Figure 11. Data from the Wisconsin Department of Tourism shows the majority of sand-producing counties experienced growth in all major tourism growth metrics between 2010 and 2013.

**Jackson County data was not available for 2010, so 2011 data were used.*
**Total Labor Income was not available for 20120, so 2011 data were used.*
**County job estimates were derived from UW-Extension Agriculture Reports, and statewide total jobs numbers were derived from U.S. Bureau of Labor Statistics data.* [28;29]
**Per Capita Income was calculated from 2011 Total Employment data because Total Labor Income was not available for the year 2010.*

The incomes earned by tourism-supported jobs were much lower than incomes in silica-sand related jobs—incomes in sand jobs were three times higher than for tourism jobs in Wood County, and in Trempealeau County, earnings in the silica sand industry paid approximately two-and-one-half times more than tourism jobs.

Finally, the tourism sector supported 26,873 direct, indirect, and induced jobs in Wisconsin's twenty industrial silica sand producing counties. The Wisconsin Department of Tourism states tourism supported a total of 7.8 percent of all Wisconsin jobs in 2013.[30,31] However each of the silica sand producing counties has tourism employment below the statewide average (see fig. 11).

The data also show the jobs created by the tourism industry are typically low-paying jobs with incomes significantly lower than those of industrial sand mining jobs. These findings regarding employment rates and wages are supported by the academic research investigating the impact of tourism in rural Wisconsin counties as they relate to employment and earnings.

Studies by David Marcouiller at the University of Wisconsin-Madison investigate the economic impacts of tourism in Wisconsin by examining tourism earnings and employment in three geographic categories: urban, rural and suburban-proximate, and remote rural (see fig. 12). The findings of this study demonstrate rural counties benefit far less from tourism than urban and suburban counties, as travel and tourism industry earnings were highly concentrated in the 25 urban and suburban counties.

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[28] University of Wisconsin Extension, "County Impact Reports," accessed March 11, 2015, http://www.uwex.edu/ces/ag/wisag/.

[29] Bureau of Labor Statistics, "County Employment and Wages in Wisconsin–Third Quarter 2013, April 16, 2014, http://www.bls.gov/regions/midwest/news-release/countyemploymentandwages_wisconsin.htm.

[30] Wisconsin Department of Tourism, "The Power of Tourism," 2014, http://industry.travelwisconsin.com/uploads/medialibrary/e4/e42c3872-f898-46f9-9c35-6aab8fef44c3-power-of-tourism-fact-sheet-2014.pdf/

[31] Although the total percentage of tourism jobs in the state of Wisconsin is slightly lower in Figure 11 (6.74 percent compared to 7.8 percent) than reported by the Wisconsin Department of Tourism, this is likely a result of changes in employment and workforce participation rates for the month used to calculate total employment in the state.

Urban counties (indicated in pink on the map) accounted for more than three-quarters of all wage and salary income and roughly 72 percent of all travel and tourism sector jobs because of the greater amenities and opportunities for recreation and leisure activities available in larger areas, such as sporting events, restaurants, museums, and performing arts (See figs. 13 and 14). On the other end of the scale, the 21 counties of remote, rural Wisconsin (indicated in green on the map) generated only 6 percent of the state's tourism wages and salary income and slightly less than 7 percent of the travel and tourism sector jobs.[32]

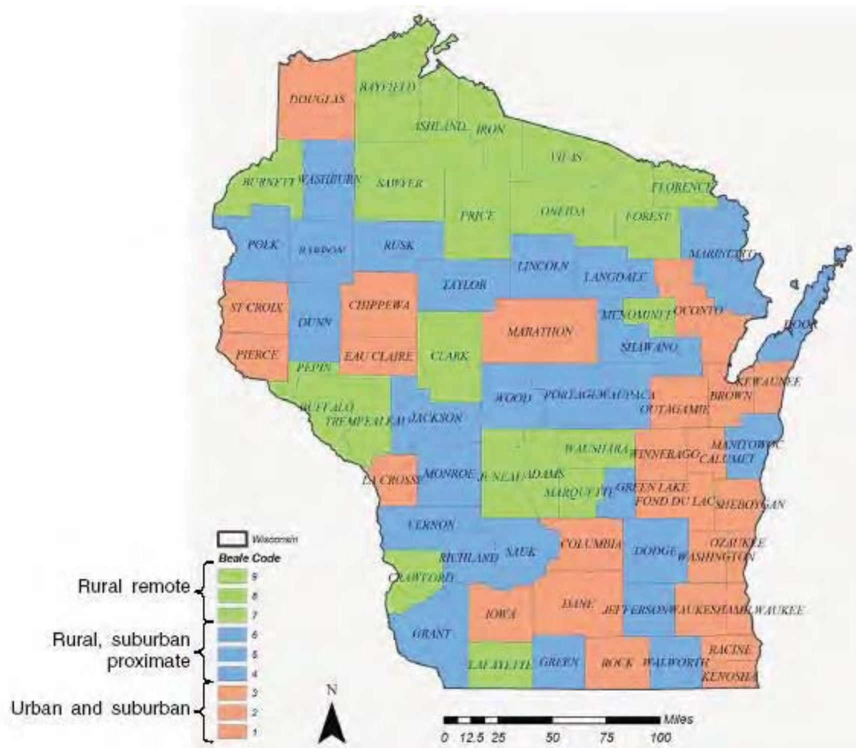

Figure 12. Among the 20 sand-producing counties in Wisconsin, five (Chippewa, Columbia, Eau Claire, Outagamie, and Pierce) are considered urban and suburban, nine (Barron, Dunn, Green Lake, Jackson, Monroe, Polk, Portage, Waupaca, and Wood) are considered rural suburban proximate, and six counties (Buffalo, Burnett, Clark, Crawford, Pepin, and Trempealeau) are considered remote rural counties.

Food preparation and serving and sales occupations were the two largest sectors for travel and tourism employment and wages in the state, accounting for roughly 74 percent of the jobs and 60 percent of the wage and salary income of the total employment picture in the ten sectors used to define travel and tourism. Wage and salary income was concentrated in the 25 urban and suburban counties of Wisconsin (see fig. 13 and fig. 14).[33]

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[32] David Marcouiller and Xianli Xia, "Distribution of Income from Tourism-Sensitive Employment," *Tourism Economics,* 14 (3), 545–565, 2008, http://urpl.wisc.edu/people/marcouiller/publications/TE.pdf.

[33] *Ibid.*

Employment (total number of jobs) by tourism sector and geographic location in Wisconsin (2002).

Tourism-sensitive sector name	NAICS code	Urban and suburban[1] (Beale Codes 1–3) Employment (jobs)	Employment (%)	Exurban, suburban proximate[2] (Beale Codes 4–6) Employment (jobs)	Employment (%)	Rural remote[3] (Beale Codes 7–9) Employment (jobs)	Employment (%)	Wisconsin total Employment (jobs)
Gasoline Stations	447	14,050	59.8	6,651	28.3	2,801	11.9	23,501
Clothing and Clothing Accessories Stores	448	15,939	86.6	1,612	8.8	851	4.6	18,402
Miscellaneous Store Retailers	453	14,597	75.8	3,313	17.2	1,356	7.0	19,266
Air Transportation	481	4,718	94.9	186	3.7	67	1.3	4,971
Scenic and Sightseeing Transportation	487	279	71.8	83	21.4	26	6.8	389
Performing Arts and Spectator Sports	711	5,998	81.1	1,122	15.2	278	3.8	7,398
Museums, Parks and Historical Sites	712	1,781	79.6	361	16.1	95	4.3	2,238
Amusement, Gambling & Recreation	713	21,559	68.0	7,514	23.7	2,645	8.3	31,718
Accommodation	721	18,390	58.1	9,603	30.4	3,646	11.5	31,638
Food Services and Drinking Places	722	131,334	73.9	36,523	20.6	9,835	5.5	177,692
All tourism-sensitive sectors		*228,645*	*72.1*	*66,968*	*21.1*	*21,599*	*6.8*	*317,212*

Note: [1]Urban counties include those classified as metropolitan. In Wisconsin, there are 25 counties in this category (see Figure 1). [2]Exurban, suburban proximate counties include those non-metropolitan counties that are either proximate to metropolitan counties or include small urban cities. In Wisconsin, there are a total of 26 counties in this category (see Figure 1). [3]Rural, remote counties are those counties that are totally rural or rural and not directly adjacent to a metropolitan county. In Wisconsin, there are a total of 21 counties in this category (see Figure 1).

Figure 13. Employment in tourism jobs in Wisconsin is highly concentrated in urban counties, and just 6.8 percent of tourism employment is in remote, rural environments. Jobs in food services and drinking places dominate the travel/tourism sector employment statistics, accounting for roughly 74 percent of the state's tourism jobs.

Wages and salaries paid by travel/tourism sectors and geographic location in Wisconsin (2002).

Tourism-sensitive sector name	NAICS code	Urban and suburban[1] (Beale Codes 1–3) Wages (US$)	Wages (%)	Exurban, suburban proximate[2] (Beale Codes 4–6) Wages (US$)	Wages (%)	Rural remote[3] (Beale Codes 7–9) Wages (US$)	Wages (%)	Wisconsin total Wages (US$)
Gasoline Stations	447	204,685,934	63.0	84,528,423	26.0	35,737,787	11.0	324,952,144
Clothing & Clothing Accessories Stores	448	233,065,942	85.7	22,705,672	8.3	16,262,386	6.0	272,034,000
Miscellaneous Store Retailers	453	246,466,327	77.8	51,359,787	16.2	18,916,201	6.0	316,742,314
Air Transportation	481	178,837,827	94.8	7,200,733	3.8	2,595,344	1.4	188,633,903
Scenic & Sightseeing Transportation	487	5,134,912	70.5	1,636,385	22.5	512,745	7.0	7,284,041
Performing Arts and Spectator Sports	711	327,070,575	95.5	12,171,486	3.6	3,409,096	1.0	342,651,156
Museums, Parks and Historical Sites	712	39,853,802	81.8	7,046,321	14.5	1,795,496	3.7	48,695,619
Amusement, Gambling & Recreation	713	306,759,495	67.4	109,045,151	24.0	39,207,706	8.6	455,012,351
Accommodation	721	267,934,889	61.6	123,712,114	28.4	43,589,556	10.0	435,236,559
Food Services and Drinking Places	722	1,297,156,829	76.9	304,321,840	18.1	84,247,281	5.0	1,685,725,950
All tourism-sensitive sectors		*3,106,966,531*	*76.2*	*723,727,910*	*17.8*	*246,273,597*	*6.0*	*4,076,968,037*

Note: [1]Urban counties include those classified as metropolitan. In Wisconsin, there are 25 counties in this category (see Figure 1). [2]Exurban, suburban proximate counties include those non-metropolitan counties that are either proximate to metropolitan counties or contain small urban cities. In Wisconsin, there are a total of 26 counties in this category (see Figure 1). [3]Rural, remote counties are those counties that are completely rural or rural and not directly adjacent to a metropolitan county. In Wisconsin, there are a total of 21 counties in this category (see Figure 1).

Figure 14. Wages and salaries of tourism jobs are highly concentrated in urban counties, and just 6 percent of the wages generated by tourism employment are earned in remote, rural environments. Among the 10 industries of the travel/tourism sector, gasoline stations had the highest percentage of wages in rural remote areas, with 11 percent of all earnings at gasoline jobs in the state occurring in rural counties. In terms of overall travel/tourism sector jobs, food service and drinking places had the most jobs in terms of absolute wages paid in remote rural areas.

Marcouiller suggests analysis of tourism employment must account for more than simply numbers of jobs; the types of jobs created, from the standpoint of wage rates, permanence, career opportunities, and skill levels employed, are also important. Additionally, the available academic research has found tourism jobs tend to be relatively low-wage, seasonal, and part-time and often impede the regional developmental objective of high-wage job creation.[34]

According to these studies, when compared with traditional primary industries in rural America such as agriculture, forestry, and mining, tourism generates predominantly lower-income job opportunities.[35] This research supports the earlier findings of this *Policy Study* which compared tourism employment and earnings to employment and earnings for jobs in the industrial sand industry in silica-sand-producing counties.

In conclusion, the academic research has found tourism jobs tend to be relatively low-wage, seasonal, and part-time and are primarily suited for first-time workers and young people with little work experience. However, tourism provides important job opportunities for low-income households and entry-level workers, those lacking higher skill levels, individuals seeking supplemental income, the retired, or those working for other nonmonetary reasons.[36] In addition, the valuable experience gained at these jobs can create significant career-ladder opportunities for dedicated tourism employees, including positions in management, financial operations, professional entertainers, and other technical occupations.

The research discussed above and the analysis of Wisconsin Department of Tourism Data have important implications for economic planning by local citizens and policymakers in areas with silica sand mining potential. These communities often engage in debate over whether to prohibit or restrict industrial sand mining for fear it will have a negative effect on the local tourism industry. However, Wisconsin tourism data show growth in direct visitor spending, total employment, total labor income, state and local tax revenue, and worker per-capita income in a majority of frac sand producing counties, suggesting industrial sand development and tourism can coexist.

It is also important for policymakers to note 75 percent of industrial sand-producing counties are considered remote rural, or rural/suburban proximate areas, which, according to the academic literature, are far less likely to reap economic benefits from the tourism and travel industries than urban counties, because rural areas lack the amenities necessary to sustain larger tourism economies. Therefore, policymakers in these communities should exercise caution when considering whether to promote tourism at the expense of other industries by restricting economic opportunities such as the traditional primary industries in rural America, including agriculture, forestry, and mining.

Impact on Agriculture

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[34] David Marcouiller and Xianli Xia, "Distribution of Income from Tourism-Sensitive Employment," *Tourism Economics,* 14 (3), 545–565, 2008, http://urpl.wisc.edu/people/marcouiller/publications/TE.pdf.

[35] David Marcouiller, "'Boosting' Tourism as Rural Public Policy: Panacea or Pandora's Box?" *Journal of Regional Analysis and Planning,* Special Issue on Rural Development Policy – 37(1):28-31. 2007, http://www.jrap-journal.org/pastvolumes/2000/v37/F37-1-marcou.pdf.

[36] *Ibid.*

Due to the importance of agriculture to the western Wisconsin economy, some people have raised concerns industrial sand mining would negatively affect the short term and long tern viability of the agriculture industry.

In the short term, there is concern silica sand mining may compete with agriculture for land use, and because of the high value of frac sand and the royalties associated with mining, it is likely some landowners would opt to lease their land for mineral development instead of continuing to farm it. This has several potential implications for agriculture, such as taking land out of production, increasing local property values, and increasing the rates farmers who rent land must pay to lease farmland.

Consider a hypothetical situation. A retired landowner who has traditionally rented his farmland to a neighboring farmer for crop production is approached by a sand mining company that wants to lease his land to develop industrial sand resources on the property. The neighboring farmer's lease expired the previous fall, thus fulfilling the terms of the rental agreement. However, the farmer still wants to rent the land for the next year, but the landowner decides to lease his land to the sand mining company. The farmer must farm fewer acres or find replacement acreage to supplement the acreage lost.

If the farmer decides to find replacement acreage, he can attempt to buy more land, thereby ensuring his tillable acreage for the foreseeable future, or try to rent more acres from another landowner. The price to buy farmland could conceivably increase because these other landowners may be hoping to be approached by mining operations, or because other farmers who have lost acreage under similar circumstances are looking for farmland to buy. If the farmer in our example decides to rent, he may find the price to lease farmland has been increased by other farmers looking to secure more acres.

This scenario would increase land values in sand-mining areas, raising the costs of inputs for farmers, although these effects are likely to be local in nature.

However, if a farmer owns his own land and is approached by a sand mining company that wants to lease his land, the potential earnings from leasing the mineral rights to the mining company would greatly exceed the expected returns from keeping the land in agricultural production. These earnings could then be used to buy new farming implements or more farmland. Thus, one of the key factors determining whether one reaps the benefits or bears the costs of sand mining is land ownership.

Some people have raised a long-term concern that land used for industrial sand mining may take decades or even centuries to return to its previous productivity. As discussed in our previous Policy Study, scientific studies examining agricultural production at reclaimed sand mine sites found crop yields were 73 to 97 percent of their original volumes within three years of reclamation, indicating frac sand mining may not cause long-term declines in farmland productivity.[37]

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[37] Isaac Orr and Mark Krumenacher, "An Introduction to the Environmental Impacts of Industrial Silica Sand (Frac Sand) Mining, The Heartland Institute, May 2015.

It is also important to note industrial sand mines are not all located on prime agricultural land. There may be even distribution of proposed or active mines on agricultural, forested, and steep slopes. Should all the agricultural land that has been permitted for mining never again be used for agricultural purposes, the overall percentage lost would be negligible compared to the much larger number of acres lost to residential and commercial development or the several hundred thousand acres of cropland left idle or used for cover crops or soil improvement and thus not harvested, pastured, or grazed, or those enrolled in Conservation Reserve, Wetlands Reserve, Farmable Wetlands, or Conservation Reserve Enhancement Programs.[38]

Finally, a short-term economic cost that is likely to persist into the long term stems from competition between agriculture and the industrial sand industry over a limited amount of railcars for transportation of frac sand and of grain and other agricultural products. Due to the volumes of sand required to hydraulically fracture a well, frac sand is often transported on unit trains of 100 cars in order to improve efficiency. However, the fall grain harvest creates an increased demand for railcars, to transport grain, creating a temporary shortage of railcars. This conflict will likely persist until new railcars are brought online to meet demand.

Historical Analysis of Economic Growth in Mining-Dependent Areas

The Power Consulting, Inc. report cited above draws on the history of metal mining in Wisconsin and economic data from a series of mining-dependent communities from across the United States to provide context for what may occur as a result of silica sand mining in west-central Wisconsin. This section summarizes the findings of the Wisconsin and national analysis by Powers Consulting Inc. and explores their applicability to industrial sand mining.

Wisconsin has a longstanding tradition of mining, as lead, zinc, iron, copper, and gold have all been mined in the state throughout its history. As noted in the report, although mining generated significant economic activity for a short period, it did not lay the foundation for prosperity in the communities in which it took place.

Lead and zinc mining in southwestern Wisconsin began in the 1820s and began declining in the 1840’s. Lead and zinc mining was revived from the 1880’s until the 1940’s, but the population declined during this period. These early mining operations decreased as the easily extracted ore deposits were exhausted.[39]

Iron mining began in Ashland and Iron Counties in the mid-1880s and continued until 1965, but a steep decline in population began in 1920 even as mining continued in Ashland County for another 45 years (see fig. 15). At first glance, the dramatic decline in population in Ashland

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[38] USDA Census of Agriculture, *2012 Census*, Volume 1, Chapter 1: State Level Data, Wisconsin, Volume 1, Complete Report, All Tables, accessed March 16, 2015, http://www.agcensus.usda.gov/Publications/2012/Full_Report/Volume_1,_Chapter_1_State_Level/Wisconsin/.

[39] Wisconsin Historical Society, “Mining in Northern Wisconsin,” accessed March 13, 2015, http://www.wisconsinhistory.org/turningpoints/tp-029/?action=more_essay.

County appears counterintuitive, as the high wages and jobs associated with mining should not lead to a rapid decline in population. However, an analysis by the U.S. Forest Service indicates the 1920's ushered in the end of the lumber era in northern Wisconsin, which was likely partially responsible for the decline in population.[40]

The second period of steep decline beginning in 1940 is likely representative of declining ore grades, which reduced the profitability of mining operations, eventually leading the to the closure of the mine in 1965. This section of the report concludes "Eighty years of iron ore mining in the Gogebic Range did not allow these counties to either stabilize their population or grow it."

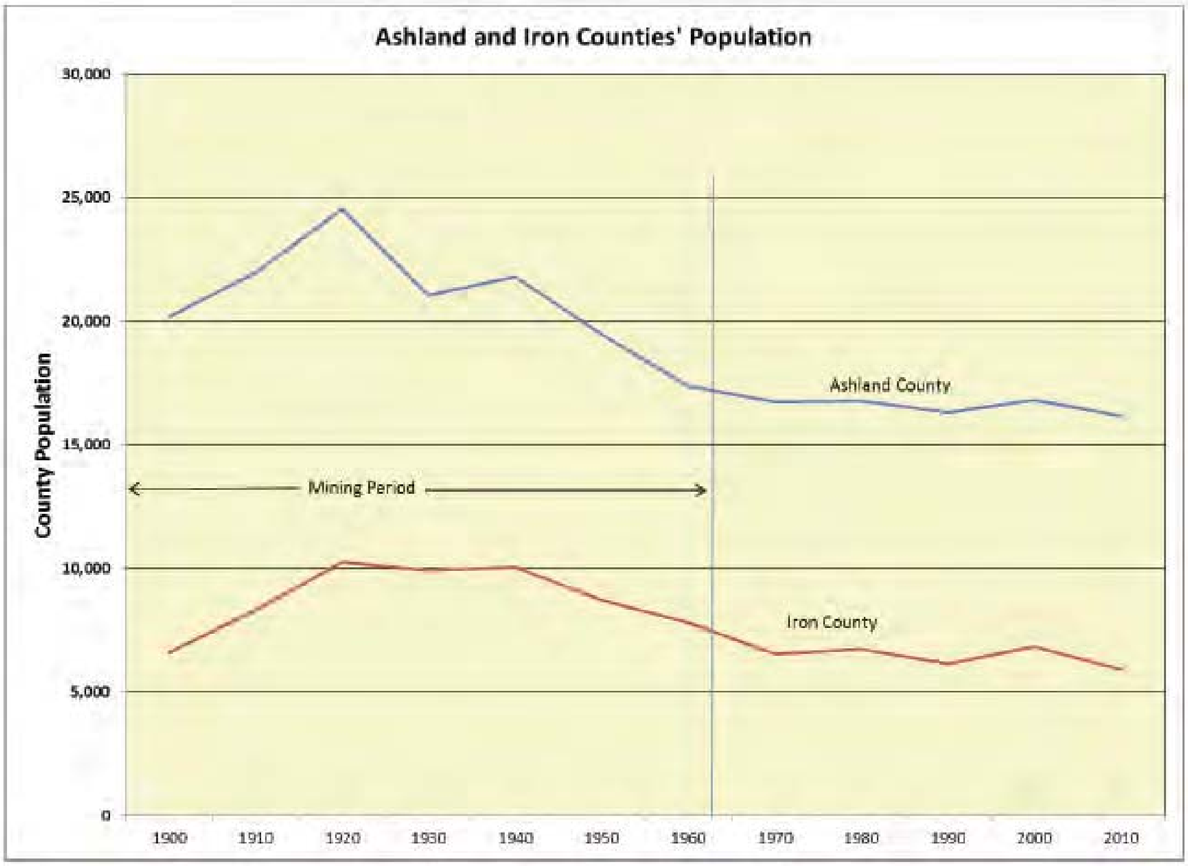

Figure 15. Around 1920, the county of Ashland, Wisconsin, experienced a dramatic decline in population, even though mining continued in the county for another 45 years. The decline was not the result of a shortcoming of the mining industry, but instead coincides with the decline of the timber industry in northern Wisconsin, as reported the U.S. Forest Service.

Next, to explore the contemporary local impact of reliance on mining in the United States, Power Consulting, Inc. examined the economic performance of all U.S. counties where mining

40 United States Forest Service, *History of Chequamegon-Nicolet National Forest,* accessed March 13, 2015, http://www.fs.usda.gov/Internet/FSE_DOCUMENTS/stelprdb5109506.pdf.

(excluding oil and gas extraction) was the source of 20 percent or more of labor earnings at some time in the 1980s, and then followed those counties through 2008.[41]

Examination of mining-dependent areas such as coal mining communities in Appalachia, lead mining in the Ozarks, coal mining in the Four Corners, and copper and iron mining in the Upper Peninsula of Michigan and the Iron Range in Minnesota, found these areas to be characterized by high levels of unemployment, slow rates of growth of income and employment, high poverty rates, and stagnant or declining populations. That led Power Consulting, Inc. to conclude, "It is clear that over the last several decades, dependence on mining did not provide a reliable path to prosperity that allowed mining communities to perform better than other American communities. In fact, mining-dependent communities lagged significantly behind the average for the rest of the nation."

When examining the historical track record of mining in Wisconsin and mining-dependent communities throughout the nation, it is important to analyze these findings critically, to understand whether they are applicable to industrial silica sand mining in Wisconsin and other states in the Upper Midwest.

As noted earlier, the decline in mining in various areas of Wisconsin was precipitated by the decline in available ore capable of being produced in an economically competitive manner, plus the simultaneous declines in other industries that had provided economic diversity to the region. Industrial sand mining differs from traditional metal mining because silica sand is an abundant resource that is unlikely to be exhausted in the short term.

To provide insight into the potential effects of industrial sand mining on western Wisconsin, Power Consulting, Inc. gives examples from mining-dependent communities throughout the country. However, drawing comparisons with areas depending on other types of mining, such as the Iron Range of Minnesota and coal-mining communities in Appalachia is a highly questionable way to assess the potential economic impacts of industrial sand mining in Wisconsin and other Midwestern states because mining-dependent communities rely on mining for 20 percent or more of their total employment earnings, which is unlikely to be the case for industrial sand mining regions.

For example, in Wood County, Wisconsin, the total labor earnings from direct, indirect, and induced jobs will be approximately $58.7 million dollars, or approximately 3.14 percent of total labor compensation, which is far below the threshold for being considered dependent on mining.[42] In addition, these communities were built around geographically concentrated ore bodies, so mineworkers constituted a higher proportion of the population living near the mining sites. Industrial sand mining ore bodies, by contrast, are spread out over a wide geographic region, so this type of mining is unlikely to become the backbone of a concentrated community, instead supplementing economic activity in a geographically dispersed group of communities.

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[41] Thomas Power, Ph.D., and Donovan Power, M.S., *supra* note 4.

[42] Wisconsin Department of Workforce Development, "2013 Wood County Workforce Profile," 2014, http://worknet.wisconsin.gov/worknet_info/downloads/CP/wood_profile.pdf.

Addressing Economic Leakage from Mining Communities
A key point addressed in a series of reports and studies weighing the costs and benefits of industrial sand mining is economic leakage, which is defined as a situation in which capital or income exits an economy instead of remaining within it, from the communities in which mining occurs.[43] These discussions provide an important basis for decision-making as local residents who will realize the negative impacts of mining activity, such as increased truck traffic and noise, wish to understand what they stand to benefit from industrial sand production in their communities.

Economic leakage depends on how interconnected the businesses in a given community are to one another. This interconnectedness creates the multiplier effect. For example, a farmer has the chance to buy feed for his cattle in a neighboring town or the local co-op. If he decides to buy from the neighboring town, it is considered leakage from his community, but if he buys from the local co-op, it is considered a linkage, and that money continues to circulate within the local economy.

The linkages, or economic multiplier, will also be influenced by the size of the economy, as larger areas generally have more businesses, which means a given dollar is able to circulate more times before leaking than is the case in a smaller area. Two economies with similar population and geographic size may have quite different multipliers, depending on their respective economic structures.[44]

Power Consulting, Inc. suggest mines tend to have limited connections with the local economy, especially if the mine in located in a rural area. With limited commercial infrastructure, the local economy cannot provide the mine with either the equipment or supplies it needs and often cannot even provision the mining households. As a result, the income generated rapidly leaks out of the community. However, the rural nature of most communities in which industrial sand mining occurs means there is bound to be significant economic leakage of earnings in these areas regardless of how they are obtained.

Conclusion

Industrial silica sand mining has experienced dramatic growth since the technological breakthrough of hydraulic fracturing and horizontal drilling transformed uneconomic oil and gas deposits into profitable drilling operations. Silica sand production more than doubled between 2005 and 2014 increasing from 31 million metric tons in 2005 to more than 75 million in 2014, and sand for hydraulic fracturing, or "frac sand" now accounts for 72 percent of all industrial silica sand mined in the United States.

The dramatic increase in production has led to the creation of thousands of jobs in the Upper Midwest. In Wisconsin, the nation's largest producer of frac sand, 189 people were employed in

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[43] Investopedia, "Leakage," accessed April 15, 2015, http://www.investopedia.com/terms/l/leakage.asp.

[44] Eugene Lewis, "Economic Multipliers: Can a Rural Community Use Them?" October, 1979, https://research.wsulibs.wsu.edu/xmlui/bitstream/handle/2376/4883/wrep_24_1979_economic_multipliers_can_a_rural_community_use.pdf?sequence=1.

the industrial sand industry in 2002. Now, estimates devised by the Wisconsin Economic Development Corporation indicate the industry employs 2,880 to 4,230 people, a 15- to 22-fold increase in industrial sand employment in twelve years. If all permitted mine sites and processing facilities became fully operational, the industry would directly employ between 4,900 and 7,100 people.

These are high-paying jobs, with total earnings consistently above the average wages in Wisconsin and exceeding the average per-capita income in the counties and communities in which they occur by 30 to 82 percent. Earnings from industrial sand mining were also two to three times greater than those for tourism-supported jobs.

Industrial sand mining presents rural communities an opportunity to diversify their economies, which are heavily reliant upon agriculture. In Wisconsin, 85 percent of industrial sand producing counties rely on agriculture for employment at a higher rate than the state average. Without economic diversity, fluctuations in crop and livestock prices have a much greater effect on local rural economies. As off-farm employment has become increasingly important for small farmers, jobs in the industrial sand industry can provide high-paying jobs in communities that otherwise may have few opportunities for family-supporting jobs.

Fears that industrial sand mining will negatively affect tourism in rural counties have not been supported by the data collected by the Wisconsin Department of Tourism, as tourism spending, employment in tourism-supported jobs, total labor income, and state and local taxes generated from tourism-supported activities have increased in a majority of industrial sand producing counties. Direct visitor spending increased and tourism-supported employment increased in industrial sand producing counties by 95 percent and 60 percent, respectively.

Academic research on patterns of Wisconsin tourism have found 72 percent of the state’s tourism jobs were located in urban or suburban counties, with remote, rural areas accounting for just 7 percent of tourism-related employment in the state. These findings demonstrate remote, rural communities, are less able to benefit from tourism than urban counties because they offer fewer amenities. These findings have important implications for state and local policymakers, as some groups who advocate restrictions or bans on industrial sand mining in favor of the tourism economy may not realize the limitations of this industry in providing high-paying jobs to rural areas.

