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Bringing Down the House: The Regulation and Potential Liability of Induced Earthquakes

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INTRODUCTION

On October 8, 1988, throngs of crazed fans filed into Tiger Stadium on Louisiana State University's oak-dotted Baton Rouge campus. The LSU football team was facing off against highly ranked rival Auburn University, and the stands quickly filled to capacity. With Auburn leading 6-0 in the fourth quarter and only two minutes left on the clock, the entire crowd was on edge. LSU's quarterback drove the team down the field, finishing the drive with a fourth-down touchdown pass to win the game. The LSU fans went wild—so wild that their collective celebration registered as an earthquake on a seismograph located on LSU's campus.[1]

While the incidents at that fateful game reflect a celebratory verve far removed from the catastrophic tragedies discussed in the following pages, those LSU fans taught us a valuable lesson: Mankind can impact his environment through his actions, so forcefully that he may change the very structure of the earth.

Man-made earthquakes—often referred to as induced earthquakes—can result from various activities, including the construction of dams and water resources; mining activities; oil and gas production; and geothermal energy production.[2] The threat of induced earthquakes is particularly troublesome in light of the recent uptick in domestic energy production. In the last decade, oil and gas extraction in the United States has seen an unprecedented growth, pushing domestic oil production to its maximum level in twenty years and bringing natural gas production to an all-time high.[3] This production boom has led to an increase in earthquakes in areas with relatively low natural seismicity.[4]

In the 1960s, geologists first recognized induced earthquakes stemming from underground fluid injections near Denver, Colorado. This period is commonly known as the Rocky Mountain Arsenal earthquake

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1. Juan M. Lorenzo, *Seismology in Sport,* 81 SEISMOLOGICAL RES. LETTERS 526, 526 (2010).

2. U.S. ENVTL. PROT. AGENCY, MINIMIZING AND MANAGING POTENTIAL IMPACTS OF INJECTION–INDUCED SEISMICITY FROM CLASS II DISPOSAL WELLS: PRACTICAL APPROACHES (Nov.12, 2014).

3. U.S. ENERGY INFO. ADMIN., SHORT TERM ENERGY OUTLOOK (STEO) (JAN. 2013).

4. A. McGarr, *Maximum Magnitude Earthquakes Induced by Fluid Injection*, 119 J. GEOPHYSICAL RES.: SOLID EARTH 1008, 1008 (2014) (citing National Research Council, *Induced Seismicity Potential in Energy Technologies,* PRESS NAT'L ACAD., 225 (2013)).

sequence.[5] Since that time, similar earthquakes have become increasingly prevalent around the country as a result of the increased use of wastewater injection disposal wells.[6] And while the Environmental Protection Agency (EPA) offers some regulation of these wells under the Safe Drinking Water Act (SDWA), the agency falls short of addressing the noticeable rise in earthquake frequency around well sites. The SDWA only addresses the contamination of drinking water sources—it does not extend regulations to matters related to induced seismicity.[7] Numerous states have reserved primacy to regulate the injection wells within their borders, enacting statutes that specifically address induced seismicity.[8]

This comment proposes that the EPA introduce regulations to reduce the risk of induced earthquakes resulting from the injection of wastewater into injection disposal wells. Part I looks at the growing problems associated with injection disposal wells and induced seismicity. Part II analyzes and compares existing regulatory schemes at both the state and federal levels. Part III explores the potential liability of well operators and examines existing causes of action through which victims of induced earthquakes may seek redress. Finally, Part IV proposes the introduction of new federal regulations that would reduce the risk of induced seismicity and provide a consistent basis for litigation to award appropriate relief to those injured as a result of induced earthquakes. Adoption of these new regulations will position the United States to continue expansion of the domestic oil and gas industry without the risk of increasing induced seismicity in the future.

I. THE GROWING PROBLEM OF INDUCED EARTHQUAKES

As the oil and gas industry expands with increasing rapidity, the use of injection disposal wells grows in kind. Every day in the United States, over two billion gallons of fluids are injected into underground formations to enhance oil and natural gas production or to dispose of excess fluids

5. In March of 1962, wastewater was injected into a well from chemical manufacturing operations at the Rocky Mountain Arsenal. The largest three earthquakes in this area were recorded at magnitudes ranging from 4.5 to 4.8 and occurred over a year after injection stopped. Justin L. Rubinstein et al., *The 2001-Present Induced Earthquake Sequence in the Raton Basin of Northern New Mexico and Southern Colorado*, 104 BULLETIN OF THE SEISMOLOGICAL SOC'Y OF AMERICA, 2162 Oct. 2014 at 1; U.S. ENVTL. PROT. AGENCY, *supra* note 2, at 11.
6. *See generally* McGarr, *supra* note 4.
7. *Infra* Part II.
8. *Infra* Part II.

flowing from that production.[9] Fugacious minerals, such as natural gas and oil, are naturally mixed with salt water as they rise to the surface during the production process.[10] On average, for every one barrel of crude oil obtained, ten barrels of salt water are produced.[11] The rapid growth in the use of hydraulic fracturing has caused wastewater volume to increase exponentially.[12] This method has used over 250 billion gallons of water since 2005.[13]

The surge in wastewater created by the production boom has necessitated the drilling of more injection wells for fluid disposal.[14] An injection disposal well is a device that places fluid, such as wastewater or brine, into or below the shallow soil layer or deep underground into porous rock formations.[15] While alternatives to deep-well injection exist, scientists and regulators agree that other options are costly and pose additional environmental risks.[16] Consequently, the majority of wastewater is disposed of by using one of the hundreds of thousands of permitted injection wells across the country.[17]

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9. U.S. GOV'T ACCOUNTABILITY OFF, GAO-14-555, DRINKING WATER: EPA PROGRAM TO PROTECT UNDERGROUND SOURCES FROM INJECTION OF FLUIDS ASSOCIATED WITH OIL AND GAS PRODUCTION NEEDS IMPROVEMENT 1 (2014).

10. *Injection Wells: An introduction to their Use, Operation, and Regulation*, GROUND WATER PROT. COUNCIL, 13 (Sept. 1, 2013), http://www.gwpc.org/sites/default/files/UIC%20Brochure%20Updated%209-2013_0.pdf. [http://perma.cc/2HXG-HS7L].

11. *Id.*

12. *Id.*

13. Elizabeth Ridlington & John Rumpler, *Fracking by the Numbers: Key Impacts of Dirty Drilling at the State and National Level,* ENV'T AMERICA 22 (2013),http://www.environmentamerica.org/sites/environment/files/reports/EA_FrackingNumbers_scrn.pdf [http://perma.cc/G37S-ZVJA].

14. U.S. GOV'T ACCOUNTABILITY OFF., *supra* note 9, at 3.

15. *Id.* at 3.The most common rock formations that bear wastewater injections are sandstone or limestone.

16. Brent Ritzel, *Fracking Industrialization & Induced Earthquakes: The Mechanisms that Connect the Disposal of Fracking Wastewater into Deep-Injection Wells to a Significant Increase in Midcontinent Seismic Activity*, FULLER FUTURE, 3 (2013), http://fullerfuture.files.wordpress.com/2013/12/frackingindustrializationandinducedearthquakes-12-2-13.pdf [http://perma.cc/NKH7-ARYC]; Ross D. Brower, et al., *Evaluation of Underground Injection Industrial Waste In Illinois,* ILLINOIS SCIENTIFIC SURVEYS JOINT REP. 2, Es-7, *http://www.isws.illinois.edu/pubdoc/ISSJR/ISWSISSJR-2.pdf* [http://perma.cc/3E8X-AUWH] ("A comparison of the economic and environmental impacts of deep well disposal with those of other disposal options shows that deep well injection ranks among the least costly options and has a less severe impact on USDW and the surface environment than does the land burial option. Class I injection places wastes in deep disposal zones that are relatively far removed from sources of drinking water.").

17. COMM. ON INDUCED SEISMICITY POTENTIAL IN ENERGY TECH. ET AL., INDUCED SEISMICITY POTENTIAL IN ENERGY TECH. 88 (2013).

The EPA classifies injection wells into six categories, Class I through Class VI, based on the similarities of the liquids being injected into the ground.[18] Class II wells represent the large majority of the six categories. As such, the remainder of this discussion will focus primarily on this class.[19] As of 2012, the United States contained over 170,000 Class II injection wells.[20] Federal regulation of Class II wells centers exclusively on the protection of drinking water, despite their correlation to regional earthquakes.[21]

Induced seismicity describes an earthquake resulting from human action that causes a "rate of energy release, or seismicity, which would be expected beyond the normal level of historical seismic activity."[22] Research on induced seismicity "increasingly indicates a credible connection between wastewater injection activities and earthquakes based on proximity and timing of the injection activities."[23] Although the general

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18. Title 40 C.F.R. § 144.6 (2013); *See also Classes of Wells*, ENVTL. PROT. EGENCY, http://water.epa.gov/type/groundwater/uic/wells.cfm [http://perma.ccb /CBB3-G9HS] (last updated Aug 2, 2012).

19. Although two additional Classes exist (Class V and Class VI), they are not germane to the present discussion. While Class V wells are the most numerous of the six categories, the fluid injections issuing from Class V wells are too shallow to be a source of induced seismicity. Class VI wells, which are used for the injection of carbon dioxide for sequestration, are similarly irrelevant, as none are currently in operation. *Classes of Wells, supra* note 18.

20. U.S. GOV'T ACCOUNTABILITY OFF., *supra* note 9, at 1.

21. U.S. ENVT'L. PROT. AGENCY, *supra* note 2, at ES-1.

22. *Induced Seismicity Primer*, U.S. DEP'T OF ENERGY, http://esd.lbl.gov /research/projects/induced_seismicity/primer.html#defined [http://perma.cc/ZC7V-3227] (last visited Sept. 7, 2014).

