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MSc Program
Environmental Technology & International Affairs

Testing the Pollution Haven Hypothesis

An analysis of the deviations in Wisconsin's regulatory and industrial behavior as a quantified measure of environmental stringency

A Master's Thesis submitted for the degree of
"Master of Science"

supervised by
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Vienna, 05.06.2016

Affidavit

I, **JOHN EDWARD HILDEBRAND**, hereby declare

1. that I am the sole author of the present Master's Thesis, "TESTING THE POLLUTION HAVEN HYPOTHESIS: AN ANALYSIS OF THE DEVIATIONS IN WISCONSIN'S REGULATORY AND INDUSTRIAL BEHAVIOR AS A QUANTIFIED MEASURE OF ENVIRONMENTAL STRINGENCY", 68 pages, bound, and that I have not used any source or tool other than those referenced or any other illicit aid or tool, and
2. that I have not prior to this date submitted this Master's Thesis as an examination paper in any form in Austria or abroad.

Vienna, 05.06.2016

Signature

Abstract

This thesis investigates the degradation of Wisconsin's environmental stringency to identify regulatory failures and noncompliant behavioral trends in pollution-intensive industries in response to the 2008 economic recession. Wisconsin was selected due the recent proliferation of industrial sand mining and concentrated animal feeding operations, which have compromised the state's long standing reputation for environmental prowess. The Pollution Haven Hypothesis argues that pollution-intensive industries and investments emigrate from countries with strict environmental policies to countries with fewer or permissive ones. Moreover, it provides a means of understanding how national and sub-national governments can manipulate environmental regulations to obtain a comparative advantage and foster economic growth. The research methodology for this paper is divided into a four-tier test that measures stringency using the following environmental indicators: pre-existing environmental indexes; industrially adjusted pollution abatement costs from manufacturers; state legislation and activities performed by the regulatory agency; and economic growth in pollution-rich industries relative to noncompliant behavior. The findings demonstrate that Wisconsin's environmental degradation has resulted in endogenous economic growth in industrial sand mining and concentrated animal feeding operations. Furthermore, the findings highlight a regressive transition in Wisconsin's overall level of environmental stringency, which, in end effect, has fostered the necessary preconditions for a new pollution haven.

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List of Abbreviations

BEA	Bureau of Economic Analysis
BWQ	Bureau of Water Quality
CAA	Clean Air Act
CAFO	Concentrated Animal Feeding Operation
CMS	Compliance Monitoring Strategy
CWA	Clean Water Act
DNR	Department of Natural Resources
EKC	Environmental Kuznets Curve
EMS	Enforcement Monitoring Strategy
EPA	Environmental Protection Agency
FCE	Full Compliance Evaluation
FDI	Foreign Direct Investment
GDP	Gross Domestic Product
ICIS	Integrated Compliance Information System
NON	Notice of Noncompliance
NPDES	National Pollution Discharge Elimination System
OECA	Office of Enforcement and Compliance Assurance
PAOCs	Pollution Abatement Operating Costs
PCE	Partial Compliance Evaluation
PHH	Pollution Haven Hypothesis
PM	Particulate Matter
SIC	Standard Industrial Classification
USCB	United States Census Bureau
WPDES	Wisconsin Pollution Discharge Elimination System
Wis. Stat.	Wisconsin Statute

“To protect and enhance our natural resources:
our air, land and water;
our wildlife, fish and forests
and the ecosystems that sustain all life.

To provide a healthy, sustainable environment
and a full range of outdoor opportunities.

To ensure the right of all people
to use and enjoy these resources
in their work and leisure.

To work with people
to understand each other's views
and to carry out the public will.

And in this partnership
consider the future
and generations to follow.”

-Wisconsin’s DNR Mission Statement

1 Introduction

1.1 Motivation

In the wake of the 2008 Recession, the state of Wisconsin was left with the largest deficit in its history. The severity was felt by many in the lower and middle classes and was reflected by the biennial state budget. The Wisconsin Department of Administration made budget cuts for every state agency as annual state spending was reduced by three billion dollars (Doyle, 2010). The agency that was hit the hardest was the Department of Natural Resources (DNR). The DNR is the regulatory body for environmental activities within the state and oversees the preservation, protection, and regulation of Wisconsin's natural resources. The DNR's main objective is to maintain air, water, and human health quality through monitoring and enforcement activities and issuing the necessary permits. However, since 2008 the DNR has experienced a continual regression--financially and authoritatively--which has ultimately undermined its purpose.

Within the last ten years the DNR has undergone a series of departmental changes that highlight several emerging trends. First, the DNR no longer has the resources to perform many of its responsibilities. Between 2007 and 2013, the department experienced a net budget decrease of $76 million, resulting in mass employee layoffs (Wisconsin Department of the Administration, 2016). The latest budget proposal from 2015 plans to further eliminate a third of the scientist positions as well as 60% of the environmental educating staff positions (Carpenter, 2015). The second concerning trend is the reduction of environmental monitoring and enforcement activities. The Wisconsin Center for Investigative Journalism found that as the number of active sand mines doubled between 2011 and 2012, the amount of monitoring inspections fell by nearly 40% (Prengaman, 2012; DNR, 2015a). Moreover, the number of violation notices had also dropped 55% from the previous administration (*Wisconsin League of Conservation Voters*, 2012). As regulatory oversight has continued to deteriorate the total amount of civil forfeitures for environmental infringements has now reached a 30-year low. Public records show the total amount of fines collected in 2015 was a mere $306,834—a drastic reduction from the $4.8 million collected in 2008 (Verburg, 2016). However, while the general decreased in regulatory efforts can be interpreted as a direct consequence of staff and budget cuts, the DNR had become more proactive in some of its other responsibilities--namely streamlining the application process for pollution permits. The third trend is the legislative direction the state has taken. Policy-makers have begun tailoring environmental legislation for polluter needs. When Gogebic Taconite, a sister company of the Cline Mining Corporation, proposed creating the world's largest open-pit iron ore mine in northeastern Wisconsin, the state legislators in collaboration with the DNR passed a bill explicitly granting ferrous mines the unprecedented freedom to dump mining waste in surrounding wetlands. The original law stated that mining operators must strive to limit or prevent any adverse impacts to wetlands. The new amendment, however, concluded that adverse effects were an inevitable part of the mining process:

> *"That because of the fixed nature of ferrous mineral deposits in the state it is probable that those deposits will result in adverse impacts to wetlands and that, therefore, the use of wetlands for bulk sampling and mining activities, including the disposal or storage of mining wastes and materials, or the use of lands for mining activities that would have a significant adverse impact on wetlands, is presumed to be necessary."*
>
> (Wis. Stat. §NR 295.40(7), 2013).

In the same year, state legislators passed another bill deferring the compliance requirements for pollution discharge elimination. Despite being a predominantly agricultural state with a high percentage of surface water eutrophication, the new bill exempts phosphorus dischargers from state concentration limits if they can argue that complying with such standards would cause substantial economic hardship (Wis. Stat. §NR 283.13(7) & 283.16, 2014).

The motivation for this paper stems from these regressive trends and the anecdotal evidence that Wisconsin has compromised its environmental strength to cope with economic shortcomings. The following chapters will therefore attempt to provide empirical evidence using the Pollution Haven Hypothesis (PHH). The PHH stipulates that pollution-intensive industries respond directly to environmental stringency and will actively seek locations with more permissive regulations. What has proven to be the most difficult aspect of the PHH is finding a measurement that best captures levels of stringency. Within PHH literature, empirical studies have utilized international trade flows, industrial employment, foreign direct investment, and manufacturing plant births to quantify environmental stringency. Most models can be implemented through the generic equation:

$$Y_i = \alpha R_i + X'_i \beta_i + \varepsilon_i$$

(Levinson, 2008)

where *Y* represents the economic activities in country or industry *i*, *R* is the measurement for stringency given cofactor α, vector *X* is the aggregate of other conventional variables (wages, technology, preference, etc.) that can alter *Y* given cofactor β, and ε represents the margin of error. The PHH posits that *R* and *Y* share a negative relationship. The research in this paper will use multiple indicators for *R* to assess the degree of growth in sand mining and concentrated animal feeding operations that has resulted from Wisconsin's weakening environmental stringency. If such a negative relationship is found, it will prove that regulatory degradation has given Wisconsin a comparative advantage in pollution-intensive industries, supporting the PHH and paving the way for a new pollution haven.

1.2 An Introduction to the Research Methodology

For my research methodology I have constructed a four-tier system of analysis to test environmental stringency using the following indicators:

1) Pre-existing indexes of environmental strength
2) Pollution abatement costs for state manufacturers
3) State legislation and regulatory activities performed by the DNR
4) Tangible growth in pollution-intensive industries relative to noncompliant behavior

The first part of the methodology will test whether Wisconsin was an environmentally stringent state prior to the 2008 recession. In order to do this, we will examine the previous studies that measure stringency through various environmental and economic indicators. The second part will quantify Wisconsin's compliance costs for manufacturers using data from the U.S. Census Bureau (USCB) to provide an understanding of the financial considerations pollution-intensive industries must make and whether operating in some states is more economically efficient compared to others. The third part of the methodology will examine the state legislation and regulatory activities using data provided by the DNR and Environmental Protection Agency (EPA). To fully grasp the extent of regulatory oversight necessary for ensuring compliance, I will explain the basic framework of environmental federalism and the statutory responsibilities of the DNR. This will also require a summary of the most prevalent pieces of federal and state environmental legislation. The final test will assess the actual growth of pollution-intensive industries. For this, I will focus on the proliferation of frac sand mining and concentrated animal feeding operations, drawing comparisons between the number of permits being issued and the disproportionate regulatory efforts made. My conclusion will summarize the findings of each phase of the methodology, its relevance to the PHH, and offer a prediction for Wisconsin's future.

1.3 State of the Art

The Pollution Haven Hypothesis, or Pollution Haven Effect, developed in the early 1990's after a wave of new environmental issues emerged. While the Brundtland Report gave new ground to acquiesce environmental degradation in impoverished countries, deforestation, biodiversity loss, ozone depletion, and global warming were underlining the growing friction between sustainable economic development and environmental protection. The PHH provided a means of understanding this relationship. The basic theory behind the PHH can best be explained through an Environmental Kuznets Curve (EKC). An EKC explains the natural degradation of the environment that occurs as result of economic growth; whereas the PHH represents the manipulation of such a transition to intentionally accelerate economic growth at the unnecessary expense of the environment. The EKC shown below in Figure 1 represent the balance between economic development and environmental degradation, illustrated as an inverted U-function. Line A represents the supply of natural resources from the environment and line C represents the demand for said resources from the growing population. As a country experiences initial growth (indicated by per capita income), pollution levels will increase until a certain maximum is reached.

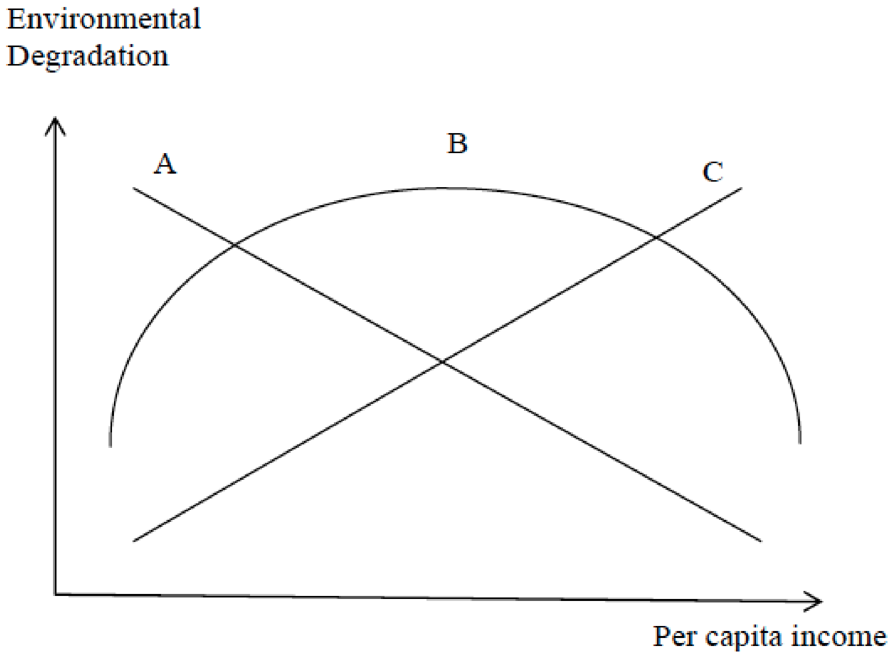


Figure 1: Environmental Kuznets Curve (Van Alstine and Neumayer, 2010)

This initial stage was explained by the International Bank for Reconstruction and Development (IBRD) in their 1992 World Development Report: "*As populations and incomes rise, a growing economy will require more inputs (thus depleting the earth's 'sources') and will produce more emissions and wastes*" (p.38). In accordance with the Brundtland Report, the IBRD also stated that: "*Successful development will inevitably involve some amount of land clearing, oil drilling, river damming, and swamp draining*" (pg. 8).

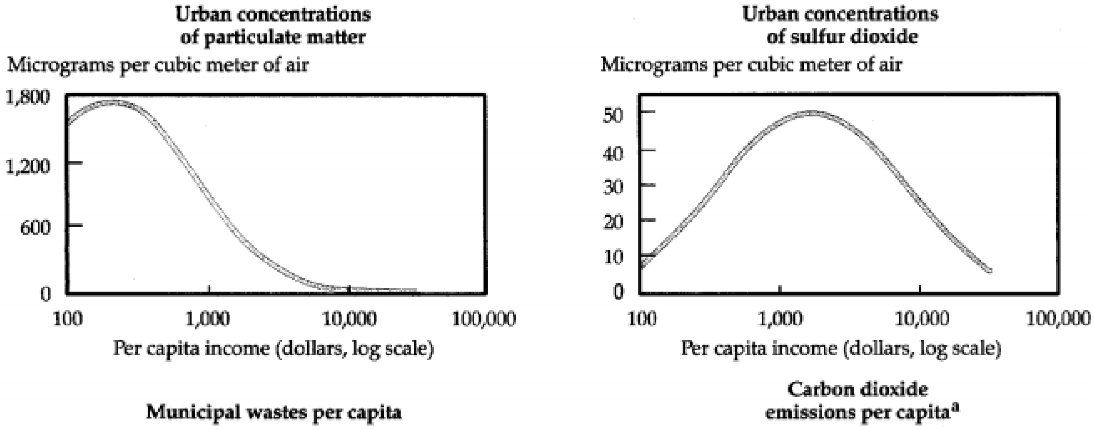


Figure 2: Environmental Kuznets Curve for PM and SO2 concentrations (IBRD, 1992)

Figure 2 shows two examples of an EKC using particulate matter and sulphur dioxide concentrations relative to per capita income. The presumption of the EKC is that at a certain level of development countries will have the economic competency to engage in less domestically polluting activities (Point B in Figure 1). These activities may include increasing production efficiency, investing in greener technology, or utilizing cleaner material inputs and energy sources. But the EKC is an overly optimistic view in that environmental degradation is inevitable for achieving economic growth. This can only be demonstrated by making static assumptions pertaining to a country's technological levels, preference, and environmental resources. However, while the threshold may be attributed to certain advancements, if the PHH is applied, the threshold may be the result of higher domestic pollution standards. In this case, countries create an incentive to increase imports from foreign countries, thereby offsetting their own pollution. From the EKC, one can begin to understand how environmental policies could affect identical sectors in two countries with different regulations.

Using a pollution tax as the measurement for stringency, Figure 3 depicts how trade flows may shift according to production costs per individual unit of output. In this graph there are two sectors (x_1,x_2), which are both producing goods domestically (Home) and importing them from abroad (Foreign(*)). Levinson and Taylor make the assumption that both sectors are identical apart from the total costs to produce at Home versus in Foreign (c^F,c^{F*}). This assumption includes pollution intensity per unit of output, wages, workforce, technology, and other conventional factors. The example shows how the total industries in sector x_1 ($\check{n}_1$) pay more to produce abroad relative to Sector x_2

($c_1^{F*}>c_2^{F*}$), given lower pollution taxes at Home than in Foreign ($\tau<\tau^*$). Assuming trade flows follow the cheapest available means, all production to the right of $\check{n}_1$ will occur in Foreign and all production to the left will occur at Home. Sector x_2 must pay a higher domestic pollution tax, meaning that production costs are significantly less abroad, resulting in increased imports from Foreign. The actual level of domestic pollution intensity, ranked from 0 to 1, therefore depends on that country's pollution taxes and relative costs. If there are higher domestic taxes pollution intensity will be less at Home, but offset by embodied pollution in imported goods from Foreign.

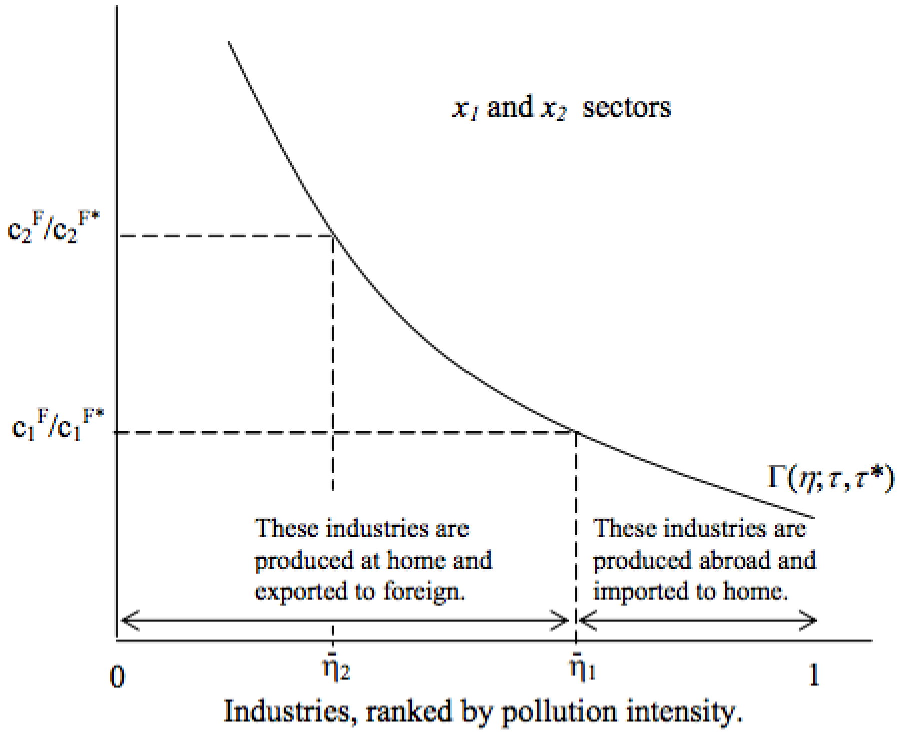


Figure 3: Foreign and Domestic trade flows relative to pollution taxes (Levinson and Taylor, 2008)

Shapiro and Walker's (2015) work also supports this model and reaffirms the effects taxes can have on actual pollution. Studying pollution taxes on U.S. manufacturers, they found that major air pollutants from manufacturing sources, such as nitrogen oxides, PM, VOCs, and sulphur dioxide, had dropped by 60% between 1990 and 2008. Moreover, the intensifying environmental regulations as a whole were able to explain the 75% drop in manufacturing pollution during that time. Even though there is empirical evidence for such behavior, countries may still choose alternative policies or make investments in environmental resources without altering their trade flows. Yet the acceleration of trade liberalization has created a precarious nature for environmental regulations. Until this point, the bulk of PHH literature has focused primarily on global economic investment flows and trade patterns. The majority of existing models typically measure environmental stringency by follow indicators:

1) Foreign Direct Investment (FDI) flows from multinational companies
2) New plant growth and location choices
3) Political corruptibility
4) Pollution abatement costs
5) Monitoring and enforcement efforts

FDI and new plant growth represent proxy data for measuring stringency based on the movement of investments relative to environmental policy. Corruptibility demonstrates stringency on the basis of economic versus environmental prioritizations and pollution leniency. Abatement costs, monitoring and enforcement efforts are direct forms of stringency that serve to prevent pollution from occurring. What makes this paper's research novel is its focus on a single U.S. state, once known for its environmental prowess, and the multifaceted approach used to trace its regulatory strength through the wake of an economic recession. However, the broader scope of the PHH has proven incredibly useful to gain insight into the interrelations of pollution, politics, and the economy, and therefore its importance and applications are worth briefly summarizing.

The PHH lends perspective to global trade patterns and the spatial distribution of economic investments. Its application has become increasingly relevant in the 21st century due to the dramatic rise in FDI and multinational economic activities. To have an idea of the immense growth in FDI, it is important to note that global FDI rose from $600 billion in 2003 to $2.1 trillion in nominal GDP by 2007 (UNCTAD, 2010). The PHH can explain why countries may intentionally compromise their environmental regulations to secure more FDI. It is therefore important to maintain a higher degree of international coordination as well as transparency to prevent any Pareto-type regulations (where one country's environment or economy is improved only through the degradation or cost of another's). Bearing this in mind, environmental policies should be prioritized within global trade agreements, moreover with cases of global trade law preventing individual countries from implementing international environmental agreements--the most recent example being India's solar panel production and the World Trade Organization[1].

Considering whether industries or profit-maximizing producers respond to environmental regulations when choosing a new location, there should be an intuitive answer. This intuition is typically reaffirmed by observations of industrial behavior. Despite the seemingly obvious correlation, economists have disputed greatly over the accuracy and importance of environmental regulations on economic flows. The following literature review will provide evidence of such endogenous economic growth and PHH behavior at the state and even county level.