Concerns that industrial sand mining would negatively impact agriculture stem from fears that farmland used for industrial sand mining will take decades or even centuries to return to productive farmland. However, studies have shown up to 97 percent of original yields have been obtained in reclaimed sand mines in other parts of the country. Although industrial sand mining may increase local land prices as landowners consider mining as an alternative to renting farmland, the amount of acreage used for industrial sand mining is far less than the acreage in conservation programs and other nonagricultural uses.

In a previous analysis, Power Consulting Inc. sought to draw comparisons between industrial sand mining in Wisconsin and mining in mining-dependent parts of the country, such as the Iron Range of northern Minnesota and coal mining towns of Appalachia. These comparisons are problematic, however, because mining-dependent communities rely on mining for 20 percent or more of their total employment earnings, which is unlikely to be the case for industrial sand mining regions. Wood County, for example, would only rely on industrial sand mining for only 3.14 percent of total labor compensation. Industrial sand mining is unlikely to become the economic backbone of the counties in which it occurs, but it can serve an import complementary role in areas relying heavily on agriculture.

Industrial sand mining has been a significant driver of economic growth in communities throughout the upper Midwest. If done in an environmentally responsible manner, industrial sand mining can be an important source of employment and earnings for decades to come.

About the Authors

Isaac Orr

Isaac Orr is a research fellow at The Heartland Institute. He previously worked as a research analyst and writer in the office of Wisconsin State Senator Frank Lasee, and prior to that interned with the Rancher's Cattleman Action Legal Fund. He graduated in 2012 with honors from the University of Wisconsin-Eau Claire, with a Bachelor of Arts degree in political science and a minor in geology.

He is the author of a Heartland Institute Policy Brief, "Hydraulic Fracturing: A Game-Changer for Energy and Economies" (November 2013), and his letters to the editor and op-eds have been published in *USA Today, The Houston Chronicle, The Washington Times,* The Hill, *American Thinker,* and *Human Events.* He is also the author of "Frac Sand Study: Lots of Scare, Little Science," published in the *Milwaukee Journal Sentinel* in October 2014. He has recorded more than a dozen podcasts on energy and environment topics for The Heartland Institute, available on Heartland's YouTube channel at HeartlandTube.
Orr writes, "I grew up on a dairy farm, and I want to preserve rural America, and rural American values. Along with agriculture, I am fascinated by geology, mining, groundwater, and other environmental issues."

Mark Krumenacher

Mark Krumenacher is a principal and senior vice president of GZA GeoEnvironmental, Inc. and is based in Waukesha, Wisconsin. Mark has served as principal, project manager, and project hydrogeologist during the past 27 years with GZA on environmental, geologic, hydrogeologic, and engineering projects throughout North America.

Krumenacher is a professional geologist with licensure nationally and in several states and is a Certified Hazardous Materials Manager. He has managed and conducted geologic, hydrogeologic, and engineering studies, remedial investigations, environmental assessments, pre-acquisition environmental due diligence, and hazardous waste management at various properties including surface and underground mines; large industrial, commercial, and urban redevelopment projects; federal Superfund sites; and state-lead environmental projects.

He has provided testimony regarding aggregate and industrial mineral mining before municipal, township, and county units of government as well as NGOs, local environmental groups, and community advisory councils to help address residents' concerns about mining.

Krumenacher is actively involved with the several mining associations, including the National Stone Sand and Gravel Association, Illinois Association of Aggregate Producers, National Industrial Sand Association, Industrial Minerals Association–North America, Wisconsin Industrial Sand Association, and Society for Mining Metallurgy and Exploration.

An Introduction to the Environmental Impacts of Industrial Silica Sand (Frac Sand) Mining

By Isaac Orr and Mark Krumenacher

Introduction

Sand has been mined for industrial processes throughout the United States for more than a century. This sand, also referred to as silica sand or industrial sand, is used for a variety of essential industrial purposes, including feedstock for glassmaking, cores for molding metal castings at foundries, metal production, feedstock for household and industrial cleaners, construction supplies such as concrete, bedding for livestock, an abrasive in toothpaste, filtering drinking water, and hydraulic fracturing, a technique used in oil and natural gas production.[1]

In recent years, the use of silica sand for hydraulic fracturing has been the largest factor driving growth in the industrial sand market, as this sand, commonly referred to as "frac sand," is crucial to the recovery of oil and natural gas from shale, tight sandstones, and other unconventional rock formations.[2] Growing demand for frac sand has led to an increase in volume and value of industrial sand produced in the United States over the course of a decade.

Prior to the proliferation of hydraulic fracturing, industrial sand was a relatively small market, largely providing sand for glassmaking, foundries, vertical hydraulic fracturing, and construction. For example, in 2005, U.S. Geological Survey (USGS) data indicate 31 million metric tons of industrial sand were mined in 35 states. This sand was valued at $700 million, averaging roughly $22.6 per metric ton. Approximately 35 percent of this tonnage was used for glassmaking, 19 percent was used at foundries, 12 percent was employed in hydraulic fracturing, and 10 percent in the construction industry.[3]

In contrast, 75 million metric tons of industrial sand and gravel were mined in 2014, nearly 2.5 times more than just a few years ago. This sand was valued at $4.2 billion, averaging about $56 per metric ton. Frac sand, not the glassmaking industry, is now the leading use for industrial sand, as 72 percent of the sand mined in 2014 was used for hydraulic fracturing and well packing. Additionally, 13 percent of the industrial sand mined was used for glassmaking, 6 percent for foundries, and just 3 percent as whole-grain fillers and for building products.[4]

[1] National Industrial Sand Association, "What is Industrial Sand?" 2011, http://www.sand.org/what-is-industrial-sand.

[2] U.S. Geological Survey, 2012 Minerals Yearbook, Silica [Advance Release], August 2014, http://minerals.er.usgs.gov/minerals/pubs/commodity/silica/myb1-2012-silic.pdf.

[3] U.S. Geological Survey, "Mineral Commodity Summaries," January 2006, http://minerals.er.usgs.gov/minerals/pubs/commodity/silica/sgindmcs06.pdf.

[4] U.S. Geological Survey, "Mineral Commodity Summaries," February 2015, http://minerals.usgs.gov/minerals/pubs/commodity/silica/mcs-2015-sandi.pdf.

Much of the growth in industrial sand production has occurred in the Midwest: 68 percent of the industrial sand mined for hydraulic fracturing was mined in this region in 2012, and that figure has grown in recent years. As a result, the leading industrial-sand-producing states in 2014 were, in order of volume produced, Wisconsin, Illinois, Texas, Minnesota, Arkansas, Oklahoma, Missouri, and Iowa, together accounting for 78 percent of the industrial sand mined in the United States.[5]

Increasing demand for industrial sand has become a significant driver of economic growth, particularly in areas where frac sand is mined, resulting in substantial growth in employment in the industrial sand industry. In Wisconsin, the leading supplier of industrial sand in the nation, data from the federal Bureau of Labor Statistics (BLS) indicate industrial sand mining employed 189 people in the state in 2002.[6] In comparison, the Wisconsin Economic Development Corporation estimates this number will grow to nearly 3,000 when existing and proposed mines become fully operational, representing a 15-fold increase in employment in the industry.[7]

Although industrial sand and gravel have been mined safely in the United States for more than a century, the recent growth in scale has raised concerns about the potential environmental impacts of industrial sand mining. These concerns have been perpetuated by environmental special-interest groups, many of whom are ideologically opposed to oil and natural gas development and the use of hydraulic fracturing. These advocacy groups have authored a series of reports raising concerns about the potential environmental, economic, and societal impacts industrial silica sand mining may have in areas where it occurs.

However, these advocacy documents, such as the *Communities at Risk* report published by Boston Action Research, do not give the reader a realistic understanding of the issue, as they are based on anecdotal evidence and not credible, scientific data. Consequently, these reports—which are unreliable because of their anecdotal nature and the use of cherry-picked data—are overly alarmist, downplaying the positive impacts of industrial sand mining while exaggerating the possibility of negative impacts and neglecting to inform the reader they are unlikely to occur.

Federal, state, and local regulators are responsible for developing rules and guidelines to protect the public interest, and these policymakers must have access to the best-available information to fulfill this responsibility. This study serves to provide a scientific, not anecdotal, analysis of the potential environmental effects of industrial sand mining. In light of the multitude of misleading claims made about industrial sand mining in various environmental reports, portions of this study

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[5] *Ibid.*

[6] Kate Prengaman, "Frac Sand Boom Creates Thousands of Jobs," *The Appleton Post Crescent*, August 20, 2012, http://archive.postcrescent.com/article/20120820/APC0101/308200091/Frac-sand-boom-creates-thousands-jobs.

[7] *Ibid.*

will be dedicated to addressing these claims in a scientific manner in an effort to develop better tools for policymakers on the subject matter.

Every society utilizes natural resources, and doing so may have an impact on the environment. Local citizens and policymakers must weigh the costs of developing a resource against the benefits derived from doing so, and they should develop that resource in the most environmentally friendly way. For this informed discussion to take place, the public must have access to the best-available information. Unfortunately, those raising fears of frac sand mining have taken advantage of the public's limited understanding of the industrial sand mining process, limited recognition of the precautions taken to minimize potential environmental impacts, limited knowledge of geology, and lack of awareness of state and local regulations on silica sand production. This *Policy Study* is the first in a series explaining the advantages and disadvantages of industrial silica sand mining and providing information so a better-informed discussion can take place.

In this *Policy Study*, the authors review the background and potential of industrial sand mining in the United States and then put that potential in the context of supply and demand for silica sand, now and into the future. Because demand for frac sand has been the main driver of growth for industrial sand production, this study will also briefly discuss the role of silica sand as a proppant for oil and natural gas recovery. The authors then consider the environmental costs and benefits of frac sand mining as they pertain to air quality, water quantity, water quality, and reclaiming mines after mining is completed.

This *Policy Study* concludes silica sand mining can be done in a safe and environmentally responsible manner with the proper oversight and environmental protections. State and local governments have done a commendable job working with environmental and industry leaders to craft legislation that protects the environment while permitting industrial sand production to move forward. Regulations crafted to specifically regulate industrial sand mining would be duplicative, resulting in higher costs without significantly increasing environmental protections.

Part 1: What Is Industrial Silica Sand?

Industrial silica sand is simply silica sand that is used for industrial purposes. This nontoxic sand is composed of the mineral quartz, which comprises 10 percent of the Earth's crust by mass, making it the most common mineral found on the surface of the Earth.[8] Industrial sand has the same chemical composition as the sand found in sandboxes, riverbeds, and beaches throughout

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[8] Minnesota Department of Natural Resources, "DNR and Silica Sand," 2015, accessed February 28, 2015, http://www.dnr.state.mn.us/silicasand/index.html.

the world; it is no coincidence that the most sought-after industrial sand deposits were formed in beach environments over the span of millions of years 400 to 500 million years ago.

Figure 1.Industrial Sand, Penny for Scale. Figure from the Minneapolis Star Tribune

Certain physical characteristics make some sand deposits more attractive for industrial uses, and thus industrial sand mining, than others. Among these properties are the size (the size of the grains can affect which uses it is best suited for), shape (whether the sand is angular or spherical), uniformity of the grain sizes (whether the grains are all relatively the same size), purity of the deposit (how much of the material is silica sand compared to other, noneconomic minerals), and durability (measured by the sand's ability to resist crushing at high pressures and withstand high temperatures). (See fig 1.)

Throughout this *Policy Study*, the authors may use the terms silica sand, quartz sand, and industrial sand interchangeably to refer to sand that has the chemical composition of silicon dioxide, or SiO_2, and is used for commercial purposes unless otherwise specified. The term frac sand will refer to industrial silica sand that is used specifically for hydraulic fracturing.

Industrial Sand Supply and Demand

The United States is the leading producer, and a major consumer, of silica sand in the world and is self-sufficient in this mined mineral commodity. Every state produces industrial sand and gravel for aggregate and construction purposes.[9] Unlike other minerals and commodities, the USGS does not have specific reserve estimates for sand and gravel for construction and industrial purposes because these resources are so abundant that accurate reserve numbers are

[9] Minerals Education Coalition, "Sand and Gravel," 2013, http://www.mineralseducationcoalition.org/minerals/sand-and-gravel.

difficult to calculate. Development of these reserves is largely influenced by land use and environmental considerations, not a limit of supply.[10]

Although deposits of industrial sand and gravel are widespread throughout the country and all states mine these resources in some capacity for construction and aggregate, sand deposits in certain states are better-suited for more specialized industrial purposes, such as glassmaking and hydraulic fracturing. As mentioned previously, much of the nation's industrial sand is mined in the Upper Midwest. Many of these industrial sand mines are located in or near an area commonly referred to as "the Driftless Area."

The Driftless Area is a region spanning 10 million acres, twice the size of Massachusetts, in central and western Wisconsin, southeastern Minnesota, northeastern Iowa, and northwestern Illinois.[11,12] It is called the Driftless Area because it was not covered by glaciers during the last glaciation, 10,000 to 12,000 years ago (see fig. 2). Because this region was never glaciated, many of the most-desirable sandstone formations for industrial sand production are near the surface with minimal overburden. Consequently, mining in these areas is more cost-effective than in areas where sandstone formations are buried underneath deep deposits of glacial sediment that would have to be removed prior to mining.

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[10] U.S. Geological Survey, Mineral Commodity Summaries 2014, February 28, 2014, http://minerals.usgs.gov/minerals/pubs/mcs/2014/mcs2014.pdf.

[11] Rodney Jacobs and Robert Wray, "Managing Oak in the Driftless Area," University of Minnesota Extension, 2013, http://www.extension.umn.edu/environment/trees-woodlands/managing-oak-in-the-driftless-area/.

[12] Statemaster.com, "Geography Statistics, Land Acreage," accessed February 28, 2015, http://www.statemaster.com/graph/geo_lan_acr_tot-geography-land-acreage-total.

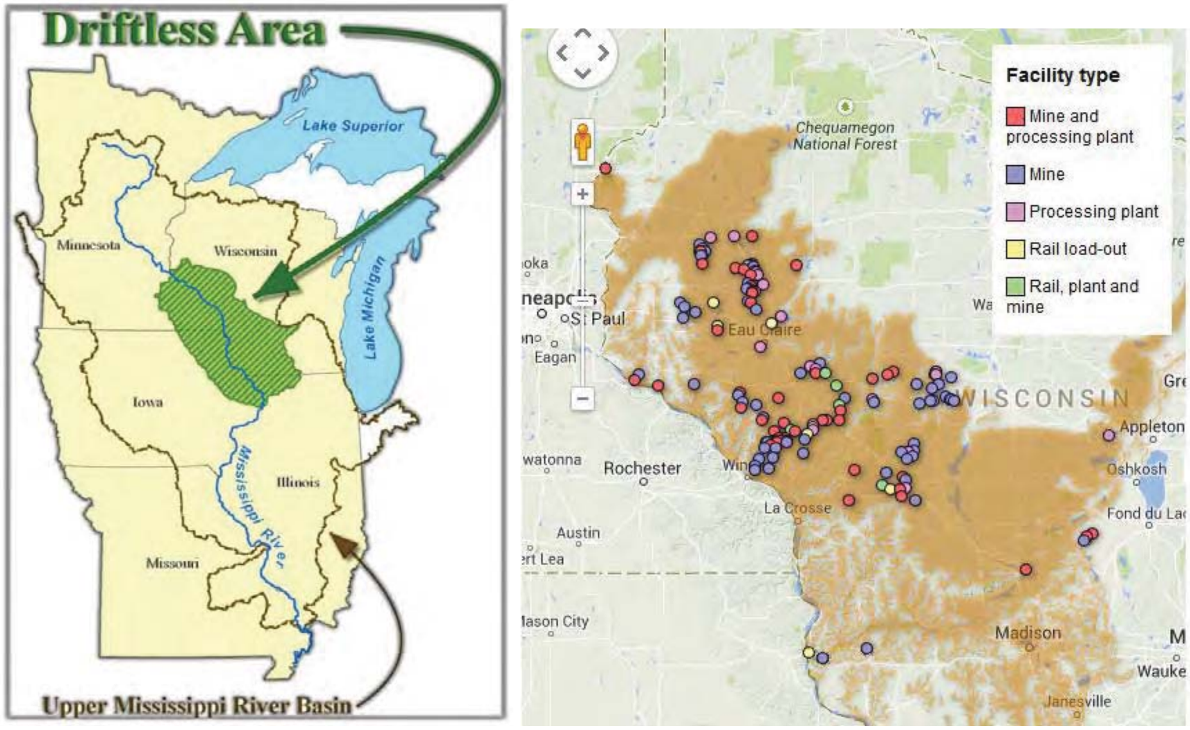

Figure 2. Left: The Driftless Area is an area of the country that was not covered by glaciers during the last ice age.[13]
Right: A map of industrial sand mining facilities in the state of Wisconsin. Many of the mining facilities are located in the Driftless Area of the state, as these sandstone deposits were not covered by glacial sediment during the last ice age and are near the surface. Figure from the Wisconsin Center for Investigative Journalism.[14]

This region is experiencing rapid growth in industrial sand mining because it is home to some of the highest-quality deposits of silica sand for hydraulic fracturing. This sand, referred to as "Northern White" by oil and gas operators because it comes from northern states and has a white color, derives from four major sandstone formations, the Jordan, Wonewoc, St. Peter, and Mt. Simon.

Another type of silica sand used for fracking in certain areas of the country is found in Texas, and other southern states, and is referred to as Brady Brown. This sand is generally of lower quality than the Northern White found in the Upper Midwest, as it is less resistant to crushing under high pressures; however, the Brady Brown is well-suited for lower-pressure hydraulic fracturing needs in the southern states. As such, it is less expensive, as it is close to market and

[13] American Forest Foundation, "Wisconsin's Driftless Area: Landscape-Scale Conservation, One Landowner at a Time," AFF E-Newsletter, Spring 2012, https://www.forestfoundation.org/wisconsin-driftless-area-spring-2012.

[14] Wisconsin Center for Investigative Journalism, Project: Wisconsin's Sand Rush, May 2014, accessed February 28, 2015, http://wisconsinwatch.org/series/frac-sand/.

approximately two-thirds of the cost of frac sand paid by energy producers comes from transporting it to the oil or gas fields.

Because the Upper Midwest has vast deposits of industrial-quality silica sand, supply is not likely to be limited by a physical shortage. However, government policies at the state and local level can affect the available supply through local zoning policies. According to USGS, local shortages of industrial sand and gravel are expected to increase owing to local zoning regulations and land development alternatives, as these zoning factors impede the ongoing development and permitting of operations producing hydraulic fracturing sand.[15] Local zoning regulations can include limits on production, town- and county-wide bans, and moratoriums similar to those enacted in municipalities and counties in Wisconsin, Minnesota, Illinois, and Iowa.

Laws in many states consider nonmetallic mining a local land use issue, so county and local governments will continue to play important roles in siting and permitting silica-sand mines.

Industrial Sand Mining and Processing

As noted earlier, industrial sand and gravel mining has occurred in the United States for more than a century. According to the USGS, in almost all cases silica mining uses open pit or dredging mining methods with standard mining equipment. Except for temporarily disturbing the immediate area while mining operations are active, sand and gravel mining usually has limited environmental impact.[16]

The first step in constructing an industrial-sand mine is to remove any vegetation, topsoil, and other noneconomic soil or rock, often referred to as “overburden,” from the mining site. Vegetation, such as trees and woody shrubs, is typically fed into a wood chipper, the byproducts of which are stored on-site to decompose into mulch, which is the mixed with the topsoil and any fill material used to reclaim the mining site to restore organic matter to the soil after mining activity has ended.

The topsoil removed from the mining area is typically used to construct earthen berms which are seeded with vegetation to create a visual barrier and make the mining process more aesthetically pleasing while preserving topsoil by preventing wind and water erosion. Mining opponents often describe this process as “strip mining.” Although this characterization is technically accurate because vegetation and overburden are removed so industrial sand producers can access the silica sand deposits, the groups prefer the phrase “strip mining” because it conjures imagery of mountaintop removal and strip mining for coal.

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[15] U.S. Geological Survey, *supra* note 4.

[16] U.S. Geological Survey, “Silica Statistics and Information,” February 5, 2015, http://minerals.usgs.gov/minerals/pubs/commodity/silica/

After the vegetation and overburden are removed, mining operations begin. Industrial sand is typically found in sandstone formations, and in order to mine and process the sand, these sandstone deposits must be disaggregated, or broken apart. The disaggregation process varies based on local geological factors, mainly how well-cemented the sand grains are to one another.

Well-cemented sandstones have sand grains that are more “stuck together,” making them harder to break apart. As a result, these sandstone formations may require blasting to break up the sand grains and crushing during the processing phase to achieve disaggregation. Loosely cemented sandstone formations are more easily disaggregated, and thus may be broken apart using heavy machinery, such as a bulldozer or large shovel, without the need for blasting or crushing.

In general, most industrial sand formations that are mined are 99 percent silica with 75 percent to 85 percent of the sand that is mined marketable, though some formations may sell 50 percent or less. Sand processing involves a physical separation of grains followed by washing, drying, and sorting of the desired grain sizes.

After blasting, the sand may be hydraulically mined and pumped to the wet plant. Alternatively, the sand may be placed in a crusher or sent through a scalping screen to remove blocks of rock or coarse sand, after which the sand will fall into a hopper where it is mixed with water and hydraulically pumped as a slurry to the wet plant. The wet plant separates finer silt material from the sand and cleans the sand grains. Equipment in the wet plant may include scalping screens to remove oversized materials, attrition scrubbing to loosen and remove certain coatings from sand grains, hydrosizers and hydrocyclones to separate the fine and coarse materials, and dewatering screens or vacuum belts.

Hydrosizers remove fine sand and silt and separate the medium and coarse sand into concentrates by utilizing an upward flow of water. The attrition scrubbers break up agglomerated particles and remove coating on the surface of the sand particles using a sand/water slurry.

Water from the washing process is typically pumped to a treatment system using ponds to allow fines to settle or using water-soluble polymers and a clarifying tank where fine materials settle and the clean water is returned to the plant for reuse. A portion of the water that passes through the wet plant will be used to make a slurry with the fine sands, which may be pumped back to the reclamation area where it can be used as reclamation fill. After dewatering, the sand is transferred by conveyor to a stockpile or directly to the dry plant and processed.

A wet plant may operate on a year-round basis. Water used in the wet plant is commonly recycled. Water use depends on wet plant capacity and production. For production levels of about one million tons per year, an estimated 250 to 500 gallons per minute of makeup water may be required to replace water lost to the product and tailings. Make-up water is obtained from quarry dewatering or high-capacity wells.

The dry plant includes a rotary drum dryer or fluidized bed dryer system and a series of screens to produce the necessary gradations of marketable sand product. Finished product is conveyed to a series of storage silos. The storage silos use conveyor belts to transport sand to the truck and railcar load-out, where the finished product is transferred into covered trucks and railcars for shipment to market. The dry plants are equipped with state-of-the-art pollution control equipment. Natural gas or propane is used as fuel for the dryer.

Industrial Sand and Hydraulic Fracturing

Demand for industrial sand has grown exponentially in the last several years due to the demand for highly specialized sand required for hydraulic fracturing, also known as "fracking." Frac sand, used to increase the recovery rates of oil and natural gas wells, has become the largest segment of the industrial sand market, overtaking glassmaking and sand for foundries (see fig. 3). Hydraulic fracturing was first conducted in 1947, and USGS data indicate sand has been commonly used as a proppant for hydraulic fracturing since the early 1950s, as sand has been used in 99 percent of hydraulic fracturing treatments and has become increasingly important for oil and natural gas production in recent years.[17]

Because the combination of hydraulic fracturing and horizontal drilling technology, and its wide-scale application, is a relatively recent phenomenon, it is beneficial for the reader to have a general understanding of how hydraulic fracturing works and the important role of industrial sand in the process. Understanding this relationship is especially important because some of the opposition to industrial sand mining stems from environmental groups attempting to prevent industrial sand mine development because they are ideologically opposed to using hydraulic

[17] Tanya J. Gallegos and Brian A. Varela, "Trends in Hydraulic Fracturing Distributions and Treatment Fluids, Additives, Proppants, and Water Volumes Applied to Wells Drilled in the United States from 1947 Through 2010—Data Analysis and Comparison to the Literature," U.S. Geological Survey Scientific Investigations Report 2014-5131, http://pubs.usgs.gov/sir/2014/5131/pdf/sir2014-5131.pdf#.

fracturing to increase production of domestic oil and natural gas reserves.

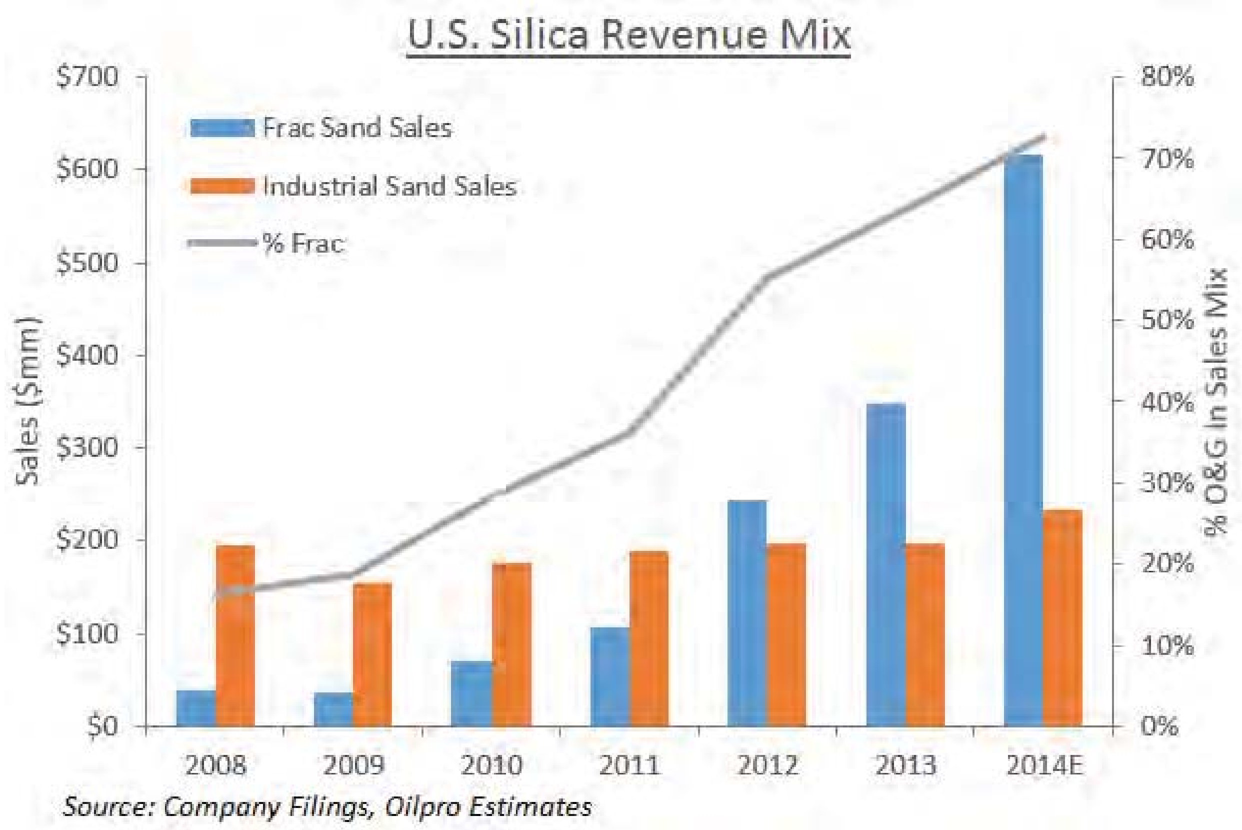

Figure 3 caption: This figure shows the rapid pace of change in the end markets served by U.S. Silica (SLCA), a leading sand miner and distributor with more than a century of operating history in the mining trade. Frac sand sales are skyrocketing, while industrial sales have stayed roughly the same. In 2008, frac sand sales were about 16 percent of U.S. Silica's business. Today, frac sand comprises about 75 percent of the firm's business.[18]

Hydraulic fracturing is the process of breaking up low-permeability oil- and gas-rich source rocks, such as shale and tight carbonate and sandstone formations, enabling the oil and gas to flow freely toward the well. It is accomplished by injecting a mixture of water, silica sand, and chemical additives at pressures of 10,000 to 15,000 pounds per square inch (psi) into wells drilled in the source rocks thousands of feet below the surface, to create small fractures in the rocks (see fig. 4).[19]

[18] Joseph Triepke, "2014 Is The Year Of Sand In US Shale Plays [Analysis & Slides]," *Oilpro.com*, September 2014, http://oilpro.com/post/5981/1-trillion-grains-per-well-sand-shale-ultimate-consumable.

[19] "Fracking," Marcellus Shale, http://www.marcellus-shale.us/fracking.htm.