23. Joanna Glowacki et al., *Hydraulic Fracturing in the European Union: Leveraging the U.S. Experience in the Shale Gas Exploration and Production,* 24 IND. INT'L & COMP. L. REV. 133–81 (2014); *see generally* A. McGarr, *Maximum magnitude earthquakes induced by fluid injection*, 119 J. GEOPHYSICAL RES.: SOLID EARTH 1008–19 (2014); Nicholas J. van der Elst et al., *Enhanced Remote Earthquake Triggering at Fluid-Injection Sites in the Midwestern United States*, 341 SCIENCE 164–67 (2013); William L. Ellsworth, *Injection Induced Earthquakes*, 341 SCIENCE 142–49 (2013); S. Horton, *Disposal of Hydrofracking Waste Fluid by Injection into Subsurface Aquifers Triggers Earthquake Swarm in central Arkansas with Potential for Damaging Earthquake*, 83 SEISMOLOGICAL RES. LETTERS 250–60 (2012); Katie M. Keranen et al., *Potentially Induced Earthquakes in Oklahoma, USA: Links between wastewater injection and the 2011 Mw 5.7 earthquake sequence*, 41 GEOLOGY 699–702 (2013); *Induced Seismicity Primer*, *supra* note 22; Cliff Frohlich, *Two-year survey comparing earthquake activity and injection well locations in the Barnett Shale, Texas* PNAS 13934–13938 (2012); PRELIMINARY REPORT ON THE NORTHSTAR 1 CLASS II INJECTION WELL AND THE SEISMIC EVENTS IN THE YOUNGSTOWN, OHIO, AREA, OHIO DEP'T OF NAT. RESOURCES (2012); AUSTIN HOLLLAND, EXAMINATION OF POSSIBLY INDUCED SEISMICITY FROM HYDRAULIC FRACTURING IN THE EOLA FIELD, GARVIN COUNTY, OKLAHOMA, OKLAHOMA GEOLOGICAL SURVEY (2011).

public and the media often blame these events on hydraulic fracturing,[24] these earthquakes "appear to be more closely related to the use of underground injection wells for disposal of drilling waste, primarily brines."[25] In fact, scientists have determined that the amount of water used in hydraulic fracturing is very rarely enough to induce significant tremors.[26] As such, several circumstances must exist for induction of an earthquake.

> [1] a fault must already exist within the crystalline basement rock;
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> [2] that fault must already be in a near failure state of stress;
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> [3] an injection well must be drilled deep enough and near enough to the fault and have a path of communication to the fault; and
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> [4] the injection well must inject a sufficient quantity of fluids at high enough pressure and for an adequate period of time to cause failure, or movement, along that fault (or system of fault).[27]

Over the last decade, however, at least half of the earthquakes, which struck the United States with a magnitude of 4.5 M_w[28] or greater have

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24. *See* Michael Bastasch, *Scientists: Fracking is Not Causing Earthquakes,* DAILY CALLER NEWS FOUNDATION (last updated, May 6, 2015).

25. Jason Schumacher et al., *Article: The Legal Landscape of "Fracking": The Oil and Gas Industry's Game-Changing Technique Is Its Biggest Hurdle*, 17 TEX. REV. L. & POL. 239, 252 (2013) (citing Terrence Henry, *How Fracking Disposal Wells Are Causing Earthquakes in Dallas-Fort Worth*, STATEIMPACT (Aug. 6, 2012, 2:52 PM), http://stateimpact.npr.org/texas/2012/08/06/how-fracking-disposal-wells-are-causing-earthquakes-in-dallas-forth-worth/ [https://perma.cc/BB8B-D9TS]; Kevin Krajick et al., *Wastewater Injection Spurred Biggest Earthquake Yet, Says Study*, THE EARTH INST., COLUMBIA UNIV. (Mar. 26, 2013), http://www.earth.columbia.edu/articles/view/3072 [http://perma.cc/5S97-R96X].

26. *Id. See generally* AUSTIN HOLLAND, EXAMINATION OF POSSIBLY INDUCED SEISMICITY FROM HYDRAULIC FRACTURING IN THE EOLA FIELD, GARVIN COUNTY, OKLAHOMA (AUG. 2011), http://www.eenews.net/assets/2011/11/02/document_pm_01.pdf [http://perma.cc/V4VK-A9YS].

27. OHIO DEP OF NAT RESOURCES, PRELIMINARY REPORT ON THE NORTHSTAR 1 CLASS II INJECTION WELL AND THE SEISMIC EVENTS IN THE YOUNGSTOWN, 17 (2012).

28. *Measuring the Size of an Earthquake,* USGS (last modified Feb. 24, 2014); *Earthquake Glossary*, USGS (last modified July. 24, 2012) (Seismographs record the vibrations that travel through the earth called seismic waves. Seismographs amplify and record ground motion as a function of time. The moment magnitude (Mw) scale is based on the concept of seismic movement, which is a measure of the seize of an earthquake based on the area of fault rupture, average amount of slip, and the force that was required to overcome the friction sticking the rocks together that were offset by faulting. Seismic movement can be calculated from the amplitude spectra of the seismic waves.).

occurred in regions that exhibit all or some of these characteristics.[29] To this end, induced earthquakes have been documented in Alabama, Arkansas, California, Colorado, Illinois, Louisiana, Mississippi, Nebraska, New Mexico, Ohio, Oklahoma, and Texas.[30] A few of these geographic regions will be discussed below.

A. Specific Examples of Induced Earthquakes

1. Youngstown, Ohio

No record existed of earthquake activity in the area surrounding Youngstown, Ohio, before 2011.[31] However, since March of the same year, low-magnitude seismic activity along a previously unknown fault shook the ground under Youngstown on twelve separate occasions.[32] These tremors are distinct due to their close proximity to a Class II injection well, the Northstar 1.[33] Although, state geologists and regulators scrutinized the link between the earthquakes and the well; Thirty-five inspections of the well took place over the course of seven months.[34] The results indicated that the well was running within its operating permits.[35] After initial inspections showed that additional data would be necessary to draw a direct correlation between the injection well and the seismic events, the Director of the Ohio Department of Natural Resources (ODNR) ordered the Ohio Geological Survey to deploy portable seismometers to the Youngstown area.[36] Injections at Northstar 1 came to a halt when the new equipment showed seismic activity below the injection well.[37] A subsequent earthquake near Youngstown forced an indefinite moratorium on three active deep injection wells and another with a permit pending in the vicinity.[38]

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29. Nicholas J. van der Elst et al., *Enhanced Remote Earthquake Triggering at Fluid-Injection Sites in the Midwestern United States*, 341 SCIENCE 165 (2013).
30. COMM. ON INDUCED SEISMICITY POTENTIAL IN ENERGY TECH. ET AL., INDUCED SEISMICITY POTENTIAL IN ENERGY TECHNOLOGIES, 34 (2013).
31. *Id.*
32. OHIO DEP'T OF NAT. RESOURCES, *supra* note 27, at 3.
33. *Id.*
34. *Id*
35. *Id.*
36. *Id.*
37. *Id.*
38. OHIO DEP'T OF NAT. RESOURCES, *supra* note 27, at 3–4.

2. Prague, Oklahoma

Moving a few states to the southwest, a suspected induced earthquake sequence ripped through Prague, Oklahoma, registering magnitudes of 5.0, 5.7, and 5.0, respectively.[39] According to the U.S. Geological Survey, these earthquakes "destroyed 14 homes, injured 2 people, and buckled pavement."[40] The earthquakes illustrated the gravity of induced seismicity and its potential to cause severe damage. Seismometers placed in the area within twenty-four hours of the first earthquake were able to record the latter two earthquakes and the 1,183 aftershocks.[41] The 5.7 M_w earthquake remains the largest "instrumentally recorded" earthquake to have hit the state of Oklahoma to date.[42]

A lack of relevant data confounded scientific efforts to tie the 2011 earthquakes to injection wells. The 2011 earthquakes in Prague did not occur until seventeen years after use of injection wells in the area commenced, but it is unknown whether smaller, unrecorded seismic events occurred before this sequence.[43] Further, as only the monthly average injection rate into the wells was reported,[44] figures for variations of higher injections are unknown.[45] Nevertheless scientists concluded that the earthquakes "necessitate reconsideration of the maximum possible size of injection-induced earthquakes and of the time scale considered diagnostic of induced seismicity."[46]

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39. Katie M. Keranen et al., *Potentially Induced Earthquakes in Oklahoma, USA: Links between wastewater injection and the 2011 Mw 5.7 earthquake sequence*, 41 GEOLOGY 699 (2013).
40. *Id.*
41. *Id.* at 700.
42. *Id.*
43. *Id.* at 699–702.
44. As of September 2, 2014, for the Arbuckle formation only, the Oklahoma Corporation Commission now requires daily monitoring and recordation of the volume, casing tubing annulus pressure, and surface injection pressure of the well. The operator must maintain this information for a minimum of three years, to be produced upon request by the Commission. For all other formations, the operator must monitor and record the injection rate and surface injection pressure for the well on a monthly basis. 31 Okla. Reg. 1001 (Sept. 2, 2014), https://www.sos.ok.gov/forms/oar/registers/Volume-31_Issue-24.pdf [https://perma.cc/WAW2-TNDS].
45. Katie M. Keranen et al., *supra* note 39, at 699–702.
46. *Id.* at 702.