1.4 Literature Review

In the 1990's, Arik Levinsson began tracking the spatial movements of new manufacturing plant births in the United States. Levinsson discovered that new plants showed susceptibility to environmental pressures when relocating. Older plants on the other hand were less influenced by the pre-existing state and national regulations due to their grandfathering nature (Levinson, 1996). Flawed legal structures have fostered inefficient pollution control in other studies as well. Fredriksson (1997), for example, found that states with subsidies for pollution abatement costs actually had higher levels of pollution. This was due to the effects financial flexibility had on manufacturers, which encouraged more entry and output behavior. Millimet and Roy (2011) compared the impact of environmental laws from contiguous states on foreign direct investment, but found little evidence that it deterred investment influxes. One explanation is that states with weaker degrees of stringency may not attract investments or create competition simply because they already lack pollution-intensive industries. As Keller and Levinson put it, "*there simply is less need to worry about industrial pollution in states with less industrial activity, and those states that do attract polluting manufacturing may respond by enacting more stringent regulation*" (p.695, 2002). However, in 2004, in a more in-depth evaluation of spatial distribution among new manufacturing plant births, Millimet found that varying county regulations in New York

[1] In 2010 the Jawaharlal Nehru National Solar Mission in India began increasing localization measures in solar component production to enhance the domestic solar industry, which alternatively limited foreign solar equipment use. The WTO's Dispute Panel found that India was in violation of its national treatment obligations under Article 2.1 on Trade-related Investment Measures that were considered discriminatory to U.S. products (United States Trade Representative, 2016).

did in fact influence plant locations and investments from both foreign-owned and domestic plants (List and Millimet, 2004).

Another PHH scenario is when two or more contiguous states degrade their regulatory strength to secure investments. This form of competitive behavior is often referred to as the "Race to the Bottom." Based on state enforcement data, Konisky offered two possible reasons behind intentionally degrading one's own environmental laws. The first explanation is that elected state officials can be compromised by private incentives, altering their own environmental behavior. For example, if the environmental regulations only affect certain industries or ones that play a crucial role in the state's economy, the industries would be motivated to seek favor among policy-makers or threaten to relocate using their economic leverage. The second explanation is that state officials prioritize economic needs over environmental. Konisky (2007) refers to this as economic voting. At the state and local level of government, economic growth is generally what determines a successful term for an elected official. Opponents of the Race to the Bottom scenario suggest just the opposite--that regulatory competition between states and sub-national governments will actually create stronger environmental regulations. Fredriksson and Millimet (2002) found that states with higher abatement costs showed a positive effect on the abatement costs of neighboring and even distant states over time; whereas those with lower costs did not exhibit any influence on other states. According to their study, the effects were noticeable within two years for the bordering states and five years for the noncontiguous states.

By the turn of the century new measures of environmental stringency were created to examine other possible endogenous factors. Damania (2003) created an alternative measure of stringency based on public expenditures, which includes environmental research and development, as well as legal enforcement costs in proportion to state GDP. Another innovative measurement quantified the behavior of individual politicians rather than the policies themselves. Supported by panel data from 33 different countries, Cole, Elliot and Fredriksson (2006) were able to demonstrate that FDI was actually conditional on government corruptibility, specified by the amount of campaign contributions a government received. If a government was deemed to have a high degree of corruptibility, the FDI lead to less stringent environmental regulations. Alternatively, for governments that were not considered corruptible, FDI lead to the development of more stringent regulations. Given the recent amendments to campaign finance laws in the country after the *Citizens United* ruling by the United States Supreme Court, it would be worth re-investigating the influence of political financing on environmental legislation[2].

Environmental monitoring and enforcement have also exponentially increased from the 20th to 21st century; in part, as a result of advancements in technology, but also through the development of legal frameworks to assure regulatory compliance. Research has shown strong evidence that monitoring and enforcing pollution regulations effectively deters noncompliant behavior (Gray and Shimshack, 2011; Earnhart, 2004; Nadeau, 1997; Earnhart and Glicksman, 2007; Shimshack and Ward, 2005; Gray and Shadbegian, 2007; Alberini and Austin, 1999; Langpap and Shimshack, 2010). One study on air pollution from steel mills concluded that facilities subjected to federal enforcement measures within a two-year period were 33% more likely to be in compliance with clean air regulations than those facilities that had not (Deily and Gray, 2007). Madat and Viscusi (1990) analyzed the behavioral trends of pulp and paper mills to find facility noncompliance rates had nearly doubled in the absence of quarterly inspections. The study demonstrated the volatility of industrial compliance rates and that, on average, pulp and paper mill pollution discharge fell roughly 20% when subject to inspections--proving the importance of enforcement on actual discharge amounts. To better illustrate the body of PHH research, Table 1, taken from Millimet and Roy's discussion series, compiles the empirical research showing endogenous environmental regulations. To test the PHH on Wisconsin several of the environmental indicators mentioned in the literature review were used. In order to prove that Wisconsin was an environmentally stringent state in the years prior to 2008, this following chapter will summarize the state's environmental profile and the existing indexes that categorize states by environmental strength. From this foundation, the methodology will continue the initial work of Arik Levinson by using the Levinson Index to quantify the most recent compliance cost data available.

[2] One example already being the owner of Gogebic Taconite personally contributed $700,000 to the Governor of Wisconsin's re-election campaign prior to the state rewriting its ferrous mining laws (Bice, Bergquist, and Marley, 2014).

Table 1: Summary of PHH Literature with Endogenous Results (Millimet and Roy, 2011)

Study	Dependent Variable	Data	Primary Measure of Environmental Regulation	Primary Instruments
Mulatu et al. (2010)	Industry shares	13 countries and 16 ISIC industries averaged over 1990–1994	Environmental Sustainability Index in 2001	Corruption in 1995; income in 1992; urbanization in 1997; schooling in 1990
Kellenberg (2009)	Value added of majority owned U.S. multinational affiliates	50 countries and nine industries over 1999-2003	Two survey-based responses from executives concerning environmental stringency and consistency of enforcement	Own country: arable land/agricultural worker; tractors/agricultural worker. Spatial lag of other countries in same region (weighted by GDP): land/agricultural worker; tractors/agricultural worker; public schools; capital/labor ratio; infrastructure; organized crime.
Cole and Fredriksson (2009)	Inbound FDI stocks and flows divided by aggregate GDP	13 OECD and 20 developing countries over 1982-1992	Lead content of gasoline	Total population
Levinson and Taylor (2008)	U.S. net imports divided by the value of shipments	132 3-digit manufacturing sectors from Mexico and Canada over 1977-1986	PAOC per unit of value added	The amount of a pollutant contributed by other sectors in the states in which the sector tends to locate (14 pollutants yields 14 instruments); weighted average of state per capita incomes
Cole and Elliott (2005)	U.S. outbound FDI stocks in Brazil and Mexico divided by total U.S. stocks in each country	31 (Brazil) or 36 (Mexico) 3-digit U.S. SIC industries over 1989-1994	PAOC per unit of value added	Lagged PAOC per unit of value added over 1973-1978; industry-level pollution intensity in 1987
Cole et al. (2005)	U.S. net exports as a share of value added	3-digit U.S. SIC industries over 1978-1992, except 1979 and 1987	PAOC per unit of value added	Follow Levinson and Taylor (2008); six types of air pollution yields six instruments
Jug and Mirza (2005)	Imports as a share of domestic sales	Nine 2-digit ISIC industries; 12 importing countries from the EU15 and 19 exporting countries from the EU15 and Central and Eastern Europe over 1996-1999	Environmental expenditures for total manufacturing	Total public expenditure; lagged investment in environmental equipment; lagged wages
Ederington et al. (2004)	U.S. imports divided by the value of shipments	394 4-digit U.S. SIC industries fover 1978-1994 except 1979 and 1987	PAOC per unit of total materials costs	Similar to Levinson and Taylor (2008) based on geographic dispersion of industries
List et al. (2004)	Number of manufacturing plant modifications and closures	New York State county-level data over 1980-1990	Ozone attainment status	Proportion of all contiguous western neighbors that are out of attainment
List et al. (2003)	Number of new manufacturing plants	New York State county-level data over 1980-1990	Ozone attainment status	Proportion of all contiguous western neighbors that are out of attainment
Fredriksson et al. (2003)	U.S. state-level inbound FDI stocks across states	U.S. state-level panel data from four manufacturing sectors over 1977-1986	Levinson (2001) index of state-level relative PAOC	Per capita GSP and the share of legal services in GSP; non-military government employment and the interaction between non-military government employment and share of legal services in GSP; corruption and its interaction with tax effort; corruption squared and its interaction with tax effort
Ederington and Minier (2003)	U.S. net imports divided by the value of shipments	374 4-digit U.S. SIC industries over 1978-1992, except 1979 and 1987	PAOC per unit of total materials costs	Four-firm concentration ratio; number of firms; value of shipments; percentage of unionized workers; industry unemployment rates; lagged changes in import and export penetrations; recent industry growth; lagged total trade

2 Methodology

2.1 Wisconsin's State Profile

For most of its existence Wisconsin has been an industrial state with abundant natural resources. Embroidered on its flag stand a sailor and miner to represent the traditional occupations. In the golden crest are the tools used by the most dominant industries at the time of statehood in 1848--mining, manufacturing, agriculture, and shipping. To put these images into context one must consider the physical characteristics of Wisconsin. In the western part of the state lie major contributories to the Mississippi River, which form its western border with Minnesota and to the east are Lake Superior and Lake Michigan. These waterways served as the main transportation routes for much of the country's natural resources and gave birth to industrial cities like Milwaukee, Chicago, and Detroit. Along the northern half of the state are vast stands of pine and hardwood forests that were once laid bare by the lumber industry for its virgin white pine. Wisconsin's geological makeup further contributed to its success. Underneath the Penokee Range sit the deposits of iron ore that fueled the steel and automotive industries for most of the 20th century. More recently, the Driftless Area in the southwest, made up of rich Cambrian sandstone, has played a key role in the sand mining boom. Wisconsin owes much of its success to these industries, but it has been home to some of the most revolutionary environmentalists of their time as well, such as Senator Gaylord Nelson (the founder of Earth Day) and Aldo Leopold (the father of wildlife ecology). Despite utilizing most of its natural resources, Wisconsin has managed to simultaneously be one of the most environmentally progressive states as we will see in the following section.

2.2 Existing Environmental Indexes

In 1991, Bob Hall and Mary Lee Kerr created the Green Index to measure the environmental profiles of all fifty states. Using 256 measures of public policy and environmental pollution, the Green Index covered practically every field of environmental regulation between 1970 and 1990. According to the index, Wisconsin ranked 16th in total environmental spending, 15th for congressional leadership and quality of life, and 5th in workplace health (Hall and Kerr, 1991). After analyzing data on the use of fertilizers, herbicides, and pesticides, as well as groundwater pollution and congressional leadership, Hall and Kerr gave Wisconsin an overall composite score of 3rd place nationally for implementing 56 different environmental policies pertaining to soil-, air-, and waste pollution (see Appendix 1). Hall and Kerr also determined that in terms of groundwater protection, Wisconsin, Iowa, and California had the toughest regulations. Similar conclusions were drawn by the Fund for Renewable Energy and the Environment (FREE). The FREE Index (1987) assessed state regulations on groundwater pollution, air pollution, and hazardous waste to determine a value for each state's environmental program. In the end, Wisconsin and California scored highest, while Mississippi and West Virginia scored the lowest. Following his Green Index, Hall went on to research the economic conditions in states with strong environmental programs. Using twenty economic indicators and twenty environmental indicators he was able to disprove the belief in the ultimatum between job growth and environmental preservation. Hall found that states with the strongest environmental records actually had the best employment opportunities and conditions for long-term economic development (Hall, 1994). After ranking all fifty states, he placed nine in the top-tier for both indicator scales. Wisconsin was among them. Finally, as a measure of environmental consciousness, the League of Conservation Voters developed an index for congressional voting. Each year the League of Conservation Voters creates a scorecard for U.S. representatives and senators for their voting records on environmental legislation. In theory, these elected officials reflect the environmental mentality of each state. Levinson took the mean score of each state's voting record and compared them to the compliance costs enacted in those states. Once again, Wisconsin was consistently ranked in the top five states (Levinson, 2001).

To lay the groundwork for this research, a comprehensive set of data had to be collected that encompassed both the environmental and economic means of pollution control. Between 1973 and 1994 the USCB, in collaboration with the EPA, compiled the pollution abatement costs of over 20,000 manufacturing plants in the United States. The Bureau published their findings in a yearly report called the Pollution Abatement Costs and Expenditure, or *PACE Survey*. As such, it represents the most comprehensive set of data for pollution abatement costs available and will be the first indicator of environmental stringency for Wisconsin.

3 Compliance Costs for Manufacturers

3.1 Pollution Abatement Costs and Operating Expenditures

As defined in the *PACE Survey*, pollution abatement costs are the costs involved in the activities to treat, capture, reduce, eliminate, or dispose of pollutants in accordance with federal, state, and local regulations. These activities occur during each stage of the production process (installation, operation, maintenance) and as part of the initial capital expenditures. Pollutants are defined as substances, which, due to their chemical composition or amount, compromise natural processes and result in unwanted environmental and/or human health effects (USCB, 2008). The survey allocates pollution abatement costs into four categories:

1) Treatment and capture
2) Recycling
3) Disposal
4) Prevention

Treatment and capture involve the removal of by-product pollutants in the post-production process before they are released into the environment. Methods of treatment and capture are typically physical separators like filters, bag houses, and wastewater treatment, but can also be used to alter the chemical or biological traits of a pollutant. Recycling refers to the retrieval and reuse of post-production waste for reprocessing. Recycling is done both on- and off-site. Disposal is the final sink for post-production waste after other abatement activities have been conducted. In many cases the final sink is a landfill or waste water well. And finally, prevention includes means, techniques, or processes to decrease the quantity of pollutants created throughout the production process. Prevention is typically maintained through production technologies or equipment modifications. In addition to the purchase, installation, and operation costs of production, total abatement costs include monitoring and testing pollution amounts. For Levinson's Index and the continued work, the measurements will be based solely on the pollution abatement operating costs (PAOCs). This is done for two reasons: first, PAOCs are generally more accurate. Operating costs for pollution prevention can be identified and separated more easily than capital investment costs, which may include expenses for irrelevant production processes. Second, PAOCs are more stable than fluctuating investment costs. For example, when a state experiences economic growth, capital costs are generally at their highest as a result of the increased investments being made independent of environmental policy. PAOCs on the other hand remain consistent over longer periods of time (Levinson, 2001).

3.2 The Levinson Index

The *PACE Survey* has been cited frequently in PHH research. Typically the data is used to estimate the exact amount a manufacturer spent on pollution control for each unit of output. Yet raw abatement costs are only one side of the coin, as they do not provide a control for the industrial composition of each state. Therefore, if a state has high abatement costs, one should not simply assume that it has strong environmental regulations. States like California and Texas, for example, have some of the country's highest pollution abatement costs but drastically different regulations and, as previously established, California is one the most environmentally stringent states according to various indexes. Alternatively, states with fewer pollution-intensive industries or more clean industries are also underestimated in the survey. To determine the actual regulatory stringency for manufacturers, Levinson developed a dynamic model in his 2001 study, *Behavioral and Distributional Effects of Environmental Policy*. Using the *PACE Survey* data, he produced an industrially-adjusted value for each state's industrial composition. The adjusted costs are calculated from the actual costs relative to the predicted costs, which he estimates using state and national abatement totals by subsector.

$$S_{st} = \frac{P_{st}}{Y_{st}}, \tag{1}$$

Equation 1 denotes the actual pollution abatement costs for each dollar of output, where P_{st} represents the abatement costs in state s in year i, and Y_{st} represents the Gross Domestic Product (GDP) from the total manufacturing industries in state s in year t. The result, S_{st}, is the unadjusted compliance costs. To get the predicted pollution abatement costs of each state Levinson creates an industrial composition control, which he equates from the following:

$$\hat{S}_{st} = \frac{1}{Y_{st}} \sum_{i=20}^{39} \frac{Y_{ist} P_{it}}{Y_{it}}, \tag{2}$$

Equation 2 indexes the manufacturing industries by their two-digit Standard Industrial Classification (SIC) codes, 20 through 39. In this equation, Y_{ist} is the contribution of GDP from industry *i* in state *s* in year *t;* Y_{it} is the total contribution from industry *i* to the national GDP in year *t;* and P_{it} is the national pollution abatement costs from industry *i* in year *t*. The result, $\hat{S}_{st}$, is the mean abatement costs per dollar of GDP weighted by the relative contributions from each industry in state *s* during year *t.*

$$S^*_{st} = \frac{S_{st}}{\hat{S}_{st}}. \tag{3}$$

In order to adjust the industrial index relative to state environmental stringency, Levinson calculates the ratio of actual PAOCs (S_{st}) to the predicted PAOCs ($\hat{S}_{st}$) using Equation 3. From S^*_{st} we can determine how stringent the regulatory costs are for industries in different states. If S^*_{st} is less than 1, it implies that industries spent relatively less in that state than in others. Alternatively, states with values greater than 1 have relatively higher compliance costs for industries and therefore more stringent environmental regulations. Table 2 accounts for the average state values for unadjusted and adjusted pollution abatement costs per dollar of output between 1977 and 1994. The two columns on the far right list the national ranking of each state according to the index values.

Table 2: Levinson Index of PAOC averages for U.S. manufacturers (2001)

STATE	UNADJUSTED COSTS	ADJUSTED COSTS	U.S. RANKING: UNADJUSTED	U.S. RANKING: ADJUSTED
AL	0.0219	1.19	9	14
AZ	0.0148	1.39	21	9
AR	0.0168	1.17	16	15
CA	0.0121	0.90	29	29
CO	0.0113	1.01	32	20
CT	0.0079	0.67	42	44
DE	0.0344	1.30	3	11
FL	0.0138	1.21	25	13
GA	0.0127	0.91	27	28
ID	0.0181	1.66	14	1

IL	0.0132	0.91	26	26
IN	0.0196	1.14	12	17
IA	0.0106	0.96	34	24
KS	0.0115	0.76	31	38
KY	0.0146	0.99	22	22
LA	0.0538	1.51	1	5
ME	0.0237	1.55	8	4
MD	0.0185	1.17	13	16
MA	0.0067	0.67	46	43
MI	0.0121	1.01	28	19
MN	0.0092	0.66	38	46
MS	0.0213	1.47	10	7
MO	0.0104	0.79	36	35
MT	0.0341	1.49	4	6
NE	0.0088	0.83	40	31
NV	0.0072	0.63	44	47
NH	0.0072	0.75	45	39
NJ	0.0158	0.82	20	34
NM	0.0306	1.64	6	2
NY	0.0087	0.77	41	36
NC	0.0088	0.82	39	33
ND	0.0105	0.77	35	37
OH	0.0139	0.82	23	32
OK	0.0103	0.58	37	48
OR	0.0139	1.22	24	12
PA	0.0169	0.91	15	27
RI	0.0075	0.72	43	41
SC	0.0160	0.99	19	21
SD	0.0056	0.68	48	42
TN	0.0165	1.10	17	18
TX	0.0311	1.39	5	8
UT	0.0164	0.93	18	25
VT	0.0065	0.66	47	45
VA	0.0118	0.96	30	23
WA	0.0196	1.37	11	10
WV	0.0433	1.58	2	3
WI	0.0110	0.89	33	30
WY	0.0259	0.72	7	40

From Table 2 we observe a noticeable discrepancy between the two average values. We see that the unadjusted values for many states are different from the adjusted values after the industrial composition has been accounted for. Iowa, for example, has an unadjusted cost value of 0.0132 and an adjusted value of 0.91, suggesting a heavy presence of pollution-intensive industries and regulatory costs. Wisconsin's value also undergoes a change, from an unadjusted average of 0.011 per dollar of output to 0.89. According to Levinson's Index, Wisconsin ranks 33rd nationally in terms of industrial compliance costs for manufacturers. This ranking seems to undermine the previous indexes showing Wisconsin as one of the more stringent states. It is important to remember that Levinson's national ranking is based on the states' average abatement costs of nearly three decades. Keeping this in mind, a closer look at the year-to-year change in adjusted values reveals that Wisconsin's abatement costs have been increasing over time and are significantly higher in the last recorded year (see Figure 4).