Figure 4

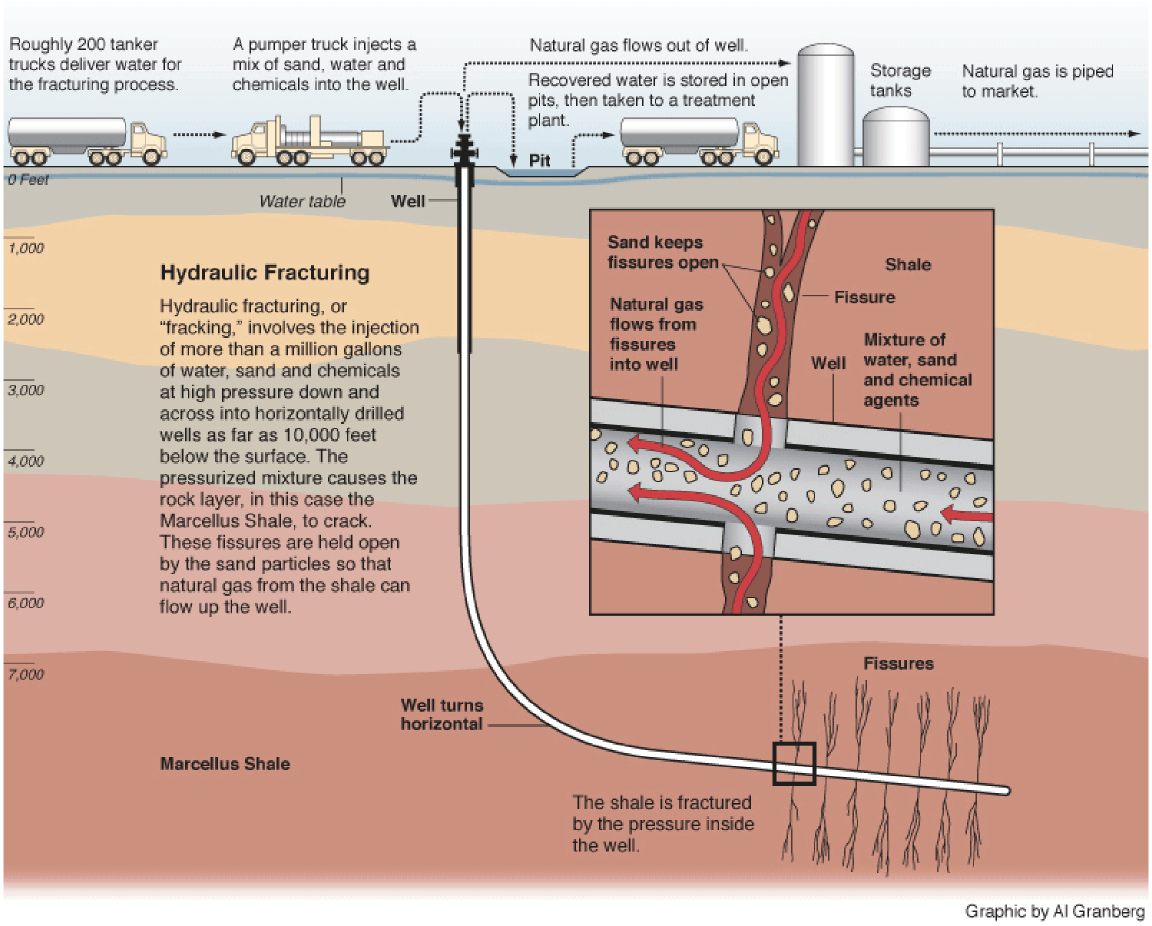

Figure 4. Hydraulic fracturing occurs thousands of feet below the surface of the earth, where water, frac sand, and chemical additives are used to create tiny fissures in shale formations, allowing the oil and natural gas trapped within them to flow up to the well. Despite claims to the contrary, peer-reviewed scientific research from universities and the federal government have found hydraulic fracturing does not contaminate groundwater.[20,21]

These high pressures are produced by a fleet of trucks on the surface pumping the mixture of water, sand, and chemical additives— collectively referred to as "fracking fluid"—into the wellbore to increase the fluid pressure within until it is high enough to exceed the breaking points of the oil- and gas-bearing source rocks. When their breaking point is reached, the rocks

[20] Samuel Flewelling and Manu Sharma, "Constraints on Upward Migration of Hydraulic Fracturing Fluid and Brine," *Groundwater*, Volume 52, Issue 1, July 29, 2013, http://onlinelibrary.wiley.com/doi/10.1111/gwat.12095/pdf.

[21] Thomas Darrah *et. al.*, "Noble Gases Identify the Mechanisms of Fugitive Gas Contamination in Drinking-Water Wells Overlying the Marcellus and Barnett Shales," *Proceedings of the National Academy of Sciences,* Volume 111, Number 39, September 15, 2014, http://www.pnas.org/content/111/39/14076.abstract.

fracture suddenly, and water rapidly rushes into the fractures, expanding and extending them deeper into the rock.[22] Each hydraulically fractured well uses between 2,500 and 10,000 tons of sand, and the sudden surge of water from the fracturing of the rocks carries billions of sand grains into the fractures.[23]

When the pumps are turned off, the fracking fluid flows back up to the surface, and the fractures deflate, much like letting the air out of a balloon. The fractures do not close completely, because the billions of sand grains wedged between the cracks serve to "prop" them open, which is why frac sand is referred to as a proppant in the oil and gas industry. These new fractures in the rock, propped open by the durable silica sand grains, form a network of pore space that allows petroleum fluids and gas to flow out of the rock and into the well (see fig. 5).[24]

Figure 5. Resource Flow Through Proppant

Figure 5. Proppant prevents the fissures created during the fracking process from collapsing and allows oil and gas to flow freely to the well. Source: Image modified from momentivefracline.com.

To optimize the flow of oil and natural gas through the fracture system, specific physical properties are necessary for frac sand that are not necessarily required for other industrial purposes, such as glass, bedding for livestock, or cores for foundries. Frac sand grains must be a particular size (typically between 8 and 140 mesh) and shape (the sand grains are well-rounded,

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[22] Hobart King, "What Is Frac Sand?" Geology.com, Accessed March 1, 2015, http://geology.com/articles/frac-sand/.

[23] Mike Ivey, "DNR Reports No Slowing In Wisconsin Frac Sand Mining Despite Oil Slump," *The Capitol Times,* January 11, 2015, http://host.madison.com/news/local/writers/mike_ivey/dnr-reports-no-slowing-in-wisconsin-frac-sand-mining-despite/article_99ed073f-6d8d-599d-9771-57688e1e76c9.html.

[24] Hobart King, *supra* note 22.

almost spherical), well-sorted (the sand grains are generally the same size), and durable (able to withstand compressive stresses of 4,000 to more than 10,000 psi).[25]

The size of the grains is important because frac sand must be small enough to fit into the fissures but large enough to optimize recovery rates. Shape is important because rounder grains have a higher hydraulic conductivity and durability than angular grains. Frac sand grains must be well-sorted (generally all the same size) to create as much connected space (porosity and permeability) between the sand grains as possible for the oil and natural gas to flow through (see fig. 6).

Finally, durability, or the strength of the frac sand, is important because sand lacking the proper strength will shatter into smaller particles in the high-stress environment of the shale formation thousands of feet below the surface. When the grains shatter, they produce fine particles, plugging the pose spaces and reducing the ability of oil and natural gas to flow through the well, creating a problem similar to having poorly sorted frac sand.

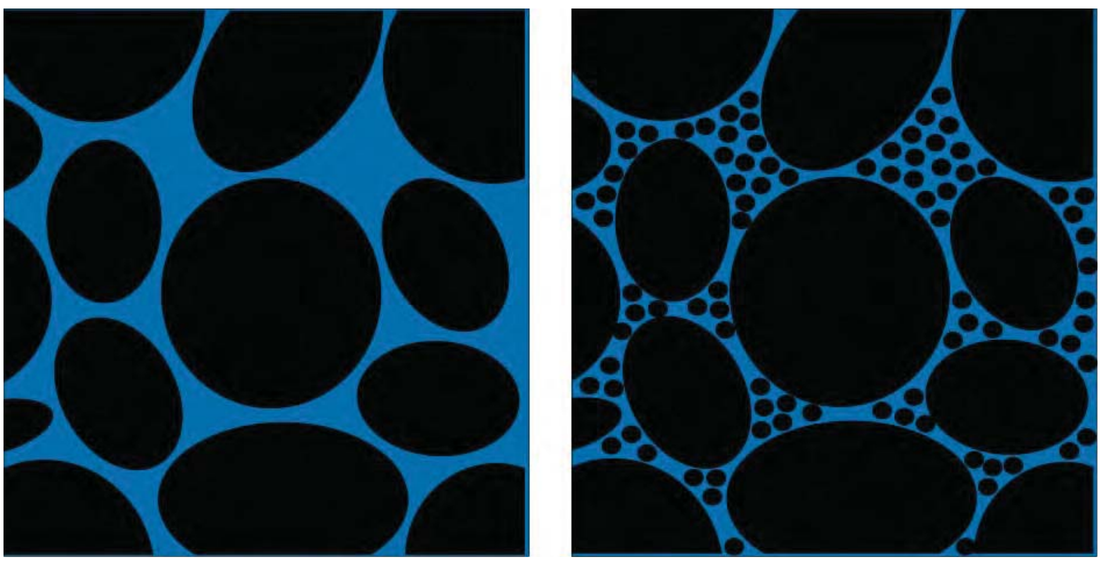

Figure 6. Left:Well-sorted industrial sand maximizes pore space, which in turn maximizes the ability of oil and natural gas to flow through the well. Right: Poorly sorted sand will have fine particles between the larger sand grains desired for hydraulic fracturing. These fine particles obstruct the pathways through which oil and gas flow to the well, reducing flow rates and well efficiency.

As recently as a few years ago, fracking fluid was 90 percent water, 9.5 percent silica sand, and 0.49 percent chemical additives, but frac sand can now compose up to 20 percent of the fracking fluid, as oil and gas producers have discovered using more sand results in higher oil and natural gas yields. As a result, it is estimated demand has been growing at a compound annual growth

[25] Horiba Scientific, "Frac Sand and Proppant Applications," accessed March 1, 2015, http://www.horiba.com/scientific/products/particle-characterization/applications/frac-sand/.

rate of 30 percent per year since the early 2000s.[26] In September 2014, PacWest Consulting Partners estimated demand for frac sand would again grow by 30 percent in the coming year; oil prices have since fallen substantially, however, causing the consulting firm to revise its 2015 estimates, now estimating an 8 percent decline in demand for frac sand.[27]

Ceramics

In addition to frac sand, oil and natural gas producers use ceramic proppants in the hydraulic fracturing process. These ceramics are made from a type of clay known as bauxite, which is mined and processed into small, ceramic beads. Ceramic proppants provide certain advantages over sand, as they are stronger, withstand greater pressures without breaking, and are more uniform in shape and size. Ceramics are more expensive, however, often costing two to three times as much as silica sand.

As a result of these cost differences, producers have overwhelmingly chosen frac sand as proppant source. USGS reports show sand has been the most common proppant for hydraulic fracturing since proppants became widely used in the 1950s. In fact, less than 1 percent of the records in the datasets indicate the use of ceramics, resin-coated ceramics, resin-coated sand, and bauxite.[28]

Sand satisfies the vast majority of hydraulic fracturing needs; thus ceramics, although physically superior, are not worth the cost at current sand prices and hence have limited application. Additionally, the bauxite used to make ceramics must also be mined, which brings up similar permitting, social, economic, and environmental concerns.

Although opposition to industrial silica sand development comes in many forms for a wide variety of reasons, certain groups are motivated by a belief they can prevent or inhibit hydraulic fracturing by limiting the supply of frac sand by enacting local moratoriums and bans on silica-sand mining.

However, proppants account for only a small portion of the total cost of fracking an oil or natural gas well (approximately 7 to 28 percent), meaning most drilling operations would be able to pay the higher costs of using ceramics instead of frac sand. Therefore, forcing oil and gas producers to switch from silica sand to ceramic proppants is unlikely to bring an end to hydraulic fracturing.

Long-Term Demand for Frac Sand

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[26] Joseph Triepke, "2014 Is The Year Of Sand In US Shale Plays [Analysis & Slides]," *Oilpro.com*, September 2014, http://oilpro.com/post/5981/1-trillion-grains-per-well-sand-shale-ultimate-consumable.
[27] Tanya J. Gallegos and Brian A. Varela, *supra* note 17.
[28] *Ibid.*

Several factors suggest there will be strong long-term demand for industrial silica sand for hydraulic fracturing. Among the key factors are gains in drilling and production efficiencies, as these enable producers to continue to increase production when prices fall, increasing demand for natural gas for electricity generation, and liquefied natural gas (LNG) exports.

Techniques such as longer well laterals (the distance the well is drilled horizontally underground), multi-well drilling pads, and closer well spacing practices have enabled energy producers to spend less capital on oil and natural gas production. Additionally, producers have discovered increasing the amount of frac sand pumped into the rock formations has resulted in greater recovery rates, increasing profitability for both oil and gas operators and silica sand suppliers.

Although oil prices have recently become volatile, due in part to the decision of the Organization of Petroleum Exporting Countries (OPEC) to continue maintaining production and market share, natural gas prices have not experienced the same volatility, because natural gas, unlike oil, is not easily transported, as natural gas must either be compressed or liquefied to be bought and sold over great distances. Therefore, domestic demand must be met by domestic supply, and as a result, increased demand for natural gas may increase demand for frac sand.

In some ways, shale gas producers have become victims of their own success, as natural gas prices have remained consistently low since hydraulic fracturing and horizontal drilling achieved their first major commercial success in 2008 in the Barnett shale of Texas (see fig. 7). Despite these low prices, natural gas production from shale plays has increased dramatically in recent years, largely due to the gains in drilling efficiencies mentioned above (see fig. 8).

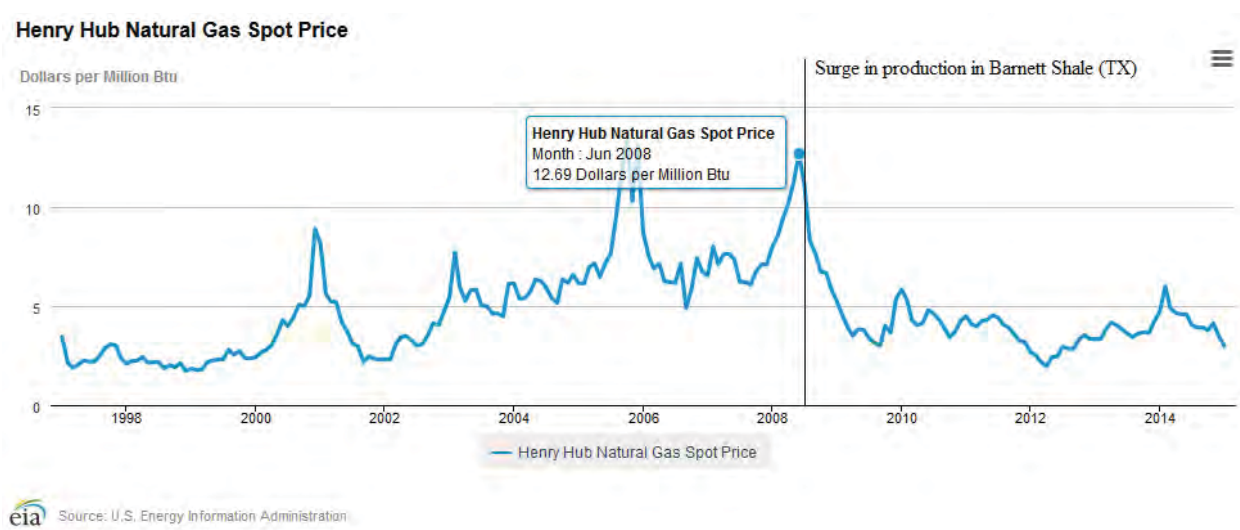

Figure 7. A modified figure from the Energy Information Administration demonstrates natural gas prices have been consistently low since hydraulic fracturing became commercially viable in the Barnett Shale in Texas.

Despite these low prices, natural gas production from shale formations has increased dramatically, as gains in efficiency have made it profitable for energy companies to produce more gas at lower prices.[29]

Approximately 40 percent of the natural gas currently produced in the United States results from hydraulic fracturing in shale or tight sandstone formations. The Energy Information Administration (EIA) estimates shale gas will account for 53 percent of all the natural gas produced in the United States by 2040, to meet growing consumer and industrial demand for gas and to make up for declines in conventional gas fields.[30]

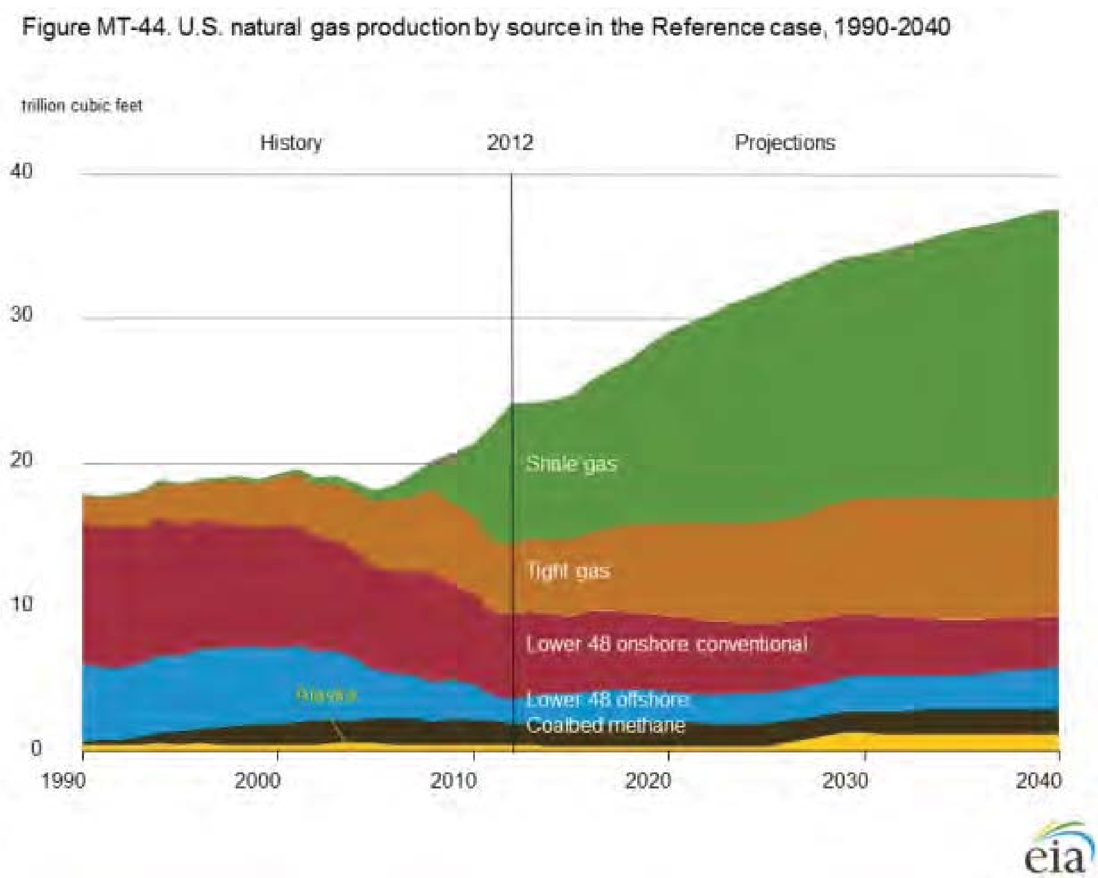

Figure 8. Energy Information Administration data indicate shale gas will become increasingly important as a share of total natural gas supply, with production from conventional wells becoming less significant over time. This obviously has important implications for frac sand demand and growth.

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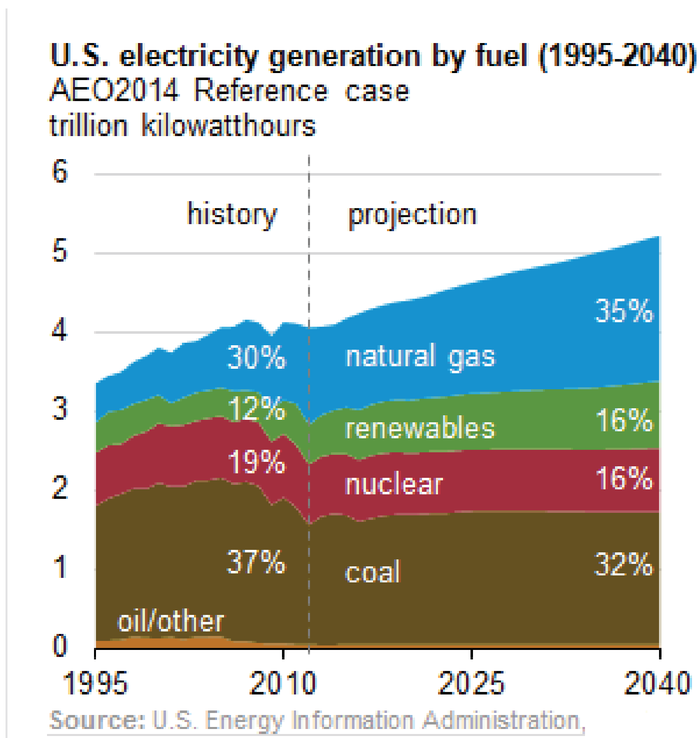
[29] Energy Information Administration, "Henry Hub Natural Gas Spot Prices," accessed March 12, 2015, http://www.eia.gov/dnav/ng/hist/rngwhhdM.htm.

[30] Energy Information Administration, "Market Trends: Natural Gas," Annual Energy Outlook 2014, http://www.eia.gov/forecasts/aeo/mt_naturalgas.cfm.

The Energy Information Administration predicts natural gas will become increasingly important as a source of fuel for generating electricity in the coming decades, accounting for 35 percent of U.S. electricity generation by 2040 (see fig. 9).[31] As conventional sources of natural gas become less productive and total energy demand increases, use of hydraulic fracturing to produce natural gas will become increasingly important in meeting the nation's demand for electricity.

Government regulations could also increase demand for shale gas. If proposed Environmental Protection Agency (EPA) Rules known as the Clean Power Plan are enacted, existing power plants will be required to reduce their carbon dioxide emissions by 30 percent from year-2005 base levels by 2030. These emissions cuts will largely be achieved by retiring coal-burning power plants and replacing their generation capacity with natural gas. These regulations are estimated to cost between $41 billion and $73 billion per year, raise electricity prices for consumers by double digit percentage points in 43 states, reduce the diversity of the fuel supply for electricity (which could increase the risk of brownouts or blackouts), and further drive up demand for natural gas, increasing the need for shale gas and the frac sand used to produce it.[32]



[31] *Ibid*.

[32] NERA Economic Consulting, "Potential Energy Impacts of the EPA Proposed Clean Power Plan," October 16, 2014, http://americaspower.org/sites/default/files/NERA_CPP%20Report_Final_Oct%202014.pdf.

Figure 9. The U.S. Energy Information Administration predicts natural gas will supplant coal as the most important fuel for electricity generation by 2040. As conventional sources of natural gas become less productive, the demand for natural gas will have to be met with increasing amounts produced using hydraulic fracturing. As a result, demand for frac sand is likely to remain significant.

Finally, demand for shale gas will also be driven by natural gas exports, as the first export terminals are scheduled to begin exporting gas in late 2015, with the U.S. Department of Energy having fully approved five export facilities and 28 others are awaiting decisions.[33] Additional natural gas export terminals are currently in the permitting phase. When these terminals come on line, the United States will become one of the most important exporters on the liquefied natural gas market.[34] According to *Bloomberg Business*, Cheniere Energy claims it will be the largest buyer of U.S. natural gas by 2020, with its liquefaction plant in Louisiana and another planned for Texas allowing it to ship approximately 6 percent of all the gas produced in the United States. As countries in Europe and Asia import increasing volumes of LNG, there will be expanded opportunities for frac sand producers as natural gas producers tap shale formations for export markets.

Increasing demand for natural gas will keep demand for frac sand high, and a recovery in oil prices could bring a further dramatic increase in demand for frac sand, as oil producers have continued to drill wells but have decided not to fracture them. Should OPEC reduce production (at present Saudi Arabia seems determined to maintain market share) or should instability affect major oil-producing countries such as Libya, Russia, and Venezuela, the resulting price increases could make fracturing of some of these wells economically viable. All these factors suggest demand for frac sand will likely be strong in the years to come.

Part 2 Environmental Impacts

The benefits of industrial silica sand mining are realized in economic terms, whereas the costs are merely theorized in the form of potential environmental impacts. Although there are more than 2,500 sand and gravel pits in Wisconsin, and probably several thousand more throughout the Upper Midwest, the prospect of large-scale silica sand mining has evoked fears about air and water pollution.[35] These fears have led several counties in Illinois, Iowa, Minnesota, and Wisconsin to enact moratoriums on permitting new sand mines, some of which are still active, whereas others have expired.

[33] Tim Puko, "Funding Dries Up for New U.S. Gas Export Terminals," *The Wall Street Journal,* February 17, 2015, http://blogs.wsj.com/moneybeat/2015/02/17/funding-dries-up-for-new-u-s-gas-export-terminals/.

[34] Zain Shauk, "U.S. Natural Gas Exports Will Fire Up in 2015," *Bloomberg Business,* November 06, 2014, http://www.bloomberg.com/bw/articles/2014-11-06/u-dot-s-dot-natural-gas-exports-will-fire-up-in-2015.

[35] Wisconsin Department of Transportation, "Non-Metallic Minerals Commodity Profile," WisDOT Multimodal Freight Network 2012, accessed March 9, 2015, http://www.dot.wisconsin.gov/business/freight/docs/profile-nonmetallic.pdf.

The potential for environmental damage is a legitimate concern, yet it must be viewed realistically and in terms of cost-benefit analysis, not merely in absolute terms. Among the key areas of environmental concern are air quality (especially as it pertains to the lung disease silicosis), groundwater depletion, contamination of surface waters and groundwater aquifers, and any potential long-term land damage, especially on land previously used for agriculture.

This study assesses each of these impacts and determines government can take reasonable measures well short of moratoria and bans to mitigate environmental damage and protect the public health while allowing the responsible development of industrial silica sand mining resources.

Air Quality

Air quality has been one of the most widely cited environmental concerns regarding industrial sand mining, especially as it pertains to particles of crystalline silica small enough to be inhaled (particles measuring below 10 micrometers in diameter), because prolonged exposure to these particles, also known as respirable crystalline silica (RCS), can cause silicosis, a preventable but potentially fatal lung disease, in occupational settings.[36]

Silicosis is an inflammation of the lung and other respiratory tissues which eventually causes fibrosis, the hardening of the lungs, reducing the ability to breathe efficiently. Symptoms include shortness of breath while exercising, fever, fatigue, and loss of appetite. Silicosis also renders the victim more susceptible to infection and diseases such as tuberculosis and lung cancer.[37]

The American Lung Association reports the silicosis death rate in the United States is generally low (between 1996 and 2005, the age-adjusted death rate due to silicosis was 0.8 per million population) but still too high, considering deaths caused by occupational exposure can be prevented by complying with safety procedures and preventative measures outlined by the Mine Safety and Health Administration (MSHA) and the Occupational Safety Administration (OSHA). [38,39]

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[36] Carson Thomas and Timothy Kelley, "A Brief Review of Silicosis in the United States," *Environmental Health Insights* 2010:4 21–26, May 18, 2010, http://www.ncbi.nlm.nih.gov/pmc/articles/PMC2879610/.

[37] Occupational Safety & Health Administration, "Silica and Silicosis," accessed March 10, 2015, https://www.osha.gov/dsg/etools/silica/silicosis/silicosis.html.

[38] American Lung Association, "Occupational Lung Disease," State of Lung Disease in Diverse Communities 2010, http://www.lung.org/assets/documents/publications/solddc-chapters/occupational.pdf.

[39] National Institute for Occupational Safety and Health, "A Guide to Working Safely with Silica," Mine Safety and Hazards Administration," accessed March 10, 2015, http://www.msha.gov/S&HINFO/SILICO/SILICAX.pdf.

Comprehensive silicosis prevention programs include substituting less-hazardous noncrystalline silica alternatives when possible, implementing engineering controls (such as blasting cabinets, local exhaust ventilation, not using compressed air for cleaning surfaces, using water sprays to control airborne dust, and using surface wetting to prevent dust from becoming airborne when cutting, drilling, grinding, etc.), administrative and work practice controls, personal respiratory protective equipment, medical monitoring of exposed workers, and worker training.[40]

It is important to note the concentrations of dust at a typical industrial sand mining operation are far lower than what is considered an occupational health hazard. This is because the sand is often handled moist and because workers exposed to the dust are not in confined buildings near the source of the dust, where the concentrations are highest. Residences near mines typically receive more dust from gravel roads than from sand mine processes.[41]

Although silicosis is an occupational hazard for workers in industries that involve exposure to RCS, fears of a public outbreak of the disease as a result of sand mining have not been supported by the air monitoring data gathered by the Minnesota Pollution Control Agency (MPCA), the Wisconsin DNR, or the studies conducted by Dr. John Richards which have provided the most extensive dataset to date on RCS levels near sand mines and processing sites in Wisconsin.

Unfortunately, previously published reports such as *Communities at Risk* have relied on anecdotal evidence (which, as noted above, can be subject to cherry-picking of data and other biases) in their discussions of the public health risks of silicosis due to RCS associated with industrial silica sand mining, rather than science-based air monitoring evidence. This report left local citizens without objective, scientific evidence on the health risks posed by sand mining operations, causing some to become unnecessarily alarmed.

This *Policy Study* examines the best-available scientific evidence on air monitoring from Dr. John Richards and the MPCA to provide citizens and policymakers with the information needed to understand the costs and benefits of sand mining in their communities. The findings of these studies show RCS concentrations in Wisconsin and Minnesota have been within the range of normal “background levels” and far below the levels considered hazardous by the MPCA.

Air Monitoring Studies

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[40] Dr. Ki Moon Bang et al., “Silicosis Mortality Trends and New Exposures to Respirable Crystalline Silica—United States, 2001–2010,” *Morbidity and Mortality Weekly Report,* February 15, 2015, http://www.cdc.gov/mmwr/preview/mmwrhtml/mm6405a1.htm.

[41] Jim Aiken, “Exploring Environmental Impacts Related to Frac Sand Mining and Processing- Minnesota Focus,” 2012, https://www.barr.com/download/244.

In Wisconsin, mining operations with production averaging more than 2,000 tons per month are required to install and operate ambient air monitors. Facilities can apply for a variance from this requirement if they can demonstrate the general public will not be exposed to significant levels of particulate matter. Variance requests must be submitted to DNR in writing. [42]

Sand mines may be granted a waiver from conducting air monitoring because, according the Wisconsin DNR, quarries and sand mines typically have few point source emissions and modeling has shown there is little chance industrial sand mining activities would cause emissions to approach or exceed the National Ambient Air Quality Standards (NAAQS). It is important to note these models do not take into account fugitive dust emissions from non-point sources, but fugitive dust control plans are typically required.[43] Additionally, although operators may be exempted from monitoring the air around their facilities, they must still be in compliance with all Wisconsin air quality standards.