3. Central Arkansas

Similarly, a series of earthquakes took place within the Fayetteville shale play[47] from 2009 to 2011 in central Arkansas.[48] Seismic activity began approximately three and a half months after injection commenced in the area.[49] The Arkansas Geological Survey, in conjunction with the University of Memphis Center of Earthquake Research and Information (CERI), initiated investigations into the incidents shortly thereafter.[50] In December 2010, after the earthquakes had increased in both magnitude and frequency, the Arkansas Oil and Gas Commission (AOGC) imposed a moratorium on the drilling of new Class II disposal wells in the surrounding area and required operators of existing wells to provide bi-hourly recordation of injection and pressure rates for six months.[51] In July 2011, AOGC established a "revised permanent moratorium area in which no additional [C]lass II disposal wells would be drilled and required four of the original seven disposal wells to be plugged." A final moratorium was authorized on February 17, 2012.[52]

4. North Texas

Farther west, within the Barnett Shale area of North Texas, 2,458 injection wells reported a maximum monthly injection rate of 1,500 barrels of water per month.[53] This region became the focus of a study conducted by the Institute for Geophysics, Jackson School of Geosciences and the University of Texas at Austin, assessing the relationship between the presence and absence of earthquakes and injection wells.[54] Most of the earthquakes identified during the study were located within close proximity to injection wells, and injections were underway at "all but one of these wells . . . at depths between 2 km and 4 km."[55] Generally,

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47. *Fayatteville Shale Natural Gas: Reducing Environmental. Impacts* http://lingo.cast.uark.edu/LINGOPUBLIC/about/ [http://perma.cc/2PHV-RRK9] (Last visited Sept. 3, 2015) ("The Fayetteville Shale is an unconventional natural gas reservoir located on the Arkansas side of the Arkoma Basin, ranging in thickness from 50 to 550 feet and ranging in depth from 1,500 to 6,500 feet.").
48. U.S. ENVTL. PROT. AGENCY, *supra* note 2, at 15.
49. *Id.* at 20.
50. *Id.* at 16.
51. *Id.*
52. U.S. ENVTL. PROT. AGENCY, *supra* note 2, at 17.
53. Cliff Frohlich, *supra* note 23, at 13934, 13935.
54. *Id.*
55. *Id.* at 13935.

injections at these wells occurred for over a year before seismic activity registered.[56]

The study's results indicate that smaller earthquakes—often of a magnitude of two or lower—had taken place much more often than reported.[57] Additionally, the study showed that induced seismicity was much more likely to occur if injection of fluids reached a critical rate.[58] Experts lauded the study for its "success at identifying previously unreported seismicity" and suggest that it could likely be used in other geographic areas to provide helpful information on induced seismicity.[59]

II. EXISTING REGULATORY SCHEMES AT THE STATE AND FEDERAL LEVELS

Both the federal government and several states currently regulate Class II injection wells. Still, only a few states have enacted regulations to specifically reduce induced seismicity. State regulations that *do* address seismicity have, in many cases, stemmed from direct reactions to actual induced earthquakes linked to injection disposal wells.[60] These direct reactions by the public typically occur only when an earthquake is severe enough to be felt by nearby residents, which garners media attention and leads to an investigation of the earthquake.[61]

A. Federal Regulation

Injection wells are federally regulated by the SDWA,[62] although it does not address induced seismicity resulting from these wells.[63] The SDWA includes the Underground Injection Control Program (UIC),[64] which focuses on preventing contamination of underground sources of drinking water (USDWs) by regulating injection wells throughout their

56. *Id.* at 13936. The Dallas-Fort Worth area was one exception, with injections occurring after only six weeks after injections began at a nearby well.
57. *Id.*
58. *Id.*
59. Frohlich, *supra* note 23, at 13934, 13937.
60. *See* CLASS II COMMERCIAL DISPOSAL WELL OR CLASS II DISPOSAL WELL MORATORIUM, ARK. OIL AND GAS COMM'N, ORDER NO. 180A-2-2011-07, http://www.aogc2.state.ar.us/Hearing%20Orders/2011/July/180A-2-2011-07.pdf. [http://perma.cc/6UKC-ML83]; COGCC UNDERGROUND INJECTION CONTROL AND SEISMICITY IN COLORADO, STATE OF COLORADO OIL & GAS CONSERVATION COMMISSION (Jan. 19, 2011).
61. Frohlich, *supra* note 23, at 13934.
62. 42 U.S.C. § 300f (2012).
63. *Id.*
64. 40 C.F.R. § 144.1 (2013).

life, spanning across "siting, construction, operation and monitoring, and closure."[65]

The UIC program that regulates Class II wells does not include specific regulations addressing seismicity, but it does give the UIC regulatory authority to provide for additional permit conditions on a case-by-case basis as necessary to protect USDWs.[66] Despite the fact that the Energy Policy Act of 2005 revised the definition of "underground injection" to exclude the injection of fluids or propping agents for the purpose of hydraulic fracturing,[67] the EPA acknowledged that new program risks have emerged, such as induced seismicity and over-pressurization of formations.[68]

Although the agency decided these risks should be handled on a state-by-state basis,[69] national guidance from the EPA will largely benefit these state programs.[70] Currently, EPA guidelines and regulations establish a process for the agency to review state programs and incorporate state regulations into federal regulations.[71] However, the EPA does not consistently incorporate these state program requirements, and as a result the EPA does not have the ability to enforce state program requirements.[72] For example, Ohio's safeguard regulations such as well-construction standards and continued monitoring of well injection pressure were finalized in 2012, but as of 2014 they had not been formally reviewed or approved.[73] Furthermore, although Oklahoma's regulations of its Class II program have been revised and finalized since the mid-1990s, the EPA has failed to review or approve these regulations.[74] This failure to incorporate state program requirements prevents the EPA from being able to take enforcement action.[75] Thus, if a state fails to take appropriate action against well operators that violate a statute the agency has no power to

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65. *UIC Frequent Questions*, ENVTL. PROT. AGENCY (last updated May 04, 2012).
66. 40 C.F.R. §§ 144.12(b), 144.52(a)(9) (2013).
67. Glowacki et al., *supra* note 23, at 146 (2014), (citing Energy Policy Act 2005, Pub. No. 109-58, 119 Stat. 594 (2005); 42 U.S.C. § 300h(d)(1) (2013)).
68. U.S. GOV'T ACCOUNTABILITY OFF., *supra* note 9, at 35.
69. *Id.*
70. *Id.*
71. *Id.* at 41. *See also* 42 C.F.R. §300(g,h) (2013).
72. U.S. GOV'T ACCOUNTABILITY OFF., *supra* note 9, at 41.
73. *Id.* at 42. Region 5 officials have "read the regulatory changes, but resource constraints have prevented them from approving them and incorporating them into federal regulations."
74. *Id.* According to EPA, Region 6 officials, "regional personnel have not reviewed or approved Oklahoma's program changes because other regional responsibilities . . . ."
75. *Id.* at 43.

enforce regulations that it has not approved by rule.[76] The same is true when a state explicitly requests assistance from the EPA.[77]

The EPA currently collects large amounts of data on Class II wells, but the information is not adequately complete or comprehensive enough to report to Congress, the public, or other interested groups.[78] Further, the data is not sufficiently thorough to allow aggregation of state information to create a report of the national EPA program.[79] Moreover, the data forms are submitted in paper format and are often filled with incomplete or blank fields, rendering the data difficult and time-consuming to summarize and report.[80]

Another source of federal regulation is the Resource Conservation and Recovery Act (RCRA). It was passed in 1976 to address the increasing problem of municipal and industrial waste.[81] Subtitle C of that act creates a federal program to handle hazardous wastes, but most wastes from fracturing and drilling are exempt from the restrictions of RCRA.[82] Under RCRA, regulations prohibit the siting of Class I wells in areas where earthquakes could occur and endanger groundwater.[83] However, rules for Class II wells do not include such a prohibition.[84]

Finally, a federal agency called the United States Geological Survey (USGS) assumes responsibility for recording and reporting earthquake activity worldwide.[85] The USGS is currently working with the EPA and the Department of Energy to better understand induced earthquakes.[86]

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76. 40 C.F.R. § 147.1(e) (2013).
77. *Id.*
78. U.S. GOV'T ACCOUNTABILITY OFF., *supra* note 9, at 45.
79. *Id.* at 47.
80. *Id.* at 47–48.
81. 42 U.S.C. §§ 6901 (2012).
82. Michael Goldman, *Fourth Annual Energy Law Symposium: Drilling Into Hydraulic Fracturing and Shale Gas Development: A Texas and Federal Environmental* Perspective, 19 TEX. WESLEYAN L. REV. 185, 203 (2012); 42 U.S.C. § 6902 (1976); *Exemption of Oil and Gas Exploration and Production Wastes from Federal Hazardous Waste* Regulation, ENVTL. PROT. AGENCY 5–6, http://www.epa.gov/osw/nonhaz/industrial/special/oil/oil-gas.pdf [http://perma.cc/78N4-GVKV]. In 1988, the EPA issued a determination that control of exploration and production wastes is not warranted under RCRA Subtitle C. In 1980, this exemption was legislatively amended to include drilling floods, produced water and other wastes associated with exploration and development or production of crude oil or natural gas. *Id.*
83. 42 U.S.C. § 6901 (2012).
84. Goldman, *supra* note 82, at 203.
85. *Natural Hazard,* U.S. GEOLOGICAL SURVEY (last modified Sept. 11, 2013).
86. *Induced Earthquakes, Earthquake Hazards Program,* U.S. GEOLOGICAL SURVEY (last modified Sept. 11, 2014).

