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Earth, Air, Water, Oil: Regulating Fracking in the Monterey Shale with Health and Environment in Mind

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Regulating Fracking in the Monterey Shale with Health and Environment in Mind

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Statement of Purpose

There are bright patches on nocturnal satellite imagery of the United States where they did not exist a decade ago—these are due to gas flaring from hydraulically fractured oil wells.[1] Hydraulic fracturing (fracking) is a means of recovering oil and natural gas; in the fracking process, toxic fluids are injected into the earth at high pressure, which can lead to various detrimental impacts on public health and the environment. Some tout this technique as the "next big thing" in energy resource production. Hydraulic fracturing now accounts for 90% of onshore oil production growth and most of the natural gas production in the United States over the last two years.[2] And, while that is good for American energy demand in the short term, this resource boom comes at a cost to our health and environment. But, before addressing these environmental and health costs, it is important to establish how much we actually benefit from fracking.

America runs on oil. American oil consumption and production statistics make it apparent that hydraulic fracturing is not a sustainable method for resource development. The United States, on average, consumes 18.6 million barrels of oil per day.[3] Oil production from domestic fracking amounts to only 4 million barrels per day.[4] American oil demand still exceeds 14 million barrels per day after taking into account all of our fracked oil. To put this demand in perspective, 14.6 million barrels of oil per day is 40% greater than China's daily oil demand, and China's population is four-times as large as the United States'![5]

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[1] Andy Rowell, "U.S. Gas Flaring Visible from Space as Fracking Industry Booms," EcoWatch, 2013
[2] "Drilling Productivity Report For Key Tight Oil and Shale Gas Regions," Energy Information Administration, 2013
[3] "2012 World Oil Consumption," Energy Information Administration, 2012
[4] "Drilling Productivity Report For Key Tight Oil and Shale Gas Regions," Energy Information Administration, 2013
[5] CIA World Factbook: China

Deconstructing hydraulic fracturing technology reveals that it is a process best suited for harvesting some of the least-accessible fossil fuel reserves. Fracking involves shooting high-pressured fluid deep into shale formations, sometimes to depths exceeding a mile. Oil and gas-bearing shale formations are composed of porous rock harboring tiny pockets of fossil fuel. The high-pressure fracking fluid opens up these pores, creating new passages and stimulating the oil and gas to flow out of the well.

Unlike conventional oil wells, where oil readily flows out of the ground, fracking is used to extract diffusely concentrated fossil fuels from resource-bearing shale formations. It serves to dig out the "dregs" of America's oil supply. Furthermore, fracked wells are short-lived. Productivity in the nation's two most-fracked shale oil plays, the Bakken Shale (North Dakota) and the Eagle Ford Shale (Texas), is not sustainable, with some predictions claiming that the boom will end within the next several years.[6]

80% of domestic shale oil is produced from the Bakken and Eagle Ford shale formations. Hydraulically fractured wells in these regions exhibit between 81 and 90% productivity loss within the first 24 months of production.[7] At these rates of decline, "40 percent of production must be replaced annually to maintain production."[8] However, within the Bakken and Eagle Ford Shale, there are only 3-times as many feasible new drilling locations in existence as currently drilled wells.[9] By 2025, the Bakken and Eagle Ford Shale will have yielded their full oil potential, a combined total of 5 billion barrels, which comprises less than 10 months of United States oil consumption.[10]

The widespread proliferation of hydraulic fracturing signals that we have reached the end of the "easy-oil" era. We are going to great lengths just to pipe a little oil out of the ground, sacrificing much in the process.

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[6] J. David Hughes, "Drill, Baby, Drill: Can Unconventional Fuels Usher in a New Era of Energy Abundance?" Post Carbon Institute, 2013.
[7] Ibid Hughes
[8] Ibid. Hughes
[9] Ibid. Hughes
[10] Ibid. Hughes

In recent years hydraulic fracturing has gained notoriety in the media because of the grave environmental and public health costs associated with it. These costs include water contamination via the migration of fracking fluids into groundwater supplies and reckless disposal of these fluids in open air pits and injection wells; large scale water withdrawals used for fracking; air emissions associated with well production and oil refining; and the potential to induce earthquakes. These problems exist across the country where fracking occurs, including in Pennsylvania, Ohio, Texas, Colorado, and North Dakota. The pervasiveness of these issues reflects major flaws in regulatory approaches to fracking in these states.

A certain measure of environmental risk comes with any resource extraction technique, from coal mining to offshore oil drilling. However, these risks can be mitigated through effective regulation. Hydraulic fracturing is problematic because both federal and statewide regulation of the technique is too lenient, exacerbating the risks inherent in this resource-extraction method. As oil companies continue to exploit shale oil and gas resources it is crucial to implement regulations that protect our communities' access to clean water and curb the pollution that stems from fracking in the United States.

The Monterey Shale

While the Bakken and Eagle Ford Shale formations are currently the most productive shale oil reserves in the United States, fracking is expected to spread elsewhere on a large scale. Of primary interest is California's Monterey Shale, which is estimated to be significantly more resource-abundant than the Bakken or Eagle Ford Shale. The Monterey Shale's technically recoverable resource estimate is 13.7 billion barrels of oil—nearly two-thirds of total recoverable oil shale in the United States.[11] Unconventional well stimulation techniques, such as hydraulic fracturing, are currently the only feasible methods that may be used to extract this oil. However, large-scale fracking in the Monterey Shale would adversely affect

[11] "Review of Emerging Resources: U.S. Shale Gas and Shale Oil Plays," U.S. Energy Information Administration, 2011

California's Central Valley and Central Coast, the state's most productive agricultural regions, which are already plagued by severe water shortage and air quality issues.

The purpose of this piece is to assess the effectiveness of fracking regulations on both the state and federal levels and develop policy recommendations for California's future fracking legislation. As of now, California's fracking regulations are perhaps the most stringent in the country, however they can be strengthened. Oil in the Monterey Shale is a highly valued asset but unless it can be extracted safely the environmental tolls may be too great to justify the excavation of those resources.

Environmental Impacts

Hydraulic fracturing refers to a multi-stage process of which fracking is only one component. The entire fracking process may be divided into three steps: the transportation of all the chemicals, sand, water and equipment involved in drilling and well stimulation to the fracking site; drilling the well, fracking the resource-rich locations, and capturing the oil or gas; and disposing of the liquid waste that is produced in the process. Each of these stages may contribute unique environmental disturbances that range from aesthetically displeasing to downright dangerous. The United States needs to consider these costs as it proceeds with shale development through hydraulic fracturing.

Water Supplies

Hydraulic fracturing requires large amounts of water—anywhere between 2 and 10 million gallons per well.[12] According to the Department of Energy, producing shale oil via fracking consumes between 2 and 5 gallons of water per gallon of oil produced.[13] Furthermore, if shale oil provided one quarter of the

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[12] David M. Kargbo, Ron G. Wilhelm, et al. "Natural Gas Plays in the Marcellus Shale: Challenges and Potential Opportunities," Environmental Science & Technology, 2010

[13] Robin Kundis Craig, "Hydraulic Fracturing (Fracking), Federalism, and the Water-Energy Nexus, Idaho Law Review, 2013

nation's petroleum demand, it would demand between 400 and 1000 million gallons of water every day.[14] When this water is extracted from local groundwater reserves, it can have an immense impact on small communities, especially during droughts.[15]

Barnhart, Texas, an agrarian town in the midst of a three-year drought, had their groundwater reserves completely depleted by resource developers that withdrew the water to frack.[16] The town's ranchers and cotton farmers were forced to cull their herds and lost up to half their crop due to these water withdrawals. [17] The Texas Commission on Environmental Quality predicts that 30 Texan communities will run out of water by the end of 2013[18] and over half of the state's residents are subject to water rations this year.[19]

Fracking's water demand disproportionately affects water stressed communities. A recent study from Ceres, "Hydraulic Fracturing & Water Stress," examined how severely fracking strained local water supplies. According to the study, 2,500 unconventional oil and gas wells operated between 2011 and 2012. These fracks used an estimated 65.8 billion gallons of water, the equivalent yearly water use of nearly 2.5 million Americans.[20] This may not seem like a lot but it makes a huge difference when put into a local context.

Half of the fracking wells drilled in the 2011-2012 period were drilled in areas of "high or extremely high water stress," defined as regions where 80% or more of available water is already being drawn for municipal, industrial or agricultural use.[21] In some states, such as Colorado, 92 percent of fracked wells were drilled in extremely high water stress areas.[22]

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[14] Ibid. Craig
[15] Ibid. Craig
[16] Suzanne Goldenberg, "A Texan Tragedy: ample oil, no water," The Guardian, 2013
[17] Ibid Goldenberg
[18] Ibid. Goldenberg
[19] "List of Texas PWSs Limiting Water Use to Avoid Shortages," Texas Commission on Environmental Quality, 2013
[20] Monika Freyman, Ryan Salmon, "Hydraulic Fracturing & Water Stress: Growing Competitive Pressures for Water," Ceres, 2013
[21] Monika Freyman, Ryan Salmon, "Hydraulic Fracturing & Water Stress: Growing Competitive Pressures for Water," Ceres, 2013
[22] Ibid. Freyman and Salmon

According to the oil and gas industry, hydraulic fracturing only consumes 2 percent of any fracking state's water supply on average.[23] This may be true, however, statistics like this can be misleading. Only 2 percent of state's total water use may be allocated toward fracking. But, fracking does not occur in equal frequency across any state, it is usually concentrated in specific areas. This results in high local water tolls. For example, fracking in Tarrant County, Texas, accounted for 10% of the state's total water use in 2011. In Wise County, Texas, fracking accounted for 19 percent of the county's total annual water use; fracking in Johnson County accounted for 29% of the locale's total annual water use.[24]

Colorado's fracking industry provides another useful example of how the practice can significantly impact local water supplies. Fracking is expected to increase Colorado's water demand by 18,700 acre-feet by 2015.[25] Most of Colorado's water sources are already over appropriated. This forces fracking operators to either import water from other states, buy irrigation rights from farmers, buy water from water suppliers, pump groundwater, lease and treat municipal wastewater, or reuse produced fracking water.[26] At a Northern Colorado surplus water auction, haulers that provide water to fracking operators outbid farmers who usually purchase the excess supply.[27] Colorado famers that can only afford to pay $100 per acre-foot of water are now competing with energy interests that are willing to pay anywhere between $1200 and $2900 per acre-foot.[28] This further illustrates how competition will arise between farmers, manufactures and the oil and gas industry when fracking is introduced to areas with tight water supplies.

