates the opportunity to provide input on the guidance documents that the WDNR has drafted.

As a member of the Wisconsin Industrial Sand Association (WISA), Fairmount Santrol supports the statements submitted by WISA regarding the WDNR's guidance documents. In addition, we believe that this guidance will help alleviate unnecessary regulatory burdens previously in place on our industry. WDNR's determination that "direct emissions of PM2.5 from a single, direct stationary source will not cause or exacerbate violation of any PM2.5 air quality standard or increment" is a refreshing perspective that is backed by scientific data both in this state and others. We at Fairmount, feel that this is a step in the right direction in regards to air permitting in Wisconsin. Through both required and voluntary fence-line monitoring programs, our facilities, as well as others, have demonstrated that industrial sand mining operations do not cause adverse air quality impacts.

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In regards to costly air dispersion modeling, Fairmount supports the WDNR on their current changes in guidance, recognizing the limitations of the modeling itself. We however, believe that in consistency with the Clean Air Act, this modeling should not be required for the renewal of minor and major source operating permits, or for new minor source construction permits. Appropriate regulation can be taken without the need for this modeling for minor sources, and has been demonstrated successfully in other states.

Fairmount would also like to express its support for the Variance Request Procedures proposed guidance. This proposed guidance document provides insight and clarity for companies looking to request a variance from ambient air monitoring requirements. This recognizes that the type of monitoring data that has been collected thus far will help better inform variance decisions in the future. This should be helpful to not only industry members, but should help streamline applications for the WDNR as well.

We understand the WDNR has been tasked with examining our industry objectively. The decisions outlined by the WDNR within these guidance documents are based on fact and science. While updating guidance documents are a start towards improved rulemaking, there is still a long way to go. This approach of utilizing proven scientific information, with repeatable results, needs to be carried into future rule making processes.

As a company actively involved in fact based discussions with other industry members and the WDNR, Fairmount would like to thank the WDNR for their efforts to help improve the air permitting process here in Wisconsin by ensuring that industry is not burdened by unsubstantiated and unnecessarily restrictive regulations.

Respectfully,

Aaron Scott
Northern Region Mine Manager

WMC

WISCONSIN MANUFACTURERS & COMMERCE

August 27, 2015

Ms. Gail Good
Ms. Kristin Hart
Mr. John Roth
Wisconsin Department of Natural Resources
101 S. Webster St.
P.O. Box 7921
Madison, WI 53707-7921

RE: Comments on WDNR Draft Guidance Documents

Dear Ms. Good, Ms. Hart, and Mr. Roth:

Wisconsin Manufacturers & Commerce (WMC) appreciates the opportunity to provide input on the Wisconsin Department of Natural Resources' (WDNR) proposed guidance documents (collectively referred to herein as the "guidance documents") entitled:

- "Air Dispersion Modeling Guidelines"
- "2015 Approach to Dispersion Modeling for Permits"
- "Guidance for Including $PM_{2.5}$ in Air Pollution Control Permit Applications"
- "Variance Request Procedures under NR 415.075(4), Wis. Adm. Code"

WMC is Wisconsin's Chamber of Commerce and Manufacturers' Association. We are the state's largest general business trade association, with roughly one-fourth of the state's private sector workforce employed by a WMC member company. We represent businesses of all sizes and across all sectors of our state's economy. WMC is dedicated to making Wisconsin the most competitive state in the nation to do business.

To that end, WMC is generally supportive of the guidance documents issued by WDNR and we believe this new guidance will help alleviate needless regulatory burdens on Wisconsin businesses.

WDNR's determination that "direct emissions of $PM_{2.5}$ from a single, direct stationary source will not cause or exacerbate violation of any $PM_{2.5}$ air quality standard or increment" represents a positive change to the air permitting regulatory framework, and is consistent with applicable statutes and regulations at both the state and federal levels. This proposed guidance is also consistent with what is being done in several other states. While we believe there is still more work that needs to be done in regards to air permitting here in Wisconsin, this change certainly improves the process and we thank WDNR for their work on this front.

WMC recognizes that industry-specific comments to the guidance document will get into more detail as to how the guidance will impact those specific industries and ways in which the guidance could be improved upon. In particular, the Wisconsin Paper Council (WPC) will be submitting comments on the proposed guidance and WMC supports the WPC comments as well.

WMC, consistent with the requirements of the Clean Air Act (CAA), continues to believe that air dispersion modeling should not be required for the renewal of minor and major source operating permits, or for new minor source construction permits. We note that minor sources are not required to obtain operating permits under the CAA, and many states (including some of our neighboring states) have chosen not to do so, while still appropriately enforcing environmental standards. Still, WMC believes the draft guidance documents mentioned above help to alleviate some needless and burdensome air-quality modeling requirements, and we support these changes.

As ambient air standards are lowered by the Environmental Protection Agency (EPA), air modeling is becoming an increasingly costly and burdensome task for applicants to endure. Requiring air modeling of $PM_{2.5}$ on a permit by permit basis is of little value, especially given that direct $PM_{2.5}$ emissions have no demonstrable impact on overall pollution concentrations. With this proposed guidance, this needlessly burdensome and costly modeling will no longer need to occur, and to that end this guidance is going to have a positive impact on businesses operating in Wisconsin.

WMC also wants to express our support for the "Variance Request Procedures under NR 415.075(4), Wis. Adm. Code" proposed guidance. Industrial sand mining is a major employer and growth industry in Wisconsin. The proposed guidance document provides additional transparency and clarity for industrial sand mining companies, whether existing sources or new, who are seeking a variance from the ambient air monitoring requirements under NR 415.075. The transparency and clarity provided by this proposed guidance will certainly be beneficial to both variance applicants as well as WDNR staff, and will have a positive impact on the business climate here in Wisconsin.

Importantly, the proposed variance procedure for industrial sand mining is also justified from an air quality protection standpoint, and is commensurate with protecting public health. Despite inflammatory and unfounded claims to the contrary from environmental groups and others, industrial sand mining is not a threat to air quality. A recent report by Dr. John Richards (attached) measured ambient crystalline silica concentrations (PM_4) at four facilities in Wisconsin over a two-year period. The data collection was done using EPA reference methods for collecting particulate matter samples.

Dr. Richards' study found mean concentrations of ambient PM_4 at these Wisconsin facilities to be less than ten percent of the California Office of Environmental Health Hazard Assessment (OEHHA) chronic exposure level of 3.0 micrograms per cubic meter – a standard that we believe is significantly overprotective in its own right. The PM_4 ambient concentrations were, according to the study, consistent with background levels and therefore not a threat to public health. The dire claims from environmental groups about the ambient air quality impacts associated with industrial sand mining are not grounded in science or data, and should be rejected accordingly. Under no circumstances do their unsupported claims provide a legitimate legal or public policy basis to remove the industrial sand mining variance procedure from the guidance document.

Again, WMC generally supports the proposed guidance documents discussed above and thanks WDNR staff for their work in this area to help improve the air permitting process here in Wisconsin. We look forward to continuing to work with you on ways to ensure Wisconsin businesses are not unduly burdened by overly costly and restrictive regulations.

Sincerely,

Lucas J. Vebber

LUCAS VEBBER
Director, Environmental and Energy Policy
Wisconsin Manufacturers & Commerce

cc: Mr. Patrick Stevens, WDNR
Mr. Bart Sponseller, WDNR

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Article

Assessment of Community Exposure to Ambient Respirable Crystalline Silica near Frac Sand Processing Facilities

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Abstract: Due the rapid expansion of frac sand production, local residents, community leaders, and state regulatory authorities have expressed concerns regarding the lack of ambient respirable crystalline silica concentration data for areas near to these facilities. Long-term average data are needed to compare the fence line concentrations against chronic reference exposure guidelines such as the one adopted by the California Office of Environmental Health Hazard Assessment (OEHHA). This paper provides comprehensive sets of 24 h respirable crystalline silica concentration measurements compiled during multi-year sampling programs at the fence lines of four Wisconsin facilities—three frac sand mines and one frac sand processing plant. The authors adapted Environmental Protection Agency (EPA) reference method PM2.5 filter-based samplers to provide respirable (PM4) filter samples. Crystalline silica content of the PM4 particulate matter samples was measured using National Institute of Occupational Safety and Health (NIOSH) Method 7500 X-ray diffraction. The respirable crystalline silica limit of quantification was 0.31 μg/m^3. The geometric mean (GM) respirable crystalline silica concentrations at the fence lines of the frac sand-producing facilities were less than 10% of the 3.0 μg/m^3 California OEHHA chronic exposure level and were consistent with background concentrations throughout the upper Midwest of the U.S.

Keywords: respirable crystalline silica; fence line sampling; frac sand mines; frac sand processing plants; community air quality; ambient particulate matter; PM4 particulate matter; PM4 crystalline silica

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1. Introduction

OEHHA has adopted a 70-year chronic reference exposure level (REL) for ambient respirable (PM4) crystalline silica [1]. OEHHA based the REL on an extrapolation of occupational hygiene epidemiological studies, most of which used in-plant PM4 crystalline silica (The terms respirable crystalline silica and PM4 crystalline silica are used interchangeably in this paper and are consistent with common terminology in crystalline silica occupational hygiene literature) measurements. OEHHA defined the REL as an ambient concentration below which adverse, non-cancer health effects are not anticipated.

In 2005, when OEHHA published the ambient respirable crystalline silica REL, no technique for direct measurement was available. The personal samplers used for in-plant worker monitoring could not be adapted for the lower concentrations present in ambient air. To help compile data for direct comparison to the OEHHA REL, Richards and Brozell [2] developed an ambient PM4 crystalline silica sampling method that combined the high volume sampling capability of PM2.5 reference method samplers meeting the requirements of 40 CFR Part 50, Appendix L [3] with the sensitive crystalline silica analytical capabilities provided by the X-ray diffraction (XRD) analysis procedures in NIOSH Method 7500 [4]. The necessary sample flow rate to achieve a 50% cut size at four micrometers was determined to be 11.1 liters per minute based on a series of tests challenging a sharp cut cyclone equipped Rupprecht-Patashnick PM2.5 sampler (now sold under the trade name Partisol 2000i) with National Institute of Standards and Technology (NIST) traceable monodisperse microspheres.