B. State Regulations

Though the EPA developed the current UIC program requirements, states can apply to the EPA to obtain primary enforcement responsibility over the injection activity within their borders, which is also referred to as primacy.[87] Currently, thirty-three states enjoy primacy granted by the EPA to regulate Class II wells.[88] Of these, only a few regulate issues of induced seismicity related to Class II wells. Alternatively, if a state does not obtain primary enforcement responsibility over its wells, the EPA implements the UIC program directly through one of its regional offices.[89]

State regulation of injection wells raises issues of federal preemption– the principle derived from the Supremacy Clause[90] that "a federal law can supersede or supplant any inconsistent state law or regulation."[91] While preemption could present obstacles to state regulation of injection wells within their borders, further exploration of those obstacles is beyond the scope of this comment.

1. Texas

The Railroad Commission of Texas (RRC) regulates Class II wells.[92] The Texas Government Code addresses safety concerns by prohibiting wells from being drilled within 200 feet of a private residence within a municipality.[93] Recently enacted amendments to Texas Administrative Code Section 3.9[94] address induced seismicity by creating stricter

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87. *UIC Program Primacy,* ENVTL. PROT. AGENCY (last updated Aug. 1, 2012).

88. Edith Allison, *EPA Regulation of Induced Seismicity and Injection Wells,* AM. ASS'N PETROLEUM GEOLOGISTS, ENERGY POLICY BLOG (JULY 16, 2014, 8:00 AM), http://www.aapg.org/publications/blogs/energy-policy/article/articleid/12906/epa-regulation-of-induced-seismicity-and-injection-wells [http://perma.cc/EXD9-2MWV].

89. *Basic Information About Injection Wells,* EPA (last updated May 04, 2012).

90. U.S. CONST. art. VI, § 2.

91. U.S. CONST. art. VI, § 2. *See also* BLACK'S LAW DICTIONARY, 1016 (Abridged 9th ed. 2009); Jennifer S. Hendricks, *Preemption of Common Law Claims And The Prospects for FIFRA: Justice Stevens Puts the Genie Back in the Bottle,* 15 DUKE ENVTL. L & POL'Y F. 65 (2004) (explaining that federal preemption can occur either expressly or impliedly, and either form of preemption can preempt positive or common law).

92. *Injection Wells: Am I Regulated?,* TEX. COMM'N ON ENVTL. QUALITY (Last modified Mar. 19, 2014), https://www.tceq.texas.gov/permitting/waste_permits/uic_permits/UIC_Am_I_Regulated.html [https://perma.cc/H86N-6SXN].

93. TEX. LOCAL GOV'T CODE ANN. § 253.005(c) (West 2011).

94. Memorandum from Christina Self on R.R. Comm'n of Tex. Office of Gen. Counsel, Adoption of Amendments to 16 Tex. Admin. Code § 3.9, Relating to Disposal Wells, and § 3.46 Relating to Fluid Injection Into Productive

application requirements and granting greater authority to the RRC to require more frequent monitoring and reporting of injection well operations.[95] The amendments incorporate additional permit application requirements, including logs, geological cross-sections, and structure maps for injection wells located in areas possessing certain conditions.[96] These conditions include complex geology, transmissive faults, or histories of seismic events that suggest increased possibilities of fluids escaping confinement to the injection interval.[97] The amendments also confirm the RRC's authority to terminate or suspend injection permits as it sees fit.[98] Furthermore, under the regulations applicants must include a printed copy or screenshot with their applications showing USGS survey results indicating the locations of any historical seismic events within a circular area of 100 square miles centered around the proposed disposal well location.[99] The § 3.9 amendments have successfully created a regulatory scheme likely to diminish induced earthquakes in Texas.

2. Arkansas

After the Fayetteville Shale Play earthquakes, AOGC ordered that a moratorium be placed on new or additional Class II commercial disposal wells and the issuance of Class II disposal well permits in the areas with increased seismic activity.[100] The AOGC found:

> Seismic activity has been enhanced, induced or triggered in other areas of the country in the past. That seismic activity occurring within the moratorium area has revealed a previously unknown or unmapped fault system . . . that may be capable of producing additional earthquakes of similar or greater magnitude as have already occurred.[101]

As a result of the Fayetteville Shale earthquakes, the 2014 AOGC General Rules and Regulations now deal proactively with induced seismicity. The rules identify the "Moratorium Zone" in which no permit

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Reservoirs (Oct. 21, 2014), http://www.rrc.state.tx.us/media/24613/adopt-amend-3-9and3-46-seismic-activity-102814-sig.pdf [http://perma.cc/2DV9-HJHU] [hereinafter Memorandum].

95. *Id.*
96. *Id.*
97. *Id.*
98. *Id.*
99. *Id.*
100. CLASS II COMMERCIAL DISPOSAL WELL OR CLASS II DISPOSAL WELL MORATORIUM, *supra* note 60.
101. *Id.*

to drill will be granted unless otherwise approved.[102] Furthermore, the rules prohibit issuance of permits to drill new Class II disposal wells or to deepen or re-complete[103] existing Class II wells within one mile of a regional fault or within five miles of a known or identified Moratorium Zone Deep Fault.[104] Further, wells are subject to heightened disposal limitations in zones stratigraphically below or above the Fayetteville Shale formation.[105] Class II permit applicants must also provide technical information, including information relating to the location of any Moratorium Zone Deep Fault within five miles—or a Regional Fault within two miles—of the proposed location of the disposal well, "with special emphasis on identifying any deep faults occurring below the Fayetteville Shale formation which extend to the basement rock."[106] Lastly, the AOGC requires installation of flow meters or other approved measuring devices on all Class II disposal wells to submit information on injection volume and pressure on "no less than a daily basis on a form prescribed by the director."[107] Altogether, the AOGC rules are evidence of Arkansas's preemptive approach to dealing with induced earthquakes.

3. Ohio

The Administrative Code of Ohio outlines a set of procedural steps that must be taken in order to operate an injection well within the state.[108] First, the statute sets forth geographical areas of review based on the average volume to be injected and vests discretionary authority in the Chief of the Division of Oil and Gas[109] to require evaluations of a proposed injection well as he or she deems necessary.[110] Examples of tests that may be required by the Chief include but are not limited to: pressure fall-off testing, geological investigations of potential faulting within the well location, and submittal of plans for the monitoring of seismic activity.[111] Further, every application for a new injection well must state the estimated average and maximum quantities and pressures of brine to be injected

102. ARK. OIL AND GAS COMM'N, GENERAL RULES AND REGULATIONS, 199 (2014).
103. *McGraw-Hill Dictionary of Scientific & Technical Terms, 6E*. S.v. "recompletion." August 4 2015, (Recompletion is the "Redrilling an oil well to a new producing zone (new depth) when the current zone is depleted.").
104. *Id.* at 201.
105. *Id.*
106. *Id.*
107. *Id.*
108. *See* OHIO ADMIN. CODE ANN. §15019-3-06 (West 2014).
109. *Id.* at §1501:9-3-01(B).
110. *Id.* § 15019-3-06.
111. *Id.*

daily and outline the methods for measurement thereof.[112] By enacting §15019-3-06, Ohio exhibited its ability to adapt to the growing problem of induced earthquakes by creating more stringent requirements for new injection wells.

4. Colorado

Colorado has experienced earthquakes since the 1800s and continues to experience them today. Although most of the earthquakes occur from natural phenomena,[113] some are attributable to induced seismicity—most notably at the Rocky Mountain Arsenal in the 1960s.[114]

In 2011, the Colorado Oil and Gas Conservation Commission (COGCC) instituted a policy requiring the Colorado Geologic Survey to review all Class II injection permits for any indicators that might result in seismicity due to injection.[115] The COGCC continuously establishes safeguards aimed at reducing the possibility of induced seismicity, including imposing caps on injection volume, mandating maintenance of pressure below the fracture gradient, and requiring input from the Colorado Division of Water Resources and the Colorado Geological Survey.[116] The COGCC also maintains the Colorado Oil and Gas Information System (COGIS) online database, which contains all records from wastewater injection wells across Colorado.[117]

The COGCC permit process involves the submission of information pertaining to operation of the proposed well, such as well construction, ground water and injection zone isolation, fracture gradient, maximum injection rate, maximum injection volume, maximum injection pressure, and injection zone water quality.[118] In 2011, the permit review process expanded to include a review for seismicity by the Colorado Geological Survey (CGS), which uses maps, the USGS earthquake database, and knowledge of the area to determine seismic potential.[119] If historical seismicity has been detected in the area of a proposed injection well, the well operator must define the seismicity potential and fault proximity prior

112. *Id.*
113. COGCC UNDERGROUND INJECTION CONTROL AND SEISMICITY IN COLORADO, STATE OF COLO. OIL & GAS CONSERVATION COMM'N (Jan. 19, 2011).
114. *Id.*
115. COMM. ON INDUCED SEISMICITY POTENTIAL IN ENERGY TECH. ET AL., INDUCED SEISMICITY POTENTIAL IN ENERGY TECHNOLOGIES, 34 (2013).
116. *Id. For Colorado's rules on Class II injection wells, see* http://cogcc.state.co.us [http://perma.cc/88CJ-83EA].
117. Rubinstein et al., *supra* note 5.
118. COGCC UNDERGROUND INJECTION CONTROL AND SEISMICITY IN COLORADO, *supra* note 60.
119. *Id.* at 3.

to permit approval.[120] Imposition of these heightened regulations creates an effective permitting and recordation process to minimize induced seismicity within Colorado's borders. Colorado is one of the few states moving forward in the direction of higher regulations in order to limit the state's liability for earthquakes.

