The Potential Impacts of Frac Sand Transport and Mining on Tourism and Property Values in Lake Pepin Communities

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Executive Summary

This report provides a review of economic theory and empirical research that is relevant for evaluating the economic impacts of "frac sand" operations and transport on the Stockholm and Pepin districts of Pepin County, Wisconsin. The authors were retained by Lake Pepin Partners in Preservation (LPPP) to write a report documenting (a) our opinions, based on currently existing data and research, about how frac sand operations and transport in the Stockholm and Pepin districts could impact the local amenity-based economy, and (b) new empirical research that could be carried out to measure the actual economic impacts.

To accomplish these objectives we first assembled census and other data files for the region, which allowed us to demonstrate the importance of unique natural amenities to the economic health of the Stockholm and Pepin districts. The statistics we present indicate that Lake Pepin economies have evolved to capitalize on natural amenity endowments, implying that actions to diminish the amenities could threaten economic health. We then surveyed economic research measuring how increases in traffic congestion, noise, and diminished air quality have adversely affected local property values in other regions of the country. We find that property value decreases ranging from 3 to 8 percent are typically estimated for these disamenities. We also examined studies measuring the impact that changes in recreation site quality can have on residents and visitors to an area. Our review of this research demonstrates that the changes in amenity conditions expected from increased mining operations and transport in the districts could have substantial economic impacts.

To summarize, we are confident that (a) the impressive amenity endowments in the Stockholm and Pepin districts contribute to higher property values, healthy population and real estate value growth, and more tourism activity relative to the remainder of the county; and (b) frac sand operations and transport absent the proposed ordinance has the potential to significantly impair property values and tourist activity in Stockholm and Pepin districts.

These conclusions are, of course, qualitative. While we have confidence that expanded frac sand operations and transport would have effects of the type described in the report, we cannot precisely estimate their actual magnitudes without additional study. Further research could generate more precise estimates by analyzing the distribution of housing prices across the county landscape to assess how amenity changes observed to date have affected recent home sale prices and trajectories. A survey of business and property owners throughout the affected and

unaffected areas of the county could also provide quantifiable measures of how people are (and expect to be) impacted by any changes brought about by frac sand operations and transport.

1. Introduction

The recent surge in demand for western Wisconsin's frac sand is creating new dilemmas and choices for local and county governments. One path would allow frac sand development and transportation to proceed apace within the existing regulatory framework, thereby generating economic activity in the extractive and transportation industries. This may, however, come at the expense of the region's traditional emphasis on amenity-based economic activity from tourism, recreation opportunities, and agriculture. A second path would place additional, targeted restrictions on frac sand operations to limit their impact on amenity-dependent areas. This approach is advocated by leaders in the Pepin County districts of Stockholm and Pepin, where an ordinance has been proposed that would restrict mining operations and limit through-transport from other areas of the county.

Both paths have merit as generic propositions. Some economic studies indicate that mining booms can generate large, albeit temporary, gains in local employment and earnings that may spillover beyond the mining sector into service and retail sectors (see Black et al. 2005, Marchand 2012). Other studies have linked reliance on energy and mining sectors to slower long run economic growth after the mining booms inevitably conclude (see James and Aadland 2011, Papyrakis and Gerlagh 2007). This is because after the boom – when the bust comes – local communities may be left with an undiversified economy and a footprint of degradation and industrial pollution that could repel natural amenity-driven economic activity and also drive down local property values.

Moving beyond generic tradeoffs, this report considers how frac sand mining and transportation could adversely impact economic activity and property values in a specific region: the Lake Pepin communities of Pepin and Stockholm along the Mississippi River in Pepin County, Wisconsin. As we describe in the next section, Stockholm and Pepin are uniquely endowed with scenic and natural amenities and their local economies have consequentially evolved to be based largely on recreation, tourism, agriculture including orchards and vineyards, and quality of life related in-migration and seasonal residency. To a greater extent than other communities lacking unique amenities, Stockholm and Pepin risk losses in property values if industrial transportation through these communities is allowed to proceed without additional regulations.

2. Overview of Lake Pepin Communities

Located on the border of Wisconsin and Minnesota, Pepin County is small, rural, and scenic. It ranks last among Wisconsin's 72 counties by land area, at 232 square miles, and 69th by 2012 population at 7,390 residents. Much of its economic activity is tied to the county's natural and scenic amenities. This is particularly true of Pepin and Stockholm townships and villages, which abut Lake Pepin, the widest naturally occurring part of the entire Mississippi River.

2.1. Natural Amenity and Resource Endowments

Raw natural amenity endowments are difficult to quantify, but efforts to do so rank Pepin County well above the average Wisconsin county. One such effort is undertaken by McGranahan (1999). He creates a county-level natural amenities index that combines climate, topography, and access to water into a measure of natural features that humans find attractive. Criteria used in the index imply that a county is more desirable with more varied terrain and a higher ratio of water to land surface. The measures of topography and water area are normalized, and the entire index is defined on a standard-normal scale meaning the average U.S. county has an amenity-scale ranking of zero.

