



HEALTH IMPACT ASSESSMENT

OF INDUSTRIAL SAND MINING IN WESTERN WISCONSIN

Cover photo: Dan Young

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TABLE OF CONTENTS

<i>Table of Contents</i>	3
<i>List of Figures</i>	4
<i>List of Tables</i>	4
<i>Acknowledgements</i>	5
<i>Executive Summary</i>	7
<i>Section 1: Introduction</i>	9
Context	10
Relevance.....	11
<i>Section 2: Methods</i>	15
Screening.....	15
Scoping.....	17
Assessment	20
Recommendations.....	21
Reporting and Dissemination	22
Monitoring and Evaluation	22
<i>Section 3: Community Health Profile</i>	23
Demographic Characteristics	23
Social and Economic Characteristics	24
<i>Section 4: Air Quality</i>	29
Connection Between Air Quality and Health	29
Existing Local Conditions	30
Potential Health Impacts.....	37
Summary	39
Recommendations.....	42
<i>Section 5: Water Resources</i>	45
Connection Between Water Resources and Health	45
Existing Local Conditions	45
Potential health impacts	48
Summary	51
Recommendations.....	54
<i>Section 6: Land Reclamation & Land Value</i>	59
Connection Between Land Reclamation, Land Value & Health	59
Existing Local Conditions	60
Potential health impacts	62
Summary	66
Recommendations.....	69
<i>Section 7: Quality of Life</i>	73
Connection Between Quality of Life & Health	73
Existing Local Conditions	74
Economics	75
Potential health impacts	76
Summary	80
Recommendations.....	83
<i>Conclusion</i>	87
<i>Appendix A Regional Asthma Data</i>	89
<i>Appendix B Industry Relations Examples</i>	91

LIST OF FIGURES

Figure 1.1. Industrial sand mines and processing facilities in Wisconsin	11
Figure 1.2 HIA scope and partner communities	12
Figure 4.1 Particulate matter size comparison.....	31
Figure 4.2 PM10 and PM2.5 air monitoring locations.....	32
Figure 4.3 PM10 monitoring data from industrial sand facilities.....	33
Figure 4.4 PM4 monitoring data from industrial sand facilities.....	37

LIST OF TABLES

Table 2.1 HIA research questions	18
Table 3.1 Level 1 Partner demographics	23
Table 3.2 Ho-Chunk enrollment and demographics	24
Table 3.3 Level 1 Partner socio-economic characteristics	25
Table 3.4 Level 1 Partner employment in mining	25
Table 3.5 Level 1 Partner clinical care and health outcomes	27
Table 4.1 National Ambient Air Quality PM10 and PM2.5 Standards	31

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EXECUTIVE SUMMARY

This health impact assessment (HIA) was performed by the Institute for Wisconsin's Health in collaboration with 15 local and tribal health departments in western Wisconsin. The impetus for the assessment was the recent rapid growth of industrial sand mining in western Wisconsin, and related concern from community members about potential environmental and health impacts of industrial sand mining. Four focus areas were selected for further study during the scoping process of this HIA: air quality, water resources, land reclamation and value, and quality of life.

There has been industrial sand mining in Wisconsin for over 100 years. However, the number of industrial sand mines has dramatically increased over the past 10 years. "Industrial sand" includes sand mined for industrial uses as diverse as glass, foundry, water treatment, and hydraulic fracturing. Hydraulic fracturing, commonly called fracking, is a process used by the energy industry to maximize the recovery of oil and gas from deep rock formations. When industrial sand is injected into rock, it props open fractures and allows oil and gas to flow into the well. In 2014, Wisconsin was the nation's largest supplier of industrial sand for oil and gas drilling, providing nearly 44% of the sand used in the United States. Wisconsin sand is desirable for its strength, uniformity, and ability to be shipped by rail to regions where fracking occurs.

The audience for this report is primarily local and tribal health departments, though other interested stakeholders will find the assessment and recommendations relevant. We recommend that this HIA be used in decision-maker discussions about the potential health effects of existing and proposed industrial sand facilities.

This assessment examines the potential positive and negative health impacts of various aspects related to existing and potential future industrial sand facilities in the context of western Wisconsin. Based on this structure, the reader should note that some potential impacts will be specific to the site and community of an existing or proposed facility.

SYNTHESIS OF FINDINGS

This HIA found that the potential exists for both positive and negative health effects from industrial sand mining. For purposes of this report we have characterized the likelihood of potential positive or negative health effects on a spectrum from "insufficient evidence" to "very likely" See page 20-21 of the full report for more information.

AIR QUALITY

Health effects from the impact of industrial sand mining on community-level air quality related to PM₁₀ⁱ are unlikely. In addition, it is unlikely that community members will be exposed to respirable crystalline silica from industrial sand mining as currently regulated; therefore, health effects from exposure are unlikely. Data collected at several facilities in the upper Midwest do not indicate that health-based standards have been exceeded in regard to these potential pollutants.

What is Health Impact Assessment?

Health impact assessment is an unbiased and scientific assessment of the potential positive and negative health effects of a proposed project, program or policy. HIAs are used to inform decision makers of the potential health implications, and provide recommendations to maximize positive health benefits, and reduce negative health outcomes.

ⁱ Particulate matter with an aerodynamic diameter below 10 µm. This size range is generally able to travel into the upper airway and is regulated by national air quality standards.

Why conduct an HIA on sand mining?

The rapid development of the industrial sand industry in Wisconsin and other upper-Midwestern states has generated a number of questions by community members and policy makers regarding potential health risks or benefits to the community. Concerns raised range from environmental topics to changes in local economics and lifestyle. Differing opinions on risks, benefits, and community values have led to divisions within and among many communities regarding whether industrial sand mining should continue in western Wisconsin.

WATER RESOURCES

The potential for health effects from impacts to *groundwater quantity* is possible. Industrial sand mining facilities that withdraw groundwater have the potential to impact surrounding wells and surface water features. However, these impacts are highly site specific and localized. If health effects do occur, the most common effects are expected to be related to stress or anxiety experienced by a limited number of individuals.

Health effects from contaminant impacts to *groundwater quality* are unlikely. In the event that water-soluble polymers are released into groundwater, impurities are expected to readily degrade and would be significantly diluted before they could come in contact with drinking water users near industrial sand sites.

LAND RECLAMATION AND VALUE

Health effects (positive or negative) from reclamation of industrial sand mines are unlikely. No community-level health effects from reclaimed industrial sand mines in Wisconsin have been identified, and reclamation plans implemented in accordance with NR 135 are likely to prevent health hazards at a mine site.

Health effects from impacts to land value from an industrial sand facility are possible. The potential for health effects is highly site specific and depends on a range of factors. The most likely negative health effects due to impacts to land value are feelings of stress for landowners who want to sell their property, especially if they experience difficulty selling it. Impacts to land value are expected to be localized, and not community-wide.

QUALITY OF LIFE

Health effects from the impact of industrial sand mining on cultural heritage or sense of place are likely. This finding does not imply that these effects will be widespread, but some individuals are likely to experience health effects.

Economic impacts from industrial sand mining are likely. Impacts may be positive or negative and will be highly dependent on the community, facility, and individual. The direction of economic impacts may change over time.

Health effects from traffic, light, and noise are possible, though they will be highly dependent on the proximity of residents to industrial sand facilities, facility design, and other factors. If health effects do occur, the most common effects are expected to be stress or annoyance from traffic or nuisance levels of light and noise.

RECOMMENDATIONS

This assessment holds two overarching recommendations for proposed or existing industrial sand facilities:

1. Development of industry standards that help to promote thoughtful review, policy, and project development, as well as positive relationships with community members, and,
2. Representation from local, tribal, or regional public health departments as part of the local permitting or review process.

Focus area-specific recommendations were also developed in consultation with community and industry partners. Those recommendations are found in the full report.

SECTION 1. INTRODUCTION

This health impact assessment examines the potential health impacts (both positive and negative) of industrial sand mining in western Wisconsin. The World Health Organization defines Health Impact Assessment (HIA) as “A combination of procedures, methods, and tools by which a policy, program, or project may be judged in terms of its potential effects on the health of a population and the distribution of those effects within the population.”¹ HIAs are conducted to inform decisions about policies, programs, or projects by analyzing the potential health benefits or risks associated with the decisions. After analyzing health data and input from stakeholders, HIA research teams develop recommendations that decision makers can use to make decisions. The intent of the HIA process is that decision makers will use the findings to reduce (or eliminate) the negative impacts on health and maximize positive health impacts.

The primary audience for this HIA is leadership from local and tribal health departments in western Wisconsin. These governmental public health departments are charged with promoting and protecting health in communities in a nonpartisan manner, and on a daily basis they work with a broad array of community stakeholders. The results of this HIA will also be useful to communities outside of western Wisconsin in which industrial sand mines currently operate or may operate in the future.

This HIA discusses four focus areas that relate to potential health impacts from industrial sand mining at the community level: air quality, water resources, land reclamation and value, and quality of life. It is outside the scope of this report to provide an in-depth explanation of industrial sand mining processes, environmental impacts, and applicable regulations in Wisconsin. Interested readers should refer to the 2016 Wisconsin Department of Natural Resources Strategic Analysis (in progress at the time of publication of this HIA) for these additional.

The Institute for Wisconsin’s Health, Inc. (IWHI) prepared this assessment with technical assistance from Habitat Health Impact Consulting and the Health Impact Project. This HIA was undertaken to inform pending decisions in four communities in western Wisconsin: Eau Claire County, Pierce County, Trempealeau County, and the Ho-Chunk Nation. Health department leadership in each of these communities served as principal advisors for the assessment process. These health departments had a vested interest in protecting the health of the public, a desire for more information on industrial sand mining, and a day-to-day working relationship with stakeholder groups.

In order to provide the most relevant findings and recommendations in the local context, this HIA modified the traditional HIA approach in two ways:

- 1) Rather than assessing the potential health impacts of a single proposed project, this HIA assesses the industrial sand mining industry in a region.

Industrial sand mining was already occurring in or near each of these communities prior to the inception of this HIA. This report can be used to inform pending or future decisions regarding industrial sand mining in western Wisconsin communities.

2) By focusing on the industry of sand mining, this HIA covers the large geographical region of 14 counties and the Ho-Chunk Nation, which operates its own tribal health department.

These modifications precluded the ability of this research team to conduct site-specific analyses of any single industrial sand facility. However, similarities between facilities within the industry and between communities near sand mines do allow for thorough and scientific review and understanding of potential health impacts of industrial sand mining in Wisconsin. Potential health impacts may be experienced differently among communities in the study area. As a result, potential health impacts indicated in this report should be understood in the context of local conditions.

CONTEXT

Industrial sand mining has been occurring in Wisconsin for over 100 years; however, the number of industrial sand mines in the state has dramatically increased over the past 10 years. As of September 1, 2015, there were 85 active industrial sand facilities in Wisconsin.² “Industrial sand” includes sand mined for industrial uses as diverse as glass, foundry, water treatment, the oil and gas industry, and other applications. Sand is used by oil and gas developers to increase the amount of the resource that can be recovered from a single well through hydraulic fracturing, or “fracking”.³ Fracking involves injecting, at very high pressure, sand and fluids into deep rock layers. When the sand is injected into the rock, it props open fractures in the rock and allows oil and gas to flow out of the rock and into the well. One term for sand used for this application is “frac sand”. In the last 15 years, horizontal drilling technology (as opposed to traditional, vertical drilling) has allowed for the development of additional oil and natural gas resources that were not previously economically viable. This specific development has contributed to the industrial sand “boom” over the last 10 years in Wisconsin and other parts of the country.

Because “frac sand” describes only a subset of the sand mined in Wisconsin, this report will instead use the term “industrial sand” in reference to the industry. In 2014, Wisconsin was the nation’s largest supplier of industrial sand for oil and gas drilling, providing nearly 44% of the sand used in the US—more than the tonnage supplied by Illinois, Minnesota, and Texas combined (the three leading producers behind Wisconsin).⁴

Industrial sand mines in western Wisconsin are typically developed in areas where layers of sandstone are near the surface (Fig. 1.1). These sandstone units are ideal for industrial sand because of the uniform composition (mostly silica [quartz] sand), roundness, size, and high crush-strength. This strength keeps the rock fractures open

deep underground. In many of Wisconsin, sandstone lies near the surface and breaks apart easily, both of which contribute to relatively low excavation and processing costs. In addition, a well-developed rail network in Wisconsin minimizes shipping costs for sand producers. Sand mined specifically for hydraulic fracturing is commonly shipped by rail to oil-producing areas such as North Dakota, Pennsylvania, Texas, and others.

Generally, industrial sand mining and processing is a relatively simple process compared to metallic mining operations. Low-energy blasting is sometimes required to break apart the sandstone units. Sand is then excavated and lightly worked to separate grains, washed to remove fines (silt or clay), and sorted to separate grains that are too large or too small. Wet sand may be dried immediately or stockpiled for drying later. Dry sand is then stored onsite and eventually shipped by rail or truck to the consumer.

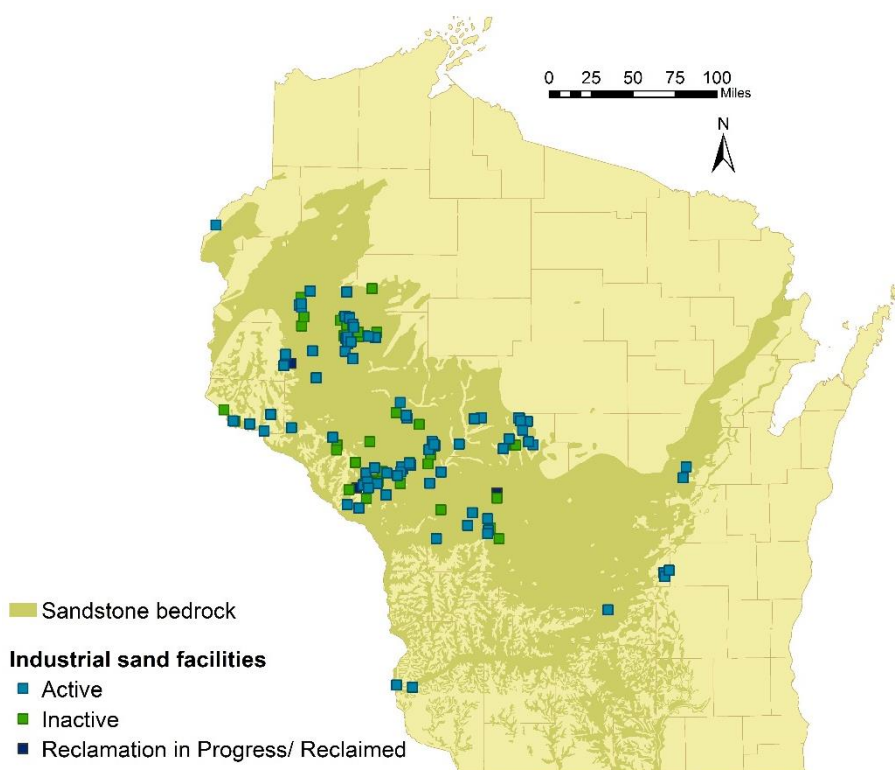


Figure 1.1. Industrial sand mines and processing facilities as of September 2015. Sandstone bedrock extent represents the rock type generally targeted for industrial sand mining. Sources: Wisconsin Department of Natural Resources and Wisconsin Geological and Natural History.

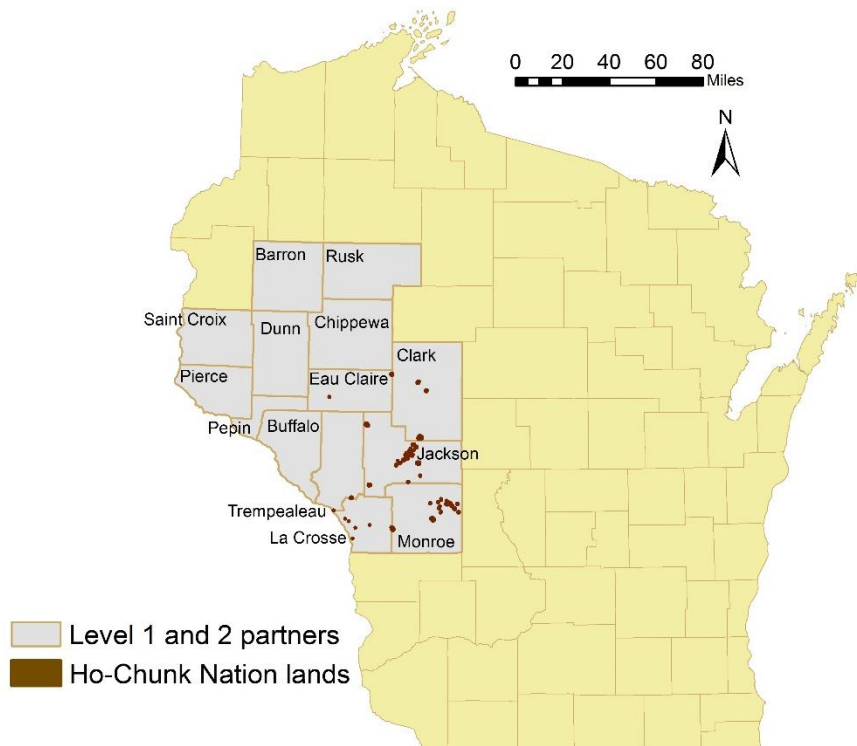
RELEVANCE

The rapid development of the industrial sand industry in Wisconsin and other upper-Midwestern states has generated a number of questions by community members and policy makers regarding potential health risks or benefits to the community. Concerns raised range from environmental topics to changes in local economics and lifestyle. Differing opinions on risks, benefits, and community values have led to divisions within and among many communities regarding whether industrial sand mining should continue in western Wisconsin. Industrial sand mining opponents often cite several reasons to increase regulations for, or ban, industrial sand mining,

including landscape change, economic instability, and potential harm to air quality and water resources. Some community members simply oppose the practices of hydraulic fracturing and mining nonrenewable resources. Those in favor of industrial sand mining have stated that potential benefits outweigh potential risks, that the creation of jobs and economic diversity will be a positive outcome for many communities, and that environmental impacts can be mitigated by proper management and regulatory oversight.

The 14-county study area for this HIA is shown in Figure 1.2. The Ho-Chunk Nation was also engaged in this study; Ho-Chunk Tribal lands are spread throughout Wisconsin and Minnesota. This large area was selected because industrial sand mining activities in this area have increased significantly in recent years and the health departments here have expressed a strong interest in an HIA.

Figure 1.2 The highlighted area indicates the geographic scope of this HIA. The HIA advisory committee consists of representatives of the 14 local health departments, Western Region Division of Public Health, Ho-Chunk Nation Department of Health (located in Jackson County), and University of Iowa Environmental Health Sciences Research Center. On this map, the scale of Ho-Chunk lands is increased for visibility.



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- ¹ World Health Organization European Centre for Health Policy. (1999). *Health impact assessment: main concepts and suggested approach*. Brussels: WHO Regional Office for Europe
- ² Wisconsin Department of Natural Resources. (2015, September 8). *Locations of industrial sand mines and processing plants in Wisconsin*. Retrieved from <http://dnr.wi.gov/topic/Mines/ISMMMap.html>.
- ³ Suchy, D.R., & Newell, D. (2011, December). *Hydraulic fracturing of oil and gas wells in Kansas*. Kansas Geological Survey Public Information Circular 32.
- ⁴ Bleiwas, D. (2015, May 26). *Estimates of hydraulic fracturing (frac) sand production, consumption, and reserves in the United States*. Retrieved from <http://www.rockproducts.com/frac-sand/14403-estimates-of-hydraulic-fracturing-frac-sand-production-consumption-and-reserves-in-the-united-states.html#.Vp-UObH2bIU>

SECTION 2. METHODS

The standard steps for health impact assessment (HIA) are screening, scoping, assessment, recommendations, reporting, and monitoring and evaluation. Each of these steps is summarized in this section.

SCREENING

The purpose of screening is to identify whether an HIA will be useful and feasible.

In early 2014, the Institute for Wisconsin's Health became aware of some of the public health assessment and communications challenges associated with industrial sand mining in western Wisconsin. IWHI staff and consultants connect frequently with local and tribal health department leaders across the state because of ongoing work related to accreditation preparation, quality and performance improvement, strategic planning, and community health assessment and planning. It was through these "circles" that awareness began.

For many years, the IWHI board of directors and management had been interested in building HIA capacity. When IWHI learned of an HIA funding opportunity from the Health Impact Project, a collaboration of the Robert Wood Johnson Foundation and The Pew Charitable Trusts, it seemed that IWHI's leadership, the industrial sand mining issue, and the Health Impact Project's interests might be a good match. IWHI requested a place on the agenda of the Wisconsin Association of Health Departments and Boards (WALDHAB) Western Region meeting on June 4, 2014 to explore this idea further. WALDHAB is a statewide organization of health department and board of health leaders that is divided into regional groups to enable regular discussion and action around public health. IWHI also engaged the University of Iowa's Environmental Health Sciences Research Center (UIEHSRC) and the Wisconsin Division of Public Health (WDPH) Western Region Office because of their involvement with air quality monitoring and public health protection, respectively.

INITIAL SCREENING EFFORTS

In the summer of 2014, IWHI's executive director approached local and tribal health department leaders in western Wisconsin to gauge interest in, usefulness of, and feasibility of a health impact assessment of industrial sand mining. This discussion began with an exploratory meeting with WALDHAB in June 2014, at which the group discussed the potential opportunity afforded by the call for proposals, the call's parameters, and HIA in general. The WALDHAB group was asked directly if an HIA using a regional approach would provide any value to the communities that the leaders represented. The potential funding opportunity was also candidly presented, including resource limits, the fact that it was unlikely that new environmental testing could be funded by such an effort, and that for a proposal to be competitive, there needed to be not just an interest in the issue, but "live" or at least impending policy

decisions under consideration in one or more communities. Attendees at this meeting expressed enthusiasm for proposal development and confidence in IWHI as an independent, unbiased primary applicant. It became clear that while the majority of the region's health departments (15 of 20), as well as many other organizations, were engaged in the topic, there was no unifying approach to data collection, analysis, or communication for the communities sharing these common interests and challenges. There was also a strong desire to gain capacity in the science of HIA through a project such as this, so that it could be applied to future issues.

DETERMINATION OF LEVEL 1 AND LEVEL 2 PARTNERS

Local and tribal health departments in Wisconsin are charged with protecting and promoting health within their jurisdictions. The departments are non-partisan entities accustomed to weighing evidence and communicating risk and benefit on a variety of issues to the public. We selected health departments as project partners because they expressed a strong interest in industrial sand mining and because of their day-to-day knowledge of (and access to) the appropriate stakeholder groups. Simply put, in our view, health departments are the *ideal touchstone* for all matters relating to potential public health risks and benefits.

The concept of Level 1 and Level 2 project partnership was developed based on the following:

- Level 1 partners are those local and tribal health departments who are currently or imminently considering a policy decision related to industrial sand mining.
- Level 2 partners are those local and tribal health departments who are not currently or imminently considering a policy decision, but who have sand mining in or very near their jurisdictions and may be making policy decisions in the future.

We asked each of the 20 local or tribal health departments that are members of the Western Region WALDHAB group to indicate if they were interested in becoming a Level 1 or Level 2 partner. We made it clear that there was no implication that the issue of sand mining was more important to Level 1 than to Level 2 partners. We also emphasized that our intent was to involve organizations that had varying views in the assessment and to carry out an assessment that was non-partisan and as bias-free as possible. Fourteen local health departments and one tribal health department expressed an interest in being project partners. Eau Claire County, Peirce County, Trempealeau County, and the Ho-Chunk Nation identified policy decisions related to industrial sand mining that were time sensitive. These communities also indicated that they were interested in becoming Level 1 partners for this study. The other counties expressed a strong interest in the assessment to inform future policies, programs, or practices and elected to be Level 2 partners. A complete list of partner communities and representatives is provided on page 6.

WHAT DECISIONS WILL BE INFORMED BY THE HIA?

- 1) At the time the HIA proposal was being developed, three townships in Eau Claire County were actively engaged in policy discussions influenced in part by silica mining: Bridge Creek had no current zoning, was in very early conversations related to silica mining, and was considering development of a comprehensive plan. Lincoln was considering developing a comprehensive plan to replace the current land use plan, and Otter Creek was considering

revisiting a 2009 comprehensive plan. The Town of Lincoln passed a comprehensive plan in August 2015. At the time of writing this report, the decisions for Bridge Creek and Otter Creek are still “in play.”

