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Shake, Rattle, and Oil: The Environmental Impacts of Wastewater Injection Wells on Earthquakes and Water Usage

Rebecca English
Texas A&M University School of Law

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SHAKE, RATTLE, AND OIL: THE ENVIRONMENTAL IMPACTS OF WASTEWATER INJECTION WELLS ON EARTHQUAKES AND WATER USAGE

By Rebecca English[†]

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[†] J.D. Candidate, Texas A&M University School of Law, Spring 2016; B.B.A. in Energy Management, University of Oklahoma, Spring 2009. I would like to thank my faculty advisor Gina Warren for her support and feedback on this Article. Lastly, I would like to thank my loving husband, for his unwavering support and encouragement throughout this entire process.

I. INTRODUCTION

With the notable increase in earthquakes across oil and gas producing states, the question of the potential cause of these seismic events has become an increasingly important topic. The central United States alone has had a substantial increase of earthquakes in just the past six years.¹ From the years 1973 to 2008 the central United States produced an average of twenty-four, magnitude 3.0 or higher, earthquakes per year.² From the years 2009–2014 there was an average of 193, magnitude 3.0 or higher, earthquakes per year, with 688 earthquakes recorded in 2014 alone.³ The practice of hydraulic fracturing has come under scrutiny as a possible cause of this seismic activity.⁴ However, recent scientific data from the United States Geological Survey links water injection wells as the potential culprit.⁵

This Article will delve into the possibility of wastewater injection wells as being the ultimate cause of the increased seismic activity in the United States. First it will outline the background of hydraulic fracturing and the water usage involved in the fracturing process. Next it will discuss the wastewater fluids as a by-product of the fracturing process and the resulting need for wastewater injection wells. Next this Article will outline the regulation of these fluids through the federal government and the state governments, with an emphasis on Texas and Ohio regulations. Lastly, this Article will outline two recommendations which will attempt to curtail the injection well-induced seismic activity problem: first by implementing quantitative field level permitting requirements, and second by expanding the implementation of water recycling techniques in the oil and gas industry.

II. HYDRAULIC FRACTURING: PAVING THE WAY FOR OIL AND GAS PRODUCTION AND THE RESULTING INCREASE IN WASTEWATER INJECTION WELLS AND INDUCED SEISMICITY

To be able to understand how oil and gas injection wells could correlate with earthquakes, one must fully understand the process of hydraulic fracturing, the wastewaters that are produced from the process, and the resulting need for the disposal of those wastewaters. This Section will lay the foundation for the hydraulic fracturing proce-

1. Justin L. Rubinstein & Alireza Babaie Mahani, *Myths and Facts on Wastewater Injection, Hydraulic Fracturing, Enhanced Oil Recovery, and Induced Seismicity*, 86 SEISMOLOGICAL RES. LETTERS 4, 1 (July/Aug. 2015), https://profile.usgs.gov/myscience/upload_folder/ci2015Jun1012005755600Induced_EQs_Review.pdf.

2. *Id.*

3. *Id.*

4. *Richter Magnitude Scale*, WIKIPEDIA, http://en.wikipedia.org/wiki/Richter_magnitude_scale (last visited Mar. 24, 2015) (stating that a seismic event with less than a 2.0 magnitude on the Richter Scale are considered “micro-earthquakes,” anything over 2.0 magnitude is considered an “earthquake”).

5. See Rubinstein, *supra* note 1.

ture by briefly elaborating on the science behind it, describing the amount of water used to hydraulically fracture a well and then by defining the wastewaters associated with it. Lastly, this Section will describe in detail the scientific data surrounding the connection between injection wells and earthquakes.

A. *Background and Context of Hydraulic Fracturing*

Beginning in the 1940s, newer technologies led to unconventional oil and gas drilling practices, which included hydraulic fracturing (“fracking”).⁶ Fracking did not become a widely used energy development technique until 2003 when natural gas was thrust into the spotlight as a highly viable energy source.⁷ Prior to these new technologies, domestic gas production in the United States was stagnant,⁸ but sharply increased when unconventional drilling became economical and energy companies started expanding their production capabilities.⁹ Fast forward to present day and the United States Energy Outlook for 2014 proposes that domestic production of oil and natural gas will continue to grow in the next several years,¹⁰ with the potential for exportation of natural gas for the first time in United States history by the year 2018.¹¹ In fact the amount of United States energy imports and exports are expected to be equal by the year 2019.¹² Exporting natural gas would not only provide jobs within the United States, but also generate geopolitical security for the nation.¹³ This development growth has been escalating significantly in the past decade. In 2007, the United States produced 1.293 trillion cubic feet of

6. *Hydraulic Fracturing*, WIKIPEDIA, https://en.wikipedia.org/wiki/Hydraulic_fracturing (last visited July 30, 2015) (stating that “fracking” is short for hydraulic fracturing).

7. *A Brief History of Hydraulic Fracturing*, EEC ENVTL., <http://www.eecworld.com/services/258-a-brief-history-of-hydraulic-fracturing> (last visited Nov. 30, 2014).

8. *Annual Energy Outlook 2012 with Projections to 2035*, U.S. ENERGY INFO. ADMIN. 61 (2012), [http://www.eia.gov/forecasts/aeo/pdf/0383\(2012\).pdf](http://www.eia.gov/forecasts/aeo/pdf/0383(2012).pdf).

9. *A Brief History of Hydraulic Fracturing*, *supra* note 7.

10. *Annual Energy Outlook 2014 with Projections to 2040*, U.S. ENERGY INFO. ADMIN. MT-24 (Apr. 2014), [http://www.eia.gov/forecasts/aeo/pdf/0383\(2014\).pdf](http://www.eia.gov/forecasts/aeo/pdf/0383(2014).pdf); see Michael Casey, *Natural Gas Exports Set to Take Off as Energy Department Approves Two New Projects*, FORTUNE (Sept. 10, 2014, 8:06 PM), <http://fortune.com/2014/09/10/natural-gas-exports-set-to-take-off-as-energy-department-approves-two-new-projects/>; see Zain Shauk, *U.S. Natural Gas Exports Will Fire Up in 2015*, BLOOMBERG BUSINESSWEEK (Nov. 6, 2014), <http://www.bloomberg.com/bw/articles/2014-11-06/u-dot-s-dot-natural-gas-exports-will-fire-up-in-2015>.

11. *Annual Energy Outlook 2014*, *supra* note 10.

12. *Annual Energy Outlook 2015 with Projections to 2040*, U.S. ENERGY INFO. ADMIN. ES-1 (Apr. 2015), [http://www.eia.gov/forecasts/aeo/pdf/0383\(2015\).pdf](http://www.eia.gov/forecasts/aeo/pdf/0383(2015).pdf) (stating that they will equal in the High Oil Price and High Oil and Gas Resource cases).

13. William O’Keefe, *An Inviting Opportunity for the American Energy Renaissance*, WASH. TIMES (Mar. 22, 2015), <http://www.washingtontimes.com/news/2015/mar/22/william-o-keefe-time-to-lift-restrictions-on-liquef/>.

shale gas, which increased sharply to 7.994 trillion cubic feet by 2011.¹⁴ In fact, by 2035 the combined shale resources are predicted to supply 49% of the country's natural gas production.¹⁵

In 2003 when hydraulic fracturing was propelled as the main technique to retrieve oil and natural gas, it comprehensively and permanently changed the industry. Indeed, with regard to shale gas, conventional vertical drilling has essentially been replaced by unconventional horizontal drilling in which fracking is used.¹⁶ Fracking is the process by which millions of gallons of water combined with additives such as gels, solvents, and sands are injected into the wellbore at extremely high pressures.¹⁷ This injection shatters or "fracks" the rock allowing for the shale rock to remain open so that oil or gas can migrate into the wellbore and be extracted at the surface.¹⁸

Despite the benefits fracking has brought to the energy industry, it has also brought an abundance of legal and policy issues. The legal issues that have come to light are mostly surrounding environmental problems, while the policy issues focus on energy independence, or the lack thereof for the United States. The environmental issues can range from animal displacement to water rights to earthquakes.¹⁹ Water problems associated with fracking are threefold: water pollution, water consumption, and the side effects of water injection wells on the underground seismic activity.²⁰ This Article will not discuss water pollution, but will focus on water consumption for fracking and the related need for disposal, such as injection wells and their potential effect on seismic activity.

