The Impact of Fracking on Freight Distribution Patterns

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16. Abstract

The increasing production of domestic energy through the use of fracking will likely alter local/regional/national economies and corresponding freight distribution patterns (highway, rail, marine, pipeline) in the United States. The proposed project will assess the impact of fracking on freight transportation demand and corresponding distribution patterns, for the purpose of identifying where the system is or will become overly stressed (in addition to identifying where excess capacity has been created due to shifts in freight transportation patterns). This will be achieved by deploying a methodology in which multiple future scenarios are defined in terms of fracking activity and energy consumption, each scenario is analyzed according to the resulting freight distribution across modal networks using a routing tool developed under a prior National Center for Freight & Infrastructure Research & Education (CFIRE) initiative, and the results evaluated according to specific performance measures.

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The Impact of Fracking on Highway Infrastructure

FINAL REPORT

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1. Introduction

The increasing production of domestic oil and gas production through the use of fracking (also known as “fracing”) places additional freight traffic on our nation’s highway system, oftentimes using roadways that were not originally designed for these volumes and associated loads. Consequently, concern has been expressed as to the damage to highway infrastructure that can be caused by fracking activity, as well as who should be responsible for roadway maintenance and repair. This is a particularly acute problem in rural communities, where the majority of fracking activity is taking place, roadways are not typically built to heavy haul standards, and jurisdictions are often manpower and financially constrained in overseeing management of the process.

The objective of this project was to investigate this consideration by reviewing logistical, safety and infrastructure challenges associated with evaluating the impact of domestic oil and gas production in the U.S.; and identifying data sources available to profile the level of past, current and anticipated fracking activity in various geographical regions. Utilizing this information, a methodology to assess the impacts to highway infrastructure was developed and applied in a case study using the Tuscaloosa Marine Shale Oil Play in Mississippi.

The project was led by Vanderbilt University, in collaboration with the University of Southern Mississippi and the University of Alabama at Huntsville. The authors would like to acknowledge financial support from the National Center for Freight & Infrastructure Research and Education (CFIRE), a consortium of University Transportation Centers funded in part by the U.S. Department of Transportation (USDOT), as well as the participation of the many individuals whose feedback was solicited through the conduct of interviews and surveys. The views expressed in this paper are solely those of the authors and do not reflect the opinions or conclusions of CFIRE, USDOT, Vanderbilt University, the University of Southern Mississippi or the University of Alabama at Huntsville.

The remainder of this report is divided into three sections, corresponding to topical areas related to the overall project objective, and which were the subject of focused research investigation and development. The narrative in each case is in the form of a white paper, which can be extracted for use in a stand-alone capacity.

2. Evaluating the Impact of Domestic Oil and Gas Development on the U.S. Transportation Sector: A Review of the Logistical, Safety and Infrastructure Challenges

Introduction

Since approximately 2005, the U.S. has experienced an unprecedented boom in domestic oil and gas production. In 2014 the U.S. averaged 8,721,000 barrels of crude oil per day, nearly reaching the historical peak production of 9,637,000 per day in 1970 (USEIA, 2015a) and representing the largest annual growth rate ever (USEIA 2015d). Also in 2014, the U.S. natural gas marketed production (which excludes gas that is flared or vented) exceeded 27 trillion cubic feet, surpassing the 1973 record of approximately 22.6 trillion cubic feet (USEIA 2015b). This increase in domestic gas production has caused net imports of natural gas to fall from around 3.7 trillion cubic feet in 2007 to record lows of less than 1.3 trillion cubic feet in 2014 (USEIA 2015e). This peak production has since waned, but is expected to be achieved again if oil prices rebound to above $80 per barrel (Bellamy, 2015).

These dramatic changes in oil and gas production have been driven by advances in two old technologies: 1) hydraulic fracturing and 2) horizontal drilling. Together, advances in these technologies have made it economical to produce oil or gas from ‘tight’ formations (where the oil or gas is trapped in impermeable rock layers), where previously it could not be profitably extracted. Consequently, domestic production of shale/tight oil has expanded from 0.34 million barrels per day in 2007 to 4.2 million barrels per day in 2014, and is now estimated to constitute 49% of total domestic crude oil production (USEIA, 2015c). Shale gas experienced a nearly six fold growth from 2 trillion cubic feet in 2007 to 11.4 trillion cubic feet in 2014 (see Figure 1) and is responsible for the sharp decline in imports noted above. Indeed, it is the technological advances associated with fracing and horizontal drilling that reversed the generally downward trend of domestic oil and gas production that had been in place since the peak of the 1970s production.

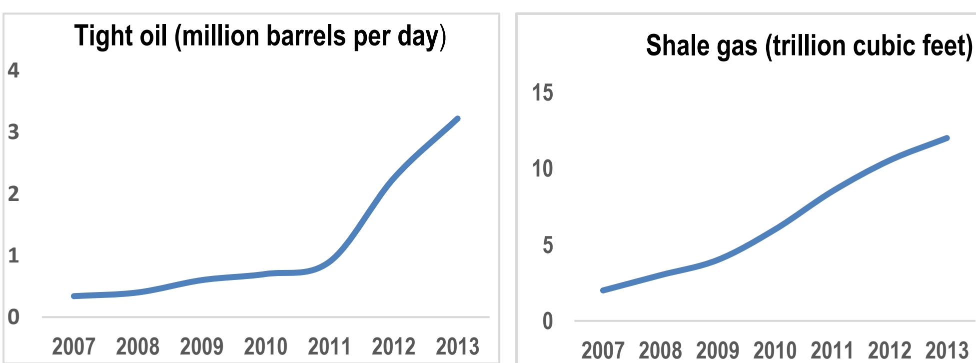


Figure 1. Increased Oil and Gas Production from Hydraulic Fracturing

Source: Energy Information Administration (EIA). *According to EIA, tight oil is oil found within low permeability reservoirs and includes, though not limited to, shale oil. However, EIA data with regards to shale oil is provided as aggregate of tight oil.*

This rapid increase in production places substantial demands on the nation's transportation infrastructure. Gas and oil wells are often located in rural areas, and supplies to drill, construct, and hydraulically fracture the well must ultimately be trucked to the site, even if other modes of transportation are available to move these materials closer to the well site from their origin, which can often be hundreds or even thousands of miles away. If gathering pipelines are not available at the well site, water and oil must be trucked off the site to the next distribution or disposal point. The impact on local roads, bridges, and communities is particularly high in areas where oil and gas development is either relatively new, or where the previous production volumes were low or infrastructure was not designed for, nor accustomed to, the weight or volume of the heavy truck traffic necessary to support the new development.

Many analysts have raised concerns regarding the adequacy of the current transportation infrastructure to meet the challenges posed by the resumption of the oil and gas boom. The general consensus appears to be that some areas of the country are facing significant strains on transportation infrastructure, especially in cities and towns that are at the center of new shale/tight oil and gas plays. More effective planning is likely needed to adequately respond to the transportation challenge and to assure that the U.S. will continue to be able to efficiently transport domestic oil and gas to a national and international market. This calls for a better understanding of the impacts of oil and gas development on transportation infrastructure.

Despite the general recognition of the need for planning to respond to the transportation challenge, few tools exist to facilitate this activity. While detailed studies have recently been conducted that focus on the impact of oil and gas development on roads, there is a paucity of tools that consider the other affected modes of transportation. It is likely that the efficiency and safety of transporting oil and gas can be greatly enhanced if effective use is made of all available transportation modes, and if systems are developed to tap potential synergies between these modes. For example, to reduce the number of oil and gas related trucks on roads, it has been suggested that greater reliance could be placed on pipelines and/or barges to transport wastewater that results from the hydraulic fracturing process (Boske, et. al. 2014; Nicholson, 2013). Analysts have also argued that delayed approval of new pipeline construction increases the transportation of oil and gas by modes, such as truck, which may pose increased safety concerns as compared to pipeline (Klass & Meinhardt, 2014; Nicholson, 2014). This highlights the importance of a more synergistic appreciation of the multi-modal nature of oil and gas transportation, and the factors that play a role in shaping which modes of transportation are available or constrained, and which are ultimately selected.

This paper presents a literature review of work undertaken to better understand the impacts to transportation infrastructure from oil and gas development, especially with respect to areas experiencing new or rapid expansion of production. This review includes studies performed by impacted communities, as well as a national synthesis of best practices to address these issues that was recently conducted by the National Cooperative Highway Research Program. Future research needs are also identified.

Logistics and Safety Challenges

There is widespread consensus in the literature that the oil and gas boom has created logistics and safety concerns on national and regional freight transportation systems. This section briefly reviews the literature addressing these challenges.

Logistics Challenges at the National Level

Transportation challenges highlighted at the national level include: 1) insufficiency of the pipeline network, 2) flaring of the natural gas because of a lack of gas pipelines in new oil producing regions, 3) exponential growth of crude oil transported by rail and the attendant safety concerns, and 4) a shortage of truck drivers. Interestingly, these four challenges all can be related to the lack of pipeline sufficiency with respect to capacity (mileage and volume) and geographical availability.

Pipeline Insufficiency

Traditionally, pipelines have been the primary means of transporting crude oil and gas in the U.S. (see Klass & Meinhardt, 2014, for a good discussion of this historical development). Indeed, pipelines and ocean vessels account for roughly 90% of all crude oil shipments to U.S. refineries (Congressional Research Service, 2014a). However, with expanded production occurring at a particularly fast pace and in new producing areas, a deficit in pipeline infrastructure has emerged despite pipeline operators' efforts to expand the network in response to the increase in production (CRS, 2014b; Association of American Railroads, 2013; United States Government Accountability Office (GAO), 2014; Maring & Mintz, 2014; Smith, 2013; Scholle, 2015). The Interstate Natural Gas Association of America (INGAA) estimates that to meet the current and future needs of the fast growing domestic gas production, about $14 billion per year through 2035 would need to be invested on the transportation of natural gas; however, this figure goes beyond pipelines and includes "new mainlines, natural gas storage fields, laterals to/from storage, power plants and processing facilities, gas lease equipment, processing facilities, and LNG export facilities" (ICF, 2014b, p.14). Production of Natural Gas Liquids (NGLs) (the propane, ethane, and certain other constituents occurring in natural gas) is also expected to increase significantly (ICF, 2014b). NGLs are major feedstocks for the petrochemical industry and have other industrial and energy uses. (ICF, 2014b). The transmission capability for NGL is particularly deficient since little infrastructure has been developed and an estimated 12,000 to 15,000 miles of NGL pipelines are needed (McCarty *et al*., 2015). INGAA reports that $1.3 billion per year through 2035 are likely needed to sufficiently expand the NGL pipeline network (ICF, 2014b).

Generally, the most visible impact of pipeline insufficiency has been increasing reliance on other modes of transportation such as barges, trucks, and rail. These modes are generally less safe than pipelines and, before the dramatic increase in oil and gas production, were only marginally involved in the transportation of crude oil or natural gas. However, the cost efficiency of pipelines, Conca (2014) argues, could be an even more compelling argument than safety for viewing pipelines as the preferred transportation mode for oil and gas. Pipelines operate at about one-third the cost of rail (not including the initial investment cost) and are more energy efficient than rail (International Energy Agency, 2014).

Flaring

Pipeline insufficiency arguably has its most important impact on natural gas, which, in contrast to oil and NGL, is almost completely reliant on pipelines for transportation. Ailworth (2014) reported that over 1,750 completed gas wells are non-operational in the Marcellus shale because of a shortage of pipelines. In plays where gas is primarily a byproduct of oil extraction, capturing the gas requires additional time and new financial investments in infrastructure to capture, process, and transport the gas (USEIA, 2014a). Where gas volumes are low, such an investment often is not economical, and gas in these areas is being flared at the well. According to EIA data, gas flaring in the US has risen from approximately 143 billion cubic feet in 2007 to around 260 billion cubic feet in 2014 (USEIA, 2014).

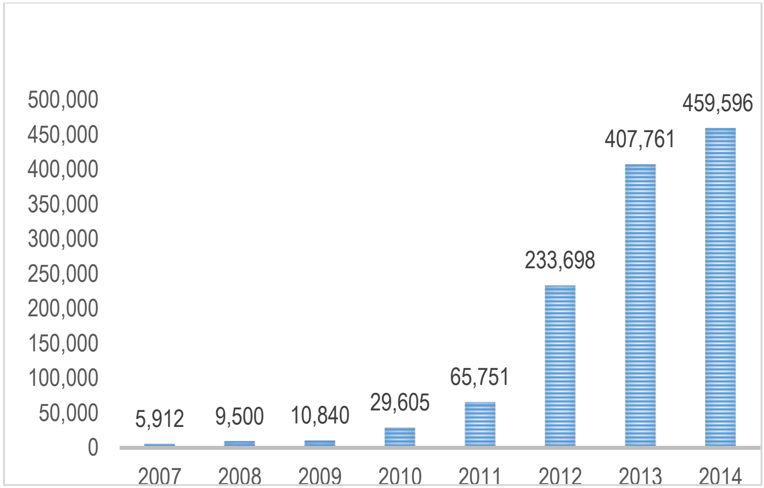
In North Dakota, which is primarily an oil play, approximately 30% of the natural gas produced from the state's wells is being flared, according to a 2013 report from *Ceres* (Salmon and Logan, 2013). The value of the gas being flared has been estimated to be over $1 billion per year (based on the market value of the North Dakota natural gas) (Salmon and Logan, 2013), and some analysts believe that this estimate is conservative (Western Values Project, 2014). Since these reports, North Dakota has implemented new targets that have been effective at reducing flaring (USEIA 2014a).