The 50% cut point at 11.1 liters per minute sample flow rate is consistent with the 50% cut size of NIOSH Method 0600 used for industrial hygiene sampling. The sharpness of the size-efficiency curve for the modified PM2.5 filter samplers is also similar to NIOSH Method 0600 [5]. Accordingly, ambient respirable crystalline silica concentration data measured using this new method are comparable to data from health effects research studies conducted using NIOSH 0600 sampling procedures and NIOSH 7500 analytical procedures.

This new ambient sampling method provided a limit of quantification (LOQ) of 0.31 μg/m^3 based on (1) a sample volume of 15.98 m^3 over a 24 h sampling period and (2) a Method 7500 X-ray diffraction detection limit of 5 μg. This respirable crystalline silica measurement LOQ is approximately 10% of the California REL of 3.0 μg/m^3.

This sampling and analytical approach provides a direct measurement of crystalline silica in the respirable size range. The method uses readily available commercial equipment that can be easily adapted for PM4 particulate matter sampling by adjusting the sample flow rate and by using polyvinyl chloride (PVC) filter media that are compatible with X-ray diffraction analyses. The well-established quality assurance procedures for operating U.S. EPA reference method PM2.5 filter samplers are directly applicable to an adjusted sampler used for PM4 particulate matter. Furthermore, the ambient data compiled with this measurement method are directly comparable to the extensive health effects database compiled over the past 30 years concerning occupational exposure to respirable crystalline silica.

Richards *et al.* [6] used this new sampling method to conduct limited sampling for respirable crystalline silica concentrations upwind and downwind of two construction sand and gravel plants in California. The South Coast Air Quality Management District (SCAQMD) [7,8] independently developed a sampling procedure similar to that developed by Richards and Brozell [2]. They used this method to measure respirable crystalline silica concentrations in Duarte, California in response to community concerns regarding respirable crystalline silica from sand and gravel plants and other sources near a school. The respirable crystalline silica sampling approaches developed independently by both Richards and Brozell [2] and the SCAQMD [7,8] provide sensitive techniques for measuring low concentrations in ambient air.

Prior to the start of this sampling program in 2012, very little ambient respirable crystalline silica data were available that were applicable to communities near frac sand-producing facilities. Both the Wisconsin Department of Natural Resources (WDNR) and the Minnesota Pollution Control Agency (MPCA) expressed concerns regarding this lack of relevant exposure data [9,10]. Sand mining and processing plants in Wisconsin decided to apply this new ambient respirable crystalline silica sampling technique to address questions and concerns raised in numerous communities near sand-producing facilities. The study presented in this paper is the first large-scale, long-term application of this measurement method.

2. Methods of Sampling and Analysis

2.1. Facility and Sampling Network Characteristics

EOG Resources, Inc. (EOG, Fort Worth, TX, USA) operates three sand mines and one processing plant in Wisconsin. These four facilities, described in Table 1, include the DS mine, S&S mine, and Chippewa Falls sand processing plant in Chippewa County and the DD mine in Barron County. Air Control Techniques, P.C. installed three respirable crystalline silica sampling sites at each of the four facilities. Two samplers were located at a site termed "Location 1" near the facility fence line at a position that was downwind of possible emission sources when the wind was from a common direction. One of these instruments served as the primary sampler, and the second served as a collocated unit for sampling precision analyses. The third sampler was installed at Location 2 on the other side of the facility. The sampler locations in the facilities and the wind roses for the study period are shown in Figures 1–8.

Table 1. Facilities conducting ambient respirable crystalline silica sampling in Wisconsin.

Facility	Number of Samplers	Sampling Dates	Operating Dates
Chippewa Falls Processing Plant Chippewa County, WI	3	Oct. 2012–Dec. 2014	All months
DS Mine, Chippewa County, WI	3	Oct. 2012–Dec. 2014	April to November each year
S&S Mine, Chippewa County, WI	3	Oct. 2012–Dec. 2014	November to April each year
DD Mine, Barron County, WI	3	Nov. 2012–Dec. 2014	November 2012 to April 2013
Total	12	-	-

As shown in Figure 1, the Location 1 sampling site at the Chippewa Falls sand processing plant was near the northern fence line at a spot approximately 10 m from the truck receiving building. This site was the only spot available that met the EPA siting requirements in 40 Code of Federal Regulations (CFR) Part 58, Appendix E [11] and had available electrical power. The wind direction and wind speed sensors were mounted on a 10 m pole located to the southeast of the main plant buildings in the center of the plant. The plant buildings to the west of the wind direction sensor resulted in some bias in the indicated wind directions from the north-northwest, west, and west-southwest shown in Figure 2.

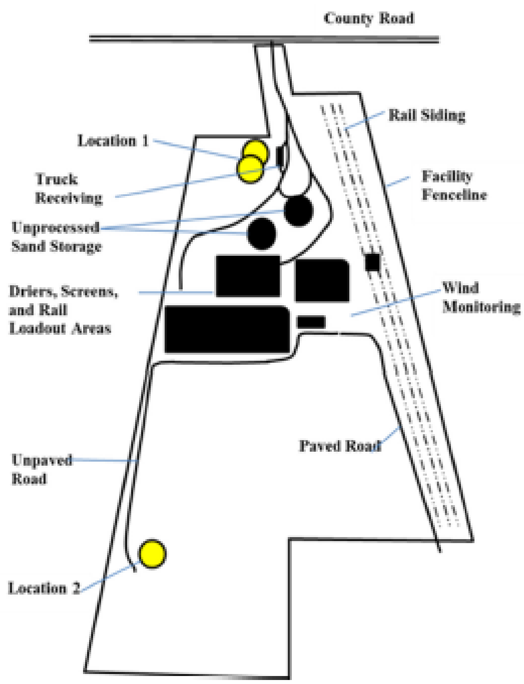


Figure 1. Chippewa Falls sampler locations.

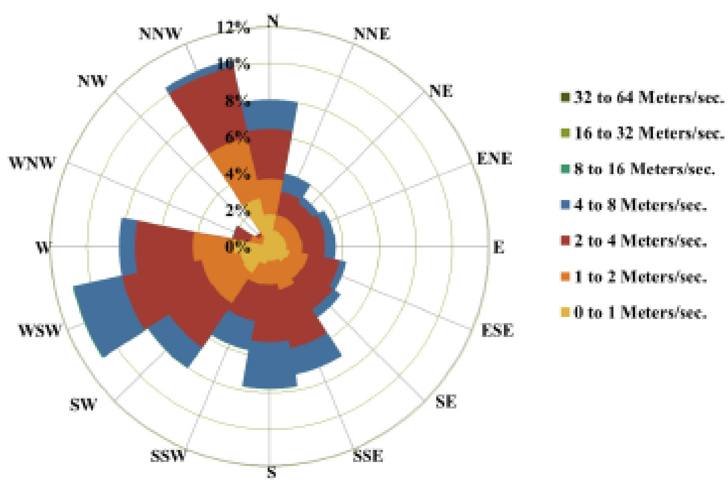


Figure 2. Chippewa Falls wind rose, October 2012–December 2014.

The samplers at the DS mine are shown in Figure 3. During most of 2013, the sampler positions were on the northeast side of all mine activity. During the latter part of 2013, the quarry activities were expanded to the east and northeast of the sampling site.

The measured wind directions at the DS mine were most frequently from the south. This was due primarily to the channeling of the winds by tall hills on the western side of the mine.

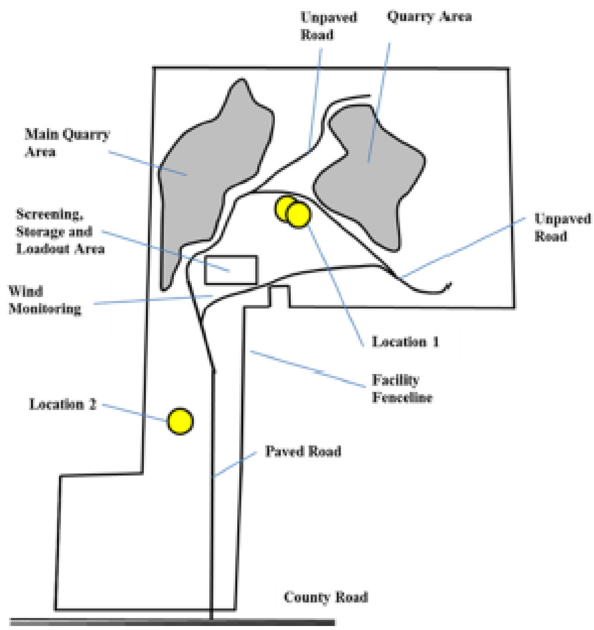


Figure 3. DS Mine sampler locations.

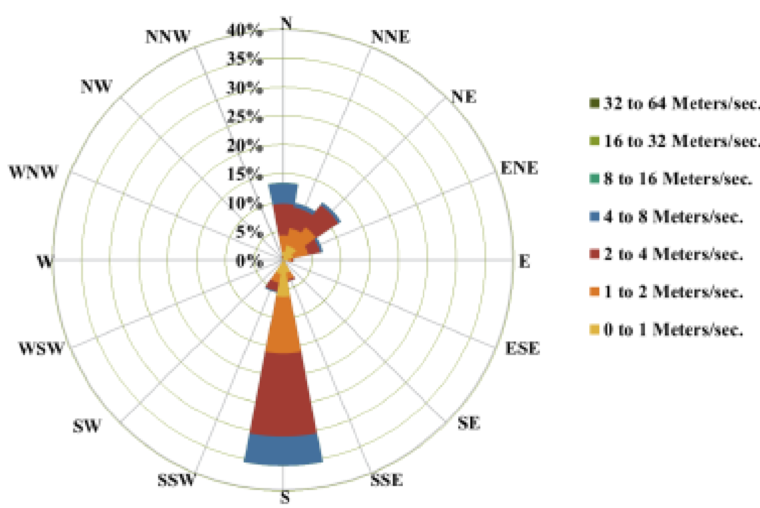


Figure 4. DS Mine wind rose, October 2012–December 2014.

The samplers at the S&S Mine are shown in Figure 5. Location 1 was selected due its downwind position when the winds were from the west, southwest, or south. Location 2 was next to the mine office on the southern edge of the mine.