B. *Fracking Water Usage and the Resulting Wastewater*

The process of hydraulic fracking initially requires large quantities of water. The amount required can range from as small as 1.5 million gallons per well to as large as 15.8 million gallons per well.²¹ This range varies with the type of geology of the rock formation, however,

14. Victor Flatt & Heather Payne, *Curtalement First: Why Climate Change and the Energy Industry Suggest a New Allocation Paradigm is Needed for Water Utilized in Hydraulic Fracturing*, 48 U. RICH. L. REV. 829, 834 (2014) (citing *Natural Gas Shale Gas Production*, U.S. ENERGY INFO. ADMIN., http://www.eia.gov/dnav/ng/hist/res_epg0_r5302_nus_bcfa.htm (last visited Aug. 23, 2015)).

15. *Annual Energy Outlook 2012*, *supra* note 8.

16. Jeffrey R. Ray, *Shale Gas: Evolving Global Issues for the Environment, Regulation, and Energy Security*, 2 LSU J. ENERGY L. & RESOURCES 75, 76–77 (2013).

17. *Id.* at 77.

18. *Id.*

19. See generally, *Unchecked Fracking Threatens Health, Water Supplies*, NATURAL RES. DEF. COUNCIL, <http://www.nrdc.org/energy/gasdrilling/> (last visited Nov. 30, 2014) (giving an example of a website that concludes hydraulic fracturing negatively impacts the environment in multiple ways).

20. Ray, *supra* note 16, at 81–83.

21. *Hydraulic Fracturing ("Fracking") FAQs*, U.S. GEOLOGICAL SURV., <http://www.usgs.gov/faq/categories/10132/3824> (last updated Aug. 19, 2015).

the average amount of water required to frack a well is between six and eight million gallons.²² It is estimated that there are over 1.1 million active oil and gas wells in the United States, excluding Texas and Colorado.²³ However other reports estimate Texas alone has more than 216,000 active oil and gas wells.²⁴ Out of this vast amount of active oil and gas wells it is estimated that 95% of the new wells being drilled today are hydraulically fractured.²⁵ Considering the amount of water necessary to frack a well and the estimated amount of active wells in the United States, the total amount of water used is sizeable. For example, in Pennsylvania alone there are 10,082 shale wells, which amounts to almost 40 billion gallons of freshwater used.²⁶

Once the well has been fractured and oil and gas production occurs, the question becomes how to dispose of the large amounts of contaminated wastewater that is generated during the fracturing process.²⁷ The amount of water that is produced back up the wellbore during the fracking process varies greatly depending on several factors including shale formation, location of the well, and operational techniques.²⁸ With that said, it has been estimated that 10,000–60,000 barrels of fluids can come back up the wellbore in a single hydraulic fracture.²⁹ At forty-two gallons per barrel,³⁰ this converts to an estimated 420,000–2,520,000 gallons of water returned to the surface. Out of the average of six to eight million gallons injected, this equals about 42%. However, the Environmental Protection Agency (“EPA”) has estimated that percentage could be even higher, between 10% and 70%.³¹ This contaminated water needs to be disposed of and wastewater injection wells are the most frequent and economical answer.³² But what

22. Flatt & Payne, *supra* note 14, at 833.

23. Matt Kelso, *Over 1.1 Million Active Oil and Gas Wells in the US*, FRAC-TRACKER ALLIANCE (Mar. 4, 2014), <http://www.fractracker.org/2014/03/active-gas-and-oil-wells-in-us/>.

24. *How Oil and Gas Disposal Wells Can Cause Earthquakes*, STATE IMPACT TEX., <http://stateimpact.npr.org/texas/tag/earthquake/> (last visited Nov. 30, 2014).

25. *Hydraulic Fracturing in the United States*, WIKIPEDIA, https://en.wikipedia.org/wiki/Hydraulic_fracturing_in_the_United_States (last updated Aug. 19, 2015).

26. Flatt & Payne, *supra* note 14, at 834.

27. Jeffrey M. Gaba, *Flowback: Federal Regulation of Wastewater from Hydraulic Fracturing*, 39 NO. 2 COLUM. J. ENVTL. L. 251, 265 (2014).

28. *Id.* at 266 (citing *see* U.S. GOV'T ACCOUNTABILITY OFF., GAO-12-156, ENERGY-WATER NEXUS: INFORMATION ON THE QUANTITY, QUALITY, AND MANAGEMENT OF WATER PRODUCED DURING OIL AND GAS DEVELOPMENT 10-11 (Jan. 9, 2012), <http://gao.gov/products/GAO-12-156>).

29. *Id.*

30. *Barrel (unit)*, WIKIPEDIA, [http://en.wikipedia.org/wiki/Barrel_\(unit\)](http://en.wikipedia.org/wiki/Barrel_(unit)) (last updated June 26, 2015) (stating that 1 barrel is 42 gallons).

31. OFFICE OF RES. AND DEV., EPA, STUDY OF THE POTENTIAL IMPACTS OF HYDRAULIC FRACTURING ON DRINKING WATER RESOURCES PROGRESS REPORT 19 (2012), <http://www2.epa.gov/sites/production/files/documents/hf-report20121214.pdf>.

32. *Basic Information about Injection Wells*, EPA, <http://water.epa.gov/type/groundwater/uic/basicinformation.cfm> (last updated May 4, 2012) (stating that injec-

exactly does this produced water consist of and why is injection the proper method of disposal?

C. *Definition of Wastewater Fluids*

The process of hydraulic fracturing has not only revolutionized the oil and gas industry, but also inadvertently shaped the water industry. Once the fracturing procedure is completed, the pressure from the fractured geological formation can cause the hydraulic fracturing fluid to flow back up the wellbore to the surface.³³ This water that arises to the surface can generally be categorized as “wastewater” and must be disposed of, treated, or reused for other fracturing procedures.³⁴ Wastewater fluids can be divided into three categories: drilling muds, flowback and produced brine.³⁵ Drilling muds consist of fluids mixed with additives that are continuously injected into the wellbore to lubricate and maintain the drill bit while drilling.³⁶ Flowback water is the fluid that comes to the surface following the fracturing of the wellbore.³⁷ This is a combination of the fluid used to frack the well and natural fluids that originate from the shale itself.³⁸ Lastly, produced brine consists of the fluids that occur after the well has been put on production.³⁹ These fluids are trapped in the geological formation with the oil and gas naturally, and arise when the oil and gas comes up the wellbore to the surface.⁴⁰

Bearing in mind the flowback and produced brine, an abundance of fluids can materialize from the well, which requires proper disposal. A Halliburton study on water recycling found that between 15%–40% of hydraulic fracturing fluid is returned as flowback in the Bakken shale (located in western Montana and eastern North Dakota); 20%–40% in the Permian Basin (located in West Texas); and 10%–40% in the Marcellus region (a shale that spans across parts of New York, Pennsylvania, West Virginia, Ohio and Kentucky).⁴¹ Despite the wide range of percentages, these numbers are substantial when considering

tion wells were a “safe and inexpensive option for the disposal of unwanted . . . byproducts”).

33. Rubinstein, *supra* note 1, at 3; *Hydraulic Fracturing Background Information*, EPA, http://water.epa.gov/type/groundwater/uic/class2/hydraulicfracturing/wells_hydrowhat.cfm (last updated May 9, 2012).

34. Rubinstein, *supra* note 1, at 4.

35. Brian G. Rahm et al., *Wastewater Management and Marcellus Shale Gas Development: Trends, Drivers, and Planning Implications*, 120 J. ENVTL. MGMT. 105, 106 (2013).

36. *Id.*

37. *Id.*

38. *Id.*

39. *Id.*

40. Rubinstein, *supra* note 1, at 2.

41. Pam Boschee, *Produced and Flowback Water Recycling and Reuse Economics, Limitations, and Technology*, OIL AND GAS FACILITIES 17 (Feb. 2014), ftp://ftp.consrv.ca.gov/pub/oil/SB4DEIR/docs/08_Boschee_2014.pdf.

the average six to eight million gallons of fluids referenced above⁴² that are initially used to frack the well.