As Klass & Meinhardt (2014) emphasize, flaring represents not only a severe economic loss but also an environmental issue. They suggest that flaring could be addressed by the Federal or state governments providing both incentives and regulatory mandates to industry to build the pipeline infrastructure needed to harness the gas that is currently being flared. Another approach may come from technological innovation as small size equipment is now being developed to facilitate the collection and liquefaction of natural gas at well sites (Fairley, 2010).

Increase in Transport by Rail

One of the most significant transportation related developments produced by the oil and gas boom has been the exponential growth of oil transported by rail. Between 2007 and 2014, crude oil transportation by rail grew from less than 6,000 carloads to over 450,000 car loads (see Figure 2). The Congressional Research Service reports a 20-fold increase in the use of rail for crude oil between 2008 and 2013 (CRS 2014b). Pipeline projects can take considerable time to permit and build, but rail infrastructure is extant and has proven to be much more flexible. Rail operators also may offer shorter-term contracts to oil producers than pipelines, making them more attractive to producers given the fluctuations in oil prices (CRS, 2014b).

Railroads are currently increasing their investments and adding terminals to handle oil shipments. Similarly, oil tank car manufacturers are investing to expand their fleet (Kruglinski, 2013). However, some analysts have called for a comprehensive study of the costs and benefits of transporting oil by rail rather than by pipeline, and calling for such a study to be undertaken quickly, before heavy investments are made to expand rail capabilities with respect to oil transportation (Klass, & Meinhardt, 2014).



Source: Association of American Railroads (2014). Data based on estimate from first half of the year (latest data available). (CRS, 2014b) estimated that over 650,000 carloads could be expected in 2014.

Figure 2. Carloads of Crude Oil Transported by Railroads

Truck Driver Shortage

The dramatic increase in oil and gas supply is exacerbating the nation's shortage of truck drivers. The American Trucking Association estimated that the shortage, as of August 2014, stood at 30,000 drivers and could rise to 239,000 by 2022 (Badkar, 2014). While the reasons for this national shortage are multiple, oil and gas development is considered a primary factor (Mangalonzo, 2013; Adams, 2014). Given the higher pay they offer, oil and gas regions are attracting a disproportionate number of truck drivers, leading to more severe shortages in other regions and for other commodities. More effective planning and utilization of other modes of transportation could reduce the pressure on the trucking industry.

Logistics Challenges at the Regional Level

Transportation infrastructure in regions with new and fast-growing oil and gas development is often not designed to withstand the heavy truck activity that modern oil and gas production requires, and the absence of gathering lines in these areas leaves roads as the only transport alternative. (Gathering pipelines take the oil or gas from its source (the well) and transport it to a larger transmission line, where it may travel to a barge, refinery, or processing plants (PHMSA, 2015)). While this impact is felt across most oil and gas regions, it has been more pronounced in regions that have experienced a significant increase in production over a short time period. North Dakota, Wyoming, and Montana are examples of states which lacked adequate transportation infrastructure when the oil and gas boom began.

Established producing regions typically have a better network of gathering pipelines, and therefore do not rely as much on roads to transport oil from the well to the next distribution point. Accordingly, the absence of gathering pipelines significantly increases truck traffic in these areas. For example, in North Dakota only 27% of crude oil produced is transported from the well by gathering pipelines (Tolliver, 2014). Lack of transmission pipelines also increases the volume of oil being trucked to rail. About 60-70% of North Dakota's oil is being sent to refineries by rail (USEIA, 2014b; Upper Great Plains Transportation Institute, 2014.) Finally, the absence of pipelines results in flaring because there are few alternatives for natural gas. Liquefying natural gas reduces its volume dramatically – by a factor of 600 (USDOE, 2013), making it much more efficient to transport. However, transportation of LNG by rail is still not approved on U.S. railroads (McAlister, 2014), although several railroad companies have applied to the Federal Railroad Administration for permits to ship LNG by rail (Hobson, 2015).

Finally, it is at the regional level that the impact of oil and gas development on transportation infrastructure is often the most intense – typically in the form of heavy truck traffic on rural roads. Wells tend to be located on private, rural land, and trucks are the primary means of transportation to and from the wells in these areas. This results in road damage and increased maintenance costs (Rahm, Fields, & Farmer, 2015; Ritzel, 2015).

The truck traffic attributed to a producing well can generally be divided into two phases. The first phase is the drilling, construction, and hydraulic fracturing of the well, which requires substantial supplies transported to the well pad (e.g., fracturing sand, piping, cement, water, etc.) and other materials transported away from the well (e.g., drill cuttings and waste water). The supplies needed to construct and fracture the well are often transported across long distances by rail or other modes before ultimately being transported to the well site by truck. Trucks carry the heavy equipment and supplies to the well and many will remain on site during the drilling, construction, or hydraulic fracturing processes. Once the well has been drilled, constructed, and fractured, the trucks involved in those activities leave the well pad. This phase can take up to three months (Energy From Shale, 2015).

In 2011, New York State published a draft environmental impact statement (DEIS) addressing the impacts of oil and gas development (NYS DEIS, 2011). The DEIS was particularly concerned with the impacts of this first phase of production on local and state roads, despite noting that this initial phase of development and associated impacts are temporary. The DEIS estimated there were approximately 3,400 round trips (combined heavy and light duty trucks) per well for a horizontal well with high-volume hydraulic fracturing (NYS DEIS, 2011). However, there are many factors that can lower this estimate, such as using multi-well pads, re-use or recycling of flow-back water, or the location of natural water sources (NTC Consultants, 2011). In particular, water management and transportation practices are improving (Rodriguez & Soeder, 2015), and are likely to lower these estimates considerably.

It is during this initial phase of drilling and development that local planners have been the most active in attempting to mitigate the negative impact of trucks on local roads (Tolliver, 2013; Tolliver, Dybing, & Mitra, 2012; Ksaibati, K.; Huntington & Ksaibati, 2010; Stroud & Ksaibati, 2013; Nothstine, 2010). It is also during this phase of production that truck related road safety concerns have been increasingly studied (Kubas & Vachal, 2014; USDOT, 2014, Schneider, 2014). In a study of high-volume hydraulic fracturing in Pennsylvania, Krofmacher, Hawker, and Winebrake (2015) found that there are ways to lessen truck usage, but better data collection and dissemination is needed for planning.

The second phase related to transportation impacts involves production of the oil or gas. After the well has been drilled, constructed, and fractured, the well then produces oil (or gas) and water, both of which must be continually trucked off site for the remaining life of the well. Oil wells initially produce high volumes of oil compared to water, but over the life of the well those ratios change and wells generally will be closed when the cost of managing the water makes the well no longer profitable (Argonne National Laboratory, 2009). An oil or gas well often produces sufficient quantities of oil (or gas) to make the well economical for many decades (Energy From Shale, 2015). Consequently, it can be argued that the time period after drilling, construction, and fracturing is the most significant in terms of the overall truck traffic to and from the well and the transportation needs of the area. However, by contrast, the NYS DEIS stated that "trucking during the long term production life of a horizontally drilled single or multi-well pad would be insignificant." (NYS EIS, 2011, p.6-301).

Safety Challenges

Given the dramatic increase in the transportation of produced oil and gas, and the materials necessary for production, incidents of spills and other accidents have been on the rise. As Furchtgott-Roth recognized, "there is no perfectly risk-free way to transport oil, or anything else for that matter" (Furchtgott-Roth, 2013b, p. v). Some transportation modes may nevertheless be safer than others, but this depends entirely on the population or particular environment whose 'safety' is being assessed, or whether the measure is simply the amount of oil spilled (Conca, 2014). As Conca (2014) highlights, if human health and property is considered, boat and pipelines are the safest modes and rail and truck are the least safe; however, if aquatic life is the target of concern, then truck and rail are the safer alternatives.

Pipeline Safety

Despite the aforementioned considerations, most commentators agree that pipeline is the safest mode for transportation of oil and gas (Ingraham, 2015; Furchtgott-Roth, 2013a). Green & Furchtgott-Roth (2013b) reviewed data on safety of oil transportation modes in the U.S. and found that road and rail have higher rates of serious incidents, injuries, and fatalities than pipelines.

Railroad Safety

The boom in transportation of oil by rail has, not surprisingly, led to an increase in spills and an increase in safety concerns (Stockman, 2014), especially in the wake of some catastrophic rail accidents. In 2013 alone, according to PHMSA data cited by Conca (2014), rail spills amounted to about 1.5 million gallons of crude oil; almost double the amount spilled from 1975 to 2012. The rail disaster in Lac Mégantic, Quebec, in which a 72-car unit train with Bakken crude derailed causing 47 deaths and substantial destruction, prompted a comprehensive evaluation of U.S. rail safety standards (CRS, 2014b). New voluntary and mandatory safety standards are now being implemented by the industry and the United States Department of Transportation, such as slower train speeds, stronger tank cars, and advanced braking systems (CRS, 2014b).

Marine Safety

Barge and ocean tanker shipments of crude oil have also increased in response to production, albeit at a fraction of the increases seen by other modes, especially rail. This is largely because of the inland location of many of the producing areas. The largest increases in oil related barge traffic have been on the Gulf coast routes from Texas and the Midwest to the refineries on the Gulf of Mexico.

A recent Congressional Research Report (CRS, 2014a) concludes that although barges and ocean vessels could play a leading role in the transportation of oil given that the majority of U.S. refineries are located near navigable waters, some safety and operational challenges limit their expansion. Chief among these is the Jones Act, a 1920 law that generally requires any tankers sailing between U.S. ports to be manufactured in the U.S. and crewed by U.S. citizens. This makes transportation by tanker less competitive given the shortage of US-built vessels and their higher cost of production and operation.

With respect to safety, the record for barges is generally recognized as the best among the available freight modes. Moreover, despite the increase in crude transportation, that safety record has remained constant while the railroads have had several significant incidents (albeit the volume being transported by rail is much higher than by barge). Barges are governed by domestic regulations enforced by the US Coast Guard. Towboats that push or pull barges are subject to an inspection regime enacted in 2008, and towboat operators are subject to “hours of service” rules that allow for six hours on, six hours off, and no more than 12 hours on in any one 24-hour period. Ocean going vessels have different hours of service rules, as do train operators. There continues to be debate regarding which mode’s ‘hours of service’ rules are actually safer, but by most metrics, barge and tanker remain one of the safest transportation options available for oil.

Truck Safety

Although trucks transport only a fraction of the volume of oil as compared to other modes, they are considered the least safe mode of transporting oil; however, the limited volume (200 - 250 barrels of oil per truck) does limit the potential impact of any individual accident. The major safety issues associated with trucks are accidents while in transit (Kubas & Vachal, 2014; USDOT, 2014). Truck accident related fatalities around the U.S. have increased by 18% during the last four years (USDOT, 2014). Texas highways, reported as “the nation’s deadliest amid a fracking boom,” experienced a 50% increase in truck-related fatalities between 2009 and 2013 according to data from the Texas Department of Transportation (Schneider, 2014). Graham et al. (2015) found that Pennsylvania counties with shale gas drilling had higher vehicle accident rates. A recent analysis of traffic deaths and U.S. Census data confirmed similar trends in six states with significant oil or gas development (Associated Press, 2014).

Focused Studies on Impacts to Transportation Infrastructure

The following studies were identified in the course of this review as constituting focused studies related to oil and gas development:

- Infrastructure Needs: North Dakota's County, Township and Tribal Roads and Bridges: 2015-2034, NDSU Upper Great Plains Transportation Institute, July 8, 2014 (Upper Great Plains Transportation Institute, 2014) (subsequently referred to as The North Dakota study);
- Impacts of Bakken Region Oil Development on Montana's Transportation and Economy: Montana Department of Transportation, January 31, 2013; (Brown, et. al., 2013) (subsequently referred to as The Montana study);
- Impacts of Energy Developments on the Texas Transportation System Infrastructure, 2011, (Prozzi, et al., 2011) (subsequently referred to as The Texas study);
- Marcellus Shale Freight Transportation Study, commissioned by the Northern Tier Regional Planning and Development Commission (PA), (Gannett Fleming, 2011) (subsequently referred to as The Marcellus study);
- North American Midstream Infrastructure through 2035: Capitalizing on Our Energy Abundance:
- An INGAA Foundation Report, Prepared by ICF International, March 18, 2014, (ICF International, 2014b) (subsequently referred to as The INGAA Pipeline Study); and
- Oil & Natural Gas Transportation & Storage Infrastructure: Status, Trends, & Economic Benefits, commissioned by the American Petroleum Institute, (IHS Global Inc., 2013) (subsequently referred to as The IHS Pipeline Study).