In the case of industrial sand mining in the Midwest, particulate matter (PM) has been monitored in three different sizes: PM10, which is 10 micrometers (also called “microns”) in diameter, PM4 (4 microns), and PM 2.5 (2.5 microns). PM10 is monitored by the Wisconsin DNR at various facilities throughout the state, and the DNR reports no instances in which facilities exceeded existing PM10 standards.[44] The latter categories, PM4 and PM 2.5, are of particular concern because these two particle sizes are small enough to be inhaled and could therefore be a source of RCS. Studies have been conducted investigating concentrations of PM4 crystalline silica in Wisconsin and Minnesota, which will facilitate an evidence-based discussion about the potential for a public health threat from RCS and industrial silica sand mining activity.

An air quality study conducted by Dr. John Richards of Air Control Techniques (ACT) investigated levels of PM4 particles at four separate EOG frac sand facilities (one processing plant and three mines) in Chippewa County and Barron County, Wisconsin, to ascertain whether these facilities were producing hazardous levels of PM4 particles. The study used stringent scientific sampling and analytical methods in accordance with guidelines established by the

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[42] Kristen Hart, “Air Pollution Requirements for Industrial Sand Mines,” Wisconsin Department of Natural Resources, June 8, 2012, https://s3.amazonaws.com/s3.documentcloud.org/documents/695606/wdnr-silica-regulations.pdf.

[43] Jason Truetel, “Sand Mining Monitoring in Wisconsin,” Presented at SME Wisconsin Annual Conference, October 7, 2014, http://higherlogicdownload.s3.amazonaws.com/SMENET/1b517024-bb1c-4b2c-b742-0136ce7a009c/UploadedImages/TCjointConference/Jason%20Treutel%20-%20Ambient%20Air%20Monitoring%20at%20WI%20Sand%20Mines.pdf.

[44] *Ibid*.

National Institute for Occupational Safety and Health (NIOSH).[45] The study also modified existing USEPA methods for measuring similar small particles to account for the specific particle size being studied and analyzed for crystalline silica.

After collecting 1,176 days of sampling data, ACT found ambient air concentrations for small, PM4 crystalline silica particles were well within the range of background concentrations in agricultural, rural, and urban areas throughout the United States. Additionally, the PM4 crystalline silica concentrations, when detected, were less than 10 percent of the California reference exposure level of three micrograms per cubic meter ($\mu g/m^3$), meaning emissions of silica dust at these facilities were far below concentrations considered conservatively protective of human health (see fig. 10).

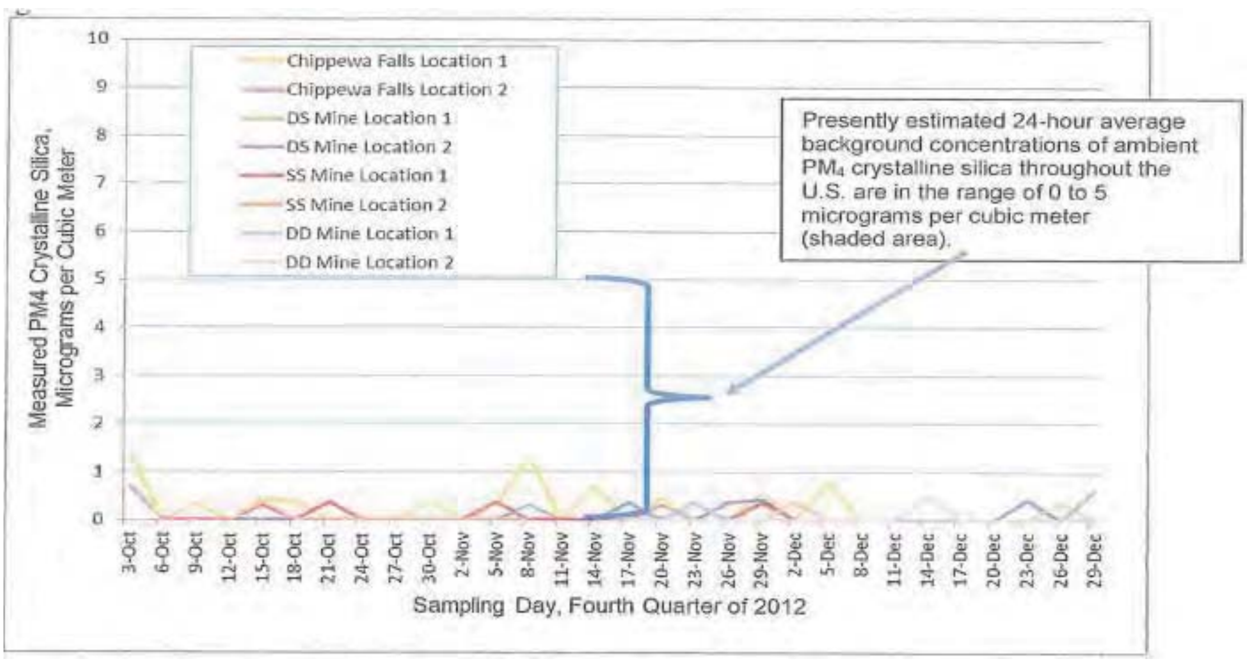
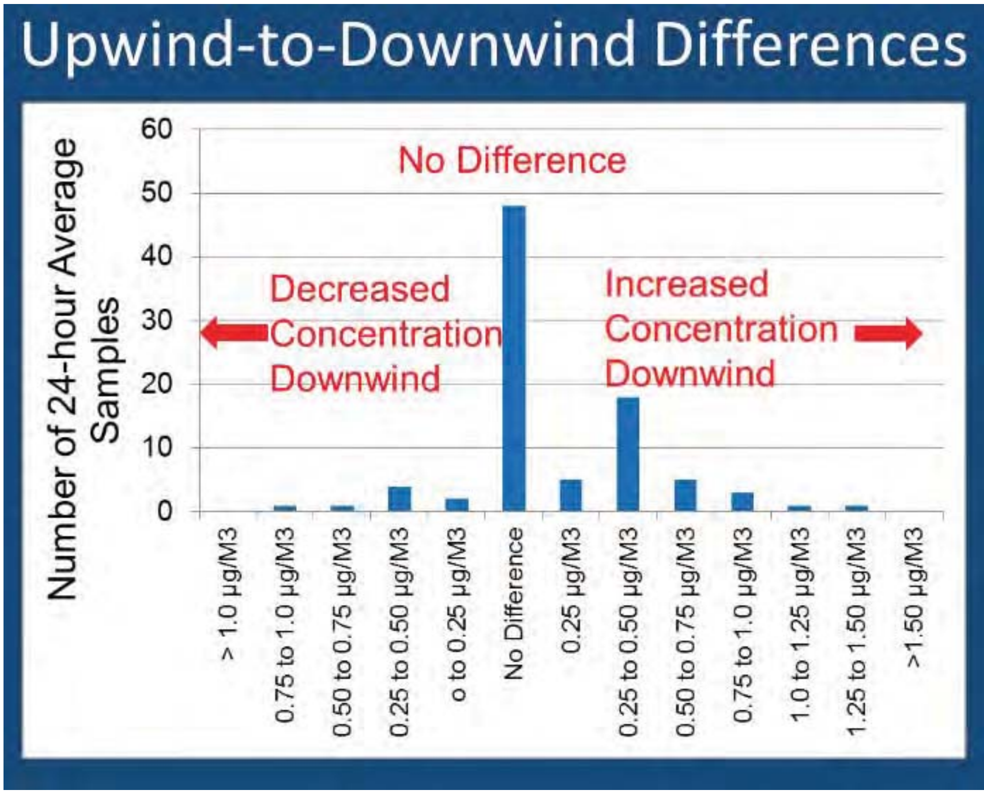


Figure 10. After conducting 1,176 days of sample data, researchers determined levels of respirable crystalline silica measuring four micrometers in diameter (PM4) were far below levels considered hazardous to human health, as PM4 levels detected were less than 10 percent of the California reference exposure level.

Another important aspect of the study is the upwind/downwind monitoring of the four facilities, which allows researchers to determine whether differing concentrations of PM4 crystalline silica at each monitor were the result of activity at the frac sand facility. In the vast majority of samples there was no observed difference in ambient crystalline silica concentrations between the upwind

[45] Dr. John Richards, "Ambient PM4 Crystalline Silica Concentrations at EOG Sand Producing Facilities in Wisconsin," *Frac Sand Mining Environmental Research Webinar, Current Status of Research Findings, pp. 85-104,* June 18, 2014, http://www.uwsp.edu/cnr-ap/clue/Documents/Mining/FracSand2014WebinarFinal.pdf.

and downwind monitors, and where concentrations did differ, the differences were extremely small and well below levels considered harmful, suggesting these industrial sand mine and processing plants are not a source of hazardous levels of respirable crystalline silica particles (see fig. 11).



[46]

Figure 11 There were no observed differences between upwind and downwind monitors in the vast majority of samples collected at four frac sand facilities throughout Barron and Chippewa Counties in Wisconsin. When differences were observed, they were extremely small, suggesting these facilities are not sources of hazardous levels of respirable crystalline silica particles.

In addition, comparison of the PM4 data collected by ACT at the eight Wisconsin locations and the PM2.5 data collected by the WDNR in Eau Claire, Wisconsin showed a consistent match across the state. These comparisons indicate regional background concentrations of ambient PM4 crystalline silica largely determined the measured concentrations regardless of the prevailing wind direction. The regional background concentrations are due to a variety of well-known sources of ambient PM4 crystalline silica, including agricultural operations, unpaved roads, construction activity, industrial sources, and the global transport of dust from the Gobi (China) and Saharan (Africa) deserts.

[46] *Ibid.*

Considering that crystalline silica comprises 12 percent of the earth's crust, any activity that disturbs rock or soil can contribute to ambient PM4 crystalline silica concentrations. Dr. John Richards, the individual leading ACT's work, summed it best when he concluded, "there is a little crystalline silica everywhere, but not a lot anywhere."

Residents of communities near frac sand sites have also raised concerns dust blowing from trucks hauling industrial sand could be a source of hazardous respirable silica particles along transportation routes. These concerns prompted authorities from the Minnesota Pollution Control Agency (MPCA) to conduct ambient air monitoring along a busy truck route in Winona, Minnesota. Using the PM4 data gathered from this monitor, the MPCA concluded dust from hauling industrial sand near the air monitoring location was not a threat to public health.

In fact, MPCA data show dust levels were so low the air monitors could not detect any at all on 94.7 percent of the days sampled over seven months. When air monitors did detect dust, it was in concentrations near 15 percent of the chronic health benchmark used by MPCA.[47] Additionally, the town of Stanton, Minnesota, selected as a reference site to compare levels of RCS with the city of Winona because Stanton does not have silica sand facilities or transportation but does have other sources of RCS such as farm fields and unpaved roads, registered more RCS than Winona.[48] The reference sampling location in Stanton confirms an MPCA belief that "Airborne silica is a fairly ubiquitous pollutant and is not unique to silica sand mining and processing facilities."

The data, which comprises about 2,000 individual samples from Wisconsin and Minnesota, indicates industrial sand operations do not generate hazardous levels of small silica particles in the ambient air near these operations, providing a positive starting point for understanding the real and perceived risks of mining, processing, and transporting industrial sand in the Upper Midwest.

Although these findings are important, they should not be surprising. The reason the sand in the Upper Midwest is sought-after for hydraulic fracturing is because it is well-rounded, has a high crush strength (meaning it is strong and resistant to fracturing), and is well-sorted. PM4 silica particles are generally created by processes that fracture silica particles into smaller pieces; the industrial sand mining process does not and cannot do that, or there would be no industrial sand

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[47] Zahra Hirji, "Trucks Hauling Frac Sand Not a Source of Lung Disease Dust, Data Shows," *Inside Climate News,* October 16, 2014, http://insideclimatenews.org/news/20141016/trucks-hauling-frac-sand-not-source-lung-disease-dust-data-shows.

[48] Minnesota Pollution Control Agency, "Air Monitoring at Minnesota Silica Sand Facilities," accessed March 10, 2015, 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#winona.

business. Doing so would be analogous to a tomato farmer smashing all the tomatoes during harvest.

Additional information will be valuable in assessing the potential public health impact of industrial sand mining, but it is important to emphasize the fears of a public outbreak of silicosis are simply not supported by the available data gathered from the recent and ongoing ambient air monitoring studies conducted at nine active and one proposed industrial sand operations in Wisconsin and two communities in Minnesota. Frac sand mining does not put the public's health at risk.

Water Quantity

Silica sand mining is often portrayed as a water-intensive industry due to the volumes of water used for washing, processing, suppressing fugitive dust, and, at some facilities, transporting sand as a slurry. The amount of water used varies greatly depending on the facility and the extent to which water is recycled, as closed-loop systems that recycle 90 percent of the water used can consume as little as 18,000 gallons per day, whereas open-loop systems can consume as much as two million gallons per day.[49]

The growth of the industrial sand industry in recent years has generated concern among some member of the public that mining and processing operations will permanently alter groundwater aquifers and water use will compete with residential, municipal, and agricultural use of groundwater and ecological systems such as springs, streams, rivers, and lakes.

However, when compared to other uses of water in Wisconsin, such as power generation, municipal public water, and agriculture, water consumption by industrial silica sand mining accounts for a very small percentage of the water used in the state. Data from the Wisconsin Department of Natural Resources (DNR) shows all nonmetal mining in the state, which includes quarry dewatering, washing sand and gravel, and industrial sand mining, accounted for just 0.71 percent of all water withdrawals in 2013 (see fig. x12).[50]

Furthermore, water consumption by industrial silica sand operations constituted just a fraction of the amount used by all nonmetallic mining operations, as water withdrawals associated with industrial sand activity used only 1.99 billion gallons of water in 2013, just 0.09 percent of the

[49] Kate Prengaman, "A sand plant by the numbers," Wisconsinwatch.org, August 19, 2012, http://wisconsinwatch.org/2012/08/a-sand-plant-by-the-numbers/.

[50] Robert Smail, "Mining and Water in Wisconsin: Water Use for Non-Metallic Mining," presentation at SME Wisconsin Annual Conference, October 7th, 2014, http://higherlogicdownload.s3.amazonaws.com/SMENET/1b517024-bb1c-4b2c-b742-0136ce7a009c/UploadedImages/TCjointConference/Robert%20Smail%20-%20Water%20Usage%20in%20Non-Metallic%20Mining.pdf.

2.121 trillion gallons consumed for all purposes throughout the state (see fig. 13). In comparison, agricultural irrigation accounted for 5 percent of total water withdrawals, using 55 times more water than industrial sand operations for mining and processing.

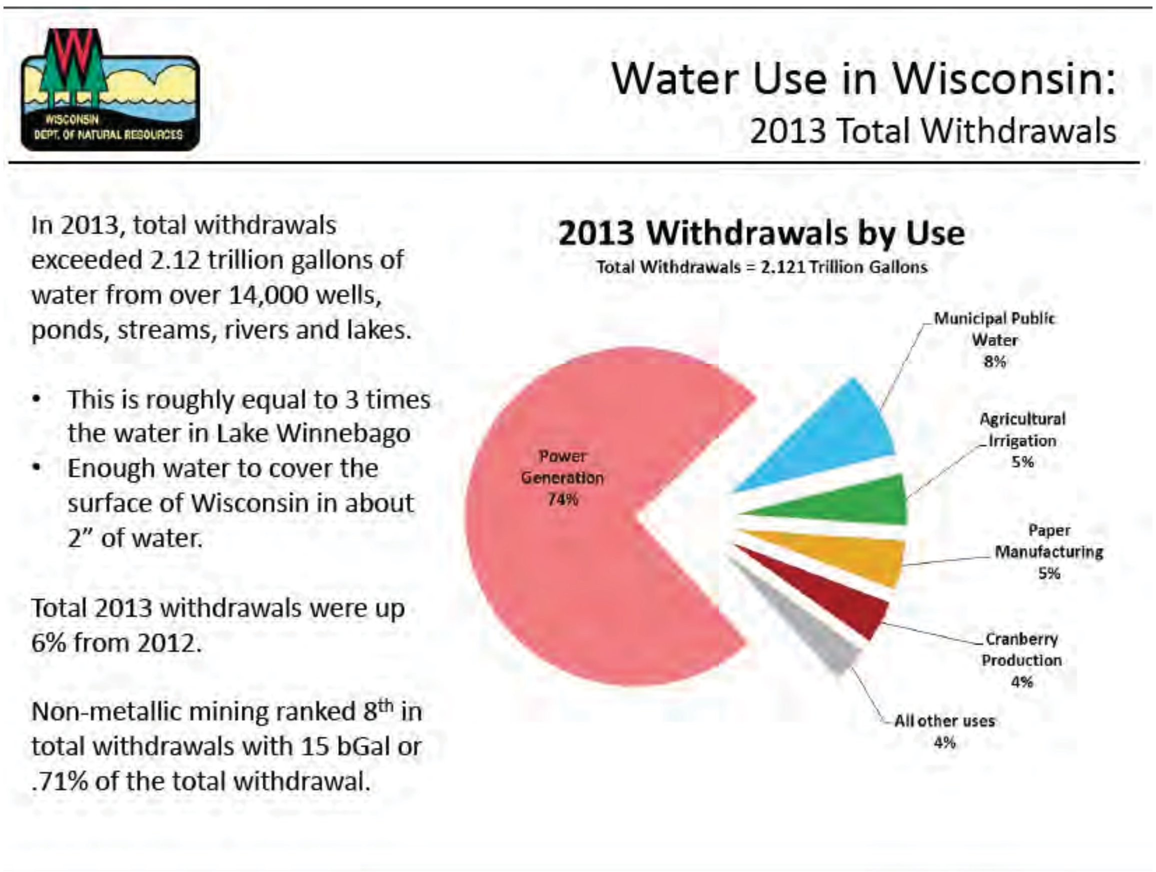
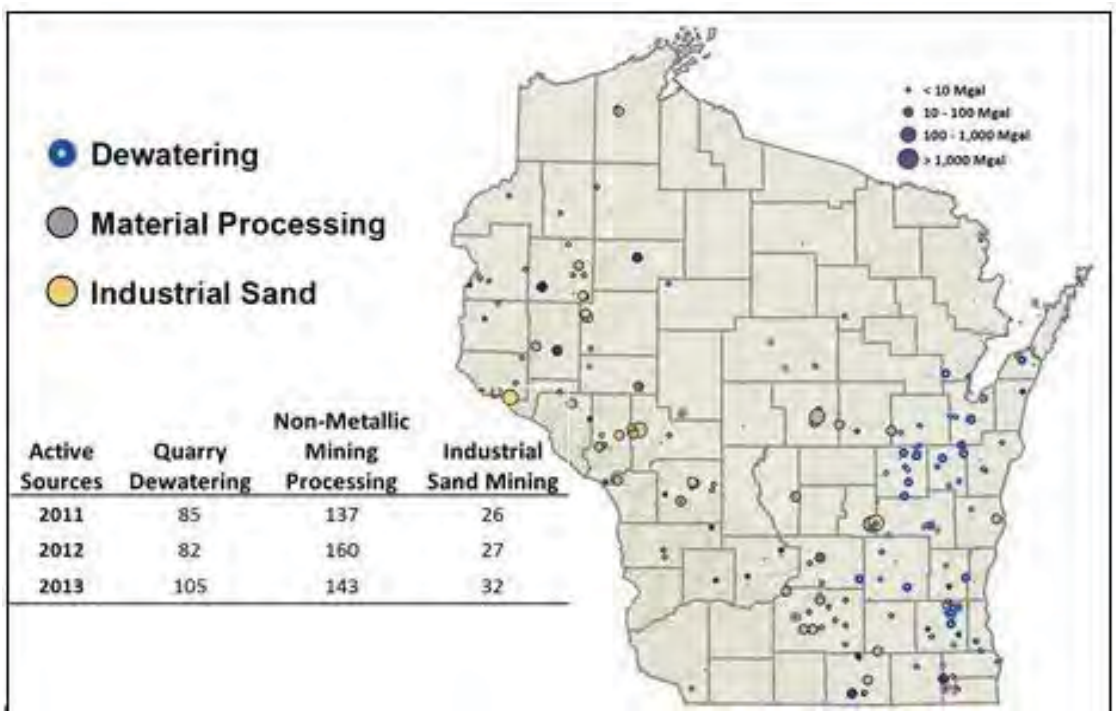


Figure 12. Total water withdrawals in the state of Wisconsin were 2.121 trillion gallons. Power generation accounted for 74 percent of this total, meaning more than 100 times as much water was used to generate electricity as all nonmetallic mining operations, which includes quarries and gravel pits in addition to industrial sand mines.

One reason industrial sand mines use so little water is the majority of plants operate closed-loop systems, which is why industrial-sand washing and processing was only the sixth-largest source of water use in the ten counties reporting presence of industrial-sand washing operations.[51] Modern, efficient closed-loop systems recycle 90 percent of the water used on site, and as a result, water consumption at sand facilities can vary between 18,000 and 250,000 gallons per day. The 10 percent of water lost in these systems results primarily from evaporation from ponds, drying moist sand, and placement of wet sand and fines (silt and clay particles) during mine reclamation.

[51] Emily Chapman *et al.,* "Communities at Risk: Frac Sand Mining in the Upper Midwest," September 2014, www.civilsocietyinstitute.org/media/pdfs/092514 CSI BAR frac sand mining report FINAL2 - EMBARGOED.pdf.

Except for relatively small amounts of water that evaporate during the mining and processing, essentially all the groundwater pumped from the aquifer is retained in the geographic basin that comprises the surface-water-groundwater aquifer system. For example, water discharged from a mine during dewatering is kept within the basin, under a permit issued by the WDNR. As a result, there is no material net loss of water from the surface-water-groundwater system.



Active Sources	Quarry Dewatering	Non-Metallic Mining Processing	Industrial Sand Mining
2011	85	137	26
2012	82	160	27
2013	105	143	32

Figure 13. Industrial sand washing, transporting, and dust suppression accounted for 0.09 percent of all water consumed in the state of Wisconsin in 2013. Because industrial sand mining accounts for such a small percentage of total water consumption in Wisconsin, by far the largest producer of industrial sand in the country, these numbers suggest industrial sand operations will not deplete water resources in other states with humid climates.

Additionally, groundwater quality and quantity are carefully considered in every stage of a mine’s existence, before permitting, while operating, and after mine closure. Groundwater experts (hydrogeologists) study the groundwater for federal, state, and local governments as well as the sand mining industry, and WDNR hydrogeologists and engineers evaluate all permits for high-capacity wells.

Sand processing operations operating high capacity wells (a well capable of pumping more than 100,000 gallons per day) must pump groundwater in accordance with a high capacity well permit from WDNR. In addition, the local mine permitting authority requires scrutiny of groundwater during development of Conditional Use Permits and reclamation plans.

Ultimately, the impact of groundwater pumping is site-specific and is based on ground surface and groundwater elevation, geology, hydrogeologic characteristics of the groundwater aquifer, proximity to surface water, and presence of other nearby groundwater users. However, the available data from Wisconsin, the largest producer of industrial sand in the nation, indicates industrial sand production accounted for just 0.09 percent of all water use in the state, demonstrating sand mining will not deplete water resources in the communities in which it occurs.

Surface-Water and Groundwater Quality

Industrial sand mines have several potential interactions with water. Surface water may be present at or near mining operations in the form of wetlands, ditches, streams, ponds, or lakes, and water from silica sand facilities may infiltrate downward and encounter groundwater. As a result, surface water and groundwater quality are two of the most commonly cited environmental concerns expressed by the general public, because they are generally the most visible.

The most obvious surface water quality impacts arise when untreated storm water or process water is discharged directly to surface water bodies through a structural failure of storm water retention ponds or wash water storage ponds. These types of negative impacts due to structural failures have occurred on more than one occasion and have resulted in the discharge of clay, silt, and fine sand into nearby waterways. Some of the affected waterways appeared cloudy for a matter of days until the fine silt and clay particles settled out of the water. Fortunately, because of the nontoxic nature of these pollutants, the impacts of these discharges were temporary.

Despite the benign and temporary nature of these incidents, Wisconsin has several environmental regulations intended to restrict mining activities to protect the state's waters. The two main regulations are the Wisconsin Pollutant Discharge Elimination System (WPDES) Storm Water Permits and the Chapter 30 and 31 Wis. Stats. waterway permits. These permits adequately address and protect surface water in the state but cannot prevent all accidents or the results of inadequate designs, construction, or procedures.

The authors of this study presume these incidents are instances of systems being improperly designed or constructed or failures to follow procedures. Whatever the case, the incidents could have been avoided by better engineering practices, and individual companies need to improve or risk the public categorizing all companies as irresponsible when it comes to industry standard of care, best management practices, and perceived concern for the environment. It may be unfair, but the general public may not view individual industrial sand mining companies in Wisconsin and Minnesota as separate independent entities, but instead as one industry, and when one company does something perceived to be negative, it affects all companies in the industry.

Although the discharge of sediment into surface waters is a form of pollution, it differs from other forms of pollution in that sand, silt, and clay particles are naturally transported by water systems on a daily basis and do not represent catastrophic events from which a stream cannot recover once the discharge has been stopped and the suspended particles have settled. In fact, these sediments are found in substantially larger proportions during and after rain events. However, despite the lack of serious long-term consequences for these discharges, the industry must achieve better compliance with surface water discharge rules.

Groundwater Pollution Concerns

Private wells are the primary source of drinking water in many rural areas, and as industrial sand mines have begun operations, local citizens have sought to understand the potential impact of these operations on the quality of their groundwater. The main concerns regarding groundwater quality are the potential for pollution from the use of polyacrylamide and acid mine runoff from operating and reclaimed sand mines. Although there have been no documented cases of contamination of groundwater aquifers or potable water supply wells from industrial sand mining operations, these concerns merit serious discussion.

A vital step in recycling water for frac-sand processing is the removal of the small clay particles from the water through the use of water-soluble polymers, one of which is polyacrylamide, a safe chemical used by most municipal drinking water and wastewater treatment facilities, to get the clay particles to “clump together” and settle out of the water faster than they would otherwise.[52] However, polyacrylamide can contain trace amounts of the chemical acrylamide, a known neurotoxin and carcinogen.

Although acrylamide is a neurotoxin, it does not present a threat to the public’s health because acrylamide degrades into carbon dioxide, ammonia, and nitrogen oxides rather quickly in the environment. In oxygen-rich soils, 74 to 94 percent of the acrylamide breaks down within 14 days. In oxygen-poor soils, 64 to 89 percent breaks down in 14 days. In river water, 10-20 ppm levels of acrylamide degrade completely in 12 days. Because horizontal groundwater flow velocities are typically on the order of centimeters per day, acrylamide will not persist long within groundwater. The rapid degradation of acrylamide greatly reduces, in fact essentially eliminates, the chances for adverse human health impacts from polyacrylamide use at industrial sand mining operations.[53]

[52] Dr. Kent Syverson, “Environmental Impacts of Sand Mining in Wisconsin,” presentation, December 2012, https://www.wicounties.org/uploads/legislative_documents/kent-syverson-wi-counties-frac-sand-commision-talk-dec-2012.pdf.

[53] Dr. Kent Syverson, “Water Resource Impacts Associated with the Sand-Mining Boom in Western Wisconsin: A Comparison Between Agricultural Activities and Sand Processing,” Geological Society of America, *Abstracts with Programs* 45:4, p. 69, May 2013, https://gsa.confex.com/gsa/2013NC/webprogram/Paper218689.html.

The water-soluble polymers used at industrial sand operations are also approved by the National Sanitation Foundation (NSF) and American National Standards Institute (ANSI) NSF/ANSI Standard 60 for treatment of drinking water. For comparative purposes, it is worth noting municipal drinking water treatment facilities add polyacrylamide directly to the drinking water; industrial sand operations add poly acrylamide to the sand wash water, which is part of the industrial sand process and not a source of drinking water.

Additionally, WDNR regulations protect surface water and groundwater by regulating storm water and surface water discharges, well drilling, and the application of materials to the land surface with the potential to impact groundwater. Any storm water or surface water discharge of industrial sand wash water is regulated by WDNR under Ch. NR 216. WDNR approves the application of products containing polymers for sediment control purposes under DNR Conservation Practice Standard 1051 to protect surface waters. WDNR has not established specific groundwater standards for polymers under Ch. NR 140, but there is minimal danger of groundwater pollution if the wash water is held in a pond, WDNR reports: "Sealed ponds will have very little potential for groundwater impacts. Unsealed ponds will likely seal themselves with the fines that are removed from the frac sand."[54]

One report on silica sand mining suggests operating and reclaimed sand mine sites could lead to acid mine drainage, but frac-sand mining does not generate acid mine drainage.[55]

The long history of nonmetallic mining and the very large number of existing nonmetallic mines in Wisconsin indicate nonmetallic mines, including industrial sand mines, do not degrade groundwater quality and quantity in Wisconsin, and thus nonmetallic mining such as industrial sand mining is compatible with the state's goal of protecting groundwater quality and quantity. Aquifers, private water supply wells, municipal wells, springs, trout streams, and exceptional and outstanding resource waters are protected through USEPA and WDNR regulations and permits, and in many instances community-oriented industrial sand mining companies enhance these efforts.

Land Reclamation

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[54] Wisconsin Department of Natural Resources, "Silica Sand Mining in Wisconsin," January 2012, p. 28, http://dnr.wi.gov/topic/Mines/documents/SilicaSandMiningFinal.pdf.

[55] Dr. Kent Syverson, *supra* note 52.

Wisconsin state law requires all nonmetallic mines be reclaimed in accordance with NR 135 Wis. Administrative Code. These rules are implemented and administered by Wisconsin counties, as the counties are required to implement a nonmetallic mining reclamation permit program in accordance with the administrative code, including adoption of an ordinance and administration of a mining reclamation program. The purpose of this program is to ensure mining sites are reclaimed to a post-mining land use, which can be agricultural, wildlife habitat, prairie, a cranberry bog, or another use the mining company and property owner agree on.

