

NOTES

Not So Natural: Manmade Earthquakes in Oklahoma and the Measured Response to Mitigate Them

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INTRODUCTION

In 2013, Oklahoma experienced 119 earthquakes of magnitude 3.0 or larger (“3+”) and five times as many magnitude 3+ earthquakes in 2014.¹ The number of earthquakes continued to increase, with 903 magnitude 3+ earthquakes in 2015.² In contrast, Oklahoma experienced only forty-one magnitude 3+ earthquakes in 2010, sixty-seven in 2011, and thirty-five in 2012.³ Subsurface injections of wastewater from hydraulic fracturing and other oil and gas recovery methods are believed to be the cause of the increase of earthquakes. Although most of the scientific community agrees that there is a relationship between the wastewater injection wells and seismic activity, Oklahoma lawmakers and regulators were slow to acknowledge this and react accordingly.⁴ Even as the relationship between wastewater injections and earthquakes in Oklahoma became clearer, the Oklahoma Corporation Commission—which is the primary oil and gas regulator in the state—was initially hesitant to issue strict regulations. Over time, and in the face of mounting public pressure, the Commission’s directives became increasingly more restrictive, and now apply to almost every disposal well in the state. Recently, the number of earthquakes has decreased.⁵ This follows a decrease in injections, but it is unclear whether it was the Commission’s directives or an overall reduction in energy exploration that caused the reduction in injections and quakes.

This Note begins by discussing the process of hydraulic fracturing, which is a growing source of the wastewater that is subsequently injected into deep disposal wells. It then chronicles the development of oil and gas regulation in the State of Oklahoma, with an emphasis on the response to the recent earthquake swarms.

1. *Earthquakes in Oklahoma: What We Know*, OFFICE OF THE SEC’Y OF ENERGY & ENV’T, <http://earthquakes.ok.gov/what-we-know/> (last visited Mar. 12, 2017) [hereinafter *What We Know*].

2. *Id.*

3. *Id.*

4. Jen Fifield, *Scientists Study Link Between U.S. Oil Drilling and Rise in Earthquakes*, PBS NEWSHOUR (July 14, 2016, 9:37 AM), <http://www.pbs.org/newshour/rundown/scientists-study-link-u-s-oil-drilling-rise-earthquakes/>.

5. See Steve Everley, *Oklahoma Earthquakes Down More than 50 Percent Since January 2016*, ENERGY IN DEPTH (May 6, 2016, 10:10 AM), <http://energyindepth.org/national/oklahoma-earthquakes-down-50-percent-january-2016/>.

The regime that emerged to deal with deep water injection in Oklahoma is then contrasted with the regimes developed by other states that have had to address the issue. The Note concludes by analyzing how Oklahoma can plan for the almost inevitable increase in oil prices, energy production, and disposal. Specifically, it discusses how Oklahoma can learn from other states' control programs, and capitalize on the current political will to create meaningful, comprehensive, and science-based regulations.

I. THE HYDRAULIC FRACTURING INDUSTRY IN THE UNITED STATES

Hydraulic fracturing (or “fracking”) was introduced in the mid-1900s, but its popularity has skyrocketed in the past half-decade⁶ in conjunction with the shale gas revolution.⁷ In 2000, shale gas comprised less than one percent of domestic gas production; by 2010, it accounted for twenty percent.⁸ This increase is not expected to taper off—the U.S. Energy Information Administration projects that by 2035, shale gas will account for forty-six percent of the United States, gas supply.⁹

This rapid increase posed significant challenges to regulators because the environmental impacts of hydraulic fracturing were largely unstudied. Furthermore, certain environmental consequences, such as earthquakes, were not yet known to be a side effect of the disposal of wastewater from fracking.¹⁰ Because of this scientific uncertainty, regulators seeking to strike a balance between economic concerns and environmental impacts were slow to react. Oklahoma's regulatory reaction to fracking provides an instructive case study of this phenomenon.¹¹

A. THE PROCESS OF HYDRAULIC FRACTURING

Hydraulic fracturing involves many complex steps. After a drill pad is built—typically there are multiple wells on each drill pad—and all of the equipment is in place, the process proceeds as follows:

- Step 1: Drill a vertical borehole into a layer of shale, which usually lies a kilometer or more below the surface (in the “production” formation).

6. 2 PHILIPPE A. CHARLEZ, *ROCK MECHANICS: PETROLEUM APPLICATIONS* 239 (1997); HYDRAULIC FRACTURING FAQs, U.S. GEOLOGICAL SURVEY (Nov. 16, 2016), <https://www2.usgs.gov/faq/categories/10132/3818>.

7. PAUL STEVENS, CHATHAM HOUSE, *THE ‘SHALE GAS REVOLUTION’: DEVELOPMENTS AND CHANGES* (2012) (“unconventional gas” refers to gas where drilling is not enough to generate a commercial flow and needs an additional stimulus (such as hydraulic fracturing) to generate the gas).

8. *Id.*

9. *Id.*

10. See Emily C. Powers, *Fracking and Federalism: Support for an Adaptive Approach that Avoids the Tragedy of the Regulatory Commons*, 19 J. L. & POL'Y 913, 914 (2011) (discussing the unforeseen consequences of hydraulic fracturing).

11. See *infra* Part IV.

- Step 2: Turn the drill bit horizontally and continue drilling, extending the borehole laterally by as much as a mile or more.
- Step 3: Coat the vertical and horizontal borehole with steel casing—which prevents gas leaks and protects groundwater from pollution—and cement it in place.
- Step 4: Use explosives to perforate the horizontal section of the well casing; detonate a small package of ball-bearing-like shrapnel.
- Step 5: Inject a mixture of water, sand, and chemicals into the borehole at high pressure, which fractures the rock and holds the fractures open, allowing oil and gas to flow out.
- Step 6: Release pressure in the flowback phase, which causes the fluid mixture in the well to return to the surface.
- Step 7: Clean the borehole and allow the well to start producing oil and gas, which often takes several days.
- Step 8: Dispose of or remediate the water that was used in the process of fracturing the well (i.e., flowback wastewater), and other contaminated water which may flow to the surface as a result of the fracturing process (i.e., produced wastewater).¹² Various methods of disposal and re-use are discussed below.

The fluid mixture injected in Step 5 is made up of around ninety-eight percent water, along with sand and other additives. The sequential fracturing of a well, where a single well can be fracked multiple times,¹³ can use between 2 million and 5.6 million gallons of water.¹⁴

After the water is injected into the well, some of it may return to the surface as flowback wastewater.¹⁵ The amount of flowback wastewater is estimated to be anywhere from twenty to sixty percent of the volume that was initially injected into the well.¹⁶ Most of the flowback occurs in the first seven to ten days, while the rest can occur over a period of three to four weeks.¹⁷ Produced wastewater is another type of wastewater that occurs naturally in the production formations and may flow out of the well, possibly throughout the entire time oil and gas are being produced.¹⁸ Although naturally occurring, produced water may nonetheless have harmful properties, including naturally occurring radioactive materials like

12. ALEX PRUD'HOMME, HYDROFRACKING: WHAT EVERYONE NEEDS TO KNOW 31–32 (2014).

13. *Drilling 101*, SHALESHOCK, <http://www.shaleshock.org/drilling-101/> (last visited Mar. 12, 2017).

14. U.S. GOV'T ACCOUNTABILITY OFFICE, GAO-12-874, UNCONVENTIONAL OIL AND GAS DEVELOPMENT: KEY ENVIRONMENTAL AND PUBLIC HEALTH REQUIREMENTS (2012).

15. Erich Schramm, *What is Flowback, and How Does it Differ from Produced Water?*, INST. FOR ENERGY & ENVTL. RESEARCH FOR NE. PA. (Mar. 24, 2011), <http://energy.wilkes.edu/pages/205.asp>.

16. *Compare id.* (finding volume of recovery is anywhere between twenty and forty percent), with Jeff Easton, *Fracking Wastewater Management*, WATERWORLD (Nov. 1, 2013), <http://www.waterworld.com/articles/wwi/print/volume-28/issue-5/regional-spotlight-us-caribbean/fracking-wastewater-management.html> (finding the volume of recovery to be up to sixty percent).

17. Schramm, *supra* note 15.

18. *Id.*

radium isotopes.¹⁹ Produced water accounts for ninety percent of all water that ultimately must be disposed. Flowback water accounts for only the small remainder.²⁰

Wastewater may be reused in the fracking process or with conventional oil wells in a method known as “enhanced oil recovery.”²¹ Enhanced oil recovery involves pumping water (waste or fresh, in liquid form or as steam) into the same oil and gas-bearing layer of rock into which the well is drilled. This raises the pressure in the rock layer, causing oil and gas that would not otherwise be recoverable to flow to the surface.²²

This type of re-use is to be contrasted with disposal of wastewater. Disposal entails pumping the water into a different geological formation, typically below the production formation, known as a “disposal” formation.²³

B. SEISMIC AND OTHER ENVIRONMENTAL RISKS

Induced seismicity and groundwater contamination are two widely reported potential consequences of fracking. However, the link between fracking and seismicity is more nuanced than a direct cause-and-effect relationship. Quakes caused directly by hydraulic fracturing and enhanced oil production have been recorded, but the scientific consensus is that the disposal of wastewater into deep formations is what causes the majority of induced earthquakes.²⁴ More specifically, Steps 1 through 6 of the fracking process—explained above—are not thought to contribute significantly to seismicity.²⁵ Instead, it is the increase in fracking wastewater that will lead to an increase in earthquakes if injected into deep formations.²⁶ Induced earthquakes are understood to occur where the movement of fluid and pressure through the Earth’s subsurface counteracts the friction that holds faults together and allows them to slip apart.²⁷ The correlation between oil and gas production and increased seismicity in Oklahoma is discussed in section II.B.