No focused multi-modal study was found. By multi-modal study, we mean a study that systematically evaluates the impact of oil and gas related transportation across the four modes that are typically involved in freight transportation (pipelines, railroad, marine, and roads). While the six studies listed above may not be an exhaustive list, we emphasize that these were found after systematic retrieval efforts and at the very least, we do consider them to be a good representation of the work performed to date.

The focused studies can be generally grouped into being directed at pipeline or highway transportation, respectively, with some reference to shipments made by rail.

Pipeline Studies

Two of these studies (INGAA Pipeline Study and the IHS Pipeline Study) address pipeline transportation and aim to assess the level of investment needed to meet the demand for pipeline infrastructure in the short, medium, and long term. Their approach consists of estimating needs based on forecasted production of oil, natural gas, and NGL. Both studies take a national (and often North American) geographical approach. Because of this broad coverage, their scope could be viewed as a general estimation of overall pipeline needs using current construction, investment trends, and forecasted national oil and gas production as the explanatory variables.

Truck Studies

The remaining four studies focused on trucking and are local or regional in scope. With this local focus, these studies assessed the impact only within limited boundaries, usually the state or region where significant oil and gas development was taking place. As a result, the impact on transportation infrastructure or on modal use or capacities beyond the area examined is not taken into account. One advantage of this approach, however, is the ability to perform a more in-depth analysis of the impacts and relevant variables in those areas.

Railroad Studies

The Marcellus Study addresses both current and future rail needs. Because the Marcellus is essentially a gas shale play, the discussion focuses on the role of railroads in transporting the needed drilling, construction, or fracturing materials (such as sand) that typically travel by rail before being trucked to well sites in the Marcellus. The aim of this aspect of the study was to forecast the current and future rail conditions and needs in the Marcellus.

NCHRP Synthesis

In 2015 the National Cooperative Highway Research Program (NCHP) published Synthesis 469, titled *Impacts of Energy Developments on U.S. Roads and Bridges* (NCHRP, 2015). The synthesis represents the first comprehensive national evaluation of the impacts to roads and bridges from energy development, as well as an overview of national best practices that states are using to understand and address these impacts.

The synthesis undertook a literature review and surveyed departments of transportation in all fifty states, D.C., and Puerto Rico regarding impacts to state and local transportation systems. The survey had a 79% response rate, and five states – the largest oil and gas producing states – were chosen for detailed follow-up interviews (NCHRP, 2015). The NCHRP synthesis reported on the types of damage occurring because of energy development, the engineering methods being used to assess damage, how states are gathering data to assess pavement remaining service life, and best practices to address the damage (NCHRP, 2015). The synthesis also reported on tools states are using to determine current and future costs associated with energy development and how they are obtaining funds to address current damages to transportation infrastructure (NCHRP, 2015). This synthesis is likely to be a valuable tool for transportation planners and policy makers facing energy development in their areas.

The synthesis also identified areas where more research is needed, including "safety, environmental, and social impacts associated with energy development on state and local roads and bridges. Of particular interest will be holistic and international views on the allocation of resources, education, and welfare" (NCHRP, 2015,). The synthesis noted the need for new work examining whether the allocation of funds to address energy development impacts could reduce the funds available for other road or highway projects. Finally, the synthesis called for better safety and crash data on rural roads in areas impacted by energy development (NCHRP, 2015).

Conclusion

Given the relatively recent increases in oil and gas development in the United States, studies regarding impacts on transportation infrastructure are just beginning to emerge, and have been dominated by local or state departments of transportation addressing major impacts in one region. Additionally, while the focus has been on the impacts to roads, there has been little emphasis on multi-modal approaches.

There is need for further objective research on freight transportation issues related to the shale revolution. A Transportation Research Board subcommittee found a "gap in the sophistication of the analyses of oil and gas impacts outside of formal transportation planning process and the analyses conducted for long-range transportation plans" (Bishak et al. 2014 p. 3). A thorough review of the modelling of transportation needs related to oil and gas development should be conducted and multi-modal planning tools developed. Best practices for transportation agencies should be gleaned from the experiences of major shale plays. The slowdown in oil and gas development provides an opportunity to reflect on the transportation issues created in the recent boom and prepare for the future.

The significant decline of oil prices has caused a slow-down in drilling across the country, such as in the Tuscaloosa Marine Shale in Louisiana and Mississippi. This has dampened the immediate need to better understand and address the transportation issues in many of these communities. However, increases in oil prices in near, medium, or long term are inevitable and will likely support eventual future growth. Additional studies can help better direct investment in transportation infrastructure and assist planners and policy makers when oil and gas development begins again in earnest in some of these areas currently experiencing slower growth. The studies identified in this paper, as well as the NCHRP's synthesis, provide a foundation to assist planners in supporting responsible oil and gas development, making the most efficient use of existing transportation modes, and minimizing impacts on communities.

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<u>3. The Real Value of FracFocus as a Regulatory Tool: A National Survey of State Regulators</u>

Introduction

The basic technique of hydraulic fracturing (also known as "fracing,"or "fracking") as a method by which to stimulate oil and gas wells to increase production has been in use for nearly seventy years, with the first commercial hydraulic fracturing job occurring in the late 1940's (FracFocus 2015c). Fracturing using explosives to stimulate oil wells goes back even further, well into the 19th century (MacRae, 2012; Energy Information Administration, 2011a). The technique involves creating fractures in the rock formations deep below the surface of a well, pumping a mixture that is approximately 98% – 99.5% water and sand, and 0.5% – 2% chemical additives into the well at high pressures, and leaving the sand (known as proppant) in place to hold the fractures open to allow gas or oil to flow (or be pumped) to the surface (FracFocus, 2015a). Horizontal drilling – a technique that allows wells to be drilled horizontally through the formation below the surface in order to capture more of the producing area from one well-pad at the surface – entered the scene on a commercial scale in the 1980's (Energy Information Administration, 1993), and in combination with hydraulic fracturing techniques has been a powerful force in the country's domestic energy boom. Indeed, these technologies have been so successful at developing natural gas reserves so quickly in the U.S. that researchers are looking at ways to duplicate this boom in China, where alternatives to coal are needed (Tian, 2014).

The rapid advances in the technologies associated with hydraulic fracturing and horizontal drilling have made it economical, in the last decade, to develop previously untapped sources of oil and gas and to substantially increase well output. For example, according to the United States Energy Information Administration, the number of producing horizontal wells in the Barnett Shale Play in Texas increased by a factor of 25 between 2004 and 2010 (Energy Information Administration, 2011b)

Despite the long history and continued use of hydraulic fracturing and horizontal drilling in the U.S. and around the world, the American public has limited familiarity with the technology, and their assessment of the actual risks can be influenced simply by the use of the word 'fracing' (Clarke, 2015). Fear of the unknown and the rapid expansion of drilling and acquisition of leases understandably has raised concern, and hydraulic fracturing has become one of the leading environmental controversies of the day. Townships and localities have spent substantial public funds litigating their authority to ban oil and gas drilling, some with more success than others. Activists across the country have called for a complete ban on the well-stimulation technique out of fear of environmental damage, perhaps not understanding that such a ban would effectively end oil and gas production in the United States because conventionally accessible reserves are near depletion or are already producing. For example, the Colorado Oil and Gas Conservation Commission has explained that "[m]ost of the hydrocarbon bearing formations in Colorado have low porosity and permeability. These formations would not produce economic quantities of hydrocarbons without hydraulic fracturing" (Colorado Oil and Gas Conservation Commission, 2015). Hydraulic fracturing and horizontal drilling are necessary technologies to a continued domestic oil and gas industry.

In the past decade, the issue of the safety of the hydraulic fracturing process has been the subject of numerous government, industry, and academic studies. The EPA is currently completing a comprehensive, multi-year study on the impact of hydraulic fracturing on drinking water resources (Environmental Protection Agency, 2015a). However, the environmental impact of oil and gas development is beyond the scope of this paper.

This paper will focus on a narrow, but key area of the controversy: disclosure (to the public or to regulators) of the chemicals used in in the hydraulic fracturing process. The driving fear in the recent history of fracing is the nature of these chemicals and whether they should be disclosed in ways that go beyond longstanding federal regulations governing disclosure of hazardous chemicals.

Disclosure of Hydraulic Fracturing Fluid Information

Like chemicals used across many industries in the United States, the precise chemical formula of some widely-used hydraulic fracturing fluids are entitled to trade secret protection under state and federal laws (CRS, 2012). However, when trade secrets are at issue in any industrial workplace setting, federal laws provide for a modified form of disclosure of chemical information that balances the need to protect workers and the environment against the need to protect proprietary information. The Emergency Planning and Community Right to Know Act (EPCRA) (42 U.S.C. § 11021) and the Occupational Safety and Health Administration's Hazard Communication Standard (29 C.F.R. § 1910.1200(g)) require identification of hazardous chemicals on Material Safety Data Sheets (MSDS) (CRS, 2012). The MSDSs must be submitted to local emergency personnel and be made available to employees at worksites (EPCRA, 1986a and OSHA, 1994a). However, these laws and regulations allow manufacturers of hazardous chemicals to make a claim of trade secret, and thereby withhold from the MSDS the specific chemical constituents that are trade secrets (EPCRA, 1986b and OSHA 1994b). In these cases, chemical manufacturers must still report the "generic class or category" of the hazardous or toxic chemical so that first responders and medical personnel have the information they need to respond in the event of an accident, but the often substantial investment in developing those chemicals remains protected under trade secret laws (EPCRA, 1986c).

This mechanism to balance trade secret protection with worker safety and the public's right to know has been in place since the 1980s, when EPCRA was enacted and OSHA's Hazard Communication Standard was established.   However, since the early to mid-2000s, when the number of wells using hydraulic fracturing technology increased rapidly, environmental groups have argued that increased disclosure of hydraulic fracturing fluids is necessary, even if private property rights (trade secrets) are infringed. Activists, environmental groups, and concerned citizens have at times demanded full disclosure of the chemical formulae found in hydraulic fracturing fluids at well sites, even where that information constitutes a protected trade secret under existing law. Although OSHA and EPCRA have nearly exclusively governed hydraulic fracturing chemical disclosure at the federal level since the 1980s (CRS 2012), in the last decade states have reacted to the demands for more transparency and many have enacted laws or regulations that address the disclosure of hydraulic fracturing chemicals.

FracFocus.Org Background

It was in the midst of this intense debate that, in 2011, the Ground Water Protection Council and the Interstate Oil and Gas Compact Commission (IOGCC) launched a new tool, the FracFocus.org Chemical Disclosure Registry (FracFocus or Registry), aimed at providing a single, on-line database where members of the public could access information on the chemicals used in the hydraulic fracturing process on a well-by-well basis.

The GWPC is a nonprofit organization "whose members consist of state groundwater regulatory agencies which come together within the GWPC organization to mutually work towards the protection of the nation's ground water supplies. . . . [Its] mission is to promote the protection and conservation of ground water resources for all beneficial uses, recognizing ground water as a critical component of the ecosystem." (Ground Water Protection Council, 2015a). The IOGCC is a "multi-state government agency" that "works to ensure our nation's oil and natural gas resources are conserved and maximized while protecting health, safety and the environment" (IOGCC, 2015). IOGCC members consist of the governors of oil and gas states and their appointed representatives. There are over two dozen member states, eight associate member states, and numerous foreign and domestic affiliates.

The Registry had the support of industry, which agreed to more transparency in chemical disclosures provided trade secret protections were in place. Industry had substantial investment in well stimulation technologies and remaining competitive in the marketplace hinged on protecting those investments.

Well operators and service providers across the country began submitting well data to the site voluntarily. If the identity of a chemical was a protected trade secret, the words "trade secret," "confidential," or similar indicator would be entered on the FracFocus form, so that anyone searching for well information on the Registry would be aware that specific information was being withheld under a claim of trade secret.

While FracFocus grew, so too did the debate regarding hydraulic fracturing. Oil and gas producing states across the country began adopting new regulations specific to hydraulic fracturing, primarily to assure well-bore integrity and promote transparency in fracturing fluid information. Indeed, within just a few years, virtually all of the oil and gas producing states enacted legislation or regulations specific to hydraulic fracturing (Hall, 2013). Vigorous debates ensued regarding trade secrets. Trade secrets are valuable and legally protected private property; these property rights in trade secrets serve to encourage the development of more efficient and "greener" fracturing technologies. And yet, also true is that environmental regulators, first responders, and medical personnel need access to the information that is essential to protect human health or the environment in the event of an incident.