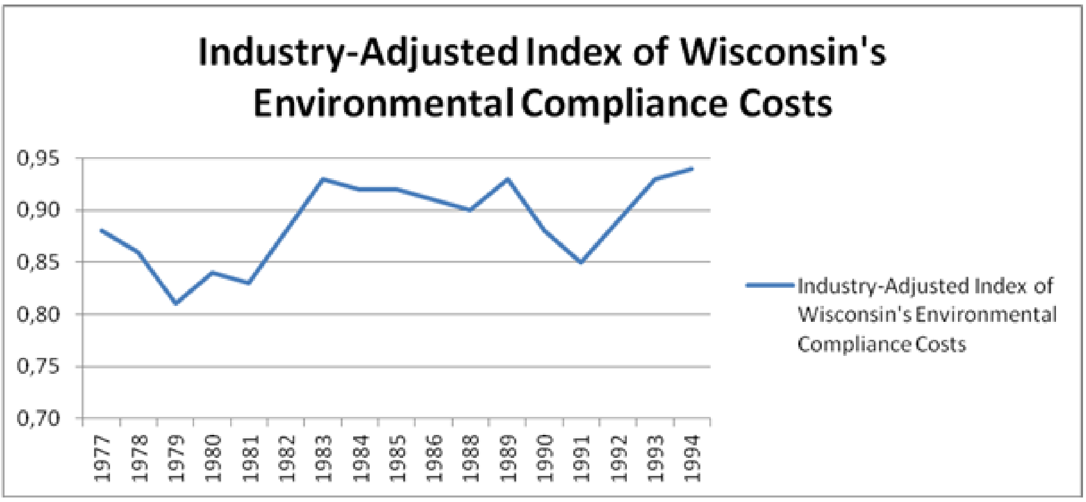


Figure 4: Wisconsin's adjusted PAOC costs by year (Levinson, 2001)

3.3 The 2005 PACE Survey

Due to budgetary reasons the *PACE Survey* was discontinued until 2005 when it was briefly reinstated. The data from Appendix 2.1 and 2.2 detail the operation costs by subsector, activity, and pollutant type. Relative to the previous years, the total abatement costs per industry had generally risen since 1994. PAOCs by 2005 had already surmounted $20.6 billion. The majority of compliance costs were made by the chemical manufacturing industries. In Wisconsin however, the highest PAOCs were spent by the paper industry. The activity that received the most allocated funds was treatment, followed by disposal then prevention and recycling. As far as specific pollution types go, air pollution control appears to be the most expensive.

Using Levinson's Model we are able to comparing the data from the Bureau of Economic Analysis (BEA) with the *PACE Survey* to calculate an average PAOC for manufacturers in Wisconsin in 2005. Examining the data (represented in Table 3.1 and 3.2) we find that the average adjusted abatement costs for Wisconsin were substantially higher than the previous values listed in Levinson's work--ascending from 0.89 to 0.96. The overall increase suggests that Wisconsin's manufacturing industries and regulatory strength had grown during the unaccounted years. The results also imply that Wisconsin has not exhibited any previously pollution haven characteristics by this measure. In order to foster a pollution haven for manufacturers the PAOCs for Wisconsin would need to be significantly lower in relation to the amount of economic growth shown by GDP contributions from state manufacturers. Furthermore, it shows that Wisconsin was more stringent closer to the time of the recession than the previous thirty years.

Due to the discontinuation of federal and state data collection on industrial abatement costs, a secondary measure of stringency was needed for the years after 2005. The next chapter will discuss monitoring and enforcement activities for facilities registered under the Clean Air Act and Clean Water Act. This variable embodies a direct measure of regulatory stringency based on the efforts made by the responsible agencies. In order to understand the responsibilities the Wisconsin state agency is required to perform, the fourth chapter first will introduce the concept of environmental federalism and the roles federal and state regulatory agencies play.

Table 3.1: Total U.S. and Wisconsin PAOCs and Industry GDP Contributions for 2005 (BEA, 2016; *PACE Survey*, 2008)
[In millions of dollars except for Levinson Model Values] *GDP Contribution Data provided by the Bureau of Economic Analysis

NAICS Industrial Code	U.S. Total GDP Contributions*	U.S. Total Abatement Costs	Wisconsin Total GDP Contribution*	Wisconsin Total Abatement Costs
Total 31-33	**1,704,173**	**20,677**	**46,622**	**552**
311-312	179,914	1,850	4,844	83
313-314	20736	256	196	2
316	13,860	51	103	2
321	34,865	566	1,424	22
322	51,945	1,796	4,718	166
323	44,649	238	2,341	22
324	142,706	3,746	-	-
325	227,299	5,217	3,194	35
326	63,543	503	2,596	20
327	49,051	696	1,317	8
331	56,636	2,291	1,761	68
332	122,936	763	5,376	28
333	114,887	315	5,657	19
334	211,046	623	4,558	2
335	43,247	190	2,450	8
336	170,697	1,319	3,829	24
337	33,783	133	953	3
338	66,198	115	1,169	1

Table 3.2: Levinson Model Results

Year	Unadjusted Cost (*S*)	Adjusted Cost (*S**)
1977-1994	0.0110	0.89
2005	0.0112	0.96

4 Environmental Federalism

4.1 Federal Environmental Legislation

The cornerstones of American environmental policy are made up of five main laws:

1) the Clean Air Act Extension of 1970
2) Clean Water Act of 1972
3) Safe Drinking Water Act of 1974
4) Resource Conservation and Recovery Act 1976
5) Comprehensive Environmental Response, Compensation, and Liability Act of 1980

Each law represents a specific pollution type and establishes the relevant federal and state standards. The Clean Air Act (CAA) regulates stationary and mobile source air emissions; the Clean Water Act (CWA) accounts for discharges of water-borne pollutants and quality assurance for surface water; the Safe Drinking Water Act regulates the quality of all current and potential drinking water sources, including groundwater, which the CWA does not specify; the Resource Conservation and Recovery Act grants the EPA authority at every stage of the hazardous and non-hazardous waste process, from generation to final disposal through a cradle-to-grave system of management; and finally, the Comprehensive Environmental Response Act created a federal "superfund" allocated to emergency clean-up services for hazardous waste, as well as the authority to pursue legal action against those responsible parties (EPA, 2016a). According to the EPA, these key pieces of legislation serve to protect public health by controlling the amounts of hazardous pollutants.

Up until the 1970's environmental regulations were almost entirely enforced by local and state governments (Paddock, 1990). When the CAA Extension and CWA were passed, the federal government quickly took the leading role. Their accession of authority coincided with the realization of an environmental crisis and represents a pivotal point in public awareness. In the years leading up to the CAA and CWA, an entire generation discovered the impacts of pesticides like DDT after reading Rachel Carson's *Silent Spring* and then watched in horror as the Cuyahoga River spontaneously burst into flames (Ditommaso, 2016). Congress hastily passed the CAA and CWA to address these issues, but in doing so, set no clear boundaries defining the roles of each level of government. Now, almost a half-century later, the federal statutes serve mostly as environmental frameworks for states to develop, implement, interpret, and enforce their own environmental regimes. The maximum pollution amounts and quality standards are established by federal laws, like the CAA and CWA, and must be fulfilled by each state. States have the ability to exceed these national standards and create independent laws if the overall effect is an increased measure of protection. The total body of environmental laws covers a broad array of issues and activities that must be managed while still maintaining each government's sovereignty. This balance is referred to as environmental federalism. Like many other aspects of American federalism, the relationship between the federal government and the state governments regarding environmental regulations is a complex of overlapping responsibilities.

4.2 The Role of the Environmental Protection Agency

The main federal authority on environment matters is the EPA. The EPA was created in 1970 by an executive order from President Richard Nixon to unify the environmental functions of multiple governmental agencies after they were suspected of collusion with the polluters they were tasked with regulating. As Anna Ni and Montgomery Van Wart explain in the *Building Business-Government Relations* guide:

> *"The agency was to be a single, independent, executive agency not at the cabinet level, and unique inasmuch as it was not created by Congress. Born in the wake of elevated concern about the environmental pollution, the agency was established...to consolidate a variety of federal research, monitoring, standard-setting, and enforcement activities to ensure environmental protection."*
>
> (p.62, 2016)

In a sense, the EPA was not merely another governmental entity, but rather a direct extension of the Executive Branch. Since its entire existence had been molded to the specific pollution concerns addressed by the CAA and CWA, the new federal authority was faced with unique set of regulatory obstacles from the onset.

> *"This piecemeal policy-making occurred in part because of the political importance of environmental issues being dealt with individually as they appeared on the public's radar screen, rather than reconstructing a framework altogether; for example, having separate departments take on different tasks. Instead of monitoring enforcement and research, Congress set out legal areas separately, like air, water, and pesticides."*
>
> (Ni and Van Wart, p.62 2016)

To synchronize federal and state policy more easily the EPA broke the United States into 10 environmental regions--Wisconsin, Minnesota, Illinois, Indiana, Michigan, and Ohio belong to Region 5. State environmental agencies like the DNR or the Minnesota Pollution Control Agency are responsible for implementing both federal and state regulations. The regional EPA offices, which take directions from their Washington D.C. headquarters, offer legal counseling to help states draft new legislation, create regulatory systems, monitor compliance, develop programs for public education and participation, and aid in enforcing existing laws. States in return are asked to create State Implementation Plans to meet federal standards. Even if states enter into formal negotiations with the EPA and sign agreements on pollution criteria for federal grants, the state agencies make practically all enforcement and permit-issuing decisions. At the local level, environmental agencies and lawyers operate in a same manner, but concentrate on smaller contracted services like waste disposal and zoning ordinances (Yale Law School, 2015). The federal government still has preemptive authority in matters that are not explicitly granted to the regional governments. Under the Supremacy Clause of the U.S. Constitution, local and state governments are barred from entering into legal areas where congressional permission is not directly given. This serves to eliminate any gray-areas in regulatory responsibilities and avoid potential friction if both governments were to execute the same legal duties (Alonso, 1978). These agencies must therefore cooperate within the limits of federalism to monitor and enforce pollution standards.

4.3 Federal Monitoring Regulations

As with any legal regime, in order to assure compliance there have to be certain mechanisms. In the United States, when the environmental movement was first underway, the General Accounting Office estimated that only 3% of total air pollution emitters were actually compliant with the designated limits (Heyes, 2000). Luckily, compliance has dramatically increased since then. Federal and state agencies now oversee more than 41 million facilities and sources regulated by 58 environmental different protection programs. The vast majority of facilities operate with air and water permits set by the CAA and CWA, with approximately 24,000 major CAA facilities, 20,000 minor CAA facilities, and 7,000 major CWA facilities (Gray and Shimshack, 2011). For such an undertaking the EPA and states collectively spend over $1 billion each year on monitoring and enforcement efforts alone.

The ultimate purpose of monitoring activities is to assure compliance among pollution permit holders and reduce the chances of future violations. Evaluations are the main form of monitoring and almost always require an on-site facility inspection. According to the EPA's Compliance Monitoring Strategy (CMS) an inspection requires a detailed report of all the regulated pollutants and emission units within a facility. For example, a facility report for an air polluter should contain a description and the amounts of the following:

1) Visible facility emissions
2) Feed rates
3) Raw material composition
4) Process rates
5) Pollution control equipment performance
6) Stack tests

(EPA, 2014a)

The CMS also encourages inspectors to make use of pollution monitoring technologies such as infrared cameras, leak detection systems, or, if necessary, photo-ionization detectors. Although off-site monitoring does exist the amount of regulated facilities that meet the preconditions to obtain one are few and usually only pertain to smaller sources like apartment complex boilers. Evaluations are also based on facility-submitted monitoring data and previous compliance reports. The types of monitoring inspections are broken down into Full Compliance Evaluations (FCEs), Partial Compliance Evaluations (PCEs), and Investigations. FCEs evaluate the level of a facility's compliance as a whole. This requires such regulatory procedures as collecting and measuring emission samples, conducting staff interviews, reviewing operation logs, and examining the installation, operation, and maintenance of pollution abatement equipment. In addition, FCEs should assess a facility's ability to meet compliance standards. To account for all monitoring activities it may take over a month to make an FCE for a single facility (Gray and Shimshack, 2011). For a PCE, compliance is determined by individual processes, like the ones mentioned above, or the evaluation of one particular feature of a facility; for example, the regulatory agency may assess the response speed a facility demonstrates for formal information requests. PCEs therefore require less time, money, and resources to determine if a facility is in compliance with a particular program, emission standard, or process (EPA, 2014a). Investigations restrict the scope of an evaluation to a single process in a more in-depth assessment. Most investigations are conducted as a follow-up to an FCE usually because of an evaluation restraint like time, knowledge, or technology. One particular EPA investigation into state permit-issuance failure revealed that in the absence of the required New Source Review/Prevention of Significant Deterioration permits, pulp, utility, and petroleum facilities were operating without any pollution control whatsoever. Consequently, after realizing their regulatory freedom, each industry underwent noticeable economic growth. Only after a review of released documents on industrial growth was the EPA made aware of the state agency's neglect (EPA, 2014a).

4.4 Clean Air Act Monitoring Activities

The guidelines for proper CAA air monitoring are described in the EPA's Stationary Source CMS program. The recommendations of the Office of Enforcement and Compliance Assurance (OECA) are that state regulators first submit a biennial CMS consistent with federal statutes for discussion and approval by the regional EPA branch. States are encouraged to keep detailed records of monitoring activities and facility-specific enforcement data and then submit it to the Integrated Compliance Information System (ICIS) for Air for review. The overall aim of the CAA CMS program is to:

1) Synchronize federal and state monitoring practices
2) Foster communication between the different levels of governmental agencies
3) Enhance federal oversight into individual states' monitoring systems

The type of permit outlines the obligations each facility must fulfill to be in compliance. The CAA requires all major air polluters and sources obtain Title V operating permits, which are issued by the state regulatory agencies. For all Title V permit holders, the EPA suggests an FCE be conducted at least once every two years. For so-called "mega-sites", like petroleum refineries, steel manufacturers, and chemical manufacturers, evaluations can be conducted once every three years. Facilities that are classified as mega-sites are determined by individual states based on facility emission units, pollutant characteristics, monitoring systems, and their overall footprint (EPA, 2014a). Minor facilities may require a Title V permit if they emit or have the potential to emit pollutants equal to or greater than 80% of the major facility thresholds. These permits are registered as SM-80's. FCEs for SM-80 polluters should be conducted once every five years. Following inspections, states are then asked to prepare a Compliance Monitoring Report describing the monitoring activity type, facility, permit application, emission units, noncompliance records, and any other general observations. However, the evaluation frequencies recommended by federal regulators are not legally binding and, moreover, there is no minimum number of evaluation frequencies that states must perform to ensure compliance.

4.5 Clean Water Act Monitoring Activities

For sources and facilities emitting water-borne pollutants, the CWA requires a National Pollutant Discharge Elimination System (NPDES) permit to monitor and prevent pollution discharge. According to the CWA-CMS, water quality standards and overall compliance is achieved by NPDES permit holders through the collaborative oversight of various regulatory agencies. The scope of the NPDES permit requirements applies to major and non-major facilities/sources much in the same way as the CAA-CMS, but for the following pollution types:

1) Pre-treated discharge

2) Bio-solids (sludge)
3) Wet weather sources
4) Pesticides

The EPA recommends that states conduct at least one comprehensive inspection every two years for major facilities. For large and medium Concentrated Animal Feeding Operations (CAFOs) with NPDES permits, the EPA recommends a comprehensive inspection only once every five years (EPA, 2014b). If the CAFO is not in possession of an NPDES permit, the state regulators should make an initial inspection to determine the facility type as well as the possible discharges and then monitor accordingly. The NPDES also takes into consideration the proximity permittees have to sensitive drinking-water sources like groundwater. For these permit holders, the CMS encourages more inspection frequencies than the federally recommended number. The use of pesticides has only recently come under the regulation of the EPA's NPDES program. However, there are still no recommended monitoring frequencies for facilities using or discharging pesticides (EPA, 2014b). NPDES compliance regulators are instructed to perform the following on-site monitoring activities for permit holders according to the facility's history and data needed:

1) Combined sewer overflow inspection
2) Bio-monitoring inspection
3) Pre-treatment sampling
4) Discharge sampling
5) Municipal separate sewer system inspection
6) Sanitary sewer overflow inspection
7) Sewage sludge and bio-solids inspection
8) Storm water inspection
9) Toxicology sampling

Furthermore, a thorough background investigation of previous compliance records should be concluded (EPA, 2014b). The data obtained should then be entered into the EPA's NPDES-ICIS.

4.6 Federal Enforcement Mechanisms

In 1989 the EPA published the Enforcement Management System (EMS) as a guide for building state enforcement programs. Enforcement activities are the proactive measures regulatory agencies take once noncompliance has been suspected or made evident. Most regulated facilities will be subject to a violation at some point in their operation. The EMS specifies that a formal enforcement action can be, "*independently enforceable without having to prove the original violation, and subjects a person to adverse legal consequences for noncompliance*" (pg. 68, 1989). Enforcement actions also occur under different circumstances from monitoring in that they require an appropriate response to noncompliant behavior, leaving room to interpret the level of misconduct by the regulatory agency in charge. This also allows states a degree of flexibility to work on a case-specific basis and by their individual needs. The EMS guide lists the violation circumstances that state agencies should consider before determining a due course of action:

1) Permit, statutory, regulatory or enforcement order schedule has been violated
2) Violation has occurred that presents an actual or imminent threat of significant harm to the environment or to the public health and safety
3) Violation has occurred which, unless corrected, would erode the integrity of an environmental protection program
4) Pretreatment program requirements are violated
5) Regulatee has failed to report
6) Source has conducted an unauthorized bypass
7) Inspection results indicate a severe problem
8) There are known or suspected operation and maintenance problems
9) Information provided by interested parties indicates a significant violation
10) There are aesthetic impacts related to the violation. These general violation screening considerations should be applied in the violation review process

(EPA pg. 40, 1989)

If the regulatory agency finds a facility in violation of one or more regulation or operating standards, several actions may be taken. The Combined Enforcement Policy of the EPA details the response measures to ensure state agencies act appropriately and with consistency. The possible federal enforcement responses are the following: Notices of Noncompliance, Administrative Compliance Orders, Civil Administrative Penalty Orders, and Civil Judicial Referrals. A Notice of Noncompliance (NON) is given when a facility does not meet a federal standard for an operation or maintenance process and/or emission amount. NONs are the most frequent forms of violation and are typically distributed for first-time offenses or less harmful pollutants. Facilities and sources are then allowed 30 days to return to compliance. If the violator fails to realign with the legal standards, they shall be issued a Civil Administrative Penalty Order. In cases of violations that pose an immediate threat to the environment and/or public health, an Administrative Compliance Order shall be given. For clear violations or extended failure to come into compliance, an EPA administrator can pass the case to the United States Department of Justice for assessment and collection of legal penalties (EPA, 2012). Due to the limits of federalism however, the EPA may only exercise its enforcement authority over a state if it determines that the state has not taken the appropriate enforcement actions or the actions are inadequate.

There are two reasons that justify using monitoring frequencies and enforcement actions as indicators for environmental stringency. First, they are activities the states directly control. The federal government sets standards, but states are the bodies actually responsible for ensuring that those standards are met and for taking action when they are violated. Therefore, the majority of activities are concluded solely by state agencies. In 2003 states carried out 96% of the inspections and 88% of the judicial lawsuits in the United States (Konisky, 2007). The second reason is to understand the extent of the agencies' responsibilities and the implications when those duties are neglected. The purpose of thoroughly examining the federal monitoring and enforcement guidelines of the CWA and CAA is to emphasize the amount of oversight, or trust in self-regulation systems, necessary to ensure compliance with environmental regulations, which state regulators are obliged to perform. As we will see in Wisconsin, the amount of effort and resources required has encouraged the state to rely more heavily on voluntary compliance. By the decentralized nature of environmental federalism, it is the responsibility of states to not only prove compliance, but also obtain the actual self-monitoring reports from the facilities. The overall effectiveness of the environmental regulations therefore is only as effective as the agencies administering them. As we will see, Wisconsin has its own monitoring and enforcement response procedures conducted by its regulatory authority, the Department of Natural Resources.

4.7 The Role of the Department of Natural Resources

The DNR is the primary regulatory body in Wisconsin. It is the sole agency responsible for issuing permits, monitoring pollution activity, and enforcing environmental regulations. The DNR conducts its monitoring activities primarily through on-site inspections according to federal guidelines and standards. The following data in Table 4 represents the total inspection frequencies, separated by pollution type and source, directly before and after the 2008 recession. The results show a tremendous decline in overall monitoring activities within a five year span.

Table 4: DNR Monitoring Overview (Bergquist, 2012)

Total Environmental Inspections	**2007**	**2008**	**2009**	**2010**	**2011**	**Change ’07 vs. ‘11**
Air Pollution	419	383	423	333	279	-33%
Large Farms	28	22	35	52	28	-
Private Wells	1,047	1,133	1,065	1,088	697	-33%
Storm Water	1,310	1,570	1,201	831	619	-53%
Environmental Cleanup	50	61	39	54	47	-6%
Hazardous Waste	278	273	287	415	283	+1%
Solid Waste and Landfill	338	337	300	283	231	-32%
Wastewater	415	400	326	157	199	-52%
TOTALS	3,885	4,179	3,676	3,213	2,383	-37%

In relation to 2007, the total amount of inspection frequencies decreased 37% by 2011. Monitoring activities for wastewater pollution types showed the largest drop, while hazardous waste monitoring increased by 1%. However, compared to 2010 the number of hazardous waste inspections actually fell by 132. Reasons for such a dramatic decrease in monitoring could be the result of the budget and staff cuts previously mentioned, but the overall implications support the preconditions for other pollution haven characteristics. There is no doubt from this data that the level of stringency in terms of monitoring has decreased, but we will need to examine the state enforcement activities to analyze how these mechanisms coincide with pollution-prone behavior.