Groundwater contamination is another danger of hydraulic fracking and deep well injection. In addition to the water and sand, the fluid mixture contains a number of chemical additives, not all of which must be publicly disclosed, due to the so-called “Halliburton loophole” in the federal Safe Drinking Water Act

19. *Id.*

20. Justin L. Rubinstein & Alireza Babaie Mahani, *Myths and Facts on Wastewater Injection, Hydraulic Fracturing, Enhanced Oil Recovery, and Induced Seismicity*, 86 SEISMOLOGICAL RES. LETTERS 1, 1–2 (2015).

21. *Id.* at 3–4.

22. *See id.*

23. *See id.*

24. *Id.* at 5; *see also* Anna Kuchment, *Drilling for Earthquakes*, SCI. AM. (Mar. 28, 2016), <https://www.scientificamerican.com/article/drilling-for-earthquakes/>.

25. *See infra* section II.B.1.

26. Easton, *supra* note 16.

27. Kuchment, *supra* note 24.

(“SDWA”).²⁸ The SDWA was passed in 1974 to protect public drinking water supplies throughout the nation by, among other things, requiring disclosure of all chemicals injected into the ground that could potentially reach drinking water supplies.²⁹ The Halliburton loophole is an exception to the SDWA, which excludes the injection of fracturing fluids from the law’s reporting requirements.³⁰ This is particularly concerning because the wastewater produced and subsequently injected into disposal wells often contains a mixture of metals, salts, and other chemicals, partly composed of the original fracturing fluid, but also chemicals released by the rocks in the area—including chromium, mercury, and arsenic.³¹ If consumed, these chemicals can have a wide range of health effects, such as infertility in adults and abnormal development in children.³²

II. OKLAHOMA’S EXPERIENCE WITH OIL, GAS, AND FRACKING

As of 2015, Oklahoma was one of the five biggest oil-producing states,³³ and produced the third most natural gas of any state.³⁴ Oklahoma’s oil and gas is primarily located in two main shale³⁵ formations: the Woodford and the Caney.³⁶ These shale formations span much of Oklahoma and are located in the Arkoma Basin (in southeastern Oklahoma), the Anadarko Basin (in western Oklahoma), and the Ardmore Basin (in southern Oklahoma).³⁷ Drilling in these basins covers all of these regions of Oklahoma and spans into the more populated areas near

28. See *The Halliburton Loophole*, EARTHWORKS, https://www.earthworksaction.org/issues/detail/inadequate_regulation_of_hydraulic_fracturing#.V0Htd9dhros (last visited Mar. 12, 2017).

29. Daniel Honberg, *Fractured Oversight: A Regional Approach to Hydraulic Fracturing Regulation*, 24 GEO. INT’L ENVTL. L. REV. 591, 595 (2012) (“The EPA administers the Safe Drinking Water Act (SDWA), under which it delegates primary enforcement and implementation of water standards to the states.”).

30. EARTHWORKS, *supra* note 28; see also Amanda C. Leiter, *Fracking, Federalism, and Private Governance*, 39 HARV. ENVTL. L. REV. 107, 121 (2015).

31. *Chemical Composition of Fracking Wastewater*, EUR. COMM’N DG ENV’T NEWS ALERT SERV. (Feb. 19, 2015), http://ec.europa.eu/environment/integration/research/newsalert/pdf/chemical_composition_of_fracking_wastewater_404na4_en.pdf; see generally Adam Garnezy, *Balancing Hydraulic Fracturing’s Environmental and Economic Impacts: The Need for a Comprehensive Federal Baseline and the Provision of Local Rights*, 23 DUKE ENVTL. L. & POL’Y F. 405, 408 (2013).

32. Harold Shaw, *Over 1,000 Toxic Chemicals Found in Fracking Water*, NAT. NEWS (Feb. 20, 2016), http://www.naturalnews.com/053040_fracking_groundwater_contamination_toxic_chemicals.html.

33. See Darren Barbee, *A Giant in Its Own Right: Oklahoma Stands Out with Oil, Gas Production*, OIL & GAS INV. (Oct. 21, 2015), <http://www.oilandgasinvestor.com/giant-its-own-right-oklahoma-stands-out-oil-gas-production-823876#p>.

34. *Rankings: Natural Gas Marketed Production, 2015*, U.S. ENERGY INFO. ADMIN., <https://www.eia.gov/state/rankings/#/series/47> (last visited Mar. 12, 2017).

35. “Shales are fine-grained sedimentary rocks that can be rich sources of petroleum and natural gas.” *What is Shale Gas?*, GEOLOGY.COM (Dec. 2010), <http://geology.com/energy/shale-gas/>.

36. David Brown, *Big Potential Boosts the Woodford*, AAPG EXPLORER (July 7, 2008), <https://archives.aapg.org/explorer/2008/07jul/woodford.cfm>.

37. *Id.*

Oklahoma City.³⁸

Between 2008 and 2015, the biggest drillers in the state drilled and completed more than 20,000 wells, with SandRidge Exploration & Production (“SandRidge”) completing the most fracked wells at a total of 6732.³⁹ As of 2016, around 2000 wells were in production, with approximately 475 of them vertical and more than 1500 of them horizontal.⁴⁰ Until the recent fall in oil prices, Oklahoma’s production capacity rapidly increased between 2010 and 2014.⁴¹ In 2010, Oklahoma produced approximately 66,000 million barrels of oil.⁴² Since then, production increased to around 128,000 million barrels per year.⁴³

A. THE OKLAHOMA CORPORATION COMMISSION

The Oklahoma Corporation Commission (“the Commission” or “OCC”) is the sole regulator of the oil and gas industry in Oklahoma. Article IX of the Oklahoma Constitution established the Commission in 1907.⁴⁴ The First Legislature of Oklahoma gave the Commission authority to regulate public service corporations, which includes oil and gas companies.⁴⁵ The U.S. Supreme Court defined a public service corporation as one whose business services are considered essential to the public welfare.⁴⁶

The Commission first began regulating oil and gas in 1914 by restricting oil drilling and production in order to prevent waste being generated from oil and gas production exceeding the transport capacity of pipelines.⁴⁷ Then, in 1915, the Oklahoma Legislature passed the Oil and Gas Conservation Act, which broadened oil and gas regulation to protect the rights of all parties that were entitled to share in the benefits of oil and gas production.⁴⁸ Over time, the Commission’s purpose and authority evolved.⁴⁹ Presently, the Commission regulates public utilities, including: oil and gas drilling, production, and environmental protection; aspects of motor carrier, rail, and pipeline transportation; most taxis,

38. *Woodford Shale*, OIL & GAS J., <http://www.ogj.com/unconventional-resources/woodford-shale.html> (last visited Apr. 1, 2016).

39. Barbee, *supra* note 33.

40. *Woodford Shale—A Complex Oil and Gas Play*, HALLIBURTON, <http://www.halliburton.com/en-US/ps/solutions/unconventional-resources/shale-gas-oil/shale-plays/woodford-shale-a-complex-oil-and-gas-play.page?node-id=hgjyd46z> (last visited Feb. 20, 2017).

41. Barbee, *supra* note 33.

42. *Id.*

43. *Id.*

44. OKLA. CONST. art. IX, § 15.

45. *Oklahoma Corporation Commission History*, OKLA. CORP. COMM’N, <https://www.occeweb.com/Comm/commissionhist.htm> (last visited Feb. 20, 2017) [hereinafter *OCC History*].

46. *Munn v. Illinois*, 94 U.S. 113 (1876) (holding that when a private company’s business affects the community at large, it becomes a public entity subject to state regulation).

47. *OCC History*, *supra* note 45.

48. *Id.*

49. *See id.*

limousine, and for-hire buses; cotton gins, private water companies, and the environmental integrity of petroleum storage tank systems.⁵⁰ Additionally, the Commission is responsible for the proper operation of fuel dispensing units (i.e., gas pumps) at retail filling stations.⁵¹ The Commission also enforces federal regulations for underground disposal of certain oil and gas waste fluids, and remediation of soil and groundwater pollution caused by leaking petroleum product storage tanks.⁵²

The Commission is made up of three elected commissioners, who each serve six-year terms.⁵³ The Commission is comprised of nine divisions and it has legislative, judicial, and administrative authority over them. With regard to hydraulic fracturing, the Oil and Gas Conservation Division (“OGCD”) regulates oil and gas well drilling and production activities in a manner that “prevents waste, safeguards mineral property rights, protects the environment, and ensures public safety.”⁵⁴ The OGCD consists of three departments: Field Operations, Technical Services, and Pollution Abatement.⁵⁵ As of 2011, the Field Operations Department had forty-eight inspectors located throughout four regions.⁵⁶

In 2015, the Supreme Court of Oklahoma decided that the OCC does not have jurisdiction when a plaintiff brings suit against oil and gas companies for damage suffered to her home during an earthquake.⁵⁷ Such claims must instead be brought in state court or federal district court.⁵⁸ The Commission had taken the position that its own hearing process should govern private tort actions.⁵⁹ If the Court had found otherwise, an injured person suing an oil company for earthquakes would have been limited to bringing the suit in front of the same organization that gave the company permission to conduct its fracking activities in the first place.