As state legislatures and regulatory agencies struggled to draft laws and regulations that would strike the right balance (and appease the lobbying efforts on both sides), industry advocated for the use of FracFocus by state regulators in order to serve the goals of transparency, but also to lessen the burden of complying with a patchwork of different reporting obligations across the country. States and the federal government ultimately took a variety of approaches (and are continuing to do so), with most adopting FracFocus as a mandatory method of compliance with the state (or federal) fracturing fluid disclosure obligations.

In the first two years of operation, data on tens of thousands of wells across the country were reported to FracFocus and FracFocus quickly became a critical information source. EPA "compiled and analyzed over two years of data" from FracFocus to support its study on the impacts of fracturing on drinking water resources (EPA, 2015b). The Department of Energy set up a task force to evaluate FracFocus (Department of Energy, 2014a). The consultants that developed the FracFocus database presented papers highlighting how analysis of the data available on FracFocus could be used to "bring a scientific approach to addressing many of the concerns expressed by the public, NGOs, and regulatory agencies regarding hydraulic fracturing" (Arthur, 2014). Indeed, as of April 23, 2013 (the date of the Harvard study discussed below), FracFocus had data on 41,239 wells (Ground Water Protection Council, 2015b). As of July 2015, there is now data on 99,734 wells available on FracFocus (FracFocus, 2015b). Even at the time of the publication of the Harvard report, FracFocus appeared to be an important tool for the public to access fracturing fluid information and for regulators to implement chemical disclosure laws.

FracFocus continues to evolve and respond to the recommendations of regulators and other stakeholders. In spring 2013, new upgrades were made to FracFocus, which became known as "Frac Focus 2.0." These upgrades included, among other things, the ability to search the site by Chemical Abstract Service (CAS) numbers or date ranges, a location on the chemical disclosure forms for "ingredients not listed on MSDS," as well as internal processes to check for errors as data is submitted (FracFocus, 2013; Department of Energy, 2014a). FracFocus 3.0 is expected to launch in 2015 with additional upgrades aimed at increasing reporting accuracy, expanding search capabilities, potentially decreasing the number of trade secret claims that are submitted, and allowing easier access by regulators and the public (FracFocus 2015d).

The Harvard Report discussed in this paper noted some of the changes made in FracFocus 2.0, for example the inclusion of non-MSDS chemicals on the FracFocus disclosure form, but concluded that the FracFocus reporting forms did not go far enough (for reasons that are beyond the scope of this paper). At the time of this survey, FracFocus 2.0 was in use, and at the time this paper was submitted for publication, FracFocus 3.0 had not yet been released.

Harvard Law School Concludes FracFocus is a Failure as a Regulatory Tool

On April 23, 2013, researchers at Harvard Law School's Environmental Law Program, Policy Initiative, published a white paper titled "Legal Fractures in Chemical Disclosure Laws: Why the Voluntary Chemical Disclosure Registry FracFocus Fails as a Regulatory Compliance Tool" (Konschnik, 2013) (hereinafter referred to as the "Harvard Report"). The Harvard Report cited three primary failings in the FracFocus tool: 1) the timeliness of FracFocus' notification to state regulators when a submission is made to FracFocus; 2) the lack of state-specific submission forms that take into account the varied state disclosure requirements; and 3) the lack of a mechanism within the Registry by which to challenge trade secret claims made on submissions to FracFocus (Konschnik, 2013).

The Harvard Report spread swiftly through the environmental and industry communities, and garnered widespread national media attention. The report itself, however, soon attracted negative attention. Media, industry representatives, and state regulators recognized a major shortcoming: the Harvard Law School researchers reached their conclusion about the value of FracFocus without interviewing regulators who were actually using the tool to support their regulatory programs. The report cites one telephone interview by a law student with a Colorado regulator as to whether he was aware of the requirement that forms be submitted to the state *and* to FracFocus, and one interview with a Pennsylvania regulator regarding the information that is submitted to the state on state forms, apart from FracFocus forms (Harvard Report, 2013). There apparently were no discussions regarding timeliness of reporting, trade secret claim procedures, or state-specific forms with these two or any other state oil and gas regulators. Fundamental questions remained: Were state regulators in fact limited in their regulatory programs by the lack of state specific forms, the timing of disclosures, or the absence of a method for challenging trade secret claims within the Registry? The experience of the government regulators is absolutely central, and that is precisely the question this paper seeks to address: What do regulators across the country think of FracFocus and how are they actually using it? Has it in fact “failed as a regulatory compliance tool” as the Harvard Report claims?

The most appropriate way to find out is to directly survey the regulators. Accordingly, we developed a survey of eleven questions aimed at discovering how states were using the tool, their general impression of the tool, and to elicit open ended feedback from state regulators regarding FracFocus.

The survey was sent to regulators in twenty states with oil and gas development and listings on FracFocus, with fourteen states responding, a response rate of 70%. We targeted regulators with responsibility for enforcement and compliance with chemical disclosures rules, well reporting rules, or FracFocus submissions in their respective states. We emphasize that all of our written and oral contacts with the state regulators were neutral in terms of our own evaluation of FracFocus. Overall, the data contradicted the Harvard Report’s conclusion that FracFocus ‘fails as a regulatory tool.’ Regulators had a positive view of FracFocus and indicated it was a useful tool in regulatory programs. Different states are using FracFocus in different ways. Indeed, regulators indicated they were using the information available on FracFocus to support their regulatory programs in novel ways perhaps not imagined by FracFocus’ creators. This paper discusses the results of that survey, how states are using FracFocus, and the impressions regulators have of FracFocus as a regulatory tool.

Methods

We compiled the survey using Qualtrics online software and sent it via email to the targeted regulatory officials for each state in which more than ten wells appeared on FracFocus as of spring 2014. These included Alabama, Alaska, Arkansas, California, Colorado, Kansas, Louisiana, Michigan, Mississippi, Montana, New Mexico, North Dakota, Ohio, Oklahoma, Pennsylvania, Texas, Utah, Virginia, West Virginia, and Wyoming. A minority of these states currently do not require mandatory reporting to FracFocus in their regulatory programs (although they do require disclosure of fracturing fluid information), and approximately two states were in the process of adopting regulations that would require the use of FracFocus, which had not yet taken effect at the time of the survey. However, we intentionally included these states in order to capture any use that state regulators may be making of the then voluntary reporting to FracFocus that was already occurring in those states. Importantly, the states surveyed included the top oil and gas producing states in the nation (EIA, 2013) and those with the most proven hydrocarbon reserves (EIA, 2014).

Prior to sending out the survey, we contacted as many states as possible by phone and e-mail to assure that the survey was directed to the regulator with the most familiarity or experience with FracFocus or chemical reporting from well operations in that state. We informed these states (by phone or email, as well as in the cover letter accompanying the survey link) that more than one person in the agency could take the survey. We then left it up to the state agencies to identify the appropriate person(s) to take the survey. Our survey records demonstrated that each responding state only submitted one survey.

We initially contacted these state regulatory agencies using information obtained from state agency websites and from FracFocus, which maintains a list of state contact information, along with a neutrally worded explanation of why we were requesting the information. The survey was anonymous in order to encourage frank answers and protect the individual respondents.

The survey asked specific questions, but also allowed room for regulators to draft their own reactions to FracFocus. Many contributed substantial detail regarding their programs and their use of FracFocus. Some of them included identifying information in their answers which we have omitted to protect the privacy and identity of those responding. Some respondents chose not to answer specific questions and that was taken into consideration in reporting of results.

Our intention was to obtain comparable data on such critical factors as the timeliness of FracFocus' notice to states when it receives reports on wells, the use of FracFocus to support regulatory programs, the states' views of the role FracFocus plays with respect to trade secrets, integration of FracFocus data with state maintained data, and the overall sense of the utility of FracFocus for state regulators charged with enforcing state chemical disclosure rules.

Results

Timeliness of State Notification

The question of whether FracFocus provides timely notice of data submission to the states may be critical to the usefulness of the data and certainly to the state's ability to determine if time sensitive disclosure obligations are being met. Accordingly, we asked the state regulators if FracFocus notified them when FracFocus received submissions from well operators and if that notification is timely.

The survey gave respondents a choice of "very timely," "timely," "not so timely," "extremely poor," and "other," with this last option allowing respondents to enter a written explanation.

Nine states answered this question. Four replied that it was “very timely,” one that it was “timely” and four states answered “other.” No state indicated FracFocus’ was “not so timely” or “extremely poor.” In the “other” category, multiple states explained that they pull the information directly from FracFocus and do so on their own schedule. Hence, as one state explained, “so it is timely, but on our schedule.” Another state in the “other” category which responded to this question did not use FracFocus.

These results appear to be in direct conflict with the Harvard Report’s opinion that “FracFocus does not notify a state when it receives a disclosure from a company operating in that state. Nor can most states readily determine when a disclosure is made” (Konschnik, 2013).

Use of FracFocus to Support State-Specific Regulatory Programs

The second conclusion of the Harvard Report was that the lack of state-specific reporting forms on FracFocus “creates barriers to compliance” because “companies are left to figure out how to account for state requirements not requested by FracFocus” and “too often . . . do not provide the additional information.” (Harvard Report p.5). This study’s survey was aimed at state regulators and their use of FracFocus, not the reporting companies; accordingly, we did not ask states about the FracFocus forms themselves, but instead sought information from the states regarding whether and how they were able to make use of data that was being reported to FracFocus (on the current, generic forms) to support the regulatory programs (that may vary from state to state).

The survey asked states whether they use FracFocus to download well data directly from FracFocus to state computer systems for use in individual state regulatory programs. Half of the respondents indicated that they use FracFocus in this way.

We also asked state regulators if they used FracFocus to gather information regarding the chemicals or water volumes used in the fracturing process. With respect to chemicals, 57% indicated that they do use FracFocus to gather such information, 29% answered they did not, and 14% answered they did not know or were not sure. Data on water volume was less represented. Thirty-six percent of the states indicated they used FracFocus to obtain such information, 43% indicated they did not, and 21% indicated they did not know or were not sure.

In addition to asking prescribed questions, the survey asked open ended questions aimed at understanding how states have used FracFocus to support their regulatory programs. The following responses indicate that states have used FracFocus in ways that often go beyond chemical reporting compliance. Indeed, these findings may be some of the most significant and surprising of this study. We have corrected minor spelling and grammar errors. Ten separate states, indicated by paragraph breaks below and key statements highlighted in bold, reported that:

“FracFocus has been a tool to provide information to the public about different hydrological fracturing processes throughout our state. It is also useful when public record requests come in to generate all important information for each citizen.”

"Our state required documents do not tell us the date or dates of Frac treatment, FracFocus captures that information and our state has found that information helpful in studies of earthquake issues in our state. The information will also be utilized in the reports to our agency regarding complaints of water contamination."

"FracFocus provides a readily available resource to provide hydraulic stimulation data to interested parties."

"Our technical staff use Fracfocus to cross-check the validity of the data submitted to us by the operator."

"MSDSs have been submitted to our agency directly; however, a few companies . . . submit their information to FracFocus.org. It has been helpful for us to direct concerned citizens to FracFocus to view MSDS that have been posted on the website. . . . I personally have obtained information from FracFocus to create an informational pie chart regarding the chemical constituents of hydraulic fracturing fluids."

"We . . . use FracFocus to verify compliance with our rules."

"[The agency] has used FracFocus to determine compliance with the requirement under the Safe Drinking Water Act to require an Underground Injection Control permit for hydraulic fracturing using "diesel fuel" as defined by EPA. EPA provided a definition through guidance and interpretive memo (not rulemaking) for the term "diesel fuel" in May of this year. The [agency] has enforced against one operator using information obtained through FracFocus."

"[This state uses FracFocus to] determine reporting and notification compliance with the state's . . . statutes and regulations. It is the only electronically available source of hydraulic fracturing chemicals data that the state can access to consider types of formulations or in cases of a spill. Very few of the [agency's] environmental programs have access to electronically available chemical data for the activities they regulate."

"We have used FracFocus to check databases of chemicals used."

"We usually just verify reporting compliance."

In addition, several states indicated that they cross-reference state reporting forms with the list of wells they obtain from FracFocus to verify that operators are in compliance with state reporting obligations. Moreover, they will contact an operator if the submissions to FracFocus do not match the submissions to the state.

Finally, one state wrote that it routinely runs reports from FracFocus "through the tools for the state regulator role." This state noted that it found valuable the feature of FracFocus that allows oil and gas inspectors to "select any specific report, anytime they need to for review" and that the FracFocus reports "can be run anytime by the regulators to check operator compliance."

Trade Secrets

The Harvard Report vigorously criticized FracFocus for its omission of legal procedures to challenge and defend claims of trade secret. From our perspective, we do not believe FracFocus has the authority, nor was it intended, to establish any such mechanisms. State law generally defines what a trade secret is and states will have different mechanisms in place by which claims of trade secret are asserted or can be challenged. In any case, it was important to understand regulators' views on whether FracFocus could be doing more to assist the states with respect to this issue.