The fact that fracking consumes so much fresh water is even more alarming because the majority of that water is completely removed from the water cycle,

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[23] Ibid. Freyman and Salmon
[24] Ibid. Freyman and Salmon
[25] Ibid. Craig
[26] Ibid. Freyman and Salmon
[27] Jack Healy, "For Farms in the West, Oil Wells Are Thirsty Rivals," New York Times, 2012
[28] Amy Mall, "New Investigation: fracking is increasing competition for water and its price in counties with drought," Natural Resources Defense Council, 2013

never to be used again.[29] 9000 fracking wells were permitted in West Virginia and Pennsylvania between 2005 and 2012.[30] On average, 4.7 million gallons of fracking fluid are injected per well fracked in these two states, with only 7% recaptured.[31] This corresponds to roughly 4.37 million gallons of water that is removed from the water cycle per fracked well in these two states. Even if the recoverable wastewater from these wells can be recycled, it still does not mitigate the permanent water tolls that fracking has on the natural hydrological system.

In addition to necessitating large water withdrawals, hydraulic fracturing can be a major source of water contamination. *Fracking fluid*, the serum that is injected into the ground during fracking, is reported to contain several known toxins. These include trimethylbenzenes, naphthalene, benzene, toluene, ethlybenzene, xylenes, acetate, and benzoic acid.[32] Groundwater reserves near fracking sites are at risk of contamination from this fluid. Contamination can occur if wells are improperly maintained, if the shale formation's natural "faultiness" promotes fracking fluid migration, or if contaminants travel along the geological fractures made during fracking.[33]

While fracking fluid itself is inherently toxic, it may become radioactive after being injected thousands of feet underground. During the fracking process, fracking fluid comes into contact with naturally occurring radioactive materials (NORMS) that are located deep in the shale formation. These radioactive materials are present in the fracking wastewater after it is pumped out of the well.[34] The wastewater that is pumped out of the well is commonly referred to as *produced water*. In addition to being radioactive, produced water has high concentrations of

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[29] Hansen, Evan, Mulvaney, Dustin et al, "Water Resource Reporting and Water Footprint from Marcellus Shale Development in West Virginia and Pennsylvania," San Jose State University, 2013
[30] Ibid. Hansen
[31] Ibid. Hansen
[32] DiGiulio, Dominic C., Wilkin, Richard T., Miller, Carlyle, "Investigation of Ground Water Contamination near Pavillion, Wyoming," Environmental Protection Agency, 2011
[33] Myers, Tom, "Potential Contaminant Pathways from Hydraulically Fractured Shale to Aquifers," National Ground Water Association, 2012
[34] Ibid. Myers

total dissolved solids (TDS), sometimes greater than 200,00 mg/L.[35] The EPA recommends treating drinking water when TDS concentrations are greater than 500 mg/L, as high TDS concentrations may signify the presence of hazardous ions, such as aluminum, arsenic, copper, lead, nitrate, etc.[36]

In a typical California oil field, 15 times more water is produced than oil,[37] all of which needs to be disposed. Given how toxic/radioactive produced water from hydraulically fractured wells is, there are valid concerns of how to responsibly dispose of it. Produced water from oil and gas operations are typically disposed of via injection into underground wells. However, in some states, such as Texas and Colorado, fracking wastewater may be disposed of in open-air pits. If improperly disposed of, fracking wastewater may contaminate drinking water supplies, creating severe health risks for those exposed to it.

Air and Climate

Fracking impacts climate and air quality through auxiliary emissions vectors, such as vehicular use associated with fracking as well as the carbon and air quality costs of refining and burning California crude oil. There is also mounting evidence that hydraulically fractured natural gas wells emit fugitive methane gas emissions, a greenhouse gas that contributes significantly to global warming processes.

Supporters of fracking argue that it is critical in helping the United States transition from coal to natural gas for electricity production. Natural gas (methane) is the most efficient fossil fuel, producing 177% more energy per molecule of carbon dioxide formed during combustion than coal.[38] Therefore, natural gas really does

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[35] Heather Cooley and Kristina Donnelly, "Hydraulic Fracturing and Water Resources: Separating the Frack from Fiction," Pacific Institute, 2012
[36] "wellcare® information for you about Total Dissolved Solids," Water Systems Council, EPA, 2007
[37] "Oil, Gas & Geothermal- Injection Wells," California Department of Conservation, 2013
[38] Anna Karion, Colm Sweeny, et al, "Methane emissions estimate from airborne measurements over a western United States natural gas field," Geophysical Research Letters, 2013

have the potential to reduce our carbon footprint, but only if it is harvested properly.

Although methane burns more efficiently than coal, unburned methane is a 25% more potent greenhouse gas than carbon dioxide over a 100-year period.[39] A recent study found that fugitive methane emissions from fracked natural gas wells in Uintah County, Utah, represented 6.2-11.7% of the total amount of methane produced. This un-captured gas is so abundant that it offsets the carbon footprint reduction associated with replacing coal burning with the natural gas produced from those leaky wells.[40] It is crucial that fracking regulations address this issue; otherwise there is no environmental benefit from fracking natural gas.

Rogue methane emissions from fracked natural gas wells are not the only way in which fracking impacts the climate. A typical "frack" job can consume between 2 and 10 million gallons of fracking fluid. An estimated 1500 truckloads of water, chemical additives, sand, and equipment are needed for every 5 million gallons of fracking fluid used.[41] Because each truck travels an average 50 miles to and from the well site,[42] this amounts to 75,000 truck miles per well (37,500 full loads, 37,500 empty loads). The bulk of these trips are devoted to transporting water (5,000,000 gallons/41,500,000 lbs./20,750 Tons) and sand (3,000,000 lbs./1,500 Tons),[43] with the truck itself weighing around 15 Tons (22,250 Tons for 1,500 trucks) [44]. Trucks emit approximately 0.00033 tons of carbon dioxide per Ton-Mile.[45] Thus, transporting the bulk of fracking materials to the well site will emit 368.3 tons of carbon dioxide. The return trip for each of these trucks will emit

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[39] Ibid. Karion et al
[40] Ibid. Karion et al
[41] George E. King, "Hydraulic Fracturing 101: What Every Representative, Environmentalist, Regulator, Reporter, Investor, University Researcher, Neighbor, and Engineer Should Know About Estimating Frac Risk and Improving Frac Performance in Unconventional Gas and Oil Wells," Society of Petroleum Engineers, 2012
[42] Ibid. King
[43] Ibid. King
[44] "How Much Does A Semi Truck Weigh?" ask.com
[45] "how we calculate," Carbon Fund

an additional 182.3 tons of carbon dioxide, for a total of 550.6 tons of carbon dioxide per fracked well.

While transporting fracking materials has a significant carbon imprint, refining mined shale oil is also very carbon intensive. Refineries are the most energy intensive industry in the United States.[46] According to the Energy Information Administration, "The petroleum refining industry uses almost 30 percent of all energy used in manufacturing and emits over 20 percent of the carbon."[47] Refinery greenhouse gas (GHG) emissions comprise 40% of California's total industrial GHG emissions and 10% of state's total GHG emissions. However, because refined fuels are used in transportation, they are also responsible for an additional 40% of California's GHG emissions from transportation.[48]

California's oil refining industry is one of the largest in the Untied States, with a refining capacity of 2 million barrels of oil per day (bpd). Central California has a refining capacity of 150,000 bpd, the Bay Area 860,000 bpd, and Los Angeles 1.25 million bpd.[49] Refineries in the LA region make up 73% of the county's top 15 volatile organic compound (VOC) emitters, a cumulative 1600-3200 tons per year. VOCs react in warm weather to form low-lying ozone, the primary component of smog. VOC emissions can cause lung problems and are sometimes carcinogenic.[50] Monterey Shale oil needs to be refined before it can be marketed, further polluting communities located near refineries.

Fracking well sites themselves can also negatively impact local air quality. VOC emissions from hydraulically fracked wells in Karnes County, Texas, had shocking health consequences for nearby residents. This example, along with others, is examined more closely in the following chapter on existing hydraulic fracturing regulation.

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[46] Julia May, "The Increasing Burden of Oil Refineries and Fossil Fuels in Wilmington, California and How to Clean them Up!" Communities for a Better Environment, 2009

[47] "Carbon Emissions in the Petroleum Refining Industry," Energy Information Administration, 1994

[48] Ibid. May

[49] Ibid. May

[50] Ibid. May

Geology and Induced Seismicity

The fracking process, which involves injecting millions of gallons of pressurized fluids into the earth, has been found to induce earthquakes locally. In general, the earthquakes that result from fracking are not large, never exceeding magnitudes of 3.6.[51] However, fracking wastewater is often disposed of via high-pressure injection into underground wells. These injections have been found to cause more destructive earthquakes, including a 5.6 magnitude earthquake in Prague, Oklahoma that destroyed 14 homes and injured 2 people.[52] Another relevant example of how fracking-related activities can cause seismic disturbances took place nearly half a century ago, in Baldwin Hills, California.

On December 14th, 1963, the Baldwin Hills Reservoir in metropolitan Los Angeles broke open, unleashing 250 million gallons of water upon the surrounding neighborhood. The damage was extensive, destroying 277 homes, killing five people and flooding a square mile of residential area with mud and rubble.[53] A decade-long study that examined the cause behind the reservoir "rupture," concluded that high-pressure, subterranean fluid injections for oil recovery in the nearby Inglewood Oil Field, was the leading reason behind the disaster.[54]

Human-induced seismic disturbances, such as those that took place in Prague, Oklahoma and at the Baldwin Hills Reservoir, demonstrate the

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[51] William L. Ellsworth, "Injection-Induced Earthquakes," Science, 2013
[52] Sharon Begley, "Study Raises New Concern About Earthquakes and Fracking Fluids," Reuters, 2013
[53] Douglass Hamilton and Richard L. Meehan, "Ground Rupture in the Baldwin Hills," Science, 1971
[54] Ibid. Hamilton and Meehan

unpredictable and disastrous consequences that hydraulic fracturing and its related activities can have. Furthermore, while effective regulations might be able to mitigate the impacts that fracking has on water and air quality, it is much harder to regulate the seismic aspect of fracking without changing the nature of the process completely. Doing so would necessitate using lower pressures while fracking and disposing of wastewater via underground injection. However, these techniques are only effective at high pressures, illustrating how fundamentally dangerous fracking is.