For enforcement activities, the state uses the Stepped Enforcement Philosophy as a guide for conducting its statutory duties. The “steps” refer to a procedural order to prevent, identify, and correct environmental law violations. They range from informal written compliance requests to legal referrals to the Wisconsin Department of Justice. According to the DNR *Enforcement Handbook*, the overall goal of the Stepped Philosophy is to obtain voluntary compliance from regulated sources and to resolve violations at the lowest enforcement level appropriate (DNR, 2013). Wisconsin’s enforcement actions include Notices of Noncompliance (NON), Notices of Violation (NOVs), Enforcement Conferences, Compliance Orders, and Referrals. If there is a possible violation the facility or source will first receive a written NON informing them of the statute allegedly being violated. NONs can be issued by most DNR staff members for identified minor violations, usually observed during on-site inspections and are not centrally logged by the department. NOVs are given for clear breaches of environmental regulations and must be made by a state environmental enforcement specialist. NOVs contain the citation code for the violation committed and indicate the possible legal consequences. NOVs will also provide a requested date for corrected compliance or a formal Enforcement Conference. Enforcement Conferences are meetings held between the DNR and alleged violators to reach an achievable solution. These conferences are typically where the NOVs, Compliance Orders, or Referrals are given. Compliance Orders are legally binding agreements to correct a violation within a given amount of time. Referrals on the other hand are formal requests to the Wisconsin Department of Justice to pursue legal action against a violator or obtain civil forfeiture through due process (DNR, 2013).

While the vast majority of violations are observed during inspections or self-reporting, a small amount are brought to the DNR’s attention by public request if six or more citizens make a formal complaint (Azar and Bochert, 2007). The data provided in Tables 5.1 and 5.2 detail the last 10 years of environmental enforcement actions by program area. Different programs use different enforcement mechanisms based on what is available to them statutorily or through rule. It is important to note that the data are for calendar years and as such the 2016 data only represents the first few months of the year. The accumulative results show a massive decline in almost every enforcement activity. The biggest change can be seen in the number of referrals to the Wisconsin Department of Justice. Compared to the activity averages from the pre-recession years (2007-2008), referrals dropped 46% by 2015, while the number of violation notices dropped 44% and enforcement conferences 21%. Compliance orders on the other hand appear to be the only activity that has noticeably increased in the past decade but only in one program area.

Table 5.1 Ten Year DNR Enforcement Activities (Sponseller, 2016)

Notices of Violation	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	Totals	10 Yr Avg
Air Management	179	123	76	67	46	46	32	46	38	11	664	66
Animal Waste CAFO	0	3	13	15	12	3	7	12	18	3	86	9
Animal Waste NonCAFO	4	4	5	6	4	2	9	9	4	0	47	5
Water Resources (FH)	45	41	46	36	19	32	32	23	35	8	317	32
Hazardous Waste	10	12	7	17	10	8	17	18	14	9	122	12
Public Water	76	76	90	68	69	51	89	83	67	19	688	69
Private Water	30	25	158	135	14	13	12	75	8	7	477	48
Repair & Remediation	23	22	30	14	9	19	14	10	3	7	151	15
Solid Waste	23	35	31	17	12	20	18	19	23	9	207	21
Waste Tires	0	0	2	0	8	0	0	0	0	0	10	1
Technical Services	1	0	0	1	29	2	0	1	0	1	35	4
Storm Water	55	71	42	23	8	23	26	21	20	8	297	30
Wastewater	50	49	32	58	29	25	42	29	36	19	369	37
Totals	496	461	532	457	269	244	298	346	266	101	3470	347

Enforcement Conferences	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	Totals	10 Yr Avg
Air Management	88	92	54	32	29	42	32	37	35	11	452	45
Animal Waste CAFO	0	2	8	13	10	2	9	13	19	5	81	8
Animal Waste NonCAFO	2	4	3	7	4	4	10	13	4	0	51	5
Water Resources (FH)	38	38	37	26	22	31	30	26	34	7	289	29
Hazardous Waste	4	10	5	7	5	7	15	14	16	9	92	9
Public Water	30	53	52	41	60	40	67	73	60	13	489	49
Private Water	12	21	13	11	12	10	11	5	7	7	109	11
Repair & Remediation	13	14	22	9	9	14	9	10	5	1	106	11
Solid Waste	19	22	30	8	12	24	16	19	19	7	176	18
Waste Tires	0	0	1	0	22	0	0	0	0	0	23	2
Technical Services	1	0	0	1	1	1	0	1	2	0	5	1
Storm Water	52	61	25	28	10	22	24	20	17	4	263	26
Waste Water	34	26	24	42	22	28	25	24	35	12	272	27
Totals	293	343	274	225	218	225	248	255	251	76	2408	241

Table 5.2 Ten Year DNR Enforcement Activities (Sponseller, 2016)

Compliance Orders	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**Totals**	**10 Yr Avg**
Air Management	0	0	0	0	1	0	3	0	0	0	4	0
Animal Waste CAFO	0	0	0	0	0	0	0	0	0	0	0	0
Animal Waste NonCAFO	0	0	0	1	0	0	0	0	0	0	1	0
Water Resources (FH)	0	0	0	0	0	0	0	0	0	0	0	0
Hazardous Waste	0	0	0	0	0	0	0	0	0	0	0	0
Public Water	5	17	24	24	20	17	16	31	27	6	187	19
Private Water	0	0	1	1	0	0	0	0	0	0	2	0
Repair & Remediation	1	1	0	1	1	1	4	0	1	0	10	1
Solid Waste	0	0	1	0	0	0	0	1	0	0	2	0
Waste Tires	0	0	0	0	0	0	0	0	0	0	0	0
Technical Services	0	0	0	0	0	0	0	0	0	0	0	0
Storm water	0	0	0	0	0	0	0	0	0	0	0	0
Wastewater	1	0	0	1	0	0	0	2	3	0	7	1
Totals	7	18	26	28	22	18	20	34	31	6	210	21

Referrals to WI DOJ	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**Total**	**10 Yr Avg**
Air Management	28	20	21	14	2	10	8	13	12	1	129	13
Animal Waste CAFO	0	0	1	4	0	1	0	2	4	0	33	3
Animal Waste NonCAFO	2	3	1	0	0	0	3	2	4	0	16	2
Water Resources (FH)	6	17	11	8	8	6	9	6	7	1	76	8
Hazardous Waste	3	2	3	4	4	3	1	1	1	0	21	2
Public Water	3	4	2	4	0	0	3	2	0	1	20	2
Private Water	2	6	5	4	3	1	3	2	1	0	27	3
Repair/Remediation	3	3	3	2	1	1	0	5	1	0	20	2
Solid Waste	1	6	3	6	0	2	5	1	2	0	29	3
Technical Services	0	0	0	1	0	1	0	0	0	0	5	1
Storm water	12	8	6	1	3	3	2	1	3	1	39	4
Wastewater	10	7	13	4	4	6	1	0	4	1	49	5
Totals	70	76	69	55	25	34	35	35	39	5	468	47

Keeping in mind the fact that PAOCs for air pollution involve the highest compliance costs, it is interesting to note that the most dramatic reduction in specific program activity is actually air management. As we can see in Figure 5, Wisconsin places far below the average for CAA enforcement activities.

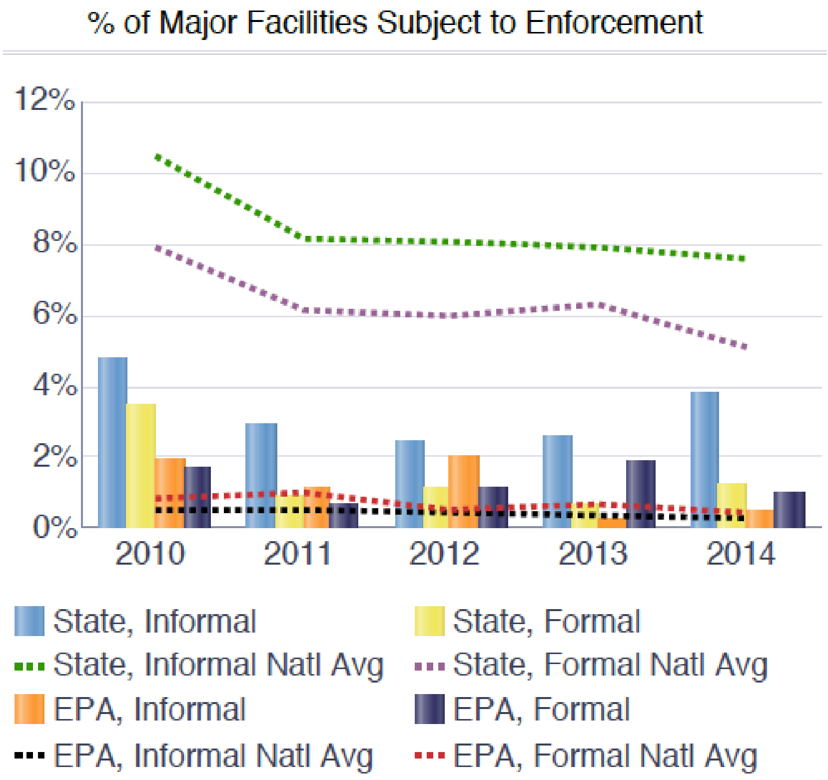


Figure 5: EPA CAA Enforcement Actions for Major Facilities (EPA, 2016b)

The lack of oversight has set the state back financially as well. A public records request by the Wisconsin Wildlife Federation in May 2015 revealed that the amount of civil forfeitures obtained by the DNR for violations dropped more than 50% since the previous state administration. The report published by the *Milwaukee Journal Sentinel* lists the total forfeitures between 2006 and 2010 as just over $15 million, compared to $6 million between 2011 to 2015 (Bergquist, 2016). Fines for wastewater pollution fell from $455,407 to $12,057 in the ten years reported, but the biggest drop in forfeitures occurred in the last two years. In 2015 the total amount paid for environmental violations was just $306,834--a 78% decrease from the previous year and the lowest amount of annual forfeitures in the last decade (see Figure 6). The Wisconsin Wildlife Federation also highlighted the fact that for 2015 no fines were even given to concentrated animal feeding operations.

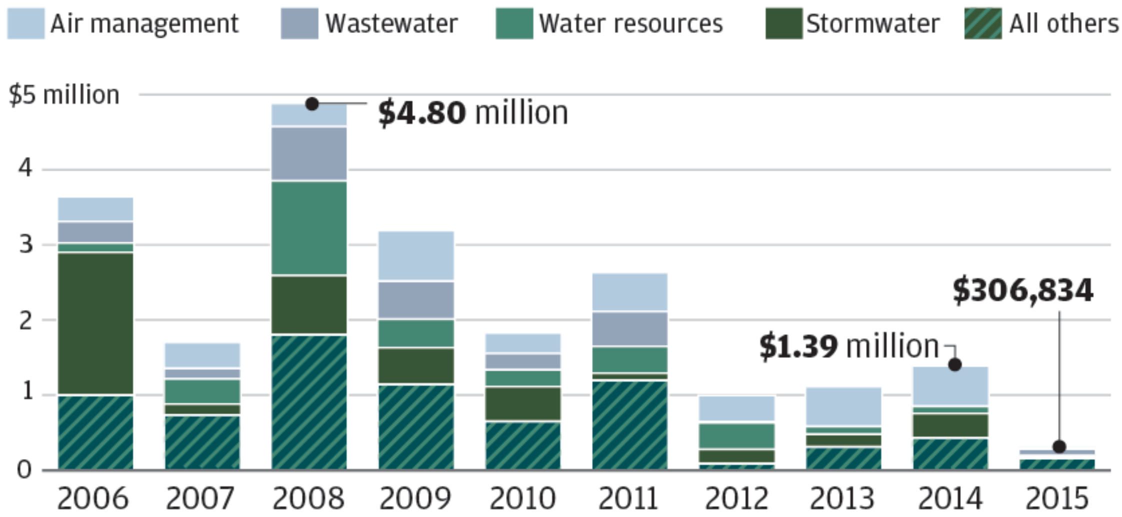


Figure 6: Forfeitures for Environmental Violations (Verburg, 2016)

What becomes clear is the regression of enforcement activities is still in sync with the Stepped procedural order, in that the degree of change reflects the level of strictness for each enforcement activity. This data trend emphasizes the DNR's determination to keep enforcement actions to the lowest level. State law makes it clear however that if a violation of any rule or term or condition of a permit is to occur, the DNR is to refer the matter to the Department of Justice "*on the basis of any information available*" (Wis. Stat § NR 283.89(1), 2001). Given that the DNR issued 27 compliance orders in 2015 for public water pollution without any legal forfeiture, it means that either the lower levels of enforcement have actually inhibited noncompliant behavior or that more polluters are getting away with more violations. In terms of enforcement, the lowest form of action is a Notice of Noncompliance, but the yearly data for NONs is not available due to their informal nature and the fact that the DNR is not required to make them public. However, Wisconsin has reported some of its compliance reports to the EPA. From this proxy data we will be able to better assess the actual behavioral changes of polluting industries to identify any negative relationship between regulatory activities and pollution suppression as documented in other work (Gray and Shimshack, 2011; Earnhart, 2004; Nadeau, 1997; Glicksman and Earnhart, 2007; Shimshack and Ward, 2005; Gray and Shadbegian, 2005; Alberini and Austin, 1999; Langpap and Shimshack, 2010). The next measure for identifying environmental stringency is to look at the economic growth in pollution-intensive industries. The following chapter will therefore examine two of the largest industries to come out of the recession: frac sand mining and concentrated animal feeding operations.

5 Industrial Growth

5.1 Frac Sand Mining

Sand mining is one of the industries that has grown exponentially since the 2008 Recession, yet it is operating with little-to-no regulatory oversight. Frac sand establishments operate under the guidelines of non-metallic mining according to the Wisconsin Statutes for Natural Resources. Chapter 135 states that non-metallic mining includes all operations or activities such as excavating, dredging, stockpiling, or crushing, for the sale or use of non-metallic minerals by the operator. The recent proliferation of sand mining across the Midwest has been driven by the hydraulic fracking industry. Hydraulic fracking uses sand in the extraction process as a proppant to create fissures in rock formations in order to release natural gas or crude oil. Researchers at the Civil Society Institute found that the amount of sand used in the fracking process has increased 30% since the industrial boom (Hopkins, et al., 2014). According to the BEA, only five sites were registered in Wisconsin as industrial sand mining establishments in 2005. As of 2015 the DNR reports 129 sand mining facilities currently in operation (DNR, 2015a). This dramatic boom in Wisconsin is partly due to the state's rich glacial deposits of Cambrian and Ordovician sandstone in the western and central parts of the state, which are ideal for industrial standards.

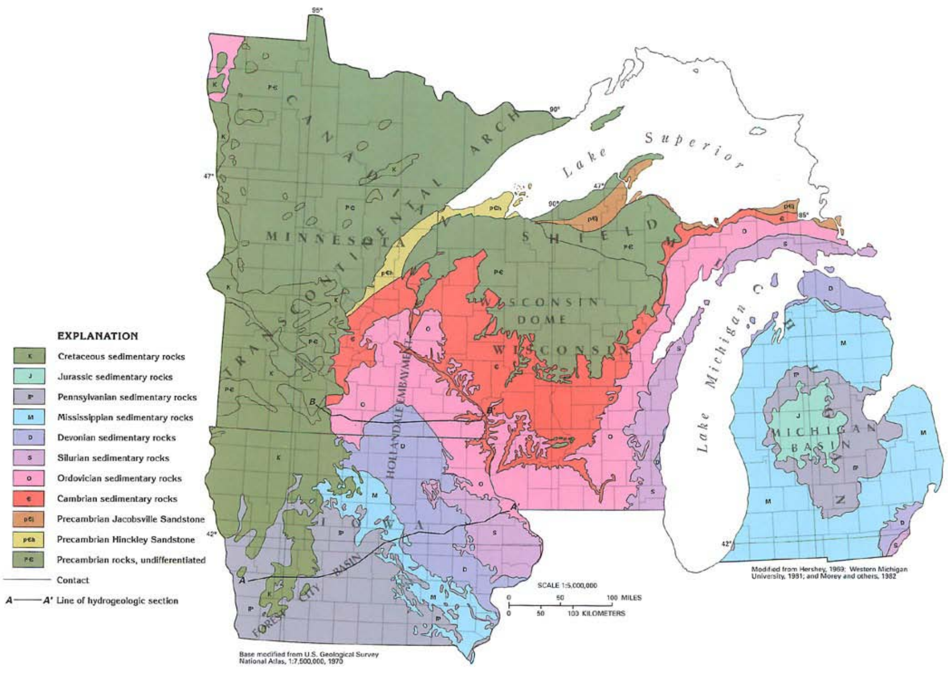


Figure 7: Midwest Geology by Sand Types (USGS, 2015)

Figure 7 from a U.S. Geological Survey, illustrates the major bedrock composition of the Wisconsin and the distribution of Cambrian (indicated in red) and Ordovician (indicated in pink) sandstone relative to other Midwest states. The standards for frac sand are stricter than one might think. Frac sand specifications require almost pure quartz formed in a small, well-rounded granule that can sustain a 6,000-14,000 psi compressive standard (DNR, 2012). Given its advantageous geology, sand mining was bound to expand, yet the exponential growth that Wisconsin experienced set it apart from other producing states. According to the League of Conservation Voters (2014b), by 2014 Wisconsin was already supplying 75% of all the frac sand used in the United States' hydraulic fracking industry. While CAFOs have experienced more gradual growth, they have caused more worry among state residents.

5.2 Concentrated Animal Feeding Operations

According to Wis. Stat. §243.03(4), a concentrated animal feeding operations is a facility, other than a pasture, where 1,000 or more animal units are confined and fed for at least a 45-day period within one year. One animal unit is equivalent to a 1,000 pound cow, with or without calf (U.S. Department of Agriculture, 1995). CAFOs have higher production efficiencies and lower costs compared to smaller farms. CAFOs have been more familiar to Wisconsin, but within the last ten years the number of dairy operations has doubled, as seen in Figure 8. The growing number of CAFOs is part of a larger national trend towards industrial agriculture. Increased demand for meat and dairy products has also fuelled the transition from traditional family operations. This transition can be seen in the following graph.

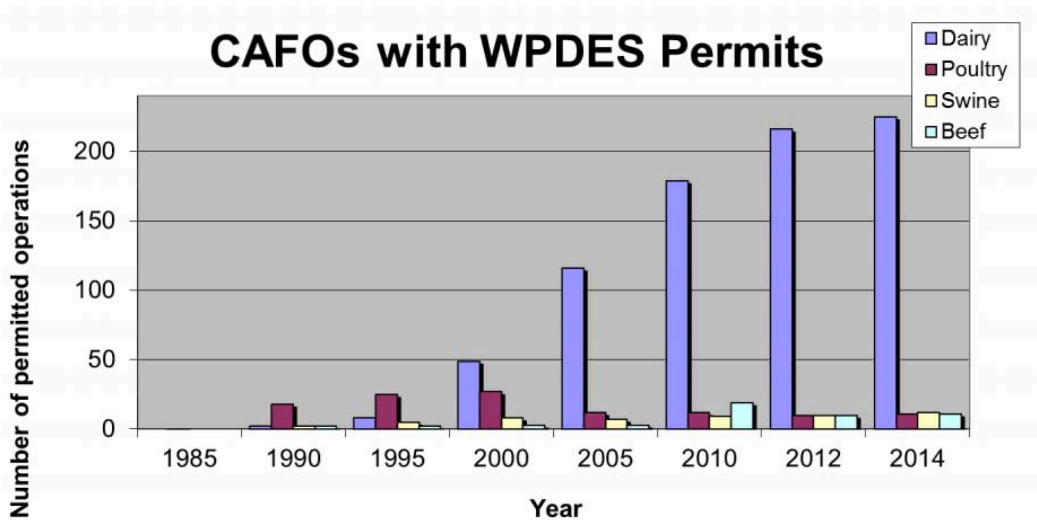


Figure 8: CAFOs in Wisconsin by Livestock and Facilities Types (DNR, 2016)

Figure 8 from the DNR website depicts the number of CAFO permits in the last twenty years. We can see that the number of dairy CAFOs quadrupled between 2000 and 2014. The latest data figures provided by the DNR list 255 permitted CAFOs currently in operation in Wisconsin, 66 of which are operating with expired permits (see Table 6).

Table 6: CAFOs in Wisconsin by Livestock and Facilities Types (DNR, 2016)

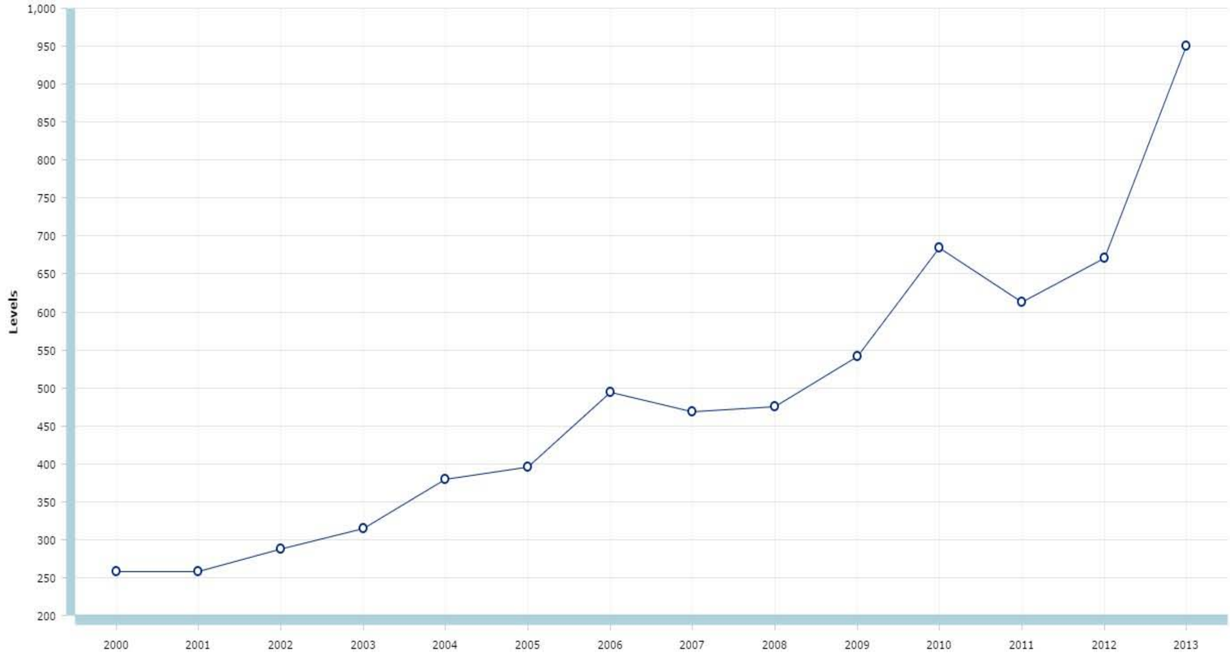
**CAFOs with more than one livestock type can be counted multiple times*

Livestock Type	Number of CAFOs*
Beef	13
Poultry	8
Dairy	240
Ducks	1
Swine	14
Turkey	2

As we can gather from the registered sites and permits, sand mining and CAFOs have undeniably prospered in Wisconsin in the last ten years. A further look shows that each industry has also provided significant GDP contributions to the state and, for sand mining, employment opportunities as well.