III. EXISTING CAUSES OF ACTION/LIABILITY

As scrutiny on oil and gas production has increased, so too has the number of personal injury and property damage lawsuits being filed in courts across the United States.[121] Heightened awareness of induced earthquakes and access to industry standards may further increase tort liability for entities that utilize injection disposal wells.[122]

Historically, earthquakes have been considered "acts of God."[123] Induced earthquakes, however, bring man-made forces into play and raise questions of liability and causation. Accordingly, lawsuits have been filed to enjoin projects that threaten to induce earthquakes.[124] In adjudicating these disputes, the principles of tort law governing allocation of fault can be applied to destruction resulting from induced earthquakes caused by human-created vibrations from various activities, such as pile driving and blasting.[125]

A. Causation

The exploration of tort liability first requires an examination of causation. Causation requires litigants to ask: "Is there a cause and effect relationship between the defendant's activity and the plaintiff's injuries?"[126] Whether a causal relationship actually exists is a question of fact,[127] determination of which—due to the highly scientific nature of

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120. *Id.*
121. William J. Jackson & Lori Warner., *Hydraulic Fracturing Litigation Case Law Update Recent Rulings in Pending Tort Litigation*, Oct. 2013 at 1.
122. Timothy D. Stark, *Tort Liability for the Central United States Earthquake Hazard*, 3 J. LEGAL AFF. AND DISP. RESOL. IN ENGINEERING AND CONSTR.152, 154 (2011).
123. Darlene A. Cypser & Scott D. Davis., *Liability for Induced Earthquakes*, 9 J. ENVTL. L. & LITIG. 551 (1994).
124. *Id.* at 552. *See* North Anna Envtl. Coalition v. Nuclear Regulatory Comm'n, 533 F.2d 655 (D.C. Cir. 1976); State of Ohio v. Nuclear Regulatory Comm'n, 814 F.2d 258 (6th Cir. 1987).
125. Cypser & Davis, *supra* note 123, at 553.
126. *Id.* at 561 (citing FOWLER V. HARPER ET. AL., THE LAW OF TORTS §20.2 at 90-91 (2nd ed. 1986)).
127. *Id.* at 562.

induced earthquakes—depends heavily on expert testimony.[128] In the proper circumstances,[129] expert scientific testimony should be adequate, despite its circumstantial nature, to prove "more probable than not that the activities of the inducer caused the earthquakes."[130] Thus, a scientist should be able to furnish the necessary causal link by providing scientific evidence from flow meters and data records to indicate that an induced earthquake occurred as a result of injection activities.

As a matter of public policy, courts may limit the chain of causation through the legal concept of proximate cause.[131] From a scientific viewpoint, the "cause" of the earthquake is "the tectonic strain released by the inducing activity."[132] In the case of induced earthquakes, the proximate cause question becomes: "Even if it can be proved that the activities triggered the quakes, should the inducer be liable for the resulting damage when the released tectonic strain actually caused the damage?"[133] Scientific literature distinguishes the "cause" of the earthquake from the "trigger" of the earthquake by stating that, "[f]rom a legal standpoint . . . the activity that triggers the release of tectonic energy as an earthquake is itself a significant 'cause' of the resulting damage."[134] Courts in analogous cases—such as those seeking compensations for flood, lightning, or fire damage—have found proximate cause satisfied by the releasing or redirecting of a destructive natural force, and thus found it proper to assign liability.[135]

Determination of proximate cause is particularly important in situations of induced earthquakes due to the high potential for damages and the possible resultant penalties. Attorney Darlene Cypser and Geophysicist Scott Davis[136] noted, "from a purely legal point of view, the

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128. *Id.*

129. In showing a causal relationship between an induced earthquake and an injection disposal well, it would be critical to have information regarding the area's history of seismicity and recorded data of the fluid injected into the well to provide concrete information to demonstrate this link. S. Horton, *supra* note 23 at 250-260 (noting that the "close spatial and temporal correlation supports the hypothesis that the recent increase in earthquake activity is caused by fluid injection at the waste disposal wells").

130. Cypser & Davis, *supra* note 123, at 562 (quoting W. PAGE KEETON ET. AL., PROSSER AND KEETON ON THE LAW OF TORTS § 41, at 269 (5th ed 1984)).

131. *Id.* at 563–66.

132. *Id.*

133. *Id.* at 563.

134. *Id.* (quoting Craig Nicholson & Robert L. Wesson, EARTHQUAKE HAZARD ASSOCIATED WITH DEEP WELL INJECTION – A REPORT TO THE U.S. ENVTL. PROT. AGENCY (U.S. Geological Surv. Bull. No. 1951, 1990)).

135. Cypser & Davis, *supra* note 123, at 563.

136. Scott Davis is a Geophysicist with the U.S. Geological Survey at the Center for Earthquake Research & Information in Tennessee.

mere fact that an occurrence may happen 'eventually' is not an excuse for inducing an earlier occurrence."[137] Further, a just determination of proximate cause is crucial because of the potential effects on the oil and gas industry. Over-penalization could hinder rather than promote oil and gas production, which would be contrary to the nation's public policy goals of energy security and economic stability.[138] Therefore, the law must strive for a balance between public policy and industry promotion when addressing proximate cause.

B. Theories of Liability

Once causation is established, the next step is to determine a cause of action or theory of liability with which to hold the inducer of the earthquake liable.[139] With injection-induced earthquakes, several causes of action might be applicable, including trespass, strict liability, negligence, and nuisance.

1. Trespass

First, one may be liable for trespass in several situations. According to the Restatement Second of Torts,

> One is subject to liability for another for trespass, irrespective of whether he thereby causes harm to another legally protected interest of the other, if he intentionally (a) enters land in the possession of the other, or causes a thing or a third person to do so, or (b) remains on the land, or (c) fails to remove from the land a thing which he is under a duty to remove.[140]

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137. *Id.* (citing *Dussell v. Kaufman Constr. Co.,* 157 A.2d 740 (Pa. 1960)). *See also Reynolds v. Texas & Pac. Ry. Co.,* 37 La. Ann. 694, 698 (1885) ("[W]here the negligence of the defendant greatly multiplies the chances of accident to the plaintiff, and is of a character naturally leading to its occurrence, the mere possibility that it might have happened without the negligence is not sufficient to break the chain of cause and effect between the negligence and the injury.").

138. *See Middle-Class Economics: Building a Clean Energy Economy, Improving Energy Security, and Taking Action on Climate Change,* THE PRESIDENT'S BUDGET FISCAL YEAR 2016, https://www.whitehouse.gov/sites/default/files/omb/budget/fy2016/assets/fact_sheets/building-a-clean-energy-economy-improving-energy-security-and-taking-action-on-climate-change.pdf [https://perma.cc/EV58-B6XV] (last visited July 25, 2015).

139. Cypser & Davis, *supra* note 123, at 566–67.

140. RESTATEMENT (SECOND) OF TORTS § 158 (1979) [hereinafter RESTATEMENT].

Section (a) of this definition applies to earthquakes induced via injection disposal wells by interpreting the injection of wastewater as causing a thing—the earthquake—to enter the land in possession of the other. Additionally, recent authorities have defined trespass as "the intentional physical interference with the exclusive possession of property."[141] Trespass has been applied to situations involving damages caused by hydraulic fracturing, contamination by chemical pollutants, and vibrations from blasting or the operation of heavy equipment.[142]

However, because trespass requires that the physical interference be intentional, suits involving induced earthquakes may fail for a lack of requisite intent. Trespass may be difficult to prove, as no company injecting fluids into an injection well does so with the intention of causing vibrations or an earthquake. On the other hand, companies do intend to inject liquid into the disposal wells, which in turn leads to the vibrations. The argument for applying a trespass theory of liability cuts both ways, depending on which act is the focus of the intent inquiry. As such, arguments on either side will be highly fact dependent.

2. Strict or Absolute Liability

The inducement of earthquakes via injection disposal wells could also be judged under a theory of strict or absolute liability. The viability of this theory of recovery turns on whether the injection of wastewater is construed to be an ultra-hazardous or abnormally dangerous activity. The Second Restatement of Torts provides six factors for determining whether an activity should be considered abnormally dangerous.[143] The factors to be considered include:

> (a) existence of high degree of risk of some harm to the person, land or chattels of others; (b) likelihood that the harm results from it will be great; (c) inability to eliminate the risk by the exercise of reasonable care; (d) extent to which the activity is not a matter of common usage; (e) inappropriateness of the activity to the place where it is carried on; and (f) the extent to which its value to the community is outweighed by its dangerous attributes.[144]

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141. Goldman, *supra* note 82, at 258; *See also Pentagon Enterprises v. Sw. Bell Tel. Co.,* 540 S.W.2d 477 (Tex. Civ. App. 1976); *Pioneer Fin. & Thrift Corp. v. Adams*, 426 S.W.2d 317 (Tex. Civ. App. 1968); *City of Garland v. White*, 368 S.W.2d 12 (Tex. Civ. App. 1963).

142. Cypser & Davis, *supra* note 123, at 569.

143. RESTATEMENT**,** *supra* note 140, at § 520.

144. *Id.*

In the context of induced seismicity, the factors tend to vitiate away from classification of injection disposal as an ultra-hazardous or abnormally dangerous activity. Although there is some degree of risk for earthquakes in the operation of injection disposal wells, that risk cannot be characterized as high.[145] Further, research indicates that the risk of these earthquakes can be mitigated by the exercise of reasonable care by the well operator.[146] Lastly, injection disposal wells are usually located in the most convenient place to dispose of the wastewater from its source. The value of disposing this wastewater, which affects the public, as well as the oil and gas industry, largely outweighs the risk.

Uniformity poses another problem in applying strict or absolute theory of liability. These proposed theories could not be applied in a uniform fashion because many states differ on whether they recognize various strict liability claims.[147] Even if a particular state recognizes strict or absolute liability, courts might not consistently hold that the injection of wastewater into disposal wells is ultra-hazardous or abnormally dangerous. Deliberation on this matter would require highly-fact specific inquiries that could lead to drastically disparate results from one court to another within the same state. For these reasons, suits based on strict or absolute liability are not likely to be successful.