Chapter 2: The Current State of Hydraulic Fracturing Regulation

The environmental and public health consequences that can result from hydraulic fracturing operations highlight the need for effective regulations to monitor these activities. While the United States does have a wide range of federal environmental and public health laws, concessions are made to the oil and gas industry that exempt them from these regulations. These loopholes enable fracking operators to violate environmental and public health interests while remaining within the confines of the law. Without a strong federal regulatory framework to monitor fracking operations, states must individually provide oversight for these activities.

Federal Regulation

The lack of federal fracking regulation is a growing liability as these mining techniques proliferate across the United States. This section will review existing federal environmental regulation and how it relates to national fracking activities.

Safe Drinking Water Act (1974)

The Safe Drinking Water Act was established to maintain acceptable public drinking water standards in the United States. Given the importance of groundwater as a municipal and agricultural necessity, the Safe Drinking Water Act administers rules for disposing of liquid waste into underground wells. Hazardous wastes are designated for disposal in "Class I" type wells. Although fracking wastes are hazardous, they were made exempt from the Safe Drinking Water Act with the passage of the 2005 Energy Policy Act. Now fracking wastes are typically disposed of in "Class II" type wells, designated for non-hazardous wastes. Class II wells are not subject to the same stringent construction and monitoring standards as Class I wells but both kinds of wells require permits.[55]

Clean Air Act (1970)

The Clean Air Act was passed to limit "Hazardous Air Pollutants" (HAPs) from stationary and mobile sources.[56] This law requires permitting for "major" sources of air pollution, defined as emissions sources located within a common area that annually emit 10 tons of a single HAP or 25 tons of any collection of HAPs. HAPs from oil and gas production sites, such as an oil well field, are specifically exempt from aggregation rules. Because individual oil or gas wells generally do not meet the HAP emission threshold, they are thus all exempt from these permitting requirements.[57]

Resource Conservation and Recovery Act (1976)

The Resource Conservation and Recovery Act (RCRA) was enacted to regulate the "generation, transportation, treatment, storage, and disposal"[58] of toxic liquid and solid waste. The EPA was in the process of compiling a list of toxic wastes

[55] William J. Brady, "Hydraulic Fracturing Regulation in the United States: the Laissez-Faire Approach of the Federal Government and Varying State Regulations," University of Denver, 2012
[56] Environmental Protection Agency, "Summary of the Clean Air Act," 2013.
[57] Ibid. Brady
[58] Ibid. Brady

that would be subject to regulation under RCRA when congress passed the Solid Waste Disposal Act of 1980, which exempted oil and gas industry liquid wastes from this law. Currently, oil and gas industry liquid waste processing (from storage to disposal) are regulated under the same RCRA protocols that are used for solid wastes. These guidelines are much less stringent than what they would be for liquid waste management.[59]

Emergency Planning and Community Right-to-Know Act (1986)

The Emergency Planning and Community Right-to-Know Act (EPCRA) requires certain businesses to report the quantities and identities of all hazardous chemicals that are manufactured, processed, or used at the workplace to regulatory authorities so that they may react appropriately in contamination scenarios. Industries are tracked according to their "Standard Industrial Classification (SIC)," a four-digit code that is assigned to every industry. Facilities with more than 10 employees, an SIC ranging between 2000 and 2999, and store threshold amounts of listed toxic chemicals, are required to report their toxic inventories under EPCRA.[60] However, the petroleum and natural gas extraction industries are listed under SIC 13 and are not subject to these reporting requirements.[61]

Comprehensive Environmental Response, Compensation, and Liability Act (1980)

The Comprehensive Environmental Response, Compensation, and Liability Act led to the formation of the federal "Superfund," which appropriates money for the remediation of toxic waste contamination sites. This law also holds private companies legally responsible in instances where they are involved in contamination episodes. Unfortunately, the law exempts petroleum, natural gas, or other such hydrocarbons, from classification as "hazardous substance[s]"[62] and

[59] Ibid. Brady
[60] Ibid. Brady
[61] Ibid. Brady
[62] "42 USC § 9601-Definitions," Cornell University Law School

companies involved in the discharge of such products are not necessarily held responsible for them.[63]

National Environmental Policy Act (1969)

The National Environmental Policy Act (NEPA) was designed to evaluate the environmental impact of federal projects. It requires that Environmental Assessments be conducted to determine the environmental impact of federal works. In cases where the impact is deemed significant, the federal departments must compile "Environmental Impact Reports" to synthesize alternatives to such projects. The 2005 Energy Policy Act exempted oil and gas related projects from the NEPA guidelines.[64]

Because federal environmental legislation does not effectively regulate fracking activities, individual states are primarily responsible for regulating fracking within their respective borders. This is logical in some respects because fracking entails excavating geologically complex terrain that is not uniform across states. The following section reviews fracking regulations in states where these activities are prevalent and the effectiveness of these rules.

State Regulation

Statewide oil and gas regulatory administrations are responsible for promoting the efficient production of state resources, while protecting individuals' property rights and reducing the environmental impacts that stem from resource development. To this end, these regulatory bodies manage the permitting for various resource extraction activities, perform environmental impact statements, as well as monitor resource extraction sites to ensure that developers comply with the state's environmental laws. In some instances, regulatory authorities provide oil

[63] Ibid. Brady.
[64] Ibid. Brady

and gas developers with guidelines and best management practices to help them operate safely.

Before oil and gas companies can begin drilling wells, they must acquire permits that specify the well location, drilling and completion and operation requirements.[65] Well drilling is a preliminary step to nearly all forms of oil or natural gas extraction techniques and well permitting helps ensure that they are constructed safely. Adequate well construction and maintenance is key to preventing pollution episodes within this industry because well integrity issues can cause oil and gas to leak into the surrounding environment.[66] In fracking operations, where millions of gallons of toxic fluids are injected into the ground and not removed,[67] maintaining well integrity is necessary to prevent these fluids from migrating into underground water reservoirs. Thus, sufficient oversight over well permitting processes can be instrumental in preventing future toxic contamination episodes.

Properly regulating the well construction process for hydraulically fractured wells is only one way to prevent contamination episodes. Fracked wells also produce a lot of wastewater. The average ratio of water to oil in domestic operations is 10: 1.[68] Produced wastewater from fracking is full of toxins and governing the disposal of this waste is another important regulatory process that can prevent groundwater contamination. Each state has different guidelines for fracking wastewater disposal.

Colorado

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[65] "State Oil and Natural Gas Regulations Designed to Protect Water Resources," U.S. Department of Energy," 2009

[66] "State Oil and Natural Gas Regulations Designed to Protect Water Resources," U.S. Department of Energy," 2009

[67] Abrahm Lustgarten, "In New Gas Wells, More Drilling Chemicals Remain Underground," ProPublica, 2009

[68] "State Oil and Natural Gas Regulations Designed to Protect Water Resources," U.S. Department of Energy, 2009

- The Colorado Oil and Gas Conservation Commission (COGCC) regulates oil and gas operations under the Oil and Gas Conservation Act.
- Well operators must submit drilling purpose, location and any water sources within 400 feet of wellhead. COGCC may reject these permits if the project threatens "public health safety and welfare," environment and wildlife resources.[69]
- Fracking-specific projects require enhanced permitting. Well operators must disclose the proposed well casing, type of fluid to be injected, the chemical analysis of this fluid and the "proposed stimulation program."[70]
- Well operators must keep Material Data Sheets updated with any hazardous chemical that is intended for use while fracking. They must also keep a record of the identity of any trade secret chemical. The COGCC director may request additional information on any onsite fracking chemicals if they think it necessary for disaster mitigation.[71]
- Fracking waste may be stored in open-air pits provided that operators receive an Earthen Pit Permit. These pits must be lined to prevent toxic migration.[72]
- All chemical spills must be reported to COGCC within 24 hours.[73]

Colorado has grown more resolute against fracking in the last couple of months. Increasingly more towns are voting to halt fracking operations, either through moratoriums or bans. Among them are Boulder, Fort Collins, Lafayette, and Longmont. Growing concern over fracking's negative environmental impacts most likely prompted these towns' decisions. But, while these towns came to their decisions through democratic processes, it seems that they are in violation of Colorado state law regarding oil and gas permitting. The Colorado state government

[69] Jason Schumacher and Jennifer Morrissey,"The Legal Landscape of 'Fracking': The Oil and Gas Industry's Game-Changing Technique Is Its Biggest Hurdle," 2013
[70] Ibid. Schumacher and Morrissey
[71] Ibid. Schumacher and Morrissey
[72] Ibid. Schumacher and Morrissey
[73] Ibid. Schumacher and Morrissey

and Colorado Oil and Gas Conservation Commission are currently suing the town of Longmont for their ban on hydraulic fracturing.

The rise of local fracking bans in Colorado is not shocking considering that Colorado recently experienced another environmental crisis regarding the storage of fracking waste fluids. In September 2013, major flooding within Colorado forced the release of 26,385 gallons of toxic fracking wastewater and 43,134 gallons of oil, according to the Colorado Oil and Gas Conservation Commission.[74]

Preliminary water quality tests administered by the Colorado Department of Public Health and Environment indicate that water supplies have not been severely contaminated by these releases. However, fracking wastewater and crude oil are known to be highly toxic. That these releases did not contaminate Colorado waters is merely coincidental and does not ensure that future contamination episodes will not impact the state's water supply. This event points out a significant gap in Colorado's oil and gas safety regulation that needs to be addressed for the ensured safety of those living around the state's fracking sites.