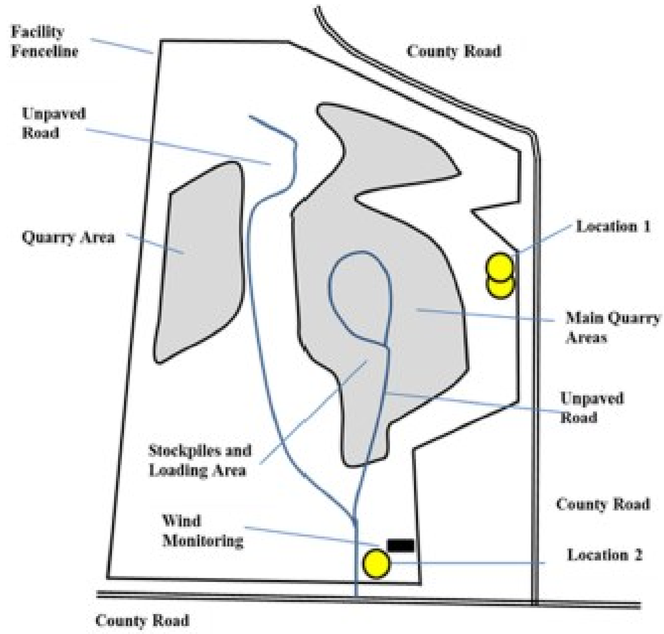


Figure 5. S&S Mine sampler locations.

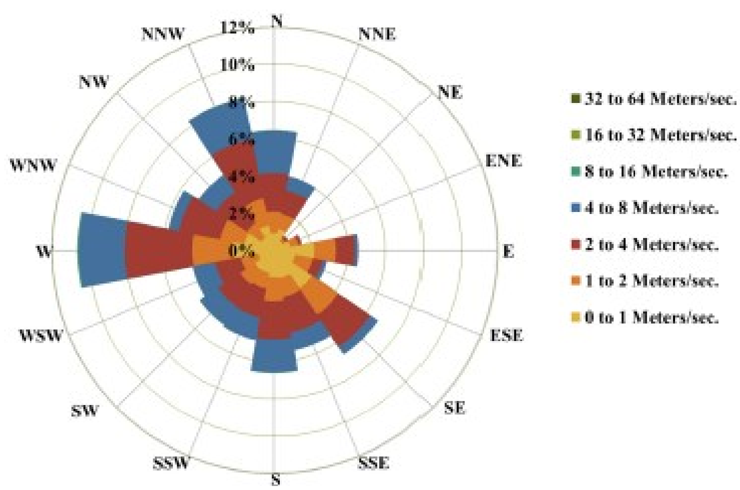


Figure 6. S&S Mine wind rose, October 2012–December 2014.

The sampling locations at the DD mine were oriented on a north-south axis. The Location 1 site was near the southern fence line. The Location 2 site was near the northern mine entrance. The wind direction and wind speed sensors were near the plant office on the northern side of the mine. The land around this mine is relatively flat. The topography did not influence the measured wind directions.

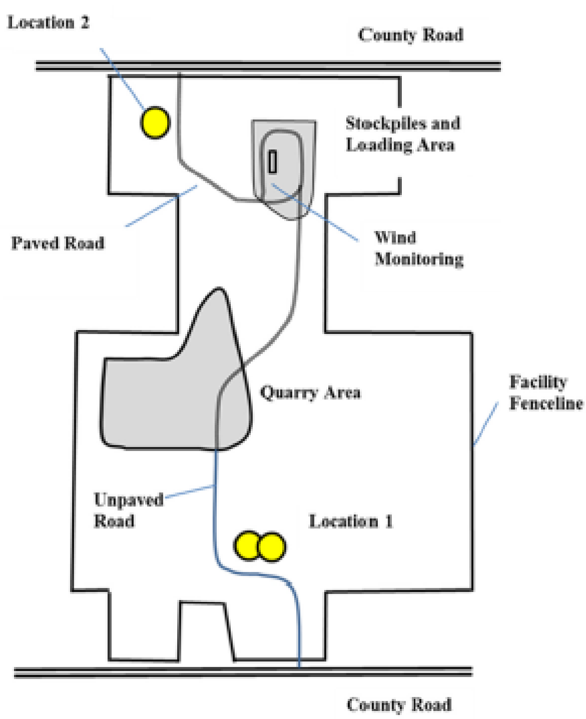


Figure 7. DD Mine sampling locations.

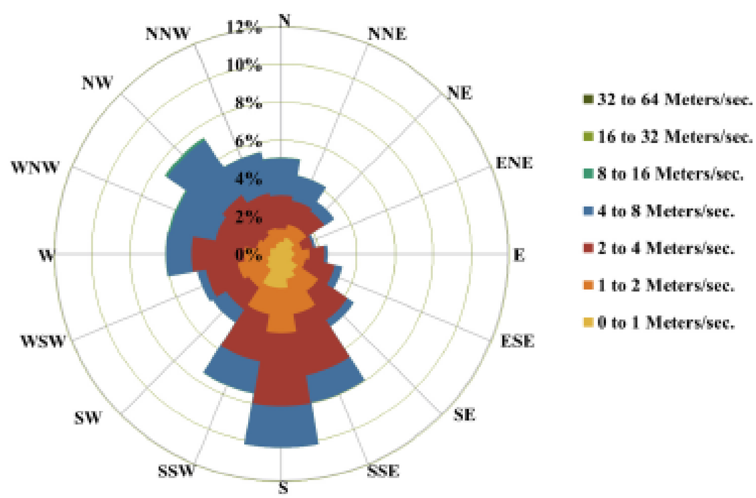


Figure 8. DD Mine wind rose, October 2012–December 2014.

A typical Location 1 site is shown in Figure 9. Each Location 1 site included a primary sampler and a collocated sampler. The samplers were mounted on platforms to avoid possible issues with snow accumulation. The sampler inlets were below the 7 m height limit specified by the U.S. EPA. The inlets of the primary and collocated samplers were 1 to 2 m apart. All of the sites with the exception of Chippewa Falls were surrounded by 2 m high chain link fence.

Figure 9. Primary and collocated Partisol 2000i samplers at the Chippewa Falls Location 1 site.

The distances between the two sampling locations ranged from 780 m at the processing plant to 690 to 1300 m at the three mines. All eight of the sampling locations satisfied the sampling site criteria specified by the U.S. EPA in 40 CFR Part 58, Appendix E [11]. The two sampling locations were 10 to 150 m from the closest fugitive dust source and 500 to 1000 m from the most distant fugitive dust source within each facility.

The processing plant in Chippewa Falls operated 24 h per day throughout the year with some days offline for maintenance and for inventory control. The three mines operated 8 to 12 h per day for four to eight months per year. The S&S mine operated during the winter from November through early April each year. The DS mine operated from early April to mid-November each year. The DD mine operated from November 2012 through April 2013. The production rates at the four facilities ranged from 500,000 to more than 2,000,000 short tons of sand per year. The operating periods are summarized in Table 1.

The samplers operated on a once-every-third-day schedule. The sampling days matched the once-every-third-day calendar schedule [12] published by the U.S. EPA and used in U.S. EPA and state agency air monitoring networks. Accordingly, the data generated using the ambient PM4 particulate matter samplers could be compared with data generated simultaneously with state agency PM2.5 samplers.

The presence of twelve PM4 particulate matter samplers at these facilities in two adjacent counties is an especially dense population of ambient air monitors. For comparison purposes, there are only twenty-three state-operated PM2.5 samplers in the entire state of Wisconsin.

2.2. Respirable Crystalline Silica Sampling Equipment

All four facilities used Thermo Scientific Partisol 2000i (Franklin, MA, USA) Federal Reference Method (RFPS-0496-117) filter samplers designed for PM2.5 sampling and adapted for PM4 crystalline silica sampling. The Partisol instruments operated in full accordance with U.S. EPA procedures specified in 40 CFR Part 50 Appendix L [3] except for (1) a sample flow rate of 11.1 liters per minute, (2) the use of a PVC filter as specified by NIOSH Method 7500, and (3) gravimetric analysis of the filters by NIOSH Method 0600. The PM4 sampling data were based on actual temperatures and pressures to be consistent with PM2.5 sampling data compiled in accordance with 40 CFR Part 50, Appendix L.

The sampler operator performed routine maintenance of the system's inlet and sharp cut cyclone. These maintenance activities occurred at the intervals consistent with U.S. EPA Quality Handbook [13].

The authors used the tare filter weight, final filter weight, crystalline silica weight, and sample volume to calculate the average mass concentration of respirable crystalline silica during each sampling period. The total sampling time ranged between 23 and 25 h to be consistent with 40 CFR Part 50 Appendix L Section 3.3 [3].

2.3. Crystalline Silica Analyses

The R.J. Lee Group, Inc. (R.J. Lee) laboratory in Monroeville, Pennsylvania conducted the NIOSH Method 0600 gravimetric analyses and the NIOSH Method 7500 X-Ray Diffraction (XRD) crystalline silica analyses of the filters. R.J. Lee is an accredited laboratory for NIOSH Method 7500 analyses and has extensive experience with this analytical method.

NIOSH Method 7500 for crystalline silica calls for digesting the filter media and re-depositing the dust onto a silver membrane filter for analysis. R.J. Lee is one of only a few laboratories that uses low-temperature plasma ashing. This procedure is more efficient and reliable than a muffle furnace and more effective than tetrahydrofuran digestion. The low temperature of the plasma also does not convert amorphous silica to cristobalite or induce other high-temperature chemical reactions that are possible in a muffle furnace.

R.J. Lee uses a custom filtration system that creates a small filter deposit onto the silver membrane. This small, concentrated deposit size increases the resolution of the scan by increasing the signal/noise ratio of the resulting diffraction pattern. R.J. Lee has two X-ray diffractometers—a PANalytical Cubix Pro unit dedicated to air silica analysis and a PANalytical X'Pert Pro unit, which handles both bulk and air silica analyses. R.J. Lee reported three forms of crystalline silica—quartz, cristobalite, and tridymite.