- 2) In fall 2014, the Pierce County Land Management Department began to re-examine the county’s conditional use permitting practices regarding inclusion of air monitoring requirements at sand processing plants. These discussions continue, and this HIA is likely to be used as a tool for making a decision on the county’s conditional permits for industrial sand mines.
- 3) When our proposal was developed, Trempealeau County, with 10 operating mines and an additional 18 permitted, had a moratorium on development of new mines in place. It was due to expire on August 31, 2014 and was not extended. The County Environmental and Land Use Committee has been frequently reviewing the impacts of sand mining at committee meetings, with potential for recommending policy change(s) at any time. A moratorium in the city of Arcadia, Trempealeau County, was in place until September 2015 and was not renewed. There continues to be great interest from a variety of stakeholders in the county, and the recommendations of this HIA will likely be factored into policy, program, and practice development in the near future.
- 4) The Ho-Chunk Nation currently has a resolution prohibiting industrial sand mining on Ho-Chunk Nation lands. This resolution may be revised at any time following completion of the HIA report. In addition, the Nation is beginning to build an air quality monitoring program, in part based on Tribal member concerns related to airborne silica, and the HIA will inform the scope and development of that program. The President of the Ho-Chunk Nation has expressed support of the HIA project; the engagement of the President of a sovereign nation underscores the importance of this issue to the Tribe, the region, and potentially to other Native American communities in the US.

At the end of the screening process, the HIA research team believed that decisions related to Tribal lands and culture, permitting, moratoria, and comprehensive planning in the four communities requesting Level 1 partnership were both important and broadly representative for the region. Further, we believed that the HIA could have implications for other industrial sand mining communities in the US.

SCOPING

The purpose of scoping is to set the parameters for what health effects the HIA will examine and what assessment approach will be used.

To initiate the scoping process and to help focus project resources on the issues of greatest importance, the HIA team engaged the representatives of stakeholder groups in each community in a survey. We sent the online survey to stakeholders who had been identified by Level 1 partners. Persons invited to participate represented the Wisconsin Industrial Sand Association, local government, university faculty, advocacy groups, and Ho-Chunk Tribal members. Survey results were analyzed to determine broad topics of interest to stakeholder groups within the Level 1 partner communities. We then shared the top-rated concerns with local and Tribal health department leadership in both Level 1 and Level 2 communities, and those leaders commented on and confirmed the topics of highest relevance.

Next, the HIA team, in consultation with Level 1 and 2 partners, prioritized which health determinants and health impacts to evaluate, and then developed research questions that directly related to the prioritized health determinants (Table 2.1). Research questions were developed for each of the four topic areas that are the focus of this HIA: **air quality, water resources, land reclamation and value, and quality of life**. Again, Level 1 and Level 2 partners offered comments and insight into research questions that would be most helpful for informing pending or future decisions in their communities. We used this feedback to finalize the research questions for this HIA.

Table 2.1 Health determinants and related research questions determined during scoping.

Health Determinant	Explanation	Central Research Question
Air Quality		
Air quality	There are many different environmental factors that can impact health. Air quality can directly impact physical well-being, management of chronic conditions, the onset of illness, and lifespan.	How will industrial sand mining potentially impact air quality?
Water Resources		
Water quality and quantity	Water quality and quantity can directly impact physical well-being, management of chronic conditions, the onset of illness, and lifespan.	How will industrial sand mining potentially impact water quality and quantity?
Land Reclamation and Value		
Soil and water quality	Land reclamation restores disturbed areas to other beneficial land uses. Reclamation serves to protect the next land user from health hazards, such as impacts to water quality, soil quality, and physical hazards from the previous land use.	How will reclamation impact health?
Investment value and Income	Potential threats to an individual's property value can lead to stress, anxiety, and resulting physical health outcomes. Property owners may also realize a loss to their property value due to an undesirable adjacent land use.	How will industrial sand mining impact property value?

Table 2.1 (cont.) Health determinants and related research questions determined during scoping.

Health Determinant	Explanation	Central Research Question
Quality of Life		
Economic & job opportunities	The impacts of employment on health have the potential to be profound and may range from mental and physical health to chronic disease prevalence and life span. Employment also provides income stability and therefore can be directly related to the ability to obtain necessities for healthy living such as food, safe housing, and health care.	How will industrial sand mining potentially impact community economics?
Social cohesion & support	The social cohesion and support determinant examines the health impacts of relationships with and support from other community members and an individual's surroundings. The determinant is measured by evaluating the health impacts of stress and disturbance to individual sense of place. Poor social cohesion or support can impact individual physical, emotional, and mental well-being by increasing stress, isolation, or other factors.	How will industrial sand mining potentially impact individual sense of place?
Culture	Cultural heritage, including family or community heritage, refers to the behavioral norms or patterns that support an individual's ability to identify with a group. Though this determinant is related to social support, it is more accurate to consider it separately. Cultural heritage can explain health inequities differently than other social determinants, though cultural inequities in health can often be attributed to underlying inequalities in social health determinants. ¹	How will industrial sand mining potentially impact cultural heritage?
Environmental aesthetics	Environmental aesthetics in this study include the presence of excessive light, noise, and traffic. These factors can impact physical and mental well-being through disruption of routine activities (sleep, recreation, relaxation), negative impact on public safety, or change in how individuals relate to their environment.	How will industrial sand mining potentially impact physical surroundings?

COMMUNITY HEALTH PROFILE

The community health profile compiled for this assessment (Section 3) provides a summary of the current health status of the four Level 1 partner communities, including measures that are representative of the population's general health and those that specifically relate to potential impacts of industrial sand mining. Key data sources for the community health profile were obtained through Wisconsin's Health Hub on Community Commons, the West Central Wisconsin Regional Planning Commission, and the 2013 Ho-Chunk Nation Community Health Assessment.

ASSESSMENT

The purpose of the assessment is to identify whether impacts are likely to occur and then to quantify or characterize the predicted impacts.

The assessment phase of this HIA consisted of four steps:

- 1) Develop a baseline community health profile for the four Level I partner communities, including general demographic data and health measures related to the four topic areas.
- 2) Identify the general practices used in industrial sand mining in Wisconsin, including general processes, distribution, applicable regulations, and the relationships between industry and local authorities. Also, identify data (collected by state or private entities) that is related to potential health or environmental impacts of industrial sand mining.
- 3) Identify the ways in which industrial sand mining practices have the potential to affect the health of local communities.
- 4) Characterize the effects on potential health pathways.

INDUSTRIAL SAND MINING PRACTICES

In order to best understand and accurately investigate potential health impacts of industrial sand mining, staff dedicated time to better understanding the range of sand mining practices in western Wisconsin. This investigation included:

- tours of above ground and underground industrial sand mines,
- personal communication with mine operators and representatives of the Wisconsin Industrial Sand Association as well as Department of Natural Resources staff who oversee sand mine permitting and data collection,
- review of the 2012 Wisconsin DNR report *Silica Sand Mining in Wisconsin* and other white papers,
- phone and in-person informant interviews with other researchers of potential environmental impacts of industrial sand mining in Wisconsin, and
- key informant interviews with Ho-Chunk Nation members who reside within the geographic scope of this HIA.

Existing conditions for each of the four focus areas are summarized in assessment sections 4-7.

CHARACTERIZING HEALTH EFFECTS

Effect characterization is a way to communicate the potential health impacts of industrial sand mining based on the findings of this HIA. It draws on the existing conditions, literature review, and perspectives of key informants regarding potential health pathways. This characterization provides a judgment of the overall likelihood, intensity (magnitude), quality of evidence, and distribution of potential health effects.

The following definitions are used in this assessment to characterize potential health effects:

Likelihood: How likely is it that a given health effect will occur in association with industrial sand mining

Insufficient evidence – The likelihood of a health effect cannot be judged based on available evidence

Unlikely – It is not likely that health effects will occur

Possible – Health effects are plausible

Likely – Health effects are probable

Very Likely – Health effects are highly probable

Intensity: The magnitude of the potential positive or negative health effects associated with industrial sand mining

Insufficient evidence – Evidence is inadequate to judge the intensity of health effects

Low – There are likely to be no or minimal health effects

Medium – Health effects may be minor; negative effects would be non-disabling

High – Positive or negative health effects may be considerable

Distribution: The expected impact based on proximity to an industrial sand facility

Occupational – Health effects, if any, may be limited to employees of the facility

Adjacent – Health effects, if any, may be experienced by individuals very near to a facility

Surrounding – Health effects, if any, may be experienced by individuals in the same community as a facility

Regional – Health effects, if any, may be experienced by individuals in western Wisconsin

Quality of evidence for the likelihood of health effects

None – There is no available evidence

Weak – Evidence is primarily anecdotal, based on media stories or individual reports

Moderate – Evidence is based on expert opinion, reports from experts, academics, industry, government, and others

Strong – Evidence is based on published studies not specific to western Wisconsin

Very Strong – Evidence is based on published studies specific to western Wisconsin

RECOMMENDATIONS

Recommendations are specific action items that describe how conditions should be amended in order to maximize health benefits and minimize negative health impacts.

Recommendations are based directly on the findings for potential health impacts and also consider feasibility of implementation. Before being finalized, the recommendations were first drafted by the HIA research team and then reviewed by Level 1 partners, Level 2 partners, and stakeholder group representatives.

This HIA offers:

- 1) **Recommendations**, which are suggested actions or policies that are likely to improve positive health impacts and minimize negative health effects.
- 2) **Considerations**, which address suggested actions that may improve health effects in some cases, but may not be relevant for all policy decisions.

REPORTING AND DISSEMINATION

Reporting and dissemination is the step in which HIA findings are compiled and communicated to decision makers, stakeholders, media, and the general public.

The reporting and dissemination stage includes sharing the HIA with all project partners, stakeholder group representatives, the Wisconsin Western Region Department of Public Health, Wisconsin DNR staff, mine operators, other decision makers in the western region, and the public. As needed, or upon request, we will plan additional dissemination of the findings by formal reporting or presentation.

MONITORING AND EVALUATION

The purpose of monitoring and evaluation is to track the effect of the HIA over time and to review the overall HIA process

The evaluation of this HIA will consider both process evaluation and impact evaluation. Process evaluation assesses the effectiveness of how the HIA was conducted and will answer the following questions:

- 1) Did the HIA process meet the *Minimum Elements and Practice Standards for Health Impact Assessment*?²
- 2) How could the process be improved to increase effectiveness and overall success?

Impact evaluation will assess the degree to which project objectives were achieved and the impact that this HIA had on stakeholders and decision makers. Monitoring and impact evaluation will occur continually for two years after the release of this report and will answer these questions:

- 1) Did project stakeholders find the process useful?
- 2) How was this HIA used to inform decisions that were pending upon the completion of this HIA?
- 3) Was this HIA used to inform policy decisions or practices that arose following the completion of this HIA?

The evaluation approach taken in this project will employ mixed methods, in which both qualitative and quantitative measures will be examined. We created the evaluation plan in consultation with Level 1 and Level 2 partners while the project was being organized. For each desired project outcome, we identified the corresponding activities, process indicators, and outcome measures before the start of the project. The HIA team presented initial ideas for measuring the outcome objectives to project partners and asked, “How will we know if this project accomplishes these outcomes?” and “Have we missed any measures that you believe are important to track?” Any measures that we considered feasible (given resource levels and timeline) were incorporated in the final evaluation plan.

¹ National Advisory Committee on Health and Disability. (1998). *The Social, Cultural, and Economic Determinants of Health in New Zealand: Action to Improve Health*. Wellington, New Zealand. Retrieved from <https://nhc.health.govt.nz/system/files/documents/publications/det-health.pdf>

² Bhatia R., Farhang L., Heller J., Lee M., Orenstein M., Richardson, M., & Wernham, A. (2014, September). *Minimum Elements and Practice Standards for Health Impact Assessment* (3rd ed.).

SECTION 3: COMMUNITY HEALTH PROFILE

This section profiles existing community health status among the four Level 1 partners in this study: Eau Claire County, Pierce County, Trempealeau County, and the Ho-Chunk Nation. The Level 2 Partners in western Wisconsin have broadly similar demographic characteristics to Level 1 partners, but addressing the health status of all partner communities in this report would not be feasible, given the resource limits of this HIA.

Describing the health status of populations in the vicinity of industrial sand mines is an important part of this HIA for two primary reasons. It broadly identifies what health challenges are currently being experienced, in order to examine whether these challenges may be affected by the presence of industrial sand mining. It also identifies potentially vulnerable population groups that may experience health inequities as a result of proposed or existing activities.

DEMOGRAPHIC CHARACTERISTICS

	Eau Claire County	Pierce County	Trempealeau County	Wisconsin
Population	99,788	40,870	29,098	5,706,871
Under 18 years of age	21%	22%	24%	23%
Over 65 years of age	13%	11%	16%	14%
Race/Ethnicity				
White	93%	97%	95%	87%
Black	0.8%	0.6%	0.4%	6%
Asian	3%	1%	0.4%	2%
Native American or Alaska Native	0.4%	0.5%	0.1%	0.9%
Hispanic	2%	2%	6%	6%

Source: Community Commons, <http://www.communitycommons.org>, 8/12/2015

The Level 1 partner counties, Eau Claire, Pierce, and Trempealeau, are primarily rural. The largest regional population center is Eau Claire, located in Eau Claire County, with a population of 67,545.

The Ho-Chunk Nation is also a Level 1 partner community, but Tribal members do not reside in a single geographic area. Community health data for the Ho-Chunk Nation is not available for all the measures reported for the county partners. Data about the

Key Facts

Level 1 Partner Ho-Chunk Nation

- Ho-Chunk Nation is not reservation-based; therefore, members do not reside in a single geographic area.
- Average income and high school graduation rates are less than the state average.

Table 3.1. Demographic characteristics of Level 1 Partner counties compared to statewide demographics

Table 3.2. Demographic characteristics for enrolled Ho-Chunk population within the 14-county geographic scope.

Ho-Chunk population is shared here with permission and is from the 2012 Ho-Chunk Community Health Profile, 2013 Ho-Chunk Nation Community Health Assessment, and the 2013 community health survey.

	Ho-Chunk Nation
Total Enrollment	2,278
Under 18 years of age	30%
Age 59+	12%

Source: Ho-Chunk Nation Heritage Preservation Office

Key Facts Level 1 Partner Counties

- Primarily rural
- Populations 93-97% white
- Unemployment lower than the state average
- Median per capita income slightly lower than the state average

SOCIAL AND ECONOMIC CHARACTERISTICS

SELECTED DEMOGRAPHICS

The connection between socio-economic factors and health is well established. Specifically, income and education are two social determinants that can have substantial impacts on health. In areas where there is a high concentration of population living in poverty and without a high school education, health inequities may be greater. Other potentially vulnerable populations include children, elderly, and rural populations.

As of June 2015, unemployment in the Level 1 partner counties was relatively low and slightly below the state unemployment rate. Shaded cells in Table 3.3 indicate the greatest discrepancies between county and state averages. These differences may be due to a variety of factors.

Eighty-three percent of the respondents to the Ho-Chunk Nation 2013 community assessment survey indicated an average annual household income below the state average. Educational attainment data compiled by the Great Lakes Inter-Tribal Epidemiology Center for the Ho-Chunk Nation Contract Health Service Delivery Area, is included in Table 3.3.

Table 3.3. Socio-economic characteristics of Level 1 Partner communities.

	Eau Claire County	Pierce County	Trempealeau County	Ho-Chunk Nation†	Wisconsin
Median income per capita	\$25,286	\$27,462	\$25,017	Not available	\$27,522
Lack of social or emotional support	16%	15%	22%	Not available	16%
Associate's degree or higher (age 25+)	43%	37%	28%	13%‡	36%
No high school diploma	7%	7%	13%	16%	10%
Unemployment	5%	5%	5%	Not available	6%
Poverty (< 200% federal poverty line)	35%	27%	30%	Not available	31%
Food Insecurity*	13%	10%	10%	Not available	13%
Income inequality** (rank among WI counties)	4.6 (#70 of 72)	4.0 (#36 of 72)	3.8 (#14 of 72)	Not available	4.3

Source: Community Commons, <http://www.communitycommons.org>, 8/12/2015

†Data from *Community Health Profile* for 2012 developed by the Great Lakes InterTribal Epidemiology Center. Represents American Indian/Alaska Natives in Ho-Chunk Community Health Service Delivery Area. This area includes 15 Wisconsin counties and one Minnesota county extending beyond the geographic scope of this HIA.

‡Associates degree attainment data not available. Shows percentage with bachelor's degree or higher.

*Food insecurity is the household-level economic and social condition of limited or uncertain access to adequate food

**Ratio of household income at the 80th percentile to income at the 20th percentile; Source: County Health Rankings (2015)

ECONOMIC DIVERSIFICATION

	Eau Claire County	Pierce County	Trempealeau County
Top 3 employers (percent of all jobs)	Health Care (19%) Government (13%) Retail Trade (12%)	Government (30%) Manufacturing (12%) Accommodation/ Food Services (11%)	Manufacturing (40%) Government (14%) Health Care (7%)
Jobs in mining, quarrying, or oil & gas extraction	< 10 (less than .02%)	77 (0.6%)	78 (0.5%)

Table 3. 4. Employment characteristics of Level 1 Partner communities.

Source: West Central Wisconsin Regional Planning Commission, 2015 2nd Quarter Quarterly Census of Employment and Wages

Of the Level 1 Partner counties, Eau Claire County is the most economically diversified, with the largest employment sector providing less than one-fifth of all jobs in the county. Trempealeau County is the least economically diversified, with two-fifths of all jobs in the manufacturing sector.

CLINICAL CARE & HEALTH OUTCOMES

Level 1 Partner Counties - Health outcomes in the study area vary among the communities and compared to Wisconsin averages. Adults in Eau Claire and Trempealeau counties self-report asthma diagnosed by a health professional at a rate much higher than Pierce County or the Wisconsin averages. Trempealeau County also has the highest premature death rate in the study area, though it is slightly below the statewide average.

Tan cells in Table 3.5 highlight the greatest discrepancies (positive or negative) between county and state averages. These differences may be due to a variety of factors and may or may not be statistically significant. Generally, Trempealeau County has the most areas of concern, as it exceeds state averages in the percentage of adults self-reporting with asthma, in the percentage of the population reporting poor or fair health, in motor vehicle collision mortality, and in suicide rates. Eau Claire County has a higher population density and number of health care providers than the other partner communities, leading to a higher number of primary care physicians.

Level 1 Partner Ho-Chunk Nation - Among American Indian/Alaska Natives within the Ho-Chunk Community Health Service Delivery Area (most of Wisconsin, excluding 11 southeastern counties), heart disease and cancer were the two leading single causes of death. It should be noted that there are members from other tribes residing in this data catchment area as well. Approximately 23% of survey respondents in the 2013 Ho-Chunk Nation Community Health Assessment reported fair or poor health – higher than the self-reported rates in the three partner counties. The Ho-Chunk Nation has an active environmental health program and is initiating its own air quality monitoring program as this assessment nears completion.

	Eau Claire County	Pierce County	Trempealeau County	Wisconsin
% Adults with asthma	18%	9%	17%	11%
% Population reporting poor or fair general health	11%	11%	16%	12%
Premature deaths per 100,000 population	236	232	300	310
Cancer mortality per 100,000 population	162	167	166	174
Motor vehicle collision mortality per 100,000 population	9	14	20	10
Suicide deaths per 100,000 population	12	12	17	13
Primary care physicians per 100,000 population	129	47	31	82

Source: Community Commons, <http://www.communitycommons.org>, 8/12/2015

Table 3.5. Selected clinical care and health outcomes of Level 1 Partner counties.

Community Health Profile Highlights	
Level 1 Partner Counties • Are better than the state average in a range (though not all) of health outcomes • Are regarded as having scenic and desirable physical environment • Generally exhibit good air quality, water quantity, and water quality • Have adequate access to health care • Lower economic diversification in rural areas	Ho-Chunk Nation • Though Nation-specific data is difficult to obtain, health outcomes are likely poorer than state average • Though members reside in many areas, as a sovereign entity the Ho-Chunk Nation places an extremely high value on protecting natural environments, whether these be tribal lands, lands on which tribal members reside, or beyond. • Has an active environmental health program and is initiating its own air quality monitoring efforts. • Exhibits adequate access to health care provided by tribal and non-tribal entities

VULNERABLE POPULATIONS

Vulnerable populations are groups that may experience health effects from a proposed project more intensely or at a greater rate than the general population. Vulnerable populations may include elderly, children, those with low educational attainment, or the impoverished. Within the Level 1 partner communities, these populations tend to be quite small in number and dispersed. With few exceptions, it is difficult to identify their location in relation to sand mining operations. It should also be noted that within the western region, certain religious groups (such as the Amish) are also present. However, these groups are generally dispersed, and this HIA did not find that these groups were likely to be differentially impacted by industrial sand mining when compared to other rural residents.

SECTION 4: AIR QUALITY

CONNECTION BETWEEN AIR QUALITY AND HEALTH

Many who oppose industrial sand mining in western Wisconsin have expressed concern over the potential health risks from air quality impacts by industrial sand operations. During the scoping phase of this assessment, Level 1 and Level 2 partners prioritized two air quality topics for consideration: particulate matter and respirable crystalline silica.

PARTICULATE MATTER

Particulate matter (PM) refers to *any* solid particles present in air. Examples of particulate matter include mold, dust, soot, and metals. Many potential sources of particulate matter exist all around us, including fires, industrial processes, agricultural tilling, unpaved roads, power plants, and diesel vehicles. Particulate matter is noteworthy because high levels of it may exacerbate respiratory and cardiovascular conditions, decrease lung function, and increase mortality.¹ Certain populations, such as those with chronic respiratory conditions, children, and the elderly, may be especially sensitive to particulate matter.²

RESPIRABLE CRYSTALLINE SILICA

In addition to the level of particulate matter, stakeholder representatives also expressed concern about how much of the particulate matter in ambient air is composed of crystalline silica (the silica fraction) and whether the silica particles are small enough to be inhaled past the upper airway and into the lungs (respirable silica). Prolonged exposure to substantial levels of respirable crystalline silica, such as occupational exposure, may lead to silicosis, lung cancer, and other airway diseases.³ The health risks from prolonged respirable crystalline silica exposure are most common among workers in occupations associated with cutting, grinding, or crushing of silica grains, such as sandblasting, stone quarrying, and others. Silicosis and silica-related diseases are considered an occupational health hazard for those exposed to high levels of respirable crystalline silica dust over extended periods of time, often many years.^{4,5} Environmental exposure (exposure to levels of respirable crystalline silica that are commonly present in ambient air) have not been associated with a high risk for respiratory illness. Respirable crystalline silica concentrations below published chronic reference levels are commonly present in ambient air, and can come from sources as diverse as agriculture, unpaved roads, and construction activity.⁶ Silica is one of the most common minerals in the earth's crust and is not unique to industrial sand, or the Midwest.⁷

FOCUS OF THIS SECTION

This section focuses on potential health risks of particulate matter and respirable crystalline silica resulting from direct excavation, stockpiling, processing, and loading of silica sand. Potential health impacts are evaluated in relation to the *community* population; potential *occupational* health effects to industrial sand facility workers are not evaluated in this report. Other potential air emissions associated with sand mining, such as diesel emissions from transportation or other activities, are generally small and highly variable among sand facilities.

EXISTING LOCAL CONDITIONS

PARTICULATE MATTER IN AIR

In general, different sizes of particulate matter originate from different processes and sources (Fig. 4.1ⁱⁱ), and these particles are typically present all around us. Particles greater than 10 μm (1 micrometer = 0.000039 inches) in diameterⁱⁱⁱ are generally too large to remain suspended for great distances and if inhaled, are (to a large extent) filtered out by the nose and upper airway.⁸ As a result, most health studies that investigate particulate matter are conducted on exposure related to PM10. PM10 refers to particles less than or equal to 10 μm , (approximately one-sixth the width of a human hair or smaller), which is small enough to travel into the upper airway.^{iv} PM4 refers to particles less than or equal to 4 μm ^v (0.00016 inches, approximately 15 times smaller than the width of a human hair) and is the size range widely referenced by regulatory agencies that monitor particulate matter for occupational health hazards.^{9,10} This is the size fraction believed to be able to travel past the upper airway and PM4 is generally interchangeable with ‘respirable’ in air quality literature. Fine particles, defined as PM2.5 (particles less than 2.5 μm in diameter), are generally considered to be the most hazardous to human health, as they can travel deep into the lungs.¹¹ PM2.5 is dominated by particulates formed from

ⁱⁱ Note that the graphic illustrates particles based on physical diameters. All OSHA, NIOSH, and EPA particulate matter regulations and sampling procedures are based on aerodynamic diameters rather than physical diameters. Aerodynamic diameter takes into account particle shape and density. For example, a particle (such as a sand grain) with a physical diameter of 65 μm and a reasonable specific density for earth materials (~2.5 g/cm³) is over 600 times more massive than a particle with an aerodynamic diameter of 10 μm .