New York

- There is a fracking moratorium in place until May 2015, while a Supplementary Generic Environmental Impact Statement is underway.
- A 2011 revised Draft of SGEIS recommends banning high-volume hydrofracking in the New York City and Syracuse watersheds, as well as on state property.[75]
- As of June 2013, 50 towns in New York State have placed bans on drilling.[76]

While New York currently has a moratorium on hydraulic fracturing some localities have decided to ban the practice in the meanwhile. Dryden, New York, is one such example. The town lies on top of the gas-rich Marcellus Shale, the same

[74] Matt Ferner, "More Oil and Gas Wastewater Spills Found in Colorado After Flooding," Huffington Post
[75] Ibid. Schumacher and Morrissey
[76] Ibid. Schumacher and Morrissey

shale formation that is widely fracked in Pennsylvania and Ohio. Norse Energy Corp USA, a natural gas company that previously leased land from Dryden denizens for fracking, is now suing the town to overturn the ban.[77] Dryden residents are concurrently suing Norse Energy Corp USA, alleging that their leases are invalid.[78]

Pennsylvania

- There are no limits on water withdrawals in Pennsylvania, but drillers need to indicate where they are drawing water.[79]
- Counties may collect impact fees from drilling companies if environmental problems arise from drilling.[80] This fee is based on the price of natural gas and was set at $45,000 per fracked well in 2012, and generated $202 million for Pennsylvania over the course of this year.[81]
- Landowners who experience water pollution after drilling may request the Pennsylvania EPA (PaEPA) to investigate the incident (10 days to investigate, 45 days to conclude). Drillers must provide an alternative water source if they are found responsible for the contamination. However, well operators may challenge the PaEPA's ruling.[82]
- Well operators must dispose of fracking waste according to the Pennsylvania Clean Streams Law and Solid Waste Management Act, which state that they cannot pollute the state's waters. Well operators may temporarily store wastewater in lined pits before proper disposal.[83]
- The PaDEP mandates operators to provide water withdrawal and waste management plans.

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[77] Jesse McKinley, "Fracking Fight Focuses on a New York Town's Ban," New York Times, 2013
[78] Katy Stech, "New York Landowners Sue Norse Energy USA Over Leases," Dow Jones Newswire, 2013
[79] Ibid. Schumacher and Morrissey
[80] Ibid. Schumacher and Morrissey
[81] "What the New Impact Fee Law, Act 13, Means for Pennsylvania," State Impact Pennsylvania, National Public Radio
[82] Ibid. Brady
[83] Ibid. Brady

- DEP maintains a list of all chemicals used in fracking and requires operators to keep lists at well sites.

While Pennsylvania fracking regulations prohibit oil and gas companies from negligently disposing of fracking wastewater and chemicals into water bodies, there have been numerous instances across the state where these companies have been involved in instances of water contamination. Of note is *Suzanne Berish et al. vs. Southwester Energy Production and Southwestern Energy Company*, where several families from Susquehanna County alleged that the defendants were guilty of "releases, spills and discharges of combustible gases, hazardous chemicals, and industrial wastes," from their local fracking operations.[84]

It is often difficult to uncover the details of Pennsylvania lawsuits involving fracking because state regulation protects the oil and gas industry's right to maintain trade secrets. For example, oil and gas companies are not forced to publicly disclose which chemicals they use while fracking, even in instances where said chemicals may have contaminated a family's water supply.

In rare cases, this pro-industry policy is reversed, as in the case *Hallowich v. Range Resources, Mark West Energy Partners, and Williams Gas/Laurel Mountain Midstream Partners,* where Judge O'Dell-Seneca's unsealed the case records, ruling that the gas companies did not have the same right as individuals to keep the court record sealed.[85] The Hallowich family brought this lawsuit against the aforementioned fracking groups, citing the "property damage and health impacts from air and water pollution caused by natural gas operations."[86]

The unsealed court record in *Hallowich v. Range Resources, Mark West Energy Partners, and Williams Gas/Laurel Mountain Midstream Partners* revealed that the Pennsylvania Department of Environmental Protection failed to maintain accurate water sampling records, including records detailing acrylonitrile (a carcinogen)

[84] Tom Zeller Jr. "New Lawsuit Filed in Fracking Country," New York Times, 2010
[85] Betsey Piette, "Fracking Records Unsealed in Pennsylvania," Workers World, 2013
[86] Ibid. Piette

contamination in the Hallowich's water supply.[87] Cases like these reveal that even good public health and safety regulations may not be sufficient to protect individuals against fracking.

Ohio

- Well permitting in Ohio requires operators to report the type, volume and concentration of acid or other fracking fluid used, the amount of pressure to be applied to the target reservoir, and on-site wastewater containment methods. Well operators must also supply the Ohio Department of Natural Resources, Division of Mineral Resources Management (DMRM) with fracking logs that record what happened during the well stimulation process and the volume and content of materials used.[88]
- Fracking well operators in Ohio are required to buy $5 million in insurance coverage for injuries or property damages to neighboring landowners.[89] However, insurance companies are starting to come to terms with the financial risk that they take in insuring fracking operations. An internal report from Nationwide Insurance, and Ohio-based company read:

> "After months of research and discussion, we have determined that the exposures presented by hydraulic fracturing are too great to ignore. Risks involved with hydraulic fracturing are now prohibited for General Liability, Commercial Auto, Motor Truck Cargo, Auto Physical Damage and Public Auto (insurance) coverage."[90]

The number of lawsuits regarding fracking in Ohio is increasing, raising the question of whether the state's regulation of such activities offer enough protection to residents enmeshed in the state's rapid shale resource development. Much like in Colorado, several Ohio towns have passed ordinances to regulate hydraulic

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[87] Ibid. Piette
[88] "Ohio Hydraulic Fracturing State Review," Ohio Department of Natural Resources, 2011
[89] Ibid. Schumacher and Morrissey
[90] Melissa D. Berry, "The Changing Business of Fracking Insurance," Reuters, 2012

fracturing locally but are meeting governmental opposition. In one lawsuit, *State of Ohio ex rel. Morrison v. Beck Energy Corporation* the court found that Ohio state law regulating oil and gas excavation is absolute and that towns lacked the authority to pass individual ordinances.[91]

The majority of fracking lawsuits in Ohio are those that attempt to invalidate lease agreements between landowners and oil and gas companies.[92] Landowners will typically sue oil and gas companies for misleading them during lease negotiations, making mistakes throughout the excavation process, non-compliance with Ohio's notary laws, or failure to make good on lease payments.[93]

Other fracking lawsuits in Ohio include *Boggs v. Landmark 4, LLC* and *Mangan v. Landmark 4, LLC* where plaintiffs sued Landmark 4, LLC, an oil and gas company, for discharging toxic fracking chemicals, including barium, manganese, and strontium, into the ground near residences in Chatham, Ohio.[94] The outcome of this case is still pending, but the allegations suggest that Ohio's fracking regulations are not upholding decent health standards.

Texas

- Oil and gas drilling in Texas is administered by the Oil and Gas Division of the Texas Railroad Commission[95]
- Drillers must acquire permits to frack and must seal wells to prevent contamination of "usable-quality water zones."[96]
- Well operators may store fracking waste in pits provided that they are maintained to prevent water contamination.[97]

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[91] Blake A. Watson, "Ohio Oil and Gas Litigation in the New Fracking Era," Ohio State University, 2013
[92] Ibid. Watson
[93] Ibid. Watson
[94] "William Boggs, et al., v. Landmark 4 LLC: Memorandum Opinion and Order," United States District Court Northern District of Ohio Eastern Division, 2012
[95] Ibid. Brady
[96] Ibid. Brady
[97] Ibid. Brady

- The state requires the disclosure of chemicals used while fracking. However, it does not mandate disclosure of chemicals that are considered trade secrets or any constituents that may enter produced water while drilling.[98]

In Texas, many legal disputes that rise in response to fracking are shrouded in secrecy. Plaintiffs that bring such cases are often coerced into signing confidentiality agreements, ensuring that the court records remain sealed. Occasionally, however, details of such court cases make it into the news. In *United States v. Range Production Company*, the EPA sued Range Resources, a prominent fracking company, for contaminating a Texas resident's water supply with benzene and methane. Range Resources was ordered to clean the contaminated wells, assess the integrity of their fracking wells, and provide clean water to the impacted residents.[99] But, despite the amount of evidence indicating that Range Resources was responsible for the water contamination, the EPA eventually dropped all charges against them. Range Resources is currently suing Steve Lipsky, a resident whose water was contaminated in this episode, for defamation.[100]

Another high profile case in Texas involves residents living in Karnes County, which is located near fracking operations in the Eagle Ford Shale. Between 2006 and 2013, residents filed 30 complaints with the Texas Commission for Environmental Quality (TCEQ) after experiencing prolonged health ailments, including headaches, nausea, rashes, vomiting, and nosebleeds.[101]

The TCEQ visited Karnes County on 6 occasions to investigate emissions from local fracking operations. The TCEQ's policy is to not take air samples unless ambient air VOC concentrations exceed 5 parts per million. However, according to the agency's records, the investigating officials did not take air samples even though they recorded VOC concentrations exceeding 5 parts per million on two occasions.

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[98] Ibid. Brady
[99] Ibid. Schumacher and Morrissey
[100] Alisha Mims, "Texas Man Sued for Defamation by Fracking Company that Contaminated his Water Supply," Ring of Fire, 2013
[101] Sharon Wilson, Wilma Subra, Lisa Sumi, "Reckless Endangerment While Fracking the Eagle Ford," Earthworks, 2013

On one of these occasions, the investigator noted that VOC concentrations were measured at 132 parts per million but that they neglected to take air samples because the air pollution was too severe to do so safely.[102]

Marathon Oil EF LLC, the company responsible for the egregious emissions in Karnes County, was found to be emitting Benzene, Toluene, and other known carcinogens. At one facility, they emitted Hydrogen sulfide at 112.5 times the permitted emissions rate, and other VOCs at 514 times the permitted emissions rate.[103] In the end, TCEQ issued violations to three facilities operated by Marathon Oil EF LLC for improperly reporting their emissions, exceeding their emissions limits, and for not properly abating their emissions. However, TCEQ never pursued the charges and Marathon was never penalized for their violations.[104]

California Regulation

Pre Senate Bill 4

Until Senate Bill 4 goes into effect in January 2014, California's Department of Conservation, Division of Oil, Gas, and Geothermal Resources (DOGGR), regulates hydraulic fracturing in California in accordance with the California Public Resources Code. The California Public Resources Code gives DOGGR responsibility for enforcing well bore and casing integrity standards as well as regulating the more active phases of well placement, drilling, and monitoring. The purpose of the California Public Resources Code is to ensure the ultimate recovery of as many resources as possible while minimizing damage to life and property.[105]

One of the main provisions of the California Public Resources Code is that it allows drillers to employ any method for removing hydrocarbons including, injecting fluids into the ground or enlargement of new channels for the underground movement of hydrocarbons, so long as it is done with the intent to

[102] Ibid. Wilson, Subra, Sumi
[103] Ibid. Wilson, Subra, Sumi
[104] Ibid. Wilson, Subra, Sumi
[105] California Public Resources Code Section 3100-3112

reduce waste.[106] However, the law does not explicitly require regulation supervisors or well operators to measure the waste produced from these wells. If there is no framework for measuring waste, then how can new drilling methods be evaluated based on this metric? This provision does not enforce clean drilling practices, rather it allows drillers to use whatever method they want toward the greatest recovery of fuel resources—even if it is environmentally unsound.