While the OCC lacks authority to resolve earthquake-related claims made by homeowners against oil companies, its authority to impose restrictions on activities that it determines may be causing those earthquakes has recently been clarified and expanded. As will be discussed in more detail below, the Oklahoma state legislature amended the OCC’s organic statute in April 2016 to clarify that it

50. *Annual Report: Fiscal Year 2012*, OKLA. CORP. COMM’N 5 (2012), <http://www.occ.state.ok.us/News/FY12%20Annual%20Report%20c.pdf>.

51. *See id.* at 35.

52. *Id.*

53. *OCC History*, *supra* note 45.

54. STATE REVIEW OF OIL & NAT. GAS ENVTL. REGULATIONS (STRONGER), OKLAHOMA HYDRAULIC FRACTURING STATE REVIEW 8 (2011), <http://www.occweb.com/STRONGER%20REVIEW-OK-201-19-2011.pdf>.

55. *Id.*

56. *Id.*

57. *Ladra v. New Dominion, LLC*, 353 P.3d 530, 532 (Okla. 2015) (“[D]istrict courts have exclusive jurisdiction over private tort actions when regulated oil and gas operations are at issue.”).

58. *Id.*

59. *Id.*

has authority to respond to emergency situations.⁶⁰ Prior to this amendment, energy companies had suggested that the OCC might lack the authority to issue binding regulations for the purpose of combatting earthquakes.⁶¹

B. INCREASED EARTHQUAKES AND SUBSEQUENT DAMAGE

In 2009, the level of seismic activity in Oklahoma dramatically increased, which coincided with an increase in oil and gas production.⁶² This increase in seismic activity included some of the strongest earthquakes ever recorded in Oklahoma. For example, an earthquake on November 2011 near Prague, Oklahoma registered at magnitude 5.6,⁶³ destroyed six houses, caused major damage to twenty homes (with average repair costs of \$80,000 per home), and caused minor damage to thirty-eight homes (with average repair costs of \$13,000 per home).⁶⁴

After that earthquake, seismic activity became more common in Oklahoma, with 2013, 2014, and 2015 each seeing a continuous increase in frequency.⁶⁵ This increase stimulated greater public concern regarding potential hazards to both local communities and the energy-industry infrastructure in Oklahoma.⁶⁶

1. OGS and USGS Data Suggest Earthquakes Correlate with Wastewater Injection Sites

Although the induced-seismicity research conducted within Oklahoma became largely politicized, the Oklahoma Geological Survey (“OGS”) eventually released its finding that the increase in seismicity is “very unlikely the result of a natural process.”⁶⁷ In drawing its conclusions, OGS observed that “the majority of earthquakes in central and north-central Oklahoma occur as earthquake swarms and not in the typical foreshock-mainshock-aftershock sequences that are

60. Joe Wertz, *House Approves Bill Clarifying Oil Regulator’s Authority to Act on Industry-Linked Earthquakes*, STATEIMPACT OKLA. (Mar. 8, 2016, 11:46 AM), <https://stateimpact.npr.org/oklahoma/2016/03/08/house-approves-bill-clarifying-oil-regulators-authority-to-act-on-industry-linked-earthquakes/>.

61. *Id.*

62. See generally William L. Ellsworth, *Injection-Induced Earthquakes*, 341 SCI. 1225942-1 (2013), <http://science.sciencemag.org/content/341/6142/1225942>.

63. Matt Dinger & Matt Patterson, *Record 5.6 Magnitude Earthquake Shakes Oklahoma*, NEWSOK (Nov. 6, 2011, 11:08 AM), <http://newsok.com/article/3620706> (stating that the strongest earthquake previously recorded in Oklahoma was a magnitude 5.5 earthquake in 1952).

64. Ziva Branstetter & Curtis Killman, *Earthquake Politics: ‘We Don’t Work in a Vacuum,’ Oklahoma State Seismologist Says*, TULSA WORLD (Feb. 10, 2015), http://www.tulsaworld.com/earthquakes/earthquake-politics-we-don-t-work-in-a-vacuum-oklahoma/article_9cea5c50-246a-5f6d-8b98-3b7979430ca6.html.

65. See *supra* notes 1–3 and accompanying text.

66. See Dakota K. T. Raynes et al., *An Emotional Landscape of Place-based Activism: Exploring the Dynamics of Place and Emotion in Antifracking Actions*, 40 HUMAN. & SOC’Y 401, 405 (2016).

67. Richard D. Andrews & Austin Holland, *Statement on Oklahoma Seismicity*, OKLA. GEOLOGICAL SURVEY (Apr. 21, 2015), http://wichita.ogs.ou.edu/documents/OGS_Statement-Earthquakes-4-21-15.pdf.

characteristic of naturally occurring earthquake sequences”⁶⁸ Notably, all of the areas that experienced a significant increase in earthquake swarms also saw increased wastewater disposal volumes over the last several years.⁶⁹

The OGS statement on seismicity from April 2015 further noted that most of the earthquakes in Oklahoma occur in the crystalline basement, which is deeper than the depth at which most oil and gas wells operate, and closer to the most heavily used disposal formations (such as the Arbuckle formation).⁷⁰ OGS concluded that directly correlating a particular injection well with a particular earthquake may be complicated because pressure from water injection and disposal may be transmitted over several miles.⁷¹

OGS’s findings came almost two years after U.S. Geological Survey (“USGS”) geophysicist William L. Ellsworth published his study on the relationship between increased seismicity and the injection of wastewater in deep disposal wells.⁷² Ellsworth had concluded that the fracking process itself had a relatively low risk of inducing damaging earthquakes,⁷³ but wastewater disposal by injection into deep wells may induce some earthquakes.⁷⁴ Furthermore, he argued that injection-induced earthquakes likely led to higher magnitude earthquakes, but thought it was difficult to conclude the extent of those contributions.⁷⁵

In the years following Ellsworth’s study, as discussed previously, the frequency at which earthquakes occurred in Oklahoma continued to increase.⁷⁶ This increase strengthened the theory that the quantity of wastewater injected into deep wells was contributing to Oklahoma’s seismic activity. In 2016, the USGS issued a press release announcing new maps that, for the first time, included both human-induced and natural earthquakes.⁷⁷ In addition to the maps, the press release contained information about the hazards related to induced earthquakes.⁷⁸ Namely, it listed the six states that face the most significant hazards from induced earthquakes: Oklahoma, Kansas, Texas, Colorado, New Mexico, and Arkansas.⁷⁹ According to the USGS, Oklahoma faces the highest potential hazard, followed by Kansas and Texas.⁸⁰ This increased-hazard level stems from the higher

68. *Id.*

69. *Id.*

70. *Id.*

71. *Id.*

72. Ellsworth, *supra* note 62.

73. *Id.* at 1225942-6.

74. *Id.* at 1225942-7.

75. *Id.*

76. Joe Wertz, *Exploring the Link Between Earthquakes and Oil and Gas Disposal Wells*, STATEIMPACT OKLA., <https://stateimpact.npr.org/oklahoma/tag/earthquakes/> (last visited Mar. 12, 2017).

77. Press Release, U.S. Geological Survey, *Induced Earthquakes Raise Chances of Damaging Shaking in 2016* (Mar. 28, 2016), <https://www.usgs.gov/news/induced-earthquakes-raise-chances-damaging-shaking-2016>. Historically, USGS maps only identified natural earthquake hazards.

78. *Id.*

79. *Id.*

80. *Id.*

number of earthquakes that Oklahoma experiences compared to its peer states.⁸¹ Lastly, the USGS reiterated that the primary cause of induced earthquakes continues to be wastewater disposal into deep underground wells.⁸²

2. Actual Data on Injection Quantities is Opaque Nationally and in Oklahoma

As previously mentioned, the process of hydraulic fracturing requires significant amounts of water, and the disposal of this water is regarded as the primary cause of the unprecedented number of earthquakes.⁸³ Additionally the nationwide increase in fracking has certainly led to an increase in wastewater disposed in injection wells.⁸⁴ However, data regarding the actual amount of water disposed of in this way is limited, in large part because government agencies do not consistently track the total water used in fracking or the actual amount of wastewater disposed in deep wells.⁸⁵ In the United States, one academic study estimated that, between 2005 and 2014, oil and gas companies used around 250 billion gallons of water to extract oil and gas from hydraulically fractured wells, generating 210 billion gallons of wastewater.⁸⁶

The Oklahoma Corporation Commission currently has information on the total amount of wastewater disposed in Oklahoma for the years 2011 through 2015.⁸⁷ In 2009, before the rise of hydraulic fracturing occurred, 849 million barrels of wastewater were injected into disposal wells throughout Oklahoma.⁸⁸ By 2014, the number of barrels of wastewater increased to 1.538 billion barrels, an eighty-one percent increase.⁸⁹ In 2015, after the Commission began regulating disposal wells, 1.5 billion barrels of wastewater were still injected into Oklahoma disposal wells.⁹⁰

81. *Id.*; see also Wertz, *supra* note 76 (“In 2014, Oklahoma was the most seismically active state in the Lower 48 and recorded three times as many quakes as California.”).

82. U.S. Geological Survey, *supra* note 77.

83. *Induced Earthquakes: Myths and Misconceptions*, U.S. GEOLOGICAL SURVEY, <https://earthquake.usgs.gov/research/induced/myths.php> (last visited Mar. 12, 2017).

84. See, e.g., Roger Drouin, *As Fracking Booms, Growing Concerns About Wastewater*, YALE ENV'T 360 (Feb. 18, 2014), http://e360.yale.edu/features/as_fracking_booms_growing_concerns_about_wastewater.