Nonmetallic mining permits are subject to uniform reclamation standards provided in NR 135 Wis. Adm. Code. These standards require the replacement of topsoil to minimize compaction and erosion, the stabilization of soil conditions and slope, establishment of vegetative cover, control of surface water flow and groundwater withdrawal, prevention of environmental pollution, and development and restoration of plant, fish, and wildlife habitat if needed to comply with an approved reclamation plan.[56]

NR 340 Wis. Adm. Code also includes mine reclamation requirements administered by WDNR which apply to a mine or portions of a mine that affect or are adjacent to navigable waterways.

Because large industrial sand mines are designed to be mined in phases (typically 30-40 acres of permitted mine are actively mined at a given time)[57] there will, in most cases, be ongoing reclamation in some areas of the mine while mining continues in others, resulting in a type of "reclaim-as-you-go" strategy.

Mine owners or operators are also required to provide the county with a bond or some other form of financial assurance as a condition of the NR 135 permit in the event an operator fails to fulfill its obligation under the reclamation plan, so the county will have sufficient funding to carry out the reclamation plan. The financial assurance must be in place before initiating mine development.

Although activists occasionally raise concerns about the quality of reclamation plans, Wisconsin administrative code ensures mines are reclaimed and vegetated to protect air quality and prevent wind erosion of the reclaimed area.

Reclaiming Farmland

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[56] N.R. 135 Nonmetallic Mining Reclamation, Wisconsin State Legislature, January 2012, http://docs.legis.wisconsin.gov/code/admin_code/nr/100/135/II/10.

[57] Dr. Kent Syverson, *supra* note 52.

Because agriculture is such a vital industry in rural communities across the Upper Midwest, there has been a considerable degree of concern about whether industrial silica sand mining will cause permanent damage to the quality of soil for agricultural purposes, such as providing pasture for livestock and growing row crops.

Studies investigating the agricultural productivity of reclaimed sand mine sites have found crop yields at reclaimed sites produced 73 to 97 percent of their original yields within three years of reclamation, suggesting silica sand mining may not cause long-term declines in farmland productivity.[58] The best yields were achieved in areas where the original topsoil was returned to the land.

Yields on reclaimed mine sites varied depending on the type of crop grown, with certain crops faring better than others. On average, corn yields achieved 73 percent of the control group productivity, average winter wheat yields were 77 percent of control, soybean yields averaged 97 percent of control group productivity, and average cotton yields were 80 percent of control, but the quality of the cotton was reduced in all the reclamation treatment scenarios.[59]

These production trends have been affirmed by other studies examining the long-term results of crop production on reclaimed sand-mine soils from 2005 to 2012. These studies proved reclaimed mine soils consistently exceed local countywide five-year average yields for all crops (corn, wheat, soybeans, and cotton) but are typically 15 to 20 percent lower than adjacent prime farmland under identical management.[60] In 2012, however, soybean yields on the reconstructed mine soils were higher than on the unmined, adjacent prime farmlands and higher than the five-year county average, for the first time.[61]

These results are of particular interest in regard to silica sand mining in the Upper Midwest because corn, soybeans, and wheat are among the major row crops planted in the region, whereas the climate is unsuitable for growing cotton.[62] Lower corn yields were attributable to low levels

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[58] W. L. Daniels, et al, "Reclamation of Prime Farmland Following Mineral Sands Mining in Virginia," SME Annual Meeting, February 25-27, 2002, http://landrehab.org/UserFiles/DataItems/5A706850676C79516461343D/Daniels%20et%20al%202002%20SME%20Reclamation%20of%20Prime%20Farmland.pdf.

[59] *Ibid.*

[60] Comparisons between reclaimed mine soils and countywide production are complicated by the fact reclaimed soils received irrigation, whereas some but not all crops throughout the county were irrigated.

[61] W. Lee Daniels and Z. W. Orndorff, "Indicators of reclamation success for mineral sands mining in the USA," 6th International Conference on Sustainable Development in the Minerals Industry, June 30, 2013- July 3, 2013, http://landrehab.org/UserFiles/DataItems/71702B51452B63547134343D/Daniels%20and%20Orndorff%20Indicators%20for%20Mineral%20Sands%202013.pdf.

[62] U.S. Census Bureau, Statistical Abstract of the United States, Agriculture, 2012, https://www.census.gov/compendia/statab/2012/tables/12s0859.pdf.

of nitrogen, which were the result of the researchers' desire to study the long-term nitrogen supply of the biosolids by not adding additional supplies of nitrogen-based fertilizer.[63]

A likely factor in the high levels of soybean production is the fact soybeans are nitrogen fixers, meaning they are able to create their own supply of nitrogen by converting nitrogen from the air into a form the plant can use.[64] Although the study did not investigate alfalfa growth on reclaimed sand-mine soils, alfalfa is also a nitrogen-fixing plant, which suggests alfalfa too may be highly productive on reclaimed soils.

Additionally, because alfalfa is a perennial plant, it develops a deeper root system than crops such as corn and soybeans. Such a root system can help prevent soil compaction, which has been recognized as a challenge for reclaiming farmland.

These findings are particularly important because soybeans are a vital component of crop rotation in the Midwest, and alfalfa is important feed for dairy cows, which are the basis of the western-Wisconsin economy.

In all of these studies, soil compaction has been recognized as a limiting factor for crop yields, as compaction can limit the extent to which roots can grow downward in the soil, thus limiting the growth of grain, particularly wheat. Chisel plowing and disking the fields, as well as growing crops with longer root systems, can be an effective way to reduce soil compaction and crusting at the surface, and can also increase water retention.

Finally, faculty and students from the University of Wisconsin River Falls are undertaking additional studies of the effectiveness of agricultural land reclamation in Chippewa County, Wisconsin. These studies will examine reclamation best practices and provide valuable information for silica sand mining companies' future reclamation efforts.

Conclusion

The United States has achieved dramatic growth in industrial silica sand mining since the technological breakthrough of hydraulic fracturing and horizontal drilling transformed once-uneconomic oil and gas deposits into profitable drilling operations. Silica sand production more than doubled between 2005 and 2014, increasing from 31 million metric tons in 2005 to more than 75 million in 2014. Sand for hydraulic fracturing, or "frac sand," now accounts for 72 percent of all industrial silica sand mined in the United States.

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[63] W. Lee Daniels and Z. W. Orndorff, *supra* note 61.

[64] University of New Mexico State University, "Nitrogen Fixation by Legumes," May, 2003, Accessed February 28, 2015, http://aces.nmsu.edu/pubs/_a/A129/.

Despite fears that industrial sand mining will generate hazardous amounts of respirable crystalline silica, studies from the Minnesota Pollution Control Agency and Air Control Techniques and other organizations have found concentrations of silica dust near frac sand facilities and transportation routes were far below levels considered hazardous to human health.

Additionally, concerns of industrial sand mining depleting groundwater and surface water resources are not supported by the data, as industrial sand operations use only a small fraction of the amount of water used for power generation and agriculture. Water quality is also unlikely to be seriously degraded by industrial sand operations, because acrylamide breaks down in aerobic environments in a short amount of time. Stormwater runoff events have temporarily reduced surface water quality with suspended particles of silt and clay, but these incidents can be mitigated by improved stormwater runoff plans.

Finally, Wisconsin N.R. Code 135 requires all nonmetallic mines to be reclaimed, and concerns that sand mining will have negative, long-term impacts on agricultural land have not been supported by scientific research. Studies have found reclaimed sand mine sites produced 73 to 97 percent of their original yields within three years of reclamation.

Industrial silica sand mining has occurred in the upper Midwest for more than a century and can be done in a safe and environmentally responsible manner. State governments and environmental protection agencies are capable of drafting reasonable rules to protect the environment while allowing for the responsible development of silica sand resources.

About the Authors

Isaac Orr

Isaac Orr is a research fellow at The Heartland Institute. He previously worked as a research analyst and writer in the office of Wisconsin State Senator Frank Lasee, and prior to that interned with the Rancher’s Cattleman Action Legal Fund. He graduated in 2010 with honors from the University of Wisconsin-Eau Claire, with a B.A. in political science and a minor in geology.

He is the author of a Heartland Institute Policy Brief, “Hydraulic Fracturing: A Game-Changer for Energy and Economies” (November 2013), and his letters to the editor and op-eds have been published in *USA Today*, *The Houston Chronicle, The Washington Times,* The Hill, *American Thinker,* and *Human Events.* He is also the author of "Frac Sand Study: Lots of Scare, Little Science," published in the *Milwaukee Journal Sentinel* in October 2014. He has recorded more than a dozen podcasts on energy and environment topics for The Heartland Institute, available on Heartland’s YouTube channel at HeartlandTube.

Orr writes, “I grew up on a dairy farm, and I want to preserve rural America, and rural American values. Along with agriculture, I am fascinated by geology, mining, groundwater, and other environmental issues.”

Mark Krumenacher

Mark Krumenacher is a principal and senior vice president of GZA GeoEnvironmental, Inc. and is based in Waukesha, Wisconsin. Mark has served as principal, project manager, and project hydrogeologist during the past 27 years with GZA on environmental, geologic, hydrogeologic, and engineering projects throughout North America.

Krumenacher is a professional geologist with licensure nationally and in several states and is a Certified Hazardous Materials Manager. He has managed and conducted geologic, hydrogeologic, and engineering studies, remedial investigations, environmental assessments, pre-acquisition environmental due diligence, and hazardous waste management at various properties including surface and underground mines; large industrial, commercial, and urban redevelopment projects; federal Superfund sites; and state-lead environmental projects.

He has provided testimony regarding aggregate and industrial mineral mining before municipal, township, and county units of government as well as NGOs, local environmental groups, and community advisory councils to help address residents' concerns about mining.

Krumenacher is actively involved with the several mining associations, including the National Stone Sand and Gravel Association, Illinois Association of Aggregate Producers, National Industrial Sand Association, Industrial Minerals Association–North America, Wisconsin Industrial Sand Association, and Society for Mining Metallurgy and Exploration.

1. Industrial sand mining

1.1. Historic sand mining in Wisconsin

Hi-Crush Comment: No Comment.

1.2. Current market

Hi-Crush Comment: No Comment.

1.3. Explanation of hydraulic fracturing

Hi-Crush Comment: No Comment.

1.4. Location of sand resources

Hi-Crush Comment: No Comment.

1.5. Current operations and trends

Hi-Crush Comment: No Comment.

1.6. Aspects of industrial sand mining

1.6.1. Overburden removal

Hi-Crush Comment: No significant impacts. Sources must obtain a non-metallic mining permit which covers reclamation. There is also financial assurance necessary before disturbing any earthen material. Overburden removal is a common practice in any construction business; mining provides a much larger area which the activity exists. Best management practices are utilized to ensure minimal impacts to the public and environment, such as: hours of operation, alternate back-up beepers (broadband alarm), and the material is inherently moist (>12% moisture) so there is no dust generated from the activity.

The strategic analysis should conclude there are no significant impacts from overburden removal due to current regulations, compliance with regulations, and implementing best management practices.

1.6.2. Excavation

Hi-Crush Comment: No significant impacts. Sources must obtain a non-metallic mining permit which covers reclamation. There is also financial assurance necessary before disturbing any earthen material. Excavation removal is a common practice in any construction business; mining provides a much larger area which the activity exists. Best management practices are utilized to ensure minimal impacts to the public and environment, such as: hours of operation, alternate back-up beepers (broadband alarm), and the material is inherently moist (>12% moisture) so there is no dust generated from the activity.

The strategic analysis should conclude there are no significant impacts from excavation due to current regulations, compliance with regulations, and implementing best management practices.

1.6.3. Blasting

Hi-Crush Comment: Blasting is primarily regulated by the Wisconsin Department of Safety and Professional Services. However, WDNR and local municipalities may govern the activity as well. It is common for companies to have enforceable conditions within local conditional use permits. Blasting can produce environmental impacts, but they are minimized by complying with state standards and proper implementation of best management practices. Impacts may include noise, vibration, dust, combustion products (pollutants), and potentially groundwater impacts.

Noise is insignificant due to the instantaneous single pulse.

Vibration has to be within standards, and are measured at various locations surrounding the blast site; DSPS has in fact investigated such measurements at one of our locations and found the blasting activity to be within standards. Therefore, when done in accordance with such standards, vibration impacts are also insignificant.

Dust from blasting is covered by WDNR fugitive dust and visible emission standards. Following best management practices, dust will be an insignificant impact; practices including blasting when winds are low. To date, the industry is not aware of any blast that has exceeded a visible emission standard, and that may be again due to the instantaneous nature in which dust produced will settle within the time period for which the standard is based; Hi-Crush recommends speaking with WDNR Air Management personnel (Compliance Engineers) on their experience and documentation of such witnessing and observations.

Combustion products (air pollution) would also be insignificant, as determined in the ruling by Judge Boldt (reference contested case of FML air pollution control construction permit, Case No. DNR-13-043); air pollutants generated by combustion properties would be within standards protective of public health.

Finally, companies may monitor groundwater wells for many different reasons and for many different properties/materials of concern; Hi-Crush performs such monitoring. Monitoring has occurred prior to any blasting (baseline establishment) and ongoing after blasting has occurred or continues to occur. This allows the company to assess if blasting may be causing any significant impact to those wells, and take appropriate action if there is a potential for impact.

The strategic analysis should conclude there are no significant impacts from blasting due to current regulations, compliance with regulations, and implementing best management practices.

1.6.4. Crushing

Hi-Crush Comment: The industrial sand industry differs in the way material is “crushed” than a typical rock crusher. This is due mostly to the inherent attributes of the raw material being mined and crushed; sand. The raw material sought and mined by “frac” sand mines is not a material of significant hardness or cementation. The sand deposits are naturally loose, and the activity of crushing is meant to serve the purpose of screening out larger ‘rock’ based materials from the sand, and the larger clumps of sand are actually fed through the crusher unit, which breaks up the material rather than reducing the size of the material of interest (the crushers do not crush the sand particles to make them smaller, the raw sand is already of the shape, size and form needed). Larger and harder materials in the raw feed (rocks) are initially screened out before the raw material enters the crusher unit. Furthermore, the raw material is inherently moist (>12% moisture), and these crusher units do not need to employ wet suppression to keep dust to a minimum. Hi-Crush recommends speaking with WDNR Air Management personnel (Compliance Engineers) on their experience and documentation of such witnessing and observations of crushers visible emissions, which will demonstrate no potential dust issues from these operations; all new primary crushers must demonstrate compliance with federal air pollution standards, and the WDNR Air Management program will have sufficient stack testing data to prove this case.

The strategic analysis should conclude there are no significant impacts from crushing due to current regulations, compliance with regulations, and the inherent raw material moisture and composition of which the crusher actually processes.

1.6.5. Processing (including use of chemicals)

Hi-Crush Comment: The only significant processing step that utilizes chemicals is the washing stage of the raw material that is mined. Significant research has been completed to demonstrate no significant impact by the use of chemicals by the industrial sand industry already; please refer to the Wisconsin Industrial Sand Association publication available at: http://www.wisconsinsand.org/assets/Water-Soluble-Polymers-and-Industrial-Sand-Mining-final-5_31_13-.pdf.

The strategic analysis should conclude there are no significant impacts from processing sand.

1.6.6. Process water and Stormwater management

Hi-Crush Comment: Please refer to comments provided under section 2.2.

1.6.7. Spill prevention and response

Hi-Crush Comment: Sufficient regulations already exist for persons/industries that have the capacity to generate a significant impact to human health, the environment, and/or may cause a fire, explosion or safety hazard. The Federal EPA also regulates spills through its Spill Prevention, Control and Countermeasure (SPCC) rule. There is little to no potential for significant quantities of hazardous materials to be spilled; most equipment and materials used that could result in a spill are of small quantities. Our facilities utilize spill-kit stations, and provide annual training on spill prevention and response.

The strategic analysis should conclude that while there may be a potential for hazardous material spills, there would be no significant impacts when facilities follow proper (or required, regulated) procedures for spill prevention and response. The analysis should also conclude that routine inspections (compliance) by department staff would be the best method of determining if a source has proper spill prevention practices in place, and they are implemented properly.

1.6.8. Storage facilities

Hi-Crush Comment: No Comment.

1.6.9. Waste management

Hi-Crush Comment: No Comment.

1.6.10. Transportation and load-out facilities

Hi-Crush Comment: WDNR should analyze impact differences between conveying material (e.g. >1 mile) vs. hauling via trucks on roadways; is there a lesser environmental impact between those two methods?

1.6.11. Reclamation

Hi-Crush Comment: Mining activities are regulated through local municipalities through non-metallic mining permits, whereby financial assurance is required to be in place prior to opening up any phase of mining. It is in a company's best interest to properly and timely reclaim mined lands in order to recuperate the financial assurance given. With financial assurance in place, mined lands will be returned to a natural state by some means (by the company or independent party). Reclaimed lands must meet certain standards or conditions, which may be based on the reclamation plan or other agreement(s), and the financial assurance is not returned to the company until such standards or conditions are met. Most companies will mine in phases such that only one or two phases may be open (active mining) at a time, and prior phases are reclaimed in series as new phases are opened; the entire planned mine site is rarely ever open in entirety. Typically, the overburden removed from a new phase is used in reclaiming a prior phase, and these activities would have the same potential impacts discussed under the Overburden Removal section.

The strategic analysis should conclude there are no significant impacts from mining; reclamation will occur and is adequately regulated to ensure proper reclamation.

2. Environmental Topics – affected environment and primary, secondary and cumulative effects (as appropriate)

2.1. Air quality

Hi-Crush Comment: There is sufficient data to show that air pollution from this industry is within state and federal standards that are protective of public health and the environment. The following concerns are addressed: air pollution control permitting and compliance, respirable crystalline silica, particulate matter impacts and monitoring, cumulative impacts, and fugitive dust.

Air Pollution Control Permitting and Compliance:

Most industrial sand mines and processing plants require an air pollution control permit from the WDNR. Regardless, any air pollution source must comply with federal and state air pollution regulations. The regulations are established to ensure the protection of the environment and public health. Through compliance with those regulations (permits), the WDNR is ensuring no significant impact to the environment or to public health. Interested parties need to understand that permit reviews always entail looking at worse case emissions, which are typically set at what is allowed by regulation and not what the facility will actually emit. This means that the analysis completed by WDNR, including potential ambient air impacts, represent conditions that are never likely to actually occur. WDNR will issue a permit that contains allowable emissions based on regulation, while the permittee demonstrates actual achieved emissions are much lower than those allowables. Yes, air pollution will exist from these operations, but complying with the regulations (permit) will ensure the protection of the environment and public health.

Respirable Crystalline Silica (RCS):

Sufficient data now exists for the WDNR to determine industrial sand mining and processing does not contribute to any significant ambient air concentrations of RCS; reference Dr. John Richards' studies (data already provided to WDNR). RCS has been a long standing issue for workplace exposures, and is regulated by OSHA/MSHA. The Federal EPA and WDNR have never established an ambient air standard for RCS, and for good reason. RCS is a particle pollutant, and sufficient regulations exist for control and abatement of particle pollution. In fact, many other states that have some form of standard or reference concentration do not require a type of control method that doesn't already exist for particle pollution. Industrial sand sources that employ current particle pollutant control technologies and best management practices for fugitive dust sources ensure proper control and abatement of any potential RCS ambient air impact. Preliminary results from ongoing studies (UWEC) have demonstrated that the raw materials being handled by industrial sand mines do not have the composition profile showing the type and size of silica necessary to produce RCS; reference Dr. Kent Syverson – UWEC, cementation study. WDNR should conclude that there is no evidence of significant ambient exposures to RCS from industrial sand mines and processing plants, and therefore no further action is required by the State to regulate the pollutant; current air pollution control regulations (and permits) are sufficient in protecting the environment and public health.

Particulate Matter Impacts and Monitoring:

WDNR should no longer utilize NR 415.075 for monitoring requirements of particle pollution. NR 415.075 is specific to "particulate" (or "particulate matter") emissions, as defined under NR 400. There are separate definitions for PM10 and PM2.5, which are not the same as "particulate". This is clearly evident in the authorities of those rules when established; NR 415 should have included PM10 designations for monitoring purposes when the rule was created (or revised) if there was an intent to utilize NR 415 for the monitoring of particles other than "particulate" (or "particulate matter"). Since NR 404 no longer contains standards for "particulate matter", the monitoring requirements under NR 415.075 no longer have a supporting standard to demonstrate attainment of through site specific monitoring. Instead, WDNR should be utilizing its authority under 285.65, Wis. Stats., if found necessary, to require any type of ambient air site specific monitoring. Until such time WDNR takes appropriate action to revise NR 415 to parallel NR 404, the specific particulate matter monitoring requirements within NR 415.075 should be waived for all ledge rock quarries and industrial sand mines. Furthermore, WDNR should not use NR 415.075 to establish monitoring at any other location than an industrial sand mine, as the rule authority does not specify monitoring of industrial sand and gravel plants (see NR 415.076).

Based on current data obtained and reviewed by WDNR, there is no evidence to support WDNR continuing to require PM10 monitoring. To date, WDNR has not received and verified any monitoring data showing an exceedance of the PM10 standards, nor has any data shown a violation of those standards. WDNR should rely on the immense amount of monitoring data already available to demonstrate the industry will not cause a violation of the PM10 standards, and no longer require these industry sources to set up and operate PM10 monitors. The demonstration of a facility not having a significant impact on ambient air is already demonstrated by the acceptable method of air dispersion modeling analyses. The site specific monitoring data is solid proof that the modeling exercise (while not even required by law, see 285.63(11), Wis. Stats.) completed during permit application review is sufficient in demonstrating attainment of ambient air quality standards; no further monitoring is needed to demonstrate this practice (modeling) is acceptable and reliable.

Finally, WDNR should recognize this industry is not a primary producer of PM2.5 emissions. Based on EPA statements, “ "Inhalable coarse particles," such as those found near roadways and dusty industries, are larger than 2.5 micrometers and smaller than 10 micrometers in diameter.” and “ "Fine particles," such as those found in smoke and haze, are 2.5 micrometers in diameter and smaller. These particles can be directly emitted from sources such as forest fires, or they can form when gases emitted from power plants, industries and automobiles react in the air.” it is clearly evident EPA intended to implement PM2.5 standards for concerns of that size fraction of particulate from a few specific types of industrial sources, which would not include ledge rock quarries or industrial sand mining and processing. Furthermore, WDNR’s monitoring network that includes stations monitoring PM2.5 has shown, via sample speciation, the PM2.5 is comprised mostly of materials other than sand or dust (quartz, silica). While it is true that permit applicants and resulting permits identify PM2.5 emissions and standards, that again is due to the necessity of review requirements, and the industry assuming all (or most) PM10 is PM2.5 to provide a potential worse case; that type of assumption in no way dictates that PM2.5 emissions actually exists from these operations. Based on the studies by Dr. John Richards, albeit for a PM4 fraction, demonstrates industrial sand sources do not generate PM2.5 emissions that would contribute to ambient air impacts (assuming all PM4 was PM2.5). Furthermore, site specific monitoring of PM10 would also support, to a degree, the probability of PM2.5 to exist and be in exceedance of standards is doubtful.

It is recommended the strategic analysis find no need to further use resources to assess and implement site specific monitoring programs, rely on the current acceptable practice of modeling to demonstrate attainment of ambient air standards, and instead support the redirection of those resources for compliance activities (inspections/enforcement). By continuing to require monitoring of any particulate pollutant would be a now unfounded burden on the industry, and would not provide additional evidence needed by WDNR to conclude satisfactory compliance with and attainment of ambient air quality standards.

Cumulative Impacts:

Current procedures followed by WDNR ensure the assessment of cumulative impacts, which is also supported by currently available monitoring data. WDNR, through air pollution control permitting, and use of air dispersion modeling, will assess cumulative impacts where there is a basis to do so (proximity, emission profile, source permit classification status, and dispersion characteristics). There is nothing further needed by WDNR to assess cumulative impacts. The assessments are supported by actual monitored ambient concentrations near industrial sources; whereby, monitoring data exists from monitors located near more than 1 industrial mine source. The monitoring data demonstrates that even with more than 1 industrial mine source operating in an area (nearly adjacent), cumulative impacts either do not exist, or the cumulative impacts are still well below the ambient air quality standards.

Fugitive Dust:

WDNR has authority to regulate fugitive dust, NR 415.04, 415.075 and 415.076. Since “frac” sand sites are not currently located in any of the areas covered under sections NR 415.04(2), (3), (4), or NR 415.075(3), comments focus on 415.04(intro) and (1), 415.075(2) and (6), and 415.076(2). Nowhere in any of those sections do the regulations contain a statement that there shall be no (zero) dust from an industrial source. Rather, the regulations specify (in general) precautions are to be taken to prevent particulate matter from becoming airborne. Therefore, so long as sources implement best management practices, and in the case of an industrial sand mine a fugitive dust control plan (415.075(6)), there will be no significant impact from fugitive dust although some dust may exist from operations.

Furthermore, while air dispersion analyses (for minor PSD sources) do not include fugitive sources, and some of those analyses may show offsite ambient concentrations that approach standards, real-time actual impacts measured by ongoing ambient monitoring demonstrates the fact that dispersion of particulate differs between stack and fugitive sources of particulate, supporting the direction by WDNR to not include fugitives in modeling. There is once again sufficient evidence from the monitoring data that sources do not contribute to a significant amount of particle pollution when complying with their permit and respective fugitive dust control plan.

Summary: An air pollution control permit is a compliance tool for the permittee. It identifies which regulations apply and how the source shall demonstrate compliance. The permit review demonstrates worse case and/or allowable emissions are within standards and protective of the environment and public health, while actual emissions are much less than those worse case and/or allowables. Air dispersion modeling is a sufficient, consistent and reliable tool utilized by WDNR to assess potential air impacts. Monitoring data supports the conclusions of the permit review and modeling assessment. WDNR should rely on, and implement, regulations as written, and the public should accept the scientific facts provided in those permit reviews and all existing data to date (monitoring data), to conclude that ambient monitoring is no longer a necessity. Rather, WDNR should shift resources from monitoring activities to compliance and enforcement activities. Ultimately, complying with the permit will result in attainment of all standards and protection of public health; future monitoring requirements should be waived.

2.2. Water

2.2.1. Surface water features and locations

Hi-Crush Comment: No Comment.

2.2.2. Surface water quality

Hi-Crush Comment: Sufficient regulations exist to protect surface water quality; Stormwater and Wastewater (NR 216). The analysis should demonstrate that the few significant violations that have occurred are not due to insufficient regulations but rather insufficient compliance assurance activities by WDNR; facilities need to be inspected more frequently by field experts to ensure proper protection systems are in

place and practices implemented. Many companies have adequate and successful Stormwater and Wastewater prevention systems in place.
WDNR has implemented the process to revise the general Stormwater permit to better fit the potential impacts specifically by the industrial sand industry.
The strategic analysis should conclude that there would be no significant impacts when facilities follow proper (or required, regulated) procedures for surface water protection. The analysis should also conclude that routine inspections (compliance) by department staff would be the best method of determining if a source has proper systems in place, and practices are implemented properly.

2.2.3. Groundwater quality
Hi-Crush Comment: No Comment.

2.2.4. Groundwater quantity
Hi-Crush Comment: WDNR should work closely with Chippewa County on their study; please refer to: http://www.co.chippewa.wi.us/government/land-conservation-forest-management/non-metallic-mines/chippewa-county-groundwater-study.

2.2.5. Wetlands
Hi-Crush Comment: The practice of wetland mitigation has been allowed under regulation for many years. The issue of wetland impacts is not new to WDNR, and not new due to the increase in the industrial sand mining industry. WDNR's authority for wetland protection was strengthened with 2011 WI Act 118, whereby compensatory mitigation would involve restoration, enhancement, establishment or preservation of wetlands to compensate for unavoidable adverse impacts. However, the analysis should make a finding that there is a need for WDNR to work more closely with, and support, facilities that have opportunities to remediate degraded wetlands.
The strategic analysis should conclude that there would be no significant impacts when facilities follow regulations and proper procedures for wetland protection and/or mitigation. The analysis should also conclude that routine inspections (compliance) by department staff would be the best method of determining if a source has proper systems in place, and practices are implemented properly.

2.2.6. Fish and aquatic species
Hi-Crush Comment: No Comment.

2.3. Land
Hi-Crush Comment: Please refer to comments provided under sections 1.6.1, 1.6.2, and 1.6.11.

2.3.1. Forests
2.3.2. Grasslands
2.3.3. Wildlife

3. Socioeconomic topics – affected environment and primary, secondary and cumulative effects (as appropriate)

3.1. Local and state economy
Hi-Crush Comment: Planning and design of new and modified sites provide opportunities to engineering and consulting firms, many of which are local as companies deal with state and local requirements; knowledge of those requirements benefits the timeliness of completing projects. Construction of new and modified sites relies on local workforces. Operation of facilities brings with it numerous job opportunities. Local and/or state taxes benefit from the high sales of product and operations. Other financial benefits (e.g. royalties, annual payments) also exist to local municipalities. Employees spend more money at local establishments (stores, restaurants, etc.), boosting support of small town businesses. The industrial sand mining industry has created a huge

economic benefit to the local and state economy. According to a study completed by Dr. Knetter (Economic Impact Study), industrial sand mining industries can result in a positive $20,000,000 impact, per facility, to the local economy (study can be made available upon request).

3.2. Property values

Hi-Crush Comment: Assessment of property values should consider the life span of the mining activity and the end result of the land that is mined; when it is reclaimed. Mining is done in phases, returning spent areas to their natural state in just a few years (via reclamation). Home owners do not typically move to a new home every 5 years. The impact, if any, to property values shouldn't shift in any significant amount over a span of residency time; a person living near a mine would only be exposed to the mining activity for a fraction of the time they would dwell in that home. Property value assessment can't properly be completed based on the expectancy of a mine to exist, or of a mine existing, but rather the property as it exists prior to any mine being located near the dwelling and after the mine has been reclaimed. The end result of such an analysis should demonstrate no significant impact; rather, it should demonstrate the property would increase/decrease with normal fluctuations in local and state home sales.

Regardless, to compensate the issue of potential property value decrease, most companies work with local municipalities and adjacent home owners to establish a home property value guarantee. Therefore, the construction, operation, and reclamation of industrial sand mines will not have any significant impact on property values.