Further regulatory gaps exist within the permitting process for fracking wells in California. Under the California Public Resources Code 3203, well operators must file a notice with the supervisor or district deputy. However, if the notice is not reviewed within 10 days after submission, the project is considered permitted.[107] It is unwise to rely on bureaucratic vigilance when permitting invasive excavation projects. If an environmentally unsound project is proposed to the supervisor during a particularly busy period, it may receive approval without review. This scenario becomes more likely as the oil development accelerates in the Monterey Shale.

The California Public Resources Code does provide some useful regulations that apply to hydraulic fracturing. It requires well operators to provide logs containing the well's history, construction details and well integrity data.[108] It also mandates that well operators prevent any contamination of the overlying and underlying bodies of water surrounding the well.[109] Operators must demonstrate that there is no cross-contamination between the well and the surrounding aqueous strata at the supervisor's request. In cases where the supervisor determines that the well location is hazardous or that the well itself poses environmental risks, they may take "any"[110] action to "remedy"[111] or limit this damage.

An objective reading of the California Public Resources Code indicates that DOGGR has the authority and power to manage any and all fracking-related

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[106] California Public Resources Code Section 3100-3112
[107] California Public Resources Code Section 3200-3238
[108] California Public Resources Code Section 3200-3238
[109] California Public Resources Code Section 3200-3238
[110] California Public Resources Code Section 3250-3258
[111] California Public Resources Code Section 3250-3258

contamination crises. However, there are some basic regulatory oversights that make it impossible for DOGGR to execute its authority. They are listed as follows:[112]

- No adequate disclosure or notice for fracking events
- Not all fracking events are documented
- Fracking chemicals are undocumented
- No data on baseline water quality in fracking areas
- Califonia's Uniform Trade Secrets Act allows companies to keep chemicals secret
- Some well operators volunteer well locations but participation is less than half

These limitations in California's current fracking legislature make it impossible for DOGGR to do its job:

- How can DOGGR monitor fracking sites if well sites are unknown?
- How can DOGGR remediate fracking-related contamination incidents if there is no public disclosure of fracking chemicals?
- How will DOGGR determine that fracking is behind certain incidences of water contamination if there is no baseline water quality testing in active zones?
- How will citizens inform the authorities of fracking transgressions if they are not properly notified of these events?

Evidently there is a huge gap within California's fracking regulations. Because DOGGR does not specifically monitor whether well operators employ hydraulic fracturing, there could be hundreds of secret fracking wells operating in California at this moment. In 2011, Halliburton representatives reported that 50-60% of new wells drilled in Kern County were fracked.[113] At least 1,527 new wells

[112] Michael Kiparsky and Jayni Foley Hein, "Regulation of Hydraulic Fracturing in California: A Wastewater and Water Quality Perspective," 2013
[113] Sharp, Renée, Allayaud, Bill, "California Regulators: See No Fracking, Speak No Fracking," Environmental Working Group, 2012

were drilled in Kern County, meaning that at least 750 of them were fracked.[114] However, none of them were officially reported as fracked wells. Considering the environmental risks associated with fracking, how could DOGGR effectively uphold public health and safety standards if they do not even know which locations are fracked?

While there are regulatory gaps that currently make it difficult for DOGGR to properly regulate fracking, another concern is whether lack of funding also impedes the state agency's ability to regulate effectively.

Although there is no severance tax on oil production in California (the only leading oil-producing state to not have one), DOGGR is funded through an assessment of $0.1426683 per barrel of oil produced.[115] The price of crude oil per barrel currently hovers between $96.51 (WTI) and $109.59 (Brent).[116] At the current assessment rate, DOGGR receives a fraction of a percent of the total value of the oil produced in California. How can they be expected to effectively monitor every well in the state when they have so little money to do so?

Current fracking regulation under DOGGR and the California Public Resource Code are further flawed by the nature of their regulatory authority, which may be termed "reactive agency." Under the California Public Resource Code, DOGGR surely has the power to enforce strict well integrity standards. However, unless DOGGR performs a spot check on a well mid-construction, it will only discover problematic wells after they have caused problems—hence the term "reactive agency." As residents living around oil and gas wells, we ought to be aware that, as of the year 2000, oil wells in Kern County have a failure rate ranging between 2 and 6 percent. As of 2005 there are 48,417 active oil wells in California[117], which corresponds to between 968 and 2,905 well failures at these failure rates.

It is important that DOGGR has the authority to amend faulty wells but we put our communities at undue risk by utilizing such unreliable technologies. These

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[114] Ibid. Sharp and Allayaud
[115] California Department of Conservation, "Assessment Process," 2013
[116] Bloomberg, "Energy & Oil Prices"
[117] California Department of Conservation, "Oil and Gas Facts for 2005," 2005

risks may be adequately mitigated if DOGGR's focus shifted from targeting faulty wells to enhancing the permitting process for well drilling.

Oil excavation in the Monterey Shale will look nothing like conventional oil operations that currently take place in California. The geology of the Monterey Shale is wildly complex and will prove challenging for even experienced shale drillers. It is crucial that DOGGR thoroughly evaluates every fracking permit that gets submitted to their office for review. That said, the Monterey Shale is so poorly understood that DOGGR might not possess adequate knowledge to properly review these permits. If that is the case, then no amount of regulation will ensure that the Monterey Shale is developed safely.

Introducing Senate Bill 4

Recognizing that California's hydraulic fracturing regulation was outdated, the state legislature passed Senator Fran Paveley's "Senate Bill 4, *Oil and Gas: Well Stimulation*," (SB 4) in September 2013. SB 4 is arguably the strongest hydraulic fracturing regulation in the United States and does provide significant oversight for these operations. The bill's most significant pro-environmental provisions are listed below:[118]

- Requires an independent scientific study of well stimulation techniques to analyze their environmental and public health impacts by January 1, 2015.
- The State Water Resources Control Board will implement programs that monitor groundwater water quality and withdrawal amounts. Well operators must comply with these programs.[119]
- Studies will be conducted that investigate how hydraulic fracturing impacts air quality.[120]

[118] "Fact Sheet: SB 4 (Pavley)," 2013
[119] "Frequently Asked Questions Regarding Well Stimulation Regulations Under Senate Bill 4," California Division of Oil, Gas & Geothermal Resources, 2013
[120] "Frequently Asked Questions Regarding Well Stimulation Regulations Under Senate Bill 4," California Division of Oil, Gas & Geothermal Resources, 2013

- Requires the Division of Oil, Gas and Geothermal Resources (DOGGR) to adopt well stimulation regulations that include full disclosure of the chemicals used during well stimulation by January 1, 2015.
- Mandates public disclosure of the quantities any chemicals used in well stimulation (although chemical recipes are protected as trade secrets).
- Requires DOGGR to complete environmental impact reports on new and existing fracking wells (Kern County excluded).
- Requires regional groundwater monitoring programs near oil and gas fields.
- Requires well operators to give 30 days advanced notice to the public and notify the water quality control board before stimulating a well.
- People living near wells are granted the right to request baseline and follow-up water quality reports from well operators.
- Provides a legal procedure for health professionals to request chemical trade secret information from oil and gas companies.
- Mandates that DOGGR provide transparency on all well stimulation operations and integrate this reporting into the state's existing environmental regulatory framework.
- Requires DOGGR to perform random checks on well sites to ensure that well operators are reporting accurate data.

One of the provisions of SB 4 requires DOGGR to roll out new guidelines for regulating statewide fracking activities. DOGGR published these guidelines in November 2013. The highlights are listed below:[121]

- Beginning in 2015, all well stimulation projects, including hydraulic fracturing and acid-based stimulation treatments, must be permitted. No permits are required in the interim.
- Fewer than 2% of wells may be exempt from SB 4's new public disclosure guidelines if the well operator requests certain well information to remain secret, including the chemical constituents used in well treatment. These

[121] "Frequently Asked Questions Regarding Well Stimulation Regulations Under Senate Bill 4," California Division of Oil, Gas & Geothermal Resources, 2013

"confidential" wells can maintain their secretive status for a maximum of 4 years, subject to 6-month extensions.

- All proposed well locations are subject to local geological review that analyzes natural fault and fracture zones to ensure that the target stimulation area is well isolated from groundwater reserves.
- Well operators must report earthquakes of magnitude 2.0 or greater that occur within the area of recent hydraulic fracturing.

These regulations provide a strong framework for monitoring well stimulation operations in California and address certain environmental and public health issues that other states' fracking regulations neglect. Most notable are the new chemical disclosure rules and provisions for environmental monitoring programs near well sites. However, SB 4 is still flawed because these provisions do not go into effect immediately, even though well stimulation activities are not being halted. The new regulations also do not address any wastewater disposal issues, a significant public health hazard posed by fracking.

It is fair to criticize California for not waiting until the January 1, 2015 deadline is met before allowing well stimulation operations to commence. New York State, which harbors a large portion of the Marcellus Shale, the same rock formation that is "fracked" so heavily for natural gas in Pennsylvania and Ohio, has placed a moratorium on fracking operations in the state until a state environmental impact report is completed. It seems unwise that California did not follow New York's example in this case, especially considering how scarce water is in Southern California and how seismically active the state is. The oil that is currently locked up in the Monterey Shale has stayed in place for thousands of years and it could not possibly go anywhere before getting fracked out. If an environmental catastrophe does occur as a result of well stimulation activities in the Monterey Shale, it will be much harder to mitigate the damage than if the state had waited until the technology's environmental impact was better understood.

The fact that fracking chemicals will not be publicly disclosed before 2015, while fracking operations are permitted across California, raises some questions

about who could be held responsible for contamination episodes that occurred before then. For example, how can well operators be castigated if toxic fracking chemicals start to show up in local drinking water supplies before it is known that those chemicals are specifically linked to fracking?