85. See, e.g., *id.*

86. Duke Today Staff, *How Much Water Does U.S. Fracking Really Use?*, DUKE TODAY (Sept. 15, 2015), <https://today.duke.edu/2015/09/frackfoot> (discussing a Duke University study which found that the water used in fracking makes up less than one percent of total industrial water use nationwide).

87. *Oil and Gas Data Files*, OKLA. CORP. COMM'N, OIL & GAS DIV., <http://www.occeweb.com/og/ogdatafiles/2.htm> (wastewater disposal data contained in Excel documents labeled “UIC Injection Volumes [year]”) (last visited Mar. 21, 2017).

88. Corey Jones, *Wastewater Disposal Volumes Rose 81 Percent in Six Years as Earthquakes Rumbled More Frequently*, TULSA WORLD (May 4, 2016, 10:16 AM), http://www.tulsaworld.com/earthquakes/wastewater-disposal-volumes-rose-percent-in-six-years-as-earthquakes/article_bfd90706-b53a-5c0f-9a50-2a9c36efcd019.html.

89. *Id.*

90. Kimberly Query, *Report: Oklahoma Disposing Oil Wastewater for Other States*, KFOR (Jan. 25, 2016, 1:08 PM), <http://kfor.com/2016/01/25/report-oklahoma-disposing-oil-wastewater-for-other-states>.

In addition to the lack of data for total water used by hydraulic fracking in the United States, there is also a lack of information regarding water use for individual wells. In the absence of hard data, experts have resorted to making general estimates on water use for individual wells.⁹¹ These estimates vary significantly, but they usually approximate that it takes between one million and more than ten million gallons of water (approximately 25,000 to 250,000 barrels) to drill and fracture a horizontal shale gas well.⁹² The difference in estimates stems from factors such as how many times a well is fracked, the depth of the well, and which shale the well is drilled in.⁹³

III. THE ECONOMIC, POLITICAL, AND LEGAL LANDSCAPE OF OKLAHOMA

Oklahoma's governmental and regulatory bodies have been hesitant to recognize a relationship between hydraulic fracturing and earthquakes. This is almost certainly due in part to Oklahoma's economic reliance on oil and gas. Oklahoma ranks as the fifth biggest U.S. producer of crude oil,⁹⁴ second in the number of active drilling rigs,⁹⁵ and sixth in crude oil reserves.⁹⁶ Additionally, some of the nation's largest energy companies are located in Oklahoma, including Devon Energy, Chesapeake Energy, and SandRidge Energy.⁹⁷ With such dependence on the energy sector, it is not surprising that Oklahoma's governmental and regulatory bodies cautiously regulated injection wells, so as not to harm oil and gas companies' economic interests.

A. POLITICAL INTERFERENCE HAS HAMPERED SCIENTIFIC RESEARCH

Allegations of politicians interfering with the OGS's findings surfaced in 2015,⁹⁸ casting doubt on the timeline of when the OGS established a connection between the seismic activity and the disposal wells. The parties implicated were

91. HEATHER COOLEY & KRISTINA DONNELLY, PAC. INST., *HYDRAULIC FRACTURING AND WATER RESOURCES: SEPARATING THE FRACK FROM THE FICTION* 15 (2012), http://www.velaw.com/uploadedfiles/vesite/e-comms/full_report.pdf.

92. *See id.* at 15–17; EASTON, *supra* note 16.

93. COOLEY & DONNELLY, *supra* note 91, at 17.

94. *Rankings: Crude Oil Production, November 2016*, U.S. ENERGY INFO. ADMIN., <https://www.eia.gov/state/rankings/#/series/46> (last visited Mar. 13, 2017).

95. *North America Rig Count*, BAKER HUGHES, <http://phx.corporate-ir.net/phoenix.zhtml?c=79687&p=irol-reportsother> (data contained in Excel document labeled "Rigs by State—Current and Historical") (last updated Mar. 24, 2017).

96. *Crude Oil Proved Reserves, Reserves Changes, and Production*, U.S. ENERGY INFO. ADMIN., https://www.eia.gov/dnav/pet/pet_crd_pres_a_EPC0_R01_mmbbl_a.htm (displaying data by area) (last updated Dec. 14, 2016).

97. *See Oklahoma: Corporations*, GLOBAL EDGE, <http://globaledge.msu.edu/states/oklahoma/corporations> (last visited May 11, 2016).

98. Benjamin Elgin & Matthew Phillips, *Big Oil Pressured Scientists Over Fracking Wastewater's Link to Quakes*, BLOOMBERG (Mar. 30, 2015, 7:00 AM), <https://www.bloomberg.com/news/articles/2015-03-30/big-oil-pressured-scientists-over-fracking-wastewater-s-link-to-quakes>.

the OGS, the President of the University of Oklahoma, and the Chairman of Continental Resources.⁹⁹ The allegations surfaced after news sources obtained emails revealing that OGS scientists knew of the relationship earlier, but instead repeatedly claimed they lacked scientific evidence.¹⁰⁰ Allegedly, when the OGS joined the USGS in recognizing the link between fracking and growing seismic risks, the President of the University of Oklahoma, the Commission, and the Vice President of Exploration of Continental Resources met with one of the primary researchers at OGS.¹⁰¹ The OGS researcher indicated that these higher-ups attempted to influence his research.¹⁰² Similar allegations of interference with research have surfaced at the University of Texas, the Colorado School of Mines, Cornell University, Boston University, and the University of Pittsburgh.¹⁰³

B. COLLAPSE OF JOBS FROM ENERGY SECTOR, DAMAGE FROM QUAKE TURN PUBLIC OPINION AGAINST OIL COMPANIES

Many of Oklahoma's recent economic woes stem from the approximately seventy percent decrease in oil prices as compared to June 2014.¹⁰⁴ The decreased oil prices are often cited as the primary cause of a \$1.3 billion budget shortfall in the state.¹⁰⁵ Because of this shortfall, sweeping budget cuts to education are being implemented, as well as seven-percent cuts to nearly every government agency and department allocation.¹⁰⁶ This may explain why, in contrast with a lack of public outcry regarding seismic activity before 2014, public opinion of oil and gas companies is now rapidly diminishing.

Another issue affecting the public opinion of oil and gas companies is the lack of adequate homeowners-insurance coverage for earthquake damage. While many insurance companies offer relatively inexpensive riders for earthquake damage, deductibles can be as high as twenty percent of the home's value.¹⁰⁷ This means that the average homeowner will usually pay out of pocket for cracked

99. *Id.*

100. *Id.*

101. Mike Soraghan, *Okla. Agency Linked Quakes to Oil in 2010, But Kept Mum Amid Industry Pressure*, ENV'T & ENERGY PUB. (Mar. 5, 2015, 1:18 PM), <http://www.eenews.net/stories/1060014342>. Harold Hamm, the Chairman of Continental Resources and a leading financial donor to the University of Oklahoma, was also involved. *Id.*

102. *Id.*

103. See ROBERT GALBRAITH ET AL., PUB. ACCOUNTABILITY INITIATIVE, *FREEDOM FRACKED?* (2015), <http://public-accountability.org/wp-content/uploads/Freedom-Fracked.pdf>.

104. Clifford Krauss, *Oil Prices: What's Behind the Volatility?* *Simple Economics*, N.Y. TIMES (Dec. 12, 2016), <https://www.nytimes.com/interactive/2016/business/energy-environment/oil-prices.html>.

105. Kimberly Query, *Oklahoma State Agencies Facing Even Deeper Budget Cuts to Make Up Additional \$235 Million*, KFOR (Mar. 3, 2016, 11:40 AM), <http://kfor.com/2016/03/03/oklahoma-state-agencies-facing-even-deeper-budget-cuts-to-make-up-additional-235-million/>.

106. *Id.*

107. Larry Buhl, *Oklahoma Earthquakes: Who Pays?*, INSIDE ENERGY (Mar. 30, 2016), <http://insideenergy.org/2016/03/30/oklahoma-earthquakes-who-pays/>.

walls, broken windows, and shifting foundations.¹⁰⁸ Additionally, this increased risk has caused multiple insurers to raise premiums.¹⁰⁹ For redress, many citizens have brought individual lawsuits against energy companies operating in Oklahoma.¹¹⁰ These lawsuits seek actual and punitive damages, as well as an injunction to prevent companies from injecting near fault lines or in densely populated areas.¹¹¹ Insurance companies have indicated that they would consider suing oil and gas companies for reimbursement if they had to pay damages to homeowners.¹¹²

C. LOW OIL PRICES, LAWSUITS THREATEN ENERGY COMPANIES WITH BANKRUPTCY

Much like the budget shortfalls facing the government, many oil and gas companies are also facing financial woes. In order to be profitable, most oil companies need the price of oil to be around \$66 a barrel.¹¹³ The average price of a barrel of oil in 2015 was \$48.67 and decreased to \$43.33 per barrel in 2016, after having fallen to nearly \$30 per barrel at the start of that year.¹¹⁴ This low price of oil has had serious economic effects, causing large oil companies like SandRidge Energy to file for bankruptcy,¹¹⁵ and other large energy companies—such as Devon Energy and Chesapeake Energy—to conduct extensive layoffs.¹¹⁶

In addition to individual damages lawsuits, oil and gas companies were recently sued by the Sierra Club.¹¹⁷ The Sierra Club brought its February 2016 lawsuit under the federal Resource Conservation and Recovery Act,¹¹⁸ which allows citizens to sue defendants who pose an “imminent and substantial endangerment to health or the environment.”¹¹⁹ The suit sought to require

108. *Id.* According to the Oklahoma Insurance Commissioner, only 8 out of 100 claims were paid in 2014. *Id.*

109. Luc Cohen, *Insurers Shun Risk as Oil-linked Quakes Soar in Oklahoma*, REUTERS (May 12, 2016), <http://www.reuters.com/article/us-usa-oklahoma-earthquakes-idUSKCN0Y30DC>.

