Attachment C

Weber Report

Bonding Requirements for Oil and Gas Wells

BONDING REQUIREMENTS FOR OIL AND GAS WELLS IN PENNSYLVANIA: COST-BASED RECOMMENDATIONS

A REPORT TO THE PENNSYLVANIA ENVIRONMENTAL QUALITY BOARD

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Bonding Requirements for Oil and Gas Wells In Pennsylvania: Cost-Based Recommendations

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Executive Summary

Pennsylvania law requires that all oil and gas well operators properly decommission their wells at the end of the well's useful life, an act often referred to as well plugging. Since 1985, it has also required that operators set aside money, a bond, before drilling so as to guarantee funds for the well's plugging. The law sets bond amounts but gives the Pennsylvania Environmental Quality Board (EQB) the authority to adjust amounts "every two years to reflect the projected costs to the Commonwealth of performing well plugging."[2]

From 1989 to 2020, the Commonwealth has paid to plug more than 3,000 wells, spending $15,100 per well on average and a minimum of $3,400 per well. By comparison, the current bond amount for a conventional well is $2,500 for an operator with few wells and, because of blanket bond provisions, $250 for an operator with 100 wells. Using data on the wells the Commonwealth has paid to plug, this report projects the cost to the Commonwealth of plugging wells in the future and makes three recommendations to the Environmental Quality Board:

1. **Adjust the bond amount to $25,000 per conventional well and $70,000 per unconventional well for the 2021-2022 period.** These amounts match projected plugging costs for a well plugged in this period and, under current law, should apply to new wells and wells drilled after April 17, 1985. The projected cost for conventional wells is based on the historical cost incurred by the Commonwealth and the observed growth rate in plugging costs. It is also consistent with what a major operator paid to plug its own wells in the 2018-2020 period. Costs to the Commonwealth, however, will likely be higher if future plugging contracts cover fewer wells than they have historically. The unconventional well amount is based on cost relationships observed in the data and differences in the characteristics of conventional and unconventional wells.
2. **Revisit bond amounts every two years to consider new information on plugging costs and to update bond amounts accordingly.** Plugging costs rose over the last three decades, growing 3.2 percent per year after accounting for inflation and changes in the types of wells being plugged. In addition to a general rise in costs, changes in the types of wells that are being plugged and the scale of plugging can also affect projected costs. Periodic consideration of new information is especially important for unconventional wells for which there is currently limited publicly available data on plugging costs.
3. **Discontinue the use of blanket bonds or bond caps.** Blanket bonds or caps create a large discrepancy between the projected cost of plugging and bond amounts. Moreover, financially secure operators already pay less to meet bond requirements in the form of lower rates charged by private insurers ("sureties").

Current bond amounts expose the Commonwealth to the risk of having to pay plugging costs for many wells. If adopted, the recommended amounts ensure that well operators bear the full financial responsibility of plugging their wells. This will continue to be the case if the Environmental Quality Board reconsiders bond amounts biennially using updated cost projections.

Adjusting bonding amounts will also encourage and enable more plugging, which restores well sites to alternative uses and reduces the risk that unplugged abandoned wells leak methane, oil, brine, or metals-rich liquids into their surroundings. This will free residents and municipalities to farm, build, or

[2] 58 Pa. Cons. Stat. § 3225.

simply enjoy the full extent of their land unencumbered by tanks, pipes, or contamination and the associated risks. This will benefit local economies as properties appreciate in value and the tax base expands.

The recommended adjustment to unconventional well bonds would increase operator costs by one-fifth of the cost of the unconventional well Impact Fee. The adjustment for conventional wells is smaller in absolute terms but might cause some wells to shift to more financially secure operators.

Introduction

Since 1921, the Commonwealth of Pennsylvania has required that oil and gas well operators decommission their wells when abandoning them.[3] Subsequent enforcement was limited and operators abandoned many wells over the rest of the 20th century without proper decommissioning, in part because of energy price drops that left operators without money to continue in business and plug old wells.[4]

Since 1985, the Commonwealth has required that an operator set aside funds, known as bonds, before drilling. The Commonwealth releases the operator from the bond requirement once the operator properly decommissions the well, which involves restoring the well site and filling the well with cement, an activity often referred to as plugging.[5] Most oil and gas producing states have bond requirements so as to encourage compliance with the law and to fund plugging when an operator is financially unable to do so.[6] Bonds therefore act as insurance that protects state governments and taxpayers from having to pay for plugging when operators become financially distressed.