3.3. Population

Hi-Crush Comment: No Comment.

3.4. Transportation

Hi-Crush Comment: No Comment.

3.5. Land use and zoning

Hi-Crush Comment: No Comment.

3.6. Agricultural lands

Hi-Crush Comment: No Comment.

3.7. Public parks and recreational lands

Hi-Crush Comment: No Comment.

3.8. Archaeological, cultural, tribal and historic resources

Hi-Crush Comment: No Comment.

3.9. Human health and safety

Hi-Crush Comment: No Comment.

3.10. Visual and auditory

Hi-Crush Comment: There are no significant impacts to visibility (and/or visual aesthetics) or auditory/acoustics. Mining has been a part of Wisconsin history for decades. The industry follows local requirements (e.g. conditional use permit) and/or state requirements for establishing berms or other visual obstructions of the industrial structures and operations. There are examples of our company constructing office buildings and storage silos to match the agricultural landscape (office building looks like a farm house, storage silos look like grain silos). Visual aesthetics from the industry is no different than most other industries, and does not pose any significant impact. Auditory impacts are minimized through the use of best management practices, such as hours of operation and alternate back-up beepers (broadband alarms), which may also be included in local permitting (conditional use permits).

4. Regulatory framework

4.1. State of Wisconsin

Hi-Crush Comment: Please refer to comments provided under section 5.2.

4.2. Local
Hi-Crush Comment: No Comment.

4.3. Federal
Hi-Crush Comment: No Comment.

4.4. Tribal
Hi-Crush Comment: No Comment.

4.5. Neighboring states
Hi-Crush Comment: No Comment.

5. Hi-Crush General Comments or Additional Topics of Concern to be addressed

5.1. Science-based Approach

WDNR should ensure only data obtained via scientifically acceptable methods be included in the report, and report should denote that important facet of the study update. Instances where WDNR receives data/opinions that are not scientifically founded, WDNR should develop a comment database, with response, to clearly document why the information is not considered (due to unscientific or unacceptable methods) and ensure commenters understand why their information was not included in the report. It is important for WDNR to include that information and response so as to avoid further reiteration of the same issues that some offer as data and reasoning to not allow (e.g. issue a permit) an industrial sand mine and/or processing plant to be constructed and operated.

5.2. State Compliance & Enforcement Activities

Current regulations support a conclusion of being sufficiently protective of the environment and public health; that is demonstrated for any industry in the state, including industrial sand mining. Mining has been an existing activity in Wisconsin for decades, and there have been regulations and policies established and retained for this specific industry by the State and local municipalities. However, those regulations are only effective when they are complied with. WDNR should consider spending more resources on compliance and enforcement activities rather than policy development. WDNR has been able to provide some level of compliance and enforcement, but it has been insufficient and inconsistent. Proper protection of the environment and public health doesn't rely on the issuance of paper documents (e.g. permits), but the determination of compliance with those regulations by routine and consistent inspections and follow-up enforcement where needed. Fair competition across the state in the industry must rely on a consistent and efficient implementation of those compliance and enforcement activities by WDNR.

It is suggested that WDNR, in this analysis, also provide a snapshot of compliance rates for this industry, as an industry alone, and across all industries for which WDNR inspects and prepares compliance determinations upon.

FairmountSantrol

April 20, 2015

Chris Willger
Wisconsin DNR
1300 W. Clairemont
Eau Claire, WI 54701

Dear Mr. Willger,

Fairmount Santrol is a well-established, highly regarded provider of sand-based products for industrial and recreation markets. We have three operations in Wisconsin that mine and process industrial sand. Fairmount is proud of our strong record of environmental stewardship and our experience managing Wisconsin's natural resources.

A key part of Fairmount Santrol's operating philosophy is to continuously look for ways to reduce our environmental footprint and ensure the protection of air and water resources. In addition, the health and safety of our workers and our neighbors in the communities where we operate is a top priority. We also maintain an environmental management system which allows all of our facilities to participate in Wisconsin's Green Tier Program. In fact we were the first mining facility to be awarded the Green Tier certification.

As a member of the Wisconsin Industrial Sand Association (WISA), Fairmount Santrol supports the statements submitted by WISA regarding the upcoming Strategic Analysis that your agency will be completing. Given our experience and strong commitment to going beyond compliance with regards to environmental stewardship and safety, we appreciate the opportunity to contribute to the Strategic Analysis by also providing our thoughtful review. We believe your analysis will provide factual, science-based information to correct much of the misinformation that exists in the general public about our industry.

Mining is among the most heavily regulated industries, and we do not object to that regulation – provided that it is clear, predictable in its application and, most important, that it is based on sound science, not on fear and misinformation. The term "fear" is not used in an effort to criticize those who express concerns about this or any other industry. Fear is natural when it comes to issues of health and safety, and the unknown. But fear should not form the basis for policy or regulatory decisions, and it should not influence content within a factual report your agency has been asked to provide.

Mining is not a new industry, and there are substantial data and studies that address many of the concerns the WDNR has been tasked with examining in order to prepare a Strategic Analysis. In fact, we feel that the original report that was prepared by the DNR in January 2012 was extremely thorough and impartial. It was clear that the process used in gathering information for this first report was methodical, and resulted in the use of science-based, factual information.

It may be helpful to include in your Strategic Analysis report a discussion of industrial sand mining relative to other industries. What are the impacts on state waters from farming, forest

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products (paper mills), food and beverage production, and industrial manufacturing? What are the other sources of fugitive dust? And how do these compare with the effects of the sand mining industry on these issues? Being able to put industrial sand mining into perspective with other longstanding industries may shed some valuable light on many of the perceived impacts, both locally and regionally.

One of the topics that your agency is tasked with investigating is air quality around industrial sand operations. There are multiple science-based studies that have been conducted recently that show industrial sand mines have no adverse impact on air quality, and therefore pose no danger to members of the community. The data collected confirmed that ambient air crystalline silica levels in the communities where industrial sand mines exist are within the range typically found throughout the Midwest. Being proactive, Fairmount engaged in an air study which was conducted at our own Maiden Rock facility. A report compiled at the end of the comprehensive year-long sampling study shows the ambient PM_4 crystalline silica levels near our Maiden Rock facility are extremely low. We found that our Maiden Rock operation emits very little PM_4 crystalline silica, and that the majority of the ambient PM_4 crystalline silica in the community comes from many other sources including farms, unpaved roads, and construction. This data has been shared with the WDNR, and we welcome the opportunity to continue to answer questions related to this study. Through best management practices, the threat of crystalline silica is an occupational health risk only – one that the industry has proven it can control.

Managing an important natural resource is a responsibility that we don't take lightly. Fairmount Santrol's presence has created many positive stories in the communities where we operate. Providing educational opportunities about the mining process through the numerous tours that we host at our facilities, organizing community meetings to encourage open dialogue among community members, and inviting school-age groups onto our sites to learn about wildlife management and land conservation, are just a few examples of how our efforts have resulted in transparent and respected relationships within our communities. This is all above and beyond the economic benefits that our operations and others within this industry provide to the State of Wisconsin. Sand mining companies in Wisconsin have made multimillion-dollar investments in their facilities and infrastructure. Thousands of good paying jobs have been created. New tax revenues are being generated at the state and local level. In total, industrial sand mining has generated hundreds of millions of dollars in overall economic impact in Wisconsin.

The sand mining industry in Wisconsin includes many responsible operators, some of which have been mining sand in our State for nearly 100 years. Fairmount Santrol is proud of our efforts to go beyond compliance and exceed expectations in every facet of our business. We recognize that partnerships between operators like Fairmount Santrol and the Wisconsin DNR are necessary and valuable. We maintain an open-door policy, and encourage members of the DNR team who are involved in this Strategic Analysis to contact us if they wish to discuss any topics at length. In addition, we would welcome any members of the DNR to tour our facilities as part of the information-gathering process.

Respectfully,

Aaron Scott
Northern Region Surface Mine Manager
Aaron.scott@fairmountsantrol.com

WISA
WISCONSIN INDUSTRIAL SAND ASSOCIATION

April 20, 2015

Mr. Christopher J. Willger
Wisconsin Department of Natural Resources
1300 W. Clairemont
Eau Claire, WI 54701

Dear Mr. Willger:

The members of the Wisconsin Industrial Sand Association (WISA) – Badger Mining Corp., Fairmount Santrol, Smart Sand and U.S. Silica – appreciate and fully support the effort undertaken by the Wisconsin Department of Natural Resources (WDNR) to update the 2012 report on Silica Sand Mining in Wisconsin as part of a broader Strategic Analysis of the industrial sand industry in Wisconsin. WISA members are all participants in the WDNR Green Tier program, which demonstrates our commitment to environmental stewardship and responsible operations, and we welcome updated, science-based analysis of our industry.

Industrial sand mining has a rich history in the Badger State, and some WISA members are currently operating mines that date back to the early 1900s. The tremendous growth our industry has experienced in recent years has concerned some Wisconsin communities, and we understand that. We have found, however, that much of that concern is the result of misunderstanding and fear. We believe the Strategic Analysis can synthesize the available facts and science to help offset that misinformation and foster a more accurate understanding of a highly regulated, longtime Wisconsin industry.

We have given thoughtful review to the information the WDNR has supplied about its plans for the Strategic Analysis and compliment the Department on the thoroughness of the preliminary analysis reflected by the Draft Topics Outline dated March 12, 2015. We offer the following questions and comments in an attempt to better understand the breadth and focus of the final report:

- The Department's 2012 Strategic Analysis included a description of the purpose of that document. Will the scope and purpose of this document be identified in the introduction of the report?

- Under Section 1, "Industrial Sand Mining," it may be helpful to provide an overview of the characteristics (size, grain, etc.) of the sand produced in Wisconsin, especially as it relates to the different geologic formations in the state.

- Consider including section 1.3, "Explanation of Hydraulic Fracturing," as a subset of the discussion in section 1.2, "Current Market." Hydraulic fracturing is just one of the many processes that utilize Wisconsin sand, and the Strategic Analysis should describe all end uses if it describes any. Focusing only on hydraulic fracturing, an activity that does not occur in Wisconsin, encourages the perception that sand is only mined for use within the oil and natural gas markets.

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- Section 2.1, “Air Quality” does not contain any subtopics. We understand that the WDNR plans on updating the 2012 study of air-related matters concerning sand mining with more current information. We encourage the WDNR to include the results of ambient air monitoring that has been performed by industrial sand operations pursuant to NR 415.075. It may be helpful to also provide an overview of current and recent air quality trends, as well as a broader discussion of the many source categories of that contribute particulate matter to ambient air, such as point sources, agricultural operations, fuel combustion, etc.

- Will section 2.3, “Land,” discuss land conditions during mining operations, or after reclamation activities have been completed? Forests and grasslands that may be affected by mining operations may ultimately be returned to those uses.

- The Strategic Analysis should include additional information about the interaction between mining activities and endangered species. It’s not clear if section 2.3.3. “Wildlife” under the “Land” section is intended to cover this issue. Will the “Fish and Aquatic Species” discussion in section 2.2.6 be included as a subset of the “Wildlife” discussion?

- Section 3.0, “Socioeconomic Topics” should include information about the relationship between the vitality of local economies and the health of the citizens living in those communities.

- Section 3.5, “Land Use and Zoning,” may be better addressed under the “Local Regulatory Framework” of section 4.2.

- The 2012 Strategic Analysis included a discussion of contaminated sites. This topic should be addressed to provide the public with information about the landfills, storage tanks and other properties managed and maintained by the industrial sand industry.

WISA is working hard to share facts about our industry and to continue a positive relationship with state agencies and the communities where member companies operate. Our Association is happy to participate in the dialogue the Strategic Analysis process will generate, and our members are available to provide further information and insight.

Thank you for taking the time to conduct this Strategic Analysis and for seeking the public input necessary to conduct a truly scientific, fact-based review. WISA looks forward to continuing this discussion about our industry. Please let us know if there are any questions.

Sincerely,

Rich Budinger

Rich Budinger
President

2809 E. Hamilton Ave. | Eau Claire, WI 54701 | (715) 497-3749 | info@wisconsinsand.org

WMC

WISCONSIN MANUFACTURERS & COMMERCE

April 20, 2015

Mr. Christopher J. Willger
Wisconsin Department of Natural Resources
1300 W. Clairemont
Eau Claire, WI 54701

Via email: DNROEEAComments@wisconsin.gov

Mr. Willger,

Wisconsin Manufacturers and Commerce (WMC) is a business trade organization with nearly 4,000 members statewide in all sectors of Wisconsin's economy. WMC's membership includes a significant number of businesses engaged in industrial sand mining and processing in Wisconsin, companies that facilitate the transportation of sand, manufacturers, retailers, and servicers of equipment used in sand mining and processing, and companies that utilize the resource in their processes including foundries, glass makers, chemical manufacturers, petroleum companies and others.

WMC supports Wisconsin Department of Natural Resources (WDNR) efforts to update its January, 2012 report *Silica Sand Mining in Wisconsin* as part of a Strategic Analysis of industrial sand mining in Wisconsin. WMC and its members look forward to assisting WDNR in utilizing sound science and credible information to update its 2012 report. It is our hope that this process will help to dispel myths and misinformation regarding an important and heavily regulated Wisconsin industry and provide greater clarity for the public, state and local government officials, and regulators.

WMC and its member companies have reviewed WDNR's Draft Topics Outline dated March 12th, 2015 and provide the following comments and questions in response:

- Section 1: WDNR should consider including a discussion of characteristics of the sand mined and processed in Wisconsin and the formations from which it is derived.

- Section 1.3: WDNR should consider including section 1.3, Explanation of Hydraulic Fracturing as a subset of section1.2, Current Market. Additionally, both sections 1.1 and 1.2 should include a greater explanation of the many manufacturing processes and other uses that rely on industrial sand, i.e., foundry casting, glass making, chemical production, landscaping, agricultural bedding, etc…

- Section 1.3: WDNR should make clear that hydraulic fracturing is not occurring in Wisconsin.

- Definition of "Frac Sand": In its 2012 report, WDNR included section 3.2, What is Frac Sand? If any such definitions are included in the updated report, WDNR should make clear that frac sand is no different than the industrial sand utilized by Wisconsin industries for well over a century.

- Section 2: WMC's member companies place a high priority on environmental quality. Many have data and expertise that could prove helpful to the Department when analyzing the environmental impacts of industrial sand mining. WMC encourages WDNR to engage the industrial sand mining community to obtain the best quality information available regarding environmental impacts.

- Section 2.1: Air quality monitoring conducted at and near industrial sand mining operations across Western Wisconsin reveals that air quality is generally excellent in the region, that trends show air quality to be improving, and that industrial sand facilities are not significant sources of air pollutants such as fine particulates PM2.5. WMC suggests the following subtopics under section 2.1, Air Quality:

    - PM10 Monitoring Data – WDNR should include an explanation of the PM10 data it collects and quality assures in partnership with industrial sand operations under NR 415.075.
    - PM4 – WDNR should discuss the relevant literature based on sound science and quality assured data including the work of Dr. John Richards.
    - Air Quality Trends and PM2.5 Background – WDNR should provide an overview of air quality trends in Wisconsin and the latest scientific thinking regarding PM2.5 formation.

- Section 3: WMC questions whether WDNR is the appropriate entity to study and report on several of the socioeconomic topics listed. The extent to which WDNR is willing and able to collect, analyze, and report on economic data is unclear at this time. For instance, does WDNR intend to analyze the precipitous drop in unemployment in Western Wisconsin that directly correlates to the growth of the industrial sand industry? Will WDNR be analyzing county sales tax revenue data? Does WDNR plan to review and include any economic impact analysis data developed by operators to date?

- Section 3: WMC suggests adding a subtopic specific to unemployment rates and a subtopic specific to local revenues that takes into account royalties, severance fees, road use fees, donations, and other payments made to local government units and school districts by industrial sand operators.

- Section 3.4: Any discussion of transportation should include a brief description of the general benefits to commerce associated with improved rail infrastructure resulting from investments related to industrial sand.

- Section 3.5: "Land use and zoning" may be better addressed under section 4.2, local regulatory framework.

- Section 4.2: WDNR should consider discussing the state regulatory perspective regarding local government units developing and applying environmental regulations that conflict with or contradict state regulations.

- Section 4.3: WDNR should significantly expand upon information contained in the 2012 report regarding federal regulations of sand mining operations.

WMC reiterates its support for WDNR's efforts to better inform and educate the public. Our organization and our members look forward to assisting WDNR in developing a fact-based, scientifically sound document and make ourselves available to the Department towards that end.

Thank you for taking the time to consider our comments and for seeking public input to help guide the Department in developing its Strategic Analysis. Please let us know if you have any questions or if we can be of assistance.

Regards,

Eric Bott
Director of Environmental and Energy Policy
Wisconsin Manufacturers and Commerce

Air
Control Techniques, P.C.

301 East Durham Road
Cary, North Carolina 27513

Office (919) 460-7811
Fax (919) 460-7897

April 20, 2015

Sent via email: DNROEEAComments@wisconsin.gov

Mr. Chris Willger
Wisconsin Department of Natural Resources
1300 W. Clairemont
Eau Claire Service Center
Eau Claire, Wisconsin 54701

Re: Wisconsin DNR Strategic Analysis of Ambient Crystalline Silica
Fenceline PM4 Crystalline Silica Concentrations in Maiden Rock, Downing, and Cataract Green

Dear Mr. Willger:

I appreciate this opportunity to submit data and information concerning air quality in the vicinity of sand-producing facilities in Maiden Rock and Downing, Wisconsin and from a greenfield background site in Cataract Green, Wisconsin. This letter addresses the following major data and information gaps that were discussed in the Wisconsin Department of Natural Resources (DNR) Silica Study[1] released in 2011.

1. "In summary, more research is needed in Wisconsin in order to ascertain the range of ambient air exposures likely to occur, both near sources of silica emissions as well as from background levels of exposure. … The best way to determine what crystalline silica impacts are near a source is to conduct monitoring, which as stated earlier, is very difficult to conduct." Page 17

2. "There are no generally accepted methods for monitoring PM4 in ambient air." Page 1

3. "A recurring theme from the literature review and survey is that very little conclusive information exists regarding sources, controls or levels of silica present in ambient air. This lack of data means it is not currently possible to determine conclusively whether or to what extent the quantity, duration or types of silica emissions in the state may be a public health concern. It would take significant additional efforts to fill in these data gaps." Page 2

Since the 2011 publication of the DNR Silica Study, Fairmount Santrol, Mathy Construction, and other companies in Wisconsin have sponsored ambient air quality studies to help fill these gaps in information concerning ambient crystalline silica concentrations. This letter provides a summary of the data compiled by Air Control Techniques, P.C. at Maiden Rock, Downing, and Cataract Green since 2012. These data are directly relevant to Section 2.1 of the DNR strategic analysis draft outline

This submittal is divided into three major sections: (1) ambient PM4 crystalline silica data compiled by Air Control Techniques, P.C. from October 2012 through December 2014 at three facilities, (2) supporting information from other sand-producing companies and regulatory agencies concerning ambient PM4 crystalline silica concentrations, and (3) information concerning the ambient PM4 crystalline silica sampling procedure that has become a "generally accepted method."

1. Ambient PM4 Crystalline Silica Sampling Data

Ambient PM4 Crystalline Silica Fenceline Concentrations—Air Control Techniques, P.C. conducted ambient PM4 crystalline silica sampling at Maiden Rock from March 2013 through March 2014. PM4 sampling at Downing and Cataract Green was conducted from August 2012 through August 2013. The purpose of all three sampling programs was to compile accurate ambient PM4 crystalline silica concentration data and to determine if the facilities contributed to increased downwind ambient PM4 crystalline silica concentrations.

Cataract Green was a greenfield site with no mining or farming activity during the sampling period. This site provided data useful for evaluating regional background concentrations of PM4 crystalline silica in the absence of local sources.

The Maiden Rock sampling program included three community-oriented samplers located on three separate sides of the facility. The Northeast site was on residential property on the hill above the underground mine and processing area. This site was inside the fenceline in an open area. The Southwest site was on residential property adjacent to both State Road 35 and the plant processing area. This site was in an area located away from the drip lines of trees and other vegetation on the property. The in-town site was on residential property adjacent to County Road S in the Village of Maiden Rock. These sampling locations are marked on the aerial view of the site shown in Figure 1.

Figure 1. Overview of Maiden Rock, Wisconsin
(Source: Google Earth)

The contributions of the Maiden Rock facility to ambient concentrations of PM4 crystalline silica were evaluated by comparing the day-by-day concentrations measured at the three widely-separated sampling locations. Only one of the three sampling locations was downwind of the facility on any specific day. Accordingly, two sampling locations provided background data while the third provided data concerning the contribution of the facility plus the background concentration.

The in-town sampling location shown in Figures 2 and 3 was on the south side of County Road S in the front yard of an ambulance garage. This sampler was located as far as possible from the edge of the road without being too close to the building.

Figure 2. In-Town Sampling Location
(Source: Google Earth)

Figure 3. In-Town Sampling Location Viewed from County Road S

The Downing sand mine sampling locations include a primary and collocated sampler (Figure 4) on the west side of the facility along County Road Q. Another sampler was located on the west side of the facility between the edge of the quarry and County Road W.

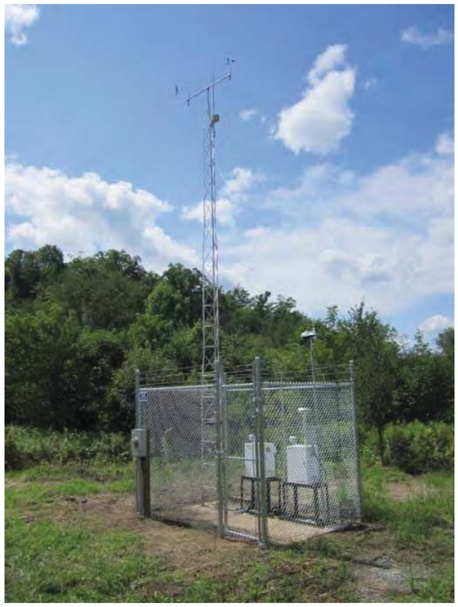
Figure 4. Downing Location 1 Viewed from County Road Q

The Cataract sampling location was in an abandoned farm field to the Northeast of the Village of Cataract. There were no trees or active farm fields within one-half mile of this sampling location.

A total of 570 sampling values, each representing a 24-hour measurement, are included in the data compiled by Air Control Techniques, P.C. and are being provided with this letter This is an exceptionally large data set that represents conditions from three different locations under all weather conditions for more than a one-year period.

The ambient PM4 crystalline silica concentrations summarized in Table 1 were very low at all three locations throughout the sampling periods. The long-term average concentrations ranged from 0.01 to 0.18 micrograms per cubic meter ($\mu g/M^3$)[1].

[1] The long-term average PM4 crystalline silica concentrations are based on LOQ values at 0.0 $\mu g/M^3$.

Table 1. PM4 Crystalline Silica Concentrations, 2012-2013					
Facility and Sampling Location	Number of 24-Hour Samples	% of Samples Below LOQ of 0.3 µg/M³	Long Term Average Concentration µg/M³	% of Chronic Reference Level µg/M³	Chronic Reference Level µg/M³
Maiden Rock Northwest	122	88	0.07	2.3	3.00
Maiden Rock Southwest	124	62	0.43	14.3	
Maiden Rock Northeast	124	77	0.12	4.0	
Downing 1	63	81	0.11	3.7	
Downing 2	62	78	0.10	3.3	
Cataract Green	75	89	0.06	2.0	

In Figure 5, the long-term average PM4 concentrations are compared to the PM4 crystalline silica lifetime continuous reference exposure level (REL) published by the California Office of Health Hazard Assessment (OEHHA)[2] These data demonstrate that the concentrations of ambient PM4 crystalline silica are well below the OEHHA chronic REL both upwind and downwind of the facilities sampled.

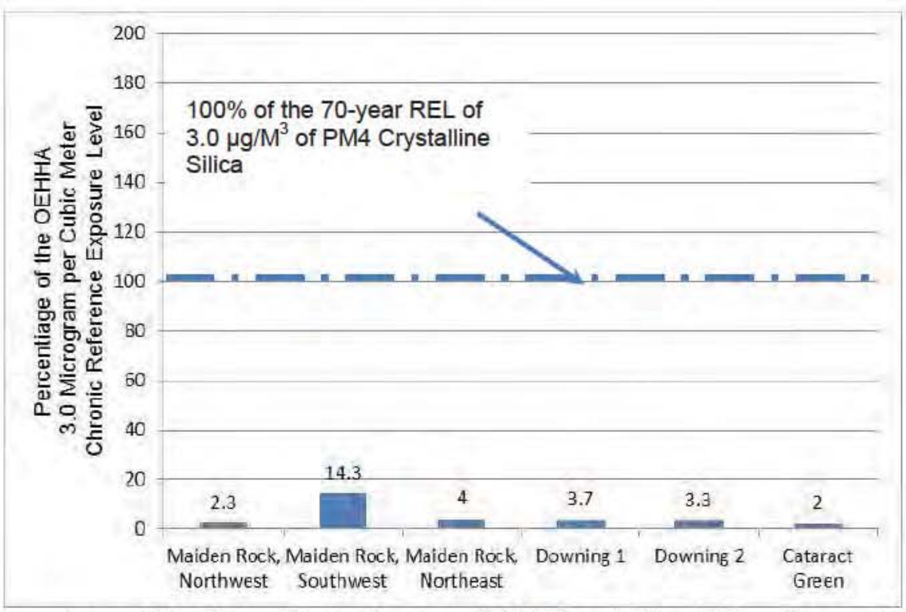

Figure 5. Comparison of the Long-Term Average PM4 Crystalline Silica Concentrations and the OEHHA 70-year Chronic Exposure Reference Level

The similarities in the PM4 crystalline silica concentration at the sampling stations at each facility and even the similarities in the concentrations measured simultaneously by samplers at most or all of the locations strongly indicate that most of the detectable values of ambient PM4 crystalline silica were due to day-to-day variations in the regional background concentrations. These clusters of sampling values above the limit of quantification (LOQ) are summarized in Table 2 for the Maiden Rock Facility.

Table 2. Clusters of Above LOQ Concentrations at Numerous Sampling Locations (Maiden Rock, WI)

Sampling Date	In-Town, µg/M^3	Southwest µg/M^3	Northeast µg/M^3	Average µg/M^3
Days with above LOQ values at all three sampling locations				
2013-JUL-06	0.69	1.75	0.50	0.98
2013-JUL-12	0.44	1.19	0.31	0.65
2013-JUL-18	0.31	0.38	0.87	0.52
2013-AUG-17	<LOQ	0.31	0.31	0.21
2013-AUG-20	0.38	1.51	0.44	0.78
2013-AUG-26	0.44	0.37	0.56	0.46
2013-SEP-04	0.44	0.75	0.56	0.58
2013-SEP-07	0.63	0.88	1.00	0.84

Regional Background Concentrations of PM4 and PM2.5 Particulate Matter—The importance of the regional background concentrations is illustrated by the similarity in the DNR PM2.5 particulate matter concentrations measured in Eau Claire and the PM4 particulate matter concentrations measured at Maiden Rock, Downing, and Cataract. As indicated in Figure 6, each of these facilities is between 40 and 60 miles from the DNR Eau Claire sampling site. Day-to-day comparisons of the DNR PM2.5 data and the facility PM4 particulate matter data are shown in Figures 7, 8, and 9. The variations in concentration are due almost entirely to changes in the regional background concentrations of PM2.5.

The regional background concentrations are due to the combined contributions of all of the sources of fugitive dust, such as agricultural sources, unpaved roads, wind erosion, global dust transport, and industrial emissions. The data compiled in this project indicate that these sources (including the sand processing facilities and sand mines) do not collectively create ambient PM4 concentrations that exceed 15% of the OEHHA 3.0 µg/M^3.