110. Buhl, *supra* note 107.

111. *Id.*

112. Cohen, *supra* note 109.

113. Andy Rowell, *Oil Industry's "Death Dance" Continues*, OIL CHANGE INT'L (Jan. 4, 2016), <http://priceofoil.org/2016/01/04/oil-industrys-death-dance-continues/>.

114. *Short-Term Energy Outlook*, U.S. ENERGY INFO. ADMIN., <https://www.eia.gov/forecasts/steo/report/prices.cfm> (last updated Mar. 7, 2017).

115. Nathan Bomey, *Oil Firm SandRidge Energy Files for Chapter 11 Bankruptcy Protection*, USA TODAY (May 16, 2016, 2:18 PM), <http://www.usatoday.com/story/money/2016/05/16/sandridge-energy-bankruptcy/84434618/>.

116. See Keaton Fox, *Devon Layoffs Begin this Morning, Tower Closed*, OKC FOX (Feb. 17, 2016), <http://okcfox.com/news/local/devon-layoffs-begin-this-morning-tower-closed>; see also Dallas Franklin, *Chesapeake Energy Lays Off Hundreds of Employees*, KFOR (Sept. 29, 2015), <http://kfor.com/2015/09/29/chesapeake-announces-layoffs/>.

117. Paul O'Donnell, *Days after Oklahoma Earthquake, Sierra Club Lawsuit Targets Chesapeake, Devon, Others*, DALL. MORNING NEWS (Feb. 17, 2016), <http://www.dallasnews.com/business/energy/20160217-earthquake-lawsuit-targets-chesapeake-devon-new-dominion.ece>.

118. *Id.*

119. Resource Conservation and Recovery Act, 42 U.S.C. § 6972(a)(1)(B) (2012).

companies to “immediately and substantially” reduce wastewater injections to levels recommended by seismologists and to “reinforce vulnerable structures” that larger earthquakes are likely to impact.¹²⁰ The suit was dismissed in April 2017,¹²¹ but the fact that it was even filed indicates that the political and legal landscape is shifting against oil and gas companies. As public opinion continues to shift, the OCC will feel an increased pressure to fix the earthquake problem.

IV. OKLAHOMA’S EVOLVING ATTEMPTS TO FIGHT EARTHQUAKES

For years after the increase in induced earthquakes had been noted by the scientific community, the Commission failed to effectively address the issue. The Commission did not take any significant action to monitor seismic activity until 2013, and did not act to decrease the seismic activity until 2015, as will be discussed below.

Part of this delay is likely attributable to the scientific community’s inability to unanimously conclude that the seismic activity and wastewater injection wells were related. However, as previously discussed, intervening political forces potentially exacerbated the delay.¹²² Additionally, the delay is also likely attributable to the Oklahoma government’s desire to best accommodate the economic interests of oil and gas companies.¹²³ The following section discusses the steps that the OCC took to address induced seismicity, once it acknowledged the potential relationship with wastewater injection.

A. THE EVOLUTION OF OCC SEISMIC REGULATIONS IN OKLAHOMA

1. The “Traffic Light” System and Data Collection

The Commission first took action regarding the earthquakes in 2013.¹²⁴ Its initial directives had little to do with restricting the wastewater disposal in deep wells, instead focusing primarily on data collection.¹²⁵ In an effort to better monitor seismic activity, the Commission implemented a continually evolving “traffic light” system.¹²⁶ Though initially conceived as a monitoring system, the traffic light system evolved into a mechanism for halting or decreasing

120. *Sierra Club v. Chesapeake Operating LLC*, No. 5:16-cv-00134-F, 2017 WL 1287546 (W.D. Okla. Apr. 4, 2017).

121. *Id.*

122. *See supra* section III.A.

123. *See id.*

124. OKLA. CORP. COMM’N, MEDIA ADVISORY—ONGOING OCC EARTHQUAKE RESPONSE 1 (Mar. 25, 2015), <https://www.occeweb.com/News/2015/03-25-15%20Media%20Advisory%20-%20TL%20and%20related%20documents.pdf> [hereinafter OCC MAR. 2015].

125. *Id.*

126. *Id.* at 1–2.

wastewater disposal in areas where seismic activity has recently occurred.¹²⁷ Under the system, in an “Area of Interest” (“AOI”) or “earthquake swarm,” a disposal well is given a “yellow-light” status in its permit, which subjects it to volume and pressure recording requirements, in addition to other evolving requirements.¹²⁸ An AOI is the ten-kilometer radius around the epicenter of magnitude 4.0 or larger earthquakes.¹²⁹ Similarly, an “earthquake swarm” is defined as an area consisting of at least two events with epicenters within 0.25 miles of one another, with at least one event with a magnitude 3.0 or larger.¹³⁰ In both AOIs and earthquake swarms, any newly proposed disposal well is subject to the yellow-light permitting program, which requires ongoing monitoring and limitations based on seismicity concerns.¹³¹

The Commission’s most significant monitoring regulation was announced in March 2015; it adopted new data monitoring and reporting rules for wells located in central Oklahoma’s earthquake-prone Arbuckle formation.¹³² The new rules require well operators to record daily injection pressure and volume measurements.¹³³ The updated daily recording requirement was a significant increase in regulation, because well operators previously were only required to record such measurements on a monthly basis.¹³⁴

2. Restrictions on Injection Below the Arbuckle, and Voluntary Reductions by Injectors

The Commission’s March 2015 directive gave well operators in AOIs one month to prove to the OGCD that their disposal wells were not injecting below the Arbuckle formation.¹³⁵ The Commission stated that there is “broad agreement among seismologists that injecting below the Arbuckle poses a potential risk of causing earthquakes, as it puts the well in communication with the solid ‘basement’ rock.”¹³⁶ Any well injecting below the Arbuckle formation was required to reduce its disposal volume by fifty percent.¹³⁷ In total, this directive applied to 347 of the approximately 900 disposal wells in the Arbuckle

127. Amy Bickel, *Oklahoma Uses Stoplight System for Wells*, KANSAS AGLAND (Feb. 1, 2015), http://www.kansasagland.com/news/earthquakes/oklahoma-uses-stoplight-system-for-wells/article_93b65ece-b622-5691-bc5c-846a1e8faa01.html.

128. *Id.*

129. *Id.*

130. *Id.*

131. OCC MAR. 2015, *supra* note 124, at 1–2.

132. *Id.*; *see also* Wertz, *supra* note 76.

133. OCC MAR. 2015, *supra* note 124, at 2.

134. *Id.*

135. *Id.* at 1.

136. *Id.*

137. *Id.*

formation.¹³⁸

Shortly after the Commission implemented this directive, the Oklahoma Geological Survey released its scientific findings in April 2015, as previously discussed in section II.B. Even with the Commission beginning work on mitigating earthquakes and the OGS releasing its scientific findings, the Governor of Oklahoma still decided to move forward with a law banning municipalities from enacting ordinances that prohibit hydraulic fracturing within their own jurisdictions.¹³⁹

After the municipality ban went into effect, in July 2015, the Commission issued its first news release in response to the increased earthquake activity in the Crescent area of the Arbuckle formation.¹⁴⁰ The Commission stated that the three oil and gas wastewater disposal wells closest to the seismicity would voluntarily decrease their wastewater injection activity, with two wells shutting down and one decreasing its activity by fifty percent.¹⁴¹ Notably, the Commission stated that the news release was not an actual directive, and the oil and gas companies undertook all reductions voluntarily.¹⁴²

3. The OCC Responds to Earthquake Swarms with Increasingly Comprehensive Local Injection Reductions

In July 2015, the Commission announced that it had received a \$200,000 grant from the Oklahoma Secretary of Energy and Environment, to be used for taking action on more oil and gas wastewater disposal wells in response to increased seismicity concerns.¹⁴³ Additionally, the Commission announced a modification to its March 2015 directive.¹⁴⁴ The March directive had previously allowed operators that were injecting below the Arbuckle formation to continue doing so, as long as they reduced their injections by fifty percent.¹⁴⁵ The July modification mandated that operators reduce the depth (referred to as “plug back”) of their wells.¹⁴⁶ Lastly, the Commission emphasized that disposal wells in the Arbuckle formation continue to have the highest potential risk for induced seismicity

138. *Id.*

139. Emily Atkin, *Fracking Bans Are No Longer Allowed in Oklahoma*, CLIMATE PROGRESS (June 1, 2015), <http://thinkprogress.org/climate/2015/06/01/3664586/oklahoma-ban-on-fracking-bans/>; see also Somin Lee, *Hydraulic Fracturing: Regulation by State vs. Federal Government?*, GEO. ENVTL. L. REV. ONLINE 1 (2016), <https://gehr.org/2016/12/27/hydraulic-fracturing-regulation-by-state-vs-federal-government/>.

140. OKLA. CORP. COMM’N, MEDIA ADVISORY—NEW ACTIONS TAKEN IN RESPONSE TO EARTHQUAKE ACTIVITY IN CRESCENT AREA (July 28, 2015), <http://occeweb.com/News/Crescent%20wells.pdf>.