2.4. Data Analysis

The PM4 crystalline silica concentration data have been divided into sixteen sets, each comprised of the data obtained at one of eight sampling locations during the October 2012 to December 2013 period or the January 2014 to December 2014 period. The geometric means of these data sets of 120 to 150 samples were compared with the OEHHA REL of 3.0 μg/m^3. Values below the LOQ of 0.31 μg/m^3 were assigned a value of the LOQ/$\sqrt{2}$ as described by Hornung and Reed [14]. Due to the large fraction of each data set below the LOQ, this substitution approach can introduce positive or negative bias into the calculation of the mean. The maximum possible bias to lower-than-true mean values was estimated by substituting the LOQ for below-LOQ values.

Upwind-to-downwind concentration differences across the facility were evaluated by compiling data for each of the four facilities from those sampling days in which the winds passed either from Location 2 to Location 1 or Location 1 to Location 2. Local background concentrations were calculated using data from both locations during days when the winds passed in a crossflow pattern to the axis of the samplers.

2.5. Program Organization

Air Control Techniques, P.C. designed the sampling program and trained the local operator of the samplers. R.J. Lee prepared the tared PVC filters and sent them to the on-site sampler operator on a routine basis. At the request of the WDNR ambient air monitoring group, the sample numbers were coded and scrambled so that R.J. Lee was blind concerning the specific facility and specific sampler providing each filter. On a biweekly basis, the filters were returned to R.J. Lee for analysis. Air Control Techniques, P.C. compiled the sampling and laboratory results.

Air Control Techniques, P.C. conducted audits of all of the samplers on a quarterly basis and three-point flow calibrations and ambient temperature, filter chamber temperature, ambient pressure, and filter chamber pressure calibrations on an annual basis. WDNR audited all twelve samplers once during the long-term sampling program.

3. Sampling Results

3.1. Average Respirable Crystalline Silica Concentrations

The primary focus in this study was on the comparison of long-term average respirable crystalline silica concentrations at the fence lines of frac-sand producing facilities and the OEHHA chronic exposure REL. The 2128 twenty-four hour average sample values measured from the eight different sampling locations (two per facility) at the four facilities have been divided into two sets: (1) October 2012–December 2013 and (2) January 2014–December 2014. This approach creates sixteen separate long-term measurements, each of which is at least twelve months in duration. Tables 2 and 3 provide summaries of these twelve and fifteen-month data sets, including (1) the number of samples below the LOQ, (2) the 99th percentile values, (3) the arithmetic means, (4) the 95th upper confidence intervals (UCL) of the arithmetic means, (5) the geometric means (GM), and (6) the geometric standard deviations (GSD).

The sixteen data sets had non-detectable concentrations ranging from 68.2% to 97.5% of the 24 h measurement values. Overall, 88% of the 2128 samples had concentrations below the LOQ of 0.31 μg/m^3. The geometric means calculated based on LOQ/$\sqrt{2}$ values substituted for the below-LOQ samples ranged from 0.22 to 0.29 μg/m^3. All of these geometric means were well below the OEHHA REL of 3.0 μg/m^3.

The possible uncertainty in the calculated geometric means using LOQ/$\sqrt{2}$ value substitution was estimated by re-calculating the geometric means by substituting the LOQ for below-LOQ sample values. This has a strong bias to higher-than-true mean values considering that the histograms of the detectable values do not indicate that a large number of below-LOQ values were just below the LOQ. These maximum possible geometric means ranged from 0.41 μg/m³ at the Chippewa Falls plant to 0.32 μg/m³ at the DD Mine—values well below the REL. Accordingly, whatever biases are inherent in the LOQ/$\sqrt{2}$ approach in data sets with very high censored data levels do not have any significant impact on the comparison of the means with the chronic exposure REL.

Table 2. Respirable crystalline silica 24 h average concentration measurements, October 2012–December 2013.

Facility and Sampling Location	Number > LOQ	Number < LOQ	% <LOQ	99th%	(LOQ/$\sqrt{2}$) Substituted for < LOQ Values			
					Mean	Mean 95th% UCL	GM	GSD
				μg/m³	μg/m³	μg/m³	μg/m³	μg/m³
Chippewa Falls, Location 1	49	106	68.2	1.34	0.33	0.36	0.29	1.59
Chippewa Falls, Location 2	20	133	86.9	0.65	0.26	0.27	0.24	1.33
DS Mine, Location 1	19	134	87.6	0.72	0.25	0.27	0.24	1.30
DS Mine, Location 2	17	133	88.7	0.50	0.24	0.25	0.23	1.22
S&S Mine, Location 1	13	137	91.3	0.50	0.24	0.25	0.23	1.21
S&S Mine, Location 2	26	123	82.6	1.44	0.30	0.33	0.26	1.52
DD Mine, Location 1	18	121	82.1	0.60	0.25	0.26	0.24	1.26
DD Mine, Location 2	16	121	88.3	0.81	0.25	0.27	0.24	1.33

Table 3. Respirable crystalline silica 24 h average concentration measurements, January 2014–December 2014 PM4 Crystalline Silica Data.

Facility and Sampling Location	Number > LOQ	Number < LOQ	% < LOQ	99th%	(LOQ/$\sqrt{2}$) Substituted for < LOQ Values			
					Mean	Mean 95th% UCL	GM	GSD
				μg/m³	μg/m³	μg/m³	μg/m³	μg/m³
Chippewa Falls Location 1	31	85	73.3	1.06	0.31	0.34	0.28	1.55
Chippewa Falls, Location 2	4	114	96.6	0.31	0.22	0.28	0.22	1.09
DS Mine, Location 1	6	112	94.9	0.38	0.23	0.23	0.22	1.11
DS Mine, Location 2	7	111	94.1	0.56	0.24	0.25	0.23	1.23
S&S Mine, Location 1	9	109	92.4	0.73	0.24	0.26	0.23	1.27
S&S Mine, Location 2	19	99	83.9	0.81	0.27	0.29	0.25	1.39
DD Mine, Location 1	4	114	96.6	0.43	0.23	0.23	0.22	1.13
DD Mine, Location 2	3	115	97.5	0.42	0.22	0.23	0.22	1.11

The upper 99% percentile values ranged from 0.31 μg/m³ at Chippewa Falls Location 2 (2014 data set) to1.44 μg/m³ at S&S Mine Location 2 (Oct. 2012–Dec. 2013 data set). These values are independent of the LOQ and provide an indication of the limited variability of the 24 hour average data. The geometric standard deviations also indicated that the range of data was low.

3.2. Upwind-Downwind Concentration Differences

The contributions of the facilities to the downwind concentrations of respirable crystalline silica were evaluated using upwind-to-downwind data during days in which the ambient air moved across the facility either from Location 1 to Location 2 or from Location 2 to Location 1. All of the upwind-to-downwind analyses were conducted by assigning zero values to samples below the LOQ. Using LOQ/$\sqrt{2}$ values for below-LOQ samples potentially obscured slight differences between the concentrations measured at the two locations at each facility.

The upwind-to-downwind differences in the 24 h average concentrations ranged from approximately −1.4 μg/m^3 to +1.5 μg/m^3. The upwind-to-downwind differences in the respirable crystalline silica concentrations were very small at all four facilities sampled. There was no detectable change in the upwind-to-downwind concentrations on 78% of the days during which the winds moved in a consistent and identifiable upwind-to-downwind direction. Figure 10 provides examples of the upwind-to-downwind respirable crystalline silica concentrations.

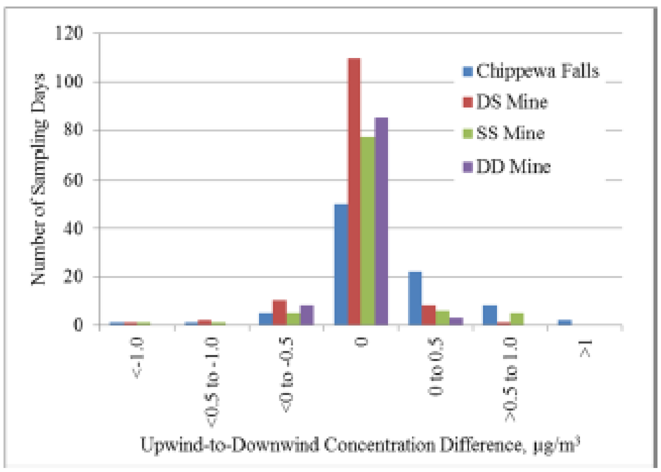


Figure 10. Upwind-to-downwind PM4 crystalline silica concentration differences, October 2012 to December 2013.

These very small upwind-to-downwind concentration increases and decreases indicate that the sand mining and processing facilities contribute very little, if anything, to the ambient respirable crystalline silica concentrations.

3.3. Local Background Concentrations

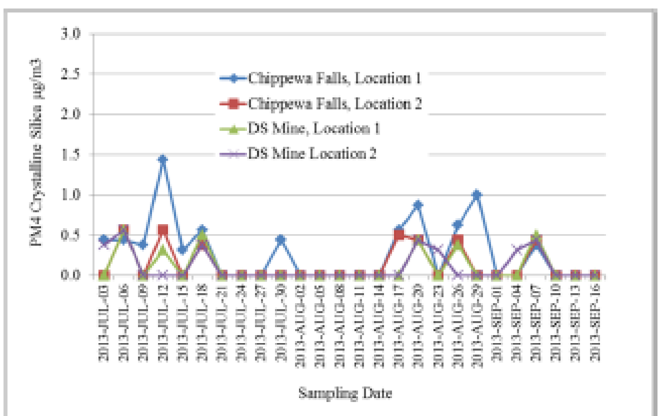
The local background concentrations of respirable crystalline silica summarized in Table 4 were determined based on concentrations measured by both the Location 1 and Location 2 samplers during days with dominant crosswinds. During these sampling days, the observed concentrations were due to local background concentrations of respirable crystalline silica. The three facilities clustered in Chippewa County had slightly higher background concentrations than the one mine (DD mine) located in the more rural Barron County.

The average local background concentrations listed in Table 4 are similar to the average concentrations summarized in Tables 2 and 3 for the entire data sets compiled from October 2012 through December 2013 and from January 2014 through December 2014. This similarity suggests that the fence line concentrations of respirable crystalline silica are within the local background concentration range.

Table 4. Local background concentrations.