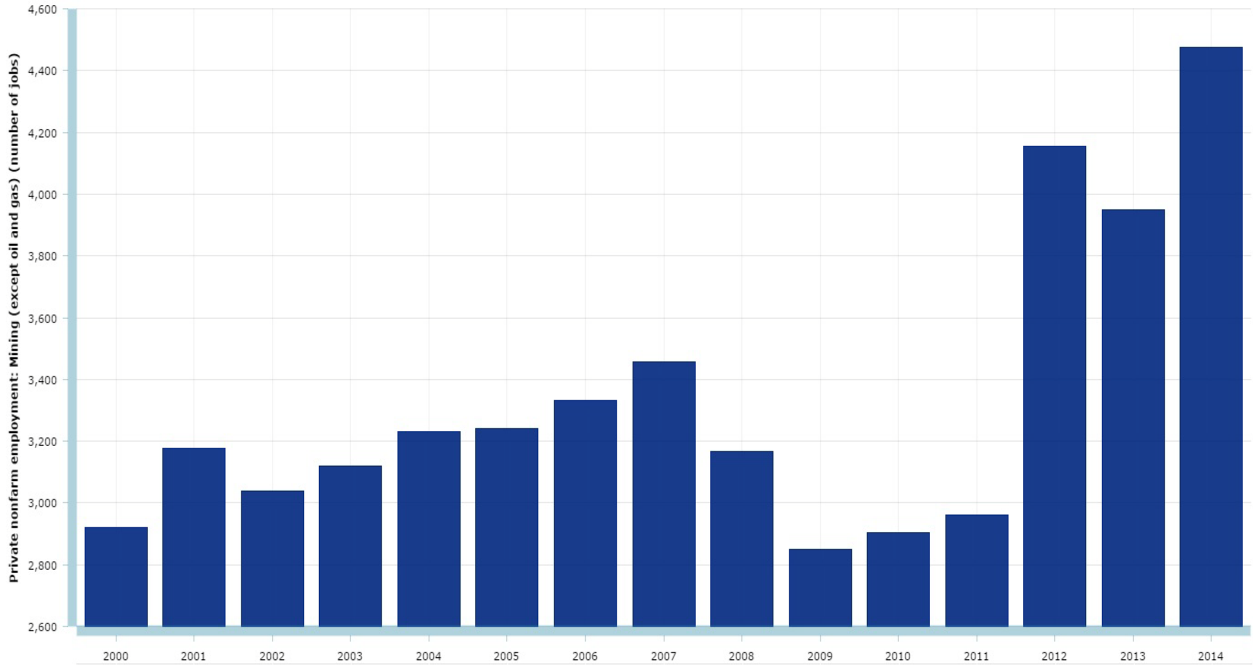
5.3 GDP and Employment Growth

The following figures (9-13) provided by the BEA illustrate the economic growth in terms of GDP contribution and employment for farming and non-oil or gas mining industries since 2000. What we can observe are a number of economic trends that correlate with 2008 recession and DNR data. First, mining activities were jumpstarted in 2009. After experiencing a temporary decline, GDP growth rose again at a staggering rate between 2012 and 2013, by which time it had grown by 50%. Employment rates demonstrate a similar pattern with a more distinguishable rise between 2011 and 2012. Supportive industries for mines grew as well, initially contributing only $1 million to the state GDP in 2010 and then $7 million by 2012—accounting for an 85% increase in just two years. Second, Figures 12 and 13 show Wisconsin's farming industry was hit harder by the recession.



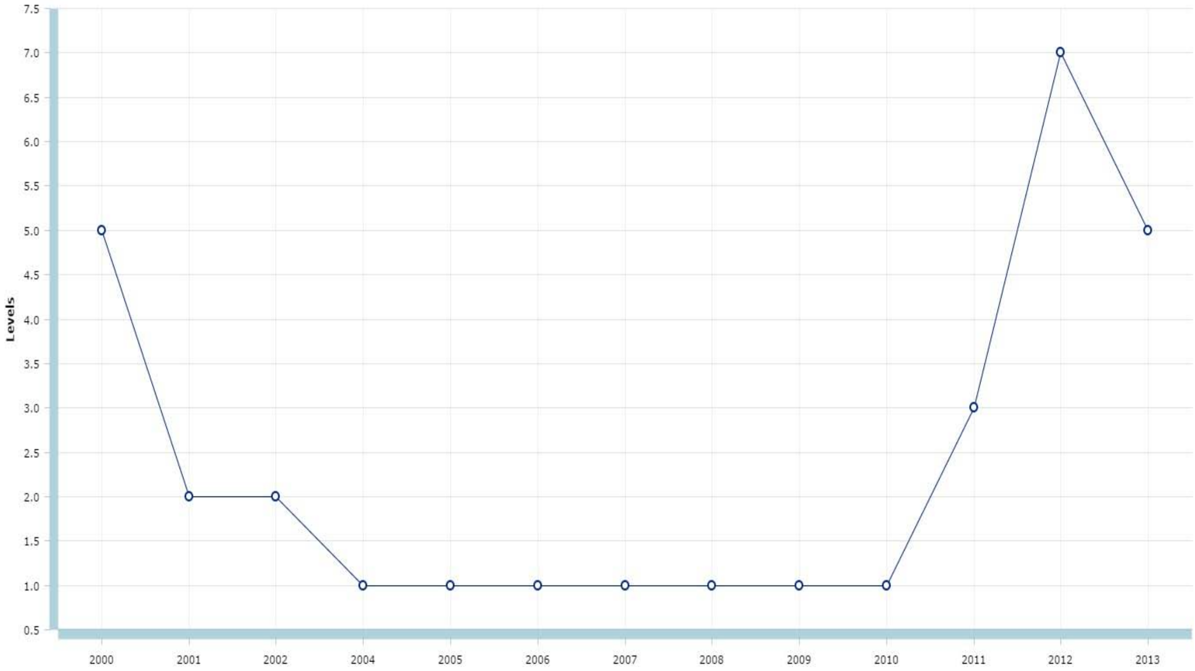
Year	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
WI	258	258	288	314	380	395	494	469	475	541	684	613	671	950

Figure 9: GDP from Mining (Non-oil or Gas) in Millions of Dollars (BEA, 2008)



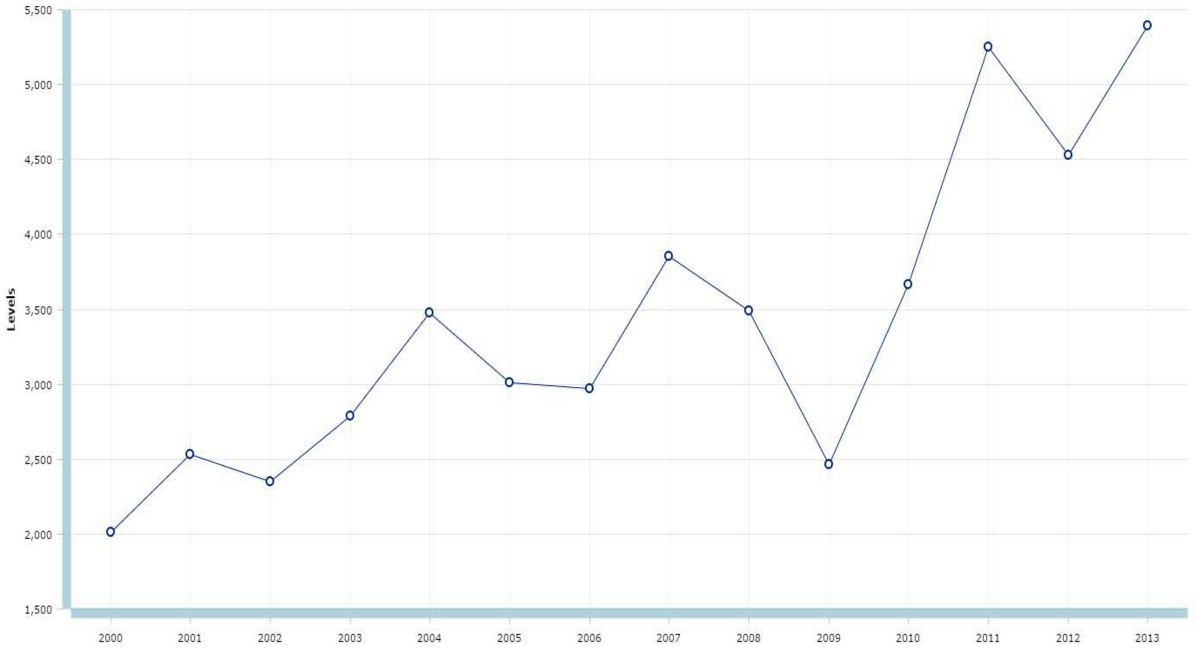
Year	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
WI	2,921	3,178	3,040	3,118	3,231	3,240	3,333	3,456	3,166	2,850	2,902	2,961	4,156	3,949	4,475

Figure 10: Total Full-Time and Part-Time Employment for Mining (Non-oil or Gas) in Millions of Dollars (BEA, 2008)



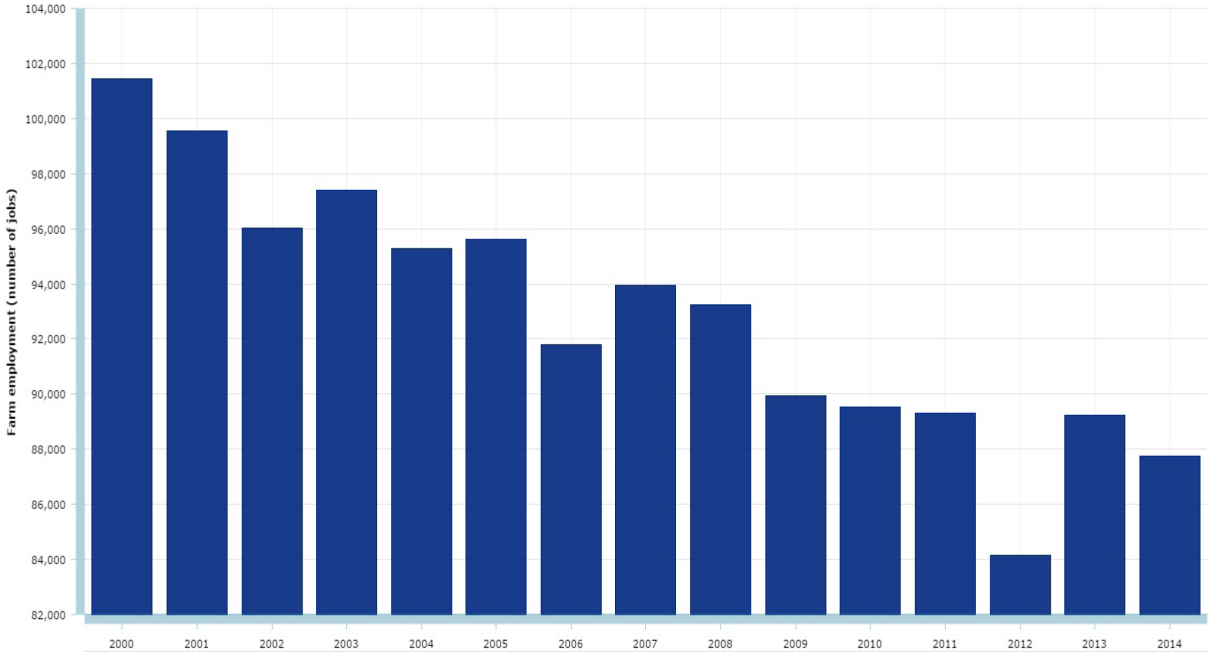
Year	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
WI	5	2	2	-	1	1	1	1	1	1	1	3	7	5

Figure 11: GDP from Mining Supportive Activities in Millions of Dollars (BEA, 2008)



Year	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
WI	2,011	2,529	2,350	2,786	3,475	3,011	2,970	3,851	3,489	2,465	3,663	5,253	4,526	5,389

Figure 12: GDP from Wisconsin Farms in Millions of Dollars (BEA, 2008)



Year	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
WI	101,442	99,561	96,029	97,400	95,267	95,600	91,783	93,948	93,230	89,931	89,535	89,302	84,161	89,236	87,753

Figure 13: Total Full-Time and Part-Time Employment for Farming in Millions of Dollars (BEA, 2008)

Farm GDP decreased almost 30% after the recession but resumed its growth again by 2011, increasing 53% from 2009 while the number of part- time and full-time farm employees steadily decreased. This economic movement highlights the transition to industrialized farming practices and reflecting the DNR's growing numbers of CAFO permits.

Comparing the actual amount of out-of-state sand mine operators to in-state, we see a remarkable increase. From the DNR permit registry we can trace the balance of economic flow in Wisconsin. The percentage of out-of-state companies operating frac sand mines in 2012 was already 40%; the other 60% came from Wisconsin-based companies. By 2015 the amount of Wisconsin owners dropped to 44%, while out-of-state operations rose to 56% (see Appendix 3). The growth in out-of-state investments is key evidence of Wisconsin pollution haven characteristics. In terms of having a competitive advantage there is also sufficient evidence. Despite proximity and resource availability, other Midwestern sand producing states did not flourish as much as Wisconsin. For example, Minnesota, Wisconsin's closest neighbor in terms of GDP, population, and geology, was not able to keep up. When Wisconsin state was producing over twenty million tons a year from its 121 active mines, Minnesota was only producing three from its nine facilities (Carey, 2015). It is possible that Wisconsin's more abundant sandstone deposits or rail infrastructure gave it the upper hand, but the state also only has one agency that regulates the entire industry versus Minnesota, which has five different regulatory agencies.

While both industries have undergone significant economic growth, it is not without concern for environmental implications. Sand mining and CAFOs are pollution-intensive industries that release high concentrations of air and water pollutants. Under law, they are therefore required to obtain pollution permits to operate in Wisconsin. Despite the fact that pollutants from sand mining are not generally hazardous to human health, it is the sheer quantities being produced state-wide that make them dangerous. CAFOs on the other hand do pose an immediate threat to residents, but have been given extremely lenient requirements for their waste management plans and pollution exemption. In fact, little has been done in response to the growth these two industries have undergone and the potential pollution they can cause. The following chapter examines the regulatory inefficiencies, outdated standards, and pollution tolerance Wisconsin policy-makers have demonstrated instead.

6 Pollution Potentials and State Legislation

6.1 Sand Mining Pollution

The DNR implements the federal CAA and CWA performance standards through the Air Monitoring System and the Wisconsin Pollutant Discharge Elimination System (WPDES). The Air Monitoring System sets the state air-borne pollution concentration limits according to federal standards and ambient monitoring requirements. The WPDES provides permits for pollutant discharge, runoff and storm-, ground-, and wastewater. Sand mines are required to obtain both of these permits. Despite the rapid industrial growth, the DNR and state legislators have failed to increase any pollution standards for permit holders. In fact, the DNR has only performed one report on industrial sand mining when the number of active sites was still in the single digits. The report however mentioned that *"as the number of sand mines and processing facilities increase, especially if clusters of these facilities begin to occur, the department may consider examining cumulative environmental impacts"* (DNR pg. 41, 2012). Meanwhile, local residents have become increasingly worried about the level of freedom with which mines are operating. The largest source of sand mining pollution comes from particulate matter (PM) in the form of fugitive silica dust. Compared to other air pollutants regulations the concentration limit for silica PM is considerably more generous (see Figure 14).

Coincidentally up until 2006, the federal standard for PM10 concentrations was actually much lower; in fact, only 50 micrograms per cubic meter compared to the 150 micrograms allowed today (DNR, 2015c). Because sand mines emit high quantities of PM10 and PM2.5, mining operators are required to obtain an Air Monitoring System permit. Exemptions can be made however. Frac sand mines are considered minor emission sources and the amount of silica PM that a single site emits does not present what the DNR considers a "significant hazard to public health" under Wis. Stat § NR 285.60 (6), allowing facilities to be excused from some state PM regulations (DNR, 2013). While silica PM does not pose an immediately danger to human health, in high quantities it has the potential to cause heart complications, asthma, or other respiratory problems. Long term exposure to silica dust can result in silicosis, a possibly fatal and irreversible respiratory condition caused by inflammation in the lungs (Midwest Environmental Advocates, 2014).

Pollutant		Primary/ Secondary	Averaging Time	Level	Definition
Carbon Monoxide		primary	8-hour	9 ppm	Not to be exceeded more than once per year
			1-hour	35 ppm	
Lead		primary and secondary	Rolling 3-month average	0.15 $\mu g/m^3$	Not to be exceeded
Nitrogen Dioxide		primary	1-hour	100 ppb	98th percentile, averaged over 3 years
		primary and secondary	Annual	53 ppb	Annual mean
Ozone*		primary and secondary	8-hour	0.075 ppm	Annual fourth-highest daily maximum 8-hr concentration, averaged over 3 years
Particulate Matter	$PM_{2.5}$	primary	Annual	12 $\mu g/m^3$	Annual mean, averaged over 3 years
		secondary	Annual	15 $\mu g/m^3$	Annual mean, averaged over 3 years
		primary and secondary	24-hour	35 $\mu g/m^3$	98th percentile, averaged over 3 years
	PM_{10}	primary and secondary	24-hour	150 $\mu g/m^3$	Not to be exceeded more than once per year on average over 3 years
Sulfur Dioxide		primary	1-hour	75 ppb	99th percentile of 1-hour daily maximum concentrations, averaged over 3 years
		secondary	3-hour	0.5 ppm	Not to be exceeded more than once per year

Figure 14: Air Pollution Concentration Limits (DNR, 2015c)

Additional air pollution results from other supportive mining activities, like operating machinery and transportation, which generate small quantities of hazardous waste such as hydraulic oil, anti-freeze, chemical solvents. Under current mining permits the DNR is not granted the administrative authority to control secondary pollution, such as odor, noise, light pollution, or other by-products consequential of mining activities.

A more threatening problem is the potential for surface water pollution. From the DNR's initial 2012 report, the Department concluded that the expected average water use per sand mine could reach two million gallons per day. During the purification process the excavated sand is washed with a chemical flocculent to treat colloidal sediment. A common flocculent frequently used by the industry contains acrylamides. The EPA has linked high concentrations of acrylamides to central nervous system damage in humans, but environmental laws in Wisconsin do not currently have any ground or surface water regulations for it (EPA, 1987). Minnesota, one of Wisconsin's neighboring states and rivals in the frac sand industry, has already added acrylamide to its Department of Health's watch list after the EPA identified the flocculent as a likely carcinogen. The Department described the chemical as exceptionally soluble with a slower biodegradability rate but high mobility, posing a potential hazard for sand mining when excavation occurs below the region's water table (Minnesota Clean Water Fund Initiative, 2013). Despite not having any state regulations for it, some Minnesota miners have already taken a precautionary approach to acrylamide and have begun using a starch-based flocculent instead (Kennedy, 2013). Wisconsin's heavy rainfall and snow melt can also lead to surface water pollution. Mining sites lack top soil with vegetation, making them susceptible to large amounts of discharge and storm water overflow. Depending on whether a facility has a high capacity well or an open wastewater holding pond, diverted storm water can carry chemical contaminants and high concentrations of sediment into nearby surface waters, possibly decreasing the pH levels and altering the water's chemical or biological composition. Additional environmental impacts of sand mining activities include lower water tables from high groundwater use, habitat loss, and wildlife displacement.

6.2 CAFO Pollution

Primary CAFO pollution is generated by organic by-products of animal waste. In Wisconsin, the largest pollution quantities are produced by dairy operations. Since a single CAFO contains 1,000 or more animal units, the amount of manure one dairy operation produces is roughly 80,000 pounds each day according to the U.S. Department of Agriculture (see Table 7). Putting that into perspective, the estimated amount of organic waste generated per day in 2014 in Wisconsin would have been 20 million pounds.