141. *Id.*

142. *Id.*

143. OKLA. CORP. COMM’N, OCC ANNOUNCES NEXT STEPS IN CONTINUING RESPONSE TO EARTHQUAKE CONCERNS 1 (July 17, 2015), <http://occeweb.com/News/DIRECTIVE-2.pdf>.

144. *Id.*

145. *Id.* at 1–2.

146. *Id.*

because of the formation's depth.¹⁴⁷

Over the next few months, the Commission's directives continued to encompass more disposal wells, and further increased the restrictions on the total amount of wastewater injected into each well. In August 2015, the Commission implemented a schedule to reduce the total disposal volumes in parts of the Arbuckle formation within the defined AOIs.¹⁴⁸ Under the plan, any operator of a well in the Arbuckle formation was required to reduce their disposal injections by thirty-eight percent before October 2, 2015, as compared to their injection volumes from 2014.¹⁴⁹ Between September and October 2015, the Commission implemented two directives that reduced injection volumes in fourteen total wells in order to respond to seismic activity in the Arbuckle formation.¹⁵⁰ In November 2015, the Commission undertook urgent action to reduce injection volumes in the Arbuckle formation after a sudden influx of magnitude 4.0 or larger earthquakes,¹⁵¹ and later had to expand the directive after seismic activity continued.¹⁵² For the first time, the Commission put disposal wells within ten to fifteen miles of the earthquake activity on notice that they should prepare for possible changes to their operations.¹⁵³ In December 2015, the Commission further increased the restrictions implemented in November, encompassing another eighty-eight wells.¹⁵⁴

4. The Oklahoma State Legislature Ensures that the OCC has Authority to Respond to Earthquakes

The Commission continued to expand its directives in late 2015. In the Cherokee area, a plan called for the four wells closest to the earthquake activity to stop operations, and for twenty-five to fifty percent cuts for forty-seven other wells.¹⁵⁵ The Commission subsequently discovered that SandRidge Energy had

147. *Id.*

148. OKLA. CORP. COMM'N, MEDIA ADVISORY—OIL AND GAS DISPOSAL WELL VOLUME REDUCTION PLAN 7–8 (Aug. 3, 2015), <http://occeweb.com/News/08-03-15VOLUME%20ADVISORY%20RELEASE.pdf>.

149. *Id.*

150. OKLA. CORP. COMM'N, MEDIA ADVISORY—CUSHING EARTHQUAKES 1 (Sept. 18, 2015), <http://occeweb.com/News/09-18-15CUSHING.pdf>; OKLA. CORP. COMM'N, MEDIA ADVISORY—CUSHING EARTHQUAKES 1–2 (Oct. 19, 2015), <http://occeweb.com/News/10-19-15CUSHING%202.pdf>.

151. OKLA. CORP. COMM'N, MEDIA ADVISORY—MEDFORD EARTHQUAKES (Nov. 10, 2015), <http://occeweb.com/News/11-10-15MEDFORD02.pdf>.

152. OKLA. CORP. COMM'N, MEDIA ADVISORY—CHEROKEE-CARMEN AREA EARTHQUAKES (Nov. 19, 2015), <http://occeweb.com/News/CHEROKEE%20ADVISORY.pdf>.

153. *Id.* at 1.

154. OKLA. CORP. COMM'N, MEDIA ADVISORY—CONTINUING RESPONSE TO EARTHQUAKES IN THE MEDFORD AND CHEROKEE AREAS (Dec. 3, 2015), http://earthquakes.ok.gov/wp-content/uploads/2015/10/12-03-15BYRON-CHEROKEE_MEDFORD.pdf.

155. *Id.* at 1.

continued disposing wastewater in the area at a higher rate.¹⁵⁶ Escalating the situation, SandRidge challenged the Commission's authority to make binding rules.¹⁵⁷ SandRidge also implied that the Commission's plan was not based on any scientific findings.¹⁵⁸ In response, the Commission announced that it was preparing to pursue legal action to confirm and enforce its rulemaking authority.¹⁵⁹ However, in January 2016, before the case was heard in court, SandRidge and the Commission reached an agreement that SandRidge would stop disposal operations at seven of its wells, with three wells ceasing operations and four being donated to the Oklahoma Geological Society.¹⁶⁰

In response to the challenge of the Commission's authority, the Oklahoma legislature unanimously passed House Bill 3158 ("HB 3158").¹⁶¹ HB 3158 states, in relevant part:

For purposes of immediately responding to emergency situations having potentially critical environmental or public safety impact and resulting from activities within its jurisdiction, the Corporation Commission may take whatever action is necessary, without notice and hearing, including without limitation the issuance or execution of administrative agreements by the Oil and Gas Conservation Division of the Corporation Commission, to promptly respond to the emergency.¹⁶²

Oklahoma House Speaker Jeff Hickman specified on the House floor that the recent earthquakes were precisely the kind of emergency situation that the legislature intended for the OCC to be able respond to, and that potential challenges from industry helped motivate passage of HB 3158.¹⁶³ Governor Mary Fallin signed the bill into law in April 2016.¹⁶⁴

The Commission continued addressing seismic activity in 2016 with its first directive released in response to earthquake activity in the Edmond area, one of

156. Richard Zeits, *SandRidge Energy: Water Disposal Controversy*, SEEKING ALPHA (Dec. 24, 2015), <http://seekingalpha.com/article/3775806-sandridge-energy-water-disposal-controversy>.

157. *Id.*

158. Alex Cameron, *OK Corporation Commission To Take On SandRidge Energy*, NEWS ON 6 (Dec. 21, 2015), <http://www.newson6.com/story/30804157/ok-corporation-commission-to-take-on-sandridge-energy>.

159. *Id.*; Mike Soraghan, *Okla. Officials May Lack Authority on Seismicity Issues*, E&E NEWS (Oct. 9, 2015), <http://www.eenews.net/stories/1060026113>.

160. OKLA. CORP. COMM'N, MEDIA ADVISORY—SANDRIDGE AGREES TO CONVERT WELLS FROM DISPOSAL TO RESEARCH, REDUCE DISPOSAL VOLUME 1 (Jan. 20, 2016), <http://earthquakes.ok.gov/wp-content/uploads/2015/10/01-20-16-SANDRIDGE-MEDIA-ADVISORY.pdf>.

161. Charlie Passut, *Oklahoma Governor Signs Bill Clarifying State's Authority to Act on Quakes*, NAT. GAS. INTELLIGENCE (Apr. 21, 2016), <http://www.naturalgasintel.com/articles/106148-oklahoma-governor-signs-bill-clarifying-states-authority-to-act-on-quakes>.

162. 2016 Okla. Sess. Law Serv. Ch. 77 (H.B. 3158) (West).

163. Wertz, *supra* note 60.

164. Passut, *supra* note 161.

the most affluent suburbs in the state.¹⁶⁵ This directive was unique because, in the past, there were always disposal wells within a three-mile radius of the earthquake activity.¹⁶⁶ However, there was not one in this case, indicating that the Commission now believed disposal wells could cause earthquakes at greater distances than previously believed. Additionally, this action also marked the first time that any wells within fifteen miles of the earthquake activity were required to take action.¹⁶⁷ One week later, because of continued seismic activity, the Commission issued another plan for disposal wells in the Arbuckle formation to reduce volume.¹⁶⁸ The Commission's plan laid out a geographical area—which encompassed twenty-seven wells within an area of twenty-four miles by twelve miles—and required those wells to reduce their volume by an average of eighteen percent.¹⁶⁹

In addition to this directive, the Commission announced its intention to enact a more comprehensive plan to address the seismic activity in the northwestern part of Oklahoma.¹⁷⁰ According to the OGCD Director, “[t]he data available indicates that a much larger approach to the earthquakes in that entire part of northwestern Oklahoma is needed, and we have been working on such a plan.”¹⁷¹ As discussed below, the Director's statement signaled a shift away from piecemeal restrictions that only targeted wells near seismic activity, and toward a more comprehensive approach that targeted all wells in a given region.

5. Action by the Governor Leads to Comprehensive Volume Reduction and Reporting Requirements

At the end of January 2016, Governor Fallin approved the transfer of nearly \$1.4 million in emergency funds to the Oklahoma Corporation Commission and the Oklahoma Geological Survey, to bolster their efforts to reduce earthquakes.¹⁷² This transfer highlights how seriously the state government perceives the risk posed by the earthquakes. Additionally, in February 2016, the Oklahoma Energy Resources Board announced that it would create a new digital system to

165. OKLA. CORP. COMM'N, MEDIA ADVISORY—EDMOND AREA EARTHQUAKES 1 (Jan. 4, 2016), <http://earthquakes.ok.gov/wp-content/uploads/2015/10/01-04-15EQ-ADVISORY.pdf>.

166. *Id.* at 3.

167. *Id.*

168. OKLA. CORP. COMM'N, MEDIA ADVISORY—FAIRVIEW AREA EARTHQUAKES 1 (Jan. 13, 2016), <http://earthquakes.ok.gov/wp-content/uploads/2015/10/01-13-16ADVISORY.pdf>.