ⁱⁱⁱ Aerodynamic diameter, not physical diameter. Aerodynamic diameter is defined as the diameter of a sphere of unit density (1000 kg/m³) having the same aerodynamic properties as the irregular particle being considered. By referring to the aerodynamic diameter of a particle, irregular particles of different densities or shapes, but that behave similarly in air, are treated the same. For example, a particle (such as a sand grain) with a physical diameter of 65 μm and a reasonable specific density for earth materials (~2.5 g/cm³) is over 600 times more massive than a particle with an aerodynamic diameter of 10 μm .

^{iv} The PM10 size range covers all particulate matter captured with a 50% cut size efficiency at 10 micrometer aerodynamic diameter in an EPA reference method-based sampler or equivalent sampler having a well-defined size-efficiency curve.

^v PM4 size range covers all particulate matter captured with a 50% cut size efficiency at 4 micrometer aerodynamic diameter in a NIOSH reference method-based sampler or equivalent sampling having a well-defined size efficiency curve.

transportation or combustion sources. Note that PM2.5 and PM4 are particle sizes included as subsets of PM10.

	Level of standard	Averaged time that sample represents	How samples are compared to the standard
PM10	150 µg/m³	24 hours	Standard not to be exceeded more than once per year on average over 3 years
PM2.5	35 µg/m³	24 hours	98 th percentile of measurements, averaged over 3 years
	12.0 µg/m³	1 year	Annual mean, averaged over 3 years

Table 4.1. Primary National Ambient Air Quality Standards for PM10 and PM2.5.

The Wisconsin Department of Natural Resources operates an air quality monitoring network to monitor PM2.5 and other pollutants throughout the state. These monitors are not specific to locations where industrial sand mining occurs; rather, they monitor community-level air quality statewide. Recent data indicate historical and present PM2.5 concentrations to be highest in the metropolitan areas of Madison and Milwaukee, though national air quality standards were not exceeded in these locations for extended periods.¹² Throughout Wisconsin, PM2.5 concentrations have been generally decreasing since 2008, and all Wisconsin counties are currently compliant with the daily and annual PM2.5 air quality standards.¹³ Two PM2.5 monitors are present within the geographic area of this assessment. A third monitor is present in Taylor County (Fig. 4.2).

Throughout Wisconsin, PM2.5 concentrations have been generally decreasing since 2008, and all Wisconsin counties are currently compliant with the daily and annual PM2.5 air quality standards

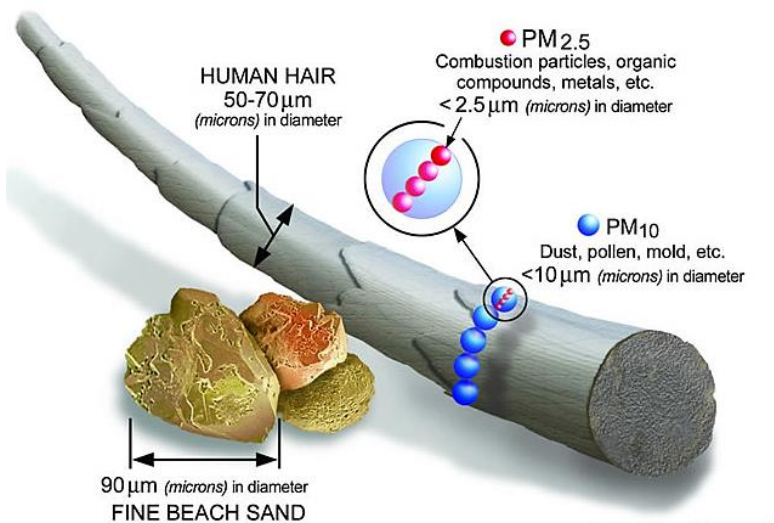


Figure 4.1. Particulate matter sizes from different sources. Particulate matter at 4 µm and below is considered respirable, or able to travel past the upper airway when inhaled. Silica sand grains mined in Wisconsin are well above the respirable size fraction, though there may be a small fraction of crystalline silica particles within the sandstones that are respirableⁱ. Image courtesy of the U.S. EPA.

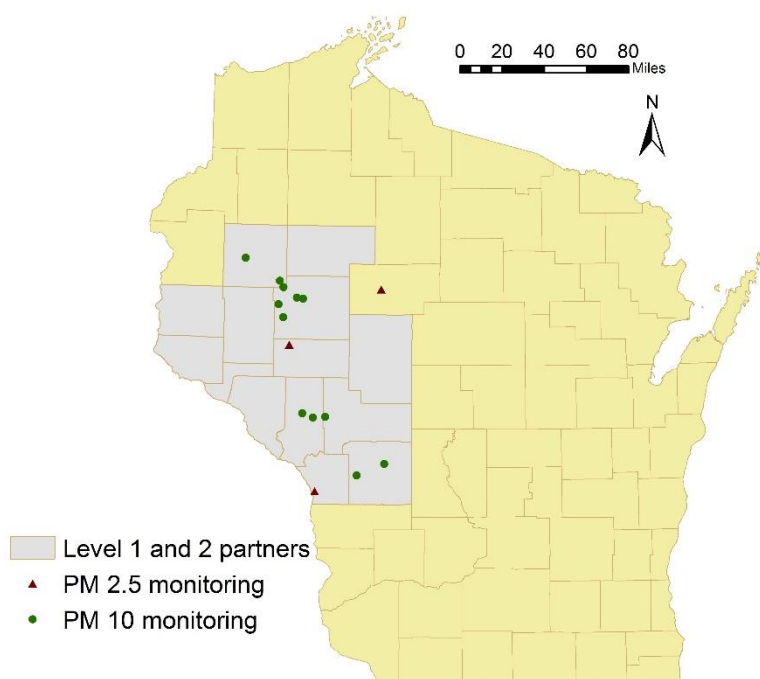
PARTICULATE MATTER MONITORING AT INDUSTRIAL SAND FACILITIES

Air emissions from industrial sand mining and processing facilities vary within the industry and by mine location; they may result from activities related to heavy equipment use, excavation and stockpiling, blasting, materials transport (loading, unloading, conveyors, uncovered trucks), and drying.¹⁴ In Wisconsin, the Wisconsin Department of Natural Resources (WDNR) has been designated by the US Environmental Protection Agency (U.S. EPA) to implement the provisions of the federal Clean Air Act for industrial sand mines. Particulate matter, air monitoring, and fugitive dust are regulated under Ch. NR 415 Wis. Adm. Code *Control of Particulate Emissions*.

Industrial sand facilities are also regulated through Ch. NR 440 *New Source Performance Standards* (particulate matter and opacity) and Ch. NR 445 *Hazardous Air Pollutants*. Air quality limits provided by WDNR air quality permits are determined based on computer-modeled maximum potential emissions from the facility and background (existing) air quality.¹⁵ Sand mines are also required by NR 415 to write and follow a WDNR-approved fugitive dust plan. Fugitive dust plans are site-specific, but commonly include provisions for using water on roads and stockpiles, paving roads, following posted speed limits on the mine sites, minimizing dust production during blasting, and conducting other site-specific activities.¹⁶ Adherence to the fugitive dust plan is evaluated during inspections by the WDNR. The WDNR Air Program conducts at least one full and two partial inspections at each active facility, each year (R. Walls, personal communication, October 21, 2015).

Fugitive dust plans are required by the Wisconsin Department of Natural Resources to manage the potential for dust to escape off-site.

Figure 4.2. Locations of PM10 monitoring at industrial sand facilities in western Wisconsin. PM2.5 monitors shown are part of WDNR statewide particulate monitoring system. Multiple monitors at a single facility are not represented. Data source: Wisconsin Department of Natural Resources.



All air monitoring equipment and operational procedures for industrial sand mines are required to meet U.S. EPA standards for particulate matter monitoring.¹⁷ As of October 2015, PM₁₀ data from 14 monitors in operation at 12 facilities were publically available from the WDNR (Fig. 4.2).¹⁸ The WDNR provides technical review and approval for monitoring plans, audits air monitoring equipment, and reviews monitoring results. Part of this review accounts for appropriate placement of air monitors with respect to prevailing wind direction, freedom from obstructions, and consideration for vulnerable populations that may be within a close proximity to a mine (J. Treutel, personal communication, July 7, 2015). Figure 4.3 shows PM₁₀ data collected at industrial sand mines and processing facilities in western Wisconsin from 2010 to 2015. Facilities with at least one year of data are shown.¹⁹

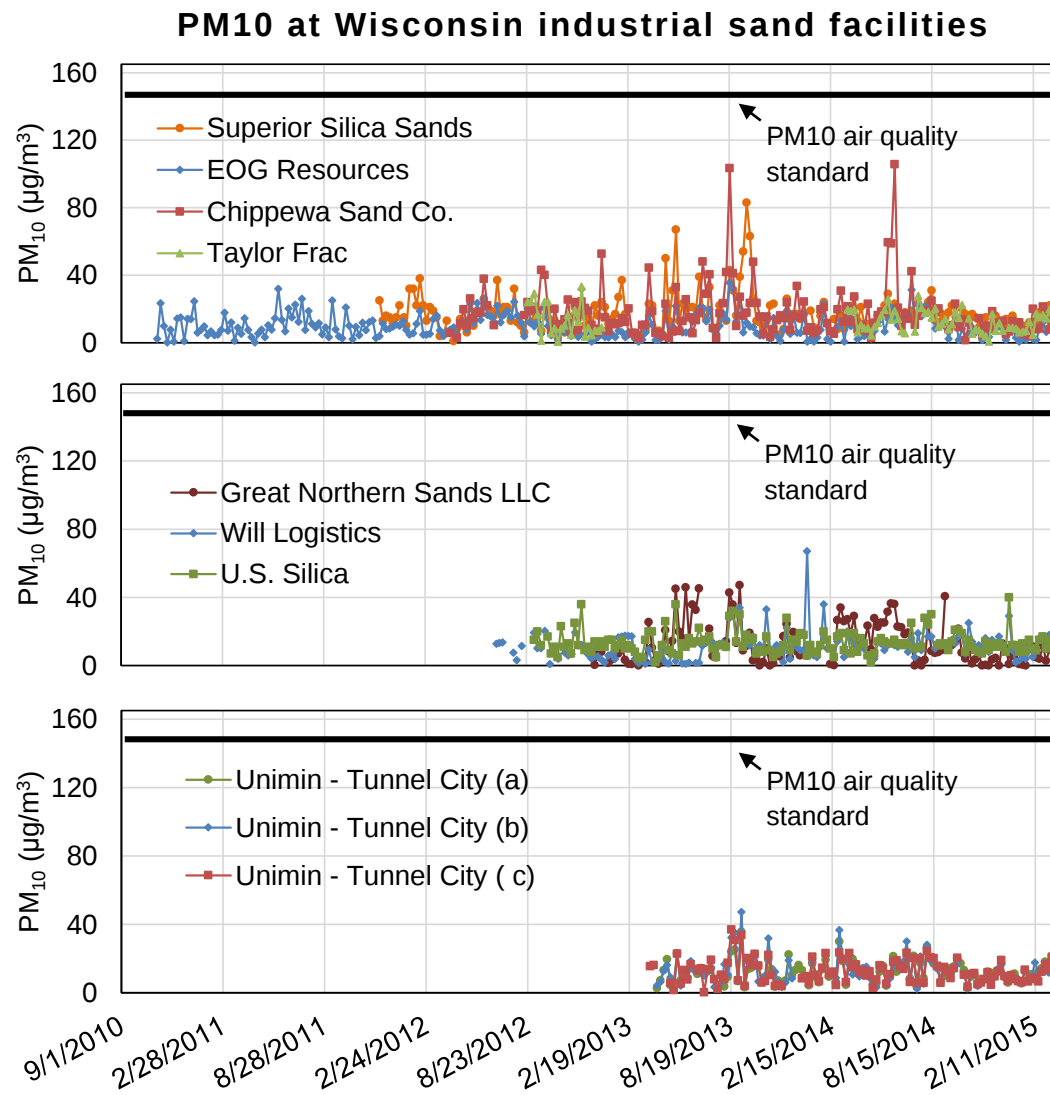


Figure 4.3. PM₁₀ data from air monitors at industrial sand mining and processing locations in western Wisconsin. Data have undergone quality assurance by WDNR. Samples were collected every six days and represent a 24-hour average of PM₁₀ concentration. Elevated values that significantly exceed the average measurements have been attributed to exceptions to standard operations, such as road construction, new mining activity, and deviation from fugitive dust plans (e.g. water truck out of service). Note that the standard indicated is not to be exceeded more than once per year on average over 3 years.

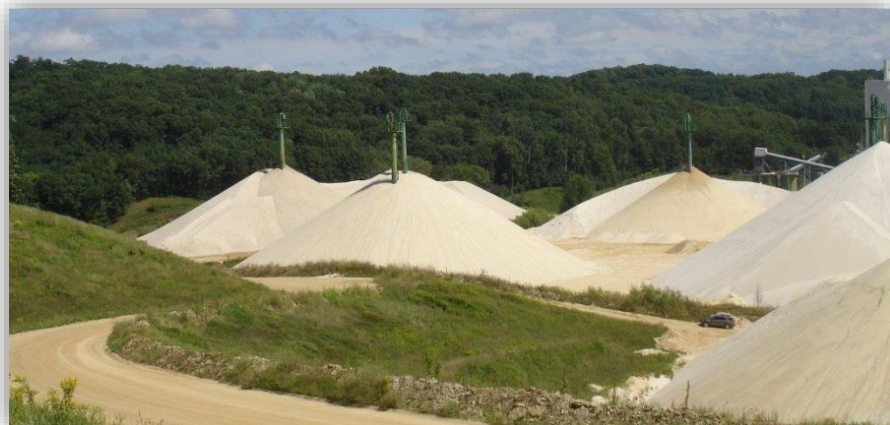
All PM10 measurements collected at the 14 different industrial sand mine monitoring locations in western Wisconsin have been below the EPA primary standard for protection of public health.

The National Ambient Air Quality Standard for PM10 is 150 $\mu\text{g}/\text{m}^3$ (microgram per cubic meter). A potential PM source is considered compliant with the PM10 standard if the PM10 measurement doesn't exceed 150 $\mu\text{g}/\text{m}^3$ more than once per year on average over three years.²⁰ This measure is the *primary standard*, that is, the standard which is most protective of public health including sensitive populations such as asthmatics, children, and elderly. As shown in Fig. 4.3, all of the PM10 measurements collected at the 14 different industrial sand mine monitoring locations have been below the primary standard.

Industrial sand mining in eastern Minnesota is very similar to western Wisconsin and data collected in Minnesota can help to further the understanding of potential environmental and health impacts of the industrial sand industry. Air quality data have also been collected and made publically available for several industrial sand facilities in Minnesota through the Minnesota Pollution Control Agency.²¹ PM10 measurements from the Shakopee Sands facility, Titan Lansing transloading facility, and Jordan Sands facility have not indicated an exceedance of the PM10 primary standard since monitoring was initiated between 2012 and 2014.

In this assessment, datasets collected in accordance with ambient air sampling operating standards (which are set by the U.S. EPA and supported in the published literature) were more heavily weighted when determining the potential risks to human health from particulate matter. It should be noted that researchers have conducted additional community-level ambient air quality monitoring for PM2.5 in western Wisconsin in the vicinity of industrial sand facilities. Walters, et al. (2015) measured PM2.5 at four industrial sand sites, collecting a total of six measurements ranging in length from approximately 6 hours to 25 hours in length.²² The equipment and methods used in this study did not meet the EPA Federal Reference Method for ambient air data collection, and not all samples represented a full 24-hour average. In addition, wind direction, wind speed, and distance to other possible particulate sources were not published as part of this study. Based on these deviations from approved air monitoring standards and the partial nature of the dataset, the research team did not find the study contributed to understanding of the issue.

Washed silica sand, stored in piles before drying and shipment. Courtesy Badger Mining Corporation.



RESPIRABLE SILICA MONITORING AT INDUSTRIAL SAND FACILITIES

To address community concern for potential health impacts from respirable crystalline silica, studies have been conducted in western Wisconsin to sample for and test the amount of crystalline silica in respirable particulate matter. In Chippewa and Barron County, PM₄ samples were collected simultaneously at upwind and downwind locations near three industrial sand mines and one sand processing plant for over two years.²³ The air samplers were operated in accordance with U.S. EPA procedures and National Institute for Occupational Safety and Health (NIOSH) standards. Over two years, 2,128 24-hour samples were collected at four locations. All samples were analyzed for silica content. The *annual average* of the values measured were compared to the California Office of Environmental Health Hazard Assessment (OEHHA) 70-year chronic (long-term) reference exposure level (REL) of 3.0 µg/m³. The annual average respirable crystalline silica concentrations at all facilities evaluated were well below (less than 10%) the REL for ambient respirable crystalline silica. This health-based value represents the level below which health effects are unlikely in sensitive populations. Adverse health effects are not anticipated from exposure to respirable crystalline silica below this level, even if the exposure occurs over a lifetime.

The study referenced this California standard because there is currently no U.S. EPA standard for crystalline silica, and Wisconsin has not adopted a REL for ambient respirable crystalline silica. The study also revealed no consistent trend of increased respirable crystalline silica at the downwind location when compared to the upwind location (upwind and downwind designations were made for each sampler based on wind direction measurements on the sampling day). These findings suggest that industrial sand facilities are not a consistent or substantial source of respirable crystalline silica.

The results of the Chippewa and Barron County study are similar to that of a respirable crystalline silica study conducted near sand facilities in Maiden Rock, Sparta, and Downing, Wisconsin.²⁴ In this study, 657 24-hour samples were collected and analyzed for silica content. The results indicated that average respirable crystalline silica concentrations at all three locations were within the range of local background concentrations and well below (less than 20%) the California OEHHA REL of 3.0 µg/m³. Results from these locations were also compared to data collected at Cataract Green, a green field planned to be developed as a mine in the future. There was no mining or agricultural activity at or around Cataract Green. The respirable crystalline silica data from the Cataract Green control site were similar to the data collected at the sand facilities. In addition, no sampling sites demonstrated significant differences in respirable crystalline silica concentration that could be attributed to wind speed.

Respirable crystalline silica has also been measured near industrial sand facilities in Minnesota. The Minnesota Department of Health recently adopted the chronic REL of 3 µg/m. Average values of respirable crystalline silica from two separate studies—a 17-month study near the Shakopee Sands facility and a nine-month study at the Jordan Sands facility—did not exceed this REL.^{25, 26} Respirable crystalline silica

Monitoring in Chippewa and Barron counties showed there was no consistent trend of increased respirable crystalline silica at downwind air quality monitors when compared to upwind monitors.

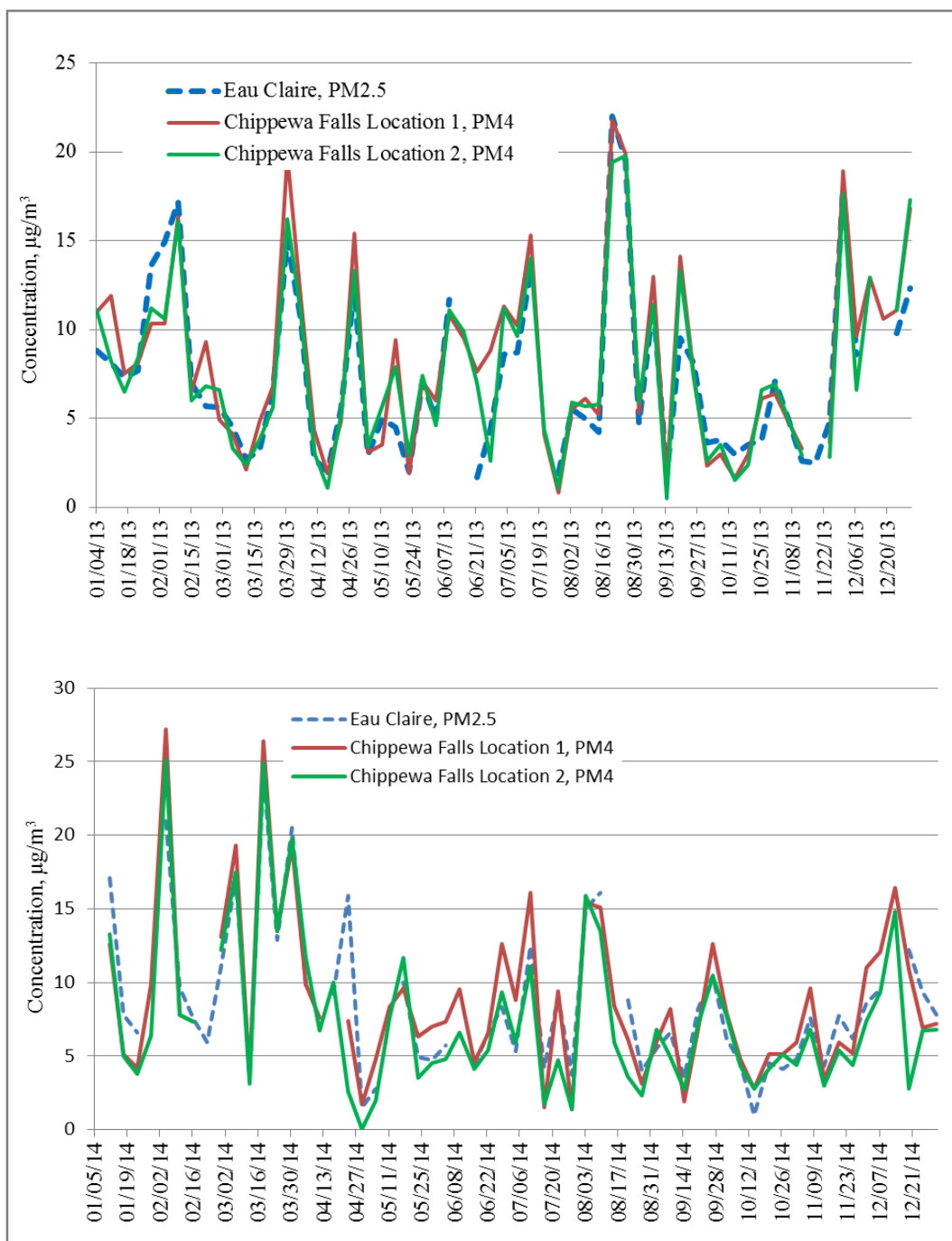
sampling was also conducted in the communities of Winona, MN and Stanton, MN. The Winona monitor measured air quality impacts that may be associated with mining-related truck traffic and activities. Stanton does not have any industrial sand related facilities or transportation, but is a rural area with unpaved roads and farm fields. This site served to measure background concentrations. There were more days of detectable levels of respirable crystalline silica at Stanton than Winona, though average respirable silica concentrations in both locations were a fraction of the REL.²⁷

Overall, the respirable crystalline silica concentrations measured in Minnesota are very similar to those measured in Wisconsin. These results provide independent confirmation of the Wisconsin respirable crystalline silica concentrations: multiple facilities in various locations sampled by different technicians indicate similar levels of respirable crystalline silica that are below health-based exposure levels.

COMPARISON OF PARTICULATE MATTER TO REGIONAL BACKGROUND CONCENTRATIONS

The Chippewa and Barron counties study also found that PM₄ concentrations measured at two locations in Chippewa County mirrored fluctuations of fine particulate matter (PM_{2.5}) measured by WDNR in neighboring Eau Claire County (Fig. 4.4). The primary standard for PM_{2.5} is 12 µg/m³ as an annual mean, averaged over three years. Figure 4.4 shows that in 2013, PM_{2.5} collected by the WDNR monitor fluctuated, but on average was below the primary standard. PM₄ measured near mine sites also fluctuated, and these variations were nearly in sync with the WDNR monitor in Eau Claire. These results indicate that the Chippewa Falls monitors were highly influenced by regional air quality, as demonstrated by the similarity to the Eau Claire monitor. Similarity between these two monitoring points support the conclusion that these facilities did not substantially contribute particulate matter within the respirable size fraction. This dataset also demonstrates the importance of collecting many points and evaluating air quality based on data collected over long time periods. Short-term air quality measurements may not accurately represent natural variability in air quality, such as seasonal or weather-related changes.