Table 7: CAFO Waste Generation Values in lbs/day/animal unit (U.S. Department of Agriculture, 1995)

Livestock Type	**Total Manure**	**Nitrogen**	**Phosphorus**	**Recoverable Manure Average %**
Beef	59.1	0.31	0.11	80
Dairy	80.0	0.45	0.07	75
Hogs	63.1	0.42	0.16	76

Chickens (layers)	60.5	0.83	0.31	93
Chickens (broilers)	80.0	1.10	0.34	93
Turkeys	43.6	0.74	0.28	78

The majority of waste can be recovered and utilized. Recoverable waste is the waste produced in confinement which can be collected and used for fertilizer. Unlike most waste covered by state law that has to be treated before it can be discharged, CAFO animal waste is legally treated as fertilizer and kept in open storage units, such as a dike pond or walled platform, for long periods of time before being applied to topsoil as fertilizer. Yet if an operator improperly manages the fertilizer, either while stored or during soil application, the nutrients and micro-organisms in the waste can lead to the spread of diseases, bio-aerosols, or surface water contamination. Liquid waste can also percolate into ground water supplies along with the nutrients and bacteria it carries. Given the sheer quantities of waste produced, CAFO pollution is presumed to be inevitable in Wisconsin. According to Wis. Stat. § NR 243.12(1) (d) for WPDES permit applications:

> *"It is the department's position that if the manure or process wastewater from a CAFO is land applied to sites in Wisconsin, pollutants from the manure or process wastewater will reach waters of the state either via leaching to groundwater or surface runoff. Also, it is the department's position that storage facilities constructed at or below grade will have some pollutant discharges to groundwater. Therefore, all large CAFOs must apply for a WPDES permit."*

The high probability of pollution discharge from CAFOs is already typical of the region. Wisconsin ranks above the national average for annual precipitation. More recently it received the highest level of precipitation in the U.S. for December—2.95 inches more than the national average (National Oceanic and Atmospheric Administration, 2016). Not surprising, the biggest fear concerning CAFOs is the potential they have to contaminate groundwater supplies. Groundwater refers to the free flowing water beneath the earth's surface, which is also the main source of drinking water in Wisconsin. The two pollutants most commonly associated with agricultural ground- and surface water contamination are phosphorus (P) and nitrogen (N). P and N are key elements used in organic and synthetic fertilizers. The amounts of P and N found in animal waste can be calculated using the data in Table 8. While P and N are essential nutrients for crop growth, excess amounts can result in eutrophication, or the depletion of oxygen concentrations in water sources. P is less soluble than N in soils, but typically attaches to particles, allowing it to migrate to bodies of water through runoff. N is highly soluble and can easily move through soil if not used in plant uptake. Naturally, when soils reach their P and N need limits and become in a sense saturated, the probability for P and N discharge is much greater. High concentrations of nitrates in drinking water can also lead to severe illnesses, especially for infants. The standard for nitrate levels in drinking water is 10 parts per million according to the Safe Drinking Water Act, but N regulations for WPDES permits are sparse and generally limited to concentrations of ammonia.

The WPDES permits still require strict monitoring activities. However, point source permit holders, like CAFOs, are entrusted with performing the necessary monitoring activities to ensure their own compliance. Considering the extent of work involved in monitoring, the actual costs for WPDES compliance are understandably high. Additional costs are also possible in the event of excessive fertilizer application. In 2001 the Wisconsin Supreme Court ruled that CAFO regulations not only applied to the confinement facilities, but also to the equipment used in fertilizing and the surrounding areas where waste was applied, regardless if the operator owned it or not. The court ruled that in the event of over- or improper soil application the operator would be held responsible and justly fined (*Maple Leaf Farms v. DNR*, 2001). This judicial decision added extra strain on state farmers--not small family farms where fertilizer application is restricted, but industrial farms that produce millions of gallons of liquid waste each year and require expensive systems for fertilizer storage. Relief came for CAFOs in two forms. First, Wisconsin allows CAFOs the freedom to develop their own waste application standards and application rates by developing a Nutrient Management Plan (NMP). This should be based on self-analyzed manure and soil tests and Best Management Practices. CAFOs should also detail the appropriate P amount for crop needs and soil application in their NMP.

Then in 2013 the DNR and state legislators amended the WPDES regulations on discharge variance to allow more opportunities to be pardoned from pollution standards, as well as more time to come into compliance. According to the Wisconsin's variance availability requirements, the DNR will grant a WPDES permit holder variance for phosphorous discharge standards if they can prove that:

1) The determination applies to the existing source
2) The permittee certifies that the existing source cannot achieve compliance with the water quality based effluent limitation for phosphorus without a major facility upgrade or sustaining significant economic hardships
3) The permittee agrees to comply with the department's decision to include in the permit a requirement to achieve compliance with the most stringent achievable interim limit, except that the department may not include an interim limit that is higher than the limit established under

(Wis. Stat. § NR 283.16 (4) (a), 2014)

After submitting the application for a variance and until the last review day when the Department can issue its decision, all of the water quality effluent regulations for the point source in question cease to be in effect and the variance will remain in place until the permit is reissued, modified, or revoked (Wis. Stat. § NR 283.16(4) (c) (d), 2014). Furthermore, the department only gives itself 30 days to act on variance applications. In the case that the DNR fails to respond by the deadline, the application is automatically approved (Wis. Stat. § NR 283.16(4) (am) 3, 2014). Originally, the conditions for variance applications were far stricter. Permittees were required to prove "*by greater weight of credible evidence*" that additional pre-existing pollution, natural systems, or infrastructure impaired compliance and that adhering to such regulations would result in significant and widespread social and financial impacts for the whole region (Wis. Stat. § NR 200.20(2), 1999), whereas the new amendments in a sense tolerate the largest form of pollution in Wisconsin and the biggest by-product of CAFO discharge.

7 Regulatory Efficiency

7.1 Noncompliant Behavioral Trends

The last year and a half has seen a subtle decline in sand mining activity. For the most part this is due to the supply and demand of oil dictating its production necessity. What we can interpret from recent behavioral trends is that the industry has been very reckless as a result of Wisconsin's lax regulatory oversight and dated pollution standards. The data on noncompliance rates in Wisconsin, which was not released by the DNR, was consequentially published in two EPA State Review Reports. The first report assessed the DNR's performance for the 2008 fiscal year. According to the report, 235 out of 451 CAA facilities were determined to be in noncompliance for that year, making a 54.5% noncompliance rate. The report also lists that only 40.6% of non-major CWA facilities with WPDES permits (including concentrated animal feeding operations) were in noncompliance at the time. Both of these noncompliance rates are considered acceptable under federal standards. However, the latest State Review Report shows that the noncompliance rate for major CAA facilities increased to 63% by 2011 and an astonishing 97.7% for CWA facilities in the same year. The EPA also found that 87% of the large CAFO facilities they inspected between 2011 and 2012 were in noncompliance with federal regulations (EPA, 2011 & 2016c). The increasing noncompliance rates for air and water polluters also occurs during the years with the lowest amount of violation notices, thus exhibiting a negative relationship between pollution-prone behavior and permissive regulations. Furthermore, the decreased monitoring and enforcement actions suggest that the DNR is relying more on the Stepped Philosophy that polluters will self-regulate. In other words, fewer pollution permit holders are being monitored for violations and the ones in violation are getting away with it.

The EPA noted that the overall performance of the DNR was not sufficient to ensure federal standards. The report highlights that the DNR failed to complete accurate monitoring reports for permit holders as well as failing to follow through with enforcement actions for potential violations. Additionally, when the DNR amended the State Environmental Policy Act, numerous legal procedures that required public participation and transparency were also eliminated from pollution permit applications.

According to the new amendments, environmental impact assessments are also no longer necessary for minor pollution permits. The department must still notify the public and provide opportunities to comment on most applications, but without an environmental impact assessment there is no available background information on the possible cumulative impacts (Vanegeren, 2014a). In doing so, the DNR has fundamentally inhibited public input from the permitting process. Simultaneously, public participation for CAFO permits has been whittled down to only substantial management modifications. As of 2014, all amendments to nutrient management terms that the DNR considers not substantial may be made without any public comment (DNR, 2014a).

Looking at noncompliance rates for sand mining, trends appear to be consistent with the EPA's State Review. A report by the Land Stewardship Project analyzed the noncompliant behavior of sand mining operators since the proliferation of the industry first started. The organization found that by 2014, 51% of mines operating in Wisconsin had had serious violations (Porter, 2014). There were also nineteen incidences where companies had bypassed state regulations by sidestepping one county's zoning laws and annexing the prospected mining land from another. In another case, regulators had to shut down the Alpine Sand facility in Trempealeau Country after it was discovered that the 1,600-acre mine was operating without any permits and had been disposing its wastewater in an unlined pool equivalent to a man-dug hole. Considering the short-term financial gains a company can make however, the $80,000 fine Alpine Sand received from the Department of Justice for a clear violation would not necessarily deter other companies from noncompliance, especially if the compliance costs are more than the financial penalties for violations (Vanegeren, 2014b). Moreover, when sand prices were high, owners were making $100 per ton and exporting some 26 million tons per year, while the estimates put Wisconsin's producing capabilities at another 60 to 70 million tons per year. The potential profits were even enough to attract multinational corporations like Fairmount Minerals.

The health impacts from silica PM on an industrial scale are still not fully understood, but the latest report by the Trempealeau County Board of Health found sufficient evidence linking silica PM to resident respiratory health problems and pollution discharge impacts on groundwater quality (Miller, et al., 2014). For sand mining, the pollution impacts on the environment will therefore need to be re-examined when the state has more resources or the EPA steps in, to assess the accumulated impacts and make the appropriate legislative changes to cope with them. The evidence for pollution haven characteristics within the CAFO industry however, is even more compelling.

7.2 Pollution Growth and Complete Regulatory Failure

Pollution behavior among CAFOs worsened to a higher degree. As reported by the DNR, over one million gallons of animal generate waste was spilled in 2013 alone. The following year nearly two million more gallons were spilled. One of the farms responsible, the Arlington Agricultural Research Station, had previously dumped 50,000 gallons of liquid waste in five different spills since 2007 (Bergquist, 2013). Another CAFO spilled 600,000 gallons of liquid manure in Marathon County. But the fine the operator received was only $464, or in other words, less than a penny per gallon (Bergquist, 2014). While the DNR was issuing the WPDES permits, the University of Wisconsin’s Department of Agriculture was testing the groundwater supply after multiple reports of contaminated wells by state residents. In Kewaunee County the Department of Agriculture found that one-third of the municipal wells had been contaminated with nitrates and coliform bacteria. Coincidentally, the county is home to approximately 100,000 cows and has the highest concentration of cows per acre in the state (Schuessler, 2015). It has furthermore been established that at least 90% of groundwater nitrate inputs originate from farming activities (DNR, 2015d). The tests also came back positive for salmonella and bovine viruses.

We can gauge the regulatory failure of the state to control CAFO pollution by looking at the percentage of NMPs per county. According to the DNR’s report on groundwater nitrates, we see that Kewaunee County had the highest percentage of NMPs (see Figure 15). This finding provides incriminating evidence that the DNR’s system of self-monitoring has utterly failed to prevent CAFO’s pollution impacts to the environment and human health.

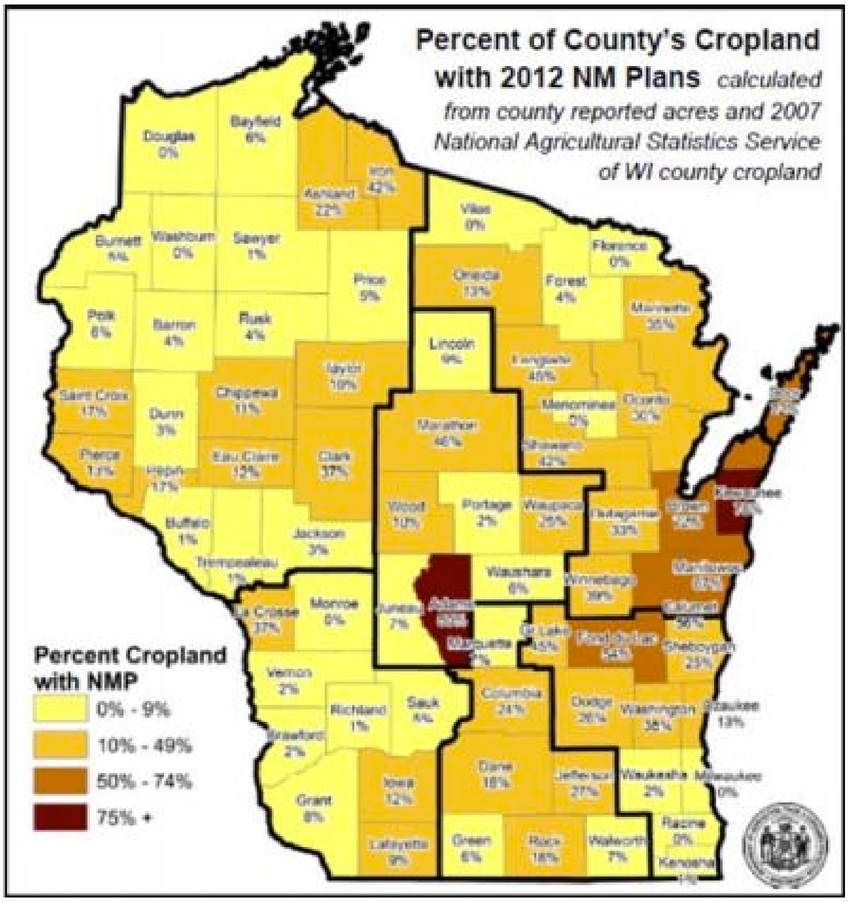


Figure 15: Percent of Cropland with Nutrient Management Plans in 2012 (DNR, 2015c)

The DNR's own Bureau of Water Quality (BWQ) published another eye-opening report on the water quality trends in Wisconsin in 2014. The Bureau compiled twenty year's worth of data from lake and river monitoring sites and found that the most severe impacts on Wisconsin's surface waters has been caused by high phosphorus concentrations. After testing over 6,000 lakes in the state, researchers discovered that more than half of the impaired lakes were a result of phosphorus pollution (see Figure 16). The high levels of phosphorus have led to Wisconsin blue-green algae problem, which has turned its habitable lakes into eutrophic dead zones depleted of oxygen. Phosphorus from fertilizers and manure attaches to soil particles where it can reside until it is utilized in plant growth, or, if there it has been over applied to soils, is carried to a nearby effluent runoff. Phosphorus, however, has been substantially decreased by improvements in waste water treatment techniques and restrictions on products like cleaning detergents. This can explain how the long-term level of phosphorus pollution has actually decreased. Compared to phosphorus though, the concentration of nitrogen in animal waste is significantly higher (see Table 8). The BWQ's report also found that nitrate concentrations rose in the majority of the long-term river stations tested, which they attributed to increased fertilizer use on crop fields (DNR, 2014b). A year after publishing the report, half of the senior scientist staff in the Bureau of Water was subsequently laid off. To explain the staff cuts, the Legislative Fiscal Bureau stated that the current executive administration believes, *"the science services positions no longer serve the core mission of the agency and should be deleted"* (Verburg, 2015). The DNR's own mentality towards environmental issues appears to be out of sync with mainstream scientific reason as well. As of 2015 state employees are no longer able to discuss controversial topics, like climate change, with the public after receiving a gag order from the head of the DNR (Roston, 2015).

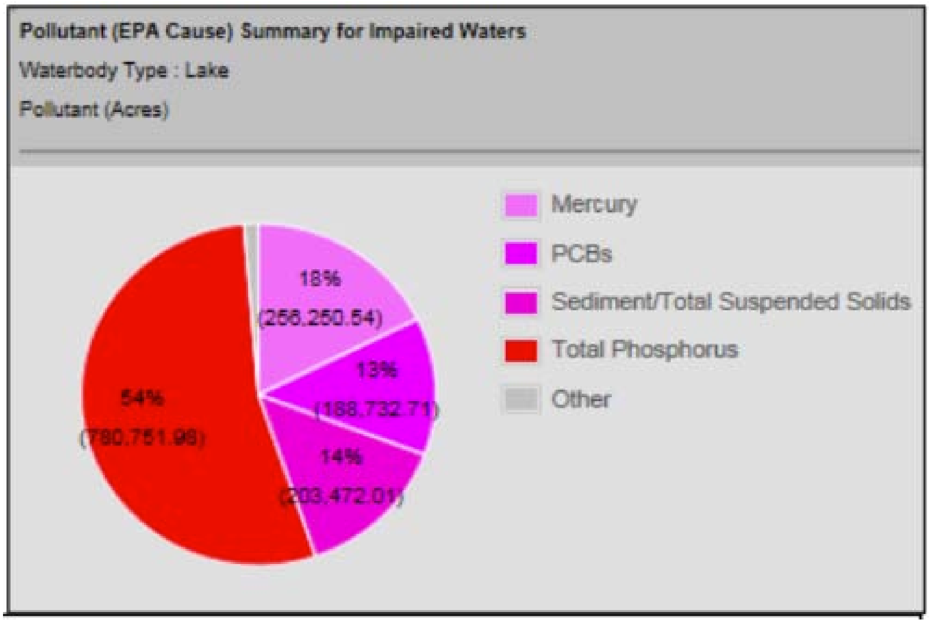


Figure 16: Impaired Lakes by Pollution Type (DNR, 2014b)

Another report from the Clean Wisconsin Organization found high concentrations of coal ash in several southeast counties' drinking systems. After analyzing the data of 967 tests performed on private wells, 45% of them came back positive with high concentrations of molybdenum leachates (Cook, Mathewson, and Nekola, 2014). This toxic material had been applied to farmlands by facilities operating under the DNR's disposal and reuse guidelines. The total amount of coal ash spread over the four counties consisted of almost one million tons.

7.3 Federal Intervention

Given the inactions of the DNR, the only way Wisconsin will be able to change its direction is by public involvement and increased federal oversight. This becomes predominantly clear considering the tools offered to the state by the EPA to comply with federal standards. The OECA, for example, provides states with the resources to achieve their CMS's, including assistance in enforcement processes; gathering evidence; documenting and monitoring permit and regulation compliance; and providing future strategies on environmental regulation development (EPA, 2014a). The fact that Wisconsin has not taken advantage of this offer in light of the growing pollution trends supports the argument that the DNR and state legislatures are intentionally allowing pollution levels to increase for economic purposes. At the moment, some progress is being made to counter the negligence of the DNR. A collective of environmental organizations in the Midwest are currently petitioning the EPA for an emergency action plan for the ground water contamination in Kewaunee County. Their plea not only requests a comprehensive environmental response, but also compensation and liability.

8 Conclusion

From the pre-existing indexes Wisconsin has shown a remarkable degree of environmental stringency prior to the 2008 recession. The results of the Levinson Index, however, are not entirely supportive of the state's initial strength. Due to the gaps in available data between *PACE Surveys*, the measure of regulatory strength by adjusted abatement costs should be considered inconclusive. Despite showing an increase from the 2001 Levinson Index, the adjusted abatement costs for 2005 only provide a glimpse of Wisconsin's stringency in one particular sector independent of other states. However, a recent statement by Wisconsin Chamber of Manufacturing and Commerce (WMC) shows that compliance costs are still very relevant for state manufacturers. Eric Bott, the WCM Director of Environmental and Energy Policy, explained that complying with Wisconsin's regulations costs manufacturers nearly $5 billion a year and can jeopardize thousands of jobs (WMC, 2015). From the other measures of stringency presented in this paper the following conclusions can be made in answer to the initial thesis question pose--whether Wisconsin's deviation from environmental stringency has fostered economic growth in pollution-intensive industries:

1) As a result of staff and budget cuts, the monitoring and enforcement efforts made by the DNR were significantly reduced;
2) Pollution-intensive industries, such as sand mining and CAFOs, grew as a result of physical advantages, but were evidently influenced by and influential in the state's environmental regulations;
3) The growth of these industries attracted a majority of out-of-state investors and created a higher rate of noncompliance and pollution-prone behavior.

The timing of Wisconsin's regressive transition to an industry-friendly state could not have come at a worse time. In order to meet the goals established by the 2015 Paris Agreement, as well as the progressive national standards set forth by the United States' Environmental Protection Agency, the incumbent administration has called upon individual states to develop their own strategies for implementation. If Wisconsin continues to neglect its regulatory duties to protect the environment and human health while other states act in accordance with the EPA's request, Wisconsin will indeed become a pollution haven.