Pepin County's topography ranking is tied for first among all of Wisconsin's 72 counties (see table 1). The topography of Pepin County is 0.77 on the normalized scale, compared to -0.29 for the average Wisconsin County and -1.19 for the least topographically endowed county (Adam County). This means that Pepin County's topography is two standard deviations more scenic than the flattest Wisconsin county and a full standard deviation above the average

Table 1: Natural Amenity Endowments of Pepin County

	Pepin County	Average Wisconsin County
Land Area (in square miles)	232	754
Population per square mile	31.1	156.7
Topography Index Ranking	1st (tied)	---
Topography Index (z-scale)	0.77	-0.29
Overall Natural Amenity Index Ranking	20th	---
Overall Natural Amenity Index (z-scale)	-0.71	-1.71

Source: Authors calculations from U.S. Census Bureau data and McGranahan (1999)

counties (Bayfield and Douglas). Pepin County also ranks high in terms of water to land area, primarily because the southwest border of the county is adjacent to Lake Pepin.

The favorable statistical rankings of Pepin County's scenic amenities match verbal descriptions that laud the rich, rolling farmland and the scenic and towering limestone bluffs overlooking Lake Pepin. Some of these bluffs are permanently protected natural areas, such as the Maiden Rock Bluff State Natural Area. The area abutting Lake Pepin has been described as having some of the "grandest scenery in the world." It also provides habitat for threatened wildlife such as peregrine falcons and a number of rare forbs.[1]

The Lake Pepin communities have other scenic, cultural, and recreational attributes that are not quantified by indices. First, the area has not experienced significant industrial booms and busts. Its bluffs and lake shore exist in a largely natural, undisturbed state.[2] This feature enhances its aesthetic appeal relative to other communities that show heavier footprints of past and present industrial activity. Second, the communities have endowments of historic and cultural amenities. For example, Pepin Township is a prominent setting in Laura Ingalls Wilder's *Little House on the Prairie* Series. Third, the communities hold one of the largest marinas on Lake Pepin, from which lake and river recreation activities are launched.

Through Pepin and Stockholm runs the Great River Road/National Scenic Byway along Highway 35 in Pepin County. It is Wisconsin's only National Scenic Byway and is part of the ten-state Great River Road National Scenic Byway, which follows the Mississippi River for 3,000 miles. The Great River Road Scenic Byway in Wisconsin was identified by a national poll as "the prettiest scenic drive in America" in the *Huffington Post*.[3] Travelers along this road stop in the towns to shop, eat at restaurants, and stay at bed and breakfasts as well as to attend annual festivals and events. The road has been a magnet for attracting federal and state grant dollars for highway improvements, recreational trails, bikeways, scenic overlooks and historical preservation.

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[1] From Wisconsin DNR website http://dnr.wi.gov/topic/Lands/naturalareas/index.asp?SNA=410 (accessed April 2013).

[2] The landscape and ecology of the area are much more complex than can be described here. In commenting on this an early reader of this report noted that

"…It isn't just the lake, but the lake and associated wetlands and floodplain forests; not just the bluffs, but the bluffs and associated dry sand prairies. [A]nd for both, the biota associated with those distinctive and much-prized habitats. [The] lake and bluffs can be appreciated passively as drive-by amenities, but their lasting draw to residents and tourists…is the complex ecosystems that embrace them."

[3] Huffington Post, May 29, 2012.

In addition to the scenic, cultural, recreational, and ecological endowments just described, Pepin County has a deep layer of Jordan sandstone below its surfaces. The shape of the deposit's silica particles and loose cementation make it an ideal material for processing into the hydraulic fracture-grade sand ("frac sand") used in the exploration, drilling, and recovery of deep oil and gas deposits elsewhere in the nation. Silica sand that can be economically processed into frac sand is found throughout much of Wisconsin, with the largest concentration in a western swath that includes Pepin County. Silica mining (often referred to as frac sand mining) has only recently become economically profitable, because of the oil and gas boom enabled by new hydraulic fracking technologies. Absent this recent boom, frac sand would not be considered an economically significant resource endowment.

2.2. Overview of Link between Natural Amenities and Economic Health

Before returning to the issue of frac sand mining, it is important to emphasize how the natural amenities in Pepin and Stockholm townships and villages have shaped their local economies. Research and economic reasoning suggest a positive link between amenity quality and in-migration of households and firms and this link is also borne out in Lake Pepin communities. McGranahan (1999), for example, finds that between 1970 and 1996 average population growth was 120 percent in non-metropolitan counties with high levels of natural amenities, while population growth was one percent in counties with low levels of natural amenities. Other studies find similar effects of broad natural amenity measures on population and employment growth (see Deller et al. 2001).

In general, there is recognition of the increasing importance of natural amenities in the location decisions of migrants and the quality of life improvements that result. Rising levels of income and wealth in nearby cities also increase demand for the types of location-specific amenities that Lake Pepin communities have. Other factors include the growing influence of retirees as a source of income. Because of the nature of retirement income, retirees base location decisions on factors other than wages and employment and may continue to be a major income source in the rural amenity-rich communities. This in-migration is one force that pushes property values up in resource endowed communities.