D. *The Relationship between Wastewater Injection Wells and Earthquakes*

Hydraulic fracturing has come under scrutiny in the past decade creating polarizing effects on the public. The range of views stretches from those stating that hydraulic fracturing has been used for long periods of time without damaging affects to the environment,⁴³ to entire websites dedicated to protesting the process.⁴⁴ However, most recent data finds hydraulic fracturing is environmentally safe. In fact one study estimates that the likelihood that hydraulic fracturing could cause earthquakes is 1:10,000.⁴⁵ Similarly, an article written by William L. Ellsworth for *ScienceMag* states that “much of the concern about earthquakes and fracking centers on the injection of wastewater, composed of flowback fluids and coproduced formation brine in deep wells, and not on fracking itself.”⁴⁶ In fact, the Texas Railroad Commission recently commented in response to a Texas citizen’s concern about hydraulic fracturing being responsible for earthquakes that “a review of the numerous studies of seismic activity in areas with oil and/or gas exploration and production indicates that seismic activity induced by hydraulic fracturing is not likely.”⁴⁷ Because of these studies, the focus has shifted from hydraulic fracturing to wastewater injection wells.

Recent data put out by the United States Geological Survey (“USGS”) in early 2014, confirms the potential relationship between the induced seismic events and injection wells. As quoted in the article:

[T]he number of earthquakes has increased dramatically over the past few years within the central and eastern U.S. Nearly 450 earth-

42. Flatt & Payne, *supra* note 14, at 833.

43. Hannah J. Wiseman, *Risk and Response in Fracturing Policy*, 84 U. COLO. L. REV. 729, 734 (2013) (citing see, e.g., Joseph H. Frantz, Jr., *Natural Gas, Range Resources, and the Marcellus Shale*, DEVELOPMENT ISSUES IN THE MAJOR SHALE PLAYS, at 2–24, (ROCKY MOUNTAIN MIN. L. FOUND., MIN. L. SERIES, Vol. 2010 No. 5) (describing fracturing as “safe and proven. . . in its 60-year history”)).

44. See generally DANGERS OF FRACKING, <http://www.dangersoffracking.com/> (last visited Nov. 30, 2014) (showing an example of an entire website devoted to “dangers” of fracking).

45. Ray, *supra* note 16, at 85 (citing C.J. de Pater & S. Baisch, GEOMECHANICAL STUDY OF BOWLAND SHALE SEISMICITY 50 (Nov. 2, 2011), http://www.cuadrillaresources.com/wp-content/uploads/2012/02/Geomechanical-Study-of-Bowland-Shale-Seismicity_02-11-11.pdf).

46. William L. Ellsworth, *Injection-Induced Earthquakes*, 341 SCI. 1225942, 1225942–4 (2013), <http://www.sciencemag.org/content/341/6142/1225942>.

47. 39 Tex. Reg. 8988 (Nov. 14, 2014); see also *Comments Received on Proposed Amendments to §3.9 and §3.46*, R.R. COMM’N OF TEX. <http://www.rrc.state.tx.us/legal/rules/proposed-rules/comments-received-proposed-amendments-to-39-and-346/> (last updated Oct. 1, 2014).

quakes magnitude 3.0 and larger occurred in the four years from 2010-2013, over 100 per year on average, compared with an average rate of 20 earthquakes per year observed from 1970 until 2000. USGS scientists have found that at some locations the increase in seismicity coincides with the injection of wastewater in deep disposal wells. Much of this wastewater is a byproduct of oil and gas production and is routinely disposed of by injection into wells specifically designed for this purpose.⁴⁸

In furtherance of this theory, a November 2011, magnitude 5.7 earthquake in central Oklahoma has also been related with an injection well that was drilled in 1993 from which the epicenter was 1.5 kilometers away.⁴⁹ Per the USGS website, from the years 1978 to 2009 there were 35.6 earthquakes of a magnitude 3.0 or higher in the State of Oklahoma.⁵⁰ Then from 2010 to 2014 there were 827 earthquakes of a magnitude 3.0 or higher.⁵¹ This ascending number demonstrates the very recent increase in earthquakes that correlates to the escalating oil and natural gas production in Oklahoma. These statistics for Oklahoma, having been an oil and gas producing state for decades, raises questions as to why the earthquakes are just now occurring.⁵² However, data has shown that the long delay between when an injection well is drilled and the occurrence of an earthquake is specific to Oklahoma geology in that it takes a long span of time to raise the pore pressure to a level that could cause earthquakes in the state.⁵³

Despite this statistical data, there are still numerous questions regarding the possible link between injection wells and earthquakes. It is a concept so foreign to some and the uniqueness of the situation raises questions as to how this could occur.⁵⁴ Cliff Frohlich, a research scientist at the Institute for Geophysics at the University of Texas at Austin describes what he calls “the air hockey table model” to help explain the science behind it.⁵⁵ Mr. Frohlich states:

48. William L. Ellsworth, *Man-Made Earthquakes Update*, U.S. GEOLOGICAL SURV. (Jan. 17, 2014, 1:00 PM), http://www.usgs.gov/blogs/features/usgs_top_story/man-made-earthquakes/.

49. See Ellsworth, *supra* note 46.

50. *Earthquakes in Oklahoma of M3+*, U.S. GEOLOGICAL SURV. (Apr. 14, 2015), <http://earthquake.usgs.gov/earthquakes/states/oklahoma/images/OklahomaEQsBarGraph.png>.

51. *Id.*

52. Ellsworth, *supra* note 46.

53. *Id.*

54. See generally Ziva Branstetter, *Quake Debate: Scientists Warn of Potential for ‘Large Earthquake’ as Injection Well Discussion Continues*, TULSA WORLD (Feb. 9, 2015, 12:00 AM), http://www.tulsaworld.com/newshomepage1/quake-debate-scientists-warn-of-potential-for-large-earthquake-as/article_c41c0e9c-d624-5b46-8c65-a07db211afae.html (explaining that there are some studies that have found a connection between earthquakes and hydraulic fracturing but no official conclusions have been made).

55. *How Oil and Gas Disposal Wells Can Cause Earthquakes*, *supra* note 24.

[Y]ou have an air hockey table, suppose you tilt it, if there's no air on, the puck will just sit there. Gravity wants it to move but it doesn't because there's friction [with the table surface]. But if you turn the air on for the air hockey table, the puck slips. Faults are the same.⁵⁶

In other words, by injecting millions of gallons of water into previously undisturbed rock formations the faults are becoming lubricated and this allows movement of the faults which can create earthquakes.⁵⁷ These man-made earthquakes are commonly referred to as "induced earthquakes."⁵⁸

The current management plans, derived from the state regulatory bodies that are in place to mitigate induced earthquakes, entail seismic monitoring as it relates to injection well locations.⁵⁹ However, without any specific requirements and parameters, these management plans can be too ambiguous to be effective. This Article will attempt to provide resolutions to this ever-growing problem by outlining a concrete permitting recommendation that is feasible and obtainable. This permitting recommendation is one that can occur without placing undue burden on the oil and gas industry and ultimately could decrease the number of earthquakes occurring in oil and gas producing states. This Article will also outline potential water recycling techniques that should occur simultaneously with the permitting recommendations.

III. CURRENT FEDERAL AND STATE REGULATORY SCHEMES AND THE TEXAS MODEL FOR NEW STATE GOVERNANCE

Like most oil and gas development procedures, wastewater injection wells are regulated at two levels: the federal and the state level. Also like most oil and gas development procedures, the bulk of the regulation is left to the states; however, the ultimate authority is granted from Congress to the EPA. This Section will discuss the limited federal authority, and then follow up with outlining the broad state authority, with a particular emphasis on Texas and Ohio.

A. *Federal Regulation through the EPA*

The United States Congress created several environmental statutes that regulate the oil and gas industry, which include: the Clean Water

56. *Id.*

57. *Id.*

58. Rubinstein, *supra* note 1.

59. Rubinstein, *supra* note 1, at 6; *Earthquakes Induced by Fluid Injection FAQs*, U.S. GEOLOGICAL SURV., <http://www.usgs.gov/faq/categories/9833/3417> (last modified Aug. 19, 2015) (asking the questions "Is it possible to anticipate whether a planned wastewater disposal activity will trigger earthquakes that are large enough to be of concern?").

Act (“CWA”);⁶⁰ the Energy Policy Act of 2005;⁶¹ the Clean Air Act (“CAA”);⁶² and lastly, and most relevant to this Article, the Safe Drinking Water Act (“SDWA”).⁶³ None of these federal statutes were created with the primary intention to regulate hydraulic fracking or injection wells; however, these oil and gas production procedures have been incorporated into the SDWA in a vague manner, leaving most of the regulation to the states.