Figure 4.4. 2013 and 2014 particulate matter (PM4) measured at the Chippewa Falls sand processing plant on opposite sides of the facility, compared to PM2.5 measured in Eau Claire. Samples were collected every 6th day; axis indicates every 14th day for legibility. From Richards, J., & Brozell, T. (2015). Assessment of community exposure to ambient respirable crystalline silica near frac sand processing facilities. *Atmosphere*, 6(8), 960–982.



POTENTIAL HEALTH IMPACTS

HOW WILL INDUSTRIAL SAND MINING IMPACT PM10?

Ambient PM10 is generated by a wide range of natural and human activities. Determining the sources of ambient particulate matter is difficult, and PM10 that can be attributed to industrial sand facilities will be variable depending on daily weather

and facility operations. Industrial sand operations such as blasting, excavation, processing, stockpiling, and loading for transport are a potential source of ambient particulate matter. However, PM₁₀ monitors at 12 different facilities in western Wisconsin have not indicated an exceedance of the primary air quality standard, and this is supported by data collected by the WDNR since late 2010 (Fig. 4.3). The health-based PM₁₀ standard of 150 µg/m³ is intended to protect even the most vulnerable populations. However, individual sensitivity to particulate matter levels and to particulate matter composition (type and size of particle) are variables that may factor into health effects resulting from exposure to particulate matter.

High levels of particulate matter may serve as asthma triggers for some individuals.²⁸ At the time of this report, there were no comprehensive epidemiological studies published to evaluate respiratory illness trends in western Wisconsin. To address the subject, the HIA research team evaluated data for hospital emergency department (ED) visits for asthma from 2002 to 2013. This data was requested from the Wisconsin Environmental Public Health Tracking (EPHT) Program at the Wisconsin Division of Public Health for the 14 counties included in this assessment. Nine of the counties did not indicate a statistically significant trend in asthma emergency department visits, and the five counties that did (Buffalo, Chippewa, Jackson, Pierce, Trempealeau) indicated both increases and decreases in asthma emergency department visits. Overall, these data do not show a clear trend in emergency visits due to asthma in western Wisconsin since 2002. This analysis looks only at emergency department visits, and as such provides a selected population perspective. Many factors could influence rates of ED visits for asthma, including the quality of health care at local clinics as well as regional programming to address asthma control. Additional detail on asthma data and statistical analysis is available in Appendix A.

Based on air quality monitoring data to date, PM₁₀ particulate matter associated with industrial sand mining in Wisconsin appears unlikely to affect human health, as long as regulated air quality standards are met. Air quality monitoring and dissemination of results will continue to be important both to ensure compliance and public understanding. The ambient air standards for particulate matter are meant to minimize health impacts to vulnerable populations such as children, the elderly, and those with pre-existing respiratory diseases. However, some individuals may be especially sensitive to air quality. Continued monitoring of community-level ambient air quality (not exclusively at industrial sites) will be useful to identify periods of elevated risk for the highly sensitive.

Industrial sand facilities are not sources of respirable crystalline silica at levels that pose a community-level health hazard.

HOW WILL INDUSTRIAL SAND MINING IMPACT AIRBORNE RESPIRABLE CRYSTALLINE SILICA?

Airborne respirable crystalline silica is a well-established occupational health hazard in industries where workers could be regularly exposed to fractured silica particles small enough to travel deep into the lungs.²⁹ As a result, industrial sand mine workers are regularly monitored for respirable crystalline silica according to Mine Safety and Health Administration (MSHA) regulations.³⁰ It is important to note that the risk for *community* exposure to respirable crystalline silica is different from

occupational exposure. Silica sand is desirable for oil and gas production due to its extreme hardness, and this hardness is one of the reasons for low concentrations in ambient air. Because of the natural hardness of silica, very high levels of energy are needed to fracture the grains into respirable size. Stockpiles, loading facilities, and processing facilities are the most likely sources of respirable crystalline silica; however, numerous monitoring datasets from industrial sand facilities in Minnesota and Wisconsin indicate that these facilities are not substantial sources of ambient respirable crystalline silica. Rather, these studies have indicated that the risk of community exposure near an industrial sand facility is the same as exposure regionally.³¹

SUMMARY

After analyzing available data, reviewing published literature, and consulting with subject area experts, the HIA research team characterized the potential for health effects as a result of industrial sand mining and processing impacts to PM10 and respirable crystalline silica:

PM10

Likelihood - Based on the available data collected at industrial sand facilities and on published epidemiologic literature, health effects from the impact of industrial sand mining on community-level air quality related to PM10 are **unlikely**.

Intensity - Available data do not indicate that the levels of PM10 are high enough to contribute to health effects at the community level. Though there may be some individuals who are exceptionally sensitive, the intensity of health effects for vulnerable populations (children, elderly, those with existing respiratory conditions) and the community are anticipated to be **low**.

Distribution - The distribution of those potentially impacted would be residents in proximity to the mine, but overall will be **site-specific and variable** across the western region.

Evidence - Evidence is **very strong** for the conclusion that industrial sand facilities are unlikely to substantially impact PM10 to the extent of exceeding air quality standards. The evidence is based on site-specific PM10 data collected using methods that meet federal standards. These data have been reviewed by air quality experts at WDNR and made publically available.

RESPIRABLE CRYSTALLINE SILICA

Likelihood - Based on the available data collected at industrial sand facilities and on published epidemiologic literature, it is unlikely that community members will be exposed to respirable crystalline silica from industrial sand mining as currently regulated; therefore, health effects from exposure are **unlikely**.

Intensity - Available data do not indicate that levels of respirable crystalline silica near industrial sand facilities or nearby communities exceed the long-term reference exposure level, and as a result, the intensity of health effects at the community level are anticipated to be **low**.

Distribution - The population most vulnerable to significant exposure (and therefore to the resultant health effects) of respirable crystalline silica would be industrial sand mine and processing facility workers. Existing data and published research do not indicate a community-level risk for exposure to respirable silica from industrial sand operations.

Evidence - Evidence is **very strong** for the conclusion that industrial sand facilities, as currently regulated in Wisconsin, are unlikely to substantially impact levels of respirable crystalline silica on a community level. The evidence is based on site-specific respirable crystalline silica data collected in Wisconsin and Minnesota. This data was collected according to federal air monitoring standards, reviewed by air quality experts, and made publically available.

Pond and railcar loop
adjacent to an industrial
sand processing facility,
western Wisconsin.
Courtesy: SmartSand



	Likelihood of potential health effects	Intensity of potential health effects	Distribution of potential health effects	Evidence for likelihood of health effects
PM10	Unlikely	Low	Surrounding	Very strong
Respirable crystalline silica	Unlikely	Low	Occupational	Very strong

Key to Effects Characterization^{vi}

Likelihood: How likely is it that a given health effect will occur in association with industrial sand mining

Insufficient evidence – The likelihood of a health effect cannot be judged based on available evidence

Unlikely – It is not likely that health effects will occur

Possible – Health effects are plausible

Likely – Health effects are probable

Very Likely – Health effects are highly probable

Intensity: The magnitude of the potential positive or negative health effects associated with industrial sand mining

Insufficient evidence – Evidence is inadequate to judge the intensity of health effects

Low – There are likely to be no or minimal health effects

Medium – Health effects may be minor; negative effects would be non-disabling

High – Positive or negative health effects may be considerable

Distribution: the expected impact based on proximity to an industrial sand facility^{vii}

Occupational – Health effects, if any, may be limited to employees of the facility

Adjacent – Health effects, if any, may be experienced by individuals very near to a facility

Surrounding – Health effects, if any, may be experienced by individuals in the same community as a facility

Regional – Health effects, if any, may be experienced by individuals in western Wisconsin

Quality of evidence for the likelihood of health effects

None – There is no available evidence

Weak – Evidence is primarily anecdotal, based on media stories or individual reports

Moderate – Evidence is based on expert opinion, reports from experts, academics, industry, government, and others

Strong – Evidence is based on published studies not specific to western Wisconsin

Very Strong – Evidence is based on published studies specific to western Wisconsin

This summary represents our best understanding of potential health effects from PM10 and respirable crystalline silica based on the available data and understanding of the science. Scientific advancement may provide additional data that should be considered by experts in the field.

^{vi} It should be noted that effects characterization relies on both qualitative and quantitative data and methods. It is also based on the evidence available at the time that this assessment is completed. As new evidence becomes available, effect characterization may change.

^{vii} This categorization doesn't imply that all individuals within the geographic area will experience health effects, only that if health effects occur, the geographic area identified is relevant.

RECOMMENDATIONS

The analysis of potential industrial sand mine impacts to PM10 and respirable crystalline silica indicated that health effects were unlikely. However, public concern around potential impacts to air quality and subsequent health effects is substantial. For proposed or existing industrial sand facilities, this assessment recommends:

1. Development of a set of voluntary industry standards, such as those suggested by the Wisconsin Industrial Sand Association (WISA) Code of Conduct, which may help to promote thoughtful review, policy and project development, and positive relationships with community members. The WISA Code of Conduct promotes, among other things:
 - a. Open dialog with stakeholders.
 - b. Consideration of stakeholder perspectives and appropriate action to minimize community impacts of industrial sand operations.
 - c. Design and operation of safe and environmentally sound industrial sand facilities.

Examples of the WISA code and other sustainability principles are included in Appendix B.

2. Representation from local, tribal, or regional public health departments as part of the local permitting or review process. This may improve positive health outcomes and minimize negative health effects. Public health representatives can provide a “health lens” to permitting discussions and serve to promote and protect public health interests in this process.

The following recommendations and considerations may also reduce negative health impacts and promote positive health outcomes. These recommendations and considerations may not be applicable for all industrial sand facilities, but may be useful for decision makers who are considering industrial sand mine applications.

	Recommendations
Existing Facilities	To minimize potential negative health effects, it is recommended that policymakers: 1 Encourage adoption of standards, such as those suggested by the WISA Code of Conduct 2 Promote transparency and public understanding by making air quality data collected at sand mines and processing facilities available to the public
Proposed Facilities	To minimize potential negative health effects, it is recommended that policymakers: 1 Encourage adoption of standards, such as those suggested by the WISA Code of Conduct 2 Promote transparency and public understanding by making air quality data collected at sand mines and processing facilities available to the public
	Considerations
Existing and Proposed	If the community is concerned about the validity of monitoring or reporting of air quality data, consider independent verification of methods and report results.

- ¹ Anderson, J.O., Thundiyil, J.G., & Stolback, A. (2011). Clearing the air: A review of the effects of particulate matter air pollution on human health. *Journal of Medical Toxicology*, 8, 166-175.
- ² US Environmental Protection Agency. (2015). Particulate Matter Health Effects. Available from <http://www3.epa.gov/pm/health.html>.
- ³ Centers for Disease Control and Prevention. (2002). *Health Effects of Occupational Exposure to Respirable Crystalline Silica* (DHHS [NIOSH] Publication No. 2002-129). Retrieved from <http://www.cdc.gov/niosh/docs/2002-129/pdfs/2002-129.pdf>.
- ⁴ Centers for Disease Control and Prevention. (2002). *Health Effects of Occupational Exposure to Respirable Crystalline Silica* (DHHS [NIOSH] Publication No. 2002-129). Retrieved from <http://www.cdc.gov/niosh/docs/2002-129/pdfs/2002-129.pdf>.
- ⁵ US Environmental Protection Agency. (1996). *Ambient levels and noncancer health effects of inhaled crystalline and amorphous silica: Health Issue Assessment* (EPA/600/R-95/115). Washington, DC: Office of Research and Development.
- ⁶ Richards, J., & Brozell, T. (2015). Assessment of community exposure to ambient respirable crystalline silica near frac sand processing facilities. *Atmosphere*, 6, 960-982.
- ⁷ Centers for Disease Control and Prevention. (2002). *Health Effects of Occupational Exposure to Respirable Crystalline Silica* (DHHS [NIOSH] Publication No. 2002-129). Retrieved from <http://www.cdc.gov/niosh/docs/2002-129/pdfs/2002-129.pdf>.
- ⁸ Anderson, J.O., Thundiyil, J.G., & Stolback, A. (2011). Clearing the air: A review of the effects of particulate matter air pollution on human health. *Journal of Medical Toxicology*, 8, 166-175.
- ⁹ Richards, J., & Brozell, T. (2015). Assessment of community exposure to ambient respirable crystalline silica near frac sand processing facilities. *Atmosphere*, 6, 960-982.
- ¹⁰ Minnesota Environmental Quality Board. (2013). *Report on Silica Sand*. Retrieved from <https://www.eqb.state.mn.us/sites/default/files/documents/23.%20March%20Final%20Silica%20Sand%20report.pdf>.
- ¹¹ Pope III, C. A., & Douglas, D. W. (2006). Health effects of fine particulate air pollution: Lines that connect. *Journal of the Air & Waste Management Association*, 56(6), 709-742.
- ¹² Wisconsin Department of Natural Resources. (2015). *Wisconsin Air Quality Trends* (AM-526-2015). Madison, WI. Retrieved from <http://dnr.wi.gov/files/PDF/pubs/am/AM526.pdf>.
- ¹³ Wisconsin Department of Natural Resources. (2015). *Wisconsin Air Quality Trends* (AM-526-2015). Madison, WI. Retrieved from <http://dnr.wi.gov/files/PDF/pubs/am/AM526.pdf>.
- ¹⁴ Wisconsin Department of Natural Resources. (2012). *Silica Sand Mining in Wisconsin*. Madison, WI.
- ¹⁵ Wisconsin Department of Natural Resources. (2012). *Silica Sand Mining in Wisconsin*. Madison, WI.
- ¹⁶ Wisconsin Department of Natural Resources. (2012). *Silica Sand Mining in Wisconsin*. Madison, WI.
- ¹⁷ Wisconsin Department of Natural Resources. (2015). [Interactive map of air monitoring locations near sand mines]. *Air monitoring map for industrial sand mines/processing plants*. Retrieved from <http://dnr.wi.gov/topic/Mines/AQSandMap.html>.
- ¹⁸ Wisconsin Department of Natural Resources. (2015). [Interactive map of air monitoring locations near sand mines]. *Air monitoring map for industrial sand mines/processing plants*. Retrieved from <http://dnr.wi.gov/topic/Mines/AQSandMap.html>.
- ¹⁹ Treutel, J. (2015, March 18). *Sand mining monitoring in Wisconsin*. [PowerPoint slides]. Industrial Sand Mining Training, Black River Falls, Wisconsin.
- ²⁰ US Environmental Protection Agency. (n.d.). PM-10 AIRTrends summary. Retrieved from <http://www3.epa.gov/airtrends/aqtrnd95/pm10.html>.
- ²¹ Minnesota Pollution Control Agency. (n.d.). [Graph illustration of facility air quality data]. *Air monitoring at Minnesota silica sand facilities*. Retrieved from <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>.
- ²² Walters, K., Jacobson, J., Kroening, Z., & Pierce, C. (2015). PM_{2.5} airborne particulates near frac sand operations. *Journal of Environmental Health*, 78(4), 8-12.
- ²³ Richards, J., & Brozell, T. (2015). Assessment of community exposure to ambient respirable crystalline silica near frac sand processing facilities. *Atmosphere*, 6, 960-982.
- ²⁴ Richards, J., & Brozell, T. (2015). Fenceline PM₄ crystalline silica concentrations near sand mining and processing facilities in Wisconsin. *Mining Engineering*, 67(10), 53-59.
- ²⁵ Minnesota Pollution Control Agency. (2015, October). *Shakopee Sand (previously Great Plains Sand) Ambient Air Monitoring, Jordan, Minnesota*. Retrieved from <http://www.pca.state.mn.us/index.php/view-document.html?gid=19962>.
- ²⁶ Minnesota Pollution Control Agency. (2015, October). *Jordan Sands Ambient Air Monitoring, Mankato, Minnesota*. Retrieved from <http://www.pca.state.mn.us/index.php/view-document.html?gid=23378>.
- ²⁷ Minnesota Pollution Control Agency. (2015, May). *Winona – Community Ambient Air Monitoring, Winona, Minnesota*. Retrieved from <http://www.pca.state.mn.us/index.php/view-document.html?gid=21302>.

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- ²⁸ Anderson, J.O., Thundiyil, J.G., & Stolback, A. (2011). Clearing the air: A review of the effects of particulate matter air pollution on human health. *Journal of Medical Toxicology*, 8, 166-175.
- ²⁹ US Environmental Protection Agency. (1996). *Ambient levels and noncancer health effects of inhaled crystalline and amorphous silica: Health Issue Assessment* (EPA/600/R-95/115). Washington, DC: Office of Research and Development.
- ³⁰ Wisconsin Industrial Sand Association. (2013, May). *Crystalline silica*. Retrieved from <http://www.wisconsinsand.org/assets/Crystalline-Silica-Final-May-2013.pdf>
- ³¹ Richards, J., & Brozell, T. (2015). Assessment of community exposure to ambient respirable crystalline silica near frac sand processing facilities. *Atmosphere*, 6, 960-982.

SECTION 5: WATER RESOURCES

CONNECTION BETWEEN WATER RESOURCES AND HEALTH

Water is a critical component for healthy living, as it is essential for human body function, sanitation, and growing and sustaining food sources. Worldwide, unsafe water as well as poor sanitation and hygiene account for approximately 5.3% of all deaths.¹ Even in developed nations, low-quality drinking water and poor sanitary control and sewage disposal are responsible for a considerable burden of disease.² The connection between water and health is based on two general attributes: water quality and water quantity. Both are important for healthy growth and development and can be compromised when existing water resources or waste products are poorly managed. Water ecosystems play an important role in purifying and providing water resources, and urban and rural land development can threaten the quality and quantity of water in these ecosystems, potentially resulting in acute or chronic health impacts as well as impacts to the environment.³

FOCUS OF THIS SECTION

This section focuses on the potential impacts to water quantity and water quality associated with industrial sand operations. It is outside the scope of this assessment to evaluate regional impacts to water resources from the industry as a whole.

EXISTING LOCAL CONDITIONS

Water Use in Wisconsin – Western Wisconsin is characterized by plentiful, high-quality groundwater aquifers that generally meet the groundwater demands in the area. Groundwater also supplies a wide variety of water ecosystems in the region, including lakes, rivers, and wetlands. Groundwater is used to support many industries including power generation, food processing, ethanol production, and a variety of types of agriculture, such as cranberry, vegetable, and dairy production. In 2013, water withdrawal for power generation, municipal water, irrigation, and cranberry farming accounted for 91% of the 2.12 trillion gallons withdrawn statewide (enough to cover the state in approximately two inches of water).⁴ In 2013, agricultural irrigation alone accounted for water withdrawal of 106 billion gallons (over 290 million gallons per day), or approximately 5% of total water withdrawal in Wisconsin.⁵

Water Use in Industrial Sand Mining - Industrial sand mines also use water in the processing of their final product, and in 2013, industrial sand mining facilities in

Industrial sand facilities accounted for 0.1% of all statewide water usage in 2013.

Wisconsin withdrew approximately 2 billion gallons of water. This is equivalent to less than 0.1% of all surface and groundwater use across the state.⁶ In areas with a high number of mines, the percentage groundwater withdrawal by industrial sand mining locally, compared to groundwater withdrawal for other uses in the area, is likely to be higher than 0.1%. For example, in northwestern Chippewa County and neighboring parts of Dunn and Barron counties, industrial sand withdrawal contributed to 12% (105 million gallons) of total high-capacity well withdrawal in 2013. This is slightly more than withdrawal for municipal uses (99 million gallons). Withdrawal for irrigation was higher than any other use, with 689 million gallons.⁷

Typically, one or more wells are constructed at sand mines to provide water for sorting and washing the sand to remove fine sand, silt, and clay-sized particles. Wash water may be recycled and reused or discharged, depending on the facility design. Additional water is used for drinking and sanitation at the facility, dust suppression, or transporting slurry (a fluid water and sand mixture).

Facilities that recycle wash water must first remove the silt and clay-sized particles from the water before reuse. This can be done by allowing particles to naturally settle (such as in a settling pond) or by treating the water (in a manner similar to that of a municipal wastewater or drinking water treatment plant). In these closed-loop systems, some water loss occurs from evaporation, infiltration, or incorporation in the fine material removed from the water, and additional water must be withdrawn to replenish the losses. Open-loop systems do not recycle processing water and require replenishment from wells at a higher rate than closed-loop systems.

Water resources regulations - The WDNR enforces several regulations that apply to groundwater use including Ch. NR 140 Wis. Adm. Code *Groundwater Quality*, NR 809 *Safe Drinking Water*, NR 810 *Requirements for the Operation and Maintenance of Public Water Systems* (for facilities that provide drinking water for more than 25 people, more than six months throughout the year), NR 812 *Well Construction and Pump Installation*, and NR 820 *Groundwater Quantity Protection*.

Wells capable of pumping 70 gallons per minute or greater are classified as high-capacity wells and are also subject to WDNR high-capacity well permit requirements for construction and maintenance.⁸ Before high-capacity wells are permitted, the WDNR reviews the well application to determine the possibility for significant impacts the well may have on “waters of the state,” which include public and private wells, streams, lakes, and wetlands.⁹ If wells are found to have a possible significant impact, they are either denied or approved with conditions to prevent the occurrence of those impacts. Through this method, the WDNR considers site-specific characteristics such as geology, hydrogeology, pumping rates, nearby existing wells, and hydrology, and evaluates whether the proposed well may cause excessive drawdown (a decrease in elevation) of the water table or other potentially adverse impacts. After high-capacity wells for industrial sand facilities are approved and registered with WDNR, well construction and pumping information is reported annually and is made available to the public through the WDNR searchable groundwater well database.¹⁰

Local permitting authorities may also carefully examine potential impacts of industrial sand facilities to groundwater and surface water by reviewing conditional use permit applications and mine reclamation plans. Authorities may also require confirmation that the applicant has considered applicable regulations and obtained appropriate permits.

The WDNR also regulates surface water discharge, stormwater discharge, and runoff management. These topics are briefly mentioned in this assessment, but are generally outside the scope of this HIA. The 2012 WDNR report *Silica Sand Mining in Wisconsin* provides additional detail about the industry process and relevant WDNR regulations and we recommend that the reader refers to this WDNR report for more information.

Water-soluble polymer use - Water used for processing at industrial sand facilities may be amended with water-soluble polymers under a WDNR permit. The permit requires that water treatment additive use must be recorded on site.¹¹ Water-soluble polymers promote the clustering of small particles, which accelerates the water-clarifying process. Treating and reusing water decreases the need for fresh water to be pumped from a well. Not all industrial sand facilities use additives to aid in water treatment; some facilities allow particles to settle naturally in water holding ponds.¹² Some facilities may directly add water-soluble polymers to settling ponds containing water treated during the wash process.

One of two commonly used polymers in the industrial sand industry is polyacrylamide, which is also used in food processing facilities, as a soil stabilizing agent, and in treatment of public drinking water.^{13, 14, 15} The concentration of water-soluble polymers added to wash water or settling ponds at mines is variable across the industry. For those facilities that use polyacrylamide, the Wisconsin Industrial Sand Association reports that most facilities typically add 6 to 7 parts per million (ppm)ⁱ of the polymer to the wash water.¹⁶ The second water-soluble polymer is polyDADMAC, also commonly used to treat municipal drinking water. PolyDADMAC is typically added to wash water at a concentration of 15 ppm.¹⁷ It should also be noted that while polyacrylamide and polyDADMAC are the most common water-soluble polymers used, there may be other additives in use at some facilities and the potential for exposure and health effects from these additives should be evaluated by the regulating authority.

Water-soluble polymers commonly used in industrial sand processing are also used in municipal water and wastewater treatment facilities.

ⁱ For reference, one part per million is roughly equivalent to one drop of water in a ten gallon tub of water.

POTENTIAL HEALTH IMPACTS

HOW WILL INDUSTRIAL SAND MINING AFFECT GROUNDWATER QUANTITY?

In general, water supply wells have an impact on groundwater, though the magnitude varies with pumping rates, seasonality, geology, surface water, well construction, and many other variables. Pumping from wells can potentially result in health, economic, and environmental impacts, such as adverse changes in water quality, lower water levels in surrounding wells, and negative effects on water ecosystems (wetlands, streams, and lakes).¹⁸ If a drinking water supply well is affected by pumping of groundwater in the area, there is the potential for impacts to an individual's access to the water necessary for daily operation of the person's farm, business, or home.

The amount of groundwater used at industrial sand facilities can be highly variable, and in part depends on facility size and the methods used for recycling the processing water. The time of year (sand washing may only occur seasonally) and the weather (more water is needed for dust control during warmer, drier periods) are also variables that can affect the amount of water used.