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Appendices

Appendix 1: Green Index 1987 National Composite Scores (Hall and Kerr, 1991)

State	Soil Conser-vation	Ground water Control	Haz-ardos Waste	Solid Waste Mgmt	Energy Conser-vation	Summary of 17 Renew America Policies			Summary of 50 Green Index Policies			Composite Score For 67 Policies	
						Total Pts	% of 170	Rank	Total Pts	% of 50	Rank	Ave. %	Rank
Michigan	7	8	9	8	3	107	62.9	12	28	56.0	10	59.45	1
Minnesota	6	5	9	9	4	114	67.1	8	31	62.0	6	64.55	
Mississippi	3	2	4	2	2	47	27.6	49	15	30.0	34	28.80	4
Missouri	6	7	8	1	4	79	46.5	27	22	44.0	19	45.25	2
Montana	5	6	3	1	6	70	41.2	33	13	26.0	38	33.60	3
Nebraska	6	6	2	6	7	82	48.2	23	16	32.0	31	40.10	2
Nevada	6	4	2	2	7	56	32.9	43	12	24.0	44	28.45	4
New Hampshire	5	5	7	5	4	92	54.1	18	19	38.0	23	46.05	2
New Jersey	6	7	10	10	5	125	73.5	3	31	62.0	6	67.75	
New Mexico	2	8	5	1	6	61	35.9	40	14	28.0	36	31.95	3
New York	5	10	8	8	7	113	66.5	9	32	64.0	4	65.25	
North Carolina	7	8	6	6	7	111	65.3	10	24	48.0	16	56.65	1
North Dakota	3	4	2	3	3	61	35.9	39	12	24.0	44	29.95	4
Ohio	8	4	5	5	4	88	51.8	22	24	48.0	16	49.90	1
Oklahoma	5	5	4	7	3	65	38.2	37	13	26.0	38	32.10	3
Oregon	2	7	5	7	8	116	68.2	6	33	66.0	2	67.10	
Pennsylvania	6	5	5	3	5	91	53.5	20	21	42.0	21	47.75	2
Rhode Island	4	6	4	7	3	95	55.9	16	31	62.0	6	58.95	1
South Carolina	5	7	5	2	6	79	46.5	25	15	30.0	34	38.25	3
South Dakota	8	6	2	2	4	63	37.1	38	5	10.0	50	23.55	4
Tennessee	3	4	7	5	7	60	35.3	41	14	28.0	36	31.65	4
Texas	2	2	5	3	7	66	38.8	36	18	36.0	28	37.40	3
Utah	4	3	2	1	3	57	33.5	42	13	26.0	38	29.75	4
Vermont	3	5	6	4	7	91	53.5	19	28	56.0	10	54.75	1
Virginia	7	6	2	3	7	95	55.9	17	19	38.0	23	46.95	2
Washington	1	6	5	5	3	91	53.5	21	28	56.0	10	54.75	1
West Virginia	5	2	4	1	1	56	32.9	44	11	22.0	46	27.45	4
Wisconsin	8	8	7	8	9	131	77.1	2	29	58.0	9	67.55	
Wyoming	3	8	1	2	1	46	27.1	50	13	26.0	38	26.55	4
Alabama	3	2	3	3	2	53	31.2	46	10	20.0	47	25.60	4
Alaska	3	3	2	2	1	56	32.9	45	9	18.0	48	25.45	4
Arizona	3	7	5	2	3	72	42.4	32	13	26.0	38	34.20	3
Arkansas	3	2	5	3	4	48	28.2	48	9	18.0	48	23.10	5
California	3	7	9	9	10	134	78.8	1	38	76.0	1	77.40	
Colorado	6	4	3	4	3	75	44.1	30	19	38.0	23	41.05	2
Connecticut	6	9	4	9	7	117	68.8	5	32	64.0	4	66.40	
Delaware	8	6	3	4	2	78	45.9	29	17	34.0	30	39.95	2
Florida	4	9	8	6	7	114	67.1	7	25	50.0	15	58.55	1
Georgia	5	7	4	3	3	80	47.1	24	16	32.0	31	39.55	3
Hawaii	4	3	2	2	4	79	46.5	26	19	38.0	23	42.25	2
Idaho	1	6	1	2	6	68	40.0	34	13	26.0	38	33.00	3
Illinois	9	5	7	7	6	97	57.1	15	22	44.0	19	50.55	1
Indiana	5	4	6	7	8	79	46.5	28	20	40.0	22	43.25	2
Iowa	10	5	5	7	7	107	62.9	11	23	46.0	18	54.45	1
Kansas	5	8	8	4	2	74	43.5	31	18	36.0	28	39.75	2
Kentucky	3	1	6	8	3	66	38.8	35	16	32.0	31	35.40	3
Louisiana	3	3	7	2	1	52	30.6	47	19	38.0	23	34.30	3
Maine	6	7	6	6	8	101	59.4	13	33	66.0	2	62.70	
Maryland	8	7	6	6	4	101	59.4	14	26	52.0	14	55.70	1
Massachusetts	4	8	9	6	8	123	72.4	4	27	54.0	13	63.20	

Appendix 2.1 National Pollution Abatement Costs by Subsector, Pollution Type, and Control Activity [in millions of dollars] (USCB, 2008)

NAIC Code	Subsector	Total GDP Contribution*	Total	Activity			
				Treatment	Prevention	Recycling	Disposal
3133	All industries	1,704,173	20 677.6	10 762.8	3 599.4	1 748.3	4 567.0
311+							
312	Food+Beverage & tobacco product mfg	179,914	1,850.4	1,016.1	207.7	134.5	59.1
313+							47.0
314	Textile Mills & Textile product mills	20736	256	151.7	18.0	24.1	15.0
316	Leather & allied product mfg	13,860	51.2	29.1	5.1	3.5	13.5
321	Wood product mfg	34,865	566.6	310.3	128.3	31.3	96.7
322	Paper mfg	51,945	1 796.2	1 072.0	189.4	118.6	416.2
323	Printing & related support activities	44,649	238.8	111.6	35.9	35.5	55.8
324	Petroleum & coal products mfg	142,706	3 746.1	1 896.2	1 294.1	273.6	282.2
325	Chemical mfg	227,299	5 217.2	2 757.9	809.6	417.2	1 232.5
326	Plastics & rubber products mfg	63,543	503.2	214.0	79.4	50.2	159.6
327	Nonmetallic mineral product mfg	49,051	696.0	398.0	125.6	50.5	121.9
331	Primary metal mfg	56,636	2 291.1	1 238.3	273.2	219.3	560.4
332	Fabricated metal product mfg	122,936	763.3	353.1	84.1	92.4	233.8
333	Machinery mfg	114,887	315.8	108.4	49.8	34.3	123.2
334	Computer & electronic product mfg	211,046	623.8	338.4	54.5	63.9	167.0
335	Electrical equipment, appliance, & component mfg	43,247	190.8	80.8	28.6	20.7	60.7
336	Transportation equipment mfg	170,697	1 319.1	592.8	173.0	157.3	396.1
337	Furniture & related product mfg	33,783	133.0	50.8	26.4	9.4	46.5
339	Miscellaneous mfg	66,198	115.5	41.9	15.3	12.1	46.2

NAIC Code	Subsector	Media			Cost category				
		Air	Water	Solid waste	Labor	Energy	Materials and supplies	Contract work	Depreciation
3133	All industries	8 629.1	6 725.2	5 323.3	4 095.9	5 712.3	2 811.2	5 209.7	2 848.4
311	Food mfg	314.1	933.1	325.6	256.8	280.5	245.8	591.0	198.7
312	Beverage & tobacco product mfg	70.5	152.9	54.1	44.1	69.1	27.6	102.3	34.4
313	Textile mills	99.5	77.2	44.4	28.6	99.3	21.4	57.7	14.1
314	Textile product mills	6.6	13.6	14.7	7.4	3.7	4.5	17.1	2.2
316	Leather & allied product mfg	3.8	33.9	13.5	10.3	7.1	13.2	14.8	5.9
321	Wood product mfg	388.2	47.2	131.2	79.7	268.2	47.0	77.3	94.3
322	Paper mfg	571.7	757.9	466.6	289.6	357.6	328.4	475.5	345.0
323	Printing & related support activities	159.2	20.1	59.5	36.0	117.7	14.0	38.6	32.4
324	Petroleum & coal products mfg	2 522.2	754.9	469.0	616.0	1 423.2	511.7	716.1	479.1
325	Chemical mfg	1 697.5	1 986.2	1 533.4	1 111.5	1 307.3	764.8	1 225.6	807.9
326	Plastics & rubber products mfg	238.6	84.6	180.0	118.7	133.8	54.0	141.1	55.7
327	Nonmetallic mineral product mfg	483.0	76.4	136.6	134.8	226.0	93.4	128.3	113.5
331	Primary metal mfg	989.5	638.4	663.1	406.7	598.9	313.8	666.1	305.6
332	Fabricated metal product mfg	196.9	284.2	282.2	206.9	158.7	111.8	207.4	78.5
333	Machinery mfg	71.7	97.1	147.0	94.6	38.2	30.1	116.9	36.0
334	Computer & electronic product mfg	164.6	270.9	188.3	185.3	142.4	86.2	144.5	65.4
335	Electrical equipment, appliance, & component mfg	62.2	59.5	69.1	58.6	42.9	18.7	51.9	18.7
336	Transportation equipment mfg	484.8	394.6	439.7	338.7	377.1	102.5	360.7	140.2
337	Furniture & related product mfg	69.1	13.0	50.9	35.5	37.8	11.4	34.2	14.1
339	Miscellaneous mfg	33.8	28.1	53.6	35.1	21.8	10.2	41.9	6.6

Appendix 2.2:Wisconsin's Total Pollution Abatement Costs by Subsector and Control Activity [in millions of dollars] (USCB, 2008)

NAICS Code	State/Subsector	Total PAOC	Total GSP Contribution*	Activity			
				Treatment	Prevention	Recycling	Disposal
	Wisconsin	522.1	46,622	301.7	56.7	36.2	127.4
311 +312	Food + Beverage & tobacco product mfg	83.7	4,844	34.0	7.3	10.2	32.2
313	Textile mills	2.2	196	1.1	.6	.4	.2
316	Leather & allied product mfg	2.3	103	1.8	.1	(Z)	.4
321	Wood product mfg	22.5	1,424	15.4	4.2	.7	2.2
322	Paper mfg	166.1	4,718	126.5	11.1	6.2	22.4
323	Printing & related support activities	22.4	2,341	14.8	3.8	1.0	2.8
325	Chemical mfg	35.2	3,194	14.7	8.3	1.3	10.9
326	Plastics & rubber products mfg	20.4	2,596	9.0	2.1	2.5	6.8
327	Nonmetallic mineral product mfg	8.9	1,317	4.9	1.8	.5	1.7
331	Primary metal mfg	68.6	1,761	38.8	6.1	3.0	20.7
332	Fabricated metal product mfg	28.8	5,376	14.8	1.7	3.2	9.2
333	Machinery mfg	19.0	5,657	9.0	1.6	1.7	6.7
334	Computer & electronic product mfg	2.8	4,558	1.1	.4	.3	1.0
335	Electrical equipment, appliance, & component mfg	8.2	2,450	3.7	1.2	.6	2.7
336	Transportation equipment mfg	24.5	3,829	10.1	5.1	3.7	5.6
337	Furniture & related product mfg	3.3	953	1.4	.3	.3	1.3
339	Miscellaneous mfg	1.9	1,169	.3	.4	.6	.6

Appendix 3: Sand Mining Operations for In-State and Out-of-State Owners

2012						2015						
FACILITY_NAME	**Operator**	**Company Headquarters**	**Town/City/Village**	**Status (Municipal Permitting)**	**Facility Type**	**FACILITY_NAME**	**Operator**	**Company Headquarters**	**Town/City/Village**	**Status (Municipal Permitting)**	**Facility Type**	**#**
Rossa Sand Mine	(Dennis and Darlene Rossa)	Wisconsin	Arcadia	In Development	Mine	10K INTERNATIONAL BORK/BRAGGER PROPERTIES	10K International	Wisconsin	Tn of Burnside	Permitted	Mine/Processing	1
Bue Sand Mine	(Nelson Diesel and Dozing)	Wisconsin	Etterick	In Development	Mine	MIKL MINE	A&M Mikl Sands	Wisconsin	Tn of Auburn	Permitted	Mine/Processing	2
Suchla Pit	(Reglin and Hesch)	Wisconsin	Arcadia	Operational	Mine	KENDALL KLEVGARD PIT	Advanced Sand & Proppant, LLC	Wisconsin	Tn of Gilmanton	Permitted	Mine	3
10K International	10K International	Wisconsin	Arland	In Development	Mine	AF GELHAR CO INC - MARKESAN PLANT	AF Gelhar	Wisconsin	Tn of Mackford	Operational	Mine/Processing	4
10K International	10K International	Wisconsin	Burnside	In Development	Mine	AF GELHAR CO INC - MARKESAN PLANT	AF Gelhar	Wisconsin	Tn of Mackford	Operational	Rail	5
Mikl Mine	A & M Mikl Sands	Wisconsin	Auburn	Proposed	Mine and processing plant	AllEnergy Sand	AllEnergy Sand	Johnston, Iowa	Tn of Arcadia	Applied	Mine/Processing	6
AF Gelhar- Union	A.F. Gelhar Mining Co	Wisconsin	Union	Proposed	Mine and Processing Plant	ALLEN'S CRANBERRY LLC	Allen's Cranberry LLC	Wisconsin	Tn of Bear Bluff	Permitted	Mine	7
A.F. Gelhar	A.F. Gelhar Mining Co.	Wisconsin	Markesan	Operational	Mine and processing plant	ALPINE SAND, LLC - SOPPA PIT MINE	Alpine Materials Corp	Wisconsin	Tn of Arcadia	Operational	Mine/Processing	8
Allen Cranberry	Allen Cranberry	Wisconsin	BEAR BLUFF	Operational	Mine	BADGER MINING - FAIRWATER	Badger Mining	Wisconsin	Tn of Green Lake	Operational	Mine/Processing /Rail	9
Alpine Materials Soppa Pit	Alpine Materials	Wisconsin	Arcadia	Operational	Mine and processing plant	BADGER MINING CORP-ALMA CENTER PLANT	Badger Mining	Wisconsin	Tn of Alma	Operational	Mine/Processing /Rail	10
Arcadia Sands	Arcadia Sands (formerly Ottowa Sands LLC)	Wisconsin	Arcadia	Operational	Mine and processing plant	BADGER MINING CORP-TAYLOR PLANT	Badger Mining	Wisconsin	Tn of Curran	Operational	Mine/Processing /Rail	11
Atlas Resin	Atlas Resin	Wisconsin	Taylor	Operational	Resin coating facility and loadout	BADGER MINING CORP- RESIN PLANT	Badger Mining Corporation	Wisconsin	Tn of Alma	Operational	Resin Coating Facility	12
Hoesley Sand Mine	B&B Sands	Wisconsin	Dodge	In Development	Mine	BADGER MINING CORP- RESIN PLANT	Badger Mining Corporation	Wisconsin	Tn of Curran	Operational	Resin Coating Facility	13
Badger Mining	Badger Mining Corp	Wisconsin	Taylor	Operational	Mine and processing plant	WELTZIEN SAND MINE	Brant Valley Excavating	Winona, Minnesota	Tn of Arcadia	Applied	Mine	14
Badger Fairwater	Badger Mining Corp.	Wisconsin	Fairwater	Operational	Mine and processing plant	GUZA PIT	Cameron Rail / Superior Silica Sands	Winona, Minnesota/Fort worth, Texas	Tn of Acradia/City of Independence	Operational	Mine/Processing	15
Bechel	Bechel Sand & Gravel, LLC	Wisconsin	Frankfort	Operational	Mine	ROSSA SAND MINE	Canadian Silica	Calgary, Alberta Canada	Tn of Arcadia	Operational	Mine	16
Highway 10 plant	Bechel Sand & Gravel, LLC	Wisconsin	Union	In Development	Processing plant	CARBO CERAMICS INC - MARSHFIELD PLANT	Carbo Ceramics	Houston, Texas	City of Marshfield	Operational	Processing/Rail	17
Bethke	Bethke	Wisconsin	Cleveland	Rejected by county zoning	Mine	CARBO CERAMICS	Carbo Ceramics (Marawood Sand and Gravel)	Houston, Texas	Tn of Wood	Operational	Mine	18
Guza Pit	Brannt Valley Excavating	Winona, MN	Arcadia	Operational	Mine	CHIEFTAIN SAND - ANDERSON	Chieftain Sand and Proppant, LLC	Denver, Colorado	Tn of Dovre	Permitted	Mine	19
Weltzien Sand Mine	Brannt Valley Excavating	Winona, MN	Galesville	In Development	Mine	CHIEFTAIN SAND - LUCKEY	Chieftain Sand and Proppant, LLC	Denver, Colorado	Tn of Dovre	Operational	Mine/Processing	20
Buffalo White Sands	Buffalo White Sands	Wisconsin	Mondovi	In Development	Mine and processing plant	CHIEFTAIN SAND - POETSCH	Chieftain Sand and Proppant, LLC	Denver, Colorado	Tn of Dovre	Permitted	Mine	21
Callaway	Callaway	Wisconsin	Bear Bluff	In Development	Mine	CHIEFTAIN SAND AND PROPPANT, LLC	Chieftain Sand and Proppant, LLC	Denver, Colorado	Tn of Dovre	Operational	Processing/Rail	22
Canadian Sand and Proppants	Canadian Sand and Proppants	Calgary, Alberta Canada	Sumner	In Development	Mine and processing plant	CHIPPEWA SAND COMPANY	Chippewa Sand Company	Wisconsin	Tn of Auburn	Operational	Processing/Rail	23
Carbo Ceramics	Carbo Ceramics	Houston, Texas	Marshfield	Operational	Processing plant	CHIPPEWA SAND COMPANY - BUCHNER MINE	Chippewa Sand Company	Wisconsin	Tn of Cooks Valley	Operational	Mine/Processing	24
Barron Sand Plant	Carmeuse Industrial Sands	Pittsburgh, Pennsylvania	Arland	Proposed	Mine and processing plant	COMPLETION INDUSTRIAL MINERALS (PANKRATZ	Completion Industrial Minerals (Pankratz	Wisconsin	Tn of Rock	Operational	Mine	25
Chieftain Sand and Proppants	Chieftan Sand	Denver, Colorado	Dovre	Proposed	Mine and processing plant	COMPLETION INDUSTRIAL MINERALS	Completion Industrial Minerals	Wisconsin	Tn of Wood	Operational	Mine	26

Buchner/Robinson Mine	Chippewa Sands Company	Wisconsin	Cooks Valley	Operational	Mine and processing plant	COMPLETION INDUSTRIAL MINERALS LLC	Completional Industrial Minerals	Wisconsin	City of Marshfield	Operational	Processing/Rail	27
Chippewa Sands Company PP	Chippewa Sands Company	Wisconsin	New Auburn	Operational	Processing plant	COULEE FRAC SAND	Coulee Frac Sand LLC	Wisconsin	Tn of Alma	Operational	Mine	28
Completion Industrial Minerals	Completion Industrial Minerals	Wisconsin	Marshfield	Operational	Processing plant	DKS STANTON MINE	DKS Construction Services	Wisconsin	Tn of Stanton	Reclamation In Progress	Mine	29
Copper Creek	Copper Road Minerals LLC	W isconsin	Byron	Proposal tabled while company waits for information from	Mine	DOINE EXCAVATING	Doine Excavating	Wisconsin	Tn of Richfield	Operational	Mine	30
Facility Name	Corporate Owner	Corporate Headquaters	Community	Operation Status	Facility Type	RIHN MINE	DRT SANDS	Wisconsin	Town of Auburn	Permitted	Mine	31
Coulee Frac	Coulee Frac LLC	W isconsin	Franklin	Rejected by town	Mine	EOG RESOURCES INC (DD Mine)	EOG Resources, Inc	Houston, Texas	Tn of Arland	Permitted	Mine	32
Curran-Houser	Curran-Houser LLC	W isconsin	Albion/Adams	Proposed	Mine	EOG RESOURCES, INC.	EOG Resources, Inc	Houston, Texas	Tn of Eagle Point	Operational	Processing/Rail	33
EOG	EOG Resources	Houston, Texas	Chippewa Falls	Operational	Processing plant	FAIRMOUNT SANTROL - READFIELD	Fairmount Sandtrol	Chardon, Ohio	Tn of Readfield	Operational	Processing/Rail	34
EOG DS Mine	EOG resources	Houston, Texas	Cooks Valley	Operational	Mine	FAIRMOUNT SANTROL	Fairmount Santrol	Chardon, Ohio	City of Menomonie	Operational	Mine	35
EOG Resources	EOG Resources	Houston, Texas	Arland	In Development	Mine and processing plant	FAIRMOUNT SANTROL	Fairmount Santrol	Chardon, Ohio	Tn of Hay River	Operational	Rail	36
EOG S&S	EOG Resources	Houston, Texas	Howard	Operational	Mine	DIAMOND BLUFF INDUSTRIAL SAND	Fairmount Santrol	Chardon, Ohio	Hager City	Permitted	Processing/Rail	37
Wisconsin Industrial Sand Company	Fairmount Minerals	Chardon, OH	Menomonie	Operational	Mine and processing plant	WISCONSIN INDUSTRIAL SAND (BAY CITY MINE -	Fairmount Santrol	Chardon, Ohio	Tn of Trenton	Operational	Processing/Rail	38
Wisconsin Industrial Sands	Fairmount Minerals	Chardon, OH	Maiden Rock	Operational	Mine (underground) and PP	WISCONSIN INDUSTRIAL SAND (BAY CITY MINE)	Fairmount Santrol	Chardon, Ohio	Tn of Isabelle	Operational	Mine	39
Wisconsin Industrial Sands	Fairmount Minerals	Chardon, OH	Trenton	In development	Processing Plant	WISCONSIN INDUSTRIAL SAND (DIAMOND	Fairmount Santrol	Chardon, Ohio	Tn of Diamond Bluff	Permitted	Mine/Processing	40
Wisconsin Industrial Sands (Bay City Mine)	Fairmount Minerals	Chardon, OH	Hager City	Operational	Processing plant	WISCONSIN INDUSTRIAL SAND LLC	Fairmount Santrol	Chardon, Ohio	Tn of Maiden Rock	Operational	Mine/Processing /Rail	41
Wisconsin Industrial Sands (Bay City Mine)	Fairmount Minerals	Chardon, OH	Bay City	Operational	Mine (underground) and PP	FAIRMOUNT SANTROL	Fairmount Santrol	Chardon, Ohio	Tn of Arcadia	Applied	Mine/Processing	42
Wisconsin Industrial Sands (Diamond Bluff)	Fairmount Minerals	Chardon, OH	Diamond Bluff	In Development	Mine (underground)	BRIDGE CREEK MINE	Five Star Properties, LLC	Pelham, Alabama	Tn of Bridge Creek	Operational	Mine	43
Five Star Properties	Five Star Properties	Pelham, AL	Augusta	Proposed	Mine	R AND J ROLLING ACRES, LLP	Glacier Sands	Wisconsin	Tn of Gilmanton	Permitted	Mine/Processing	44
Proppant Specialists	FTS International	Brady, TX	Readfield	Operational	Processing plant	GREAT NORTHERN SAND LLC	Great Northern Sand	Dallas, Texas	Tn of Dovre	Operational	Dryer/Processing /Rail	45
Proppant Specialists	FTSI	Brady, TX	Tomah	Operational	Processing plant	GREAT NORTHERN SAND LLC	Great Northern Sand	Dallas, Texas	Tn of Dovre	Operational	Mine	46
Proppant Specialists	FTSI	Brady, TX	Arcadia	In Development	Mine and processing plant	RICHARDSON QUARRY	Greg Bechel Trucking & Excavating LLC	Wisconsin	Tn of Frankfort	Operational	Mine	47
Larson/Stanton/Johnson	Glacier Sands	Wisconsin	Mondovi	In Development	Mine	CHOPPER FARMS	HANSEN SAND PRODUCTS, LLC	Wisconsin	Tn of Hansen	Operational	Mine	48
R & J Rolling Acres, LLP	Glacier Sands	Wisconsin	Gilmanton	In Development	Mine and processing plant	HI-CRUSH PROPPANTS LLC - WYVILLE	Hi Crush Operating LLC	Houston, Texas	Tn of Byron	Operational	Mine/Processing /Rail	49
Seven Sands, LLC	Glacier Sands	Wisconsin	Montana	Rejected by county	Mine and processing plant	HI CRUSH PROPPANTS LLC	Hi Crush Proppants LLC	Houston, Texas	Tn of Bridge Creek	Operational	Mine/Processing	50
Starkey Dry Plant and Rail Loading	Glacier Sands	Wisconsin	Cochrane	Rejected by county	Processing plant	HI CRUSH PROPPANTS LLC	Hi Crush Proppants LLC	Houston, Texas	City of Augusta	Operational	Mine/Processing /Rail	51
Goose Landing Sand	Goose Landing Sand LLC	Wisconsin	Alma	In development	Mine and Processing Plant	HI-CRUSH BLAIR LLC	Hi-Crush Blair LLC	Houston, Texas	Tn of Springfield	Permitted	Mine	52
Great Northern Sand Mine	Great Northern Sand	Dallas, TX	Dovre	In Development	Mine and processing plant	HI CRUSH WHITEHALL	Hi-Crush Proppants LLC	Houston, Texas	City of Independence & Tn Whitehall	Operational	Mine/Processing /Rail	53