It is worth emphasizing that economic reasoning suggests natural amenity endowments enhance local property values to a greater extent than they enhance local wages and earnings.

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This is because of a principle known as compensating differentials (see Roback 1982, 1988). The basic idea is that, when all else is equal, people are willing to accept lower wages in order to work and live in nice places. Employers benefit from having access to an affordable labor pool, suggesting the possibility of abnormally high profits, relative to what one would otherwise expect for the location and customer base. In a competitive marketplace, however, other factors adjust that prevent this – namely, property values. This is another reason why there tends to be upward pressure on property values in amenity rich locales. By contrast, the mining industry pays relatively high wages in part to attract labor to an otherwise less attractive type of work.

2.3. Statistical Evidence of the Benefits from Lake Pepin Amenities

Statistics are useful for understanding how Lake Pepin economies and property values are evolving because of their unique natural amenity endowments. Table 2 and table 3 on the following page compare the Lake Pepin communities, which are directly adjacent to the lake and to the Great River Road, with the broader county. As the table 3 shows, Lake Pepin communities are experiencing faster population growth when compared to the remainder of Pepin County. This finding is consistent with the idea that the unique natural amenities along Lake Pepin have attracted healthy growth in recent years for quality of life reasons. Median incomes are generally also higher in the Lake Pepin regions. This is consistent with theories suggesting that natural amenities will attract well educated, high-earning professionals. In fact, the table indicates that 22.3 percent of the housing in Lake Pepin communities is for seasonal and recreational use. This is a strong indication that natural amenities are attracting wealthier, second-home buyers to the area. This market could be impaired by heavy industrial frac sand operations and transport as discussed in the next section.

Tables 2 and 3 also show that property values tend to be higher in the Lake Pepin communities when compared to the remainder of the county. This is true whether we measure property values based on median housing values, or by real estate equalized value data collected by the State of Wisconsin Department of Revenue. Moreover, the number of housing units and the value of real estate grew at a much faster rate in Lake Pepin communities over the past decade when compared to the remainder of the county. These comparisons support the idea that natural amenities in Lake Pepin communities are capitalized into higher property values thereby supporting growth in property tax receipts for the county as a whole. As we describe in the next

Table 2: Statistical Composition of Lake Pepin Communities

	Stockholm Township	*Stockholm Village*	*Pepin Township*	*Pepin Village*	*Pepin County*
Population (2010)[a]	197	66	721	837	7469
Housing Units (2010)[a]	122	89	443	490	3579
Seasonal Housing (2007-2011)[a]	41	43	69	102	322
Median Housing Value (2007-2011)[a]	$231,300	$225,00	$160,400	$142,500	$139,200
Median Family Income (2007-2011)[a]	$66,563	$67,083	$59,219	$55,208	$59,086
Equalized Real Estate Value (2011)[b]	$34.9	$17.4	$86.6	$64.2	$550.4
FTE Jobs Attributed to Tourism (2011)		45-50[c]	?	?	96[d]

Sources and Notes: a) The source is the U.S. Census Bureau. The data on housing and family income are reported in the American Community Survey as five-year estimates over 2007-2011. The seasonal housing data indicate the number of housing units that are used for seasonal, typically recreational, purposes. The median housing value is for all owner-occupied units. b) The source is the State of Wisconsin Dept. of Revenue. The data are reported in millions of dollars. c) The source is the Stockholm Merchants Association Position Paper on Frac Sand Mining. The number of FTE jobs attributed to tourism are spread over Stockholm Township and Stockholm Village; we do not have estimates for Pepin Village or for Pepin Township. d) The source is the State of Wisconsin Dept. of Tourism.

Table 3: Key Comparisons of Lake Pepin Communities and the Remainder of Pepin County

	Pepin and Stockholm Townships and Villages	*Remainder of Pepin County*
Population Growth based on Census Data (2000-2010)[e]	11.7%	1.2%
Population Growth based on Corrected Data (2000-2010)[f]	6.0%	1.2%
Housing Unit Growth based on Census Data (2000-2010)[e]	33.6%	11.7%
Housing Unit Growth based on Corrected Data (2000-2010)[g]	27.4%	11.7%
% of Housing that is Seasonal/Recreational (2007-2011)[e]	22.3%	2.8%
Equalized Real Estate Value per Housing Unit (2011)[e]	$177,586	$142,626
Inflation Adjusted Growth in Equalized Value (2000-2011)[h]	53.3%	30.4%

Sources and Notes: e) Authors calculations from published U.S. Census Bureau data. f) Authors calculations from corrected U.S. Census Bureau data as described to us by the Wisconsin Demographic Service Center. The correction increased the 2000 population estimate for Stockholm Township from 75 to 163 people but it did not change the 2000 population estimates for other townships and villages in Pepin County. h) Authors calculations from corrected U.S. Census Bureau data as described to us by the Wisconsin Demographic Service Center. The correction increased the 2000 housing unit estimate for Stockholm Township from 65 to 107 but it did not change the 2000 housing unit estimates for other townships and villages in Pepin County. h) Authors calculations from Wisconsin Dept. of Tourism data.

section, property values are threatened if industrial frac sand operations and transport proceeds without additional, targeted regulations.