The potential does exist for groundwater withdrawal by an industrial sand facility to impact nearby wells, though negative effects can be expected to be localized. The same potential to impact nearby water supply wells exists for other high-capacity wells (such as those used for municipalities or agriculture). Areas with several high-capacity wells in proximity to one another are generally more at risk for negative consequences for water resources.

As of this assessment, the research team is not aware of water quantity issues for private wells that have been directly attributed to industrial sand mines, though possible impacts to private wells have been reported in the media.¹⁹ Some facilities have agreements to repair or replace neighboring wells if impacts occur.²⁰ In 2012, the Wisconsin Geological and Natural History Survey began a five-year study of high-capacity well pumping and the future of groundwater resources in Chippewa County based on current and anticipated water use.²¹ Preliminary findings from the study are available on the Chippewa County website and final results may prove useful to better understand the potential impacts of industrial sand mining, groundwater use by other industries, and future groundwater resources.²² Additional research to evaluate impacts from high-capacity wells in western Wisconsin is being considered (M. Lehman, personal communication, November 6, 2015).

Health effects are possible if a private well is impacted by pumping from another nearby well. Actual health effects depend on the water demands for residential, farm, or business use, as well as the impact to the well (e.g., occasional loss of water or a completely dry well) and availability of other sources of water. Individuals that experience severe impacts to water quantity such that a new well must be drilled may experience economic losses and disruption to water access for basic needs, such as for drinking, sanitation, and farm or business use. This may result in stress, anxiety, and associated health effects. Individuals that experience only minor impacts to

Negative effects from groundwater pumping to other wells, if any, are expected to be localized.

water access may still experience stress and associated health effects. Individuals most likely to experience water quantity issues are residents in proximity to an industrial sand facility, though not all residents will be impacted. In general, it is not anticipated that any special population groups (such as low income or elderly persons) would be particularly vulnerable to water quantity health effects. However, if such individuals were among those whose well was directly impacted, they may have increased difficulty in dealing with both the emotional and financial stressors associated with the situation.

Experts who have a good understanding of geology, hydrogeology, and well construction can evaluate potential impacts to surrounding wells or water ecosystems before pumping begins. The WDNR's application process for high-capacity wells requires a systematic review to avoid substantial health, economic, or environmental impacts from proposed wells. This process takes into account the potential effects of the proposed well within the context of water wells and withdrawal. Independent groundwater modeling can also provide information on potential impacts, or lack thereof, on nearby wells.

HOW WILL INDUSTRIAL SAND MINING IMPACT GROUNDWATER QUALITY?

The three primary chemicals stored and used at mines are

- petroleum for operating equipment at mines and processing operations
- blasting agents
- water-soluble polymers used in sand washing

Throughout the scoping stage of this HIA, the potential for groundwater contamination from water-soluble polymers was the most commonly indicated water quality concernⁱⁱ. Neither polyacrylamide nor polyDADMAC, are associated with adverse human health impacts. There is currently no evidence indicating that water-soluble polymers have impacted water quality at industrial sand processing facilities in Wisconsin or neighboring Minnesota (R. Walls, personal communication June 26, 2015).

Acrylamide, which is present in low concentrations as an impurity in polyacrylamide, is listed as a likely human carcinogen and neurotoxin by the U.S. Environmental Protection Agency (EPA). The U.S. EPA does not have a regulatory limit for acrylamide in water, but does regulate the amount of residual acrylamide allowable in polyacrylamide used in drinking water treatment, such that the effective allowable concentration of acrylamide in drinking water is 0.5 ppbⁱⁱⁱ.²³ Acrylamide is also present in fried starchy foods (potato chips, french fries), coffee, tobacco smoke, and other food and household products.^{24,25,26} This is the most common route of exposure

ⁱⁱ The potential for acrylamide contamination of groundwater was prioritized during scoping. This report acknowledges concern that has been raised regarding the use of chlorinated public water supply by a sand facility and the potential for formation of nitrosamines in the presence of polyDADMAC. Due to the overall rarity of chlorinated water use by mines in the region, the likelihood and potential health effects of this scenario were not evaluated.

ⁱⁱⁱ EPA methods 8032A and 8316 can be used for testing water for acrylamide.

Acrylamide is readily biodegradable and has not been detected in groundwater at Wisconsin or Minnesota industrial sand facilities.

to acrylamide for most people.²⁷ Health effects from exposure to acrylamide have been found to be most likely for people that work with acrylamide, or live close to where acrylamide is used in high concentrations, such as plastics and food processing plants.²⁸

At the reported typical rate of polyacrylamide addition to the clarifying process (6 to 7 ppm), the approximate concentration of the acrylamide monomer is 1 part per billion (ppb)^{iv,v}.²⁹ In facilities that recycle wash water, the recycled water will typically have some fresh water and additional water-soluble polymers added. This can increase the amount of residual acrylamide present in the wash water recycling loop^{vi}. Depending on how much breakdown of acrylamide occurs during the recycling process, acrylamide concentrations in the water washing process loop may range from 1.5 ppb to 12 ppb, though this is highly site specific.³⁰

Potential pathways for acrylamide to enter the environment exist where:

- 1) water that has been treated with polyacrylamide is permitted to infiltrate into the ground,
- 2) fine materials removed during the clarifying process are stored and water infiltrates into the ground, or
- 3) water is unintentionally discharged from ponds to the ground or to streams.

Acrylamide readily breaks down in soil and water, though degradation rates will vary depending on environmental conditions. Typically, acrylamide will degrade faster in environmental conditions where oxygen is present (aerobic conditions), such as surface water and soils. Degradation rates are typically slower in the absence of oxygen (anaerobic conditions), such as water-logged soils or groundwater, or at lower temperatures.³¹ Depending on soil conditions, acrylamide concentrations may decrease by as much as 50% in the first 21-36 hours.³² In aerobic soil conditions, the U.S. EPA has estimated 74% to 94% of acrylamide may breakdown in 14 days; 64% to 89% of acrylamide may breakdown in anaerobic, waterlogged soils in 14 days.³³

Considering the highly degradable nature of acrylamide in soils and the low anticipated amount of acrylamide present in industrial sand processing water (not drinking water), it is possible that any acrylamide that may infiltrate soil or groundwater could be below permissible *drinking* water standards within a few days.³⁴ Providing for the distance between industrial sand mines and residential wells, average groundwater flow velocities, and absence of acrylamide detections in groundwater near industrial sand facilities, it is unlikely that acrylamide persists in the environment at levels that could be hazardous to human health.

Groundwater monitoring at industrial sand facilities may be conducted in the interest of public safety and to ease public concern. Water quality data collected before and after mining begins can establish baseline data to better understand pre-mine

^{iv} The approximate concentration of residual acrylamide can be estimated if the polyacrylamide used is potable-grade. Residual acrylamide in non-potable grade polyacrylamide can be estimated, but has not been confirmed by manufacturer laboratory testing, so the exact amount is unknown.

^v One part per billion is roughly equivalent to one drop of water in a 10,000 gallon swimming pool.

^{vi} Water-soluble polymers may also be added to the water loop when belt presses are used to remove water from waste materials, potentially resulting in additional acrylamide impurities in the water loop.

conditions. Chippewa County has required monitoring of acrylamide for four mines since 2011. During this time, acrylamide has not been detected in groundwater samples from these mines. Additional monitoring for acrylamide or other water quality parameters may be required in some counties as part of local ordinances or reclamation monitoring (R. Walls, November 16, 2015, personal communication).

There have been at least four documented cases of accidental release of water and sediment from holding ponds at industrial sand mines in Wisconsin during the past four years.^{35,36,37,38} These failures were attributed to structural failure of a pond or erosion-control feature. Adherence to regulation and proper engineering and maintenance techniques may have prevented these failures. This type of release may impact private property and may be temporarily detrimental to waterways and ecosystems, leading to release of sediment-laden water that may also contain additives from the washing process. Human health impacts of this type of release have not been specifically evaluated in Wisconsin. The extent of impact to human health is highly site specific and depends on whether personal property is impacted or if the release affects an individual's access to food or drinking water. Human health impacts at the community level are unlikely given the overall rarity of these occurrences throughout the history of the industry in Wisconsin, and the rarity of surface water being relied on for drinking throughout the region. Though these releases have been rare, holding pond design is a factor that can be considered by permitting authorities in an effort to eliminate potential hazards. Individuals most likely to experience impacts from unintentional releases are residents in proximity to an industrial sand facility.

Finally, it should be noted that there is ongoing research by the Wisconsin Geological and Natural History Survey evaluating site-specific differences in metals concentrations of sandstone units which are commonly exposed at industrial sand mines (J. Zambito, personal communication, Nov. 10, 2015). This research will help to provide a baseline dataset for better understanding the relationship between rock type, water quality, and industrial sand mining.

SUMMARY

Following analysis of the range of industry practices, review of published literature, and consultation with subject area experts, the HIA research team characterized the potential for health effects as a result of impacts by industrial sand operations on water resources in western Wisconsin.

WATER QUANTITY

Likelihood – Based on consultation with subject experts and anecdotal reports, the potential for health effects from impacts to groundwater quantity is **possible**. Industrial sand mining facilities that withdraw groundwater have the potential to impact surrounding wells and surface water features, but these impacts are highly site specific and localized.

Intensity – There are many variables that will determine the magnitude of health effects from impacts to an individual's drinking water supply well. If health effects do occur, the intensity is expected to be **low to high**.

Distribution – If health effects occur, they are most likely to occur to few individuals in the **adjacent** area. Not all individuals near industrial sand facilities will experience these effects, and it is possible that no health effects will occur.

Evidence – Evidence is **moderate** that impacts to a private water supply are possible.

WATER QUALITY

Likelihood – Health effects from impacts to groundwater quality are **unlikely**. In the case that water-soluble polymers are released to the groundwater, impurities are expected to readily degrade and would be significantly diluted by either surface water or fresh water before they could come in contact with drinking water users near industrial sand sites.

Intensity – The most commonly used water-soluble polymers are not associated with adverse health effects. The acrylamide monomer that may be present at low concentrations as an impurity in the water-soluble polymer polyacrylamide is likely to be degraded in soil or groundwater. Therefore, intensity of health effects is expected to be **low**.

Distribution – If health effects occur, they are most likely to occur to few individuals in the **adjacent** area. Not all individuals in an adjacent area will experience these effects, and it is likely that no health effects will occur.

Evidence – Evidence is **strong** that impacts to water quality are unlikely. Acrylamide has not been detected in groundwater near industrial sand mines in Minnesota or Wisconsin, and the evidence for the ability of acrylamide to readily biodegrade in the environment is strong.

	Likelihood of potential health effects	Intensity of potential health effects	Distribution of potential health effects	Evidence for likelihood of health effects	Notes
Groundwater quantity	Possible	Low to High	Adjacent	Moderate	Potential health effects are not unique to impacts from industrial sand facilities
Groundwater quality	Unlikely	Low	Adjacent	Strong	

Key to Effects Characterization^{vii}

Likelihood: How likely is it that a given health effect will occur in association with industrial sand mining

Insufficient evidence – The likelihood of a health effect cannot be judged based on available evidence

Unlikely – It is not likely that health effects will occur

Possible – Health effects are plausible

Likely – Health effects are probable

Very Likely – Health effects are highly probable

Intensity: The magnitude of the potential positive or negative health effects associated with industrial sand mining

Insufficient evidence – Evidence is inadequate to judge the intensity of health effects

Low – There are likely to be no or minimal health effects

Medium – Health effects may be minor; negative effects would be non-disabling

High – Positive or negative health effects may be considerable

Distribution: the expected impact based on proximity to an industrial sand facility^{viii}

Occupational – Health effects, if any, may be limited to employees of the facility

Adjacent – Health effects, if any, may be experienced by individuals very near to a facility

Surrounding – Health effects, if any, may be experienced by individuals in the same community as a facility

Regional – Health effects, if any, may be experienced by individuals in western Wisconsin

Quality of evidence for the likelihood of health effects

None – There is no available evidence

Weak – Evidence is primarily anecdotal, based on media stories or individual reports

Moderate – Evidence is based on expert opinion, reports from experts, academics, industry, government, and others

Strong – Evidence is based on published studies not specific to western Wisconsin

Very Strong – Evidence is based on published studies specific to western Wisconsin

^{vii} It should be noted that effects characterization relies on both qualitative and quantitative data and methods. It is also based on the evidence available at the time that this assessment is completed. As new evidence becomes available, effect characterization may change.

^{viii} This categorization doesn't imply that all individuals within the geographic area will experience health effects, only that if health effects occur, the geographic area identified is relevant.

RECOMMENDATIONS

Policy makers should seek to understand the specific impacts to water resources that are expected at proposed mines so they can better understand the range of potential health effects. For proposed or existing industrial sand facilities, this assessment recommends:

1. Development of a set of voluntary industry standards, such as those suggested by the Wisconsin Industrial Sand Association (WISA) Code of Conduct, which may help to promote thoughtful review, policy and project development, and positive relationships with community members. The WISA Code of Conduct promotes, among other things:
 - a. Open dialog with stakeholders.
 - b. Consideration of stakeholder perspectives and appropriate action to minimize community impacts of industrial sand operations.
 - c. Design and operation of safe and environmentally sound industrial sand facilities.

Examples of the WISA code and other sustainability principles are included in Appendix B.

2. Representation of local, tribal, or regional public health departments as part of local permitting or review process. This may help improve positive health outcomes and minimize negative health effects. Public health representatives can provide a “health lens” to permitting discussions and serve to promote and protect public health interests in this process.

The following recommendations and considerations may also reduce negative health impacts and promote positive health outcomes. These recommendations and considerations may not be applicable for all industrial sand facilities, but may be useful for decision makers considering industrial sand mine applications.

	Recommendations
Existing Facilities	To minimize potential negative health effects, it is recommended that policymakers: 1 Encourage adoption of standards, such as those suggested by the WISA Code of Conduct. 2 Request that each existing facility: • establish a contact point for residents to ask questions or lodge complaints, • develop action plans to ensure response to and resolution of complaints, • develop action plans in the event of water contamination • make water quality testing results available to the public to increase transparency • develop plans to address impacts, reasonably attributed to facility operation, to other water supply wells. This can promote positive community relationships and ease public concern.

	Recommendations
Proposed Facilities	To minimize potential negative health effects, it is recommended that policymakers: 1 Encourage adoption of standards, such as those suggested by the WISA Code of Conduct. 2 Request that processing facilities under consideration include designs to recycle process water. This design significantly reduces the amount of water needed and may reduce the likelihood of impact to neighboring wells. 3 During the proposal consideration phase, establish a public or joint public/private contact point for residents to ask questions or lodge complaints, and establish action plans to ensure quick response to and resolution of complaints. 4 Request water quality and water level baseline data to be collected from nearby existing wells, or monitoring wells if necessary. Monitoring of water quality and water level in these wells can establish baseline data, and ease concern of nearby well owners. Policy makers should note that new monitoring wells can serve as new potential pathways for groundwater contamination, and should be employed conservatively. 5 Request that facilities develop plans to address impacts, reasonably attributed to facility operation, to other water supply wells. In addition, water quality testing results should be made publically available. This can promote positive community relationships and transparency, and ease public concern.
	Considerations
Existing and Proposed	1 Groundwater modeling should be performed and made publically available where there is sufficient data to conclude that impacts on existing wells are potentially likely. This can promote positive community relationships and transparency, and ease public concern.^{ix} 2 If polyacrylamide is used, request that potable-grade polyacrylamide is used, such that the residual acrylamide concentration in process water can be calculated.

^{ix} Appropriate methods and considerations for groundwater modeling should follow recent technical procedures such as those described by Anderson, M., Woessner, W., & Hunt, R. (2015). *Applied groundwater modeling: Simulation of flow and advective transport* (2nd ed.). Elsevier Science.

- ¹ Prüss-Üstün, A., Kay, D., Fewtrell, L., & Bartram, J. (2004). Unsafe water, sanitation and hygiene. In M. Ezzati, A.D. Lopez, A. Rodgers, & C. Murray (Eds.), *Comparative quantification of health risks – global and regional burden of disease attributable to selected major risk factors volume 1* (1321-1352). Geneva: World Health Organization.
- ² Prüss-Üstün, A., Kay, D., Fewtrell, L., & Bartram, J. (2004). Unsafe water, sanitation and hygiene. In M. Ezzati, A.D. Lopez, A. Rodgers, & C. Murray (Eds.), *Comparative quantification of health risks – global and regional burden of disease attributable to selected major risk factors volume 1* (1321-1352). Geneva: World Health Organization.
- ³ World Health Organization. (n.d.). *Policy Brief – Water, health and ecosystems: the linkages*. Retrieved from <http://www.who.int/heli/risks/water/water/en/>.
- ⁴ Smail, B. (2014, October 7). *Mining and water in Wisconsin: Water use for non-metallic mining*. [PowerPoint slides]. SME Wisconsin Annual Conference Presentation, Eau Claire, Wisconsin. Retrieved from <https://higherlogicdownload.s3.amazonaws.com/SMENET/1b517024-bb1c-4b2c-b742-0136ce7a009c/UploadedImages/TCjointConference/Robert%20Smail%20-%20Water%20Usage%20in%20Non-Metallic%20Mining.pdf>.
- ⁵ Smail, B. (2014, October 7). *Mining and water in Wisconsin: Water use for non-metallic mining*. [PowerPoint slides]. SME Wisconsin Annual Conference Presentation, Eau Claire, Wisconsin. Retrieved from <https://higherlogicdownload.s3.amazonaws.com/SMENET/1b517024-bb1c-4b2c-b742-0136ce7a009c/UploadedImages/TCjointConference/Robert%20Smail%20-%20Water%20Usage%20in%20Non-Metallic%20Mining.pdf>.
- ⁶ Smail, B. (2014, October 7). *Mining and water in Wisconsin: Water use for non-metallic mining*. [PowerPoint slides]. SME Wisconsin Annual Conference Presentation, Eau Claire, Wisconsin. Retrieved from <https://higherlogicdownload.s3.amazonaws.com/SMENET/1b517024-bb1c-4b2c-b742-0136ce7a009c/UploadedImages/TCjointConference/Robert%20Smail%20-%20Water%20Usage%20in%20Non-Metallic%20Mining.pdf>.
- ⁷ Parsen, M.J., and Gotkowitz, M.B. (2015). *Chippewa County groundwater study – interim report*. Retrieved from <http://co.chippewa.wi.us/home/showdocument?id=7228>.
- ⁸ Wisconsin Department of Natural Resources. (n.d.). *Wisconsin water use 2014 expanded withdrawal summary*. Retrieved from <http://dnr.wi.gov/topic/WaterUse/documents/WithdrawalReportDetail.pdf>.
- ⁹ Wisconsin Department of Natural Resources. (n.d.). *High capacity well*. Retrieved from <http://dnr.wi.gov/topic/Wells/highCapacity.html>.
- ¹⁰ Department of Natural Resources Drinking Water System: High Capacity Wells. Available at [http://prodoasext.dnr.wi.gov/inter1/hicap\\$.startup](http://prodoasext.dnr.wi.gov/inter1/hicap$.startup)
- ¹¹ Wisconsin Department of Natural Resources. General permit to discharge under the Wisconsin Pollutant Discharge Elimination System, nonmetallic mining operations. Retrieved from http://dnr.wi.gov/topic/wastewater/documents/46515_permit.pdf.
- ¹² Wisconsin Department of Natural Resources. General permit to discharge under the Wisconsin Pollutant Discharge Elimination System, nonmetallic mining operations. Retrieved from http://dnr.wi.gov/topic/wastewater/documents/46515_permit.pdf.
- ¹³ U.S. Environmental Protection Agency. (n.d.). *Acrylamide hazard summary*. Retrieved from <http://www3.epa.gov/airtoxics/hlthef/acrylami.html>.
- ¹⁴ National Sanitation Foundation. (n.d.). *NSF fact sheet polyelectrolytes and NSF/ANSI Standard 60*. Retrieved from http://www.nsf.org/newsroom_pdf/NSFFactSheetPolyelectrolytes.pdf
- ¹⁵ Minnesota Department of Health. (2014 August). *Acrylamide and drinking water*. Retrieved from www.health.state.mn.us/divs/eh/risk/guidance/gw/acrylinfo.pdf.
- ¹⁶ Wisconsin Industrial Sand Association. (2013 June). *Water soluble polymers and industrial sand mining*. Retrieved from http://www.wisconsinsand.org/assets/Water-Soluble-Polymers-and-Industrial-Sand-Mining-final-5_31_13-.pdf.
- ¹⁷ Wisconsin Industrial Sand Association. (2013 June). *Water soluble polymers and industrial sand mining*. Retrieved from http://www.wisconsinsand.org/assets/Water-Soluble-Polymers-and-Industrial-Sand-Mining-final-5_31_13-.pdf.
- ¹⁸ University of Wisconsin Water Resources Institute. (n.d.). *Groundwater drawdown factsheet*. Retrieved from <http://aqua.wisc.edu/publications/pdfs/GroundwaterDrawdown.pdf>.
- ¹⁹ Hoffman, M. (2013, April 3). Sparta farmer eyes sand mines as cause of well issues. *LaCrosse Tribune*. Retrieved from http://lacrosetribune.com/news/local/sparta-farmer-eyes-sand-mine-as-cause-of-well-issues/article_a3c483f4-9b4a-11e2-b27f-001a4bcf887a.html.
- ²⁰ Town of Howard Mining Agreement with EOG Resources. Retrieved from <http://www.wisctowns.com/uploads/ckfiles/files/Town%20of%20Howard%20Developers%20Agreement.pdf>
- ²¹ Parsen, M.J., and Gotkowitz, M.B. (2013). *Managing Chippewa County's groundwater—today and tomorrow*. Wisconsin Geological and Natural History Survey Factsheet 07. Retrieved from <http://www.co.chippewa.wi.us/home/showdocument?id=68>.

- ²² Parsen, M.J., and Gotkowitz, M.B. (2015). *Chippewa County groundwater study – interim report*. Retrieved from <http://co.chippewa.wi.us/home/showdocument?id=7228>.
- ²³ U.S. Environmental Protection Agency. (n.d.). *Acrylamide hazard summary*. Retrieved from <http://www3.epa.gov/airtoxics/hlthef/acrylami.html>.
- ²⁴ Minnesota Department of Health. (2014 August). *Acrylamide and drinking water*. Retrieved from www.health.state.mn.us/divs/eh/risk/guidance/gw/acrylainfo.pdf.
- ²⁵ Center for Disease Control. (2009, November). *Acrylamide factsheet*. Retrieved from http://www.cdc.gov/biomonitoring/pdf/Acrylamide_FactSheet.pdf.
- ²⁶ National Toxicology Program. (2005, February). *NTP-CERHR monograph on the potential human reproductive and developmental effects of acrylamide* (NIH Publication No. 05-4472). Retrieved from https://ntp.niehs.nih.gov/ntp/ohat/acrylamide/acrylamide_monograph.pdf.
- ²⁷ Minnesota Department of Health. (2014 August). *Acrylamide and drinking water*. Retrieved from www.health.state.mn.us/divs/eh/risk/guidance/gw/acrylainfo.pdf.
- ²⁸ Department of Health and Human Services. (2012, December). *Acrylamide* (CAS #79-06-1). Retrieved from <http://www.atsdr.cdc.gov/ToxProfiles/tp203-c1-b.pdf>.
- ²⁹ Wisconsin Industrial Sand Association. (2013 June). *Water soluble polymers and industrial sand mining*. Retrieved from http://www.wisconsinsand.org/assets/Water-Soluble-Polymers-and-Industrial-Sand-Mining-final-5_31_13-.pdf.
- ³⁰ Barr Engineering. (2013 October). *Environmental impacts of water treatment chemicals at industrial sand mines*. Retrieved from <https://www.barr.com/download/331>.
- ³¹ U.S. Environmental Protection Agency. (1985). *Health and environmental effects profile for acrylamide* (Technical Report EPA/600/X-85/270). Springfield, VA: U.S. Department of Commerce.
- ³² U.S. Environmental Protection Agency. (1985). *Health and environmental effects profile for acrylamide* (Technical Report EPA/600/X-85/270). Springfield, VA: U.S. Department of Commerce.
- ³³ U.S. Environmental Protection Agency. (1985). *Health and environmental effects profile for acrylamide* (Technical Report EPA/600/X-85/270). Springfield, VA: U.S. Department of Commerce.
- ³⁴ Wisconsin Industrial Sand Association. (2013 June). *Water soluble polymers and industrial sand mining*. Retrieved from http://www.wisconsinsand.org/assets/Water-Soluble-Polymers-and-Industrial-Sand-Mining-final-5_31_13-.pdf.
- ³⁵ Baran, M. (2012, May 18). *Frac sand sediment spills into St. Croix River*. MPR News. Retrieved from <http://www.mprnews.org/story/2012/05/18/environment/frac-sand-sediment-saint-croix-spill>.
- ³⁶ Herald Newsroom. (2014, September 9). *Sand mine in Trempealeau County agrees to pay \$60K on allegations it violated water pollution laws*. Pierce County Herald. Retrieved from <http://www.piercecountyherald.com/content/wisconsin-news-roundup-sand-mine-trempealeau-county-agrees-pay-60k-allegations-it-violated>.
- ³⁷ Luhmann, S. (2013, July 10). *DNR: Sand mines violated stormwater permits*. LaCrosse Tribune. Retrieved from http://lacrossetribune.com/news/local/dnr-sand-mines-violated-stormwater-permits/article_1b7a400e-e912-11e2-b9c6-001a4bcf887a.html.
- ³⁸ Kremer, R. (2013, April 22). *Trempealeau County frac sand site ignores DNR, sees massive runoff*. WPR News. Retrieved from <http://www.wpr.org/trempealeau-county-frac-sand-site-ignores-dnr-sees-massive-runoff>.