We asked states whether they were satisfied with FracFocus' approach to identifying when claims of trade secret have been made on a submission to FracFocus. All of the states responding indicated that they were either neutral, satisfied, or very satisfied. No state indicated it was dissatisfied. We did not have a response to this question that allowed respondents to draft their own statements; however, two states used other comment areas to specifically address the trade secret issue. One state commented, "we have a trade secret process -- that is not FracFocus's purview." Another state noted that "[a]lthough FracFocus provides the capability to list legislatively protected trade secret and proprietary business information chemicals in a systems approach, each state has their own requirements for protection of this information."

Overall Satisfaction and State Views Regarding FracFocus

Because we expected there would be aspects of FracFocus and the states' use of it that went beyond the specific questions asked, we asked respondents how satisfied they were with the Registry overall. Forty-six percent responded that they were "very satisfied," 38% indicated they were "satisfied," and 15% indicated they were "neutral." Not one respondent replied that they were "dissatisfied" or "very dissatisfied." These results are significant because these respondents are the very ones charged with enforcing the hydraulic fracturing regulations. Surely if FracFocus was anything like the "fail[ure]" described in the Harvard Report, these respondents would have been the first to notice it. On the contrary, our survey results demonstrate that state regulators overwhelmingly find the site a useful and important regulatory tool.

Interestingly, the question that received perhaps the most robust response from regulators was one asking states to write anything they would like us to know about how regulators view FracFocus. The comments from the regulators are below (with any identifying information deleted). Each paragraph represents a different state's response, with minor typos or grammatical errors corrected and key comments highlighted in bold.

"The issue of trade secret status of chemicals used in hydraulic fracking is probably the most important issue regarding the hydraulic fracking debate."

"It appears to offer some queries that provide[] useful information."

“In the past, it has been helpful to direct citizens to the website when they have concerns regarding chemical disclosure of fluids used for hydraulic fracturing”

“I think the overall opinion of regulators is positive. My only suggestion would be to allow bigger data dumps by regulators. We are currently limited to a six month period”

“FracFocus has been a very handy tool to identify what types of chemicals companies are using in their hydraulic fracturing stimulations in our state. I am able to use the information we get from the query that our database creates to determine which companies are using diesel fuel in their stimulations, and to cross reference that with the information that is on FracFocus pretty easily. . . . I use FracFocus at least twice a week to determine which companies are out of compliance with our regulations, so I am pretty familiar with the site and how easy it is to use. The information that is provided is also great because it lets a person know what most of the chemicals are that are being used for a specific well, and the information is generally pretty user friendly to read. In my experience, I feel like some companies feel as if reporting to the FracFocus website is a joke, but once they have to hear from me, they quickly understand that this is not a joking matter and that it is important to report not only because it is a state regulation, but because the people want to know as well.”

“It is quite effective and an efficient way to access, in a consistent format, hydraulic fracturing chemical data; and, to make that data readily available to the public.   Although FracFocus provides the capability to list legislatively protected trade secret and proprietary business information chemicals in a systems approach, each state has their own requirements for protection of this information.”

“We believe FracFocus has been a positive tool to assist in the disclosure of hydraulic fracturing information.”

Increasing Use of FracFocus

In the four calendar years FracFocus has been active or accepted submissions (January 1, 2011 through December 31, 2014), the website has received 1,090,512 hits, with 744,649 of these representing unique hits (Ground Water Protection Council, 2014). These numbers have been trending upwards each year.

States overall have a very positive view of FracFocus and are using it in their regulatory programs in robust and even novel ways. They overwhelmingly informed us that the timing of submissions is either quite good or not an issue, with no states expressing dissatisfaction with the time in which they are notified of submissions to the site. These findings directly contradict the opinion set forth in the Harvard Report regarding the timeliness of submissions. The Harvard Report concluded that “FracFocus does not notify a state when the site receives a disclosure form about a well in that state. Nor can most states readily determine when a disclosure is made” (Konschnik, 2013). It is not clear how the Harvard Law School researchers reached this conclusion regarding FracFocus, but it is not supported by the experience of the regulators.

The states also viewed the Registry's approach to identifying trade secrets positively, with no states objecting to the way FracFocus handles submission of trade secret information. The Harvard Report's critical view, claiming that FracFocus failed because it did not contain a "robust trade secret regime" (Konschnik, 2013), does not fit with the regulators' perspectives. In written comments, many states make clear that they never expected FracFocus to address the issue of trade secrets and the public's right to information because this was a responsibility of state law, not a failure of the chemical disclosure registry. Indeed, many fail to see how a national registry such as FracFocus would have the capability or the jurisdiction to address trade secret claims in the way that the Harvard Law School researchers demanded. As the states surveyed were apparently well aware, each state has its own laws regarding what constitutes a trade secret and what procedural mechanisms for making or challenging a trade secret claim are available, as well as differing courts or administrative bodies for interpreting the law and ruling on trade secret disputes. This kind of "robust trade secret regime" is well beyond the purview of a national chemical disclosure registry. As one state regulator succinctly wrote, "we have a trade secret process – that is not FracFocus' purview."

States also made no objections regarding the need for state specific forms. Some regulators indicated they often compared submissions to FracFocus with submissions made to the state to ascertain compliance. Other states made their own pie charts with the data that is available on FracFocus, but the lack of forms that are targeted to individual states was not an issue raised by the state regulators and did not appear to impact their generally positive view of the utility of the Registry.

Finally, the results of the survey indicate that FracFocus has provided an extra measure of accountability for operators, in that several states are using the site to double check submissions that are made to the state against submissions made to FracFocus, and are promptly following up with operators when compliance issues come to light. Some have even used information obtained from FracFocus to support enforcement actions. As one of the regulators effectively stated, "I feel like some companies feel as if reporting to the FracFocus website is a joke, but once they have to hear from me, they quickly understand that this is not a joking matter." State regulators are also downloading data from FracFocus and creating their own spreadsheets and graphics with data they deem important to their own state programs. States are using FracFocus features that allow oil and gas well inspectors to quickly access well information when they need it. Indeed, states are using FracFocus in ways perhaps not even dreamed of by its creators: to monitor earthquake issues or the illegal use of diesel fuel in fracturing treatments.

Conclusions and Policy Implications

The national attention received by the Harvard Report has surely been harmful to a serious effort to strike a balance between the needs of the public and regulators, and the property rights of oil and gas service companies. We have demonstrated that far from being a "fail[ure]," FracFocus actually does an excellent job with respect to the very issues on which the Harvard Report expressed concern: in general, FracFocus delivers information on a timely basis, provides data on the crucial issues of the nature of the chemicals used in fracturing, and supports states in their efforts to enforce state specific chemical disclosure laws while providing a mechanism to identify and maintain trade secret protection to an acceptable degree.

This paper represents the first comprehensive survey of state regulators and the first attempt to obtain a data-driven analysis of how FracFocus is being used and whether it is effective as a regulatory tool.   The survey had a very high response rate for a study of this kind at 70% (Sheehan, 2006), increasing confidence in the results.

In the national debate regarding hydraulic fracturing, discussions are often driven by emotions rather than facts; the Harvard Report, a paper from a prestigious research university, was never subjected to peer-review and yet was well covered by the press, was used to inform the Department of Energy's Task Force Report on FracFocus 2.0 (USDOE, 2014a), and inevitably increased the heat of the debate without taking into consideration all of the relevant facts. This is unfortunate because, as our study shows, websites like FracFocus are an important tool for regulators in the responsible development of domestic oil and gas resources and for keeping the public informed. At present, we are not aware of another chemical disclosure registry such as FracFocus which allows such easy access to information regarding chemicals used across an entire industry and searchable by specific location. At least one regulator also noted the uniqueness of this registry: "Very few of [the state agency's] environmental programs have access to electronically available chemical data for the activities they regulate."

The use of FracFocus continues to increase every year. Additional oil and gas producing states and the federal government continue to adopt FracFocus as a legally required mechanism for the reporting of fracturing fluid information. Kentucky became the most recent state do so, with its law taking effect in June 2015, and Michigan's rules requiring the use of FracFocus took effect in March 2015.   The United States Department of the Interior, Bureau of Land Management also adopted reporting to FracFocus with respect to hydraulic fracturing on certain public lands in March of this year (USDOI, 2015). The U.S. Environmental Protection Agency used FracFocus data to generate certain state-level summaries on chemical data and water usage (EPA 2015b). EPA also is relying on FracFocus data to support its study on the impacts of oil and gas development on drinking water resources (EPA 2015b), the draft of which was released in June 2015 (EPA 2015c). Finally, in May 2014 EPA issued an Advance Notice of Proposed Rulemaking (ANPR) soliciting comments as to whether EPA should develop regulations under its Toxic Substances Control Act (TSCA) authority governing the reporting of chemicals used in hydraulic fracturing, including whether the FracFocus registry should be included in any proposed rule (EPA, 2014).   The ANPR received over 235,000 comments that are currently under review by EPA.

FracFocus continues to evolve and has been responsive to changes suggested by the federal government, authors of the Harvard Report, and other stakeholders. The third version of the Registry, FracFocus 3.0, is expected to be released in 2015 and will adopt many of the recommendations set forth in the Secretary of Energy Advisory Board (SEAB) report (Department of Energy, 2014b), including improved quality control and improved data and search functions (FracFocus, 2015d).

The results of our survey show how third party data collection sites such as FracFocus can provide considerable support to regulators, inform the public, as well as provide consistency to a regulated community that operates nationwide.

In direct contrast to the Harvard Report's conclusion, the data demonstrate that FracFocus is a strong regulatory tool that is being used by the majority of the largest oil and gas producing states to support their programs. The results of this study may be used to share information among states regarding additional ways to use FracFocus to augment existing regulatory programs. For example, the survey results indicate that states may be able to make more use of the water volume usage being reported to FracFocus. Indeed, it is likely that states will continue to develop new ways to use the significant data available on FracFocus and it would be helpful for states to have the benefit of other states' efforts. The results of this study may facilitate such an exchange.

As other oil and gas producing states consider how to manage chemical disclosure, FracFocus should receive serious consideration, not only for its chemical disclosure attributes, but for the varied beneficial uses that regulators (and potentially others) will continue to make of the available data. Operators and service companies often operate across state lines (some across many state lines) and consistency of disclosure obligations between states make accurate reporting more likely and lessens regulatory burdens. The data obtained in this study support the continued use of FracFocus.

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4. Assessing Impacts to Transportation Infrastructure from Oil and Gas Extraction in Rural Communities: A Case Study in the Mississippi Tuscaloosa Marine Shale Oil Play

Introduction and Background

Oil and gas may be unique among major manufacturing businesses because of the decentralized location of the source of the economic activity – the well. When a major business decides to locate in a rural area, it is often easier for state legislators to see the benefits of investing in surrounding infrastructure. As a result, many states are more willing to provide local governments with transportation-related grants or financial assistance programs designed to attract "brick and mortar" businesses. For example, Florida has developed an Economic Development Transportation Fund (the "Road Fund") which provides up to $3 million to local governments to improve public transportation for a specific company's new location or expansion (*1*).

In the case of oil and gas it has proved more difficult in some states to convince lawmakers to invest in transportation infrastructure and maintenance at the local level. Some local officials we surveyed believe the reason for this is the lack of a single business location. Oil and gas wells -- and the heavy trucks that service them -- tend to be spread out within a county, mostly dotting the rural landscape on private property, often not visible from public roads. This is especially the case in the Tuscaloosa Marine Shale (TMS) oil play in Mississippi, which does not have a history of the large-scale high-volume hydraulic fracturing that other communities have experienced, but is well positioned for growth. Accordingly, the TMS provides an important case study with potential to assist other rural communities that may be impacted when oil prices support renewed drilling activity

Across the nation, the roads most negatively impacted by traffic associated with high-volume hydraulic fracturing and horizontal drilling are those local and county roads that are outside of the federal or state system. State and federal highways are primarily maintained by a state's department of transportation and generally receive revenue generated by the gas tax and from the federal government. State and federal roads, unlike county and rural roads, are therefore generally built to support the high volume of heavy truck traffic that modern oil and gas development demands. Accordingly, truck traffic does not damage state roads as significantly as it impacts local roads. This presents a special bind for counties or townships that are responsible for rural roads: Counties and rural communities have less money than the state to address maintenance and repair, often do not get a share of the fuel tax that the state receives to provide for roads (or if they do, it is inadequate), and yet their roads are the most severely impacted and far more in need of funding during oil and gas operations.

Drawing from existing literature and the data gathered, we set forth potential strategies that states and under-funded counties may employ to maintain local road quality when drilling increases in the future, and we identify important underutilized and novel data sources to assess impact potential. The current decline in drilling activity across the country presents an ideal time for oil and gas producing localities to assess their approaches to road maintenance and encourage responsible development of petroleum resources while preserving transportation infrastructure.