3. Negligence

Alternatively, the inducer could be held liable under a theory of negligence, which would ask whether the defendant owed a duty of care to the plaintiff and whether that duty had been breached. In an action for negligence, "[n]otice that certain actions have caused harm in the past will make future harm foreseeable . . . [s]uch circumstances create a duty to investigate the potential for harm, and failure to investigate can be

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145. *See* van der Elst, *supra* note 23, at 165 ("Although most injection wells are not associated with large earthquakes, the converse is not true.").

146. *See* Ellsworth, *supra* note 23, at 148–49.

147. For example, in 1996 Louisiana tort reform limited ultra-hazardous activity to blasting with explosives and pile driving. Acts 1996, 1st Ex. Sess. No. 1 §1 (amending Louisiana Civil Code art. 667). *See also Turner v. Big Lake Oil*, 96 S.W.2d.221 (Tex. 1936) (holding that Texas does not recognize the abnormally dangerous activity doctrine); *see also* Dave Neslin, *Hydraulic Fracturing Litigation: Recent Developments and Current Issues in Cases Involving Alleged Water Supply Impacts,* DAVIS GRAHAM & STUBBS LLP, http://www.dgslaw.com/images /materials/Neslin-RMMLI-Hydraulic-Fracturing%20Litigation.pdf [http://perma.cc /J7T8-KV4Y]; Blake Watson, *Hydraulic Fracturing Litigation Summary,* (July 22, 2015), https://www.udayton.edu/directory/law/documents/watson/blake_watson _hydraulic_fracturing_primer.pdf [https://perma.cc/9HDJ-3ZKB].

negligence."[148] Accordingly, several courts have found negligence to be a viable option as a theory in cases involving vibrations or concussion damage.[149]

Negligence promises to be a practicable theory under which to judge cases involving induced earthquakes, especially in cases where statutory or regulatory authority imposes specified duties on operators. For example, in some instances the well operator is required by statute or regulation to report the volume and pressure of wastewater injected into the well on a daily or weekly basis. Other statutes set a maximum volume pressure or maximum total injection per day. In those circumstances, negligence would come into play where the well operator breached his duty as set forth by the regulation or statute. The Restatement asserts that when a standard of conduct defined by legislation or regulation will be adopted by a court in hearing claims of negligence:

> The court may adopt as the standard of conduct of a reasonable man the requirements of a legislative enactment or an administrative regulation whose purpose is found to be exclusively or in part (a) to protect a class of persons which includes the one whose interest is invaded, and (b) to protect the particular interest which is invaded, and (c) to protect that interest against the kind of harm which has resulted, and (d) to protect that interest against the particular hazard from which the harm results.[150]

Negligence actions would also be particularly useful in scenarios where a history of seismicity existed in the area. In that case, operators would bear a greater standard of care, as they would or should know about the potential for earthquakes in the region. For these reasons, a lawsuit alleging negligent disposal injection is relatively likely to be successful in an induced earthquake situation.

4. Nuisance

Nuisance is another theory of liability that can be used to award damages to victims of induced earthquakes. Nuisance "refers to the interest invaded or the harm caused rather than the nature of the conduct causing the harm."[151] Two types of nuisance claims exist—private

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148. Cypser & Davis, *supra* note 123, at 576 (citing Brooks-Calloway Co. v. Caroll, 29 S.W.2d 592, 593 (Ky. 1930).
149. *See id.* at 578.
150. RESTATEMENT, *supra* note 140, at § 286.
151. Cypser & Davis, *supra* note 123, at 581.

nuisance and public nuisance.[152] A private nuisance consists of an unreasonable interference with the use or enjoyment of a property interest on one's land, with duration being an important factor.[153] Comparatively, a public nuisance arises following a substantial and unreasonable interference with a right common to the general public. Nuisance may arise out of: (1) a physical harm to the property; (2) a physical harm to a person on his property "from an assault on his senses or by other personal injury; [or] (3) an emotional harm to a person from the deprivation of the enjoyment of his property."[154]

Generally, for a nuisance claim to be actionable, a defendant must engage in either an intentional invasion of another's interests, a negligent invasion of another's interests, or assert conduct blameworthy on the grounds that it is abnormal and invades another's interests.[155] In the induced earthquakes scenario, the most applicable of these three actionable activities would be the negligent invasion of another's interests. For instance, when an oil company or other entity injects wastewater into a disposal well in such a way to induce seismic activity on a person's property, that act would most likely invade the landowner's interests in that property. While there would be a lack of intent to cause the seismic activity, a viable claim for relief would still exist if the fluctuations in injections were determined to be a cause of the earthquake. Proof of due care is generally not a defense in a nuisance case because courts only look to the effect rather than the culpable conduct of the defendant.[156] Therefore, the theory of nuisance liability could apply to an induced earthquake situation where the earthquake caused physical harm both to the property and a person on his property through the negligent invasion of the homeowner's interests.

In summation, various causes of action may be used to build a case in the situation of induced seismicity for plaintiffs injured in these situations. Plaintiffs may find it possible to apply some combination of the theories of trespass, strict or absolute liability, negligence, and nuisance as they seek relief for injuries resulting from earthquakes induced via injection disposal wells.

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152. RESTATEMENT**,** *supra* note 140, at § 821(A).

153. Cypser & Davis, *supra* note 123, at 581(quoting WILLIAM L. PROSSER ET AL., CASES AND MATERIALS ON TORTS 847 (7th ed. 1982).

154. Goldman, *supra* note 82, at 203; 42 U.S.C. §6902 (2012), (citing Walton v. Phillips Petroleum Co., 65 S.W.3d 262 (Tex. App. 2001), abrogated by In re Estate of Swanson*,* 130 S.W.3d 144 (Tex. App. 2003)).

155. Z.A.O., Inc. v. Yarbrough Drive Ctr. Joint Venture, 50 S.W.3d 531 (Tex. App. 2001) (quoting Hicks v. Humble Oil & Ref. Co., 970 S.W.2d 90 (Tex. App. 1998)).

156. *See* Hill v. Villarreal, 362 S.W.2d 348 (Tex. Civ. App. 1962); Goldman, *supra* note 82, at 257.

Since these disputes would be rooted in highly fact-intensive inquiries, defendant companies will likely push to settle or dismiss these tortious actions. To date, numerous cases have arisen as a result of the increasing prevalence of induced earthquakes. Perhaps unsurprisingly, the broad majority of these cases have been dismissed or settled.

C. Specific Examples of Litigation

An increasing number of plaintiffs with homes near injection wells and hydraulic fracturing sites have begun filing lawsuits attempting to link earthquakes to activities operated by oil and gas companies.[157] In *Hearn v. BHP Billiton Petroleum (Arkansas) Inc.*, plaintiff homeowners filed a class action in response to defendant's hydraulic fracturing and subsequent use of injection wells to dispose of wastewater.[158] The action settled for an undisclosed amount, thus leaving no guidance for future courts as to how to deal with the issue of causation.[159]

In Prague, Oklahoma, a woman brought a complaint against twenty-six companies for damage to her home and person after several induced earthquakes of magnitudes of 5.0 or greater in November 2011.[160] The plaintiff sought at least $75,000 in compensatory damages in addition to punitive damages, attorney fees, and court costs for injuries she sustained as a result of the earthquakes.[161] The chimney in plaintiff's home collapsed during the vibrations, which caused rocks to fall on her lap and legs. The plaintiff sustained physical injuries that would likely necessitate future knee replacement surgery.[162] One defendant, Spess Oil, maintained that they had not done anything wrong, arguing, "[w]e inject the water at low pressure, so we do not believe that is causing these earthquakes . . . but [the plaintiff has] to blame someone."[163] Plaintiff alleged causes of action including absolute liability and negligence.[164] The case was dismissed by

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157. Theodore Tsekerides et al., *Fracking and Earthquakes?*, PROD. LIAB. MONITOR (Oct. 14, 2013), http://product-liability.weil.com/news/fracking-and-earthquakes/ [http://perma.cc/H99H-LZPQ].

158. Hearn v. BHP Billiton Petroleum (Arkansas) Inc., et al, No. 4:11-cv-474 (E.D. Ark. June 9, 2011).

159. Tsekerides et al., *supra* note 157.

160. D. Ray Tuttle, *Fault Lines: Prague woman suing energy companies over earthquakes,* THE J. RECORD (Aug. 6, 2014).

161. *Id*.

162. *Id*.

163. *Id*.

164. Ladra v. New Dominion, *No.* CJ-2014-115 (23rd Dist. Ok. Filed Aug. 04, 2014), http://www.eenews.net/assets/2014/08/06/document_ew_01.pdf [http://perma.cc/S8YB-KCUL]; *See also,* Ladra v. New Dominion, LLC, 2015 OK 53.

the district court.[165] However, the Oklahoma Supreme Court reversed.[166] The Oklahoma Supreme Court reasoned that, "Because this case does not seek to reverse, review, or modify an OCC order, but simply seeks to recover damages, jurisdiction is proper in the district court."[167] By ruling that the plaintiff could seek damages against these two companies, the court cleared the way for similar lawsuits regarding liability for induced earthquakes.