The SDWA was enacted in 1974 and amended in 1986 and 1996, to set standards to protect drinking water nationwide against contaminants,⁶⁴ making the focus of the SDWA corruption of groundwater resources.⁶⁵ This was further enforced when the Energy Policy Act of 2005 was enacted and Congress amended the SDWA to exclude “the underground injection of fluids or propping agents (other than diesel fuels) pursuant to hydraulic fracturing operations related to oil, gas, or geothermal production activities,”⁶⁶ in other words the Act excludes wastewater fluids and thus enforces that it was created to protect drinking water, not the oil and gas industry.⁶⁷ This exclusion from the federal statutes has left most of the regulation to the individual states. Perhaps as this Article will explain below, leaving this regulation to the states is a good thing.

Although oil and gas activities are exempt from the SDWA, injection wells are, however, regulated by the Underground Injection Control (“UIC”), a subset of the EPA.⁶⁸ In spite of minimal requirements the UIC does offer guidance as to what constitutes an injection well. The UIC defines an injection well as “any bored, drilled, or driven shaft or a dug hole where the depth is greater than the largest surface dimension that is used to discharge fluids underground.”⁶⁹ The UIC then categorizes wells into six classes of “underground injection” with each category specifying different regulatory requirements.⁷⁰ Category Class II includes wells that inject wastewaters associated with oil and gas production with which this Article is concerned.⁷¹ There are

60. Clean Water Act, 33 U.S.C. §§ 1251–1387 (2006 & Supp. 2015).

61. Energy Policy Act of 2005, 42 U.S.C. §§ 15801–16524 (2006 & Supp. 2015).

62. Clean Air Act, 42 U.S.C. §§ 7401–7671q (2006 & Supp. 2015).

63. 42 U.S.C. §§ 300f–300j–26 (2006 & Supp. 2011).

64. *Safe Drinking Water Act (SDWA)*, EPA, <http://water.epa.gov/lawsregs/rulesregs/sdwa/index.cfm> (last updated April 15, 2015).

65. *The Safe Drinking Water Act Amendments of 1996*, EPA, <http://water.epa.gov/lawsregs/guidance/sdwa/theme.cfm> (last updated Nov. 16, 2012).

66. *Regulation of Hydraulic Fracturing Under the Safe Drinking Water Act*, EPA (last visited Nov. 30, 2014), http://water.epa.gov/type/groundwater/uic/class2/hydraulicfracturing/wells_hydroreg.cfm.

67. *See id.*

68. 42 U.S.C. §§ 300f–300j–26; *Underground Injection Control Program*, EPA, <http://water.epa.gov/type/groundwater/uic/index.cfm> (last updated Aug. 20, 2015).

69. *Basic Information about Injection Wells*, *supra* note 32.

70. *Underground Injection Control Program*, *supra* note 68.

71. *Id.*

an estimated 144,000 Class II wells in operation in the United States, which inject a total of over two billion gallons of brine every day.⁷²

The federal standards required under the UIC for Class II Injection wells are fairly broad. The requirements include disclosing information such as: the geological formation, in which the wastewater will be injected, the stimulation program, a description of the injection procedure, monitoring plans, identifying water sources within proximity to the well, surface features and well construction plans.⁷³ However, none of these requirements are tailored to consider or prevent induced seismic events specifically.

B. *Texas and Ohio—A Look at Two Current State Regulatory Strategies*

Not all states have the authority to be the primary regulator of injection wells.⁷⁴ The UIC “primacy program” grants authority to individual states to obtain “primary” enforcement of injection well regulations.⁷⁵ A state may obtain authority over all six categories of injection wells under the UIC, or just certain categories.⁷⁶ To gain authority, the UIC requires that the state regulatory program to be, at a minimum, as stringent as the federal program,⁷⁷ which, as stated above, is not a hard test to satisfy. Most oil and gas producing states have been granted authority under this program including: Texas, Oklahoma, North Dakota, Utah, New Mexico, Wyoming, West Virginia, and Ohio.⁷⁸ Interestingly, several key oil and gas producing states have not been granted “primacy” and are *only* regulated under the current EPA-UIC program, including Pennsylvania and New York.⁷⁹ Lastly, Colorado, Montana, South Dakota, and California are all regulated under a combination state-EPA program.⁸⁰

Despite the numerous states that have been granted “primacy” under the UIC program, all but two states have yet to address the issue of induced seismic events such as earthquakes and injection wells, likely because of the recentness of the problem, but possibly as well as a lack of understanding of the issues. Texas and Ohio, on the other hand, have taken the lead in attempting to develop a solution, or at the very minimal, acknowledging the issue. This Section explores

72. *Class II Wells – Oil and Gas Related Injection Wells*, EPA, <http://water.epa.gov/type/groundwater/uic/class2/index.cfm> (last updated May 9, 2012).

73. 40 C.F.R. § 146.24(a)–(b) (1988).

74. *UIC Program Primacy*, EPA, <http://water.epa.gov/type/groundwater/uic/Pri-macy.cfm> (last updated May 13, 2015).

75. *Id.*

76. *Id.*

77. *Id.*

78. *See id.*

79. *See id.*

80. *UIC Program Primacy*, *supra* note 74.

each state's respective considerations of the connection between earthquakes and injection wells.

1. Ohio Regulations—Acknowledgment and Consideration

Ohio is an oil and gas producing state that was granted primacy under the UIC of the EPA in 1983,⁸¹ meaning that Ohio is essentially self-regulated. Ohio has more than 200 active injection wells,⁸² which in 2013 alone had over sixteen million barrels of wastewater injected into them.⁸³ This was a large increase from 2012 in which slightly more than two million barrels of wastewater were injected.⁸⁴ Up until the recent Texas memorandum addressed below, Ohio was the only state that had taken into account the potential induced seismic activity into their permitting requirements,⁸⁵ and they do so by enforcing broad guidelines to regulate injection wells and their proximity to faults.

The Ohio Department of Natural Resources (“ODNR”) is the administrative agency that oversees oil and gas well permitting, as well as injection well permitting.⁸⁶ When submitting an application to drill an injection well in Ohio, the ODNR requires the applicant to show “whether . . . the proposed activities will not comply or will pose an unreasonable risk of inducing seismic activity, inducing geological fracturing, or contamination of an underground source of drinking water.”⁸⁷ This somewhat unclear statement is satisfied by several requirements enacted to help alleviate potential earthquakes. These requirements include: (1) “no new injection wells may be located in areas proximal to known geological faults”; (2) “no wells may be drilled into Precambrian basement rock”; and (3) “before a permit is issued ODNR may require operators to provide a complete suite of geophysical logs any information regarding existing geological faults, a plan to monitor any seismic activity.”⁸⁸ Furthermore, the ODNR distinguishes between the federally enforced EPA rules that require in-

81. *Underground Injection Control (UIC)*, ODNR DIVISION OIL & GAS RESOURCES, <http://oilandgas.ohiodnr.gov/industry/underground-injection-control> (last visited Nov. 30, 2014).

82. *Class II Brine Injection Wells of Ohio*, ODNR DIVISION OIL & GAS RESOURCES, <http://www.midwestenergynews.com/wp-content/uploads/2014/07/ShaleClassIIwells07112014.pdf> (last visited Nov. 30, 2014).

83. Kathiann M. Kowalski, *Fracking Wastewater is big business in Ohio*, MIDWEST ENERGY NEWS (July 18, 2014) <http://www.midwestenergynews.com/2014/07/18/fracking-wastewater-is-big-business-in-ohio/>.

84. *Id.*

85. Wiseman, *supra* note 45, at 793.

86. *See generally* ODNR DIVISION OF OIL AND GAS RESOURCES, <http://oilandgas.ohiodnr.gov> (last visited Nov. 30, 2014).

87. OHIO REV. CODE ANN. § 6111.044 (West, Westlaw current through 2015).

88. ODNR, *Ohio's Class II Injection Wells*, YOUTUBE (Nov. 14, 2012), <https://www.youtube.com/watch?t=83&v=twg3An4IHpc>.

jection wells be inspected annually, and the ODNr rules which require the wells to be inspected four to five times per year.⁸⁹

Although these rules implemented by the ODNr are a step in the right direction, they are ambiguous and incomplete. They bring up many questions such as: what is considered “an area” proximal to known geological faults? How far away must the well be from “this area”? What Ohio lacks is a definitive measurable standard in terms of proximity to fault zones with tendencies for seismic activity. In other words, Ohio needs a quantitative codification to act as a starting reference for operators to follow. Nonetheless, Ohio should be applauded for taking those first steps to understand and mitigate the problem of earthquakes and injection wells.