SECTION 6: LAND RECLAMATION & LAND VALUE

CONNECTION BETWEEN LAND RECLAMATION, LAND VALUE & HEALTH

LAND RECLAMATION

Land reclamation refers to the restoration of land previously used but no longer needed for industrial sand mining. Land may be restored to a quasi-natural state or amended for people-friendly purposes, such as parks or recreational areas. Land reclamation and health are connected through several pathways. These pathways include the potential for exposure to health hazards as well as support for healthy behaviors (such as walking, bicycling, and recreation) that may improve individual physical, mental, or social well-being.

LAND VALUE

Land or property value can also be connected with health. Land that is used for ranching, farming, or recreation can provide individuals with employment and income, thereby supporting access to health care, healthy food, and recreational activities. For landowners who intend to sell their land, a high property value may provide additional buying power. Where property values decrease, however, associated health outcomes may include stress or decreased purchasing power.

FOCUS OF THIS SECTION

The topic of land use is both broad and complex. During the scoping process for this HIA, we selected two focus areas: industrial sand mine reclamation and potential impacts to property values from industrial sand facilities. However, there are additional environmental and human health impacts from the development of land for use by industrial sand facilities that are not discussed in this report, such as wildlife displacement, increased water runoff, erosion, or impacts to water ecosystems. The magnitude of these environmental impacts and the potential for associated health effects is highly site specific, and an in-depth assessment of these impacts is outside the scope of this HIA. However, policymakers should seek to understand potential site-specific health effects associated with changes in land use at proposed facilities.

EXISTING LOCAL CONDITIONS

Regulations and permitting - The landscape in western Wisconsin has undergone significant changes over the past 150 years; it has changed from being primarily undeveloped hilly terrain accompanied by dense forests, to modern row-crop and cranberry agriculture, dairy farms, and urban development. This region is presently dominated by a rural, agricultural landscape with small cities and towns, and a few larger urban areas. Within this region, industrial sand facilities are generally present in rural areas or near small towns. Some of the regulations that industrial sand facilities are subject to are overseen by county and township authorities. In some instances, villages have annexed mines and provide the regulatory framework. The regulatory framework among villages, towns, and counties varies across Wisconsin. Examples of different regulations that may be administered by local authorities include:

- land reclamation (post-mining land use as required in Ch. NR 135 Wis. Adm. Code *Nonmetallic Mining Reclamation*);
- shoreland zoning ordinances (requirements for development near rivers, streams and navigable lakes, ponds, or flowages);
- erosion control and storm water management;
- zoning;
- conditional-use permitting (conditions that a developer must meet if the intended use is different from the zoned use; not applicable in areas without zoning administration);
- erosion control and storm water management;
- town licensing (may specify conditional uses in a non-zoned area);
- developer's agreement; and
- road use agreement

Before mine development can begin, a conditional use permit (if applicable), reclamation permit, and financial assurance for reclamation must be approved by local authorities that oversee NR 135 *Nonmetallic Mining Reclamation* (county or town, depending on which authority has adopted the ordinance). Following public notice, public input for these permits may be collected through public hearings. Permits related to high capacity wells, air emissions, wastewater discharge and many other applicable regulations must also be sought from local and state authorities. It should be noted that WDNR has oversight of the Non Metallic Mining Program, though the Wisconsin Administrative Code distributes Regulatory Authority to counties and towns to enact the program. WDNR then audits each county or town to ensure the standards in the code are appropriately carried through by the regulatory authority. If a regulatory authority is found to not be compliant with NR 135, the WDNR has the authority to take the program over and revoke regulatory authority from the county or town. As of the end of 2015, this has not happened in Wisconsin. Additional information on the local and state regulatory framework is described in the WDNR report *Silica Sand Mining in Wisconsin*.¹

"Land use decisions should be local but regulatory oversight should be left at the appropriate regulatory agency with the expertise to address the issue."

Mining industry employee,
Trempealeau County
(response to stakeholder
scoping survey)

Reclamation – There are many different types of land uses for areas that may be developed for industrial sand mining. These include crops, vegetables, pasture, upland vegetation, and in some cases, limestone aggregate mining. Post-mining land uses may include agriculture, wildlife habitat, recreational areas, and other types of development. After industrial sand mining operations are completed, land is reclaimed to the use prescribed in the approved reclamation plan.

Toy and Daniels (1998) define reclamation as “the treatment of disturbed areas to create stable landforms and edaphic [soil] conditions to sustain predetermined land uses with minimal maintenance.”² Land reclamation at industrial sand mines is a process that begins relatively early in the mine life. Most industrial sand mines are divided into “cells” that are developed individually. Therefore, only small areas of a typical mine are actively excavated at any given time, and when excavation is complete in a given cell, reclamation of that area will begin while excavation of another cell is underway. This ongoing reclamation is required by NR 135, and is not precluded by mine size.

Reclamation strategies vary by site and the strategies used depend on both the land use prior to mine development and the post-mining land use options. These strategies are described in the reclamation plan prepared in accordance with NR 135. Advanced land reclamation techniques, described as ‘geomorphic reclamation’ or ‘topographic reconstruction’ have been successfully employed by at least one western Wisconsin industrial sand facility—Badger Mining Corporation. In this method, reclaimed land is reconstructed to mimic pre-mine topography, minimize erosion, and minimize post-reclamation maintenance.^{3,4} This reclamation effort strives to restore the post-mining landscape more closely to its pre-mining appearance and improves soil and water retention by striving to achieve hydrologic equilibrium. In another example, two underground mines in Pierce County, Wisconsin, are currently being reclaimed as bat habitat. These mines serve as the state’s second and third largest bat hibernation area, providing habitat for over 100,000 bats.^{5,6}

Critical, scientific review of proposed reclamation plans by regulating authorities and public input can help eliminate potential exposure to human safety and health hazards that may exist at a mining operation following reclamation. Such potential hazards might include electrically-charged equipment, blasting agents, petroleum, oil, and other liquid chemicals; and physical hazards such as structures, equipment, and open excavations. Well-developed reclamation plans, properly implemented and maintained, generally result in successful reclamation and beneficial reuse of the land. A well-developed plan will thoroughly evaluate all potential pathways for impacts to human health and the environment and address ways to prevent negative health effects through these pathways. Long-term reclamation success may be measured by prevention of excessive water runoff, soil runoff, or damage to water ecosystems; and achievement of vegetative cover, vegetation diversity, wildlife establishment, and hydrologic response.^{7,8}

NR 135 Wis. Admin. Code
Nonmetallic Mining Reclamation establishes reclamation standards for, but is not limited to:

- Surface water and groundwater protection
- Habitat restoration and wetlands protection
- Topsoil, slope, and vegetation management

Reclamation activities at the Badger Mining Corporation facility near Taylor, WI. Courtesy: Badger Mining Corporation



POTENTIAL HEALTH IMPACTS

HOW WILL RECLAMATION OF INDUSTRIAL SAND MINES IMPACT HEALTH?

Different post-mine land uses have different effects on the environment and may contribute to different health effects for the end-user. For example, reclamation of a mine to a prairie or wooded area will have different impacts to soil structure, vegetation diversity, wildlife establishment, and groundwater recharge than reclamation to row-crops. Land that is reclaimed to natural areas such as prairie, oak savannah, wetland, or lakes may provide habitat for wildlife that are economically beneficial (e.g. important pest-controllers and pollinators such as bats, birds, and bees). In addition, though private property is developed for mining in western Wisconsin, this land may become accessible to the public following reclamation and subsequently used for recreation. Access to recreational areas can improve physical and mental health and well-being by promoting physical activity and relaxation.⁹ Improved physical and mental health has been shown to decrease the occurrence of chronic diseases, increase lifespan, and promote healthy weight.¹⁰ The degree of impact is dependent on land ownership prior to mine development, recreational alternatives available to the general public in the area of a recently developed mine, and the level of recreational use of the property prior to mine development. An example of public recreational use of reclaimed mine property is the Badger Mining Corporation sponsorship of the annual WDNR nine-day gun deer hunt for disabled persons, ongoing since 2001.¹¹

All land uses have an impact on the environment. These impacts should be evaluated during review of reclamation plans in order to minimize negative human health effects. Reclaiming land so it can be used for heavy agriculture, such as row-crops, will have a different impact on soil, groundwater, and surface water, compared to land reclaimed for woodland or prairie. Regular tilling may compact the soil or lead to

erosion. This can impact the amount of water able to infiltrate into the ground, or the amount of sediment in water ecosystems. Agricultural areas may be irrigated or undergo regular application of herbicides, pesticides, or nutrients (such as nitrogen) that can infiltrate or run off to drainage areas, thereby potentially impacting waterways or private drinking wells if improperly managed. Similarly, use of reclaimed land for pasture will have different impacts on vegetation, soil, water quality, and water ecosystems compared other types of land use.

If reclamation plans are poorly designed or improperly implemented, features such as unstable sediment piles or steep bedrock walls could pose a human safety concern. Potential environmental implications of poorly designed or improperly implemented reclamation plans may include excessive water runoff, soil erosion, and an influx of sediment into nearby water ecosystems. Human health hazards have not been identified at mine sites that have been reclaimed in accordance with NR 135. Attention to reclamation processes and maintenance of reclaimed land can eliminate potential negative health, safety, or environmental impacts from the mine site. However, different post-mine land uses will have different potential impacts to the environment and to human health, and these variables should be considered when developing the reclamation plan. The individuals most impacted by reclamation are anticipated to be residents that live in proximity to an industrial sand facility. It is not anticipated that special population groups would be particularly vulnerable to reclamation-related health effects.

The majority of sand mines in Western Wisconsin are above ground. However, it should be noted that underground mine reclamation approaches differ from those used for surface mines. Underground mines may encompass hundreds of acres, be located more than 100 feet below ground, and lie beneath agricultural land, forests, and roads, with no noticeable impact on surface land use. That said, surface reclamation may be undertaken for the above ground processing or loading facilities associated with the underground mine.

HOW WILL RECLAMATION OF INDUSTRIAL SAND MINES IMPACT AGRICULTURE?

The literature regarding reclamation of industrial sand mines to agriculture is sparse. To date, there has been little research completed in Wisconsin regarding soil health following land reclamation from sand mining to agriculture. This may be due in part to the low number of industrial sand mines that have completed mining to the point of reclamation, or there may be no impetus to document reclamation practices in technical or other publications. Though some agricultural land has been developed for industrial sand mining in Wisconsin, many areas mined for silica sand were either not farmed or were unsuitable for farming due to steep topography or poor soils (H. Dolliver, personal communication, July 8, 2015).

In 2014, University of Wisconsin-River Falls researchers began a five-year study in Chippewa County to investigate impacts of mining reclamation on soil health, which can have implications for many different types of post-mine land use (not just agriculture). This study is being conducted in collaboration with Chippewa County

Land Conservation and Forest Management. As of the publication of this HIA report, no results of this study were available. The first annual report is expected to be published in March 2016.

Outside of Wisconsin, only a few studies have investigated impacts of sand mining and reclamation on crop yield. Daniels et al. (2003) studied crop performance in an area in Virginia reclaimed after mineral sands mining (a process slightly different from industrial sand mining). Three years after reclamation, corn and soybeans planted in the reclaimed area produced yields 73% and 97%, respectively, when compared to corn and soybeans planted in non-mined areas.¹²

Reclamation to agricultural use is not appropriate or necessarily desirable for all areas that are being developed for industrial sand mining. For areas that were productively farmed prior to mining, reclamation to agricultural land may be appropriate and has been demonstrated to be achievable in other parts of the US. For industrial sand mines in Wisconsin, topsoil excavated during mining may be stored during mine development along with other mined material not suitable for processing or marketing. Mechanical handling and storage of topsoil can negatively impact soil structure, organisms in the soil, and other factors that contribute to soil quality. Some mining companies mitigate these disturbances during reclamation by amending the soil and using specific tillage practices.¹³ For example, at Badger Mining Company in Taylor, Wisconsin, organic material such as tree branches and stumps that are removed during mine excavation are composted and added into the topsoil to improve soil structure and chemical balance (M. Lehman, personal communication, October 23, 2015).

It should be noted that agriculture, especially row-crop production, is an intensive land use that also has environmental impacts when compared to less demanding uses such as pasture, woodland, or prairie. The human health impacts of agriculture as an end land use are also different from other land uses. Agricultural land provides income and employment for a landowner or renter, and may result in associated health benefits. In addition, property taxes on agricultural land are generally lower than taxes on other property classifications, because agricultural property is assessed at “use value” (the ability to produce farm income) rather than full market value.¹⁴

Regardless of the particular setting, the environmental and potential human health impacts of various end land use options should be carefully evaluated in the development and implementation of industrial sand mine reclamation. Landowners who lease agricultural land to industrial sand facilities are most likely to be impacted by reclamation of land to agricultural use. It is not anticipated that any special population groups would be particularly vulnerable.

HOW WILL INDUSTRIAL SAND MINING IMPACT LAND AND PROPERTY VALUE?

Landowners who lease or sell their land to an industrial sand facility will receive income in the form of lease payments, royalties, or sale price. Increased income is associated with better health, and if the landowner had minimal or no previous income, the transaction would provide increased access to basic services such as healthy food, housing, health care, and other necessities.^{15,16} In addition, increase in individual income has been found to be associated with a small but significant increase in one's self-rated health.¹⁷ If the landowner already had access to basic services, the transaction may offer a continuation of that ability, along with potential to enhance the individual's buying power.

Property adjacent to an industrial sand facility may increase, decrease, or show no change in value. Potential impacts to property valuation are highly site specific and dependent on a range of variables. Much of the information regarding the positive or negative impact of industrial sand mines on adjacent property land value in western Wisconsin is anecdotal, and the authors of this HIA are not aware of any comprehensive Wisconsin-based study on property values and industrial sand mines. One study conducted by a certified residential appraiser in the Maiden Rock area did not find evidence that the presence of the Maiden Rock underground industrial sand mine affected the real estate market in Maiden Rock.¹⁸ However, this mine is below ground, largely not visible from the highway, and relies on product shipment by train, so the example may not be representative of impacts to adjacent property values in other parts of the state. Anecdotal evidence from western Wisconsin suggests the potential impact on land value in the vicinity of sand mines is mixed, as both property value increases and decreases have been reported.¹⁹ Property value increases are plausible if, for example, land that was previously being used for production agriculture is leased (or sold) for mine development, because land is typically valued much higher for mineral rights than for agricultural use.

The literature does support that the introduction of “undesirable facilities” to a community may impact property values. These effects can in part be the result of anticipated human health risks for individuals living close to the facility. However, the magnitude of property value impacts is inconsistent in the literature.²⁰ A summary of empirical studies by Farber (1998) indicated that property values in the vicinity of waste facilities could be negatively influenced by proximity to the facility and were commonly correlated with distance. The study also indicated that introducing a facility, even when perceived to be undesirable, may have a *positive* impact on property values if it is a source of local employment. Similarly, Ready (2010) found that impacts to property values by landfills in Pennsylvania were dependent on distance from the facility to a property, but that some landfills had no impact on property values, regardless of distance.²¹ Though none of these studies serve as a direct analogue for industrial sand facilities, they do indicate that facilities typically perceived as “undesirable” may not impact property values in the same way in all communities.

One of the confounding factors for property value impacts is that buyers and sellers may have different sensitivities to the perceived risks of a particular facility.²²

Potential buyers that see mine development as undesirable will not be interested in purchasing a property near a mine or where mine development is anticipated. Some buyers may be less sensitive to proximity to a mine, though this 'acceptable' distance could range from adjacent to miles away from a mine or processing facility. However, there are certainly instances in which properties situated close to a mine are likely to be devalued as a result of their proximity to the mine, perceived health risks, traffic, sightlines, or other impacts attributable to the industrial sand facility. The literature indicates that the impact on property values can change over the lifespan of a facility, and that the way the facility is portrayed by the media or groups opposing the facility may affect an individual's perception of the facility.^{23,24}

Negative health effects from impacts to adjacent property value are possible, though these effects will be highly dependent upon individual circumstances. One scenario is that in which a landowner unable to afford basic needs attempts to sell property and is unable to receive full market value, resulting in decreased equity or purchasing power. More likely, however, are potential health effects from the stress that landowners may feel if they fear they may have difficulty selling their property, or if indeed they are unable to sell their property at all. Increased stress can lead to negative health outcomes and may manifest as feelings of anxiety, anger, or physical symptoms, such as high blood pressure.^{25, 26, 27} There are reported instances of Wisconsin industrial sand mining companies making fair market or above fair market offers to purchase properties that are difficult to sell (R. Kosheshek, personal communication, November 10, 2015). Fair market value guarantees are present in some town or county agreements with industrial sand facilities, such as for the Town of Howard in Chippewa County.²⁸ Having this type of guarantee in place prior to mine construction can help reduce anxiety or stress for landowners who want to sell their property; it can also prevent negative health effects from lost property value. These arrangements can build positive relationships and ease public concern.

When considering the impacts of industrial sand mining on land value, policy makers should be aware of the potential for localized impacts to property values, the potential health effects of changes to land value, and emerging research on this topic.ⁱ Individuals most impacted by land value changes are anticipated to be residents who live in proximity to an industrial sand facility and wish to sell their property. It is not anticipated that special population groups would be particularly vulnerable.

SUMMARY

Following analysis of the available evidence, review of published literature, and consideration of expert opinion, the HIA research team characterized the potential for

ⁱ The research team acknowledges the 2006 assessment of property value impacts of a proposed Michigan mine conducted by G. Erickcek. However, neither this study nor the theoretical model included in it have been peer-reviewed or published. Our research has found that property-value impacts are highly site-specific and that the Erickcek study does not contribute to the understanding of the issue.

health effects as a result of impacts by industrial sand operations to land reclamation and land value.

LAND RECLAMATION

Likelihood – Based on the regulatory framework, consultation with industry representatives, and consultation with land conservation experts, health effects (positive or negative) from reclamation of industrial sand mines are **unlikely**. No community-level health effects from reclaimed industrial sand mines in Wisconsin have been identified, and reclamation plans implemented in accordance with NR 135 are likely to prevent health hazards at a mine site.

Intensity – The intensity of health effects from land reclamation are anticipated to be **low**. Expert opinion and current practices by some facilities indicate that land reclamation can be performed in a manner that minimizes environmental and health impacts.

Distribution – Though health effects are unlikely, if any health effects do occur, they are likely to take place among residents **adjacent** to mining operations.

Evidence – Evidence is **moderate** that industrial sand facilities are unlikely to impact health as a result of reclamation. The evidence is mostly based on expert opinion, media stories, and anecdotal reports.

LAND VALUE

Likelihood – Health effects from impacts to land value from an industrial sand facility are **possible**. The potential for health effects is highly site specific and depends on a range of factors. The most likely health effects due to impacts to land value are feelings of stress for landowners who want to sell their property, especially if they experience difficulty selling it. Any impacts to land value are expected to be localized, and not community-wide.

Intensity – The intensity of health effects from impacts to property value may be **low to high** as impacts to an individual's income (and related ability to obtain basic services) or an individual's feelings of stress will be variable, as will the impacts to an individual's property value.

Distribution – If health effects occur, they are most likely to occur in the area **adjacent** to an industrial sand facility.

Evidence – Evidence is **strong** that impacts to land value are possible. However, not all facilities will impact land value in the same way, and not all property owners near industrial sand facilities will experience health impacts in the same way.

	Likelihood of potential health effects	Intensity of potential health effects	Distribution of potential health effects	Evidence for likelihood of potential to impact health effects	Notes
Land reclamation	Unlikely	Low	Adjacent	Moderate	
Property value	Possible	Low to High	Adjacent	Strong	The distribution is anticipated to be in the adjacent area, but does <i>not</i> imply that <i>all</i> individuals in the area will experience these effects

Key to Effects Characterizationⁱⁱ

Likelihood: How likely is it that a given health effect will occur in association with industrial sand mining

Insufficient evidence – The likelihood of a health effect cannot be judged based on available evidence

Unlikely – It is not likely that health effects will occur

Possible – Health effects are plausible

Likely – Health effects are probable

Very Likely – Health effects are highly probable

Intensity: The magnitude of the potential positive or negative health effects associated with industrial sand mining

Insufficient evidence – Evidence is inadequate to judge the intensity of health effects

Low – There are likely to be no or minimal health effects

Medium – Health effects may be minor; negative effects would be non-disabling

High – Positive or negative health effects may be considerable

Distribution: the expected impact based on proximity to an industrial sand facilityⁱⁱⁱ

Occupational – Health effects, if any, may be limited to employees of the facility

Adjacent – Health effects, if any, may be experienced by individuals very near to a facility

Surrounding – Health effects, if any, may be experienced by individuals in the same community as a facility

Regional – Health effects, if any, may be experienced by individuals in western Wisconsin

Quality of evidence for the likelihood of health effects

None – There is no available evidence

Weak – Evidence is primarily anecdotal, based on media stories or individual reports

Moderate – Evidence is based on expert opinion, reports from experts, academics, industry, government, and others

Strong – Evidence is based on published studies not specific to western Wisconsin

Very Strong – Evidence is based on published studies specific to western Wisconsin

ⁱⁱ It should be noted that effects characterization relies on both qualitative and quantitative data and methods. It is also based on the evidence available at the time that this assessment is completed. As new evidence becomes available, effect characterization may change.

ⁱⁱⁱ This categorization doesn't imply that all individuals within the geographic area will experience health effects, only that if health effects occur, the geographic area identified is relevant.

RECOMMENDATIONS

Policy makers should seek to understand the specific impacts expected at proposed sand mines to better understand the range of potential health impacts. For proposed or existing industrial sand facilities, this assessment recommends:

- 1. Development of a set of voluntary industry standards, such as those suggested by the Wisconsin Industrial Sand Association (WISA) Code of Conduct, which may help to promote thoughtful review, policy and project development, and positive relationships with community members. The WISA Code of Conduct promotes, among other things:
 - a. Open dialog with stakeholders.
 - b. Consideration of stakeholder perspectives and appropriate action to minimize community impacts of industrial sand operations.
 - c. Design and operation of safe and environmentally sound industrial sand facilities.

Examples of the WISA code and other sustainability principles are included in Appendix B.

- 2. Representation from local, tribal, or regional public health departments as part of local permitting or review process. This may improve positive health outcomes and minimize negative health effects. Public health representatives can provide a “health lens” to permitting discussions and serve to promote and protect public health interests in this process.

The following recommendations and considerations may also reduce negative health impacts and promote positive health outcomes. These recommendations and considerations may not be applicable for all industrial sand facilities, but may be useful for decision makers who are considering industrial sand mine applications. Regarding reclamation, decision and policy makers should keep in mind that in cases where the reclaimed mine property will remain private property, input into mine reclamation should focus first on public safety, second on meeting state and local regulations, third on appearance and potential for nuisance, and lastly on the personal preferences of the local decision makers and the public.

Recommendations	
Existing Facilities	To minimize potential negative health effects from land reclamation, it is recommended that policymakers: 1 Encourage adoption of standards, such as those suggested by the WISA Code of Conduct. 2 Request that each existing facility: a. establish a contact point for residents to ask questions or lodge complaints, b. develop action plans to ensure response to and resolution of complaints.