Another dimension of the amenity-based economy is the revenue and jobs that are generated by tourism-related activity along Highway 35, Wisconsin's portion of the Great River Road. There were 45-50 jobs in Stockholm attributed to tourism compared to 96 jobs for the entire county of Pepin. The differences in jobs on a per-capita basis are stark and consistent with verbal descriptions of tourism trips through Lake Pepin communities. Businesses owners along Lake Pepin attest that the majority of visitors come from Minnesota, with most of the remainder coming from Wisconsin cities such as Menominee, Eau Claire, and La Crosse.[4] As we describe in the next section, tourism activity is threatened with diminution if industrial frac sand operations and transport proceeds without additional, targeted regulations.

3. Theory of the Potential Effects of Industrial Frac Sand Transport

3.1. Setting Prior to Frac Sand Demand Boom

To frame the mining issue in Pepin County, it is useful to begin with some conceptual background. We conceive of a landscape – the county in our context – that is defined by political boundaries and characterized physically by the topography and endowment of natural resources. In Pepin County the political boundaries consist of individual townships that have some local decision making authority. The natural amenities in the county arise from its position on Lake Pepin in the west and the bluffs and rolling landscapes further east. The primary natural resource endowments include the lake itself, the bluffs and wildlife habitat, the historical amenities (and recently, the high volumes of frac sand available for mining).

The landscape also contains a stock of manmade infrastructure such as road networks, business facilities, and housing areas. Given the physical and infrastructure characteristics of the landscape, economic actors – households and firms – make decisions on *how* to pursue their objectives, and *where* to engage in their activities. To begin, households select a neighborhood in which to live based on their income and tastes for the many and varied attributes of the available neighborhoods. Scenic attributes of different neighborhoods are often an important determinant of household choices, as are other place-based features such as local traffic congestion, noise levels, and air quality. The notion that households base migration decisions on amenities and dis-

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[4] This information comes from the Stockholm Merchants Association Position Paper on Frac Sand Mining.

amenities has long been an accepted idea in economics, formally dating back to Tiebout (1956). In Tiebout's model, households "vote with their feet", by migrating to areas that provide optimal bundles of public services, natural amenities, and taxes, among other things.

Based on households' demand for neighborhoods and the supply of housing units across the landscape a set of neighborhood home prices arises. Different neighborhoods have different prices based on the supply of homes and the stock of attractive place-based features. For example, we expect that neighborhoods with high scenic beauty, low levels of industrial noise, better access to recreation opportunities, and little traffic congestion will be more in demand – and hence command higher market prices. Knowing this households decide where to live, given these prices, their income, and their own sense of how important local amenities are relative to price. Households are individually and collectively 'in equilibrium' – i.e. do not wish to move – when they have located to a neighborhood that contains the correct combination of home price and place-based features, given their unique circumstances. So long as nothing changes in the landscape, this relative housing market stability can continue for some time.

Firms in the landscape earn money (and pay their workers – the households) by using the landscape and its infrastructure to produce something to sell. In a tourism-based economy firms rely on the scenic beauty of a place, and the leisure opportunities it provides, as inputs to production. These inputs are used to produce opportunities for natural, cultural, and historical based tourism and vacation experiences. Rising levels of income and wealth in other regions also act as a force to increase demand for tourism activities and for property in amenity rich neighborhoods. In a mining economy firms focus on extracting the resource endowment for use outside of the landscape; in general place-based attributes of the landscape are not important in this sector.

Given the demand for the products in the various sectors – tourism and mining in these two examples – a distribution across space of income-generating activities emerges. The business economy is 'in equilibrium' when firms are not entering and leaving the market, and the types of employment opportunities are relatively fixed among the existing sectors. Like the housing market there is a strong spatial aspect to the business economy, in that tourism and mining activities are highly location specific, and the available earnings depend on resource endowments and features of the landscape.

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The spatial aspects of economic activity within Pepin County prior to the boom in frac sand demand are clear from table 2. The higher property values along Lake Pepin indicate that neighborhood-specific amenity demand from households and businesses are reflected in property values along Lake Pepin. The county as a whole was broadly in an 'equilibrium', with stable populations and property values during 2000-2010. The Lake Pepin communities, however, have been experiencing rapid growth via in-migration, with the resultant adjustments in property values and per capita earnings.

The aggregation of households' and firms' decisions and their interactions leads to the main economic characteristics of the landscape: incomes, the size and types of business sectors, housing prices, traffic patterns, and the general well-being of residents. Absent abrupt outside pressures, the features of the landscape may be stable for some time. However, abrupt outside pressures can disrupt the economy and lead to different aggregate characteristics. In Pepin County the increased demand for frac sand could dramatically change the distribution of economic activity in the county, which has the potential to ripple through to affect the general characteristics of the landscape.

3.2. Externalities from Frac Sand Transportation and Extraction

Abrupt disruptions of this type are not bad things in general, though there will be individual people who are made better and worse off from the change. Economic theory suggests that policies should not try to prevent local changes that result from outside market forces when those forces work incrementally through the economic pricing system. For example, increased frac sand mining could drive up the wages owners of tourism businesses must pay their workers. Other things unchanged this is positive for wage earning workers and negative for wage paying tourism firms. Economic policies to regulate frac sand mining in order to prevent this competitive market effect from occurring would not be justified on economic grounds.