These conclusions are consistent with previous ambient PM4 crystalline silica studies conducted by Richards and Brozell[3] and the South Coast Air Quality Management District[4,5] using sampling and analytical procedures similar to those used in this project. Additional information concerning these earlier studies is available in the 2011 DNR report.[1]

Mr. Chris Willger
Wisconsin Department of Natural Resources
April 20, 2015
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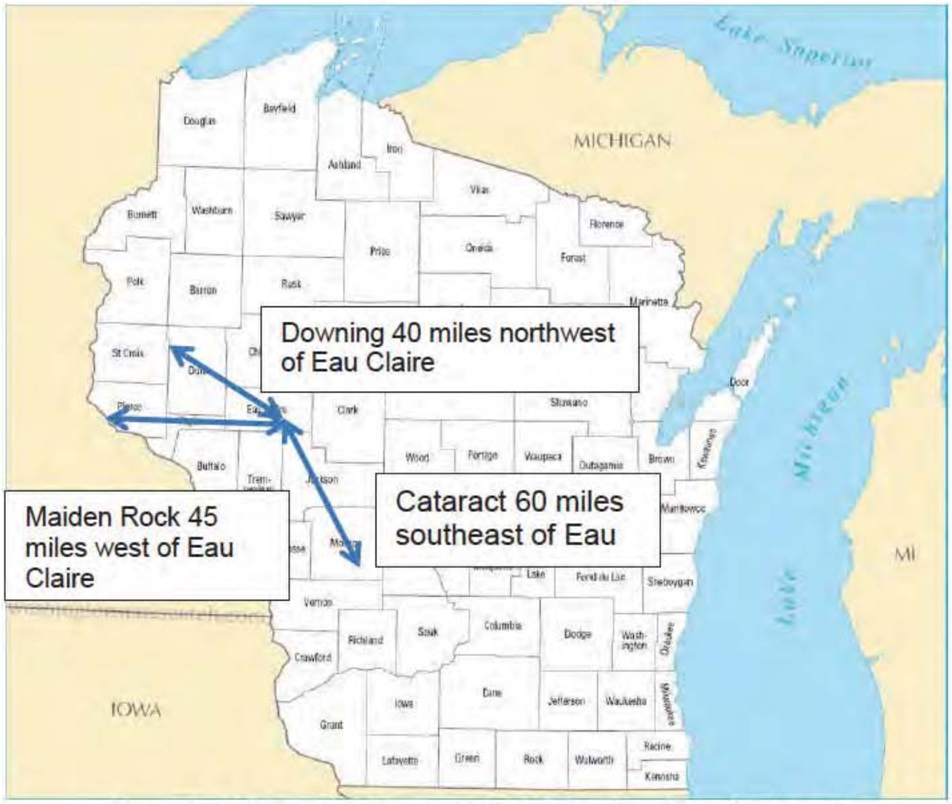

Figure 6. Distances Between the Sampling Locations and the DNR Eau Claire PM2.5 sampling site

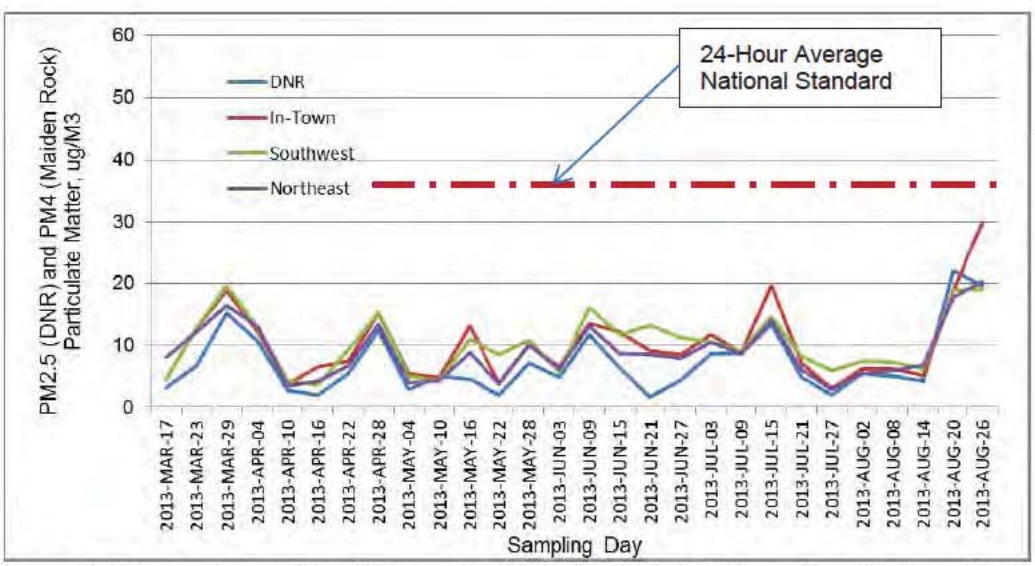

Figure 7. Comparison of the Wisconsin DNR PM2.5 data from Eau Claire with the PM4 data from Maiden Rock

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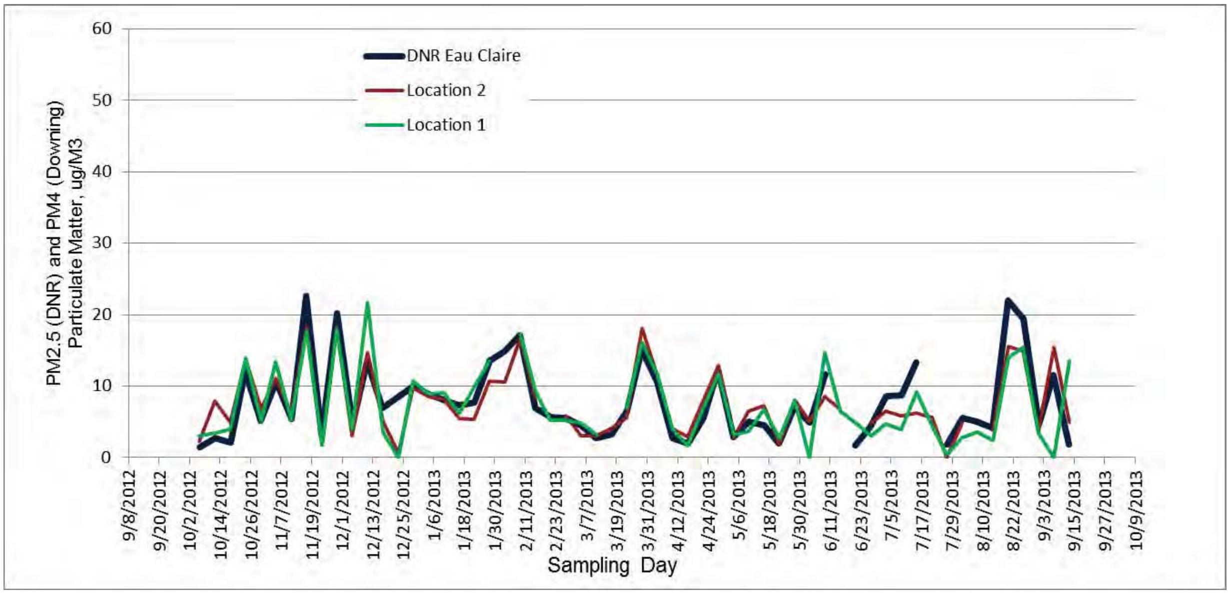

Figure 8. Comparison of the Wisconsin DNR PM2.5 data from Eau Claire with the PM4 data from the Downing Sampling Locations

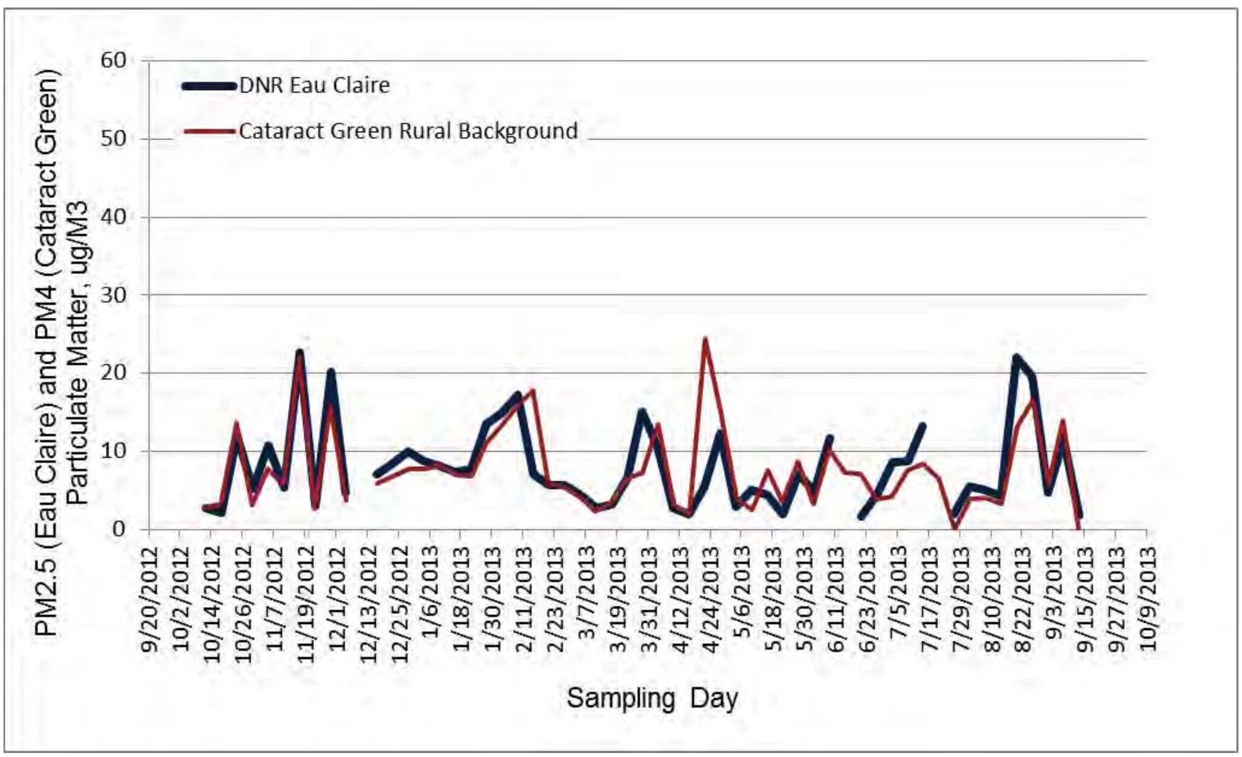

Figure 9. Comparison of the Wisconsin DNR PM2.5 data from Eau Claire with the PM4 data from the Cataract Green Rural Background Sampling Site

Mr. Chris Willger
Wisconsin Department of Natural Resources
April 20, 2015
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Upwind-Downwind Differences in PM4 Crystalline Silica Concentrations

During days when the winds blew consistently across the facility being sampled, it was possible to determine the upwind-downwind concentration change in the PM4 crystalline silica concentrations. These differences provided an indication of the increase in the PM4 crystalline silica concentrations above the regional background level that were due to contributions from the facility. As indicated in Figures 10 and 11, these differences were non-detectable within the precision limitations of the method at the very low PM4 crystalline silica concentrations.

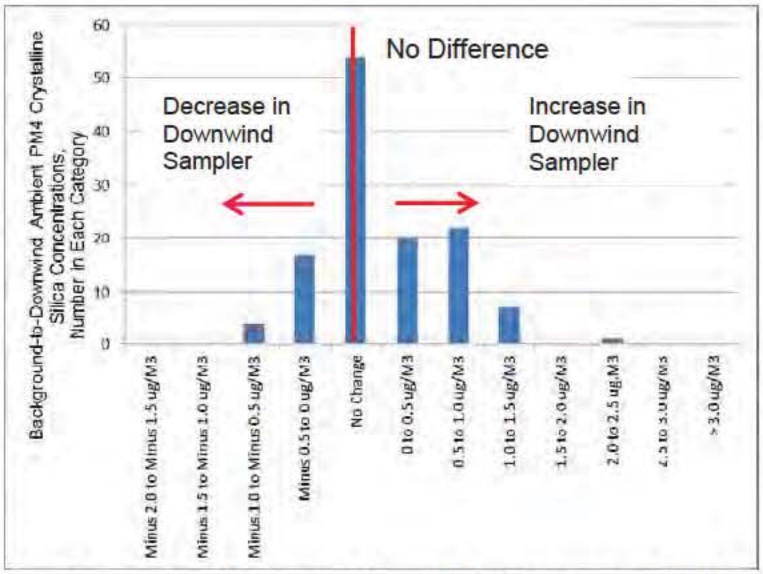

Figure 10. Number of Sampling Days with Upwind-to Downwind Differences in the PM4 Crystalline Silica Concentrations Measured at Maiden Rock

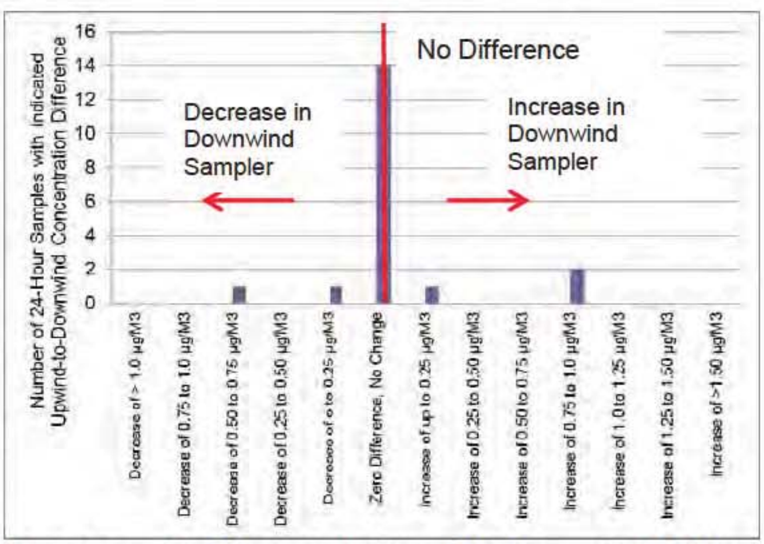

Figure 11. Number of Sampling Days with Upwind-to Downwind Differences in the PM4 Crystalline Silica Concentrations Measured at Downing

The very low ambient PM4 crystalline silica concentrations measured at both upwind and downwind sampling locations are also consistent with the very hard characteristics of crystalline silica that minimize formation of respirable particles. There is insufficient energy in both the industrial processes and community fugitive dust sources to form significant numbers of particles in the PM4 size range. The high moisture content of as-mined sand, along with wet suppression systems, and fugitive dust control systems used by the sand-producing facilities all contributed to the low ambient PM4 crystalline silica concentrations downwind of the facility.

The consistency of the PM4 particulate matter data at Maiden Rock, Downing, and Cataract sampling locations and the PM2.5 particulate matter data measured by DNR at the Eau Claire sampling location also indicate that the PM2.5 concentrations near the plants are well below the PM2.5 National Ambient Air Quality Standard (NAAQS) of 35 micrograms per cubic meter. None of the 570 daily average PM4 particulate matter concentrations exceeded the NAAQS. The PM2.5 levels at the Maiden Rock, Downing, and Cataract are very similar to those at the Eau Claire sampling site.

2. PM4 Crystalline Silica Concentrations Measured by Others

Minnesota PCA—Since DNR prepared the 2011 Silica Study, the Minnesota Pollution Control Agency (MPCA) has conducted PM4 crystalline silica sampling in Winona and Stanton, Minnesota. The Winona sampling location was on a building downwind from a sand loading operation. The Stanton sampling location was in a farming area without any sand mining or processing activities. The Winona and Stanton data are available on the MPCA website and in Reference 6.

MPCA used PM4 crystalline silica sampling and analytical procedures that are essentially identical to those used at the EOG facilities in Wisconsin. They sampled every sixth day, a frequency that is one-half the sampling frequency at Maiden Rock.

MPCA has released data compiled from January through August of 2014. They made thirty 24-hour measurements at Winona. Twenty-eight of these measurements were below their limit of quantification of 0.30 micrograms per actual cubic meter. Two of the thirty measurements were between 0.30 and 0.40 micrograms per actual cubic meter. The Winona data set is very similar to measurements made at the Maiden Rock and Downing facilities in Wisconsin.

MPCA has also conducted PM4 sampling in the Stanton agricultural area. Nine of the twenty-four measurements were above the limit of quantification of 0.30 micrograms per actual cubic meter. The maximum value measured over the eight-month period was 0.80 micrograms per cubic meter. This maximum concentration was consistent with maximum values measured at the Maiden Rock, Downing, and Cataract sampling locations in Wisconsin.

Both the Winona and Stanton sampling data sets indicate that PM4 crystalline silica concentrations are low in both urban areas with sand-handling activities and rural areas without sand handling operations. All of the Minnesota data, like the Maiden Rock, Downing, and Cataract data, are in the normal background range for the Upper Midwest.

Minnesota Sand-Producing Facilities—Two sand-producing facilities in Minnesota have reported PM4 crystalline silica data.[7,8] Their sampling procedures have slightly higher limits of quantification. All of the data compiled at these sites are well below the OEHHA chronic reference level, and most of the measurements are below their limit of quantification. These recently released data are available on the Minnesota Pollution Control Agency website.

South Coast Air Quality Management District Sampling in Duarte, California—The South Coast Air Quality Management District (SCAQMD) independently developed a PM4 crystalline silica sampling procedure similar to the procedures of Richards and Brozell used in the Maiden Rock, Downing, and Cataract sampling programs. They conducted sampling for a three month period on the grounds of the Royal Oaks Elementary School in Duarte.[4,5] This school is several miles from two sand-producing plants to the south in Irwindale and two sand producing plants to the east and northeast in Azusa. The school is also close to I-210, I-605, and a dry Arroyo moving southwest from the San Gabriel Mountains. The SCAQMD measured a maximum concentration of 1.1 μg/M^3 during their study. Most of the data were at or close to their limit of quantification of 0.40 μg/M^3. None of the 24-hour measurements approached the OEHHA REL.

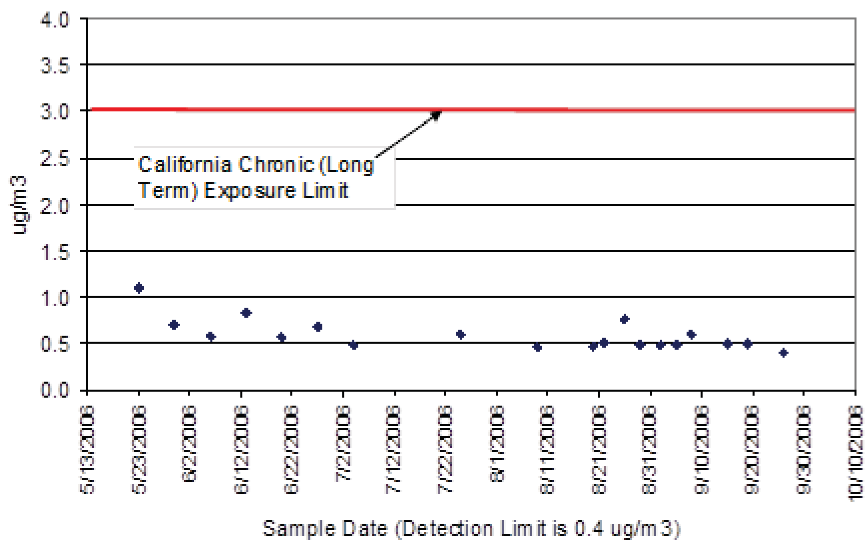

Figure 12. SCAQMD PM4 Crystalline Silica Data in Duarte, California

Wisconsin Sand-Producing Facilities—Air Control Techniques, P.C. has also conducted long-term ambient PM4 crystalline silica sampling programs at other facilities in Wisconsin. These data are being summarized in a separate submittal.

3. PM4 Crystalline Silica Sampling and Analysis Procedures

In 2004, Richards and Brozell[3] modified EPA reference method PM2.5 ambient samplers designed in accordance with 40 CFR Part 50, Appendix L to measure PM4 crystalline silica in ambient air. The flow through the sharp-cut cyclone in the PM2.5 sampler was modified to yield a 50% efficiency cut size of 4.0 micrometers instead of 2.5 micrometers—a relatively minor change. The performance of this instrument to provide PM4 rather than PM2.5 particulate matter data was confirmed by challenging the instrument with monodisperse, accurately-sized NIST-traceable microspheres.

Using this approach, well-established quality assurance requirements provided an effective means to minimize sample flow rate variability and to optimize filter weighing precision. Furthermore, the particle cut size curve of the adjusted Appendix L instruments was similar to that of NIOSH Method 0600. The main adjustment necessary to an Appendix L qualified sampler was a change in the 50% efficiency cut size of the instrument to adjust from PM2.5 to PM4.

The flow-adjusted samplers were operated with PVC filters to allow for NIOSH Method 7500 analyses of crystalline silica. This is a well-established method for crystalline silica analyses. This method is used extensively by OSHA and MSHA for analyses of samples from occupational exposure sampling programs.

The sampling and analysis procedures for PM4 crystalline silica have now been in use for over ten years and have worked especially well. Agencies, such as the Minnesota Pollution Control Agency have also adopted these procedures. The South Coast Air Management District independently developed a similar sampling and analysis method for their studies in California. Air Control Techniques, P.C. has used these sampling and analysis procedures in numerous studies.

During the August 2012 through March 2014 studies at Maiden Rock, Downing, and Cataract in Wisconsin, the PM4 crystalline silica sampling and analysis procedures worked well during all weather conditions. The seven samplers operated with an availability of over 98%. Each of the samplers passed biweekly audits and leak checks. Field blank filters consistently met EPA specifications. The precision of the samplers as indicated by the PM4 particulate matter data was excellent.

One of the main advantages of the sampling and analysis procedures is that they are available to anyone interested in conducting a methodical sampling program based solidly on well-established ambient monitoring principles and procedures. The PM4 samplers are identical to EPA reference method PM2.5 samplers used by DNR, many other state agencies, and the U.S. EPA. These PM2.5 samplers can be converted to PM4 samplers simply by adjusting the sample flow rate and changing to PVC filters instead of Teflon filters—adjustments that can be made easily. NIOSH Method 7500 is a well-established analytical method available for crystalline silica analyses. The extensive quality assurance procedures required for this type of study have been in routine use by EPA, state agencies, and industrial facilities for many years.

The sampling method used by Air Control Techniques, P.C. is a logical extension of the U.S. EPA's PM2.5 sampling procedures and NIOSH's crystalline silica analysis procedures. These PM4 crystalline silica sampling and analysis procedures have become generally accepted.

4. Discussion

The PM4 crystalline silica data summarized in this letter are not surprising. Previous studies in arid and semi-arid regions of the U.S. prone to much higher airborne fugitive dust emissions than Wisconsin have reported low ambient PM4 crystalline silica concentrations. The processes used at sand producing facilities have inherently low PM4 crystalline silica emissions due to (1) the high moisture levels of the sand in some of the process areas, (2) the high-efficiency fugitive dust capture systems used in areas where the sand has low moisture levels, and (3) insufficient energy levels used in the sand handling processes to reduce very hard crystalline silica particles down to the PM4 size range. While the entire mineral industry continues to work toward reduced in-plant worker exposure, the results of the sampling programs discussed in this letter indicate that emissions to the ambient air from sand mining and processing facilities are very small and result in ambient concentrations that are well within the range of regional background concentrations.

The ambient PM4 crystalline silica data compiled during the extensive sampling programs at the three facilities do not support claims made by individuals conducting short-term, limited sampling with hand-held instruments that are not specific for crystalline silica and are subject to significant biases. These flawed data used to support these claims should not be used to evaluate ambient PM4 crystalline silica air quality. Due to the very low concentrations of ambient PM4 crystalline silica, it is especially important to use ambient air sampling methods closely tied to U.S. EPA ambient sampling methods and crystalline silica analytical methods based on NIOSH procedures.

The PM4 crystalline silica data provided with this letter and the data compiled simultaneously at other Wisconsin sand-producing facilities will be available in the near future in peer-reviewed publications. Unfortunately, publication processes are relatively slow. DNR does not have to wait for these publications to confirm the accuracy of the data. DNR has a highly qualified and experienced ambient monitoring staff that can evaluate the data and supporting records provided with this letter.

5. Recommendations

The extensive ambient PM4 crystalline silica data set included with this letter will be very useful to DNR in addressing community concerns regarding ambient levels of crystalline silica in the vicinity of sand-producing facilities. These data demonstrate that PM4 crystalline silica concentrations at the fencelines of the sand-producing facilities are identical to the regional background concentrations. These data should be summarized in the document being prepared by DNR.

I have provided a summary of the PM4 crystalline silica data and extensive supporting sampling and quality assurance data for the 570 daily average values. I recommend that DNR evaluate all of these data to confirm the accuracy of the data and the consistency of the sampling procedures to well-established U.S. EPA and DNR ambient monitoring procedures. In a similar fashion, data provided by others should be critically evaluated as well. Data sets included and discussed in the DNR document have records that demonstrate that the data were obtained using (1) sampling methods specific for crystalline silica, (2) sampling quality assurance procedures (including audit and leak check procedures) similar to those required by EPA references, (3) samplers positioned in locations meeting EPA guidelines in 40 CFR Part 58, Appendix E, (4) sampling programs conducted over sufficient time periods to assess long-term average concentrations, and (5) sampling programs conducted in accordance with comprehensive protocols. Studies not meeting these basic requirements should be given little weight or emphasis in the document being prepared by DNR.

The fenceline sampling programs conducted at the three facilities discussed in this letter were performed to address a specific gap in available data identified in the DNR 2011 publication. The consistently low concentrations measured in this comprehensive sampling program along with the data from similar sampling programs in Wisconsin and Minnesota demonstrate that these specially-oriented fenceline sampling programs for PM4 crystalline silica are not needed on a long-term basis. The question raised by DNR has been answered—the PM4 crystalline silica levels near sand-producing facilities are similar to regional background concentrations in both rural farming areas and urban areas in the Midwest.

In the 2011 document, DNR correctly stated that regulatory programs already in place in Wisconsin to control particulate matter emissions and air quality provide protection to the communities near sand-producing facilities and other community, municipal, and industrial sources. The PM4 crystalline silica data in this submittal confirm DNR's conclusion. Residents near sand-producing facilities and community leaders with sand-producing operations in their jurisdictions should be assured by the DNR document that comprehensive and stringent emission controls are already in effect based on (1) DNR emission limits and permit requirements, (2) U.S. EPA NSPS Subpart OOO emission control requirements, and (3) MSHA in-plant exposure limits. This is a heavily regulated industry.

References

1. Wisconsin Department of Natural Resources. "Report to the Natural Resources Board: Silica Study." Report AM 407. 2011.

2. California Office of Environmental Health Hazard Assessment (OEHHA). "Chronic Toxicity Summary, Silica (Crystalline, Respirable)." February 2005.

3. Richards, J., T. Brozell, C. Rea, J. Boraston, and J. Hayden. "PM_4 Crystalline Silica Emission Factors and Ambient Concentrations at Aggregate-Producing Sources in California." Air and Waste Management Journal, Volume 59, Pages 1287-1296, November 2009.

4. South Coast Air Quality Management District. “Sampling and Analysis of Samples Collected in the Cities of Duarte and Azusa.” Report MA 2006-01, 2006.

5. South Coast Air Quality Management District. “AQMD Presents Council With Initial Results of Monitoring of Vulcan Mining Dust in Duarte.” Web-based article. 2006.

6. Minnesota Pollution Control Agency. “Winona-Community Ambient Air Monitoring.” June 24, 2014. Available at http://www.pca.state.mn.us/index.php/air/air-quality-and-pollutants/silica-sand.

7. Minnesota Pollution Control Agency. “Tiller-North Branch Ambient Air Monitoring.” April, 2014. Available at http://www.pca.state.mn.us/index.php/air/air-quality-and-pollutants/silica-sand.

8. Minnesota Pollution Control Agency. “Shakopee Ambient Air Monitoring.”_April, 2014. Available at http://www.pca.state.mn.us/index.php/air/air-quality-and-pollutants/silica-sand.

I have attached a CD that includes the voluminous raw data from the PM4 sampling programs conducted by Air Control Techniques, P.C. at the three facilities. I will be glad to address any questions that you may have concerning the sampling results and quality assurance records.

Thank you for considering this information in the DNR strategic analysis of ambient crystalline silica.

Regards,

John Richards, Ph.D., P.E.
President, Air Control Techniques, P.C.

Attachment: PM4 crystalline sampling supporting data and quality assurance information

Air Control Techniques, P.C.

301 East Durham Road
Cary, North Carolina 27513

Office (919) 460-7811
Fax (919) 460-7897

April 20, 2015

Sent via email: DNROEEAComments@wisconsin.gov

Mr. Chris Willger
Wisconsin Department of Natural Resources
1300 W. Claremont Avenue
Eau Claire Service Center
Eau Claire, Wisconsin 54701

Re: Wisconsin DNR Strategic Analysis of Ambient Crystalline Silica
PM4 Crystalline Silica Sampling at EOG Resources, Inc. facilities

Dear Mr. Willger:

I appreciate this opportunity to submit data and information concerning air quality in the vicinity of EOG Resources, Inc. (EOG) sand producing and processing facilities in Wisconsin. This letter addresses the following major data and information gaps that were discussed in the Wisconsin Department of Natural Resources (DNR) Silica Study[1] released in 2011.

1. "In summary, more research is needed in Wisconsin in order to ascertain the range of ambient air exposures likely to occur, both near sources of silica emissions as well as from background levels of exposure. … The best way to determine what crystalline silica impacts are near a source is to conduct monitoring, which as stated earlier, is very difficult to conduct." Page 17

2. "There are no generally accepted methods for monitoring PM4 in ambient air." Page 1

3. "A recurring theme from the literature review and survey is that very little conclusive information exists regarding sources, controls or levels of silica present in ambient air. This lack of data means it is not currently possible to determine conclusively whether or to what extent the quantity, duration or types of silica emissions in the state may be a public health concern. It would take significant additional efforts to fill in these data gaps." Page 2

Since the 2011 publication of the DNR Silica Study, EOG has made "significant …efforts" to help fill these gaps in information concerning ambient crystalline silica. This letter provides a summary of the data compiled by Air Control Techniques, P.C. at EOG facilities since 2012. These data are directly relevant to Section 2.1 of the DNR strategic analysis draft outline.

This submittal is divided into three major sections: (1) ambient PM4 crystalline silica data compiled by EOG from October 2012 through December 2014 at four EOG facilities, (2) supporting information from other sand-producing companies and regulatory agencies concerning ambient PM4 crystalline silica concentrations, and (3) information concerning the ambient PM4 crystalline silica sampling procedure that has become a "generally accepted method." I have also provided a short discussion section and recommendations.

1. Ambient PM4 Crystalline Silica Sampling Data

Ambient PM4 Crystalline Silica Fenceline Concentrations—Air Control Techniques, P.C. conducted ambient PM4 crystalline silica sampling at four EOG Resources, Inc. (EOG) facilities from October 2012 to the present. Sampling was conducted at the Chippewa Falls sand processing facility, at two sand mines in Chippewa County, and at one sand mine in Barron County. The purpose of these four sampling programs was to compile accurate ambient PM4 crystalline silica concentration data and to determine if the facilities contributed to increased downwind ambient PM4 crystalline silica concentrations.

Data compiled from October 2012 through December 2013 were provided in a comprehensive report to DNR dated March 31, 2013.[2] A second report summarizing data compiled from January 2014 through December 2014 was submitted to DNR on March 31, 2015.[3] Both reports include complete sets of field data sheets, audit and calibration records, laboratory results sheets, chain-of-custody sheets, and sampler operating data files.

A total of 2,128 sampling values, each representing a 24-hour measurement, are included in the data compiled by Air Control Techniques, P.C. and are being provided with this letter This is an exceptionally large data set that represents conditions from four different facilities operated through all four seasons under all weather conditions for more than a two-year period.

The ambient PM4 crystalline silica concentrations summarized in Tables 1 and 2 and Figures 1 and 2 were very low at all four facilities throughout the sampling periods. The long-term average concentrations ranged from 0.01 to 0.18 micrograms per cubic meter ($\mu g/M^3$)[1].

[1] The long-term average PM4 crystalline silica concentrations are based on LOQ values at 0.0 $\mu g/M^3$.