	Recommendations
Proposed Facilities	To minimize potential negative health effects from land reclamation, it is recommended that policymakers: 1 Include local or regional health department representatives on applicable and permitting panels. Reviewers should consider potential health effects of the reclamation plan, including health effects of the proposed end land use(s). 2 Establish a public or joint public/private contact point for residents to ask questions, and establish action plans to ensure quick response to and resolution of complaints during the proposal consideration phase. 3 Support reclamation techniques, such as geomorphic reclamation, that aim to return post-mine landscape to the pre-mining appearance, promote soil and vegetative health, and improve water retention in the reclaimed area. 4 Support end land uses that create opportunities for healthy, active living, where feasible. To minimize potential negative health effects from land value it is recommended that policymakers: 1 Review the pros and cons of an industry guarantee to provide fair market value for neighboring property owners.
	Considerations
Proposed Facilities	To minimize potential negative health effects from land value, policymakers may consider: Establish a public or joint public/private contact point for residents to ask questions, and establish action plans to ensure quick response to and resolution of complaints during the proposal consideration phase.

- ¹ Wisconsin Department of Natural Resources. (2012). *Silica Sand Mining in Wisconsin*. Madison, WI.
- ² Toy, T.J., & Daniels, W.L. (1998). Reclamation of disturbed lands. In: R.A. Meyers (Ed.), *Encyclopedia of environmental analysis and remediation*. (pp. 4078-4101). New York, NY: Wiley.
- ³ Toy, T.J., & Daniels, W.L. (1998). Reclamation of disturbed lands. In: R.A. Meyers (Ed.), *Encyclopedia of environmental analysis and remediation*. (pp. 4078-4101). New York, NY: Wiley.
- ⁴ Badger Mining Corporation. (2014) *Annual Environmental Report*. Retrieved from <http://dnr.wi.gov/topic/GreenTier/Participants/Reports/BadgerMining2014.pdf>
- ⁵ Fairmount Minerals. (2014). Bat protection efforts stepped up as White Nose threat grows. *Neighbors Newsletter* 1, 3.
- ⁶ Fairmount Minerals. (2013). Bat night highlights conservation partnership. *Neighbors Newsletter*, 2.
- ⁷ Toy, T.J., & Daniels, W.L. (1998). Reclamation of disturbed lands. In: R.A. Meyers (Ed.), *Encyclopedia of environmental analysis and remediation*. (pp. 4078-4101). New York, NY: Wiley.
- ⁸ Wisconsin Administrative Code. *Nonmetallic Mining Reclamation* NR 135, 135.15
- ⁹ Godbey, G. (2009). Outdoor recreation, health, and wellness: understanding and enhancing the relationship. *RFF Discussion Paper* 9-21. Retrieved from http://papers.ssrn.com/sol3/papers.cfm?abstract_id=1408694
- ¹⁰ Blair, S., Kohl, H., Paffenbarger, R., Clark, D., Cooper, K., & Gibbons, M.D. (1989). Physical fitness and all-cause mortality: A prospective study of healthy men and women. *Journal of American Medical Association*, 262(17), 2395-2401.
- ¹¹ Badger Mining Corporation Special Hunt. Retrieved from <http://bmcspecialhunt.com/>.
- ¹² Daniels, W., Schroeder, P., Nagle, S., Zelazny, L., & Alley, M. (2003). Reclamation of prime farmland following mineral sands mining in Virginia. *Mining Engineering*, 42-48.
- ¹³ See for example Barr Engineering, (2011, November 10). Sparta Plant reclamation plan prepared for US Silica. Retrieved from <http://www.co.monroe.wi.us/wp-content/uploads/2012/01/20111110153305.US-Silica-DraftReclamationPlan-20111110reduced.pdf>
- ¹⁴ Legislative Audit Bureau. (2010). *Use Value Assessment of Agricultural Land Letter Report*. Madison, WI. Retrieved from http://legis.wisconsin.gov/lab/reports/10-usevalueassessment_ltr.pdf.
- ¹⁵ Ecob, R., & Smith, G.D. (1999). Income and health: What is the nature of the relationship? *Social Science & Medicine*, 48, 693-705.
- ¹⁶ Sorlie, P.D., Backlund, E., & Keller, J.B. (1995). US mortality by economic, demographic, and social characteristics: The national longitudinal mortality study. *American J. of Public Health*, 85(7), 949-956
- ¹⁷ Gunasekara, F.H.I., Blakely, T., & Carter, K. (2008). Paper from Population Health Congress: *Do income changes over time affect changes in self-rated health?* Brisbane, Australia.
- ¹⁸ Richardson, P.W., & Ducklow, B.M. (2011, January 15). Comparative study of Maiden Rock markets. Submitted in *Response to Citizen Concerns* by Fairmount Santrol, January 17, 2011. Report is part of conditional use permit application on file with Pierce County Land Management Committee.
- ¹⁹ Dir, A. (2014, March 30). Frac sand mines credited for rising, dropping property values. *Wisconsin Watch*. Retrieved from <http://wisconsinwatch.org/2014/03/frac-sand-mines-credited-for-rising-dropping-property-values/>.
- ²⁰ Schively, C. (2007). Understanding the NIMBY and LULU Phenomena: Reassessing our knowledge base and informing future research. *Journal of Planning Literature*, 21(3), 255-266.
- ²¹ Ready, R.C. (2010). Do landfills always depress nearby property values? *J. Real Estate Rsch*, 32(3), 321-340
- ²² Zeiss, C., & Atwater, J. (1989). Water facility impacts on residential property values. *Journal of Urban Planning and Development*, 115 (2), 64-80.
- ²³ McCluskey, J., & Rausser, G. (2003). Hazardous waste sites and housing appreciation rates. *Journal of Environmental Economics and Management*, 45(2), 166-176.
- ²⁴ McClelland G.H., Schulze, W.D., & Hurd, B. (1990). The effect of risk beliefs on property values: A case study of a hazardous waste site. *Risk analysis: an official publication of the Society for Risk Analysis*, 10(4), 485-497.
- ²⁵ World Health Organization European Centre for Environment and Health. (2011). *Burden of disease from environmental noise*. Bonn, Germany: WHO Regional Office for Europe.
- ²⁶ Babisch, W. (2005). Noise and health [Guest editorial]. *Env. Health Perspectives*, 113(1), A14-A15.
- ²⁷ World Health Organization European Centre for Environment and Health. (2011). *Burden of disease from environmental noise*. Bonn, Germany: WHO Regional Office for Europe.
- ²⁸ Town of Howard Mining Agreement with EOG Resources. Retrieved from <http://www.wisctowns.com/uploads/ckfiles/files/Town%20of%20Howard%20Developers%20Agreement.pdf>

SECTION 7: QUALITY OF LIFE

CONNECTION BETWEEN QUALITY OF LIFE & HEALTH

Quality of life is an umbrella term that can refer to a variety of themes. The ways in which quality of life impacts individual health are variable among different individuals and may change over time. Individuals who perceive that they have a good quality of life are more likely to experience better health outcomes.

FOCUS OF THIS SECTION

Three quality of life themes are addressed in this health impact assessment: cultural heritage and sense of place; economics; and the environmental factors of traffic, light, and noise.

CULTURAL HERITAGE AND SENSE OF PLACE & HEALTH

Emotional, spiritual, or social connection to a place may be closely linked to an individual's sense of identity, nostalgia, or place.¹ The Dictionary of Urban Geography defines 'sense of place' as "the attitudes and feelings that individuals and groups hold vis-à-vis the geographical areas in which they live. It further commonly suggests intimate, personal and emotional relationship between self and place."² The idea of 'sense of place' goes beyond the *quality* of a place and focuses on an individual's *satisfaction with* and *personal connection to* a place. An individual's sense of place is influenced by many different factors, including socio-economic status, health, age, and built environment.³ Measureable characteristics of this bond may include attitude or ingrained cultural stances, values, and environmental perception.⁴ When individuals are strongly bonded to their surroundings, their sense of place can be disturbed by a perceived or realized threat to their environment, and negative perceptions of an individual's environment have been associated with poor health outcomes.⁵

ECONOMICS & HEALTH

The body of socioeconomic literature strongly supports a correlation between socioeconomic status, mortality, and morbidity. Individuals with lower income, education, and work skills suffer from higher disease and death rates.^{6,7,8} Low community-level socioeconomic status has been found to be associated with infant and adult mortality, suicide, long-term illness, negative child health outcomes, chronic diseases, and other poor health outcomes.⁹ Income provides the opportunity

for an individual to have control over life circumstances such as access to housing, healthy diet, and appropriate medical care. It also contributes to differences in mental health outcomes, including reduced stress levels.¹⁰ A secure, financially and emotionally rewarding job can lead to positive health benefits, such as improved social well-being, mental well-being, and life expectancy.^{11,12}

Income inequality (the difference in an individual's income compared to others in the area) has been found to have adverse health impacts at the community level. It can break down social cohesion, increase crime rates, and impose a perceived lack of well-being, all of which can contribute to poor health outcomes.^{13,14}

TRAFFIC, LIGHT, NOISE, & HEALTH

A wide range of factors can influence the potential health effects from traffic, including the type and frequency of vehicles, individual proximity to roadways, roadway design, and many others. Potential health effects could include nuisance noise and light. High traffic volume can increase the risk of injury. Increased traffic volume can also adversely impact air quality through the release of fine particulates from vehicle exhaust.

Ongoing exposures to light and noise can trigger a range of health effects, which may be partly dependent on magnitude, timing, duration, and personal tolerance. Annoyance or nuisance effects have been associated with noise levels in the range of 40-55 decibels, which is approximately the level of noise produced by light traffic. Noise levels of 40-60 decibels can adversely affect sleep.¹⁵ Excessive light and noise can impact human health by disturbing sleep, relaxation, cognitive focus and memory in children, and by causing annoyance, can manifest in physical symptoms such as higher stress hormones or blood pressure, anger, and anxiety.^{16,17,18} Generally, short, high frequency, intense, intermittent sounds have greater negative health effects than continuous, low frequency, low intensity, long sounds.¹⁹

EXISTING LOCAL CONDITIONS

CULTURAL HERITAGE & SENSE OF PLACE

Federally-recognized Ho-Chunk Nation Tribal trust lands are present in western Wisconsin (Fig. 1.2) and dispersed throughout this landscape are sites of archaeological and cultural significance to the Ho-Chunk Nation. The Nation's Tribal Historic Preservation Office maintains a database of these sites. Though Ho-Chunk Nation lands in Wisconsin are not developed for industrial sand mining, sand mines may be adjacent to Tribal lands or to private property on which Tribal members reside. State statutes direct the Wisconsin Department of Natural Resources, in cooperation with the Wisconsin Historical Society, to identify and protect any archaeological sites or other cultural resources recorded by the Historical Society that could be adversely impacted by permitting or other action by the WDNR.²⁰

However, not all locations of importance to Ho-Chunk history, customs, and culture are registered with the Wisconsin Historical Society.

Non-Tribal residents of the region may also closely identify with historical and modern land uses for agriculture, livestock, fishing, hunting, and recreation. These industries are reminiscent of ancestral activities and as such, cultivate a sense of place or nostalgia. For residents in the region, preserving these historical attributes can be important for maintaining their sense of place.

ECONOMICS

The data in the Community Health Profile (Section 3) provide a basic overview of the economic picture for Level 1 partner communities. This economic overview also provides a context for assessing the potential economic importance of industrial sand mining in these communities. Unemployment rates for Eau Claire, Trempealeau, and Pierce counties are 5%, which is slightly below the statewide average. Currently, employment is dominated in these counties by jobs that are not directly or indirectly related to sand mining (Table 3.4). In the western region of Wisconsin, job growth has been relatively steady since 2001, well before the increase in industrial sand mining activity that the region experienced in the late 2000's.²¹ The western region exhibits a generally stable job market and industrial sand employment in Eau Claire, Pierce, and Trempealeau counties accounts for less than 1% of all jobs.²²

TRAFFIC, LIGHT, AND NOISE

Industrial sand facilities are primarily present in rural areas or near small towns. The road infrastructure in these areas is primarily county roads and two-lane highways. In addition to passenger vehicle traffic, truck traffic from transport of retail goods, agricultural products, and sand and gravel excavation may be present. The primary sources of light and noise would be major industry within an area (such as agriculture, retail goods, construction, and others), daily activity from passenger traffic, and regular operations of small businesses.

In areas where industries rely heavily on trucks to transport goods, state statutes and the Facility Development Manual from the Wisconsin Department of Transportation provide local governments with the tools to manage impacts to roads.²³ Road upkeep and maintenance agreements are a tool for local authorities to negotiate with industrial roadway users. Negotiations may include how wear and tear on roads will be financed and managed. These agreements can help ensure that a traffic-generating industry (e.g., industrial sand, construction, waste hauling, or others) provides compensation for road maintenance.²⁴

POTENTIAL HEALTH IMPACTS

HOW WILL INDUSTRIAL SAND MINING IMPACT CULTURAL HERITAGE AND SENSE OF PLACE?

The development of a mine in a rural area can impact perceptions around cultural heritage preservation or sense of place for some individuals. Development of a mine or processing facility will change the landscape and may impact sight lines of nearby residents. In addition to affecting the landscape, rail or road traffic and noise associated with mining or processing operations can change the soundscape of an area. Similarly, lights associated with the construction and operation of an industrial sand mine can change the degree of sky darkness in rural areas. Many of these impacts may only last while the mine is in operation, but others may last for many years after a mine is closed. Even after reclamation activities are complete, establishment of mature vegetation in a reclaimed area may take decades. If substantial water drawdown occurs in an area, this may affect wetlands that attract wildlife or streams used for fishing. Within the western region, there are individuals that strongly identify with and rely on hunting and gathering activities. Although the potential environmental impacts of mines may not have direct health effects, they may locally impact these lifestyles and traditions. Any or all of these changes can disrupt an individual's sense of place or cause discomfort because they alter "how things used to be." These types of changes may be perceived as a threat to an individual's environment and a loss of the familiarity, history, or meaning of a place for an individual. Researchers have coined the term "solastalgia" to describe this phenomenon: "pain or distress caused by the loss of, or inability to derive, solace connected to the negatively perceived state of one's home environment".²⁵ Concern for these types of changes even prior to the development of a mine can cause anxiety and mental stress that may range from minor to severe in different individuals.²⁶

Though industrial sand mining and processing occurs in 13 of the 14 counties included in this assessment, it is not currently permitted on Ho-Chunk Nation lands within these counties. Industrial sand mining activity may conflict with cultural views about land use and tradition. Natural resources such as water and white sand, as well as specific areas used for ceremonies, hold special significance to Nation members. In order to better understand the cultural conflicts with industrial sand mining in the Ho-Chunk Nation, the HIA research team conducted key informant interviews with Tribal members in western Wisconsin. The following quotations illustrate the interviewees' sentiments regarding industrial sand mining and cultural heritage:

"This goes against our beliefs culturally...We have to live more in harmony and sand mining disrupts this harmony." (Monroe County resident, Ho-Chunk Nation member)

"The land is given to us by our Creator, we are supposed to be stewards of it. They [sand mines] are disturbing [the] natural

process of the earth.” (Jackson County resident, Ho-Chunk Nation member)

“Our role is to take care of Mother Earth. We’ve always been taught every layer of earth is holy...the white sand itself is holy to us, it is used in our ceremony.” (Juneau County resident, Ho-Chunk Nation member)

“All of our ceremonials are held at Grandma’s property. We will be hearing trucks when we should be enjoying nature.” (Eau Claire County resident, Ho-Chunk Nation member, on proposed industrial sand mine in Eau Claire County)

It is critical to note that impacts to human health from disturbance of cultural heritage or sense of place will be highly variable among individuals exposed to a similar situation and may vary based on timing, location, facility size, individual proximity to the site, extent of visible changes to the landscape, and other factors. Some individuals may feel little to no effects from changes to their environment and may not perceive these changes as threats. Other individuals may feel substantial effects such as high levels of stress or a negative perception of their environment, which in turn may be associated with anxiety or depression.^{27,28} In addition to the psychological effects of stress, stress may be associated with physical and behavioral conditions such as high blood pressure, poor immune response, gastrointestinal conditions, sleep disturbances, and other conditions.²⁹

The degree of control that individuals feel they have over a perceived or realized threat may impact the stress levels associated with the change, as lower perceived control over the environmental change is correlated with higher levels of stress.³⁰ Therefore, the ability for community members to have input into the permitting process or have open dialogue with current mine operators on facets that may impact an individual’s quality of life (e.g., traffic, light, noise, sightlines, proximity to adjacent properties, or cultural and historical areas) may improve the perceived control a community feels over a change to their environment. Some facilities have (in addition to other mitigation techniques) constructed berms to block sight of and noise from a mine, minimized mine traffic by loading directly to rail from processing facilities, and limited operation and blasting hours to avoid negative noise and light impacts. The opportunity for local residents to provide comment during the permitting process could allow some residents to feel a greater level of control over a change to their surroundings, thereby potentially decreasing adverse health impacts.³¹

“Road use issues are a large concern in some communities. This issue covers many facets.”
Mining industry representative,
Trempealeau County
(Response to stakeholder scoping survey)

HOW WILL INDUSTRIAL SAND MINING IMPACT ECONOMICS AND HEALTH?

It is outside the scope of this HIA to provide an economic analysis of the industrial sand mining industry. Rather, this assessment addresses health effects as they relate to the potential economic impacts of industrial sand mines. Similar to agriculture and other market-based industries, the economic impact of industrial

sand mining in Wisconsin is difficult to quantify, as market fluctuations can drastically change industry outlook—for better or worse—over a short period of time. The mining industry is historically cyclical, and individuals who directly or indirectly rely on industrial sand mines for income will likely experience economic impacts due to market fluctuations. When determining the impact to individuals, potential variables may include: whether they experience direct employment, indirect employment, or no employment gains, or whether they are affiliated with a business that could be impacted (positively or negatively) by an industrial sand facility.

The Wisconsin Economic Development Corporation has estimated the number of sustainable jobs from the industrial sand sector at between 2,500 and 3,000 statewide.³² Other sources have estimated as many as 7,100 jobs would be directly supported if all permitted industrial sand mines and processing were fully operational.³³ The industrial sand industry has created jobs through direct employment and indirect employment in industries such as construction, transportation, and manufacturing. In some areas, these jobs may be significantly above the average pay in a given community.³⁴ The average earnings for quarry and mine employees (not exclusively industrial sand mining) in Eau Claire, Peirce, and Trempealeau counties is over \$77,000.³⁵ This is approximately \$18,000 - \$30,000 higher than the median household income for these communities.³⁶ Industrial sand facilities may also contribute to tax revenue and economic diversification for the western region.^{37,38}

“Jobs associated with sand mining are an important way of diversifying the economy in areas dominated by agriculture.”
University professor, Eau Claire County (response to stakeholder scoping survey)

In addition to economic benefits, there are also economic costs to industrial sand mining. Some industrial sand facilities are not able to employ all workers year-round, and market downturns have resulted in lost jobs. During this assessment period (2014-2015), a downturn in the global oil market led to less oil drilling and a reduced demand for industrial sand, leading to layoffs for multiple silica sand facilities in Wisconsin.³⁹ As discussed previously in this section, loss of income can create stress and anxiety in unemployed workers and extended unemployment may lead to financial burden. There is also evidence from the Blair-Taylor school district (Trempealeau and Jackson counties) that the introduction of a sand mine increased property values to the point that formula-based financial aid from the state was reduced.⁴⁰ Though industrial sand mining has provided employment opportunities and economic benefits, researchers agree that only a small percentage of total jobs in the region will be within the industrial sand industry, and that thus far, the industry has not proved to be a source of economic vitality.^{41,42,43} Therefore, it is unlikely that economic cycles within the industry will have a significant impact on community-level economic stability.

HOW WILL INDUSTRIAL SAND MINING IMPACT TRAFFIC, LIGHT, AND NOISE EMISSIONS, AND COMMUNITY HEALTH?

TRAFFIC

Some citizens in the vicinity of industrial sand mines have expressed concern that taxpayers will be responsible for the financial burden of potential road degradation resulting from industrial sand mine truck traffic.⁴⁴ Indeed, industrial sand trucks will increase the number of vehicles on roads that may have been constructed for lighter or less frequent use, such as the roadways in areas previously zoned for agricultural use.⁴⁵ However, not all industrial sand mines rely on trucks for raw or processed product transportation to the same degree. Shipment of industrial sand by rail is less expensive than shipment by truck, and many mines primarily (or exclusively) ship via rail for this reason.⁴⁶ Once again, this underscores the need to look at potential health impacts on a site-by-site basis or to seek clarity in the case of pending plans and permits.

Since the actual impact of a particular industrial sand facility on traffic levels will be site-specific and highly variable, only the *potential* health impacts of industrial sand mine traffic can be assessed. Health impacts from vehicle traffic are dependent on the timing of traffic, vehicle type, number of vehicles or trucks, road surface, and other factors. Increased road traffic may increase the potential for crashes and injuries, air emissions, degradation of road conditions, or nuisance noise and light. Health effects of these impacts may include a threat to physical safety, air quality, or a perceived threat to an individual's environment if residents experience intolerable increases in noise or light from traffic. To better determine potential adverse health impacts, local authorities need to evaluate the increase in traffic from an industrial sand mine relative to pre-mining and existing seasonal traffic patterns, on a site-specific basis. Potential health effects to individuals could be minimized if facilities use measures that minimize vehicle traffic, such as direct-to-rail loading and transport, transport routes that minimize local residents' exposure to facility traffic, or other measures.

In a recent study conducted in Chippewa County by the National Center for Freight & Infrastructure Research & Education, researchers evaluated the use of road upgrade and maintenance agreements.⁴⁷ This study found that these agreements have proven useful for industry and local authorities, but that more tools and guidance are needed for negotiating road use agreements that span multiple jurisdictions (e.g. county, town, and state). Using well-negotiated road upkeep and maintenance agreements with industrial sand facilities may prevent potential negative economic impacts to taxpayers who live near truck routes.

"Town residents like the quality of the farm community, but also like what the local mine does for the community." Pierce County resident (response to stakeholder scoping survey)

LIGHT AND NOISE

Light and noise impacts from industrial sand facilities are highly variable. These types of impacts depend on the location, size of the facility, season, blasting (if any), where

and when excavation and processing occur, distance to adjacent property owners, and many other factors. Sources of noise from industrial sand operations may include vehicle traffic, train traffic, blasting, processing (crushing, washing, and drying), and on-site heavy machinery. Sources of light may include traffic, machinery, or ground-illuminating lights, if mining or processing occurs at night. Health effects from light and noise on an individual scale may range from imperceptible to significant and will vary according to the intensity and frequency of disturbances as well as individual sensitivity to them. Light and noise emissions from industrial sand facilities in the region are most likely to cause health effects from annoyance or nuisance exposure. These types of impacts can be mitigated through facility design, such as berms, ridges, or trees that can block noise and sound for nearby residents. Some facilities have limited the noise impacts to the immediate area by installing non-traditional heavy machinery back-up alarms that are less likely to be heard away from the mine site (T. Lindblad, personal communication, May 6, 2015). Policy makers should seek to understand the specific light, noise, and traffic expected at proposed sand mines and solicit public input, so they can better understand the range of potential health impacts.

SUMMARY

Following analysis of the range of industry practices, review of published literature, and consultation with subject area experts, the HIA research team characterized the potential for health effects as a result of impacts by industrial sand operations to the following aspects of quality of life:

CULTURAL HERITAGE & SENSE OF PLACE

Likelihood – Based on survey results, in-person interviews with community members, and a review of relevant literature, health effects from the impact of industrial sand mining on cultural heritage or sense of place are **likely**. This finding does not imply that these effects will be widespread, but *some* individuals are likely to experience health effects.

Intensity – There are many variables that will impact an individual's feelings of disturbance of sense of place or cultural heritage. As a result, the intensity of these effects is anticipated to range from **low to high**.

Distribution – The population most likely to experience health effects are those in the **surrounding** community.

Evidence – Evidence is **strong** that health effects are likely, should an individual experience a disruption to his or her sense of place or cultural heritage.

ECONOMIC

Likelihood – Economic impacts from industrial sand mining are **likely**. Impacts may be positive or negative and will be highly dependent on the community, facility, and individual. The direction of economic impacts may change over time.

Intensity – The intensity of health effects may range from **low to high** as there are many variables that factor into this measure. In addition, the intensity of economic impacts and subsequent health effects may change over time.

Distribution – Economic impacts from industrial sand mining may impact individuals in the **surrounding** area, though this does not imply that every individual will experience impacts, or the same intensity of impacts. Regional impacts may result from direct or indirect employment (especially transportation and construction), economic diversification, and others.