Pennsylvania law gives the Environmental Quality Board the authority to adjust bond amounts "every two years to reflect the projected costs to the Commonwealth of performing well plugging."[7] The statement recognizes that unplugged wells abandoned by defunct operators become the responsibility of the Commonwealth, which then has to pay for plugging. It also recognizes that the bond amount should match the cost of plugging, so that operators—not the Commonwealth and its taxpayers—pay for plugging.

From 1989 to 2020, the Commonwealth paid to plug more than 3,000 wells. Using the associated cost data, this report projects the cost to the Commonwealth of plugging wells in coming years and makes three recommendations to the Environmental Quality Board. First, the Board should adjust the bond amount to $25,000 per conventional well and $70,000 per unconventional well for the 2021-2022 period. The amounts match projected plugging costs for a well plugged in this period and, under current law,

[3] Act 322 of 1921 introduced the first plugging requirements for gas wells. Similar requirements for oil wells had existed since the late 1800s. 58 Pa. Con. Stat. § 3203 defines an abandoned well as "any well that has not been used to produce, extract or inject any gas, petroleum or other liquid within the preceding 12 months, or any well for which the equipment necessary for production, extraction or injection has been removed, or any well, considered dry, not equipped for production within 60 days after drilling, redrilling or deepening, except that it shall not include any well granted inactive status."

[4] Weber, McClure, and Simonides, *The Boom, the Bust, and the Cost of Cleanup: Abandoned Oil and Gas Wells in Pennsylvania and Implications for Shale Gas Governance*.

[5] Through the rest of the report, I will use "plugging" to refer to all that is involved in decommissioning a well according to state standards.

[6] Davis, *Policy Monitor—Bonding Requirements for US Natural Gas Producers.*

[7] 58 Pa. Con. Stat. § 3225.

should apply to new wells and wells drilled after April 17, 1985. Second, it should revisit bond amounts every two years to consider new information on plugging costs and to update bond amounts accordingly. Plugging costs rose over the last three decades, growing 3.2 percent per year after adjusting for inflation and changes in the types of wells being plugged. Lastly, the Board should discontinue the use of blanket bonds or bond caps because they create a discrepancy between bond amounts and projected plugging costs.

By encouraging and enabling more well plugging, adjusting bond amounts will reduce the risk that abandoned wells leak methane, oil, brine, or metals-rich liquids into their surroundings. Abandoned wells have also been shown to discourage building in their vicinity. Well plugging and site restoration frees local residents and property owners to farm, build, or simply enjoy the full extent of their land unencumbered by tanks, pipes, or contamination and the associated risks. This has broad benefits for local economies in the form of higher property values and a larger tax base.

The recommended adjustment to unconventional well bond amounts would increase operator costs by far less than did the unconventional well Impact Fee, which the Commonwealth introduced in 2012 and applied retroactively to all unconventional wells.[8] Despite increasing costs by more than would the recommended bond adjustment, the Impact Fee had imperceptible effects on drilling and production. The recommended adjustment for conventional wells is smaller in absolute terms but might cause some wells to shift to operators that are more financially secure.

In the next sections, the report explains the purpose of plugging wells, the role of bonding, and current bond policy. It then presents the methods, data, and findings for the projected cost to the Commonwealth of plugging wells in the 2021-2022 period. The final sections address the role of blanket bonds, the wells to which adjusted bond amounts should apply, and the likely effects of the adjusted amounts on the oil and gas industry in Pennsylvania.

The Purpose of Plugging

Unplugged abandoned wells create a pathway for subsurface gases or liquids to migrate into groundwater, the soil, or to the surface. Deterioration of the steel casing surrounding a well bore—or the cement surrounding the casing—opens this pathway for migration.[9] Plugging wells and restoring their sites addresses problems caused by wells already leaking and constraining land use. It also largely eliminates risk from wells that may cause damage in the future, a risk that grows as wells age and their steel and concrete deteriorate.