2. Texas Regulations—The Start of a New Regulatory Scheme

Like Ohio, Texas was given primacy over their injection well program, which is regulated by the Texas Railroad Commission (“RRC”).⁹⁰ Interestingly, the Texas Railroad Commission regulates Class II injection wells but the Texas Commission of Environmental Quality (“TCEQ”) regulates all other classes of UIC wells.⁹¹ Texas, because of its sheer size and geological history, has immense amounts of oil and natural gas reserves.⁹² Texas not only has the booming Permian region in West Texas, but also the Eagle Ford shale in south Texas. In fact, over 33,000 new natural gas wells have been drilled across the state between 2005 to 2014.⁹³ Because Texas has vast amounts of untapped oil and gas reserves that are constantly being produced, it also has large amounts of wastewater in need of disposal.

The RRC has certain permitting requirements for injection wells that are governed under Section 3.9 of the Texas Administrative Code.⁹⁴ This Code states that “general, saltwater or other oil and gas waste . . . may be disposed of, upon application to and approval by the commission, by injection into nonproducing zones of oil, gas, or geothermal resources.”⁹⁵ The Code goes on to require the applicant to provide information regarding the injection wells proximity to freshwater formations; distance of the well from the nearest town; information regarding the casing of the well; and the name of the disposal

89. *Id.*

90. *See generally Oil & Gas*, R.R COMM’N TEX., <http://www.rrc.state.tx.us> (last visited Nov. 30, 2014).

91. *Injection Wells: Am I Regulated?*, TEX. COMM’N ON ENVTL. QUALITY, https://www.tceq.texas.gov/permitting/waste_permits/uic_permits/UIC_Am_I_Regulated.html (last updated March 26, 2015).

92. *U.S. Crude Oil and Natural Gas Proved Reserves*, U.S. ENERGY INFO. ADMIN. (Dec. 4, 2014), <http://www.eia.gov/naturalgas/crudeoilreserves/> (stating that North Dakota’s proven reserves increased in 2013, second only to Texas).

93. Flatt & Payne, *supra* note 14, at 844.

94. 16 TEX. ADMIN. CODE § 3.9 (2015).

95. *Id.* § 3.9(1).

formation, among other requirements.⁹⁶ However, the Code does not specify any requirements regarding potential issues with seismic activity from these injection wells.⁹⁷

On August 5, 2014, Texas made a bold move toward being the first state to *specifically* address the induced seismic event dilemma by issuing a proposed amendment to Section 3.9 of the Administrative Code. The proposed amendment, drafted by the RRC specifically addresses that earthquakes have occurred “in areas where there is coincident oil and gas activity.”⁹⁸ In response to this, the proposed amendment requests an additional paragraph to the code that requires the applicant to include the results of a review of data from the USGS website regarding the locations of any historical seismic events within an “estimated radius of the 10-year, five pounds per square inch (psi) pressure front boundary of the proposed disposal well location.”⁹⁹ The proposed amendment further defines those terms: “A pressure front is the zone of elevated pressure that is created by the injection of fluids into the subsurface.”¹⁰⁰ “A 10-year, five psi pressure front boundary is the boundary of increased pressure of five psi after ten years of injection at the maximum requested permit injection volume.”¹⁰¹ In other words, a pressure front is what will happen with the well over ten years at maximum pressure based on the historical data for that area. For example, if the pressure zone of the injection well is 3,000 psi when the oil and gas operator starts injecting into the disposal well, and the operator injects for ten years; as they inject the pressure will increase. This formula indicates how far from the well pressure will have increased five times after ten years. This will provide a radius from the well in which to evaluate the historical seismic data indicated by the USGS.

To find this information, the proposed amendment advocates requiring applicants to use the USGS historical seismic online database. This database allows applicants to insert the latitude and longitude of the injection well and pull any historical seismic event in the United States, from 1973 to the present, with a magnitude of 3.0 or larger.¹⁰² Lastly, the proposed amendment would require the applicant to provide “additional information . . . to demonstrate that fluids will be confined if the well is to be located in an area where conditions exist that may increase the risk that fluids will not be confined to the injec-

96. *Id.* § 3.9(3)(A)–(C).

97. *Id.* § 3.9; see also *Injection Wells: Am I Regulated?*, *supra* note 91.

98. 39 Tex. Reg. 6775 (Aug. 29, 2014) (codified as amended at 16 TEX. ADMIN. CODE §§ 3.46, 3.9).

99. *Id.*

100. *Id.* at 6778.

101. *Id.* at 6775.

102. *Id.* (stating that the USGS historical seismic information can be found at <http://earthquake.usgs.gov/earthquakes/search/>).

tion interval.”¹⁰³ Furthermore, the RRC has determined that the addition of these requirements will not be an economic burden on state or local government, and will only cost approximately \$300 more per application to gather the necessary data.¹⁰⁴

This proposed amendment was placed in the August 29, 2014, issue of the Texas Register for a thirty-day comment period. During the comment period, the RRC received thirty-six comments from various industry professionals, interested citizens, and even the EPA.¹⁰⁵ The comments vary from total support for the amendment to requests for minor changes. The biggest concern centered around the calculation of the psi formula because “the assumptions and approximations used by applicants. . . would be highly interpretive and . . . could be non-uniform and misleading.”¹⁰⁶ Based on this feedback, the Commission revised the amendment to Section 3.9 by requiring an applicant to submit the information obtained from the USGS website regarding historical seismic events within a quantitative area of 100 square miles, or 6.1 miles¹⁰⁷ centered from the injection well head.¹⁰⁸ After the thirty-day comment period, and a substantial evaluation of each comment, the RRC’s proposed amendment was enacted as an agency regulation effective November 17, 2014.¹⁰⁹ This enactment makes Texas the first state to attempt to quantify the relationship between earthquakes and injection wells.

IV. SIMULTANEOUS MITIGATION BY FIELD LEVEL PERMITTING AND CONTINUOUS DEVELOPMENT IN WATER RECYCLING TECHNIQUES

Relying on the above-described EPA and USGS findings, it is clear that injection wells are contributing to two environmental concerns: induced earthquakes and water consumption. These concerns have already been expressed in several lawsuits, and it is safe to anticipate more to come.¹¹⁰ A solution that tackles both problems simultaneously is needed. This Article proposes implementation of a two-fold

103. *Id.* at 6778.

104. 39 Tex. Reg. at 6776.

105. *Id.* at 8988.

106. *Id.*

107. 16 TEX. ADMIN. CODE § 3.9(3)(B).

108. *Id.*

109. 16 TEX. ADMIN. CODE § 3.9.

110. See generally Adam Wilmoth, *Lawsuit Filed Over Oklahoma Earthquakes*, NEWSOK (Feb. 10, 2015), <http://newsok.com/lawsuit-filed-over-oklahoma-earthquakes/article/5392433> (a lawsuit filed in Oklahoma regarding one of the earthquakes); see generally *Ruling Allows Oklahoma Earthquake Lawsuit to Go to Trial*, N.Y. TIMES (June 30, 2015, 5:46 PM), http://www.nytimes.com/aponline/2015/06/30/us/ap-us-earthquake-lawsuit-oklahoma.html?_r=0; see generally Joleen Chaney, *Lawsuit Takes Aim at OK Oil Companies For Increased Earthquake Activity*, NEWS9 (Mar. 30, 2015, 10:28 PM), <http://www.news9.com/story/28655946/lawsuit-takes-aim-at-ok-oil-companies-for-increased-earthquake-activity>.

strategy described in this Section: first is a field based administrative permitting overhaul aimed at preventing seismic events without causing negative effects on drilling programs and second is an expansive water-recycling plan aimed at conservation through the emerging and complex oil and gas water recycling industry.