Evidence – Evidence is **strong** that economic impacts are possible in western Wisconsin.

TRAFFIC, LIGHT, & NOISE

Likelihood – Health effects from traffic, light, and noise are **possible**, though they will be highly dependent on the proximity of residents to industrial sand facilities, facility design, and other factors.

Intensity – The intensity of health effects from exposure to traffic, light, and noise may be **low to high**, as individual sensitivity to identical exposure can be highly variable.

Distribution – If health effects occur, they are most likely to occur in the **surrounding** area of an industrial sand facility.

Evidence – The evidence for potential health effects as a result of traffic, light, and noise exposure is **strong**. However, not all facilities will impact traffic, light, and noise in the same way.

	Likelihood of potential health effects	Intensity of potential health effects	Distribution of potential health effects	Evidence for likelihood of health effects	Notes
Cultural Heritage & Sense of Place	Likely	Low to high	Surrounding	Strong	Though effects are 'likely' for some individuals, this does not imply that <i>all</i> individuals will experience these effects.
Economic	Likely	Low to high	Surrounding	Strong	
Traffic, Light, Noise	Possible	Low to high	Surrounding	Strong	Potential health effects are not unique to impacts from industrial sand facilities.

Key to Effects Characterizationⁱ

Likelihood: How likely is it that a given health effect will occur in association with industrial sand mining

Insufficient evidence – The likelihood of a health effect cannot be judged based on available evidence

Unlikely – It is not likely that health effects will occur

Possible – Health effects are plausible

Likely – Health effects are probable

Very Likely – Health effects are highly probable

Intensity: The magnitude of the potential positive or negative health effects associated with industrial sand mining

Insufficient evidence – Evidence is inadequate to judge the intensity of health effects

Low – There are likely to be no or minimal health effects

Medium – Health effects may be minor; negative effects would be non-disabling

High – Positive or negative health effects may be considerable

Distribution: the expected impact based on proximity to an industrial sand facilityⁱⁱ

Occupational – Health effects, if any, may be limited to employees of the facility

Adjacent – Health effects, if any, may be experienced by individuals very near to a facility

Surrounding – Health effects, if any, may be experienced by individuals in the same community as a facility

Regional – Health effects, if any, may be experienced by individuals in western Wisconsin

Quality of evidence for the likelihood of health effects

None – There is no available evidence

Weak – Evidence is primarily anecdotal, based on media stories or individual reports

Moderate – Evidence is based on expert opinion, reports from experts, academics, industry, government, and others

Strong – Evidence is based on published studies not specific to western Wisconsin

Very Strong – Evidence is based on published studies specific to western Wisconsin

ⁱ It should be noted that effects characterization relies on both qualitative and quantitative data and methods. It is also based on the evidence available at the time that this assessment is completed. As new evidence becomes available, effect characterization may change.

ⁱⁱ This categorization doesn't imply that all individuals within the geographic area will experience health effects, only that if health effects occur, the geographic area identified is relevant.

RECOMMENDATIONS

Policy makers should seek to understand the specific sense of place; economic; and light, noise, and traffic impacts expected at proposed sand mines to better understand the range of potential health effects. For proposed or existing industrial sand facilities, this assessment recommends:

- 1 Development of a set of voluntary industry standards, such as those suggested by the Wisconsin Industrial Sand Association (WISA) Code of Conduct, which may help to promote thoughtful review, policy and project development, and positive relationships with community members. The WISA Code of Conduct promotes, among other things:
 - a. Open dialog with stakeholders.
 - b. Consideration of stakeholder perspectives and appropriate action to minimize community impacts of industrial sand operations.
 - c. Design and operation of safe and environmentally sound industrial sand facilities.

Examples of the WISA code and other sustainability principles are included in Appendix B.

- 2 Representation from local, tribal, or regional public health departments as part of the local permitting or review process. This may improve positive health outcomes and minimize negative health effects. Public health representatives can provide a “health lens” to permitting discussions and serve to promote and protect public health interests in this process.

The following recommendations and considerations could reduce negative health impacts and promote positive health outcomes. These recommendations and considerations may not be applicable for all industrial sand facilities, but may be useful for decision makers who are considering industrial sand mine applications.

Recommendations	
Existing Facilities	To minimize potential negative health effects from impacts, it is recommended that policymakers:
	Cultural Heritage and Sense of Place
	1 Request that each existing facility establish a contact point for residents to ask questions, and develop action plans to ensure response to and resolution of complaints.
	2 Request that facilities strive for minimizing impacts to sense of place by listening to and considering stakeholder perspectives for sense of place issues important to the surrounding community.
	3 Support efforts to develop constructive relationships between mining companies and Indigenous Peoples, including suggestions in the ICM <i>Indigenous Peoples and Mining Position Statement</i> . ⁴⁸

	Recommendations
Existing Facilities	Traffic, Light, and Noise: 1 Be familiar with how to assess roadway impacts from truck traffic and establish a process for mitigating impacts from high-volume industries in accordance with state statutes. 2 Promote full consideration of stakeholder perspectives related to noise, light, or other tangible impacts from industrial sand mines. 3 Request that each existing facility establish a contact point for residents to ask questions, and develop action plans to ensure response to and resolution of complaints.
Proposed Facilities	To minimize potential negative health effects from impacts, it is recommended that policymakers: Cultural Heritage and Sense of Place 1 During the proposal consideration phase, establish a public or joint public/private contact point for residents to ask questions, and develop action plans for response. 2 Encourage facility design that minimizes impacts to the soundscape and sightlines of nearby residents. 3 Consult with Tribal Historical Preservation Office to evaluate the potential for impact to cultural or archeological sites. Economics: Evaluate and consider all potential positive and negative economic impacts of a proposed industrial sand facility during the permitting process. Traffic: 1 Be familiar with how to assess roadway impacts from truck traffic and establish a process for mitigating impacts from high-volume industries in accordance with state statutes. 2 Encourage facility design plans that include provisions to minimize the impact of sand transport, such as direct-to-rail shipment. Traffic, Light, and Noise: 1 During the proposal consideration phase, be sure to fully consider all stakeholder perspectives related to noise, light, and other tangible impacts from industrial sand mines. 2 During the proposal consideration phase, establish a public or joint public/private contact point for residents to ask questions, and establish action plans for response to and resolution of complaints.
	Considerations
Proposed Facilities	To minimize potential negative health effects from economic impacts, policy makers may consider: Encourage sustainable business models that work to minimize impacts to mine employees during seasonal or market fluctuations.

- ¹ Hawke, S. (2012). Heritage and sense of place: Amplifying local voice and co-constructing meaning. In I. Convery, G. Corsane, & P. Davis (Eds.), *Making sense of place – Multidisciplinary Perspectives* (pp. 235-246). Woodbridge, UK: Boydell Press.
- ² Wylie, J. (2009). Sense of place. In D. Gregory, R. Johnston, G. Pratt, M. J. Watts, & S. Whatmore (Eds.), *The dictionary of human geography* (5th ed.). Chichester, UK: Wiley-Blackwell.
- ³ Williams, A., & Kitchen, P. (2012). Sense of place and health in Hamilton, Ontario: A case study. *Social Indicators Research*, 108(2), 257–276.
- ⁴ Ogunseitan, O.A. (2005). Topophilia and the quality of life. *Environmental Health Perspectives*, 113(2), 143-148.
- ⁵ Williams, A., & Kitchen, P. (2012). Sense of place and health in Hamilton, Ontario: A case study. *Social Indicators Research*, 108(2), 257–276.
- ⁶ Feinstein, J.S. (1993). The relationship between socioeconomic status and health: A review of the literature. *The Milbank Quarterly*, 71(2), 279-322.
- ⁷ Feinstein, J.S. (1993). The relationship between socioeconomic status and health: A review of the literature. *The Milbank Quarterly*, 71(2), 279-322.
- ⁸ Sorlie, P.D., Backlund, E., & Keller, J.B. (1995). US mortality by economic, demographic, and social characteristics: The national longitudinal mortality study. *American Journal of Public Health*, 85(7), 949-956.
- ⁹ Yen, I.H., & Syme, S.L. (1999). The social environment and health: A discussion of the epidemiologic literature. *Annual Review of Public Health*, 20, 287-308.
- ¹⁰ Kosteniuk, J., & Dickinson, H. (2003). Tracing the social gradient in the health of Canadians: Primary and secondary determinants. *Social Science & Medicine*, 57(2), 263-276.
- ¹¹ World Health Organization. (2000). *Mental health and work: Impact, issues and good practices*. Geneva, Switzerland: G. Harnois & P. Gabriel.
- ¹² The Work Foundation and London Health Commission. (2005). *Healthy work: productive workplaces*. England: D. Coats & C. Max.
- ¹³ Wilkinson, R.G. (1996). *Unhealthy societies: The afflictions of inequality*. London: Routledge.
- ¹⁴ Yen, I.H., & Syme, S.L. (1999). The social environment and health: A discussion of the epidemiologic literature. *Annual Review of Public Health*, 20, 287-308.
- ¹⁵ London Health Commission. (2003). *Noise and health: Making the link*. Retrieved from http://hiaconnect.edu.au/old/files/Noise_and_Health.pdf.
- ¹⁶ World Health Organization. (2011). *Burden of disease from environmental noise*. Bonn, Germany: F. Theakston (ed.).
- ¹⁷ Babisch, W. (2005, January). Noise and health [Guest Editorial]. *Environmental Health Perspectives*, 113(1), A14-A15.
- ¹⁸ World Health Organization. (2011). *Burden of disease from environmental noise*. Bonn, Germany: F. Theakston (ed.).
- ¹⁹ London Health Commission. (2003). *Noise and health: Making the link*. Retrieved from http://hiaconnect.edu.au/old/files/Noise_and_Health.pdf.
- ²⁰ Wisconsin Department of Natural Resources. (2012). *Silica Sand Mining in Wisconsin*. Madison, WI.
- ²¹ West Central Wisconsin Regional Planning Commission. (2015). *2nd quarter quarterly census of employment and wages, Eau Claire County, Trempealeau County, Pierce County*.
- ²² West Central Wisconsin Regional Planning Commission. (2015). *2nd quarter quarterly census of employment and wages, Eau Claire County, Trempealeau County, Pierce County*.
- ²³ Stelzner, B. (2011, December). Frac sand mining—Local government roadway impacts. Retrieved from <http://www.tdawisconsin.org/data/publications/wtda-sand-mine-article-dec-2011.pdf>.
- ²⁴ Stelzner, B. (2011, December). Frac sand mining—Local government roadway impacts. Retrieved from <http://www.tdawisconsin.org/data/publications/wtda-sand-mine-article-dec-2011.pdf>.
- ²⁵ Albrecht, G., Sartore, G., Connor, L., Higginbotham, N., Freeman, S., Kelly, B., ... Pollard, G. (2007). Solastalgia: the distress caused by environmental change. *Australasian Psychiatry*, 15 Suppl., 95-98.
- ²⁶ Albrecht, G., Sartore, G., Connor, L., Higginbotham, N., Freeman, S., Kelly, B., ... Pollard, G. (2007). Solastalgia: the distress caused by environmental change. *Australasian Psychiatry*, 15 Suppl., 95-98.
- ²⁷ Albrecht, G., Sartore, G., Connor, L., Higginbotham, N., Freeman, S., Kelly, B., ... Pollard, G. (2007). Solastalgia: the distress caused by environmental change. *Australasian Psychiatry*, 15 Suppl., 95-98.
- ²⁸ Spelgewinde, P.C., Cook, A., Davies, P., & Weinstein, P. (2009). A relationship between environmental degradation and mental health in rural Western Australia. *Health & Place*, 15, 865-872.
- ²⁹ University of Maryland Medical Center. (2013) *Stress*. Retrieved from <http://umm.edu/health/medical/reports/articles/stress>.
- ³⁰ Evans, G.W., & Cohen, S. (1987). Environmental stress. In D. Stokols & I. Altman (Eds.), *Handbook of environmental psychology* (571-610). New York: Wiley
- ³¹ Evans, G.W., & Cohen, S. (1987). Environmental stress. In D. Stokols & I. Altman (Eds.), *Handbook of environmental psychology* (571-610). New York: Wiley

- ³² Prengaman, K. (2012, August 19). Frac sand boom creates thousands of jobs. Retrieved from <http://wisconsinwatch.org/2012/08/sand-boom-creates-jobs/>.
- ³³ Orr, I. & Krumenacher, M. (2015, May). *Economic impacts of industrial silica sand (frac sand) mining*. Retrieved from <https://www.heartland.org/policy-documents/economic-impacts-industrial-silica-sand-frac-sand-mining>.
- ³⁴ Power, T.M., & Power, D.S. (2013, May). *The Economic Benefits and Costs of Frac-Sand Mining in West Central Wisconsin*. Retrieved from http://www.iatp.org/files/2013_05_30_FracSandMining_f.pdf.
- ³⁵ West Central Wisconsin Regional Planning Commission, *2015 2nd Quarter Quarterly Census of Employment and Wages, Eau Claire County, Trempealeau County, Pierce County*.
- ³⁶ U.S. Census Bureau. United States quick facts, 2010-2014 income, in 2014 dollars. Available at <http://quickfacts.census.gov/qfd/index.html>.
- ³⁷ Prengaman, K. (2012, August 19). Frac sand boom creates thousands of jobs. Retrieved from <http://wisconsinwatch.org/2012/08/sand-boom-creates-jobs/>.
- ³⁸ Economic Modeling Specialist Inc. (2011). *The economic impact of frac sand mining: A look at jobs and earnings in Wood County, Wisconsin*. Moscow, ID: Robison, H., Nadreau, T., & Wright, J.
- ³⁹ Kremer, R. (2015, October 13). More layoffs announced in frac sand industry. WPR News. Retrieved from <http://www.wpr.org/more-layoffs-announced-frac-sand-industry>
- ⁴⁰ Kremer, R. (2013, August 28). Frac sand mine leaves nearby school districts with less state aid. WPR News. Retrieved from <http://www.wpr.org/frac-sand-mines-leave-nearby-school-districts-less-state-aid>.
- ⁴¹ Power, T.M., & Power, D.S. (2013, May). *The economic benefits and costs of frac-sand mining in west central Wisconsin*. Retrieved from http://www.iatp.org/files/2013_05_30_FracSandMining_f.pdf.
- ⁴² Orr, I. & Krumenacher, M. (2015, May). *Economic impacts of industrial silica sand (frac sand) mining*. Retrieved from <https://www.heartland.org/policy-documents/economic-impacts-industrial-silica-sand-frac-sand-mining>.
- ⁴³ Economic Modeling Specialist Inc. (2011). *The economic impact of frac sand mining: A look at jobs and earnings in Wood County, Wisconsin*. Moscow, ID: Robison, H., Nadreau, T., & Wright, J.
- ⁴⁴ Orr, I. & Krumenacher, M. (2015, September). *Roadway impacts of industrial silica sand (frac sand) mining*. Retrieved from <https://www.heartland.org/policy-documents/roadway-impacts-industrial-silica-sand-frac-sand-mining>.
- ⁴⁵ Stelzner, B. (2011, December). Frac sand mining—Local government roadway impacts. Retrieved from <http://www.tdawisconsin.org/data/publications/wtda-sand-mine-article-dec-2011.pdf>.
- ⁴⁶ Wisconsin Department of Natural Resources. (2012). *Silica Sand Mining in Wisconsin*. Madison, WI.
- ⁴⁷ Hart, Adams & Schwartz, <http://midamericafreight.org/wp-content/uploads/FracSandWhitePaperDRAFT.pdf>
- ⁴⁸ International Council on Mining and Metals. (2013). *Indigenous Peoples and Mining Position Statement*. Retrieved from <https://www.icmm.com/publications/icmm-position-statement-on-indigenous-peoples-and-mining>

CONCLUSION

It has been a privilege to work with the individuals and organizations that made this assessment possible. A special note of appreciation goes to Audrey Boerner MS, for her integrity and extraordinary effort.

The Institute for Wisconsin's Health hopes that this report will be a valuable and practical resource for local and tribal health departments and for policy makers in Wisconsin as they seek to promote the health and safety of the people in their jurisdictions.

We acknowledge the complexity of the issues examined in this report and welcome additional input moving forward.

A handwritten signature in black ink, appearing to read 'Nancy Young', with a stylized flourish at the end.

Nancy Young

Executive Director

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APPENDIX A: REGIONAL ASTHMA DATA

Table A.1 presents age-adjusted rates of asthma emergency department visits by county of interest in two-year periods from 2002 through 2013. The data on asthma emergency department visits are collected from emergency room discharge records and include all visits with an ICD-9 code of 493 in the principal diagnosis field. Data were grouped in two-year intervals to improve rate stability. Direct age-adjusted rates were calculated using the 2000 US standard population for Wisconsin. Table A.2 presents the results of a series of linear regressions that were conducted to assess the linearity of age-adjusted asthma rates over time by county of interest. For each county, two-year time categories were regressed on the age-adjusted rate to test if a linear trend (either increasing or decreasing) best fit the data. Fisher exact tests (F-tests) were used to test the statistical significance of the linear fit. The F-tests and accompanying p-values are also presented (Table A.2). Source data are available on the Wisconsin EPHT public data portal (dhs.wisconsin.gov/epht).

Table A.1. Two-year age-adjusted rates of asthma emergency department visits by county of interest

County	2002-2003	2004-2005	2006-2007	2008-2009	2010-2011	2012-2013
BARRON	24.5	30.8	32.3	34.5	33.5	32.9
BUFFALO	13.5	12.5	19.9	21.9	30.9	23.4
CHIPPEWA	36.6	36.2	26.7	29.7	21.5	13.6
CLARK	18.6	19.2	18.6	18.7	23.7	20.6
DUNN	26.6	26.7	29.2	28.4	21.9	21.4
EAU CLAIRE	30.9	24.3	27.9	30.6	25.0	22.3
JACKSON	61.2	57.5	37.1	34.3	33.7	31.2
LA CROSSE	21.9	22.8	20.4	21.3	21.0	16.7
MONROE	38.7	38.5	41.9	43.2	34.2	35.1
PEPIN	18.0	24.3	34.2	41.1	25.1	32.4
PIERCE	21.5	24.8	24.3	30.3	29.1	28.0
RUSK	39.8	47.4	34.5	27.7	36.9	34.9
ST. CROIX	21.0	25.1	22.7	24.4	20.2	20.6
TREMPEALEAU	26.3	24.9	23.0	21.8	22.1	15.1

Table A.2. Fisher exact test for linear regressions used to assess trends in age-adjusted asthma rates over time by county of interest

County	F-Value	P-Value	Direction of Trend
BARRON	5.9	0.072	Positive
BUFFALO	9.5	0.037*	Positive
CHIPPEWA	31.4	0.005*	Negative
CLARK	2.7	0.179	Positive
DUNN	3.3	0.145	Negative
EAU CLAIRE	2.0	0.232	Negative
JACKSON	18.3	0.013*	Negative
LA CROSSE	5.6	0.077	Negative
MONROE	1.0	0.372	Negative
PEPIN	1.5	0.287	Positive
PIERCE	8.2	0.046*	Positive
RUSK	1.4	0.299	Negative
ST. CROIX	0.7	0.438	Negative
TREMPEALEAU	17.9	0.013*	Negative
*statistically significant at $p < 0.05$			

APPENDIX B: INDUSTRY RELATIONS EXAMPLES

WISCONSIN INDUSTRIAL SAND ASSOCIATION (WISA) CODE OF CONDUCT

GUIDING PRINCIPLES

- To lead in ethical ways that benefit society, the environment and the economy – People, Planet and Prosperity;
- To design and operate industrial sand facilities in a safe and environmentally sound manner;
- To promote clean water and clean air, minimization of waste and conservation of energy and other critical resources in the mining and processing of industrial sand;
- To collaborate with state and local governments in the state of Wisconsin in the development of effective, efficient and scientifically based safety, health, environmental and land use laws, regulations and standards;
- To be a leader in education and research on the health, safety, and environmental effects of crystalline silica and industrial sand mining and processing operations;
- To communicate with stakeholders and listen to and consider their perspectives – seek a “balance” between competing interests, consistent with People, Planet, Prosperity;
- To make continual progress toward a goal of no accidents, injuries, occupational disease cases at or from industrial sand operations in the state of Wisconsin, and to openly report health and safety performance;
- To work with carriers to foster the safe transport of industrial sand, to work with carriers and other stakeholders to minimize to the extent commercially feasible the impact of transporting sand;
- To instill a culture throughout all levels of the member company organizations to continually advance these guiding principles.

PERFORMANCE STANDARDS

ENVIRONMENTAL:

WISA member shall be a participant in good standing in the Wisconsin DNR Green Tier Program, as a Tier 1 participant, for each of its industrial sand facilities within the state of Wisconsin. If a WISA member opens a new industrial sand facility in the state of Wisconsin, the WISA member shall apply for Tier 1 participation in the Wisconsin DNR Green Tier Program for that facility within 45 days of that facility becoming operational, i.e., beginning to ship or sell industrial sand for commercial purposes.

Upon application for membership in WISA, the applicant shall not have any of the following:

Within 60 months, a judgment of conviction entered against it, any managing operator of it, or any person with a 25% or more ownership interest in the WISA member for a criminal violation of an environmental regulation.

Within 36 months a civil judgment entered in a Wisconsin Circuit Court or Wisconsin United States District Court against it, any managing operator of the applicant, or any person with a 25% or more ownership interest in it for a violation of an environmental regulation involving a covered facility that resulted in substantial harm to public health or the environment.

Within 36 months, the WISA member, any managing operator of the WISA member, or any person with a 25% or more ownership interest in the WISA member has been referred to the Wisconsin Department of Justice for enforcement of an environmental regulation involving a covered facility or activity that resulted in substantial harm to public health or the environment.

Within 24 months, the WISA member, any managing operator of the WISA member, or any person with a 25% or more ownership interest in the WISA member has been issued an environmental citation by the Wisconsin Department of Natural Resources involving a covered facility or activity that resulted in substantial harm to public health or the environment.

SAFETY:

Adopt the National Industrial Sand Association's (NISA) Silicosis Prevention Program and implement the NISA Occupational Health Program (OHP), which means that each member of WISA is required at a minimum to conduct dust monitoring for respirable crystalline silica and medical surveillance per the guidelines set forth in the NISA OHP (as it may be amended from time to time) in connection with their Wisconsin industrial sand facilities. Further, WISA members will report annually the results of medical surveillance and dust sampling at their Wisconsin industrial sand facilities to WISA.

Maintain an average respirable crystalline silica dust exposure level for each major job category, for each Wisconsin industrial sand facility, at or below .05 mg/m³.

COMMUNITY

(Including land use, transportation, community outreach and emergency response initiatives):

Dialog with stakeholders, and action as appropriate, to minimize the community impacts of industrial sand operations, e.g., tangible efforts to reduce noise, light pollution, blasting impacts, visual impacts, impact of truck and rail traffic;

Establish a program to communicate relevant information concerning Wisconsin facilities to local communities;

Engage local communities to identify and promote local community education projects, e.g., facility open houses, tours;

Develop and manage wildlife habitat;

Engage the local community to identify and promote local environmental projects.

POST MINING LAND USE/RECLAMATION

Adopt reclamation plans to provide post-mining economic and/or environmental value to the affected communities; engage the stakeholders when appropriate in connection with reclamation and post-mining land use planning; maintain compliance with mining permit and reclamation plan.

MANAGEMENT

Chief Executive Officer (or equivalent) written commitment to Guiding Principles and Performance Standards;

With regard to the Performance Standards, submit a report annually to WISA by February 15 of each year, starting in 2014, describing the results for each Standard for the prior calendar year.

INTERNATIONAL COUNCIL ON MINING & METALS

10 PRINCIPLES OF THE SUSTAINABLE DEVELOPMENT FRAMEWORK

01. Implement and maintain ethical business practices and sound systems of corporate governance.
02. Integrate sustainable development considerations within the corporate decision-making process.
03. Uphold fundamental human rights and respect cultures, customs and values in dealings with employees and others who are affected by our activities.
04. Implement risk management strategies based on valid data and sound science.
05. Seek continual improvement of our health and safety performance.
06. Seek continual improvement of our environmental performance.
07. Contribute to conservation of biodiversity and integrated approaches to land use planning.
08. Facilitate and encourage responsible product design, use, re-use, recycling and disposal of our products.
09. Contribute to the social, economic and institutional development of the communities in which we operate.
10. Implement effective and transparent engagement, communication and independently verified reporting arrangements with our stakeholders.



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