In addition to its delayed implementation, SB 4 is also troublesome because it merely gives the public environmental protections that should have been in effect in the first place. Families should not have to prohibit their children from playing outside because nearby fracking sites are polluting the air with harmful VOCs. Farmers should not have to worry that the groundwater that use for irrigation is contaminated with carcinogenic compounds. The following chapter is devoted to examing how fracking the Monterey Shale will disproportionally affect communities in California's Central Valley and Coastal regions. Water scarcity and air quality issues already affect these areas and fracking will do nothing to improve their situation.

Chapter 3: Assessing Environmental Vulnerability in the Monterey Shale

The Monterey Shale covers a space of 1752 square miles, stretching through California's San Joaquin and Los Angeles Basins.[122] These basins are both home to biologically diverse and sensitive wildlife communities, as well as some of the most agriculturally productive land in our country—the California's Central Coast and Central Valley. It just so happens, that the Central Coast and Central Valley are two of California's most productive oil regions and the bulk of new fracking operations will likely take place in these areas.[123] The environmental vulnerability of these two regions makes the potential public health, seismological, and climatological ramifications of fracking in the Monterey Shale considerably more grave. This

[122] U.S. Energy Information Administration, "Review of Emerging Resources: U.S. Shale Gas and Shale Oil Plays," July, 2011
[123] U.S. Energy Information Administration, "Review of Emerging Resources: U.S. Shale Gas and Shale Oil Plays," July, 2011

chapter will review these environmental vulnerabilities and assess how fracking would exacerbate them.

Water Scarcity and Agriculture

Water scarcity issues in the Central Coast and Central Valley are inextricably tied to agricultural water demand in these areas. The Central Valley alone contains one sixth of the United States' irrigated farmland[124] and provides up to 25 percent of the nation's annual food supply.[125] This behemoth agro-industry is valued at $17 billion per year.[126] However, maintaining such a productive agrarian economy is not without costs. An estimated 20 percent of the United States' total groundwater usage is pumped within the Central Valley, and groundwater reserves in the region have subsided by 60 million acre-feet since 1960.[127] The Central Valley is afflicted by an estimated 3.45 million acre-feet per year in groundwater overdraft.[128] With water resources stretched so thin, the Central Valley has not one drop of it to spare.

Although the Central Coast's agricultural industry is not as large as the Central Valley's, it is nothing to scoff at. The Central Coast hosts an approximate 438,000 acres of irrigated farmland.[129] Monterey County alone consumes 600,000 acre-feet of water per year, with 90 percent of it allocated for agricultural use.[130] Just as in the Central Valley, the Central Coast is also under severe water stress. Urban and agricultural growth over the past 30 years have placed additional strain on the region's freshwater supply, leading to increased saltwater intrusion into

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[124] Claudia C. Faunt, "Groundwater Availability of the Central Valley Aquifer, California," United States Geological Survey, 2009
[125] "The Central Valley Region," USDA Forest Service Gen. Tech. Rep., 2003
[126] Ibid. Faunt
[127] Ibid. Faunt
[128] Pete Canessa, Sarge Green, David Zoldoske,"Agricultural Water Use in California: A 2011 Update," Center for Irrigation Technology, 2011
[129] Ibid. Faunt
[130] Harry Cline, "Water Crisis Growing on California's Central Coast," Western Farm Press, 2012

aquifers and groundwater overdraft.[131] Saltwater intrusion in California's Central Coastal region reduces fresh groundwater access by 200 acres annually.[132]

Water scarcity in the Central Coast has led to some areas resorting to alternative means for improving their freshwater supplies. Nacimiento and San Antonio Lakes were built to improve coastal freshwater supplies. However, the added reserves are still not enough to meet the region's demand. Paso Robles, whose groundwater table declined by 70 feet since 1997 due to heavy irrigation withdrawals, receives 17,500 acre-feet of water from Nacimiento Lake but is also building a sewage treatment plant to further bolster their freshwater supply.[133] Castroville is another coastal town that relies heavily on treated sewage to meet their agricultural water needs. The town's recently built sewage treatment facility provides 13,000 acre-feet of freshwater per year, nearly 60 percent of the town's agricultural needs. [134]

While individual towns may find solutions to their water shortages, disputes over water rights are still common within the Central Coast. Fights over who owns the water in the Twitchell Reservoir are a prime example. The Twitchell Reservoir was built in the region between San Luis Obispo and Santa Barbara Counties in 1959 as a means of recharging groundwater for agricultural use. Sedimentation in the reservoir became a critical issue in the 1990s and is still a point of contention between local farmers and the Santa Maria Valley Water Conservation District board, who are arguing over who owns the water in the reservoir and who should pay to clean it up.[135]

Air Quality

The Central Valley has one of the most severely degraded environments in the United States. The region's air quality is heavily impacted by emissions from the

[131] Ibid. Cline
[132] Ibid. Cline
[133] Ibid. Cline
[134] Ibid. Cline
[135] Karen White, "Grand Jury Report on Twitchell Dam Disputed," Lompoc Record, 2001

agricultural, transportation, and oil industries. These effects are compounded by the Central Valley's geography—a flat plain flanked on three sides by mountains that force air stagnation. Additionally, the agricultural pollution has degraded local water supplies, exacerbating the Central Valley's water scarcity issues.

Poor air and water quality in the Central Valley contribute to a host of public health issues. The San Joaquin Valley, for example, has the highest levels of particulate matter and ozone in the United States, with asthma rates three times the national average.[136] A recent study found that the if the Central Valley met national air quality standards for ozone and particulate matter concentrations, the region would save $6 billion dollars per year in health care costs.[137] With the Central Valley's population hovering around 4 million people, these savings would be over $1,000 per capita. The crisis is so severe that the Center for Race, Poverty, and the Environment is suing the EPA for not implementing an effective air quality improvement plan.[138]

History with the Oil Industry

There have been several recent incidents where California's oil and gas industry has negligently disposed of waste or contributed to water contamination. Among them is *Starrh and Starrh Cotton Growers v. Aera Energy LLC* where Aera Energy LLC disposed of flowback water from oil production in unlined pits on property neighboring Starrh and Starrh Cotton Growers' (Starrh) land. The wastewater percolated through the ground, contaminating groundwater used by Starrh.[139] ExxonMobil and Shell Oil companies, two of the largest oil companies, jointly own Aera. If these oil heavyweights cannot be trusted to excavate

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[136] Tracie Cone, "California's Central Valley Slammed by Record Air Pollution," Huffington Post, 2012
[137] Jonathan London, Ganlin Huang, Tara Zagofsky, "Land of Risk, Land of Opportunity: Cumulative Environmental Vulnerabilities in California's San Joaquin Valley, UC Davis Center for Regional Change, 2011
[138] Ibid. Cone
[139] Case Law, "Starrh and Starrh Cotton Growers v. Aera Energy LLC," 2007

responsibly, then who can? Unfortunately, careless waste disposal practices are endemic to the California oil production industry.

As of April 9th, 2013, the California Regional Water Quality Control Board for the Central Valley Region, was investigating Vintage Production California, an oil company, for dumping hydraulic fracturing waste fluid into an unlined retention pond without the necessary permits.[140] The investigation found that Vintage was responsible for the illegal discharges and will be fined $60,000.

Vintage Production California (Vintage) is a subsidiary of Occidental Petroleum Corporation, one of the leading oil companies in California. In 2010, California's Division of Oil, Gas & Geothermal Resources (DOGGR) awarded Vintage the Outstanding Lease Award for Pleito and North Shafter Oil Fields in the Central Valley.[141] It is alarming that such an experienced oil company is engaged in illegal practices. How can DOGGR, the organization responsible for ensuring that oil excavation is done safely in California, reward oil companies that are doing the exact opposite?

Geology and Productivity

Compared to other oil-bearing shale formations, like the Bakken Shale, the Monterey Shale is younger and more seismically active.[142] Increased seismic activity means that Monterey Shale is more heavily faulted than the Bakken Shale. Drilling oil wells in faulty areas is risky for two reasons. In the same way that fractures created through hydraulic fracturing can create pathways for fluids to migrate into groundwater supplies, natural faults may also conduct fracking fluid toward groundwater reserves. Additionally, fracking in seismically active regions may jeopardize the oil well's integrity because seismic shifting could damage the well.

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[140] California Water Boards, "Central Valley Water Board Implementing Enforcement Actions for Alleged Unpermitted Discharge of Hydraulic Fracturing Waste," 2013

[141] Examiner, "Oil Company Caught Dumping Wastewater, Water Board Investigating," 2013

[142] Sarah Phelan, "How the Monterey Shale Came To Be," Bay Nature, 2013

Well failure increases the chance that fracking wastewater will contaminate groundwater supplies.

In addition to being more seismically active, the Monterey Shale also differs from the Bakken in that it is highly porous but with low permeability.[143] High permeability is crucial to enhanced oil recovery productivity, which is another factor that is limiting unconventional oil production in the Monterey Shale.[144]

To date, there have been no major successes tapping the Monterey Shale's unconventional oil reserves. Venoco Inc., one of California's premier oil companies, drilled 29 wells in the Monterey Shale between 2010 and 2012, reporting no "material levels of production or reserves."[145]

Amidst all the hype surrounding the Monterey Shale and its 15.4 billion barrels of oil are skeptics who question whether it is really worth recovering. The oil is certainly there but perhaps fracking is not what will ultimately get it out. Harold Hamm, CEO of Continental Resources, the oil company responsible for fracking most of North Dakota's Bakken Shale, commented that the "code" to access the oil in the Monterey Shale has yet to be broken.[146] Mark Nechodom, director of California's Department of Conservation, echoed this sentiment in an interview conducted shortly after the passage of Senate Bill 4. He said, "There is no reason to assume that fracking is the key to the Monterey shale. There's a big assumption that somehow the Monterey is suddenly going to be available because of fracking. [The oil industry is] actually less sanguine than the rest of the world because they're the ones that are going to have to make the investments."[147]

Hamm and Nechodom's perspective on this issue shed new light on how Senate Bill 4 will impact fracking in the Monterey Shale. Fracking has always been

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[143] William R. Berry II, Deborah M. Olson, et al. "Geological and Petrophysical Evaluation of the Pioneer Anticline Area," Michigan Technological University
[144] Ibid. Berry, Olson et al.
[145] Jim Carlton, "Oil Firms Seek to Unlock Big California Field," The Wall Street Journal, 2013
[146] Amy Harder, "Harold Hamm Down on California's Monterey Shale," National Journal, 2013
[147] Amy Harder, "California's Top Oil regulator on Fracking, Climate change, Fossil Fuels," National Journal, 2013

legal in California and the oil industry has been fracking in the Monterey Shale long before SB 4 formally regulated the technique. The Lost Hills, Rose, North Shafter, Hondo, Point Aguello, Elk Hills, and Belridge oil fields are portions of the Monterey Shale, located in the Central Valley, where fracking occurred years before the passage of Senate Bill 4.[148] However, the oil industry is still uncertain that hydraulic fracturing technology, as it exists today, can unlock the Monterey Shale's full oil potential. This indicates that the oil industry is still not technologically equipped to economically access the majority of Monterey Shale oil.