Table 1. PM4 Crystalline Silica Concentrations, 2014

EOG Facility and Sampling Location	Number of 24-Hour Samples	% of Samples Below LOQ of 0.3 μg/M^3	Long Term Average Concentration μg/M^3	% of Chronic Reference Level μg/M^3	Chronic Reference Level μg/M^3
Chippewa Falls 1	116	73.3	0.15	5.1%	3.00
Chippewa Falls 2	118	96.6	0.01	0.4%	
DS Mine 1	121	95.0	0.02	0.6%	
DS Mine 2	121	95.0	0.03	1.0%	
SS Mine 1	118	92.4	0.04	1.4%	
SS Mine 2	117	83.8	0.09	2.8%	
DD Mine 1	118	96.6	0.01	0.5%	
DD Mine 2	117	97.4	0.01	0.4%	

Table 2. PM4 Crystalline Silica Concentrations, October 2012-December 2013

EOG Facility and Sampling Location	Number of 24-Hour Samples	% of Samples Below LOQ of 0.3 μg/M^3	Long Term Average Concentration μg/M^3	% of Chronic Reference Level μg/M^3	Chronic Reference Level μg/M^3
Chippewa Falls 1	155	68.4	0.18	6.0%	3.00
Chippewa Falls 2	153	86.9	0.07	2.3%	
DS Mine 1	151	87.4	0.06	2.0%	
DS Mine 2	150	88.7	0.05	1.7%	
SS Mine 1	149	91.3	0.04	1.3%	
SS Mine 2	149	81.0	0.17	5.7%	
DD Mine 1	139	87.1	0.06	2.0%	
DD Mine 2	136	88.2	0.06	2.0%	

In Figures 1 and 2, the long-term average PM4 concentrations are compared to the PM4 crystalline silica lifetime continuous reference exposure level (REL) published by the California Office of Health Hazard Assessment (OEHHA)[4] These data demonstrate that the concentrations of ambient PM4 crystalline silica are well below the OEHHA chronic REL both upwind and downwind of the facilities sampled.

Mr. Chris Willger
Wisconsin Department of Natural Resources
April 20, 2015
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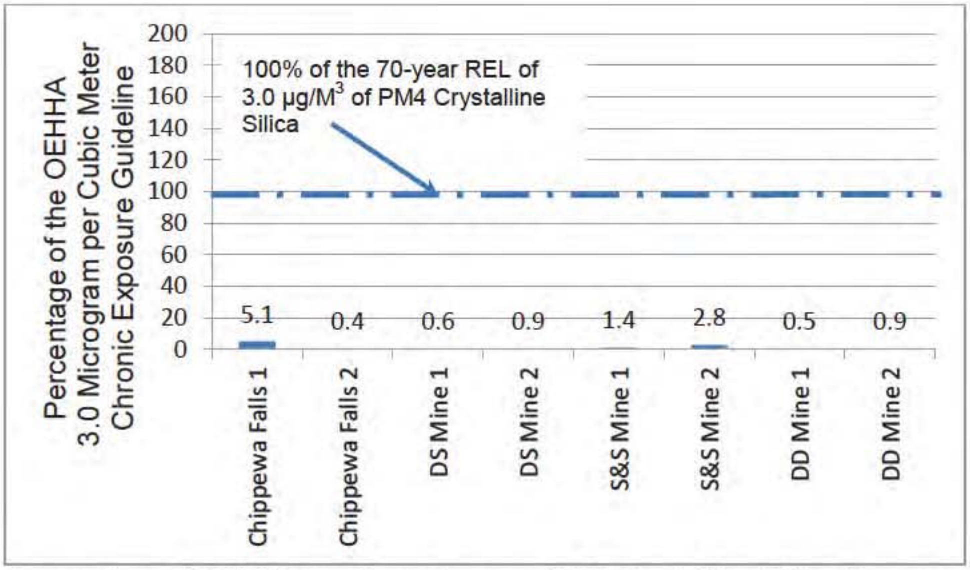

Figure 1. Comparison of 2014 Long-Term Average PM4 Crystalline Silica Concentrations and the OEHHA 70-year Chronic Exposure Reference Level

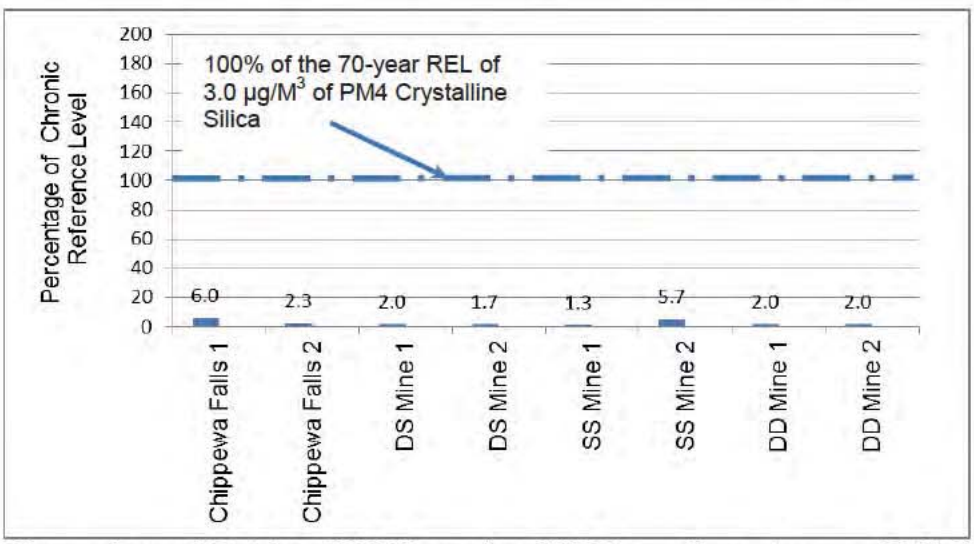

Figure 2. Comparison of October 2012-December 2013 Long-Term Average PM4 Crystalline Silica Concentrations and the OEHHA 70-year Chronic Exposure Reference Level

The similarities in the PM4 crystalline silica concentration at the two sampling stations at each facility and even the similarities in the concentrations measured simultaneously by samplers at most or all of the locations strongly indicate that most of the detectable values of ambient PM4 crystalline silica were due to day-to-day variations in the regional background concentrations.

Regional Background Concentrations of PM4 and PM2.5 Particulate Matter—The importance of the regional background concentrations is illustrated by the similarity in the PM4 particulate matter concentrations measured at Chippewa Falls and the PM2.5 concentrations measured by DNR at their Eau Claire sampling site. A day-to-day comparison of the Chippewa

Falls PM4 particulate matter data and the DNR PM2.5 particulate matter data is shown in Figures 3 and 4. The variations in concentration are due almost entirely to changes in the regional background concentrations of PM2.5.

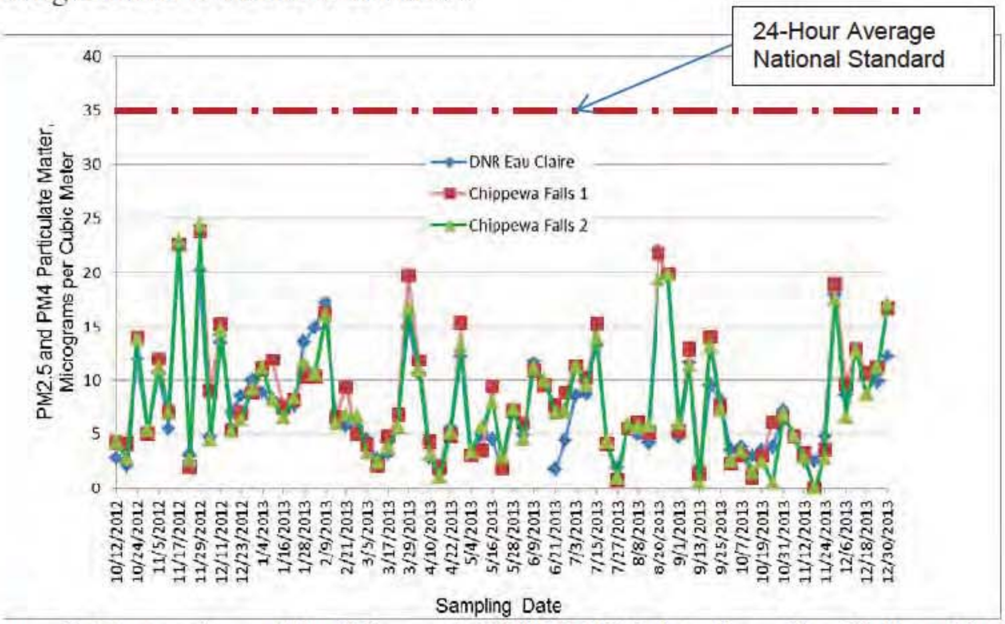

Figure 3. Comparison of the Wisconsin DNR PM2.5 data from Eau Claire with the PM4 Particulate Matter data from Chippewa Falls Locations 1 and 2, October 2012-December 2013

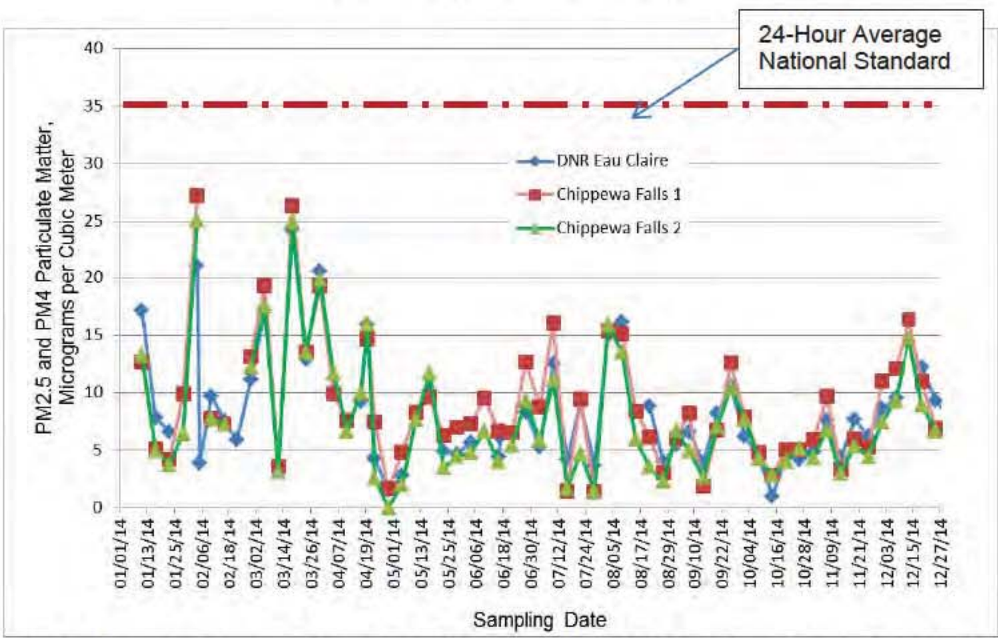

Figure 4. Comparison of the Wisconsin DNR PM2.5 data from Eau Claire with the PM4 Particulate Matter data from Chippewa Falls Locations 1 and 2, January 2014-December 2014

The regional background concentrations are due to the combined contributions of all of the sources of fugitive dust, such as agricultural sources, unpaved roads, wind erosion, global dust transport, and industrial emissions. The data compiled in this project indicate that these sources (including the EOG sand processing facilities and sand mines) do not collectively create ambient PM4 concentrations that exceed 6% of the OEHHA 3.0 $\mu g/M^3$.

These conclusions are consistent with previous ambient PM4 crystalline silica studies conducted by Richards and Brozell[5], the South Coast Air Quality Management District[6,7] using sampling and analytical procedures similar to those used in this project. Additional information concerning these earlier studies is available in the 2011 DNR report.[1]

The very low ambient PM4 crystalline silica concentrations measured at both upwind and downwind sampling locations are also consistent with the very hard characteristics of crystalline silica that minimize formation of respirable particles. There is insufficient energy in both the industrial processes and community fugitive dust sources to form significant numbers of particles in the PM4 size range. The high moisture content of as-mined sand, the wet suppression systems, and the fugitive dust control systems used by EOG all contributed to the low ambient PM4 crystalline silica concentrations downwind of the plant.

The consistency of the PM4 particulate matter data at Chippewa Falls and the PM2.5 particulate matter data measured by DNR at the Eau Claire sampling location also indicates that the PM2.5 concentrations near the plant are well below the PM2.5 National Ambient Air Quality Standard (NAAQS) of 35 micrograms per cubic meter. None of the 2,128 daily average PM4 particulate matter concentrations exceeded the NAAQS. The PM2.5 levels at the Chippewa Falls plant are very similar to those at the Eau Claire sampling site.

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5. Recommendations

The extensive ambient PM4 crystalline silica data set included with this letter will be very useful to DNR in addressing community concerns regarding ambient levels of crystalline silica in the vicinity of sand-producing facilities. These data demonstrate that PM4 crystalline silica concentrations at the fencelines of the sand-producing facilities are identical to the regional background concentrations. These data should be summarized in the document being prepared by DNR.

I have provided a summary of the PM4 crystalline silica data and extensive supporting sampling and quality assurance data for the 2,128 daily average values measured through December 2014. I recommend that DNR evaluate all of these data to confirm the accuracy of the data and the consistency of the sampling procedures to well-established U.S. EPA and DNR ambient monitoring procedures. In a similar fashion, data provided by others should be critically evaluated. Data sets included and discussed in the DNR document should be supported by records that demonstrate that the data were obtained using (1) sampling methods specific for crystalline silica, (2) sampling quality assurance procedures (including audit and leak check procedures) similar to those required by EPA references, (3) samplers positioned in locations meeting EPA guidelines in 40 CFR Part 58, Appendix E, (4) sampling programs conducted over sufficient time periods to assess long-term average concentrations, and (5) sampling programs conducted in accordance with comprehensive protocols. Studies not meeting these basic requirements should be given little weight or emphasis in the document being prepared by DNR.

The fenceline sampling programs conducted at the four facilities discussed in this letter were performed to address a specific gap in available data identified in the DNR 2011 publication. The consistently low concentrations measured in this comprehensive sampling program along with the data from similar sampling programs in Wisconsin and Minnesota demonstrate that these specially-oriented fenceline sampling programs for PM4 crystalline silica are not needed on a long-term basis. The question raised by DNR has been answered—the PM4 crystalline silica levels near sand-producing facilities are similar to regional background concentrations in both rural farming areas and urban areas in the Midwest.

In the 2011 document, DNR correctly stated that regulatory programs already in place in Wisconsin to control particulate matter emissions and air quality provide protection to the communities near sand-producing facilities and other community, municipal, and industrial sources. The PM4 crystalline silica data in this submittal confirm DNR's conclusion. Residents near sand-producing facilities and community leaders with sand-producing operations in their jurisdictions should be assured in the DNR document that comprehensive and stringent emission controls are already in effect based on (1) DNR emission limits and permit requirements, (2) U.S. EPA NSPS Subpart OOO emission control requirements, and (3) MSHA in-plant exposure limits. This is a heavily regulated industry.

References

1. Wisconsin Department of Natural Resources. "Report to the Natural Resources Board: Silica Study." Report AM 407. 2011.

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3. EOG Resources, Inc. Letter to Mr. Jason Treutel, Wisconsin DNR, March 31, 2015

4. California Office of Environmental Health Hazard Assessment (OEHHA). "Chronic Toxicity Summary, Silica (Crystalline, Respirable)." February 2005.

5. Richards, J., T. Brozell, C. Rea, J. Boraston, and J. Hayden. "PM_4 Crystalline Silica Emission Factors and Ambient Concentrations at Aggregate-Producing Sources in California." Air and Waste Management Journal, Volume 59, Pages 1287-1296, November 2009.

6. South Coast Air Quality Management District. "Sampling and Analysis of Samples Collected in the Cities of Duarte and Azusa." Report MA 2006-01, 2006.

7. South Coast Air Quality Management District. "AQMD Presents Council With Initial Results of Monitoring of Vulcan Mining Dust in Duarte." Web-based article. 2006.

8. Minnesota Pollution Control Agency. "Winona-Community Ambient Air Monitoring." June 24, 2014. Available at http://www.pca.state.mn.us/index.php/air/air-quality-and-pollutants/silica-sand.

9. Minnesota Pollution Control Agency. "Tiller-North Branch Ambient Air Monitoring." April, 2014. Available at http://www.pca.state.mn.us/index.php/air/air-quality-and-pollutants/silica-sand.

10. Minnesota Pollution Control Agency. "Shakopee Ambient Air Monitoring." April, 2014. Available at http://www.pca.state.mn.us/index.php/air/air-quality-and-pollutants/silica-sand.

I have attached a CD that includes the voluminous raw data from the PM4 sampling programs conducted by Air Control Techniques, P.C. at four facilities from October 2012 through December 2014. I will be glad to address any questions that you may have concerning the sampling results and quality assurance records.

Thank you for considering this information in the DNR strategic analysis of ambient crystalline silica.

Regards,

John Richards, Ph.D., P.E.
President, Air Control Techniques, P.C.

Attachment: PM4 crystalline sampling supporting data and quality assurance information

eog resources

EOG Resources Inc.
421 West Third Street, Suite 150
Fort Worth, TX 76102

April 20, 2015

Mr. Chris Willger
WDNR, Eau Claire Service Center
1300 W. Clairemont
Eau Claire, WI 54701

RE: Wisconsin Department of Natural Resources (WDNR) Industrial Sand Mining Strategic Analysis

Dear Chris,

Protecting the environment and quality of life in Wisconsin is important to everyone, and EOG Resources, Inc. (EOG) appreciates the opportunity to provide comments on the *Strategic Analysis for Sand Mining in Wisconsin Draft Topics Outline* (March 21, 2015).

Section 1 Industrial Sand Mining

Section 1 of the draft topic outline closely mirrors the WDNR January 2012 Sand Mining Report. Recommendations to improve accuracy and understanding are described below.

1.2 Current Markets.

Comment: remove or simplify this section. Including 'current' markets or trends can rapidly date published reports. For this reason, this section should be removed or simplified for hydraulic fracturing markets such as, "the growth of industrial sand mining for use in hydraulic fracturing is part of a long-term, national strategy to develop domestic sources of energy." If WDNR intends to keep this section, markets for all sand mining industries such as glass, foundry sand or bedding should be represented as well.

1.3 Explanation of Hydraulic Fracturing.

Comment: remove this section. Hydraulic fracturing is not an element of industrial sand mining in Wisconsin, it is an end use for sand products, similar to concrete, molds for ferrous castings, or glass. Confusion as to if and where hydraulic fracturing is occurring in Wisconsin has been created as a result of this focus. If WDNR intends to keep this section, clarification and an explanation of all end uses for industrial sand should be represented.

1.4 Location of Sand Resources.

Comment: provide clarity to this section. Less than 1% of the land area in Wisconsin is used for nonmetallic mineral extraction, and only a portion of this land area is for industrial sand mining (see WDNR 2014 NR 135 Summary Report). While resources can only be extracted where they occur in nature, it must be made clear that sand mining is not occurring over a large portion of the State as resource maps may unintentionally suggest.

Section 2 Environmental Topics

Section 2 of the draft topic outline is valuable since much has been learned and should be shared as a result of scientific research at the State and local level over the last few years. A sampling of this research is provided, along with recommendations for making this information available to the public as part of the Strategic Analysis below.

2.1 Air Quality.

Comment: share up-to-date research and expand public understanding of air quality issues. In December, 2011, EOG partnered with Dr. John Richards, Air Control Techniques, P.C., to develop a sampling program aimed at measuring ambient levels of respirable (PM4) crystalline silica. The purpose of the program was to measure background levels of PM4 crystalline silica and determine whether EOG facilities contribute to increased downwind ambient PM4 crystalline silica concentration. The voluntary program used well-established sampling and analysis protocols developed by NIOSH and the EPA. Sampling and weather data was provided to WDNR to add to the body of knowledge on PM4 crystalline silica (see letters to Jason Truetel dated March 31, 2014 and March 31, 2015).

Sampling program results indicate that measurements of PM4 crystalline silica are consistently low and well within measured background concentrations at all four EOG facilities. These data coincide with ambient air sampling results for particulate matter conducted by the WDNR, and data in recently published reports such as *Wisconsin Air Quality Trends*, April 2014, WDNR Publication AM-523-2014.

Separate, science-based research is underway to further characterize air quality. For example, UW Eau Claire Department of Geology has an ongoing study looking at the composition of sandstone cement under the direction of Dr. Brian Mahoney. The main idea is that fine-grained particulate matter liberated during mining and processing is primarily derived from interstitial material, not the sand grains themselves. The study has been active for two years. So far researchers have documented very little (<1%) interstitial silica cement.

As another example, the University of Minnesota Duluth, Natural Resource Research Institute (NRRI) is collaborating with Dr. Patricia Cleary, an atmospheric chemist at UW Eau Claire, to launch a comprehensive regional analysis of airborne particulate matter, which will be an expansion of the studies conducted by Dr. John Richards over the last several years.

Community members, regulators and decision makers in all levels of government deserve science-based, accurate, easy-to-understand, and up-to date information about crystalline silica in the ambient air. In order to expand public understanding of air quality issues, conclusions from these and other, science-based research projects must be made available to the public with adequate background information including:

- particulate matter and crystalline silica (what it is and how it is formed)
- characteristics of coarse and fine particles (formation, composition, source)
- particulate matter standards and guidelines (EPA, MSHA/OSHA, California OEHHA)
- accepted ambient air and occupational health sampling methods
- influences on concentrations of crystalline silica in the ambient air
- differences between occupational health and ambient air exposures of PM4 crystalline silica
- health effects due to long-term exposure to ambient PM4 crystalline silica
- analysis of verified data collected by WDNR and others through approved sampling protocols

2.2.2 Surface Water Quality.

Comment: Update WDNR design standards for storm water controls and share with interested groups. Last year, EOG examined the effectiveness of our surface water treatment systems designed to meet current WDNR standards, and adjusted them to improve removal of colloidal clays. A similar review is underway at the Department in conjunction with the reissuance of the WDNR nonmetallic mining storm water permit, and should be shared with interested groups as part of the Strategic Analysis prior to issuance of the new general permit.

2.2.3 Ground Water Quality.

Comment: share up-to-date research and expand public understanding of ground water quality. The WDNR has a vast amount of resources, personnel, and information on ground water quality on its online water supply page that should be incorporated into the Strategic Analysis for Sand Mining.

2.2.4 Groundwater Quantity.

Comment: share up-to-date research and expand public understanding of ground water quantity. WDNR statistics indicate agricultural irrigation is the major ground water user in the state, and sand mining accounts for less than 1% (see presentation March 19, 2015 by WDNR Bob Smail, at http://www.wrpr.com/Articles/FracSandSeminar/GroundwaterUseandManagementinWI.pdf). In October, 2012, EOG partnered with other public and industry stakeholders to support science-based research to understand the cumulative impacts of changes in ground water recharge and ground water use on water resources in West-Central Wisconsin through the Chippewa County Department of Land Conservation and Forest Management, the United States Geology Survey, and the Wisconsin Geological and Natural History Survey.

An interim report for the 5-year study, *Chippewa County Groundwater Study-Interim Report*, March 13, 2015, is available on the Chippewa County website. A final report is due in Fall, 2017. Consider including interim report conclusions in this section of the Strategic Analysis to provide accurate and up-to-date information on ground water quantity. Consider also developing fact sheets to aid local governments in better understanding relevant issues and regulations associated with nonmetallic mining, such as *Understanding Groundwater*, distributed by the Aggregate Producers of Wisconsin.

Section 3 Socioeconomic Topics

Comment: share up-to-date research and expand public understanding of socioeconomic topics. Socioeconomic issues are generally addressed by planning commissions and other units of local government. The Strategic Analysis is welcomed as a tool to bring facts and science to the forefront and bridge solutions. Consider assisting local governments navigate issues such as noise, transportation or property values through the development of fact sheets containing accurate information sources and solutions, as well as recommendations to promptly address unresolved resident and/or community concerns.

Thank you for this opportunity to provide comments. If you have any questions, please contact me at Tim_Wernicke@eogresources.com.

Sincerely,

Tim Wernicke

Tim Wernicke
General Manager

March 10 2015

Dear Mr Willger

This is in regards to the strategic analysis of industrial frac sand and mining frac.

As a cancer survivor I am very concerned about any frac mining or frac sand handling in eastern St Croix County and western Dunn County.

The dust from these faciliti are very dangerous to the people. And why do these company come up here into a heavy populated area. We have seen silica in Arizona and Texas, where there isnt many people. Is it because these states have kicked these Co. out of there ???

I have driven through Roskin Wisc the sand wash, you can see all the dust particles in the air. My throat got sore and tight. till about 12-14 miles away from these Silica (frac sand) causes cancer. And we have enough of that dease already.

I followed a truck from the Knapp pit. and had the same effect on my throat also. Please check with Mr Chrispen Pierce PHD from Eau Claire on the air quality.

This dust is far far more cancer causing and harmful than wood burning stoves.

Silica warnings are on all paint products and whereever it is put. But we are not exposed to the fumes of that 24-7.

Please also look up the film "The price of sand" on "fracking sand @ g mail." Com. this is a real eye opener on frac sand mining.

So please really really consider the people who live near these areas some are cancer survivors and it is detrimental to these people as well as our children.

Thank you for reading this, cancer is truly no fun to fight. So it is up to you to help see that people exposed to this dust is just as horrible.

Thanks again.

[redacted]

April 17, 2015

Chris Willger

WDNR

1300 West Clairemont Ave.

Eau Claire, WI 54701

Dear Chris Willger:

I am writing comments and concerns I have about sand mining in Northwestern Wisconsin per an article in the Eau Claire Leader of March 20, 2015.

I have been a resident of Chippewa County for over 30 years and was born and raised in Barron County, both counties having numerous sand mines and processing plants. I don't think I have ever seen such mass destruction of the countryside I and so many others have loved for decades and generations. Barron County looks like it was hit by a bomb, especially the southwestern part where there is heavy mining. Most of the farmers and residents who sold out to the sand companies are living with the destruction around them; how they tolerate the noise, dust, and destruction is beyond my comprehension. Many mines are near creeks and dry runs we know they pollute, and one is so close to our family cemetery you can feel the earth shake when you visit family graves. This is very disturbing.

But my main concern, beside the destruction of our beautiful countryside and state, is the health problems not being addressed. We live about 3-4 miles from the sand processing plant in Chippewa Falls. The sand companies declare there is no or very little pollution from this plant. Please let me tell you differently. We have driven near the plant in <u>many</u> different types of weather conditions. There have been many times, even from a long distance, that you can see a large brown haze and cloud spreading from the plant and when the wind picks it up, it is all over. The sand company declares this is not a problem. Those people with respiratory conditions are completely at risk due to this and the other processing plants in the area as the wind takes the silica sand <u>everywhere</u> – it has no boundaries. And there is a great concern for the water quality where the fracking is being done. I've heard reports that in some areas water is disappearing, and/or being polluted

Where all of this sand mining is going is really disturbing as more and more land is being obtained and our state is being "sold out," or as Wisconsin is known now as, "open for business." Who knew it would be at the cost of the very land we walk on and the air we all breathe? The medical community also needs to take a closer look at the effects of silica sand mining. Many of them are not even aware of what is going on with sand mining and how their patients may be affected.

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I know my comments are probably repetitious to concerns you have already heard, but where does it all end? I know this letter echoes the concerns of so many people. Please let my comments be of some use and understanding to the DNR, who I hope will defend land usage, along with human health, and limit sand mines in Wisconsin. Please protect Wisconsin citizens from the effects for decades and more to come. Thank you.

Sincerely,

[redacted]

R.E. "Frac" Sand Mines Survey [redacted]

To Whom It May:

Let me begin by saying that I no longer trust the DNR to protect either the people or the environment in Wisconsin. Walker and his Tea Party Legislature, State Supreme Court and AG's office are collectively owned by corporate America. The head of the DNR is an ignorant Walker appointee, so she only does as told. There are, sadly, a lot of employees who joined the DNR because they believed they could protect and preserve the vast natural resources of this state; trained professionals who've found their hands are tied and their voices gagged.

Only the Director (or whatever her title is!) can set policy, and DNR employees can't challenge or disagree with her/Walker's wishes. He's taken millions from miners... we'll have mines in spite of their environmental impacts. This "survey", for all the hype, will have all the impact of a fart in a tornado: NONE!!!

For all your pretense, you'll totally ignore the public's input and go on, business as usual. Since you already have all the biology, botany, hydrology, atmospheric, etc., etc. experts, asking us dumbasses what the impact of these mines are is, at best, disingenuous, and at its worst pure political bullshit. I really believe this, and believe your "findings" will prove my conviction.

A group I'm part of tried to get straight talk out of Deborah Dix about Hi-Crush's Augusta mine, and got bureaucratic psycho-babble. Very shortly after our meet, Dix was promoted from investigating mines to representing them as a "Liason Officer", and Hi-Crush (following a lot of burr-under-the-saddle letters to the AG's officers) was fined — Rah-rah! — a grand total of 50 G's for its numerous violations. And two (2) railroad carloads of sand paid that!

But then ... the AG's from what political freaking party ...?!? The fix is in, boys!

Your Agency, the sacred DNR, TWICE tried to submit mining company's EIS at Ladysmith's gold/copper mine as "approved". Your DNR would have gotten away with it, too, except that scientists from half-a-dozen Universities proved you were only reitering corporate lies. And Rio Tinto, at that! You keep really impressive company.

You people tried to put the Penokee Hills gang's iron mine on the fast track, too, and I think you ran up against some pissed-off Anishinabe and Ho Chunk folks. THEY got money enough to tie those miners up in court for years, and that's why they've pulled out. At least for now. But it's obvious to us in the field, fighting to save our environments, our homes — Hell, our lives! — from silica sand mines, that the WDNR is both unable and unwilling to actually assist the people; your masters (the Gov + his minions) are owned by Corporate America, and you are protecting your jobs. In this country, everything is about money, and morality is just another commodity for sale. Sad but true.

And, PLEASE: spare us all your selfish, righteous indignation. Walker and his legislature, your masters, wanted the mines to have carte blanche, so if I threw a beer can into a two-mile creek, I got arrested; a mine could destroy that creek by filling it with wastes