On the other hand, economic theory favors policies to discourage the activity when the outside shock is large or abrupt enough to alter the competitive nature of markets, or when the shock introduces spillover costs onto existing residents and business, which are not compensated or mitigated through market interactions. The former may occur if an expansion of the mining industry causes other sectors to completely disappear, leaving only one main employer. The latter refers to the notion of *external costs* or *externalities*, and if these costs are large or

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widespread enough, public intervention to mitigate the changes brought about by the outside shock is warranted.

The changes brought about by the increased demand for frac sand in Pepin County are associated with several specific types of externalities. As we discuss in more detail in the next section, the extent to which any of these have measureable effects is an empirical question. The following list describes several qualitative examples:

a) Increased congestion on local and scenic roadways. It is expected that expanded frac sand mining and unregulated transportation will lead to an increase in truck traffic on local streets and the scenic roadway along the river. Unregulated, the trucks would travel year round through Lake Pepin communities carrying 80,000 to 100,000 pound loads. The increased traffic congestion and noise may cause two external costs. Homeowners may see a drop in property prices if the additional truck congestion and noise negatively affect the quality of their neighborhoods. Business owners serving customers traveling the scenic river way may see a drop in visitors if the increased truck congestion reduces the attractiveness of touring on the river road.

b) Local land use spillovers. Expansion of industrial frac sand mining and transport will lead to noise and light pollution and congestion spikes in residential areas bordering the sites and the roads used for transport.

c) Decreases in local air quality. Sand mining may create local increases in particulate matter air pollution, both at the mining site and via truck transport. There are potential costs of the air quality degradation associated with elevated mortality and morbidity risks for county residents.

d) Pecuniary and non-pecuniary impacts on leisure activities. Changes in the landscape arising from the expansion of mining may affect the availability and quality of outdoor recreation opportunities in the area. This may have pecuniary effects if it reduces the number of visitors who come to the country as tourists. It may also impact the quality of life for local residents, whose use of the local landscape is impacted. The latter constitutes a potential well-being loss that is not reflected in market outcomes.

e) Existence values. Scenic river ways and roadways are so-designated because they are deemed to have a cultural value associated with them. Implicit in this designation is the presumption that the resource will be maintained for future generations to experience.

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4.   Review of Empirical Estimates

The discussion in the previous section was intended to lay out the different pathways through which the expansion of frac sand mining, processing, and transportation in Pepin County could lead to external costs. The extent to which these externalities actually occur is an empirical question that requires careful data analysis to answer. In general there are three empirical tasks. First, analysis is needed to predict how an increase in mining activities would alter the actual environmental outcomes. For example, measurements would be needed on how the increased mining and transportation activities alter the temporal and spatial distribution of traffic congestion, local air quality, scenic vistas, water quality, and other physical/landscape attributes. Second, a causal link would need to be established between changes in environmental outcomes and things that matter to residents. Examples of the latter include property values, earnings from the tourism sector, recreation opportunities, and health outcomes. Once there is evidence of an effect, the final (and related) empirical task is to measure the size of the economic damages from increased mining operations, as they manifest through the various externality channels.

Economists have developed several tools for establishing the existence and measuring the size of external damages of the types we are interested in here. In this section we review these tools and survey some of the empirical findings from other areas, which are relevant for our context.

4.1. Property Value Approaches

The main approach for understanding how environmental externalities affect property values is the hedonic model (Palmquist, 2005). The premise of this model is that a residential property is a bundle of many individual attributes that households care about. Familiar examples include square feet, structure maintenance and quality, and characteristics of the lot. Locational aspects such as school quality and the state of the surrounding landscape are also components of the bundle. The market price of a particular property depends on the bundle of attributes, and prices adjust when attribute levels change. Most obviously, larger houses cost more than smaller houses, all else equal. Using regression analysis it is possible to measure how other attributes, such as aspects of the surrounding environment, cause prices to fluctuate. Specifically, it is possible to estimate percentage changes in home prices from a change in environmental

conditions by using data on home prices, structural characteristics, neighborhood attributes such as school quality, and measures of surrounding environmental outcomes.

The property assessment and environmental economics literatures contain several examples of hedonic studies that are relevant for the Pepin County case. For example, a handful of papers have examined how an increase in traffic congestion on local roadways affects property values of proximate homes. New estimates from Larsen (2012) suggest that properties in a small urban area that front 'high traffic' streets sell for 8% less than similar properties not affected by traffic. Restricting attention to homes that are at least somewhat exposed to traffic, the author finds that a doubling of traffic volume leads to a 2% decrease in home values. A related externality arises from transport noise. To understand how exposure to noise pollution affects property values, several researchers have examined how proximity to airport takeoff and landing zones impacts prices. Pope (2008) is among the more recent and compelling papers in this area. He finds that homes exposed to periodic plane traffic resulting in 55 to 60 decibels (comparable to noise from a normal conversation), sell for a price discount of 2.3% relative to similar homes, while homes in the 65 to 70 decibel range (comparable to a noisy restaurant) sell for a 5.1% discount. For context, according to information gleaned from web searches, a dump truck at a 50-foot distance registers 84 decibels.[5] These traffic congestion and noise studies suggest there is potential for the increased road congestion and noise from mining transport to impact property values in the towns of Pepin and Stockholm.