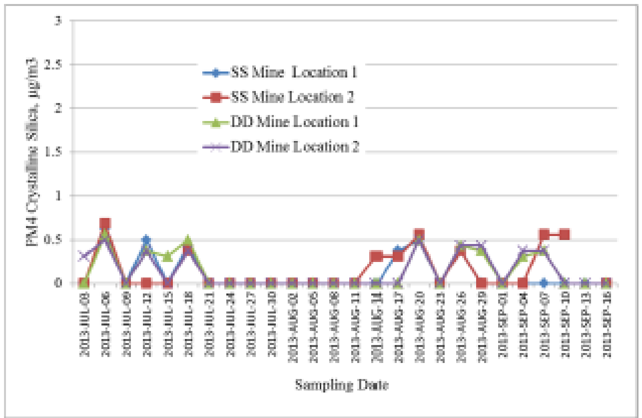
Facility	Number of 24 h Samples October 2012–December 2014	Respirable Crystalline Silica Concentrations		
		Average		Maximum μg/m^3
		Values Below LOQ Treated as 0.0 μg/m^3	Values Below LOQ Treated as LOQ/$\sqrt{2}$ μg/m^3	
Chippewa Falls	194	0.043	0.236	0.56
DS Mine	58	0.052	0.249	0.88
S&S Mine	182	0.067	0.260	2.10
DD Mine	124	0.015	0.228	0.63

The local background range has been further evaluated by comparing day-by-day concentration variations observed in the entire network of eight primary samplers located across an area of more than 70 km in the two-county area. The relatively consistent variations in both the upwind and downwind location sampling data at all four facilities are most apparent during summer periods when the ambient respirable crystalline silica concentrations are at a maximum. For example, data from the period July 3, 2013 through September 16, 2013 are illustrated in Figure 11a. All measured concentrations values at the eight samplers varied together regardless of wind direction and facility-specific operations. These consistent variations observed throughout the multi-year sampling program in the network of samplers suggest that measured fence line concentrations are in the local background range for Western Wisconsin. This is further indicated by the fact that both the S&S and the DD mines (Figure 11b) did not operate during the two and one-half month period addressed in Figure 11b.



(a)

Figure 11. *Cont.*



(b)

Figure 11. Variations in PM4 Crystalline Silica Concentration at the (a) Chippewa Falls Plant and the DS Mine, July 3, 2013 to September 16, 2013; (b) the SS and DD Mines, July 3, 2013 to September 16, 2013.

The variations in the local background concentrations were further evaluated by comparing the measured PM4 particulate matter concentrations at the Chippewa Falls processing plant with a WDNR operated PM2.5 monitoring site in Eau Claire, Wisconsin twenty three kilometers away from Chippewa Falls.

Comparisons of the PM4 particulate matter data and the WDNR PM2.5 data [15] are provided in Figures 12 and 13. It is apparent that the variations in local PM2.5 particulate matter concentrations measured by WDNR at Eau Claire are very similar to the variations in PM4 particulate matter concentrations at both locations at Chippewa Falls. This suggests that most of the PM4 particulate matter measured at Chippewa Falls was background PM2.5 particulate matter.

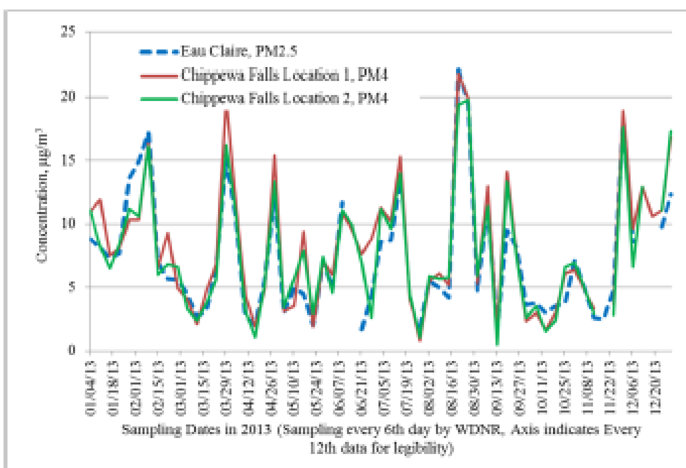


Figure 12. Comparison of the WDNR PM2.5 data from Eau Claire with the PM4 particulate matter data from Chippewa Falls Locations 1 and 2, October 2012–December 2013.

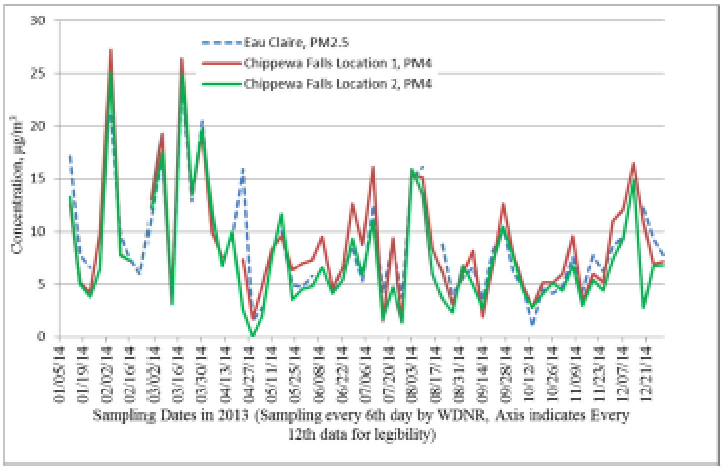


Figure 13. Comparison of the WDNR PM2.5 data from Eau Claire with the PM4 particulate matter data from Chippewa Falls Locations 1 and 2, January 2014–December 2014.

The PM4 particulate matter data compiled at Chippewa Falls were very similar to the PM2.5 particulate matter data compiled by WDNR. The relatively small differences observed during some sampling days appear to be due primarily to a nearby major highway and urban sources that affected PM2.5 particulate matter air quality near the WDNR Eau Claire PM2.5 sampler but not the Chippewa Falls PM4 particulate matter samplers.

As expected, the PM4 particulate matter concentrations at Chippewa Falls were slightly higher on average than the PM2.5 particulate matter concentrations at Eau Claire due to the fact that the PM4 size range extends further into the coarse mode of ambient particulate matter. The PM2.5–PM4 particulate matter comparison suggests that the daily variations in respirable crystalline silica regional air quality are primarily due to variations in the local background concentrations.

3.4. Sampling Method Performance

The sampling programs included frequent and comprehensive quality assurance procedures. The scope of the quality assurance (QA) analyses included (1) the use of collocated samplers along with the primary sampler at each of the four facilities, (2) biweekly audits of the sample flow rates, (3) yearly three-point sample flow rate calibrations, (4) yearly ambient pressure, filter chamber pressure, ambient temperature, and filter chamber calibrations,(5) filter blank analyses, and (6) review of the five min average sampler operating data recorded by the Partisol 2000i samplers.

The use of a collocated sampler at the primary sampling location was one of the main quality assurance checks. All four facilities operated sampler networks with a collocated sampler operating every twelfth day. All four facilities achieved coefficient of variance values for the PM4 particulate matter well within the maximum allowed 10% value limit specified in 40 CFR Part 58, Appendix A [16]. Due to the fact that 88% of the respirable crystalline silica concentrations were at or below the LOQ, it was not possible to calculate the coefficient of variance for the respirable crystalline silica concentrations at any of the four facilities.

The sampling network operator for all four facilities performed sampler audits every two weeks—a frequency that is twice as high as required by 40 CFR Part 50 Appendix L [3], the EPA quality assurance handbook [13], and the sampler manufacturer's recommendations. The purpose of the frequent audits was to confirm proper operation of the samplers as often as possible to identify problems related to sampler operation. All twelve samplers used in these studies successfully passed the sample flow rate, air temperature, filter temperature, ambient pressure, and sample gas pressure audits conducted during the long-term sampling programs.

In addition to the operator audits, Air Control Techniques, P.C. conducted an independent audit of each sampler on a quarterly basis. All twelve samplers used in these four sampling programs passed each of these quarterly audits. Each sampler also passed a WDNR audit.

Air Control Techniques, P.C. conducted three-point calibrations using an NIST traceable Chinook Engineering calibrator. The calibrations were conducted at the beginning of each study and at the twelve-month point in each study.

The Partisol instruments logged the sample flow rate, air temperature, sample gas temperature, air pressure, and electrical operating conditions every five minutes during sampling. The voluminous set of data downloaded from the eight primary samplers and the four collocated samplers demonstrated that the instruments worked extremely well throughout the long-term sampling programs.

Every tenth filter was installed in the sampler and immediately recovered. These blank filters were analyzed to check for any filter damage and contamination problems. More than 98% of the blanks had crystalline silica levels below the LOQ. There were small variations in the PM4 particulate matter levels in a small fraction of the blanks. The low blank values demonstrate that the filter handling procedures were good.

All twelve of the Partisol 2000i instruments provided data availability exceeding 98% despite an especially severe winter in 2012–2013. There were no problems with leak checks performed during routine audits. One sampling day at one site was lost due to heavy snow that prevented safe access to the sampling location. One of the instruments developed a problem with the display screen that resulted in the loss of data for three sampling days. Overall, the instruments performed extremely well.

4. Discussion

The results of this ambient respirable sampling program have been evaluated by (1) comparison of the long-term average data reported here with short-term data in previously published studies, (2) evaluation of the susceptibility of crystalline silica to form fragments in the respirable size range, and (3) evaluation of data concerning sources that could contribute to the observed background concentrations.

4.1. Comparison of Measured Data with Previous Studies

The long-term average respirable crystalline silica concentrations in this study are similar to those measured by the Minnesota Pollution Control Agency (MPCA) in Winona and Stanton, Minnesota [17]. The MPCA used sampling and analytical procedures similar to those of Richards and Brozell [2] while sampling at these two locations over an eight-month period in 2014. In the City of Winona, with a frac sand transloading operation, only two of the thirty 24 h measurements were above the LOQ of 0.31 μg/m^3. The maximum measured values at Winona were 0.4 μg/m^3. At the MPCA background site of Stanton [17], nine of the thirty three 24 h measurements were above the LOQ. The maximum concentration at Stanton, MN was 1.3 μg/m^3. The Stanton area is dominated by agricultural sources and has no frac sand-producing facilities. Low respirable crystalline silica levels were also measured at Shakopee Sand [18] and Tiller-North Branch in Minnesota [19].