The experience of other shale oil and gas states have demonstrated that the importance of time cannot be overstated. Local and county roads are typically not designed for the volume of heavy truck traffic that modern drilling necessitates, and as a result these roads can incur immediate and significant damage. As Bierling noted, "when the energy sector moves into a new area, the impacts on infrastructure are extremely rapid; years of damage can occur in a few weeks" (*2*).

Hydraulic Fracturing and Horizontal Drilling

Horizontal (or directional) drilling is a well drilling technique in which the drill bit first moves down vertically through the rock formation, and then angles off horizontally to drill laterally through the formation.

Hydraulic fracturing is a process by which the well is stimulated to produce viable quantities of oil or gas and begins after the well is drilled. The process involves pumping a mixture consisting primarily of water and sand, and approximately 0.5-2% chemicals, at high pressure down the well to create fractures in the rock where oil or gas is trapped, allowing it to more freely flow or be pumped to the surface for collection (*3*).

Both horizontal drilling and hydraulic fracturing are old technologies, but together and with recent advances, they have enabled companies to access oil and gas resources that were previously uneconomical to produce, enabling what has often been referred to as the "shale revolution" and "one of the landmark events in the 21st century" (*4*), bringing the United States to the top of the list of the world's oil and gas producing nations (*5*).

It is well accepted that hydraulic fracturing and horizontal drilling are necessary components to a continued and robust domestic oil and gas industry, accounting for nearly 80% of new wells drilled in the U.S. as of 2014 (*6*). Well development requires heavy truck traffic to construct, drill, and fracture the well, and to move produced materials (water and oil/gas) to processing stations and ultimately to market. Road impacts associated with oil and gas development have been studied extensively in recent years, with estimates of 890-2,300 heavy truck trips needed per well (*7, 8, 9, 10, 11, 12*). Most of the heavy truck trips are compounded to a few weeks or months during the initial well development and hydraulic fracturing phases, and tend to decrease during the production phase (40). Local and rural roads across the nation were constructed primarily to transport agricultural products, and many oil and gas producing communities have struggled with the rapid deterioration of their infrastructure and inadequate resources to address these new impacts. For example, one study estimated 3700-4400 truckloads needed *per year* for cattle shipments, not far from the truck volumes that are occurring *over a matter of weeks and months* during some well development (41).

The Mississippi Tuscaloosa Marine Shale Oil Play

The Mississippi TMS is predominately a tight oil play located mostly in central Louisiana but also spans several counties in Southwest Mississippi. An oil or gas "play" describes a series of oil or gas fields in the same area that share similar geology (e.g., depth). In this paper, we focus on two counties in Mississippi that have experienced most of the TMS drilling operations: Amite

County and Wilkinson County. As of February 2016, five oil companies in the Mississippi TMS had produced a total of approximately 6,200,000 barrels of oil, with virtually all of that production occurring in Amite and Wilkinson counties (Figure 1).

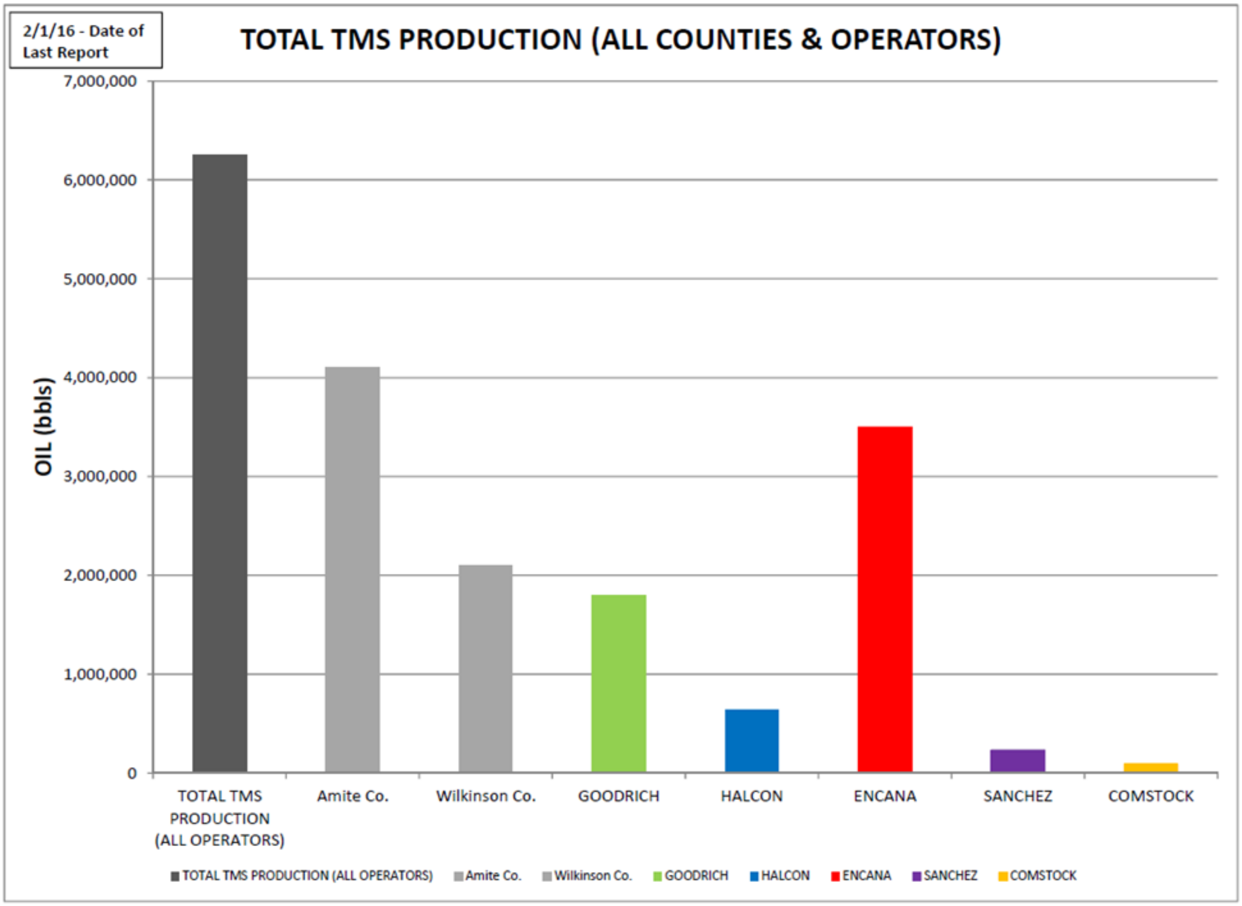

Figure 1. Total TMS Oil Production by County and Operator. Source: Mississippi Oil and Gas Board.

In 2013, the State of Mississippi reduced the severance tax to attract large-scale horizontal drilling in the TMS (*13*). However, while state governments seek to attract oil business, there have been few major efforts at the state level to pro-actively address the impacts to rural roads that will accompany any significant increase in drilling in the TMS. Any efforts that were underway largely stopped when drilling activities slowed given the drop in oil prices.

Currently, Mississippi's proven reserves of oil are considered small in comparison to other U.S. states (Figure 2). However, there are studies suggesting that the TMS may hold as many as 7.0-9.1 billion barrels of recoverable oil (*14, 15*), making it larger than the Baaken in North Dakota. Accordingly, the TMS has tremendous growth potential (*16*).

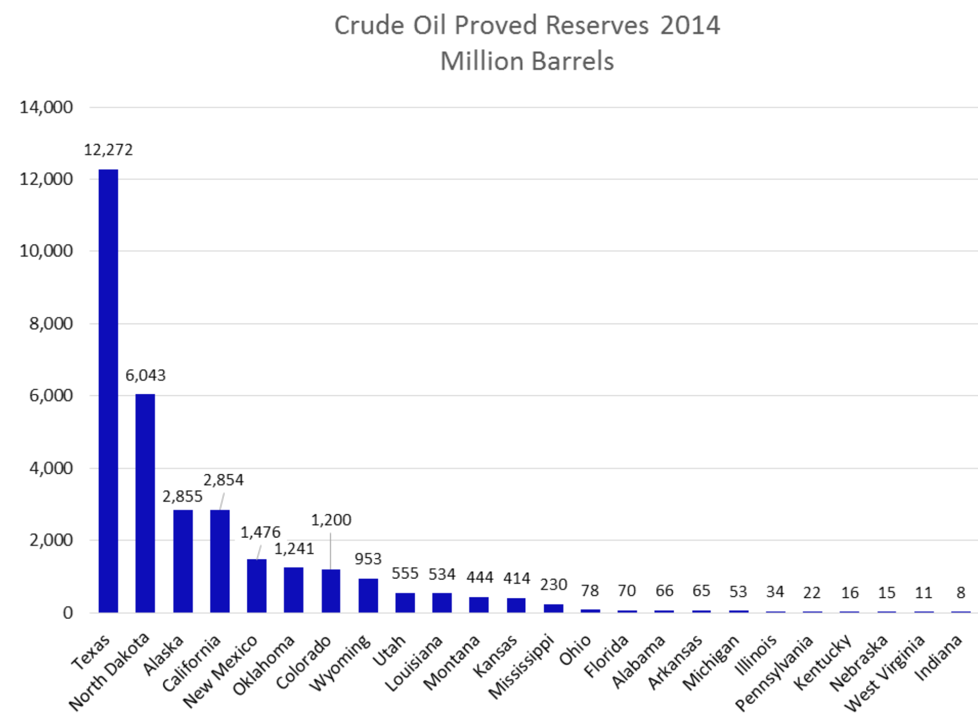

Figure 2. Proven oil reserves by state. Source: authors compiled data from the U.S. Energy Information Administration

Materials, Methods and Data

To gather data on estimating impacts to roads from oil and gas development, and to identify best practices for rural communities to address those impacts, we first conducted a literature review of the primary studies. A plethora of studies have addressed the impacts of oil and gas development on transportation infrastructure (*2, 7, 8, 9, 10, 11, 12, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30, 31, 32, 33).* Many of these studies provide important data, impact formulas that quantify the relationship between truck traffic and road degradation, including potential economic impact to roads expressed on a per-well basis, and methodologies to further quantify road impacts. Implementing many of these methods often requires sophisticated data on local road conditions using video or other monitoring equipment or personnel that may not be available in rural communities.

To develop a methodology to address this gap, we attended in-person meetings of the "Transportation Pooled Fund Project: State Responses to Energy Sector Developments," a multi-state effort funded by eight state Departments of Transportation (DOTs), which included meetings and discussions among DOT representatives from Montana, Pennsylvania, Ohio, Texas, North Dakota, Louisiana, Washington, and California (*34*). We conducted follow up interviews with several of these states.

We also interviewed local property owners in the Mississippi TMS with leased wells on their land, and local officials in Pike, Amite, and Wilkinson counties. We included Pike County, despite the lack of major TMS oil production there, because Pike County roads are impacted by neighboring county oil development. Additionally, we contacted members of the County

Boards of Supervisors with responsibility for roads, attorney advisors to the Board of Supervisors, port officials, and county economic development authorities. We obtained data and information from the Mississippi Oil and Gas Board (MSOGB), and interviewed officials from the Mississippi Department of Transportation (MDOT) and the MDOT Office of State Aid Road Construction. Finally, we mined well-specific data from FracFocus.Org on water volume use. All interviewees' names or positions were kept confidential to respect privacy and confidentiality.

By combining data from these different sources, we developed a methodology that can convey important information about the magnitude and potential locations of transportation impacts from increased drilling, and inform mitigation responses achievable in under-funded communities.

Data Sources and Method of Analysis

Water Volume

The amount of water used in a fracturing job and how that water is transported to and from the well site is arguably the largest predictor of heavy truck trips and consequent road impacts (*11*). Communities concerned about road impacts should better understand water use. Water data used in the fracturing process is now collected as part of mandatory and voluntary reporting to FracFocus.Org, and therefore can now be more easily accessed by planners than in the past. FracFocus.Org is a hydraulic fracturing chemical disclosure registry established to provide the public with information, on a well-by-well basis, of the chemical constituents used in the hydraulic fracturing process. Many states have now adopted mandatory reporting to FracFocus.Org for hydraulic fracturing operations (*35*), including Mississippi. Although FracFocus.Org is primarily considered a chemical disclosure reporting site, many transportation planners may not be aware that the forms submitted to FracFocus contain information regarding the total volume of water used to hydraulically fracture a well.

We mined data from FracFocus.Org for every available TMS well in Wilkinson and Amite counties. We recorded the water volume used per well by well name, and then compared these with the well names in the data obtained from the MSOGB on currently producing TMS wells to assure we were using well and water data only on the wells located in the Mississippi TMS. Using this process we verified that fifty-two of the fifty-four TMS wells listed with the MSOGB were also listed on FracFocus.

Roads and Bridges

To visually display where roads or bridges may be most impacted or vulnerable to increased oil development, we combined and analyzed data on existing and potential well sites, salt water disposal well locations, bridge conditions, and road segments by the government entity with maintenance and repair responsibility for those segments. This data was obtained from MDOT, MSOGB, and the National Bridge Inventory (NBI).