Freight railway traffic through neighborhoods also creates nuisances related to noise, trembles, fear of accidents, and visual blight. Several hedonic studies have estimated the impact of distance to railways on residential property values, but a study by Simons and El Jaouhari (2004) is probably the most relevant. Their study examines the before and after impacts of reconfigured freight railroad traffic patterns during the late 1990s in Cuyahoga County, Ohio. After the reconfiguration, some lines experienced substantial reductions (e.g., from 50 to 5 trips per day) and others experienced substantial increases (e.g., from 10 to 45 per day). Using standard hedonic regression models, Simons and El Jaouhari compare the sale prices of properties in close proximity to rail lines before and after the traffic reconfiguration. Their estimates suggest that properties within 750 feet of lines having increased freight traffic fell from 5% to 7% as a result of the associated externalities.

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[5] From http://ops.fhwa.dot.gov/wz/workshops/accessible/Schexnayder_paper.htm, accessed April 2013.

Researchers have also used hedonic property models to examine how proximity of residential properties to locally undesirable land uses – landfills, industrial zones, hazardous waste sites – impacts home prices. This literature is large enough that several meta-analyses (summaries of empirical estimates from several papers) have been conducted. For example, Ready (2010) summarizes papers that have estimated how home prices vary with distance to landfills. He reports that properties adjacent to high volume and low volume sites sell for 13.7% and 2.7% discounts, respectively, relative to similar non-exposed properties. The price discounts fall with distance so that a home one mile away from a high volume landfill sells for 7.8% less than a comparable distant property and a one mile distance from a low volume site sells for 1.4% less. Newer primary studies include Davis (2011), who finds that homes located within two miles of power plants sell for 3-7% less and Taylor et al. (2013), who find that homes in a large urban area have 5% price discounts when they are near to large industrial or commercial properties. When the industrial/commercial property is also listed as containing hazardous waste materials the price discount is 7.5%. These studies are relevant for the Pepin County context if the enhanced mining activities create external costs such as local congestion, noise, landscape disamenities, or health risks similar to those implied by the urban and suburban industrial sites that are the focus of the locally undesirable land use literature.

Although most of the hedonic price literature examining environmental issues has focused on urban areas, there are a small number of studies looking at rural areas. These have mainly examined how rural property values are impacted by proximity to large scale agricultural operations. A recent example is Herriges et al. (2005), who consider how livestock operations affect rural property values in Iowa. The authors demonstrate that being near livestock operations negatively impacts property values, with the actual magnitude depending on the technology at the facility, its distance, and the direction of prevailing winds (for reasons of odor). For example, an upwind facility located 0.25 miles distance employing older waste handling methods decreases property values by 14%; the similar figure for a facility 0.50 miles distant is 8%. These estimates suggest that rural homes, like those in urban areas, can be affected by proximity to industrial-like activities.

4.2. Measuring Health Impacts

A second class of models that economists have used to understand the external costs of

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environmental externalities focuses on health impacts. There are many pollutant types that affect human health through their impact on mortality risks and morbidity outcomes. Ambient particulate matter (PM) – especially $PM_{2.5}$, which includes particles with diameter less than 2.5 microns (thirty times smaller than a human hair) – has been identified as a particularly important driver of pollution-related fatalities and illnesses. PM affects health through the respiratory and cardiovascular systems and leads to elevated risks of heart disease, asthma attacks, bronchitis, and other heart and lung problems. Children, the elderly, and people with pre-existing conditions are particularly susceptible to elevated air pollution of this type.[6] This is relevant in the Pepin County because there is some speculation that frac sand mining activities can lead to elevated levels of both $PM_{2.5}$ and crystalline silica, a solid that can vary in size across the range at which PM is measured.

To understand the economic consequences of the health risk associated with exposure to pollution, economists use the concept of willingness to pay (WTP). This measures the amount of money a person would (and could) pay to secure an improved outcome or to prevent a worse outcome. It is a measure of economic value because it reflects tradeoffs – i.e. a willingness to pay some amount of money means those funds are not available for use on other things. Importantly, WTP is a method of measurement, and not an indication of what a person actually *does* pay. One way that economists measure the willingness to pay for changes in health risks is via the use of carefully structured surveys. In a typical application individuals report choices that reveal tradeoffs they are willing to make between income and changes in mortality or morbidity risk, which can inform policy decisions. For example, if exposure to a new pollution source (e.g. $PM_{2.5}$ from frac sand mining) changes the risks members of the exposed population face for a serious nonfatal illness, we would want to know the WTP amongst people in the population to avoid the risk change. In a state of the art study Cameron and DeShazo (2013) present several estimates of this type. The authors present estimates of individuals' willingness to pay for a suite of health profile outcomes that are relevant for environmental risks. Specifically, the willingness to pay by a single person for a 1 in 100,000 reduction in the risk of a yearlong nonfatal illness (followed by complete recovery) is $20.42. If all the people in a community of 10,000 people experienced this risk reduction (or avoided an increase) due to a policy action, its economic