The long-term average concentration values measured in this study were lower than the shorter time period data of up to 2.8 μg/m^3 of respirable crystalline silica compiled by Richards *et al.* [6] at the fence lines of two large sand and gravel plants in San Diego and Tracy, California. The data summarized in the present paper were similar to the 0.4 to 1.1 μg/m^3 respirable crystalline silica concentrations measured by the SCAQMD [7,8] during a four-month sampling program at an elementary school close to four sand and gravel plants in Duarte, California. The concentrations measured in this study were slightly below those measured by the California Air Resources Board in Lompac, California [20]. These California-oriented studies reported slightly higher concentrations probably due to higher background concentrations in these semi-arid areas due to wind-entrained dust and also due to large agricultural operations close to several of the sampling locations.

The respirable crystalline silica concentrations measured in this study were slightly lower than the values measured by Stacey *et al.* [21] in communities close to construction sites in England and by the Environmental Health Board of Queensland Health at construction sites in Queensland, Australia [22]. The lower concentrations near frac sand producing facilities in Wisconsin were probably due to the lack of energy-intense frac sand handling equipment and especially hard characteristics of the grains of frac sand.

Shiraki and Holmen [23] measured higher concentrations of crystalline silica at a sand and gravel plant near Tracy, California; however, their data were limited to the analyses of PM10 samples. They could not detect crystalline silica in their PM2.5 particulate matter samples, and they did not measure respirable crystalline silica. Due to the size dependence of the crystalline silica content of particulate matter, it is difficult to convert PM10 crystalline silica concentration data to a PM4 respirable crystalline silica basis.

Saiyed *et al.* [24] reported high ambient crystalline exposure levels in the village of Ladakh, India at an elevation of 11,000 feet in desert air. He suspected high exposure to crystalline silica due to frequent desert wind storms and to venting of kitchen emissions. High concentrations of crystalline silica have also been reported by Bhagia [25] for slate-producing villages in India. The conditions studied by Sayied *et al.* and by Bhagia are not relevant to the types of possible exposures in communities near frac sand producing facilities in the Upper Midwest of the U.S.

The 24 h average respirable crystalline silica concentrations measured at the four facilities using data from days when the samplers were located crosswind were generally consistent with the 0 to 2.6% by weight crystalline silica content in PM2.5 particulate matter estimated by Davis *et al.* [26] for 22 urban areas in the U.S.. At annual average PM2.5 levels of 8 to 10 μg/m^3 in Wisconsin [27], the estimate of Davis *et al.* is equivalent to 0.21 to 0.26 μg/m^3. Slightly higher crystalline silica levels should be present in PM4 particulate matter considering that the PM4 size range extends slightly more than the PM2.5 size range into the coarse mode of atmospheric particulate matter.

The respirable crystalline silica concentrations measured in this study were less than the levels that could be estimated using a ratio of respirable crystalline silica of 0.1 times the PM10 concentration as discussed by EPA [28]. In 1996, when EPA published their ambient respirable crystalline silica document, there were only very limited data on respirable crystalline silica concentrations. EPA relied primarily on the data of Davis *et al.* [26] for the 15 micrometer 50% cut size samples.

The limited short-term ambient respirable crystalline silica data in previous publications and reports are generally consistent with the low levels measured in this study at the fence lines of all four sand-producing facilities.

4.2. Susceptibility of Frac Sand to PM4 Particle Formation

Frac sand must meet American Petroleum Institute specification RP 19C for size distribution, roundness, and crush resistance. Frac sand is used due, in part, to its especially high resistance to pulverization. High energy is needed to fracture small particles from the large grains of crystalline silica particles. Quartz, the form of crystalline silica in frac sand, is considered one of the most difficult-to-grind minerals used in industry. Due to this especially high resistance to fragmentation, the handling of frac sand has a low vulnerability to the formation of particles in the respirable size range.

The smallest grain size of frac sand that satisfies API specifications is 105 micrometers—a size that is more than 40 times larger in diameter and more than 70,000 times larger in mass than a respirable 4-micrometer (aerodynamic size) particle. The extraction, screening, and drying processes used in frac sand mining and processing do not impose the energy needed for significant attrition of the crystalline silica grains to form PM4 particles.

The as-mined sand has a high moisture content, which suppresses the release of even the binding materials between the grains of crystalline silica. Once screened and dried, the large frac sand particles are handled in equipment with high efficiency ventilation and control systems. Accordingly, low emissions are expected.

4.3. Sources Contributing to Local Background Concentrations

The localized background concentrations measured using data from samplers during crosswind flow periods indicate that in Western Wisconsin, the combined set of natural and anthropogenic sources generate localized background respirable crystalline silica concentrations that average less than 0.26 μg/m^3 (values below the LOQ treated as LOQ/$\sqrt{2}$) and have maximum 24 h average concentrations that are usually below 2.1 μg/m^3. These levels are consistent with the probable contributions of respirable crystalline silica from the numerous farms and unpaved roads throughout the study area in Wisconsin. Contributions to ambient background concentrations are expected considering the very high respirable crystalline silica concentrations of more than 1000 μg/m^3 reported in studies of farmer exposure by Nieuwenhuijsen [29], Norton and Gunter [30], Syzkman *et al.* [31] and Archer *et al.* [32]. Stopford and Stopford [33] found quartz levels in farm soil particles less than 4.25 μm that ranged from 10.5% to 44.5% by weight, and Gillette [34] has suggested that global transport of soil dusts contributes to ambient levels of crystalline silica in distant urban areas. Agricultural sources almost certainly are a major contributor to local background concentrations in areas such as Wisconsin. All four facilities sampled in this project were bounded on at least two sides by active farms.

The long-term average PM4 crystalline silica concentrations measured at the four facilities were very similar to estimated maximum crystalline silica concentrations calculated by the WDNR [9] based on PM2.5 elemental silicon data compiled from 2001 to 2009 at three U.S. EPA-operated PM2.5

speciation sites in Wisconsin. WDNR calculated maximum crystalline silica concentrations of 0.10 μg/m^3 in Mayville (Dodge County), 0.14 μg/m^3 in Milwaukee (Milwaukee County), and 0.32 μg/m^3 in Waukesha (Waukesha County). In calculating these maximum concentrations, WDNR assumed that 100% of the elemental silicon was in the form of crystalline silica.

4.4. Additional Research Needed

Additional sampling is needed to evaluate respirable crystalline silica concentrations at the fence lines of other industrial, agricultural, and community sources. More long-term average concentration data are needed concerning the seasonal variability of background concentrations, especially in arid areas subject to wind entrainment of crystalline silica containing soil. Analysis of the respirable crystalline silica levels contributed by globally transported desert dust would be helpful in analyzing daily variations in measured concentrations. Procedures for characterizing concentration data below the LOQ of 0.31 μg/m^3 would be helpful in analyzing the data, especially the background concentrations.

The variability in the susceptibility to attrition of grains of sand in various soils and rocks would be helpful in evaluating site-to-site differences in respirable crystalline silica concentrations.

5. Conclusions

The geometric mean respirable crystalline silica concentration for the entire data set was 0.26 μg/m^3 when values below the limit of quantification were treated as LOQ/$\sqrt{2}$ concentrations. The long-term average concentrations for the entire data set of 2128 twenty-four hour respirable crystalline silica measurements and the long-term averages at each of the four facilities were less than 10% of the California OEHHA [1] 70-year chronic reference level of 3.0 μg/m^3.

All four facilities operated samplers in an upwind-downwind configuration. Analyses of the data during days when the air moved across the facilities over the samplers indicated that the respirable crystalline silica concentrations changed from −1.4 μg/m^3 to +1.5 μg/m^3. There were no significant differences in the upwind-to-downwind long-term concentrations for the three sand-producing mines and the processing plant. The measured respirable crystalline silica levels were in the background concentration range. Accordingly, these data indicate that the exposure to respirable crystalline silica near frac sand producing facilities is the same as exposures in areas throughout this region.

The PM2.5 U.S. EPA Federal Reference Method samplers adapted for PM4 particulate matter sampling worked well in all four sand mine and sand processing facility sampling programs. The sampling and analytical techniques provided a sensitive lower limit of quantification of 0.31 μg/m^3. Comparisons of the PM4 particulate matter data compiled from primary and collocated samplers demonstrated precise results. All twelve of the primary and collocated samplers passed routine audits conducted on both a biweekly and quarterly basis over more than a two-year period. Filter blank analyses confirmed proper field and laboratory procedures.

The sampling and analytical procedures used in this study are readily available to others wishing to evaluate ambient PM4 crystalline silica concentrations. Samplers meeting the design requirements of 40 CFR Part 50, Appendix L [3] and equipped with PM2.5 50% cut size sharp cut cyclones can be modified for respirable particulate matter sampling by adjusting the sample flow rate from 16.7 liters per minute to 11.1 liters per minute. The crystalline silica fraction of the PM4 particulate matter samples can be measured using NIOSH Method 7500 X-Ray Diffraction analyses with an LOQ of 5 µg. PVC filters with an average pore size of five micrometers are used to facilitate the X-Ray Diffraction analyses. These filters are identical to those used for occupational exposure sampling. The respirable crystalline silica measurement technique uses commercially available EPA reference method samplers and well-established NIOSH analytical procedures.

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Author Contributions

John Richards and Todd Brozell jointly designed the sampling program and selected the sampling locations. John Richards prepared the test program protocols. Todd Brozell trained the operator and conducted the on-site quarterly audits. John Richards and Todd Brozell jointly reviewed the data and prepared the paper.

Conflicts of Interest

The authors have no financial interests in the facilities sampled. The authors served as independent contractors to the facilities to select the sampling equipment, select the sampling locations, prepare the test program protocols, train the sampler operator, conduct quarterly audits of all of the samplers, and reduce the data compiled throughout the sampling program.

References

1. California Office of Environmental Health Hazard Assessment. Chronic Toxicity Summary, Silica (Crystalline, Respirable), 2005. Available online: www//oehha.ca.gov/air/chronic_rels/pdf/SILICAcREL_Final.pdf (accessed on 31 May 2015).
2. Richards, J.; Brozell, T. *Ambient PM4 Crystalline Silica Monitoring Method Development*; Report to CalCIMA; California Construction and Industrial Materials Association: Sacramento, CA, USA, 2005.
3. U.S. Environmental Protection Agency. Reference Method for the Determination of Fine Particulate Matter as PM2.5 in the Atmosphere. 40 CFR Part 50, Appendix L. 1997. Available online: http://www.gpo.gov/fdsys/granule/CFR-2011-title40-vol2/CFR-2011-title40-vol2-part50-appL (accessed on 31 May 2015).