Gregory Weber	Gregory Weber	Wisconsin	Dover	In Development	Mine	MARTINSON MINE	High Country Sand, LLC	Winona, Minnesota	Tn of Otter Creek	Permitted	Mine	54
Hi Crush Proppants	Hi Crush Proppants	Houston, TX	Wyeville	Operational	Mine and processing plant	HUNGRY RUN CRANBERRY	Hungry Run Cranberry	Wisconsin	Tn of Lincoln	Operational	Mine	55
Hi Crush Proppants	Hi Crush Proppants	Houston, TX	Oakdale	Operational	Mine and processing plant	JEFF IGNATOWSKI MINE	Jeff Ignatowski	Wisconsin	Tn of Cary	Operational	Mine	56
Hi Crush Augusta	Hi Crush Proppants LLC	Houston, TX	Augusta	In Development	Mine and processing plant	COMPLETION INDUSTRIAL MINERALS LLC	JS Weiler Leasing	Wisconsin	Tn of Auburndale	Operational	Mine	57
High County Sand	High County Sand LLC	Winona, MN	Otter Creek	Proposed	Mine	KAW VALLEY - SONSALLA/ PRONSCHINSKE MINE	KAW Valley Companies, Inc	Kansas City, Kansas	Tn of Arcadia	Operational	Mine/Processing	58
Hungry Run Cranberry Cranberry	Hungry Run Cranberry Cranberry	Wisconsin	Warrens	Operational	Mine	KRAEMER COMPANY - TWESME TWESME QUARRY	Kraemer Company Company	Wisconsin	Tn of Preston	Operational	Mine/Processing	59
Interstate Energy Partners Partners	Interstate Energy Partners Partners	Plymouth, MN	Grantsburg, WI	Operational	Mine and processing plant processing plant	KRAEMER COMPANY - WHISTLER'S WHISTLER'S PASS QUARRY	Kramer Company Company	Wisconsin	Tn of Dodge	Operational	Mine	60
Jackson Sand	Jackson Sand	W isconsin	Taylor	Permitted	Mine and processing plant	LEGACY BOGS - 1	Legacy Bogs - 1	Wisconsin	Tn of Bear Bluff	Released	Mine	61
Swanson	K Frac LLC	W isconsin	Blair	In Development	Mine	PANTHER CREEK SAND, LLC	Manly Brothers	Troy Grove, Illinois	Tn of York	Operational	Mine	62
Kendell Klevgard	Kendell Klevgard	W isconsin	Gilmanton	In Development	Mine	MARAWOOD SAND AND GRAVEL	Marawood Sand and Gravel 200, LLC	Wisconsin	Tn of York	Operational	Mine	63
Twesme Quarry	Kraemer Company	W isconsin	Preston	In Development	Mine	BUE SAND MINE	Mark Nelson - Nelson Materials, LLC	Wisconsin	Tn of Ettrick	Operational	Mine	64
Whistle Pass Quarry	Kraemer Company	W isconsin	Dodge	Operational	Mine	BLACK CREEK LIMESTONE CO	MCC, Inc	Wisconsin	Tn of Hortonia	Operational	Mine	65
Legacy Bogs 1	Legacy Bogs	W isconsin	Bear Bluff	Operational	Mine and processing plant	MCNAULTY PIT #120	Milestone Materials (Mathy Construction Co)	Wisconsin	Tn of Irving	Operational	Mine/Processing	66
Legacy Bogs 2	Legacy Bogs	W isconsin	Bear Bluff	Operational	Mine	MURPHY PIT	Milestone Materials (Mathy Construction Co)	Wisconsin	Tn of Brockway	Operational	Mine/Processing	67
Legacy Bogs 3	Legacy Bogs	W isconsin	Bear Bluff	In Development	Mine and processing plant	MILESTONE MATERIALS - CATARACT GREEN PIT #184	Milestone Materials (Mathy Construction Co)	Wisconsin	Tn of Little Falls	Applied	Mine/Processing	68
Marawood Sand and Gravel	Marawood Sand and Gravel	W isconsin	York	Operational	Mine	MILESTONE MATERIALS - WILSON QUARRY #384	Milestone Materials (Mathy Construction Co)	Wisconsin	Tn of Springfield	Operational	Mine	69
Mathy/Milestone	Mathy/Milestone	W isconsin	Springfield	Operational	Mine	ARCADIA SAND CO	Mississippi Sand LLC	Kirkwood, Missouri	City of Arcadia	Operational	Mine/Processing	70
Midwest Frac	Midwest Frac LLC	W isconsin	Arland	In Development	Mine and processing plant	HIGHWAY 10 SAND PROCESSING PLANT	Muskie Proppant, LLC	Wisconsin	Tn of Union	Operational	Processing	71
Muskie Proppant	Muskie Proppant LLC	W isconsin	Eau Claire	Rejected	Processing Plant and Rail Load-out	NORTHERN INDUSTRIAL SANDS - FRY HILL MINE	Northern Industrial Sands	Wayzata, Minnesota	Tn of Sioux Creek	Permitted	Mine	72
Slaby Pit	North Creek Sands LLC	W isconsin	Arcadia	Operational	Mine	NORTHERN RAIL AND TRANSLOAD	Northern Rail and Transload	Wayzata, Minnesota	Tn of Dovre	Permitted	Process/Rail	73
Northern Frac Sand	Northern Frac Sand	W isconsin	Wisconsin Rapids	In Development	Processing plant	OPELT SAND & GRAVEL	Opelt Sand & Gravel	Wisconsin	Tn of Levis	Operational	Mine/Processing	74
Panther Creek	Panther Creek	W isconsin	Marshfield	Operational	Processing plant	PANTHER CREEK SAND, INC - MARSHFIELD	Panther Creek Sand, Inc.	Wisconsin	City of Marshfield	Operational	Processing/Rail	75
Panther Creek	Panther Creek Sand, LLC, operated by Manly Bros	W isconsin	Neillsville	Operational	Mine and processing plant	SEGERSTROM MINE	Paramount Sand	Wisconsin	Tn of Unity	Permitted	Mine/Processing	76
Sagerstrom	Paramount Sand	W isconsin	Strum	In Development	Mine and processing plant	PATTISON PRAIRIE DU CHIEN RAIL LOAD-OUT	Pattison Sand Company, LLC	Clayton, Iowa	City of Prairie du Chien	Operational	Rail	77
Pattison Sand Co.	Pattison Sand Co.	Clayton, IA	Bridgeport	Proposed	Mine and Processing Plant	PATTISON SAND COMPANY - BRIDGEPORT MINE	Pattison Sand Company, LLC	Clayton, Iowa	Tn of Bridgeport	Operational	Mine/Processing	78
Hwy 64 Mine	Preferred Sands	Radnor, PA	Auburn	In Development	Mine	AUBURN MINE	Preferred Sands	Radnor, Pennsylvania	Tn of Auburn	Permitted	Mine/Processing	79
LeGesse Mine	Preferred Sands	Radnor, PA	Cooks Valley	Operational	Mine	LAGESSE MINE	Preferred Sands	Radnor, Pennsylvania	Tn of Cooks Valley	Operational	Mine/Processing	80
Preferred Sands	Preferred Sands	Radnor, PA	Blair	Operational	Mine and processing plant	PREFERRED SANDS	Preferred Sands	Radnor, Pennsylvania	Tn of Bloomer	Permitted	Process/Rail	81

Preferred Sands PP	Preferred Sands	Radnor, PA	Bloomer	Operational	Processing plant	ROGGE MINE	Preferred Sands	Radnor, Pennsylvania	Tn of Cooks Valley	Permitted	Mine	82
Rogge Mine	Preferred Sands	Radnor, PA	Cooks Valley	In Development	Mine	PREFERRED SANDS OF WISCONSIN, LLC BLAIR	Preferred Sands of Wisconsin LLC	Radnor, Pennsylvania	City of Blair	Operational	Mine/Processing /Rail	83
Q-Rail Spur	Q-Rail Spur LLC (rail facility for Taylor Frac LLC)	Wisconsin	Blair	Proposed?	Rail Load-Out	PTL PROP SOLUTIONS - AVON TERRITORY	PTL Prop Solutions	Oklahoma City, Oklahoma	Tn of Alma	Permitted	Processing	84
Quality Excavating	Quality Excavating	Wisconsin	Weston	Operational	Mine	PTL PROP SOLUTIONS - MEEK TERRITORY	PTL Prop Solutions	Oklahoma City, Oklahoma	Tn of Alma	Permitted	Mine/Processing	85
Soppa Sand Pit 2	Reglin and Hesch	Wisconsin	Arcadia	Operational	Mine	ROBERT NELSON	Robert Nelson	Wisconsin	Tn of Arland	Operational	Mine/Processing	86
Claude Rigelman	Rigleman	Wisconsin	Knapp	Operational	Mine	SAND PRODUCTS - BLAIR MINE	Sand Products of WI LLC	Msukegon, Michigan	City of Blair	Permitted	Mine/Processing /Rail	87
Chalsma Mine	Robert and Gretchen Chalsma	Wisconsin	Springfield	Proposed	Mine	RYAN BARTH - PLATTE VALLEY	Sand Technologies, LLC	Wisconsin	Tn of Buffalo	Operational	Mine/Processing	88
Robert Nelson	Robert Nelson	Wisconsin	Arland	Operational	Mine	SHADOWLAND HOLDINGS	Shadowland Operating LLC	Houston, Texas	Tn of Orange	Applied	Mine/Processing / Rail	89
Ryan Barth- Platts Valley	Ryan Barth	Wisconsin	Buffalo	In Development	Mine	PATZNER SAND PIT	Sierra Frac Sand	Tatum, Texas	Tn of Arcadia	Operational	Mine	90
Sand Tech (Barth land)	Sand Tech LLC	Watertown, MN	Chimney Rock	Rejected	Mine	Soppa Sand #2 (FINAL RECLAMATION IN PROGRESS)	Sierra Frac Sand	Tatum, Texas	Tn of Arcadia	Reclamation in Progress	Mine	91
Sandy Bruder	Sandy Bruder	W isconsin	Arland	In Development	Mine	SUCHLA PIT 2 (FINAL RECLAMATION IN PROGRESS)	Sierra Frac Sand	Tatum, Texas	Tn of Arcadia	Reclamation in Progress	Mine	92
Sandy Bruder	Sandy Bruder	W isconsin	Prairie Farm	In Development	Mine and processing plant	SIOUX CREEK SILICA	Sioux Creek Silica	Wisconsin	Tn of Sioux Creek	Permitted	Mine/Processing	93
Schneider	Schneider	W isconsin	Arcadia	Proposed	Mine	FAIRVIEW CRANBERRY COMPANY - HIXTON MINE	Smart Sand, Inc	Yardley, Pennsylvania	Tn of Curran	Operational	Mine/Processing /Rail	94
Patzner Sand Pit	Sierra Frac Sand LLC	Tatum, TX	Arcadia	Operational	Mine	FAIRVIEW CRANBERRY MINE - OAKDALE	Smart Sand, Inc	Yardley, Pennsylvania	Tn of Oakdale	Operational	Mine/Processing /Rail	95
Sioux Creek Silica	Sioux Creek Silica LLC	W isconsin	Sioux Creek	Proposed	Mine and processing plant	CSP SOURCE ENERGY SERVICES PROPPANTS LP	Source Energy Services Proppants LLP	Calgary, Alberta Canada	Tn of Sumner	Operational	Mine/Processing	96
Fairview/Smart Sand	Smart Sand	Yardley, PA	Oakdale	In Development	Mine and processing plant	SOURCE ENERGY SERVICES PROPPANTS LP - WEYERHAEUSER	Source Energy Services Proppants LLP	Calgary, Alberta Canada	Vg of Weyerheauser	Permitted	Processing/Rail	97
Smart Sand	Smart Sand Inc	Yardley, PA	Hixton	Proposed	Mine and Processing Plant	D95 NORTH SITE SPARTAN SAND, LLC (TENNESON)	Spartan Sand, LLC	Muskegon, Michigan	Tn of Preston	Permitted	Mine/Processing	98
South Alma Sand 1	South Alma Sand, LLC	W isconsin	Alma	In Development	Mine and processing plant	D95 SOUTH SITE - SPARTAN SAND, LLC (TENNESON)	Spartan Sand, LLC	Muskegon, Michigan	Tn of Preston	Permitted	Mine	99
South Alma Sand 2	South Alma Sand, LLC	W isconsin	Alma	In Development	Mine and processing plant	BUFFALO WHITE SANDS, LLC (Segerstrom)	Superior Sand Systems (Buffalo White Sands)	Fort Worth, Texas	Tn of Buffalo	Operational	Mine	100
Southern Precision Sands	Southern Precision Sands	Birmingham, AL	Bangor	In Development	Mine and processing plant	SUPERIOR SILICA SAND - ARLAND DRY PLANT	Superior Silica Sands	Fort Worth, Texas	Tn of Arland	Operational	Processing	101
Steve & Beth Segerstrom	Steve & Beth Segerstrom	W isconsin	Mondovi	In Development	Mine	SUPERIOR SILICA SAND - CHURCH RD MINE	Superior Silica Sands	Fort Worth, Texas	Tn of Arland	Operational	Mine/processing	102
Steve Stamm	Steve Stamm	W isconsin	Modena	In Development	Mine	SUPERIOR SILICA SAND - CHURCH RD MINE WET PLANT	Superior Silica Sands	Fort Worth, Texas	Tn of Arland	Permitted	Processing	103
Glaser Mine	Superior Silica Sands	Fort Worth, Texas	Auburn	Operational	Mine	SUPERIOR SILICA SAND - CLINTON DRY PLANT	Superior Silica Sands	Fort Worth, Texas	Tn of Clinton	Operational	Processing/Rail	104
Superior Silica Sands	Superior Silica Sands	Fort Worth, Texas	Clinton	Proposed	Mine	SUPERIOR SILICA SAND - LP MINE	Superior Silica Sands	Fort Worth, Texas	Tn of Arland	Permitted	Mine	105
Superior Silica Sands PP	Superior Silica Sands	Fort Worth, Texas	Clinton	In Development	Processing plant	SUPERIOR SILICA SANDS - FLS MINE	Superior Silica Sands	Fort Worth, Texas	Tn of Arland	Operational	Mine/Processing	106
Superior Silica Sands PP	Superior Silica Sands	Fort Worth, Texas	New Auburn	In Development	Processing plant	SUPERIOR SILICA SANDS - NEW AUBURN DRY PLANT	Superior Silica Sands	Fort Worth, Texas	Tn of Dovre	Operational	Processing/Rail	107
Swinney	T. Swinney	Dallas, TX	Cooks Valley	Proposed	Mine and Processing Plant	SUPERIOR SILICA SANDS - THOMPSON HILLS MINE	Superior Silica Sands	Fort Worth, Texas	Tn of Arland	Operational	Mine/Processing	108
Emberts Mine	Taylor Creek Transit	W isconsin	Auburn	Proposed	Mine	GLASER MINE	Superior Silica Sands	Fort Worth, Texas	Tn of Auburn	Operational	Mine/Processing	109
Taylor Frac	Taylor Frac	W isconsin	Taylor	In Development	Mine and processing plant	TAYLOR FRAC, LLC	Taylor Frac, LLC	Wisconsin	Tn of Springfield	Operational	Mine/Processing	110

Taylor Frac	Taylor Frac LLC	W isconsin	Preston	In Development	Rail load-out	SOUTH RIVER ROAD Trans	Taylor Frac, LLC	Wisconsin	Tn of Preston	Operational	Rail	111
Bear Creek Cranberry	Tim Shaw	W isconsin	Oakdale	In Development	Mine and processing plant	TEA SAND PROP COMPANY	Tea Sand Proppant Company	Wisconsin	Tn of Arland	Permitted	Mine	112
U.S. Silica (Grant?)	U.S. Silica	Frederick, MD	Grant	Proposed	Mine and Processing Plant	DS MINE	The Kraemer Co / EOG Resources, Inc.	Wisconsin/Houston, Texas	Tn of Cooks Valley	Operational	Mine	113
U.S. Silica Sparta	U.S. Silica	Frederick, MD	Sparta	In Development	Mine and processing plant	S & S MINE	The Kraemer Co / EOG Resources, Inc.	Wisconsin/Houston, Texas	Tn of Howard	Operational	Mine	114
Unimin	Unimin	New Canaan, CT	Portage	Operational	Mine and processing plant	BARTON SAND AND GRAVEL CO. - GRANTSBURG (Interstate	Tiller Corporation	Plymouth, Minnesota	Tn of Grantsburg	Operational	Mine/Processing	115
Unimin	Unimin	New Canaan, CT	Tunnel City	Operational	Mine and processing plant	US SILICA - FAIRCHILD	U.S. Silica Company	Frederick, Maryland	Tn of Fairchild	Applied	Mine/Processing /Rail	116
Vista Sand	Vista Sand	Granbury, TX	Menomenie	Proposed	Rail Load-Out	U.S. SILICA COMPANY - SPARTA FACILITY	U.S. Silica Company	Frederick, Maryland	City of Sparta	Operational	Mine/Processing /Rail	117
Vista Sand	Vista Sand	Granbury, TX	Glennwood	Proposed	Mine	UNIMIN CORPORATION	Unimin Corporation	New Canaan, Connecticut	Tn of Pacific	Operational	Mine/Processing /Rail	118
Boese Mine	Western Wisconsin Sand Company	W isconsin	Auburn	Operational	Mine and processing plant	UNIMIN CORPORATION - HIXTON	Unimin Corporation	New Canaan, Connecticut	Tn of Curran	Applied	Mine	119
						UNIMIN CORPORATION - TUNNEL CITY PLANT	Unimin Corporation	New Canaan, Connecticut	Tn of Greenfield	Operational	Mine/Processing /Rail	120
						WEICHELT TRUCKING	Weichelt Trucking	Wisconsin	Tn of Arpin	Operational	Mine	121
						BOESE MINE	Western Wisconsin Sand Company	Wisconsin	Tn of Auburn	Operational	Mine	122
						WHITE HAVEN SANDS	White Haven Sands, LLC	Wisconsin	Tn of Bloomer	Applied	Process/Rail	123
						WISCONSIN PROPPANTS	Wisconsin Proppants, LLC	Wisconsin	Tn of Mentor	Operational	Processing/Rail	124
						WISCONSIN PROPPANTS - WEST HIXTON	Wisconsin Proppants, LLC	Wisconsin	Tn of Curran	Operational	Mine	125
						BEAR CREEK CRANBERRY	Wisconsin White Sand, LLC	Wisconsin	Tn of Oakdale	Operational	Mine/Processing	126
						WISCONSIN WHITE SAND, LLC - OAKDALE	Wisconsin White Sand, LLC	Wisconsin	Tn of Byron	Operational	Processing/Rail	127