A. *Following Texas's Lead with Exacting Permitting Requirements*

The year 2014 and the beginning of 2015 were groundbreaking for the oil and gas industry, not only because of the increased energy outlook for the United States,¹¹¹ but also because of new scientific data released from the USGS confirming injection wells could be a contributing factor to the increased amount of induced seismic events across the country.¹¹² Like any other evolving and developing industry, regulation needs to keep up with, not only the growing activity, but also the growing concerns associated with the industry. Now that statistics support the theory that seismic events and injection wells correlate, the individual states need to re-evaluate their regulations required by the oil and gas administrative agency.

Individual states should implement regulations on a field-wide basis. The primary reason states need to be in control of this regulatory task is the great variation in the sheer number of injection wells in each state across the nation. This variation depends not only on the state's oil and gas reserves, but also on its opposition or approval of oil and gas activity.¹¹³ Currently Pennsylvania only has seven wastewater disposal wells and New York has only six, while West Virginia has seventy-four, and Ohio has 200.¹¹⁴ It is clear that Ohio bears the brunt of the Marcellus disposal-well activity, and that brunt is attributed to Ohio's regulations' being amenable to the injection-well process as well as having the appropriate geology required to inject wastewater. Three-fourths of the injection wells located in the Marcellus Shale are found in Ohio, but 56% of the wastewater Ohio treats comes from the states of Pennsylvania and West Virginia.¹¹⁵ These statistics are likely the reason Ohio was the first state to attempt a broad change in the regulations to adapt to the potential earthquakes. This adaptation is commendable, but the state's regulatory methods are too vague to quantify the point at which an injection well is safe.

111. See *Annual Energy Outlook 2015*, *supra* note 12, at 4.

112. See generally *Induced Earthquakes*, U.S. GEOLOGICAL SURV., <http://earthquake.usgs.gov/research/induced/> (last modified June 23, 2015).

113. See Abrahm Lustgarten & Krista Kjellman Schmidt, *State-by-State: Underground Injection Wells*, PROPUBLICA (Sept. 20, 2012, 12:00 PM), <http://projects.propublica.org/graphics/underground-injection-wells>.

114. Boschee, *supra* note 41, at 18; Kowalski, *supra* note 81.

115. Boschee, *supra* note 41, at 18. Ohio bearing the brunt of the injection wells in the Marcellus Shale could be due to suitable underground geology as well.

Texas's regulatory structure, on the other hand, provides a good model for addressing the dangers of seismic events. However, this Article does not set out to say that the enacted formula of the Texas Administrative Code, which deals with the required USGS historical data covering events within 100 square miles of the well head,¹¹⁶ is the sole correct formula. As evidenced by the industry comments,¹¹⁷ the formula raises some concerns. However, Texas's attempts to determine a measurable standard to use as a benchmark are not only admirable, but also necessary.

Although the new Texas standard is calculable and a significant step in the right direction, the state standards should be implemented on a field-wide basis as opposed to a state-wide basis. An oil and gas field is defined as "an area consisting of a single reservoir or multiple reservoirs all grouped on, or related to, the same individual geological structural feature and/or stratigraphic condition."¹¹⁸ Assuming that a state's susceptibility to seismic events from an injection well is uniform across the state is improper, especially in a state as large as Texas. Different oil and gas fields have varying characteristics that make them either more or less susceptible to induced earthquakes.¹¹⁹ Some characteristics that would make a field more susceptible include whether the underground faults are large enough to produce earthquakes of greater than 3.0 magnitude, which can be felt on the earth's surface; and whether the fluid-pressure changes are large enough to produce an earthquake.¹²⁰ In other words, the geological fields in the Fort Worth, Texas, Barnett Shale area are much different than the geological fields in Midland, Texas and, therefore, might require a different standard to determine which locations are safe for injection wells. In fact, in the comments for the proposed Texas amendment discussed above, Chevron USA Inc. echoed this thought of field-wide standards by expressing that the company does see a relationship between seismicity and injection wells, but only in certain areas.¹²¹ Upon consideration of this comment, the RRC acknowledged that some areas are more responsive to injection wells, but the Commission chose to keep the new regulations at a statewide level, as opposed to a field-wide level.

Despite Texas choosing a statewide uniform standard, the state's acknowledgement and attempt to alleviate the situation is decisive and

116. 16 TEX. ADMIN. CODE § 3.9(3)(B).

117. *Comments Received on Proposed Amendments*, *supra* note 47.

118. *Oil and Gas Field Code Master List*, U.S. ENERGY INFO. ADMIN. (Feb. 27, 2015), <http://www.eia.gov/naturalgas/fieldcode/> (stating that there are over 65,000 oil and gas fields in the United States).

119. Rubinstein, *supra* note 1, at 2.

120. *Id.*

121. E-mail from Steve Perry, State Gov't Affairs Manager, Chevron USA Inc., to R.R. Comm'n of Tex. (Sept. 29, 2014), <http://www.rrc.state.tx.us/media/24193/comments-3-9-and-3-46-seismic-august2014-chevron.pdf>.

advantageous to the oil and gas industry. States should follow this lead and amend their current permitting requirements to reflect quantifiable regulations on a field-wide basis. It is an inexpensive way to attempt to ensure that injection wells are drilled in a secure and appropriate manner without interfering with faults that could produce seismic activity.¹²² Taking this expense and the data from the USGS into account (data that deems fracking safe with regard to not only groundwater contamination, but also earthquakes), using Texas's technique would ease the concerns states have with oil and gas production. Using this technique would also eliminate any bans or moratoriums some states have enacted. Many studies have been done regarding fracking, including a 2009 study by the United States Department of Energy, which found that hydraulic fracking is "safe and effective."¹²³ If that does not solidify that fracking is safe, then a recent study by Mark Zoback, a Stanford University geophysicist, should.¹²⁴ Mr. Zoback found that fracking in California has not contaminated, and likely will never contaminate, any water supply.¹²⁵ In terms of earthquakes, a 2012 study conducted in the Inglewood Oil Field in California found that there was no effect on seismic activity from fracking.¹²⁶ However, the permitting techniques developed by Texas should eliminate this need and allow the states to receive the revenues and jobs associated with the injection-well process.

B. *Water Recycling—The Future of the Oil and Gas Industry*

Although quantifiable permitting requirements are one possible solution to the problem, the ultimate solution would be to recycle and reuse wastewater byproduct of hydraulic fracturing. According to predictions from the Organization for Economic Cooperation and Development ("OECD"), water use will increase by 55% between 2000 and 2050.¹²⁷ The OECD also predicts that by 2050 40% of the world's population "will live in river basins under severe water stress."¹²⁸ An article by Francis Gassert, published in 2013, states that one quarter of croplands lack adequate water, and 56% of irrigated land is under

122. 39 Tex. Reg. at 6777 (2014).

123. Rock Zierman, *Why Such Hysteria over Fracking?*, L.A. TIMES (June 21, 2013), <http://articles.latimes.com/2013/jun/21/opinion/la-oe-zierman-california-fracking-moratorium-20130621>.

124. *Id.*

125. *Id.*

126. *Id.*

127. Flatt & Payne, *supra* note 14, at 829 (citing OECD, *Water Security for Better Lives*, OECD STUDIES ON WATER 15 (OECD Publishing 2013), http://www.oecd-ilibrary.org/environment/water-security_9789264202405-en).

128. *Id.* (quoting OECD, *Water Security for Better Lives*, in OECD STUDIES ON WATER 15 (OECD Publishing 2013), http://www.oecd-ilibrary.org/environment/water-security_9789264202405-en).

high-water stress.¹²⁹ This lack of water supply is global, but in the United States one in ten watersheds lack water to the point that demand is greater than supply.¹³⁰ A study by the Texas Water Development Board (“TWDB”) predicts that water needed for fracking in Texas will increase from 37,000 acre-foot (“AF”) per year to 120,000 AF by 2020–2030.¹³¹ This study also predicts that the total water demand will be approximately 22 million AF by 2060, but the supply will only be 15.3 million AF per year.¹³² Taking this into account, it is imperative state governments prepare for the future by not only properly allocating our water sources, but also considering new ways to recycle water.