4. National Institute of Occupational Safety and Health. Method 7500, Silica, Crystalline by XRD (Filter Deposition), Issue 4, 2003. Available online: http://www.cdc.gov/niosh/docs/2003-154/pdfs/7500.pdf (accessed on 31 May 2015).
5. National Institute of Occupational Safety and Health. Method 0600, Particles Not Otherwise Regulated, Respirable; 1998. Available online: www.cdc.gov/niosh/docs/2003-154/pdfs/0600.pdf (accessed on 31 May 2015).
6. Richards, J.; Brozell, T.; Rea, C.; Boraston, G.; Hayden, J. PM4 crystalline silica emission factors and ambient concentrations at aggregate-producing sources in California. *Air Waste Manag. J.* **2005**, *59*, 1287–1296.
7. South Coast Air Quality Management District. *Sampling and Analysis of Samples Collected in the Cities of Duarte and Azusa*; Report MA 2006-01; South Coast Air Management District: Diamond Bar, CA, USA, 2006.
8. South Coast Air Quality Management District (2008). Sampling and Analysis of Samples Collected in the Cities of Duarte and Azusa, Follow-Up #4; Report MA 2008-03; 2008. Available online: http://www.azusarock.com/docs/AQMD2008FollowUp.pdf (accessed on 31 May 2015).
9. Wisconsin Department of Natural Resources. Report to the Natural Resources Board, Silica Study; August 2011. Available online: http://dnr.wi.gov/topic/AirQuality/documents/Final SilicaReport.pdf (accessed on 31 May 2015).
10. Minnesota Environmental Quality Board. Report on Silica Sand; March 20, 2003. Available online: https://www.eqb.state.mn.us/sites/default/files/documents/March%20Final%20Silica%20Sand%20report%20with%20award%20sticker.pdf (accessed on 12 July 2015).
11. U.S Environmental Protection Agency. Probe and Monitoring Path Siting Criteria for Ambient Air Quality Monitoring. 40 CFR Part 58, Appendix E. Amended 15 January 2013. Available online: http://www.ecfr.gov/cgi-bin/text-idx?tpl=/ecfrbrowse/Title40/40cfr58_main_02.tpl (accessed on 13 July 2015).
12. U.S. Environmental Protection Agency. Sampling Schedule Calendar. Available online: www.epa.gov/ttnamti1/calendar.html (accessed on 12 July 2015).
13. U.S. Environmental Protection Agency. Quality Assurance Handbook for Air Pollution Measurement Systems Volume II Ambient Air Quality Monitoring Program. EPA Publication EPA-454/B-13-003 May, 2013. Available online: http://www.epa.gov/ttnamti1/files/ambient/pm25/qa/QA-Handbook-Vol-II.pdf (accessed on 13 July 2015).
14. Hornung, R.W.; Reed, L.D. Estimation of average concentration in the presence of nondetectable values. *Appl. Occup. Environ. Hyg.* **1990**, *5*, 46–51.
15. Jason Treutel (Wisconsin Department of Natural Resources); John Richards, (Air Control Techniques, P.C.). Personal communication, 2015.
16. U.S Environmental Protection Agency. Quality Assurance Requirements for SLAMS, SPMs, and PSD Air Monitoring. 40 CFR Part 58, Appendix A; Amended 15 January 2013. Available online: http://www.ecfr.gov/cgi-bin/text-idx?SID=84ef9f0996c2e59ff713c5ea7a8f4ffd&mc=true&node=ap40.6.58_161.a&rgn=div9 (accessed on 16 July 2015).
17. Minnesota Pollution Control Agency. Winona Community Air Monitoring, January 2014–September 2014; January 2015. Available online: Available online: http://www.pca.state.mn.us/index.php/view-document.html?gid=21302 (accessed on 16 July 2015).

18. Minnesota Pollution Control Agency. Shakopee Sand (Previously Great Plains Sand) Ambient Air Monitoring, July 2012–December 2013; April 2014. Available online: http://www.pca.state.mn.us/index.php/air/air-quality-and-pollutants/air-pollutants/silica-sand-mining/air-monitoring-data-at-minnesota-silica-sand-facilities.html#shakopee-sands (accessed on 31 May 2015).
19. Minnesota Pollution Control Agency. Tiller-North Branch Ambient Air Monitoring, November 2012–December 2013; April 2014. Available online: http://www.pca.state.mn.us/index.php/air/air-quality-and-pollutants/air-pollutants/silica-sand-mining/air-monitoring-data-at-minnesota-silica-sand-facilities.html#tiller-north-branch (accessed on 31 May 2015).
20. California Environmental Protection Agency, Air Resources Board. Pilot Monitoring Study of Crystalline Silica in Ambient Air in Lompoc, California, 2003. Available online: http://www.cdpr.ca.gov/docs/specproj/lompoc/arbsilica_0403.pdf (accessed on 31 May 2015).
21. Stacey, P.; A.; Thorpe, P.; Roberts, P. Levels of Respirable Dust and Respirable Crystalline Silica at Construction Sites. Report of the Health and Safety Laboratory, England; 2011. Available online: http://www.hse.gov.uk/research/rrpdf/rr878.pdf (accessed on 31 May 2015).
22. Environmental Health Board, Queensland Health. Health Risk Assessment of Community Exposure to Silica from Airport Link/Northern Busway Construction Activities, 2012. Available online: https://www.ehp.qld.gov.au/air/pdf/airportlink-qh-report.pdf (accessed on 31 May 2015).
23. Shiraki, R.; Holmén, B.A. Airborne respirable silica near a sand and gravel facility in central California: XRD and elemental analysis to distinguish source and background quartz. *Environ. Sci. Technol.* **2002**, *36*, 4956–4961.
24. Saiyed, H.N.; Sharma, Y.K.; Sadhu, H.G.; Norboo, T.; Patel, P.D.; Patel, T.S.; Venkaiah, K.; Kashyap, S.K. Non-occupational pneumoconiosis at high altitude villages in central Ladakh. *Br. J. Ind. Med.* **1991**, *48*, 825–829.
25. Bhagia, L.J. Non-occupational exposure to silica dust in vicinity of slate pencil industry, India. *Environ. Monit. Assess*. **2009**, *151*, 477–482.
26. Davis, B.; Johnson, R.; Stevens, R.; Courtney, W.; Safriet, D. The quartz content and elemental composition of aerosols from selected sites of the EPA Inhalable Particulate Network. *Atmos. Environ.* **1984**, *18*, 771–782.
27. Wisconsin Department of Natural Resources. Wisconsin Air Quality Trends; April 2014. Available online: http://dnr.wi.gov/files/PDF/pubs/am/AM523.pdf (accessed on 31 May 2015).
28. U.S. Environmental Protection Agency (EPA). *Ambient Levels of Noncancer Health Effects of Inhalable Crystalline and Amorphous Silica*; U.S. EPA: Washington, DC, USA, 1996.
29. Nieuwenhuijsen, M.J.; Noderer, K.S.; Schenker, M.B.; Vallyathan, V.; Olenchock, S. Personal exposure to dust endotoxin and crystalline silica in California agriculture. *Ann. Occup. Hyg.* **1995**, *32*, 24–31.
30. Norton, M.R.; Gunter, M.F. Relationships between respiratory diseases and quartz-rich dust in Idaho, U.S.A. *Am. Mineral.* **1999**, *84*, 1009–1019.
31. Syzkman, J.; Mintz, D.; Creilson, J.; Wayland, M. Impact of April 2001 Asian Dust Event on Particulate Matter Concentrations in the United States; U.S. EPA Trends Report; 2001. Available online: http://www.epa.gov/airtrends/aqtrnd03/pdfs/1_asiandust.pdf (accessed on 31 May 2015).
32. Archer, J.; Cooper, G.; Reist, P.; Storm, J.; Nylander-French, L. Exposure to respirable crystalline silica in Eastern North Carolina farm workers. *Am. Ind. Hyg. Assoc. J.* **2002**, *63*, 750–755.

33. Stopford, C.; Stopford, W. Respirable quartz content of farm soil. *Appl. Occup. Environ. Hyg.* **1995**, *10*, 196–199.
34. Gillette, D. Soil derived dust as a source of silica: Aerosol properties, emissions, deposition, and transport. *J. Expo. Anal. Environ. Epidemiol.* **1995**, *7*, 303–311.

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WTBA
WISCONSIN TRANSPORTATION BUILDERS ASSOCIATION

Via Email

Ms. Gail Good, gail.good@wisconsin.gov
Ms. Kristin Hart, kristin.hart@wisconsin.gov
Mr. John Roth, john.roth@wisconsin.gov
Wisconsin Department of Natural Resources
101 S. Webster Street
P.O. Box 7921
Madison, WI 53707-7921

RE: Comments on WDNR Draft Guidance Documents on Air Management

Dear Ms. Good, Ms. Hart and Mr. Roth:

Wisconsin Transportation Builders Association (WTBA) appreciates the opportunity to provide comments on the following Wisconsin Department of Natural Resources' (WDNR) proposed guidance documents:

- "Air Dispersion Modeling Guidelines";
- "2015 Approach to Dispersion Modeling for Permits";
- "Guidance for Including $PM_{2.5}$ in Air Pollution Control Permit Applications"; and
- "Variance Request Procedures under NR 415.075(4), Wis. Admin. Code."

Wisconsin Transportation Builders Association ("WTBA") is a statewide association of approximately 250 companies that plan, design, construct and maintain all types of transportation facilities. Its members are an essential component of creating and maintaining the necessary infrastructure to support a vibrant Wisconsin economy. Many of its members own and operate non-metallic mining facilities. Its members have been actively involved in monitoring ambient air from those facilities and developing the technical foundation underlying the WDNR's conclusion that direct emissions of $PM_{2.5}$ do not cause or exacerbate violations of the $PM_{2.5}$ National Ambient Air Quality Standard ("NAAQS").