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[6] Basic information on PM can be found at http://www.epa.gov/pmdesignations/basicinfo.htm (accessed April 2013).

value to the community would be over $200,000 per year (all people receive and value the risk reduction). More dramatically, if a policy leads to a 1 in 100,000 decrease in the risk of an illness profile that includes 5 years of sickness followed by death, a typical person would be willing to pay $90.09 to have the risk decrease. This larger value for a more serious health profile implies a community of 10,000 people would collectively be willing to pay over $900,000 to avoid the increased risk.

Estimates of the economic value of risk reductions of this type need to be carefully connected to the changes in risk for different health outcomes, which in turn depend on the specific nature of the externality. As such there is substantial scope for the misuse and misinterpretation of estimates such as those presented in Cameron and DeShazo (2013). Nonetheless, when changes in local air pollution lead to measurable changes in the risk of major illness or fatality, the economic benefits of avoiding these risks can be substantial.

More generally, economists have studied the impact of changes in air quality on residential property values. One high-profile paper of this type is Chay and Greenstone (2005). They use nationwide, county level data of housing values during the 1970s and 1980s, and exploit the fact that air quality was improved much more dramatically in the subset of the counties that were out of compliance with the federal Clean Air Act. Coinciding with the air quality improvements, home prices in the counties that were forced into compliance increased 3% to 5% more than home prices in counties that experienced less dramatic air quality improvements. It is not entirely clear why improved ambient air quality increased property values, but one plausible channel is through the reductions in health risks that typically accompany air quality improvements.

4.3. Recreation Impacts

A second area in which the concept of willingness to pay is relevant, is the consequences of changes in landscape characteristics for recreation use. Though people do not often pay a market price for using the outdoors for recreation purposes, such activities contribute directly to well-being and therefore have economic value. There is a large literature investigating how environmental quality contributes to the value of outdoor recreation (see Phaneuf and Smith, 2005, for a comprehensive review). The basic premise of this literature is that people spend leisure time and transportation costs to access recreation destinations such as lakes, parks, hiking

trails, etc. If the environmental quality characteristics of their intended destination are no longer adequate to support the activity, they will either forgo participation (thereby losing the well-being the visit would have provided) or journey to an alternative destination (which may require more time and travel expense to reach). Economists use the value of the travel time and expenses needed to access a recreation site as a proxy for a person's willingness to pay for a visit. Similarly they use the extra travel time and expense needed to reach a destination of acceptable quality as a proxy for additional willingness to pay for a higher quality experience (e.g., cleaner water, superior landscape views, better visitor infrastructure). Table 1 in Phaneuf and Smith (2005) provides a rough summary of several estimates of willingness to pay for various generic recreation trips. They report estimates that are in the $30 to $40 per person, per trip range for activities such as hiking, wildlife viewing, fishing, hunting, boating, and swimming. Values for changes in recreation destination quality are harder to generalize because they depend on the specific features of the landscape of interest, and the range of alternatives available to local populations. One dimension that may be relevant for the Pepin County context is the role of congestion, which has usually been studied in the context of crowding at recreation destinations. For example, Timmins and Murdock (2007) consider how congestion at lakes throughout Wisconsin affects the value of recreation fishing trips. On average they find that a 20% increase in congestion at the site reduces willingness to pay by approximately $15 – roughly half to a third of the trip value, based on the estimates reported in Phaneuf and Smith.

It is important to note that the estimates of willingness to pay discussed here and in the previous subsection are different from (and therefore additive with) estimates of economic impacts flowing from changes in market activity. Said another way, they are reflections of the changes in well-being that residents and visitors may experience if environmental conditions change, regardless of what is happening in other sectors. It is also important to stress that the recreation value summaries discussed here are illustrative of potential magnitudes, but may not be directly applicable to the Pepin County context.

4.4. Impacts on Environment-Dependent Businesses

A final way that changes in environmental quality can affect well-being is through the impact on the market demand for tourism-related goods and services. For example, the demand for recreation fishing guide services depends on the stock of fish available in a lake. If the fish

stock falls the demand for the guide's services will fall, and his enterprise will earn less money. Similar observations can be made for businesses serving visitors to ocean beaches following an oil spill, and winter sport activity providers facing climate-changed induced shorter business seasons. Understanding the impact of these environmental shocks requires measuring demand (use flows) before and after the change, and then converting the lost use flows into lost profits for the affected firms and industries. An example of this for a large scale oil spill in Spain is described in Garza-Gil et al. (2006), and there are several papers exploring the impacts of climate change on tourism (e.g. Hernandez and Ryan, 2011). There are few academic-style studies of changes in tourism demand at the scale of the Pepin County case; we expect these are more often presented as consulting outputs that are not in wide public circulation.