Bridge Data. To obtain bridge condition data for Wilkinson and Amite counties, we used GIS shapefiles of the NBI. The NBI ranks bridges according to a rating scale for various bridge elements. We selected two attributes likely to be most indicative of the ability of the bridge to withstand increased heavy truck loads -- superstructure and substructure conditions – and averaged their rating scores. The rating scales for both superstructure and substructure (Items 59 and 60 in the NBI elements) were the same and are as follows:

N = NOT APPLICABLE

9 = EXCELLENT CONDITION

8 = VERY GOOD CONDITION - no problems noted.

7 = GOOD CONDITION - some minor problems.

6 = SATISFACTORY CONDITION - structural elements show some minor deterioration.

5 = FAIR CONDITION - all primary structural elements are sound but may have minor section loss, cracking, spalling or scour.

4 = POOR CONDITION - advanced section loss, deterioration, spalling or scour.

3 = SERIOUS CONDITION - loss of section, deterioration of primary structural elements. Fatigue cracks in steel or shear cracks in concrete may be present.

2 = CRITICAL CONDITION - advanced deterioration of primary structural elements. Fatigue cracks in steel or shear cracks in concrete may be present or scour may have removed substructure support. Unless closely monitored it may be necessary to close the bridge until corrective action is taken.

1 = “IMMINENT" FAILURE CONDITION - major deterioration or section loss present in critical structural components or obvious vertical or horizontal movement affecting structure stability. Bridge is closed to traffic but corrective action may put it back in light service.

0 = FAILED CONDITION - out of service; beyond corrective action

We excluded bridges marked as “N” (which were most often culverts) and then averaged the NBI rating for superstructure and substructure condition for each bridge within Amite and Wilkinson counties to obtain a final bridge condition score. We then utilized three rating colors for purposes of mapping these bridges and displaying their conditions, as set forth in Table 1. Bridge colors displayed in Figures 5-7 correspond to these condition ratings.

Bridge Point Color	Range of Final Average Ratings of Bridge Condition	Condition Ratings Scale (from NBI)	
Red	0-4.5	0 = failed	5 = fair
Orange	5-6.5	1 = imminent failure	6 = satisfactory
Green	7-9	2 = critical	7 = good
		3 = serious	8 = very good
		4 = poor	9 = excellent

Table 1. Color Display Scale for Final Rating Score

Dividing the bridge conditions into three color-coded rating levels allows planners to more easily assess priorities, and we chose division points that would accurately reflect the level of risk presented by the bridge if heavy truck traffic substantially increased. Bridges that ranked below "Fair" (average score of 4.5 or below) could reasonably be assumed to be at the highest risk of impacts if major increases in heavy truck traffic occurred and should therefore generally be given priority by planners. Bridges ranked "good" or better (average score of 7 and above) generally could be expected to have a greater ability to withstand increased truck traffic. Bridges colored orange (average score of 5-6.5) are considered "fair" or "satisfactory" and fall within an area of caution if truck traffic increased significantly, but may not be as highly prioritized as those bridges ranked below "fair" if resources are limited.

Road Data. We interviewed members of the MDOT and MDOT's Office of State Aid Road Construction which provides funding for some county roads. We also interviewed county government officials in Wilkinson, Amite, and Pike counties to better understand local funding for road repair and maintenance. We obtained road functional class data from MDOT in the form of GIS shapefiles which we extracted by county. For Amite and Wilkinson counties, we selected road segments by the entity responsible for maintenance and repair, and color-coded these segments to distinguish the responsible county government.

Well Locations

Oil Wells. The MSOGB maintains data regarding oil wells in the TMS. When Mississippi lowered the severance tax on horizontal wells, the MSOGB segregated data on these wells in the TMS in the database under the shale name "Tuscaloosa Marine Shale Oil Pool." There are very few vertical wells that are drilled in the TMS and vertical wells do not produce the substantial truck traffic associated with horizontal wells (*12*). Accordingly, the fifty-four horizontal wells listed by the MSOGB in the Tuscaloosa Marine Shale Oil Pool database can be expected to contain all of the wells of interest in the TMS at the time the data was generated in February 2016.

We converted the TMS well database into a GIS layer. From that larger dataset, we extracted all wells that were currently producing, all wells for which a permit had been obtained, all wells for which a permit had been obtained but the operator had let the permit expire, and all wells for which the permit had been obtained but the permit was cancelled.

Currently producing wells have an accurate location (latitude and longitude) that the MSOGB field inspector collects when the well is spudded (when the drill bit enters the ground on its way to the authorized depth); however, permitted wells generally do not have a latitude and longitude associated with the permit application. In the earlier part of this decade, because of the potential oil "boom" in the area and the rush of permit applications submitted, MSOGB began collecting an estimated latitude and longitude on permit applications. Accordingly, for some permitted wells in the TMS, an approximate location is available which allows planners to map locations of potential well sites where trucks will be entering and exiting, providing insight as to which areas of the county (and specific roads) are likely to experience more truck traffic if drilling increases. As of the date of our collection of permit data (February 2016), there were 160 actively permitted wells in the TMS, and 18 of those do not have associated latitude and longitude. There were 247 wells with cancelled or expired permits, and the majority of those wells (163) do not have an associated latitude or longitude. There are 54 actively producing wells.

Lease activity is generally recognized as a leading indicator of potential future oil and gas growth in an area (*36*), as is the number of drilling permits issued (*17, 32*). Permit data often can be more easily accessed by local planners and will provide important information on the number and location of potential well sites. Understanding the location of permitted sites enables a better assessment of which roads may experience increased truck traffic and the potential magnitude of those increases.

If information of well development is communicated to those with responsibility for local roads early in the process, counties may have more time to analyze potential impacts to roads around a particular well site and react.

Water Sources and Salt Water Disposal Wells. Drilling and hydraulically fracturing an oil well requires substantial volumes of water. Much of the fresh water used in the hydraulic fracturing process flows back to the surface (called "flowback water"). Wells also produce water along with oil or gas (called "produced water"). Flowback and produced water must be disposed of or treated before release to the environment. In the TMS, virtually all of the flowback and produced water is trucked to underground injection wells for disposal, otherwise known as salt water disposal wells (SWDs), which are regulated by the MSOGB. We obtained shapefile data from the MSOGB in order to display the locations of the SWDs in relation to existing or potential future oil wells to enable planners to better identify which rural roads are most likely to be impacted by trucks leaving oil well sites to dispose of water at SWDs.

Results and Discussion

Water Volume Used in Hydraulic Fracturing in the TMS

One of the most surprising findings of our study is that the water volumes being used in the TMS for hydraulic fracturing are substantially larger than the national average, which has serious implications for road impacts. A preliminary draft of a U.S. Environmental Protection Agency (EPA) study collected data on water use from FracFocus and concluded that the national median volume of water used during hydraulic fracturing operations at a single well is 1.5 million gallons (*37*). However, EPA noted that this estimate includes many types of wells, including vertical wells, which typically use less water than horizontal wells. Looking specifically at horizontal wells, a recent study found that the national median water volume used to hydraulically fracture a horizontal oil well is approximately 4.0 million gallons (*38*). By contrast, we found that the median water volume used to fracture an oil well in the TMS is 11.9 million gallons, nearly three times the national median for these types of wells (Figure 3). Factors that influence the volume of water needed per well tend to be local in nature, such as the geology of the formation and the technology used at the well (39).

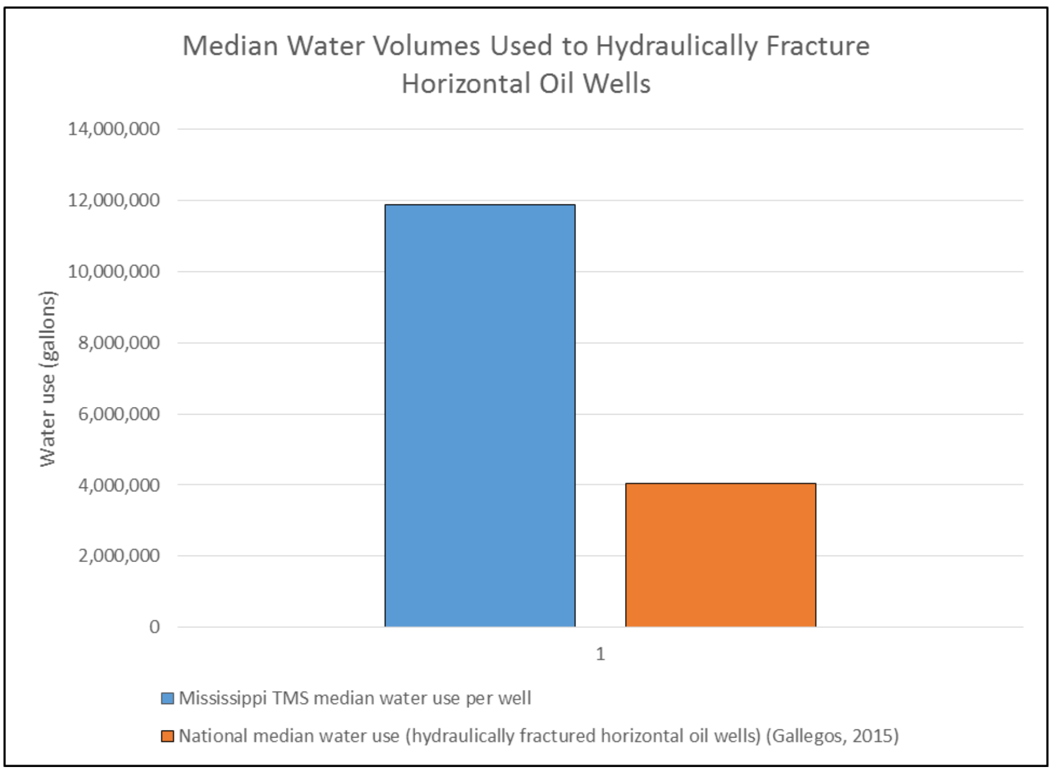

Figure 3. Comparison of median water volumes used to hydraulically fracture an oil well in the Mississippi TMS and nationally.

Figure 4 shows the average water use per TMS well, along with the maximums and minimums per well. This finding is significant because even if all the fresh water used in the fracturing process is piped to the well (which it is not), EPA estimates that 5-75% of this water will return to the surface and must be managed (*37*). In Mississippi, and in many other states, this flowback water is being trucked, along with produced water, to SWD wells for disposal.

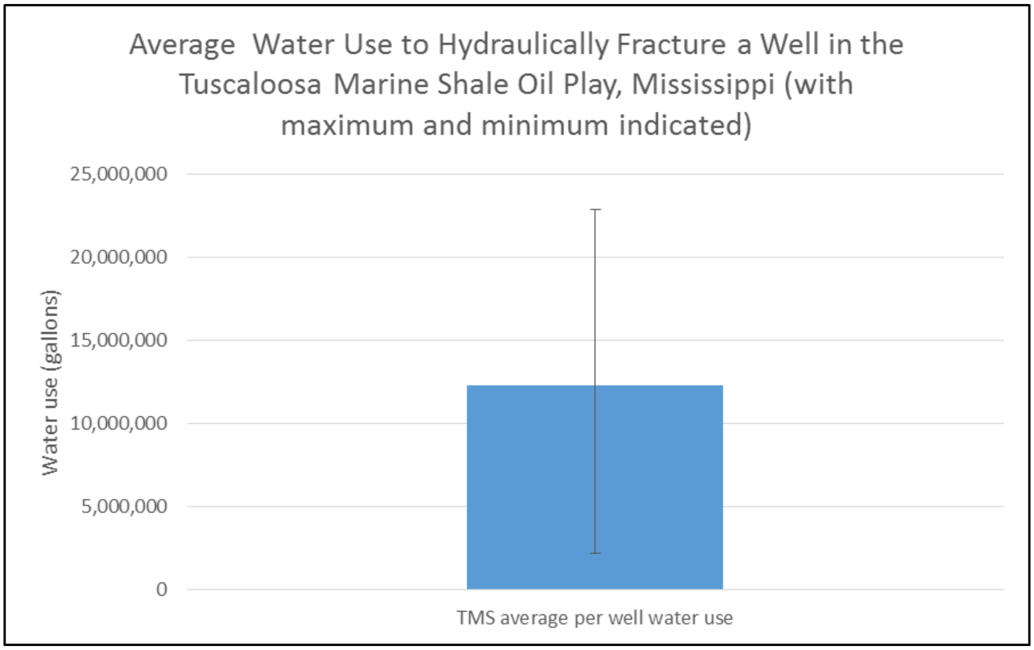

Figure 4. Average water volume used in hydraulically fracturing a well in the Mississippi TMS oil play. Black bar represents the minimum and maximum water volume usage per well.