169. *Id.*

170. *Id.*

171. *Id.*

172. OFFICE OF GOVERNOR MARY FALLIN, GOVERNOR MARY FALLIN APPROVES TRANSFER OF EMERGENCY FUNDS TO AID OKLAHOMA'S EARTHQUAKE RESPONSE 1 (Jan. 28, 2016), http://earthquakes.ok.gov/wp-content/uploads/2015/04/FOR-IMMEDIATE-RELEASE-01_28_2016.pdf.

collect data on wastewater disposal wells in the state.¹⁷³ The purpose of the system is to establish a standard format for disposal well operators to submit data to the Corporation Commission, while assisting the agency in collecting and analyzing disposal well data.¹⁷⁴

Concern about the seismic activity was further reflected in February 2016, when the Commission increased its regulatory role by announcing a more aggressive volume cutback plan.¹⁷⁵ The plan covered 245 disposal wells in the western part of Oklahoma (where significant earthquake activity had yet to occur) in the Arbuckle formation, and ordered that they cut their volume production by an average of forty percent.¹⁷⁶ Additionally, in releasing its directives, the Commission began including the exact number of gallons by which wells would be reducing their injection volumes, and also including specific wells.¹⁷⁷ In the February 2016 directive, injection volume was reduced by approximately half a million barrels a day.¹⁷⁸ In March, the Commission took a similar action focused on the central part of Oklahoma.¹⁷⁹ This plan encompassed more than 400 disposal wells in the Arbuckle formation, and sought to reduce the injection volume of the entire area to forty percent (or 300,000 barrels) of their 2015 volumes.¹⁸⁰ In addition to the volume reduction, the Commission also dictated that any disposal well not previously encompassed in an AOI is now required to perform daily volume recording and weekly volume reporting for use by regulators and researchers.¹⁸¹

B. EFFECTIVENESS OF THE COMMISSION'S SEISMIC REGULATIONS

New data suggest that the total number of earthquakes occurring in Oklahoma has been continually decreasing.¹⁸² Specifically, the number of earthquakes in Oklahoma that occurred in 2015 (903) as compared to 2016 (623) suggests that

173. OFFICE OF GOVERNOR MARY FALLIN, OERB RESEARCH GRANT TO MODERNIZE WASTEWATER REPORTING SYSTEM 1 (Feb. 16, 2016), http://earthquakes.ok.gov/wp-content/uploads/2015/01/OERB-Press-Release-02_16_2016.pdf.

174. *Id.*

175. OKLA. CORP. COMM'N, MEDIA ADVISORY—REGIONAL EARTHQUAKE RESPONSE PLAN FOR WESTERN OKLAHOMA 1 (Feb. 16, 2016), <http://earthquakes.ok.gov/wp-content/uploads/2015/01/02-16-16WesternRegionalPlan.pdf>.

176. *Id.* at 1.

177. *Id.*

178. *Id.*

179. OKLA. CORP. COMM'N, MEDIA ADVISORY—REGIONAL EARTHQUAKE RESPONSE PLAN FOR CENTRAL OKLAHOMA AND EXPANSION OF THE AREA OF INTEREST (Mar. 7, 2016), <http://earthquakes.ok.gov/wp-content/uploads/2015/01/03-07-16ADVISORY-AOI-VOLUME-REDUCTION.pdf>.

180. *Id.*

181. *Id.*

182. See Everley, *supra* note 5; see also Seth Borenstein, *After New Regulations, Oklahoma's Shakes Calm Down A Bit*, NEWSOK (Nov. 30, 2016, 4:02 PM), <https://newsok.com/after-new-regulations-oklahomas-shakes-calm-down-a-bit/article/5529080>; *What We Know*, *supra* note 1.

the Commission's directives are having their desired effect.¹⁸³ In the month of June 2015—the peak of Oklahoma's seismic activity—the state experienced 183 earthquakes of magnitude 2.8 or larger.¹⁸⁴ While the number of earthquakes of that magnitude remained relatively unchanged in January 2016—during which there were 172 earthquakes—the subsequent months each had significantly fewer earthquakes.¹⁸⁵ In February 2016, 130 magnitude 2.8 or larger earthquakes were recorded, while 86 were recorded in March, and 82 were recorded in April.¹⁸⁶ Notably, the decrease in earthquakes coincides with the implementation of the Commission's volume-reduction directives. This decrease seemingly provides further muster to the scientific conclusions that a causal relationship exists between wastewater injections and earthquakes.

Although earthquake activity in Oklahoma decreased during 2016, there were still significant earthquakes that caused alarm.¹⁸⁷ In September 2016, an earthquake registered as magnitude 5.8, making it the largest earthquake ever recorded in Oklahoma.¹⁸⁸ Subsequently, the Governor declared a state of emergency in the northeast area of Oklahoma that was most affected by the earthquake.¹⁸⁹ The earthquake occurred in Osage County, which is the only county in Oklahoma regulated by the U.S. Environmental Protection Agency (“EPA”)—as opposed to the Commission—under the Osage Tribe Allotment Act of 1906.¹⁹⁰ In regulating the wells in Osage County, the EPA deferred to the Commission's recommendation.¹⁹¹ Seismic activity continued to plague the same region of Oklahoma when a magnitude 4.3 earthquake occurred in the first week of November 2016.¹⁹² Another state of emergency was declared during the second week of November, when a magnitude 5.0 earthquake occurred between Tulsa and Oklahoma City, which was felt by multiple states.¹⁹³

183. *What We Know*, *supra* note 1.

184. Everley, *supra* note 5.

185. *Id.*

186. *Id.*

187. Jim Magill, *Number of Oklahoma Earthquakes Down this Year: State Geologists*, PLATTS (July 6, 2016), <http://www.platts.com/latest-news/natural-gas/houston/number-of-oklahoma-earthquakes-down-this-year-26485701>.

188. Jon Herskovitz, *Oklahoma Sept. 3 Earthquake was Strongest Recorded in State—USGS*, REUTERS (Sept. 7, 2016, 5:46 PM), <http://www.reuters.com/article/us-oklahoma-quake-idUSKCN11D2QR>.

189. Press Release, Gov. Fallin Declares State of Emergency for Pawnee County after Earthquakes, Office of Governor Mary Fallin (Sept. 3, 2016), https://www.ok.gov/triton/modules/newsroom/newsroom_article.php?id=223&article_id=25079.

190. Adam Wilmoth & Paul Monies, *EPA to Shut Down Osage County Wells Following Pawnee Earthquake*, NEWSOK (Sept. 6, 2016), <http://newsok.com/article/5517005>.

191. OKLA. CORP. COMM'N, MEDIA ADVISORY—LATEST ACTION REGARDING PAWNEE AREA (2016), <http://www.occ.state.ok.us/News/2016/09-12-16Pawnee%20Advisory.pdf>.

192. OKLA. CORP. COMM'N, ADVISORY—PAWNEE (2016), https://earthquakes.ok.gov/wp-content/uploads/2015/10/Pawnee-Media-Advisory-Oklahoma-Corporation-Commission-11_04_2016.pdf.

193. OKLA. CORP. COMM'N, ADVISORY 4—CUSHING (2016), <http://www.occeweb.com/News/2016/11-08-16CUSHING%20PLAN.pdf>.

According to the current director of the OGS, the decline in earthquakes has occurred mostly in areas impacted by the Commission's directives.¹⁹⁴ However, he cautioned that it has yet to be seen whether this decrease is a lasting result.¹⁹⁵ Furthermore, it is important to note that the decrease in earthquakes occurred during a time when oil and gas companies were fracking significantly fewer new wells. In the period from January to May 2016, approximately 319 new wells were fracked in Oklahoma.¹⁹⁶ Over this same five-month span in 2015, approximately 797 new wells were fracked.¹⁹⁷ This decrease represents an approximately sixty percent reduction in the number of new wells being fracked throughout Oklahoma. Interestingly, this decrease in newly fracked wells—which are the wells that generate the majority of the wastewater—is a substantially greater decrease than any of the Commission's mandated volume reductions. This strongly suggests that the Commission's directives have had a relatively small economic burden on oil and gas companies, because economic forces were already causing companies to produce less wastewater.

It is unclear whether the Commission's directives were responsible for any volume reductions, or if the reductions happened merely because it was no longer economical for oil companies to frack new wells. There remains a question as to what will happen if and when oil prices rebound and make it profitable to frack new wells. While many felt that the directives were having their desired effect, there is still a significant concern regarding the frequency of "big" earthquakes.¹⁹⁸ In the past, the balance between regulation and the economic prosperity of oil and gas companies leaned in favor of the companies. If the Commission is serious about mitigating the earthquakes, when fracking becomes profitable again and wastewater increases, the Commission needs to work with oil and gas companies to explore disposal alternatives.

V. OTHER STATES' RESPONSES

Oklahoma is not the only state dealing with induced seismic activity. Kansas, Ohio, and Texas have each implemented measures to mitigate increases in seismic activity.

194. *Everley*, *supra* note 5.

195. *Id.*

196. *Find a Well*, FRACFOCUS, <http://www.fracfocusdata.org/DisclosureSearch/StandardSearch.aspx> (under "State," select "Oklahoma"; then input "01/01/16" to "05/27/16" into the "Build Date Filter"; then select "Search").

197. *Find a Well*, FRACFOCUS, <http://www.fracfocusdata.org/DisclosureSearch/StandardSearch.aspx> (under "State," select "Oklahoma"; then input "01/01/15" to "05/27/15" into the "Build Date Filter"; then select "Search").

198. Matthew Philips, *Why Oklahoma Can't Turn Off Its Earthquakes*, BLOOMBERG (Nov. 7, 2016), <https://www.bloomberg.com/news/articles/2016-11-08/why-oklahoma-can-t-turn-off-its-earthquakes>.