In a pending suit, *Finn v. EOG Resources Inc.*, four residents of Alvarado, Texas allege damages to several homes and a general diminution of property values within a large geographic area of the Barnett Shale.[168] Plaintiff landowner sought injunction on "further oil and gas extraction via fracking along with punitive damages."[169] The lawsuit alleges negligence, nuisance, and strict liability.[170] Presently this case is in the discovery phase with no imminent resolution in the future.[171]

In February 2014, the *2010-2011 Guy Greenbrier Earthquake Swarm Victims v. Chesapeake Operating, Inc. and BHP Billiton Petroleum (Fayetteville) LLC*, suit was filed in the circuit court in Faulkner County, Arkansas; roughly one month later, the suit was dismissed with prejudice on March 31, 2014.[172] Similarly, *Davis v. Chesapeake Operating, Inc. and BHP Billiton Petroleum (Fayetteville) LLC* was filed on February 12, 2014, but was dismissed with prejudice on March 20, 2014.[173] The plaintiffs in both of these cases asserted causes of action for public nuisance, private nuisance, absolute liability, negligence, trespass, deceptive trade practices, and outrage.[174] Disposition of neither case imparted any guidance with which to move forward on the issue of induced seismicity litigation.

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165. Ladra v. New Dominion, LLC, 2015 OK 53, "The district court dismissed the case on October 16, 2014, explaining that the Oklahoma Corporation Commission (OCC) has exclusive jurisdiction over cases concerning oil and gas operations."

166. Ladra v. New Dominion, LLC, 2015 OK 53.

167. Ladra v. New Dominion, LLC, 2015 OK 53.

168. *Will Earthquakes Shake up the Shale Wastewater Debate?* LAW360 (May 27, 2014), http://www.law360.com/articles/539206/will-earthquakes-shake-up-the-shale-wastewater-debate [http://perma.cc/TA4D-MYWG].

169. *Id*.

170. *Fracking by EOG, Shell Caused Damaging Tremors, Suit Says,* LAW360 (Aug. 02, 2013), http://www.law360.com/articles/462214/fracking-by-eog-shell-caused-damaging-tremors-suit-says [http://perma.cc/PMB4-6CDC].

171. *Will Earthquakes Shake up the Shale Wastewater Debate?, supra* note 168.

172. Barclay R. Nicholson, *Analysis of Litigation Involving Shale & Hydraulic Fracturing*, 46 (June 1, 2014), http://www.nortonrosefulbright.com/files/20140101-analysis-of-litigation-involving-shale-hydraulic-fracturing-104256.pdf[http://perma .cc /CWP8 -AV7E].

173. *Id*.

174. *Id*.

All of these cases illustrate the immense difficulty in bringing suit for injury resulting from induced seismicity. The Oklahoma Supreme Court Ruling in *Ladra v. New Dominion*, may have turned a proverbial tide in litigation for damages in cases of induced earthquakes. However, this case is just a small step in the direction of solving this issue. Causation should not be so daunting as to preclude a plaintiff from recovering damages for injuries in every case. Nevertheless, that precise scenario is largely representative of the current landscape, so much so that this problem needs to be either addressed in court or statutorily mandated.

IV. PROPOSED FEDERAL REGULATORY MECHANISMS

As a solution to the growing threat posed by induced earthquakes, new federal regulatory mechanisms must be enacted to reduce induced seismicity and to create interstate consistency for the purposes of litigation. It is evident that the "industry needs clear requirements under which to operate, regulators must have a firm scientific foundation for those requirements, and the public needs assurance that the regulations are adequate and are being observed."[175] This comment proposes the introduction of new federal regulations that would reduce the risk of induced seismicity and provide a consistent basis for litigation to provide appropriate relief to those injured as a result of induced earthquakes.

A. The Need for Federal Regulatory Mechanisms Versus The Existing State Mechanisms

Federal, rather than state, regulatory mechanisms for induced earthquakes are necessary for several reasons. First, the earthquakes' ability to cross state boundaries necessitates federal regulation to create consistency among states. As an example, even though the Raton Basin extends across the borders of both Colorado and New Mexico, the two states have divergent records of historical seismicity due to their separate record keeping systems.[176] Second, the repercussions of these inconsistencies will only be amplified by growth in the oil and gas industry. Increased production creates a larger need for wastewater injection wells, thus increasing the threat and frequency of induced earthquakes that will bear out more lawsuits and higher liability.

As the energy business grows, the need for consistent regulation across state lines becomes more pressing from a corporate standpoint. Oil and gas companies will inevitably have wastewater injection wells in more

175. Ellsworth, *supra* note 23, at 149.
176. Rubinstein, *supra* note 5, at 10–11.

than one state. As such, these corporations must follow different permitting guidelines for each well, meaning that their legal counsel will waste valuable resources to ensure compliance in each state. The United States is pushing to become a more energy independent nation; making it easier for companies to comply with Class II regulations will promote industry health and growth. Induced earthquake regulation will be most successful at the federal level because of the uncontrollable nature of earthquakes, the promotion of the oil and gas industry, and the efficiency created through consistent, uniform rules. By creating a national structure that controls production, legislators will avoid the numerous pitfalls built into the current patchwork of federal and state laws that exists today.

B. Proposed Regulation to Reduce Induced Earthquakes Caused by Injection Wells

To limit the likelihood of induced earthquakes and create a structure for litigation in this area, uniform federal regulations are of critical importance.

1. Regulation Structure

Structurally, the new federal regulation should be completely separate from the SDWA. The new regulation will serve the specific purpose of regulating wells to limit induced earthquakes, a purpose entirely unrelated to the current SDWA's goal of protecting the nation's drinking water. In a new EPA regulatory scheme that aims to fully regulate injection wells and reduce induced seismicity, the objective of reducing induced earthquakes must be a proactive and primary policy goal rather than one that is merely peripheral. Several different subsections should be created to address the new content in the proposed regulation,[177] including: the application process for new wells; the process for the operation of existing wells; data collection; research; procedural policies upon the detection of seismicity; enforcement; and liability.

2. Application Process for New Wells

First, the application process for new wells should include an evaluation of the land area surrounding the proposed well to determine where the geological faults lie in relation to the proposed location. A history of any seismicity in the proposed well vicinity should also be

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177. *See generally* Memorandum, *supra* note 94.

analyzed as a precaution.[178] Further, the well operator should submit the predicted volume and pressure of water to be injected into the well on a daily basis. Scientists should also be required to assess the pressure buildup potential by evaluating the storage capacity of the well.[179] Additionally, it is vital to contextualize the orientation of the proposed site in relation to other important community structures—such as hospitals, fire stations, and other emergency facilities—that would be crucial in the event of an earthquake.[180] Doing so ensures that these facilities remain functioning and accessible for emergency services if an earthquake does occur.

In addition, the federal regulation should create a mechanism to prohibit construction of new wells where induced earthquakes are likely to occur if more drilling takes place, particularly in areas where known induced earthquakes have historically occurred.[181] Lastly, the regulation should provide for an oversight committee,[182] which would be imbued with the authority to require additional tests as it sees fit, based on any additional circumstances that may arise.[183]

Current Colorado, Texas, Oklahoma, and Ohio statutes support a rigorous application process that includes seismicity tests. This commonality, coupled with the particularized histories of induced seismicity in those states, indicates that rigorous application procedures should be a key aspect in any federal regulation promulgated by the EPA.

3. Existing Wells

The proposed regulation will not force existing disposal wells to apply as new wells, but will rather hold those wells to the new standards of

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178. *See* U.S. ENVTL. PROT. AGENCY, *supra* note 2, at 28.

179. *Id.* at 28.

180. *See* S. Horton, *supra* note 23, at 250–60 ("The UIC does not limit the proximity of waste disposal wells to active seismic zones or to critical facilities [*e.g., hospitals, schools, or nuclear power plants*] based on the potential to induce or trigger earthquakes." The number of disposal wells and induced earthquakes associated with these wells will likely increase dramatically with the increase in natural gas prices, and as this happens, limiting these wells to active seismic zones or critical facilities may become a problem in many areas of the country.); *See* Memorandum, *supra* note 94.

181. CLASS II COMMERCIAL DISPOSAL WELL OR CLASS II DISPOSAL WELL MORATORIUM, *supra* note 60.

182. *Infra* Enforcement pp.1230–33.

183. *See* Ohio Admin. Code Annotated §15019-3-06 (2014) for some of the tests that can be required by the chief, such as pressure fall off testing, geological investigations of potential faulting with the well location, and submittal of plans for the monitoring of seismic activity, as well as any other test that the chief may deem necessary.

enforcement—including data collection through the installation of flow meters[184]—and liability for noncompliance.

If past seismicity has been reported in the vicinity of the well, scientists will have to immediately launch the cost-benefit analysis and evaluate whether the well should remain in operation. This analysis must include a determination of whether future seismic activity at levels that would impact nearby communities would be likely to occur as a result of continued fluid injection in the well.[185] Determination of viability turns on an evaluation of whether it would be more detrimental to society to keep the injection well in operation, or whether the benefits of the wastewater injection outweigh the minimal associated seismic risk presented by the well.

4. Data Collection

Regular reporting of the volume and pressure rates of the fluids being injected into these disposal wells is key in predicting induced earthquakes.[186] As such, weekly reporting of the volume and pressure of wastewater injected into the wells must be required,[187] along with a mandatory monthly report of the week–to–week data issued to the oversight program.[188] Improving the timely collection of injection data by a regulatory agency[189] will provide the much-needed information on hydraulic conditions potentially associated with induced earthquakes.[190] This goal can be achieved through the implementation of approved measuring devices to be required on all wells.[191] As a measure of proactivity, early engagement of all well operators will be critical, especially in areas determined to be susceptible to injection-induced

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184. ARK. OIL AND GAS COMM'N GENERAL RULES, *supra* note 102 at 201.
185. Levels approximated greater than a magnitude of 4.0 should be considered as threatening impact on nearby communities.
186. *See* van der Elst, *supra* note 23, at 164–67; Ellsworth, *supra* note 23, at 142–49.
187. *See generally* Ellsworth, *supra* note 23, at 149 (2013) (Ellsworth recommends daily reporting of volumes, peak and mean injection pressures, as well as measurement of the pre-injection formation pressure.); *See* 31 Okla. Reg. 1001 (Sept. 2, 2014).
188. *See Infra* Enforcement pp.1230–1233 for information on the oversight committee.
189. *Id.*
190. Ellsworth, *supra* note 23, at 149.
191. *See e.g.*: ARK. OIL AND GAS COMM'N, *supra* note 101, at 204:General Rule H-1: Class II Disposal and Class II Commercial Disposal Well Permit Application Procedures (s)(7) which states, "Flow meters, or other measuring devices approved by the Director, shall be installed on all Class II Disposal and Class II Commercial Disposal Wells and Permit Holders shall submit accurate injection volume and pressure information, on no less than a daily basis, on a form prescribed by the Director."

seismicity.[192] Well operators must be made aware of the data collection requirements and possible penalties before any injection begins at the wells.