However, in the grand scheme of global water consumption, the water consumed and used for fracking and the resulting wastewater produced is minor compared to other industries. For example, a 2013 article reports that it takes four million gallons of water to complete a frack job.¹³³ The following lends perspective to how much four million gallons is:¹³⁴

New York City consumes four million gallons of water every six minutes. Four million gallons is about 1.3% of the amount of water used in car washes every day. Just one of the 15,889 golf courses across the United States uses four million gallons of water in less than one summer month.¹³⁵

Looking at individual states’ oil and gas water consumption compared to other industries, the consumption is minimal. In 2012, 85.5%

129. Francis Gassert, *One-quarter of World’s Agriculture Grows in Highly Water-Stressed Areas*, WORLD RESOURCES INST. BLOG (Oct. 31, 2013), <http://www.wri.org/blog/2013/10/one-quarter-world%E2%80%99s-agriculture-grows-highly-water-stressed-areas>.

130. Flatt & Payne, *supra* note 14, at 830.

131. Russell Johnson et al., *Water Schemes Across the Shale Plays: Acquisition, Recycling, and Disposal of Water for Fracturing in Texas*, in DEV. ISSUES IN MAJOR SHALE PLAYS: WHAT’S ON THE HORIZON? ROCKY MOUNTAIN MIN. LAW FOUND. (May 2014), available at 2014 No. 2 RMMLF-INST PAPER NO. *6B-1.

132. *Id.*

133. Dana Bohan, **Update IV* Hydraulic Fracturing and Water Use: Get the Facts*, ENERGY IN DEPTH (July 16, 2013, 12:12 PM), <http://energyindepth.org/national/hydraulic-fracturing-and-water-use-get-the-facts/> (note that this article was written in 2013, therefore the amount of water needed to frack an oil and gas well has increased since. See *supra* note 21).

134. See generally Jesse Jenkins, *Energy Facts: How Much Water Does Fracking for Shale Gas Consume?* THE ENERGY COLLECTIVE (Apr. 6, 2013), <http://theenergycollective.com/jessejenkins/205481/friday-energy-facts-how-much-water-does-fracking-shale-gas-consume> (noting that water consumption on an industrial level is all relative, and without comparing oil and gas water consumption to other industries, one cannot comment on the amount).

135. Bohan, *supra* note 133; see also Michael Buteau, *U.S. Golf Course Closures Exceed Openings for Eighth Year*, BLOOMBERGBUSINESS (Jan. 26, 2014, 11:00 PM), <http://www.bloomberg.com/news/articles/2014-01-16/golf-course-closings-outpace-openings-for-eighth-straight-year> (stating that the number of golf courses in the United States in 2014 was 14,564.5).

of Colorado's water use was irrigation and agriculture while only 0.1% was used for oil and gas production.¹³⁶ In Texas, the Tarrant Regional Water District ("TRWD"), which services the Barnett Shale in North Texas, reported in 2011 the percentage of water sold to oil and gas companies for drilling operations was a measly 0.54%.¹³⁷ In Oklahoma, oil and gas production is anticipated to grow in the next forty-five years and it is estimated that water usage in the oil and gas sector will only be 5% by 2060.¹³⁸ Lastly, in 2011 Pennsylvania only used 1.9 million gallons of water per day for Marcellus Shale development compared to the 24.3 million gallons of water used per day for irrigation, or the 440 million gallons used for industrial purposes.¹³⁹

Reviewing these statistics, it is easy to see that water usage for oil and gas production is not nearly as substantial and consuming as other sectors. However, with continued growth in oil and gas production expected and water sources becoming more and more limited and valuable, it is still important for the oil and gas industry to consider recycling techniques. In fact, it would behoove the oil and gas industry to be proactive in addressing environmental concerns such as water consumption and recycling.

Therefore, water recycling needs to be the main focus when it comes to wastewater from oil and gas production. However, water recycling is a tall order and there is severe skepticism as to whether recycling can become economical and efficient enough to make it a worthwhile investment. Like any emerging industry, the water recycling industry suffers from a lack of substantial funding.¹⁴⁰ In fact only 6% of water is reused in Pennsylvania,¹⁴¹ 8% in West Virginia,¹⁴² and 5% or less in the Eagle Ford Shale in Texas.¹⁴³ Ultimately, these numbers need to increase dramatically.

A significant barrier to the mass adoption of oil and gas wastewater recycling is due to the expensive, tedious nature of removing total dissolved solids ("TDS") from the wastewater. TDS is a measure of dissolved salts, organic matter, inorganic matter, and minerals.¹⁴⁴ The composition of the fluids varies geographically,¹⁴⁵ and the recycling process also varies depending on economic factors of the oil and gas

136. Bohan, *supra* note 133.

137. *Id.*; see also *Hydraulic Fracturing and Water Use in Barnett Shale*, BARNETT SHALE ENERGY EDUC. COUNCIL (Apr. 16, 2012), http://www.bseec.org/hydraulic_fracturing_and_water_use_in_the_barnett_shale.

138. Bohan, *supra* note 133.

139. John A. Arway, *Straight Talk*, PA. ANGLER AND BOATER (Jan. 2011), http://fishandboat.com/images/people/exec_dir/straight_talk/2011_01_02_robbery.pdf.

140. Flatt & Payne, *supra* note 14, at 107.

141. *Id.*

142. *Id.*

143. *Id.*

144. Boschee, *supra* note 41, at 18.

145. *Id.*

company such as the number of wells, amounts of wastewater needing recycling, and available infrastructure for recycling options.¹⁴⁶

Although industry representatives acknowledge the importance of wastewater recycling,¹⁴⁷ few have taken the initiative and invested the money necessary for recycling. The slowing of the economy and the fall in commodity prices the past seven years has significantly hindered the ability of oil and gas companies to expand upon and improve recycling methods.¹⁴⁸ For instance, Devon Energy, an Oklahoma based corporation, started recycling small amounts of water in the Barnett Shale.¹⁴⁹ However, Devon abandoned these efforts in 2008 because it cost \$4.43 per barrel to recycle the water as opposed to the \$2–2.50 per barrel it cost to inject the water into disposal wells.¹⁵⁰ This was a 40% cost increase that could not withstand declining commodity prices.¹⁵¹

However, there are current initiatives taking place. Halliburton is on the forefront of water recycling techniques with their CleanWave service, which includes a portable service unit used to treat wastewater from hydraulically fractured oil and gas wells.¹⁵² The unit uses an electrical process that can treat and remove TDS from the wastewater allowing the water to be reused for another fracturing job.¹⁵³ The CleanWave is capable of treating twenty barrels of water per minute,¹⁵⁴ which equates to a significant amount of total water treated. Halliburton tested the CleanWave in remote Utah where winter conditions make it difficult for continuous truckloads of wastewater to be transported to disposal wells or treatment facilities.¹⁵⁵ The CleanWave portability allowed the unit to remain at the well site during the winter months, reducing transportation costs as well as creating a significant reduction in water management costs.¹⁵⁶

146. *Id.* at 19.

147. Alison Sider et al., *Drillers Begin Reusing 'Frack Water'*, WALL ST. J. (Nov. 20, 2012, 3:56 PM), <http://online.wsj.com/articles/SB10001424052970203937004578077183112409260> (quoting Salvador Ayala VP of well-production, regarding reducing freshwater used in hydraulic fracturing “is no longer just an environmental issue—it has to be an issue of strategic importance”).

148. Johnson, *supra* note 131, at *6B-19.

149. *Id.*

150. *Id.*

151. *Id.*

152. *See CleanWave? Water Treatment Service: Mobil Service for Produced and Flowback Water*, HALLIBURTON WATER MGMT. SOLUTIONS, http://www.halliburton.com/public/bar/contents/Data_Sheets/web/Sales_Data_Sheets/H07734.pdf (last visited Nov. 30, 2014).

153. *Id.*

154. *Id.* at 1.

155. *CleanWave Water Treatment Service*, HALLIBURTON WATER MGMT. SOLUTIONS 11, https://www.laprogressive.com/wp-content/uploads/2014/08/CleanWave_Service.pdf, (last visited Aug. 22, 2015).