Although the Bakken and Eagle Ford Shale are quite different from the Monterey Shale, drilling experience in the former two can still improve our understanding of the latter. As of now, the Bakken and Eagle Ford Shale comprise 80 percent of total domestic shale oil production. However, these two shale formations combined only contain little over one-third the amount of estimated recoverable oil that exists in the Monterey Shale. There are over 15 billion barrels of oil to be had in the Monterey Shale—41 percent of the United States' shale oil reserve! But, such large numbers can be deceiving.

To date, Monterey Shale oil has proven to be very energy intensive, with operations in the rich shale play producing a meager 12.7 barrels per day from 675 wells.[149] Early oil production in the Bakken and Eagle Ford plays dwarf this figure, raising questions of whether it is worth it to scale up production in the Monterey Shale. We might drill hundreds more wells in the Monterey Shale before finding the sweet spots where oil is holed up.

The notion that conventional fracking is not the answer to large scale Monterey Shale oil production is supported by studies that point to the formation's geological complexity. Developing the shale successfully will largely be dependent on locating prime extraction spots and employing fracking techniques suited to that

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[148] Nabil EL Shaari, SPE, Baker Hughes, W.A. Minner, StrataGen Engineering, R.F. LaFollette, "Is There a 'Silver Bullet Technique' For Stimulating California's Monterey Shale?" Society of Petroleum Engineers, 2011

[149] J. David Hughes, "Drill, Baby, Drill: Can Unconventional Fuels Usher in a New Era of Energy Abundance?" Post Carbon Institute, 2013.

location. In other words, a lot of research still needs to be done on how to best access oil here.

Chapter 4: How to Best Regulate Hydraulic Fracturing in the Monterey Shale

Policy Recommendations

Current hydrofracking regulations do not adequately address the Central Valley and Central Coast's preexisting water and air quality problems. While a statewide moratorium or ban on fracking would be the most effective way to prevent any further damage in these environmentally sensitive regions, these solutions are politically unappealing and have already been rejected in California's state legislature. In light of this, implementing an environmental bond system is perhaps the most innovative strategy to prevent fracking-related environmental disasters in the Monterey Shale.

The premise of an environmental bond system is simple. It requires corporations to post a bond valued at the cost of remediating the worst-case contamination episode that could result from the corporation's proposed activities. If said activities damage the environment as outlined in the bond's parameters, the corporation automatically forfeits the entire bond. In the case of hydraulic fracturing, this system would require oil companies to post a bond valued at the cost of remediating groundwater contamination that could result from fracking, on a well-by-well basis. If the fracking does not lead to groundwater contamination, the oil company may reclaim the bond. Effective environmental monitoring programs, such as those proposed in SB 4, would identify when fracking contamination occurs. This monitoring could be used to determine when an oil company must forfeit their environmental bond.

Environmental bonds work by shifting environmental responsibility from the public to firms engaging in the hazardous activities.[150] Under the current regulatory system, when fracking accidents occur, the public or regulatory authorities may sue oil and gas companies for the damages. However, under this system, the public is burdened with proving that the oil company is responsible for the alleged environmental damage. An environmental bond would shift the burden of proof to the oil company.[151]

Under an environmental bond system, oil companies would have to take into account the cost of polluting before engaging in hazardous activities, such as hydraulic fracturing. This encourages them to research safer methods of oil extraction because doing so would lower the value of the bond and reduce the risk of forfeiture.[152]

While an environmental bond system would mitigate some of the risk involved in hydraulic fracturing, it does not address other issues such as how to responsibly dispose of fracking wastewater and how to reduce air quality impacts. These issues would require revisions to existing federal environmental regulations, including the Safe Drinking Water Act and Clean Air Act. The Safe Drinking Water Act should prohibit the disposal of fracking wastewater in "Class II" disposal wells for non-hazardous liquids. The Clean Air Act should aggregate HAP emissions from individual oil wells within an oil field and reclassify them as a single pollution source. These revisions would force oil companies to meet HAP emissions standards as described in the Clean Air Act and develop safer methods for disposing toxic fracking wastewater.[153]

In addition to implementing an environmental bond system and revising federal environmental regulations, California may also benefit from exacting a severance tax on oil produced in the state. California is the only large oil producing state that does not have a severance tax on oil. A severance tax on oil of 6% would

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[150] Jason F. Shogren and Joseph A. Herriges et al. "The Limits to Environmental Bonds: Lessons from the Labor Literature," Iowa State University, 1991
[151] Ibid. Shogren and Herriges et al.
[152] Ibid. Shogren and Herriges et al.
[153] See "Chapter 2: The Current State of Hydraulic Fracturing Regulation"

generate between $125 and $400 million annual revenue for the state, with most of the financial burden falling on the federal government, oil producers and refiners.[154] Implementing such a tax would positively impact the environment because it would reduce in-state oil production.[155] The production decline would initially be small but could increase over time.[156]

The environmental benefits of a statewide severance tax are twofold. The money generated through the tax could be allocated to California's environmental regulatory commissions, such as the State Water Resources Control Board or Air Resources board to fund water and air quality management and monitoring programs. A program that addressed air quality improvement in the Central Valley could save billions of dollars annually in health costs for the region's residents.[157] Recent California legislation proposing an oil severance tax was marketed as a way to raise money for the state's ailing university system.[158] Another option would be to allocate the tax revenue toward California's existing "green" projects, such as the state's high-speed rail initiative.

Putting a severance tax on California's oil production has the added benefit of reducing in-state oil production in the long term. The tax raises oil production costs, encouraging oil companies to terminate less-productive wells.[159] The tax also discourages future investment in the oil company, which leads to lower production rates.[160] In all, lower profits lead to lower production rates, which could discourage hydraulic fracturing in California.

An environmental bond system and severance tax on oil are methods that could potentially prevent fracking-related accidents or reduce fracking production across California. However, only a ban or temporary moratorium on fracking can

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[154] Frank Camm and Christopher W. Myers, "A California Oil Severance Tax: Who Gains? Who Pays?" RAND Corporation, 1982
[155] Ibid. Camm and Myers
[156] Ibid. Camm and Myers
[157] See "Chapter 4: Assessing Environmental Vulnerability in the Monterey Shale"
[158] Patrick McGreevy, "Democratic lawmakers revive oil extraction tax for California," Los Angeles Times, 2013
[159] Ibid. Camm and Myers
[160] Ibid. Camm and Myers

completely protect communities from the dangers of fracking. While a statewide ban or moratorium on fracking has already proven politically unfeasible, local bans on fracking could be more practical. Santa Cruz, California, passed a moratorium on fracking earlier this year.[161] This reflects similar actions taken against fracking by small towns across the United States. In 2013, three towns in Colorado, Boulder, Fort Collins and Lafayette, also passed moratoriums or bans on fracking.[162] Local political action like this could protect the communities most vulnerable to fracking in the Monterey Shale. As Hydraulic Fracturing continues to proliferate in California and across the United States, only strict and innovative regulations can protect America's communities from the environmental perils inherent in this practice.

Concluding Remarks

Considering that hydraulic fracturing and its associated techniques are not sustainable, long-term forms of oil production, and have been shown to have a measurable negative impact on public health in the environment, there is no question that a stronger regulatory framework is needed to manage this activity. And yet, the research presented in this paper suggests that fracking is inherently dangerous and even good regulations cannot ensure that it can be done safely. The only infallible way to evade the hazards posed by fracking is to ban it outright. However, doing so in the oil rich regions of the Monterey Shale, where the oil industry is already so prominent, may not be practical. We need an alternative approach.

While it is my conviction that hydraulic fracturing ought to be banned in the Monterey Shale, the passage of SB 4 marks the start of full-scale development of this resource. The purpose of this piece is to raise awareness around these activities and to offer a few new ideas on how to deal with them. However, there is much more

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[161] "Interim Ordinance of the County of Santa Cruz Imposing a Temporary Moratorium on Oil and Gas Exploration and Development Within the Unincorporated Area of Santa Cruz County," 2013

[162] Joe Eaton, "Results Mixed on Colorado and Ohio Fracking Ban Initiatives," National Geographic, 2013

work to be done. It would be useful to know more about how fracking the Monterey Shale will foment competition over water between Central California's agricultural and oil interests. A deeper understanding of how increased hydraulic fracking in the Monterey Shale would impact California's seismic activity would also be valuable. This information would be nicely augmented by analyses of how deep well wastewater injections, such as those used to dispose of fracking wastewater, impact groundwater hydrology over time.

While there is still a lot about hydraulic fracturing that is not completely understood, there is a lot of effort being made to study it more closely. Fracking is a popular issue and there are many environmental organizations and journalists working hard to inform the public about its negative impacts. It will also be exciting to see how certain provisions outlined in SB 4 will take effect. These include the new guidelines that California's State Water Resources Control Board is developing to address fracking and DOGGR's proposed independent scientific studies on fracking's environmental impacts. There is a lot to look forward to in the coming year but while we wait around for these important updates, it is critical to keep in mind that research alone will not address the problems with fracking. Civic action is necessary to convince political leaders that we need better fracking regulations. Writing letters to congress and voting on new regulatory initiatives is crucial to improving environmental legislation. The fight against hydraulic fracturing has only just begun and the power is in our hands to force state legislature and regulatory agencies into action against this unhealthy technology.

References

Drilling productivity report for key tight oil and shale gas regions. (2013). (Drilling Productivity Report). United States: Energy Information Administration.

CIA world factbook: China. (2013). Retrieved 12/12, 2013, from https://www.cia.gov/library/publications/the-world-factbook/geos/ch.html

List of texas PWSs limiting water use to avoid shortages. (2013). Retrieved 12/8, 2013, from http://www.tceq.texas.gov/drinkingwater/trot/droughtw.html

What the new impact fee law, act 13, means for pennsylvania. (2013,). *Stateimpact*

Energy and oil prices. (2013). Retrieved, 2013, from http://www.bloomberg.com/energy/

Frequently asked questions regarding well stimulation regulations under senate bill 4. (2013). ().California Department of Conservation.