5.   Methodology for Measuring Local Impacts

Among other things, the discussion in the previous section summarized the extent to which property values in other places have been influenced by negative externalities similar to those that may arise from frac sand mining and transport in Pepin County. We emphasize that this summary is illustrative, and should not be interpreted as reflecting the actual economic losses that may arise. In this section we therefore describe the type of data necessary to quantify actual effects in Lake Pepin and surrounding communities. We note that some adverse effects may have already occurred if prospective buyers of property in and around Stockholm and Pepin are anticipating that heavy frac sand operations and transport will soon become a reality. Consistent with this view is a comment from Sharon O'Flannigan, a realtor at Coldwell Banker who works in the Lake Pepin areas. She states:

> "The Pepin corridor is nearly dead as it relates to real estate … Sand fracking is now having an impact on real estate as well. It is difficult to know how this issue will play out but the topic came up several times concerning the [Lake Pepin corridor] property and actually had the effect of killing a potential sale."[7]

There are two possible approaches to statistically measuring the regional and local effects from increased mining and transport. The first approach would exploit existing data on mining

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[7] This quote is from personal email correspondence during March 2013.

activity and real estate markets, while the second would require collection of original survey data from Lake Pepin locales and surrounding areas. We briefly discuss these two possibilities in the subsections that follow.

5.1. Using Existing Data

The starting point for assembling a mining activity data set is the map of frac sand mines included as figure 1 in the appendix. The map shows the spatial location of frac mining and transport facilities as of November 2012 but it does not indicate opening dates nor does it describe transportation routes. To obtain more detailed information we have contacted the Wisconsin Department of Transportation (DOT) officials that created the map. We have asked the DOT officials for more information about the timelines of each site and on the volume of outgoing traffic.

After assembling the mining activity data, we would try to match it with spatial and temporal data on real estate activity in those counties. The real estate data would need to track market activity before and after the onset of frac sand mining. Using terminology from clinical trials in medical research, we would identify 'treatment' and 'control' groups of properties based on their proximity to frac sand mining facilities, transport routes, and trans-loading facilities. Alternatively, we could use county tax assessor data of property values before and after frac sand mining. The drawback of tax assessor data is that it does not always accurately characterize actual fair market values of properties – particularly if assessments lag important changes in the property markets.

Using these data sets, we would employ 'panel regression' econometric methods to estimate how real estate activity – e.g., the number of properties for sale, time on market, and selling price – compares across the treatment (those exposed to frac sand externalities) and control (those not exposed) groups. This would give us an overall estimate of the impact of frac sand mining-related externalities on nearby properties, net of any other factors impacting the real estate market. This approach would be well vetted in the economics literature, as it would mirror very standard estimation procedures. Another benefit of the approach is that it would fully utilize the temporal and spatial variation in mining activity over the entire western Wisconsin region. The drawback is that it would not generate estimates that are specific to the Lake Pepin setting.

5.2. Creating Survey Data

An alternative and perhaps complementary approach is to create a data set specific to the Lake Pepin setting by surveying business owners, real estate professionals, and residents of Stockholm and Pepin. The survey would focus on how business and real estate conditions changed after it become known that frac sand mining and transport could become a reality. It would also query households to find out the various ways that the prospect of increased mining-related activity has changed (or will change) their day-to-day activities and long-term plans. As part of the survey effort we would also study nearby locations that are already fully affected by frac sand mining activities, as well as locations where frac sand development is not anticipated. These latter steps are needed to provide information to account for any changes not related directly to the anticipated effects of the mining expansion.

6.   Conclusions

This document presents a review of secondary data sources and existing empirical research that is relevant for analyzing the economic impacts of frac sand operations and transportation in Pepin County. While a primary study would be needed to offer quantitative conclusions, several qualitative conclusions are supported by our review. In particular, we are confident that: 1) impressive amenity endowments in Stockholm and Pepin communities are responsible for higher property values, healthy population and real estate value growth, and tourist activity; and 2) frac sand operations and transportation absent the proposed ordinance has the potential to significantly impair property values and tourist activity in Stockholm and Pepin.

The reasons for our confidence are threefold. First, the economies and property values of Lake Pepin communities have evolved to match predictions from more general economic theory. Those theories predict that location-specific natural amenities will boost local property values and support non-extractive economies, which is precisely what has happened in Lake Pepin communities. Second, empirical evidence demonstrates how the introduction of noise, industrial traffic congestion, and related dis-amenities has lowered property values in a multitude of settings and locations. Third, resistance from local property and business owners in Stockholm and Pepin to heavy industrial frac sand operations and transportation demonstrates that these are real threats to their quality of life and to the investments they have made in Lake Pepin communities.

To conclude, we emphasize that nothing in this report is meant to suggest that frac sand mining and transport is generically bad for local economies. For some areas the recent surge in demand for frac sand may provide a needed economic lift with little in the way of adverse consequences on other sources of wealth and income. Lake Pepin communities, however, were already on a healthy economic trajectory prior to the frac sand boom because of their unique natural amenity endowments. For these particular communities, the costs of local frac sand activity may exceed the benefits in both the short and long run.

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Appendix: Map of Frac Sand Mining in Western Wisconsin

FRAC SAND MINES, PROCESSING AND TRANSLOADING LOCATIONS