156. *Id.*

Other initiatives include research studies performed by Texas A&M University, in which a membrane filtration system would pre-treat frack water, saving money for the operator.¹⁵⁷ Fountain Quail Water Management, LLC also implemented a potential recycling technique using mobile evaporators at a commercial recycling facility in Parker County, Texas.¹⁵⁸ This stationary facility has allowed significant progress in the oil and gas water-recycling field. Future plans predict the facility will be able to recycle 7,000 barrels of produced water per day.¹⁵⁹

Yet another initiative was the 2012 proposed RRC amendments to Section 3.8 and Section 4 of the Texas Administration Code. These amendments encourage oil and gas developers to use recycling technologies.¹⁶⁰ The amendments, which were enacted March 26, 2013, redefined “commercial recycling” to provide for a streamlined process for approval of on-site recycling methods,¹⁶¹ and amended the definition of “fresh makeup water pit” to allow hydraulic fracturing fluids without a permit.¹⁶² The amended rules were enacted to encourage recycling in the Texas oil and gas industry¹⁶³ by allowing operators that are commercial recyclers to bypass a permit for freshwater pits.¹⁶⁴ The policy behind these amendments rests on the concept that relaxing the requirements, time, and money spent on recycling techniques will increase and spark momentum in the emerging oil and gas water recycling industry as a whole.¹⁶⁵

Perhaps the most innovative and potentially beneficial system comes by way of Sandbox Resource Solution’s two-part system of using microencapsulating flocculent dispersion¹⁶⁶ and desalination.¹⁶⁷ This two-part system takes wastewater and cleans it out so that it can be reused for other oil and gas production. The wastewater can also be reused for agricultural purposes and, possibly one day, even drink-

157. Johnson, *supra* note 131. (stating that this technique could save operators \$8000 per completion).

158. *Id.*

159. *Id.*

160. *Id.* at *6B-17.

161. *Cf.* 16 TEX. ADMIN. CODE § 3.8 (2012).

162. *Id.*

163. *Id.*

164. *Id.*

165. Christi Craddick, *Water Conservation and Recycling Symposium*, R.R. COMM’N OF TEX., <http://www.irc.state.tx.us/about-us/commissioners/craddick/water-recycling-symposium/> (last visited July 20, 2015).

166. *Micro-encapsulating Flocculent Dispersion*, SANDBOX RESOURCE SOLUTIONS (last visited Mar. 27, 2015), <http://www.sandboxresourcesolutions.com/index.php/technology/micro-encapsulating-flocculent-dispersion> (stating that this process strips and binds hydrocarbons, iron, sulphides, suspended solids, and naturally occurring radionuclides).

167. SANDBOX RESOURCE SOLUTIONS, <http://www.sandboxresourcesolutions.com/> (last visited Mar. 27, 2015).

ing water.¹⁶⁸ Sandbox has been working on a producing well site in Montana, where it is using its technology to clean the wastewater in a shipping container located on the well site.¹⁶⁹ The clean water is pumped to a wetland adjacent to the property where it is used for agricultural purposes. Even the cattle are currently drinking the water.¹⁷⁰ The cost to pump the water is approximately one dollar per barrel.¹⁷¹ At forty-two gallons per barrel, that is approximately two cents per gallon.¹⁷² This is a very progressive initiative for the oil and gas water recycling industry. In fact, Sandbox is making substantial headway; the company hopes to have a zero-waste oil and gas lease by the end of 2015. Zero-waste would mean the using everything from the oil and gas produced to the byproducts leaving no waste behind.¹⁷³

Despite the capital-intensive water recycling technologies and the lack of financial investment, industry leaders such as Halliburton and Sandbox Resource Solution, and state administrations like those in Texas, are paving the way for wastewater recycling. Although the CleanWave only recycles for hydraulic fracturing reuse, perhaps in time, technologies will be perfected and become economically justifiable. These technologies would allow wastewater to be treated to potable standards similar to those of Sandbox. These investments will be a positive step for the oil and gas industry, not only by doing their part to mitigate the water crisis, but also by addressing environmental concerns without hampering production.

V. CONCLUSION

The concept of energy security has become increasingly important and in present day appears to be attainable in the United States. The current technologies of oil and gas development have allowed the nation, for the first time, to realistically consider achieving energy independence. The vast amount of reserves in the United States provides an option for the country to become a self-sustaining nation in terms of energy.¹⁷⁴ Combining these reserves with the innovation of horizontal drilling has not only opened doors for great amounts of production, but has also allowed operators to minimize surface disturbance and produce less waste.¹⁷⁵

168. *Id.*

169. Telephone Interview with Chris Tesarski, President, Sandbox Resource Solutions (Mar. 20, 2015).

170. *Id.*

171. *Id.*

172. *Id.*

173. *Id.*

174. Ray, *supra* note 16, at 91.

175. *Environmental Benefits of Advances Oil and Gas Exploration and Production Technology*, U.S. DEP'T OF ENERGY OFFICE OF FOSSIL ENERGY DOE-FE-0385, 36, 57 (1999), <http://www.netl.doe.gov/kmd/cds/disk25/oilandgas.pdf>.

Expanding domestic oil and gas production benefits the United States for many reasons. Geopolitically, energy independence allows the United States to shift away from relying on imported oil from the Middle East. This reliance is very dangerous, especially with emerging anti-western militant groups like the Islamic State in Iraq and Syria (“ISIS”).¹⁷⁶ As ISIS gains control of more oil-saturated areas in the Middle East, the United States’ reliance on oil imports from the region becomes more risky. ISIS’s control of oil production affects the oil industry because the United States relies on having the oil imported. Some also predict that ISIS could be selling oil on the black market and making profits up to \$3 million per day.¹⁷⁷ Without regulation on the sale of this ISIS controlled oil, the United States could be relying on an oil supply that is simply not obtainable.

Economically speaking, energy independence would benefit the United States by allowing the country to save the money used on imports and filter it back into the domestic oil and gas production industry. In 2014 the United States imported an estimated nine million barrels of petroleum per day.¹⁷⁸ However, overall imports have decreased in the past ten years. In 2005, the United States imported 12.55 million barrels of petroleum per day; however, in 2013 the United States spent \$427 billion on imports.¹⁷⁹ This is a significant amount of money that can be used toward developing new techniques or water recycling technologies.

Lastly—and perhaps most importantly—energy independence will create jobs. “Employment in the oil and gas industry rose 40% from 2007 to 2013 despite a decline in the United States economy.”¹⁸⁰ If the United States was a self-sustaining energy nation, employment would rise in the energy industry, but job creation does not stop in the oil and gas sector. In the past ten years, employment in the oil and gas industry has more than doubled, helping create jobs in other industries such as transportation, construction, and manufacturing.¹⁸¹

To achieve energy independence—or even continue to expand the United States oil and gas industry—it is important for the industry to address the environmental concerns. Induced earthquakes and water

176. See Nick Thompson et al., *ISIS: Everything You Need to Know About the Rise of the Militant Group*, CNN (Feb. 10, 2015, 11:59 AM), <http://www.cnn.com/2015/01/14/world/isis-everything-you-need-to-know/> (discussing the effects of the rise of ISIS on the world stage).

177. *Id.*

178. *How Much Petroleum Does the United States Import and From Where?* ENERGY INFO. ADMIN. (last visited July 30, 2015), <http://www.eia.gov/tools/faqs/faq.cfm?id=727&t=6>.

179. Kiran Dhillon, *Why are U.S. Oil Imports Falling?*, TIME (April 17, 2014), <http://time.com/67163/why-are-u-s-oil-imports-falling/>.

180. David Blackmon, *Oil & Gas Boom 2014: Jobs, Economic Growth and Security*, FORBES (Feb. 20, 2014, 5:19 PM), <http://www.forbes.com/sites/davidblackmon/2014/02/20/oil-gas-boom-2014-jobs-economic-growth-and-security/>.

181. *Hydraulic Fracturing*, *supra* note 6.

consumption are two important issues that can not only be addressed but also mitigated. Ideally, oil and gas companies should strive to recycle as much wastewater as possible, especially considering how precious our sources of water are becoming. However, current technologies make it difficult for oil and gas companies to economically recycle the wastewater they produce in mass quantities. Considering these challenges, the best near-term solution to alleviate potential seismic activity from wastewater injection, is for the states to implement quantifiable geological permitting regulations on a field-wide basis. With the help of the historical seismic data from the USGS, these amendments can help mitigate the earthquakes that are occurring from injection wells and hopefully evolve the oil and gas industry to make it sustainable enough to create energy independence and to ensure it is still environmentally safe.

The oil and gas industry should champion state-level, field-wide implementation of injection well permitting regulations while petitioning for investment of time and capital into water recycling technologies. Most importantly, these strategies are not mutually exclusive and not only can, but *should*, occur simultaneously. This simultaneous use of these strategies will allow the oil and gas industry to reduce earthquakes and become a leader in developing energy independence for the United States.