If only 10% of the median water used in a horizontal TMS fracturing job flows back to the surface for disposal, approximately 1.2 million gallons would be transported in almost 200 tank trucks (assuming 6,000 gallon truck capacity), each weighing upwards of 88,000 pounds over a matter of days or weeks (*32*).

Methodology to Assess Projected Areas of Impact

Combining spatial data regarding the location of: 1) producing and permitted wells; 2) underground injection wells where produced and flowback water from wells will be trucked for disposal; and 3) county roads and bridges with indicators of bridge conditions, can quickly inform planners of which road segments or bridges may warrant a more detailed analysis regarding their ability to withstand increases in heavy truck traffic. We assembled these data for both Wilkinson and Amite counties, with Figure 5 serving as an example of the spatial results compiled for Amite County. County roads are indicated in purple and are the responsibility of counties to maintain and repair. State roads are indicated in black and generally are built to higher standards and have more funding for repair.

Figure 5 shows that in Amite County, the vast majority of the prospective, permitted, and currently producing TMS wells are in the southern half of the county. In Wilkinson County (not shown), the southeastern portion of the state has more concentrated well activity (both currently producing wells and potential wells based on the locations of permitted wells). In Amite County, the SWD wells tend to be concentrated in the northeastern and southwestern parts of the county (Figure 5), whereas in Wilkinson County SWD wells are both more numerous and more dispersed throughout the county, with clusters near the Mississippi River on the western border and in the northeastern part of the county. Accordingly, depending on

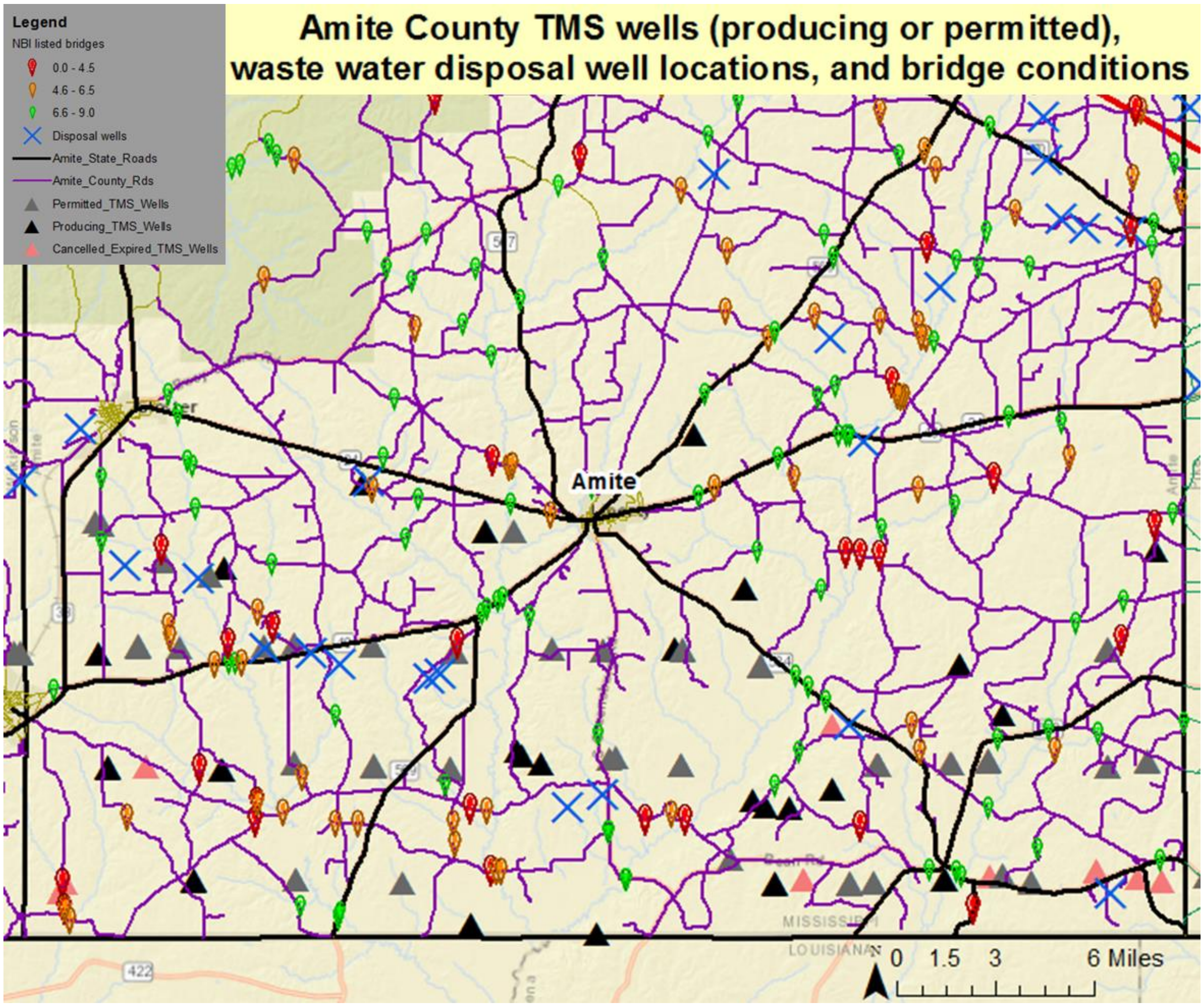

Figure 5. Amite County, Mississippi, active and potential oil well sites, waste water disposal wells, county and state roads, and bridge conditions.

SWD well capacity, routing trucks to particular SWD wells may be one method to mitigate road impacts. Planners can also take into account general directional flow of oil and water leaving a well to better understand what routes may be most impacted. Water will be headed to the SWD wells, but oil will often be headed for pipelines, ports, or trucked directly to refineries on the nearby Gulf Coast.

This methodology can also aid in identifying areas where the quickest route to a state road is one which involves traversing a bridge that may not be capable of withstanding increased truck loads (Figure 6), or areas where producing and permitted wells indicate a potential for future growth but coincide with a substantial number of vulnerable bridges (Figure 7). Although with

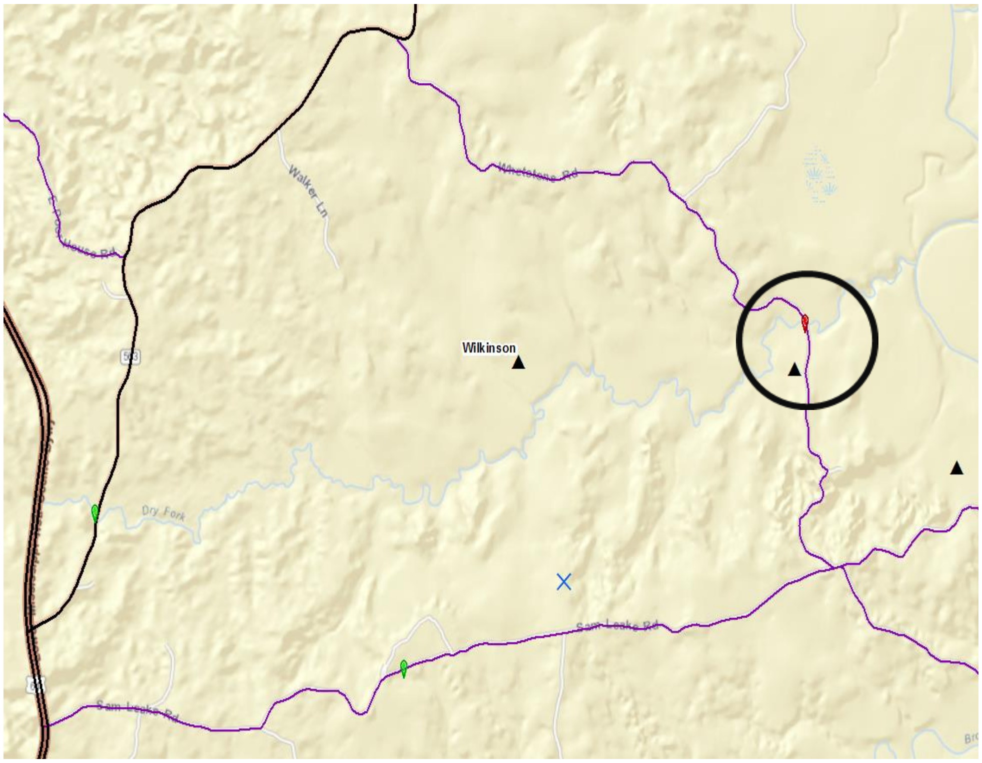

Figure 6. Wilkinson County well location (black triangle shown in circle) where shortest route to state road requires travel over sub-standard bridge.

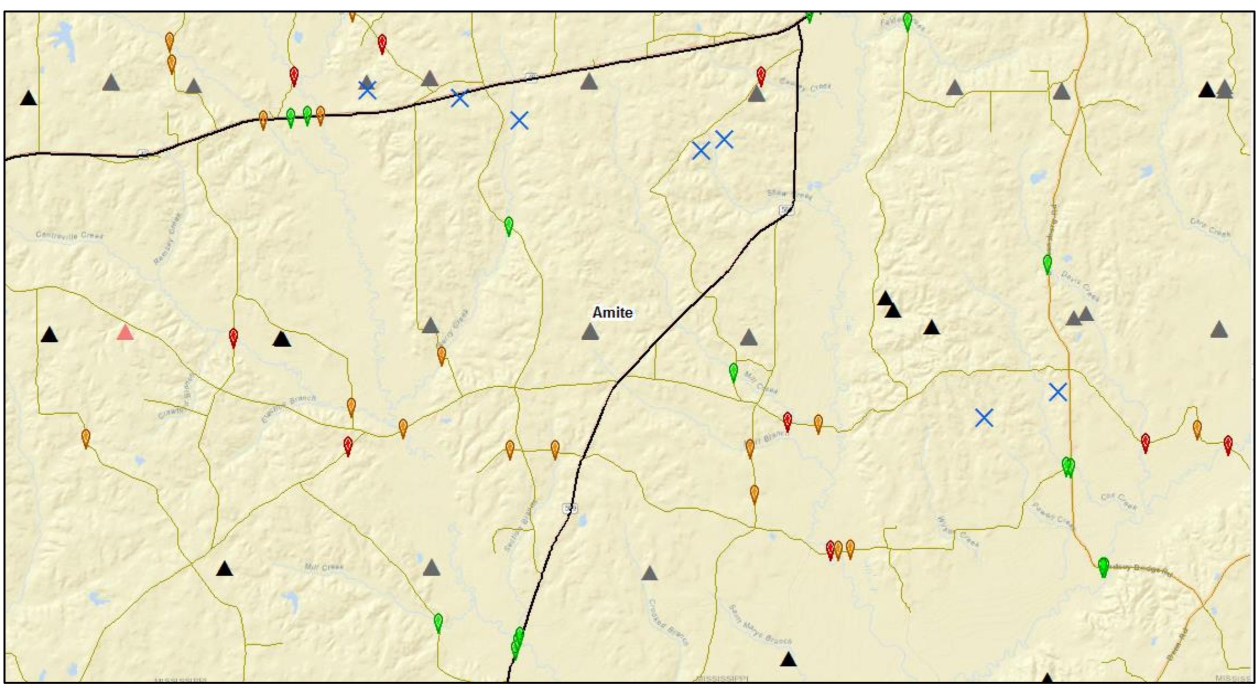

Figure 7. Amite County area with significant numbers of potential or already producing wells along county roads with numerous vulnerable bridges.

respect to roads a baseline assessment of current pavement conditions is an important component of understanding what impact any increase in truck volume will have (*12, 24*, *32*), understanding what routes and bridges are likely to be most impacted is a critical first step that can serve to better direct scarce resources and develop response strategies.

Conclusions

Local government entities could benefit from a spatial analysis that utilizes the locations of permitted and existing wells as a proxy for understanding where development is likely to continue and therefore what routes may be most impacted. While it may be difficult to obtain precise numbers of expected future truck volumes, this paper describes a methodology for determining what areas of a county (and therefore what roads) are likely to see increased traffic when drilling increases, and what bridges along those routes may be particularly vulnerable to increased heavy truck traffic. Understanding the primary sources of water, the likely destination points of water and oil leaving the well by truck, and road and bridge conditions (where it is possible to quantify with present resources) is also crucial to developing mitigation strategies.

Assessing water volume use per well is critical for local planners to reduce truck traffic by focusing on water management practices, such as piping fresh water to wells or treating and disposing of waste water on site. For underfunded local governments, these are relatively small investments that could provide important benefits.

States – especially poor states such as Mississippi – should be doing more to offset the significant burden to local roads that high volume hydraulic fracturing and horizontal drilling can bring to a concentrated area. Roads are expensive and counties are generally not funded sufficiently to maintain roads beyond the "farm-to-market" types of trucking activity for which their roads were originally designed. Access to well sites is critical for a robust energy sector, and where states seek to encourage responsible development of these resources to promote economic growth, states should direct funding – whether from severance taxes or otherwise – at levels sufficient for counties to provide adequate infrastructure.

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