WTBA fully supports WDNR's above conclusion. Accordingly, WTBA supports the proposed guidances as it eliminates the need for costly, burdensome and unnecessary modeling associated with the permitting of miner sources such as non-metallic mining facilities.

WTBA appreciates WDNR's efforts to improve and streamline Wisconsin's air permitting process by issuing guidance that reflects sound technical conclusions.

If you have any questions, please contact Pat Goss at WTBA (608) 256-6891 / pgoss@wtba.org.

1 S Pinckney St # 300 Madison, WI 53703 (608) 256-6891

From: Patricia Hammel <attyhammel@herricklaw.net> Sent: Thu 08/27/2015 9:06 PM

To: Roth, John A - DNR; Hart, Kristin L - DNR; Good, Gail - DNR

Cc:

Subject: Proposed Program Guidelines re: Air Pollutant Dispersion Modeling Guidelines, Including PM 2.5 in Air Pollution Control Permit Applications and Variance Request Procedures u

Dear Mr. Roth, Ms. Hart and Ms. Good;

I have not had a great deal of time to review these proposed modeling guidelines, permit application exclusions and variance request procedures, however I would note the following:

1) The D.C. Circuit Court decision that is relied upon to exempt applicants from providing data for PM 2.5 emissions does not support exempting applicants from providing date for PM 2.5 emissions. It appears, and the EPA's position on it also appears to support requiring this data from applicants pending: "...As a result of the Court's decision, federal PSD permits issued henceforth by either the EPA or a delegated state permitting authority pursuant to 40 CFR 52.21 should not rely on the PM 2.5 SMC to allow applicants to avoid compiling air quality monitoring data for PM 2.5 ..." from March 4, 2013 publication of the U.S. Environmental Protection Agency titled "Circuit Court Decision on PM 2.5 Significant Impact Levels and Significant Monitoring Concentration."

2) The Appendix B linked to the Draft Guidance Air Dispersion Monitoring Guidelines which is the basis for Wisconsin DNR's optimistic conclusion that "...direct emissions of PM 2.5 from existing sources, minor new sources, and minor modifications of sources will not cause or exacerbate violations of any PM 2.5 standard or increment..." only includes one county in which industrial "frac" sand mining is presently occurring, Eau Claire County, and none of the counties where it is most prevalent in western Wisconsin. Most of the June 2015 technical document is focused on Dane and Waukesha Counties where no industrial sand mining is present. Eau Claire County only seems to have been added in 2011 or so, while other counties and communities in the northern, eastern and southern parts of the state were monitored over a period of 13-14 years.

Based on the review of multiple urban sources of PM 2.5 emissions in other parts of the state, the DNR's Draft Guidance for Including PM2.5 in Air Pollution Control Permit Applications goes on to conclude that:

> "...Examination of the science behind particle pollution leads to the conclusion that only combustion and high temperature industrial sources directly emit significant amounts of PM 2.5 . PM 2.5 emissions will not be estimated in an air permit review for fugitive dust sources, mechanical handling, grain handling, and other low temperature particulate sources. " and that

> "The PM 2.5 TSD concludes that it is not appropriate or informative to perform air quality modelling for direct emissions of PM 2.5 from individual sources and, instead, makes a finding using a weight of evidence approach, that direct emissions of PM 2.5 do not cause or exacerbate a violation of the ambient air quality standards or increment..."

See more about: Patricia Hammel.

Continued on Next Page…

Proposed Program Guidelines re: Air Pollutant Dispersion Modeling Guidelines, Including PM 2.5 in Air Pollution Control Permit Applic...

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Junk | More
Delete | Respond | Quick Steps | Move | Tags | Editing | Zoom

From: Patricia Hammel <attyhammel@herricklaw.net>
Sent: Thu 08/27/2015 9:06 PM
To: Roth, John A - DNR; Hart, Kristin L - DNR; Good, Gail - DNR
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Subject: Proposed Program Guidelines re: Air Pollutant Dispersion Modeling Guidelines, Including PM 2.5 in Air Pollution Control Permit Applications and Variance Request Procedures u

and so goes on to instruct applicants that they should assume that "…mechanical processes such as crushing, grinding, sanding, sizing, evaporation of sprays, suspension of dusts, etc. are not sources of PM 2.5 emissions and not include PM 2.5 emission estimates for these types of sources in the application." Furthermore, it goes on to state that modeling/monitoring of PM 2.5 emissions "will not be performed" by DNR. The "conclusion" that sand mining cannot be a significant source of PM 2.5 emissions is based on the study of PM 2.5 emissions in parts of the state where industrial sand mining is absent. DNR has never monitored PM 2.5 emissions from sand mining, and refuses to regulate dust despite a 2012 request from over 70 health care workers in western Wisconsin to do so because it says it's not a problem based on no evidence.

Finally we have the "Variance Request Procedure under NR 415.075(4), which will allow industrial sand mining facilities who may have been doing some dust emission monitoring to stop doing any monitoring. Given that the Draft Guidance for Including PM 2.5 in applications has "concluded" that industrial sand mining just cannot produce PM 2.5 fugitive dust and the DNR will not look for it, and the statements in the preamble of the variance request document's emphasis on the absence of any legal duty to notify the public of a variance request, the outcome of most variance requests is not difficult to predict.

Crystalline silica dust is monitored and regulated by New York, Texas, Virginia, California, New Jersey and Minnesota. NIOSH and other state agencies recognize that it's a serious health hazard causing permanent respiratory damage, heart disease and arthritis. Minnesota has a fraction of the number of industrial sand mines that Wisconsin has; partly because they have less sand suitable for hydraulic fracturing of oil and gas, but also because their industry is regulated to protect people, trout streams, and nature. By further exempting industrial sand mining from air quality regulation contrary to federal guidelines and without doing any meaningful scientific inquiry into the issue, Wisconsin's DNR is literally burying its head in the sand.

Fourteen counties passed a resolution for a moratorium on new permits for industrial sand mines at this year's Wisconsin Conservation Congress meeting in April, including Chippewa, Columbia, Crawford, Eau Claire, Pierce, St. Croix, and Waupaca Counties which are all currently the site of industrial sand mining facilities. That resolution was passed again by the W.C.C. Environmental Committee on Saturday August 22. These proposed guidance documents violate the public's trust in the state agency tasked with protecting "the ecosystems that sustain all life."

See more about: Patricia Hammel.

FW: PM2.5 measurements around frac sand mines - Message (HTML)

From: Hart, Kristin L - DNR

Sent: Fri 08/28/2015 11:14 AM

To: Roth, John A - DNR; Good, Gail - DNR

Cc: Stewart, Andrew M - DNR

Subject: FW: PM2.5 measurements around frac sand mines

Message | 10 28 14_0564.JPG (537 KB) | 10 28 14_0565.JPG (746 KB) | 10 28 14_0566.JPG (571 KB) | 10 28 14_0568.JPG (339 KB) | 10 28 14_3679.JPG (751 KB)

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Kristin Hart
Phone: (608) 266-6876
kristin.hart@wisconsin.gov

From: Patricia J. Popple [mailto:sunnyday5@charter.net]
Sent: Friday, August 28, 2015 2:05 AM
To: Hart, Kristin L - DNR
Subject: PM2.5 measurements around frac sand mines

Dear Ms. Hart:

Attached are 5 pictures taken at a blast site in Eau Claire County close to Amish and other homes.
Comment from the PHOTOGRAPHER:

One of the biggest blasts I have been at. I was told I had to get off the road from where I was parked because I was in the blast zone. I moved to the east and parked. The plume came over me and I went into a coughing attack. I told myself I was a fool and I should roll up my window and get out of there. It was massive. The plume hung around for more than 5 minutes. It was probably less than 200 yards from Amish homes.

See more about: Hart, Kristin L - DNR.

Continued on Next Page…

FW: PM2.5 measurements around frac sand mines - Message (HTML)

From: Hart, Kristin L - DNR

Sent: Fri 08/28/2015 11:14 AM

To: Roth, John A - DNR; Good, Gail - DNR

Cc: Stewart, Andrew M - DNR

Subject: FW: PM2.5 measurements around frac sand mines

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It is critical that the State of Wisconsin set a standard for respirable crystalline silica particulates. The DNR and the State of WI are remiss in not doing so with the proliferation of the industry that continues to be permitted without consideration for those living near the mines and other facilities. In my estimation the written guidance should be tossed and the DNR authorities be required to study the real issues with a vengeance using the available science and additional research studies with appropriate and new equipment. There are people living very close to these mines. Animals, plants and other life are affected!

Several states have set standards and should be used as models.

To date, the DNR and the State of WI are listening to the industry and large numbers of lobbyists. This approach must change.
Ms. Hart: I have spoken to you and at the time you were not even aware of the NIOSH Studies reported a year ago. People living in states where hydraulic fracturing is practiced by the oil and gas industry are receiving Wisconsin's "dust"! Wherever there is transload of frac sand to trucks or trains or to the rigs in the hydraulic fracturing field, the dust flies and affects the workers. No respirator is effective enough to protect workers from disease. What about the human beings living in homes, being cared for in nursing homes or attending day cares or schools nearby in those states? The are impacted.
Please get a grip on the problem. In 2012, the people in WI appealed to the DNR to do a study on silica issues. The paper clearly demonstrates the issues.
At that time, the report indicated there was not time nor money. In my opinion, a great deal of valuable time has been lost since that paper was written.

Please open the attachments and note the serious consequences of blasting. Fugitive dust also comes from crushing, heavy winds that carry away huge mounds of respirable crystalline silica along with the smaller particulates that can not be seen, industrial sludge that lands on the highways where it dries and is wisked away by winds and passing vehicles after it Please bring in true scientists who have made great strides studying particles that can't be seen with the naked eye. Take a look at the science behind nano-sized particulates that invade cells in the human and animal organs. Add a moratorium to the development of any future sand mines in the state of WI until specific scientific studies can prove there is no danger! Consider the wide range of people impacted in the counties where frac sand mining is occurring.

I would like to know the source of information that brought the State of Wisconsin and the DNR to the conclusion that it was not necessary to monitor nor to be no longer concerned about respirable crystalline silica, PM 2.5's, and the dangers inherent in the type of product being mined for use in the oil and gas industry.

Sincerely,

See more about: Hart, Kristin L - DNR.


10/28/2014


10/28/2014


10/28/2014


10/28/2014


10/28/2014