5. *Research*

The proposed regulation would require that all data be sent to USGS on a quarterly basis for scientific study,[193] intended to research and reduce induced seismicity. This data dissemination will help create a more accurate system with which to assess whether an earthquake was in fact induced as a result of the action of man.[194] A critical use of the data will be to develop an understanding of why some injection wells trigger seismic activity while others do not, especially when those wells "seemingly have similar mechanical and geological characteristics."[195] Better knowledge of the "stress and pressure conditions at depth; the hydrogeologic framework, including the presence and geometry of faults; and the location and mechanisms of natural seismicity at a few sites will be needed," in order to get a better grasp on induced earthquakes in the future.[196]

6. Procedure When Seismicity is Detected

When seismicity is detected, there should be a mandatory shut–in of the disposal well until scientists can thoroughly study the seismicity of the area and perform tests to determine the possibility of a high magnitude earthquake in the future. Thereafter, oversight officials should conduct a cost benefit analysis[197] to evaluate whether it would be more beneficial or more detrimental to society to keep the well open and in operation.

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192. U.S. ENVTL. PROT. AGENCY, *supra* note 2, at 29.

193. *Induced Seismicity Primer*, US DEP'T OF ENERGY, http://esd.lbl.gov/research/projects/induced_seismicity/primer.html#defined [http://perma.cc/ZC7V-3227] (last visited Sept. 7, 2014) ("It is worthwhile to have both public and private research access to the data. Availability of these data to a broad spectrum of researchers could result in an increased understanding of the fundamental processes involved in fluid movement within the Earth's crust. This information may find application in several disciplines including geothermal energy production, non-geothermal electrical energy production, petroleum recovery, CO2 sequestration, and earthquake studies".).

194. For a scientific analysis of numerous case histories which looks at the upper limit to the seismic movement and an explanation of how to estimate the maximum earthquake that could be induced by a given fluid injection project, *see* McGarr, *supra* note 4, at 1008–19.

195. *See generally* Frohlich, *supra* note 23, at 13934–13938.

196. *See generally* William L. Ellsworth, *supra* note 23, at 149. For an explanation of two major limiting factors identified by Ellsworth and Frohlich that can significantly contribute to fault rupture and the inducement of earthquakes from wastewater injection *see* Ritzel, *supra* note 16, at 3).

197. *Infra* Enforcement; This cost benefit analysis should analyze the cost, profits, and service of the existing injection disposal well, in comparison to the

7. Enforcement

An oversight program similar to that of the UIC Program should be put into place to ensure compliance, enforce data collection, and implement injection well shut–ins. The program should use an online system similar to the COGIS, which contains all of the wastewater injection well record information in Colorado.[198] The use of an online program will allow the EPA to avoid the technical difficulties created by the paper recordation process currently in place.[199] The program would address compliance by reviewing, accepting and denying new well applications, addressing missed monthly recording requirements through adjudication and probation hearings, and enforcing both temporary and permanent shut-in procedures as necessary where seismicity has been detected.

Since the mandatory monthly data recordation and reporting requirements will create a standard of care through negligence per se,[200] the regulation should also include monetary penalties for breach of this standard. These penalties can be enforced proportionally, based on the severity of the breach, for various failures to follow through with reporting and recording requirements, to timely report mechanical problems and to meet any other requirement that the program deems worthy of sanction.[201] Penalties for these negligence per se offenses would be invested towards funding further research on induced seismicity.

Additionally, the EPA and USGS scientists should consider using a traffic light system[202] to implement federal monitoring of wells. The use of a traffic light system could be beneficial to regulate and lessen induced seismicity. In such a system, lower levels of seismicity are permissible, but trigger

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likelihood that the well will create a seismic disturbance of a significant magnitude to be disturbing to surrounding residents.

198. Rubinstein, *supra* note 5, at 3.

199. *Supra* Part II, Section 1.

200. *Infra* Liability.

201. *See* OKLA. ADMIN. CODE § 165:10-5-6 (2014) (Oklahoma includes penalties in its statute for activities such as: failing to comply with initial mechanical integrity testing and reporting requirements, failing to comply with period mechanical integrity testing and reporting requirements, failing to submit forms, and failing to timely notify the Commission of mechanical failure or down-hole problems).

202. Ellsworth, *supra* note 23, at 142–49, (citing M.D. Zobach, *Managing the seismic risk posed by wastewater disposal*, EARTH MAGAZINE 57, 38-43 (2012) (Traffic light systems include setting "seismic activity thresholds that prompt a reduction injection rate or pressure or, if seismic activity increases, further suspension or injection."); *See generally*, Nicholas Deichmann & Domenico Giardini, *Earthquakes Induced by the Stimulation of an Enhanced Geothermal System below Basel (Switzerland)*, 80 SEISMOLOGICAL RES. LETTERS 784–98 (2009), for a scientific study on the Traffic Light system used in Basel, Switzerland.

"additional monitoring and mitigation requirements when seismic events are of sufficient intensity to result in a concern for public health and safety."[203] In a traffic light system, operations can continue without further measures in the green stage; some operational changes are required to reduce the probability of seismicity in the yellow stage.[204] In the red stage, the operations are suspended to allow for analysis. Traffic light systems have proven useful in foreign jurisdictions[205] and could be beneficial to the United States in this context.

8. Liability

The principal hurdle for potential plaintiffs in litigating an induced earthquake claim has been proving causation. Inability to do so seems to be the main reason for most of the dismissals in the cases discussed supra, where causation proved to be the main reason for dismissal.[206] If scientists can properly identify a causal relationship between an earthquake and a company's injection of wastewater into a disposal well, it would seem obvious, as a matter of public policy, that the company's actions should be held as the proximate cause of the induced earthquake. Nevertheless the causal link is not always clear.

However, this challenge is mitigated by the proposed regulation's incorporation of a negligence per se standard surrounding monitoring and reporting. Well operators and companies would be found negligent per se[207] if they failed to report the required information and then subsequently caused an earthquake through their injections.[208] This legislative standard of care allows courts to hold well operators accountable in the event of a breach of their duty, regardless of other proof of causation. In a negligence per se case, the plaintiff would have to prove that he or she falls within the class of persons the statute was designed to protect and that his or her injury is the type that the

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203. COMM. ON INDUCED SEISMICITY POTENTIAL IN ENERGY TECH. ET AL., *supra* note 17, at 118.

204. *Id.* at 156.

205. For instance, the traffic light system has been effectively implemented in Basel, Switzerland. *See* Deichmann & Giardini, *supra* note 202, at 784–98.

206. *Supra* Part III.

207. Rains v. Bend of the River, 124 S.W.3d 580, 589 (Tenn. Ct. App. 2003) (Negligence per se arises when a legislative body pronounces in a penal statute what the conduct of a reasonable person must be, whether or not the common law would require similar conduct.).

208. The law is unsettled as to how a jury should proceed when there is a statute. Is the jury limited to deciding whether or not the defendant violated the statute? Does the statute create a presumption of negligence that the defendant can rebut? Does the statute just serve as mere evidence of negligence? We do not know. The law is not settled in this area. *See* FRANK MARAIST ET AL., TORT LAW: THE AMERICAN AND LOUISIANA PERSPECTIVES 151 (2012).

statute aims to prevent.[209] This statutory protection for a class of plaintiffs would be a huge development in pursuing recovery for those injured as a result of injection-induced earthquakes. Further, the development is necessary due to the continued expansion of the as the oil and gas industries and the resultant increase of litigation involving injection-induced earthquakes.

CONCLUSION

The problems surrounding induced earthquakes are growing and will only continue to do so as the oil and gas industry exponentially expands and creates more and more wastewater. The boom in the nation's energy production insist upon the construction of more wastewater injection wells, and those wells are in turn creating an urgent need for earthquake prevention through regulation.

Although the federal government currently regulates injection wells through the Safe Drinking Water Act, and although some states have enacted safeguards to limit induced earthquakes, comprehensive federal regulation is crucial to fully regulating these wells and actively reducing induced seismicity. Current federal regulation of injection wells is insufficient, and state regulations, while effective in some cases, operate on too small of a scale.

Without a doubt, a federal regulatory scheme would benefit the entire nation. By fostering business efficiency through the standardization of permitting processes and the reduction of excessive future litigation—an inevitable trend in the face of the growing public awareness of the oil and gas industry. Induced earthquakes bring up important questions of liability and causation, which not only threaten businesses with protracted future litigation, but also bar recovery by potential victims injured by induced earthquakes. Both of these problems can be ameliorated through federal regulation. To this end, the EPA must create comprehensive regulations to both reduce induced seismicity and support further growth in the oil and gas industry in the United States.

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209. *See Rains*, 124 S.W.3d at 591; FRANK MARAIST ET AL., TORT LAW: THE AMERICAN AND LOUISIANA PERSPECTIVES 148 (2012).

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