In 2013, Kansas experienced seismic conditions similar to Oklahoma's.¹⁹⁹ In response, the Kansas Corporation Commission implemented a "Seismic Action Plan" in September 2014 that installed a seismic monitoring network and response plan.²⁰⁰ The Kansas Commission's first order limited all Arbuckle disposal wells to no more than 25,000 barrels of fluid per well, per day in Harper and Sumner Counties.²⁰¹ It also defined large volume Arbuckle disposal wells as those injecting more than 5000 barrels per day in these counties, and imposed daily monitoring and monthly reporting requirements for all large-volume Arbuckle disposal wells.²⁰² Two months after the initial order, the Kansas Commission reduced daily disposal volume in areas of seismic concern to 12,000 barrels per day, per well.²⁰³ After two more months, daily disposal volume in areas of seismic concern was further reduced to 8000 barrels per day, per well.²⁰⁴ These specific disposal restrictions by volume are more precise than the percentage decreases implemented by the Oklahoma Commission. If the total amount of water being injected into disposal wells is the cause of seismic activity, it makes sense for Oklahoma to follow Kansas's model, rather than reducing injection on a percentage basis.

The Kansas Commission's regulations seem effective, because 120 days after implementing the order, there were 87 fewer total earthquakes than in the 120 days prior to the order, according to data from the USGS National Earthquake Information Center.²⁰⁵ In the 180 days prior to the Kansas Commission's order, there were 47 earthquakes of magnitude 3.0 or larger.²⁰⁶ In the 180 days after the Commission's order, there were 20 earthquakes of magnitude 3.0 or larger.²⁰⁷ Of course, like in Oklahoma, the real reason for a decrease in injections and quakes may be the reduction in fracking after the fall of oil prices.²⁰⁸ Because there are significantly fewer injection wells in Kansas than in Oklahoma, it was arguably easier for the Kansas Commission to devise a plan that restricted a finite quantity of wastewater that was allowed to be disposed in injection wells. Additionally, these restrictions are arguably more useful in determining the exact wastewater volume that would avoid causing substantial earthquake activity.

In Texas, where the oil and gas industry has a stronger presence than in Kansas, regulators have yet to comprehensively restrict wastewater injection wells.

199. *Induced Seismicity*, KAN. CORP. COMM'N, http://www.kcc.state.ks.us/induced_seismicity/index.htm (last modified Feb. 29, 2016).

200. *Id.*

201. *Id.*

202. *Id.*

203. *Id.*

204. *Id.*

205. *Id.*

206. *Id.*

207. *Id.*

208. *Id.*

Rather, the Railroad Commission of Texas—the primary regulator of the state’s oil and gas industry—has thus far only implemented restrictions on the permitting process for injection wells.²⁰⁹ This lack of restrictions compared to Oklahoma likely stems from the fact that Texas has experienced fewer earthquakes than Oklahoma.²¹⁰ However, there is cause for alarm because many of the earthquakes are occurring in heavily populated areas, like Dallas.²¹¹

In other states—such as Pennsylvania—permits for injection wells are rarely approved, because the overall subsurface geology in Pennsylvania is not suited for deep well injection.²¹² Pennsylvania has fewer than ten injection wells operating in the state and instead ships its wastewater to Ohio.²¹³ In Pennsylvania, the U.S. EPA maintains control of the injection well permitting process.²¹⁴

VI. ALTERNATIVE WASTEWATER DISPOSAL METHODS

Besides underground injection, the other four most common disposal options for wastewater are: (1) recycling for re-use in fracking or other enhanced recovery methods, (2) treatment and discharge to surface waters, (3) storage in open-air pits, and (4) spreading on roads for ice or dust control.²¹⁵ All of these options present significant risks of harm to public health or the environment.²¹⁶

Commercial-scale recycling operations have met with promising results. In 2013, companies such as Halliburton, Baker Hughes, and FTS International began treating wastewater for re-use in enhanced recovery operations in dry areas like Texas in order to cut the high cost of transporting millions of barrels of water to oil and gas wells and, subsequently, to disposal wells.²¹⁷ Halliburton and Exxon Mobil Inc’s XTO Energy studied the use of Halliburton’s H2OForward

209. Ryan Sitton, *Calls to Halt Texas Injection Wells Because of Earthquake are Premature*, DALLAS NEWS (Sept. 9, 2016), <http://www.dallasnews.com/opinion/commentary/2016/09/09/calls-halt-texas-injection-wells-earthquake-premature>.

210. Reuters, *Oil and Gas Could Be Responsible for Nearly 90% of Texas Earthquakes*, FORTUNE (May 18, 2016), <http://fortune.com/2016/05/18/oil-gas-texas-earthquakes/>.

211. Terrence Henry, *How Fracking Disposal Wells Are Causing Earthquakes in Dallas-Fort Worth*, STATEIMPACT TEX. (Aug. 6, 2012), <https://stateimpact.npr.org/texas/2012/08/06/how-fracking-disposal-wells-are-causing-earthquakes-in-dallas-fort-worth/>.

212. *Deep Injection Wells: How Drilling Waste Is Disposed Underground*, STATEIMPACT PA., <https://stateimpact.npr.org/pennsylvania/tag/deep-injection-well/> (last visited Feb. 26, 2017); Charles W. Abdalla et al., *Marcellus Shale Wastewater Issues in Pennsylvania*, PENNSYLVANIA EXTENSION (2011), <http://extension.psu.edu/natural-resources/water/marcellus-shale/waste-water/current-and-emerging-treatment-and-disposal-technologies>.

213. STATEIMPACT PA., *supra* note 212.

214. *Id.*

215. Kate Slusark, *Report: Five Primary Disposal Methods for Fracking Wastewater All Fail to Protect Public Health and Environment*, NAT. RES. DEF. COUNCIL (May 9, 2012), <https://www.nrdc.org/media/2012/120509>.

216. *Id.*

217. Nichola Groom, *Fracking Water’s Dirty Secret—Recycling*, SCI. AM. (July 15, 2013), <https://www.scientificamerican.com/article/analysis-fracking-waters-dirty-secret/>.

recycling service on XTO Energy wells in New Mexico.²¹⁸ They found cost savings between \$70,000 and \$100,000 per well.²¹⁹ Because of the significant savings that recycling wastewater can generate, a requirement by states that drillers recycle and reuse a certain percentage of their wastewater seems increasingly plausible.

Jurisdictions may also encourage or require companies to transport wastewater to states that are willing to dispose of it for a price. Ohio is one such state to which oil and gas companies transport their wastewater for disposal in injection wells.²²⁰ The wastewater transported to Ohio is often generated in Pennsylvania and West Virginia, where disposal restrictions are more stringent.²²¹ The cost of transporting wastewater for deep-well injection into a neighboring state usually ranges from approximately \$3 to \$7 per barrel.²²² For a newly fracked well, the cost could reach \$100,000 for transporting over 14,000 barrels of flowback water.²²³ Additionally, it may be necessary to transport produced wastewater, which could potentially amount to 3400 barrels a day.²²⁴

CONCLUSION

It appears that some combination of the Commission's directives and the economic downturn are starting to decrease the number of earthquakes in Oklahoma. While this is positive news, this result may not be lasting. As energy prices rise again, the total volume of wastewater that needs to be disposed of will increase. The Commission's current directives restrict the volume of individual wells, but do not restrict the total volume of wastewater injected underground. Therefore, the directives will have to be revised again if energy companies seek to drill more wells in order to increase disposal capacity. Increases in drilling are already on the horizon. The Commission released a statement in December of 2016 regarding its projections and plans for 2017.²²⁵ The Commission indicated that it was expecting to see a significant increase in oil and gas drilling activity in the South Central Oklahoma Oil Province ("SCOOP") and the Sooner Trend Anadarko Basin Canadian and Kingfisher counties ("STACK").²²⁶

Oil and gas companies should keep exploring alternative means of wastewater disposal. In addition to increased restrictions, oil and gas companies will continue to face private lawsuits and public outrage. While injecting wastewater

218. *Id.*

219. *Id.*

220. STATEIMPACT PA., *supra* note 212.

221. Easton, *supra* note 16.

222. *Id.*

223. *Id.*

224. *Id.*

225. Press Release, Okla. Corp. Comm'n, New Year, New Plays, New Plans (Dec. 20, 2016), <https://earthquakes.ok.gov/wp-content/uploads/2016/12/20-16-OCC-News-Release.pdf>.

226. *Id.*

into deep wells is usually the cheapest method of disposal, other concerns may ultimately make an alternative means of disposal more attractive. Any company that can demonstrate a feasible option to reduce injections will gain first-mover advantages. Regulators would almost certainly seize on the technology and require competitors to implement it as well.

The Oklahoma Commission could potentially play a role in this by directing oil and gas companies to recycle larger portions of their wastewater for re-use. This option would at least ensure that all companies operate under the same restrictions, and would also encourage technological innovation.

Finally, assuming that people are less concerned with induced seismicity when it is unlikely to directly affect them, the Commission could require disposal wells to be relocated to more sparsely inhabited parts of Oklahoma. By mandating that injection wells move far away from populated areas, fewer people would experience property damage or injury. Using this solution, it might also be realistic for the state to create a compensation fund for victims of earthquake property damage (or mandate that industry creates one) because of the reduction in the probable amount of total losses from rural as opposed to urban or suburban quakes.²²⁷ At a minimum, reducing the potential value of claims might allow insurers to create a more functional insurance market for earthquake damage as well.

227. See generally Kate Konschnik, *Regulating Stability: State Compensation Funds for Induced Seismicity*, 29 GEO. ENVTL. L. REV. 227 (2017).