The central valley region. (2003). (Forest Service Gen. Tech. Rep No. PSW-GTR-187).United States Department of Agriculture.

Review of emerging resources: U.S. shale gas and shale oil plays. (2011). (). Washington D.C.: U.S. Energy Information Administration.

Wellcare® information for you about total dissolved solids. (2007). (Water Systems Council Publication).Water Systems Council.

State oil and natural gas regulations designed to protect water resources," U.S. department of energy. (2009). (). Morgantown, WV: U.S. Department of Energy.

Ohio hydraulic fracturing state review. (2011). (). OH: Ohio Department of Natural Resources.

Starrh and starrh cotton growers v. aera energy LLC, (Court of Appeal, Fifth District, CA 2007).

Central valley water board implementing enforcement actions for alleged unpermitted discharge of hydraulic fracturing waste. (2013). (Media Release). Fresno, CA: Central Valley Regional Water Control Board.

Interim ordinance of the county of santa cruz imposing a temporary moratorium on oil and gas exploration and development within the unincorporated area of santa cruz county, (2013).

2012 world oil consumption. Retrieved 12/4, 2013, from http://www.eia.gov/countries/index.cfm?view=consumption

How much does A semi truck weigh? (). Message posted to http://answers.ask.com/business/transportation/how_much_does_a_semi_truck_weigh

Carbon emissions in the petroleum refining industry. (2000). Retrieved, 2013, from http://www.eia.gov/emeu/efficiency/carbon_emissions/petroleum.html

William boggs, et al., v. landmark 4 LLC: Memorandum opinion and order, (United States District Court Northern District of Ohio Eastern Division

California public resources code, 3100

California public resources code, 3200

Comprehensive environmental response, compensation, and liability act, 9601U.S.C. (1980).

California public resources code, 3250

Begley, S. (2013, 7/11/13). Study raises new concern about earthquakes and fracking fluids. *Reuters*

Berry, M. D. (2012, 9/10/12). The changing business of fracking insurance. *Thomson Reuters*

Berry, W. R., Olson, D. M., & Crane, D. J.*Geological and petrophysical evaluation of the pioneer anticline area.* (No. DE-AC22-94BC14892).Michigan Technical University.

Brady, W. J. (2012). *Hydraulic fracturing regulation in the united states: The laissez-faire approach of the federal government and varying state regulations.* (). Denver, CO: University of Denver Sturm College of Law.

California Department of Conservation. (2013). Assessment process. Retrieved, 2013, from http://www.conservation.ca.gov/dog/for_operators/Pages/assessments.aspx

California Department of Conservation.Oil and gas facts for 2005. Retrieved, 2013, from http://www.consrv.ca.gov/dog/Pages/statistics.aspx

California Department of Conservation. (2013). Oil, gas & geothermal- injection wells. Retrieved, 2013, from http://www.conservation.ca.gov/dog/general_information/Pages/class_injection_wells.aspx

Camm, F., & Myers, C. W. (1982). *A california oil severance tax: Who gains? who pays?" RAND corporation, 1982.* (No. R-2975-CSA/RC).RAND Corporation.

Canessa, P., Green, S., & Zoldoske, D. (2011). *Agricultural water use in california: A 2011 update.* (Center for Irrigation Technology Staff Report). Fresno, CA: California State University, Fresno.

Carbon Fund.How we calculate. Retrieved, 2013, from http://www.carbonfund.org/how-we-calculate

Carlton, J. (2013, 9/22/13). Oil firms seek to unlock big california field. *The Wall Street Journal*

Cline, H. (2012, 1/6/12). Water crisis growing on California's central coast. *Western Farm Press*

Cone, T. (2012, 1/7/12). California's central valley slammed by record air pollution. *Huffington Post*

Cooley, H., & Donnelly, K. (2012). *Hydraulic fracturing and water resources: Separating the frack from fiction.* (Pacific Institute Publication). Oakland, CA: Pacific Institute.

Craig, R. K. (2013). Hydraulic fracturing (fracking), federalism, and the water-energy nexus. *Idaho Law Review, 49*(241)

DiGiulio, D. C., Wilkin, R. T., & Miller, C. (2011). *Investigation of ground water contamination near pavillion, wyoming.* (U.S. EPA Publication). Ada, OK: U.S. Environmental Protection Agency.

Eaton, J. (2013, 11/6/13). Results mixed on colorado and ohio fracking ban initiatives. *National Geographic,*

Ellsworth, W. L. (2013). Injection-induced earthquakes. *Science, 341*, 142. doi:10.1126

Faunt, C. C. (2009). *Groundwater availability of the central valley aquifer, california.* (No. 1766). Reston, VA: United States Geological Survey.

Ferner, M. (2013, 10/9/13). More oil and gas wastewater spills found in colorado after flooding. *Huffington Post*

Freyman, M., & Salmon, R. (2013). *Hydraulic fracturing & water stress: Growing competitive pressures for water.* (). Boston, MA: Ceres.

Goldenberg, S. (2013, 8/11/13). A texan tragedy: Ample oil, no water. *The Guardian*

Hamilton, D., & Meehan, R. L. (1971). Ground rupture in the baldwin hills. *Science, 172*, 333.

Hansen, E., Mulvaney, D., & Betcher, M. (2013). *Water resource reporting and water footprint from marcellus shale development in west virginia and pennsylvania.* (Downstream Strategies Publication). Durango, CO: San Jose State University.

Harder, A. (2013, 10/16/13). Harold hamm down on California's monterey shale. *National Journal*

Harder, A. (2013, 10/16/13). California's top oil regulator on fracking, climate change, fossil fuels. *National Journal*

Healy, J. (2012, 9/5/12). For farms in the west, oil wells are thirsty rivals. *The New York Times*

Hughes, J. D. (2013). *Drill, baby, drill: Can unconventional fuels usher in a new era of energy abundance?* (). Santa Rosa, California: Post Carbon Institute.

Kargbo, D. M., Wilhelm, R. G., & Campbell, D. J. (2010). Natural gas plays in the marcellus shale: Challenges and potential opportunities. *Environmental Science and Technology, 44*(15), 5679.

Karion, A., Sweeney, C., Pétron, G., Frost, G., Hardesty, M., Kofler, J., . . . Conley, S. (2013). Methane emissions estimate from airborne measurements over a western united states natural gas field. *Geophysical Research Letters, 40*(16), 4393.

King, G. E. (2012). *Hydraulic fracturing 101: What every representative, environmentalist, regulator, reporter, investor, university researcher, neighbor, and engineer should know about estimating frac risk and improving frac performance in unconventional gas and oil wells.* (No. SPE 152596).Society oF Petroleum Engineers.

Kiparsky, M., & Hein, J. F. (2013). *Regulation of hydraulic fracturing in california: A wastewater and water quality perspective.* (). Berkeley, CA: Berkeley Law, University of California.

London, J., Huang, G., & Zagofsky, T. (2011). *Land of Risk/Land of opportunity: Cumulative environmental vulnerability in california's san joaquin valley.* (). Davis, CA: UC Davis Center for Regional Change.

Lustgarten, A. (2009, 12/27/09). In new gas wells, more drilling chemicals remain underground. *Propublica*

Maccioli, F. (2013, 4/10/13). Oil company caught dumping wastewater, water board investigating. *Examiner*

Mall, A. (2013, 6/19/2013). New investigation: Fracking is increasing competition for water and its price in counties with drought. Message posted to http://switchboard.nrdc.org/blogs/amall/new_investigation_fracking_is.html

May, J. (2009). *The increasing burden of oil refineries and fossil fuels in wilmington, california and how to clean them up!* (). Huntington Park, CA: Communities for a Better Environment.

McGreevy, P. (2013, 2/13/13). Democratic lawmakers revive oil extraction tax for california. *Los Angeles Times*

McKinley, J. (2013, 10/23/13). Fracking fight focuses on a new york Town's ban . *The New York Times*

Mims, A. (2013, 11/11/2013). Texas man sued for defamation by fracking company that contaminated his water supply. *Ring of Fire Radio*

Myers, T. (2012). Potential contaminant pathways from hydraulically fractured shale to aquifers. *Ground Water, 50*(6), 872.

Fact sheet: SB 4 (pavley), (2013).

Phelan, S. (2013, 9/2/13). How the monterey shale came to be. *Bay Nature*

Piette, B. (2013, 3/26/13). Fracking records unsealed in pennsylvania. *Workers World*

Rowell, A. (2013). U.S. gas flaring visible from space as fracking industry booms. Retrieved 12/4, 2013, from http://ecowatch.com/2013/01/28/fracking-gas-flaring-visible-from-space/

Schumacher, J., & Morrissey, J. (2013). The legal landscape of 'Fracking': The oil and gas Industry's game-changing technique is its biggest hurdle. *Texas Review of Law & Politics, 17*, 239.

Shaari, N. E., Hughes, B., Minner, W. A., & LaFollette, R. F. (2011). *Is there a "silver bullet technique" for stimulating california's monterey shale?* (No. SPE 144526).Society of Petroleum Engineers International.

Sharp, R., & Allayaud, B. (2012). *California regulators: See no fracking, speak no fracking.* (). Oakland, CA: Environmental Working Group.

Shogren, J. F., Herriges, J. A., & Govindasamy, R. (1991). *The limits to environmental bonds: Lessons from the labor literature.* ().Iowa State University.

Stech, K. (2013, 5/20/13). New york landowners sue norse energy USA over leases. *Rigzone*

U.S. Environmental Protection Agency. (2013). Summary of the clean air act. Retrieved, 2013, from http://www2.epa.gov/laws-regulations/summary-clean-air-act

Watson, B. A. (2013). Ohio oil and gas litigation in the new fracking era. *Ohio State Law Journal Furthermore, 74*, 47.

White, K. (2001, 8/13/01). Grand jury report on twitchell dam disputed. *Lompoc Record*

Wilson, S., Subra, W., & Sumi, L. (2013). *Reckless endangerment while fracking the eagle ford: Government fails, public health suffers and industry profits from the shale oil boom.* (). Washington D.C.: Earthworks.

Zeller, T. (2010, 9/15/10). New lawsuit filed in fracking country. *The New York Times*