Several studies and cases illustrate the health risks posed by unplugged abandoned wells and therefore the benefit of plugging them. Water in and around unplugged wells can contain pollutants, such as barium, chloride, and arsenic.[10] In a sample of 46 abandoned wells discharging water on the Navajo

[8] 58 Pa. Con. Stat. § 3225.
[9] Alboiu and Walker, *Pollution, management, and mitigation of idle and orphaned oil and gas wells in Alberta, Canada*.
[10] Woda et al., *Methane concentrations in streams reveal gas leak discharges in regions of oil, gas, and coal development.*

Nation, 15 wells had water with levels of arsenic above EPA standards.[11] Arsenic is a carcinogen and even short-term exposure can harm health.[12] Further, methane leaking into groundwater can create foul-smelling and toxic hydrogen sulfide when it oxidizes.[13] The potential for groundwater contamination is illustrated by a study of oil-and-gas-related groundwater contamination events in Texas and Ohio. The study found that unplugged abandoned wells accounted for 14 percent and 22 percent, respectively, of contamination events over the study period, generally the 1980s through the early 2000s.[14]

Unplugged abandoned wells also leak gases into the air, particularly methane. Emissions of methane can harm air quality when methane oxidizes and creates ozone. Ozone is harmful when inhaled, causing damage to the heart and lungs and worsening chronic conditions such as asthma.[15] Further, if methane leaks into enclosed spaces it can cause an entire house to explode, though this is not common.[16] Globally, methane is a potent greenhouse gas, with roughly 30 times more warming potential than carbon dioxide over 100 years and as much as 87 times higher over 20 years.[17] A study of methane leaks from abandoned oil and gas wells in Pennsylvania found that such wells account for as much as seven percent of the annual anthropogenic methane emissions in the Commonwealth. To put the number in perspective, it is equivalent to the annual greenhouse gas emissions from 200,000 to 250,000 passenger cars.[18]

In addition to the environmental and health risks, unplugged abandoned wells take up space and are an eyesore on the landscape, appearing as uncultivated or unmowed islands in fields or backyards. Wellheads, which are made up of pipes and valves, often extend about six feet into the air and can be accompanied by metal tanks, pipes, and pumps, all of which are removed as part of plugging. By removing well equipment and the risks associated with an open well, plugging expands land-use possibilities for the surrounding acreage. A recent study found that, over nearly fifty years, there was roughly twice as much building activity in the two acres surrounding wells that were plugged compared to the two acres surrounding wells that were not plugged.[19] This illustrates how unplugged wells constrain or deter local residents from fully using their property.

Forgoing construction on and investment in land with unplugged wells has broad implications for community well-being because it suppresses the local tax base that funds local schools, roads, and other services. The same study estimates that by depressing investment, an unplugged well reduced the market value of the typical surrounding property by around $22,000 (12 percent). In the case of the school district in the study area with the most abandoned unplugged wells—McGuffy School District—this tax base

[11] U.S. Environmental Protection Agency, *Technical Memorandum: Investigation of Abandoned Wells on Navajo Nation*.
[12] U.S. Environmental Protection Agency, "Drinking Water Standard for Arsenic."
[13] Dusseault, Jackson, and MacDonald, *Towards a Road Map for Mitigating the Rates and Occurrences of Long-Term Wellbore Leakage;* U.S. Department of Labor, "Hydrogen Sulfide".
[14] Kell, *State Oil and Gas Agency Groundwater Investigations*.
[15] *Nuvolone, Petri, and Voller, The effects of ozone on human health*.
[16] Quinton, "Why 'Orphan Oil and Gas Wells Are a Growing Problem for States."
[17] U.S. Environmental Protection Agency, "Understanding Global Warming Potentials."
[18] Kang et al., *Direct measurements of methane emissions from abandoned oil and gas wells in Pennsylvania.*
[19] Harleman, Weber, and Berkowitz, *Environmental Hazards and Local Investment: A Half-Century of Evidence from Abandoned Oil and Gas Wells.*

effect translates into $112 less school revenues per student each year.[20] The forgone revenue across all schools and local governments in the county exceeds $500,000 annually.[21]

The Purpose of Bonds

Oil and gas operators are legally bound to plug their wells when they abandon them, and the Pennsylvania Department of Environmental Protection can fine operators that do not comply with plugging requirements. Fines, however, are meaningless when applied to operators that have dissolved or have no means to pay them. The upfront nature of bonds avoids this problem. Because operators post bonds as a requirement for receiving a permit to drill a new well, the bond amount is secured even if the operator later falls into financial distress. Bonds, therefore, act as an insurance policy that protects the Commonwealth from having to use public revenues to pay an operator's plugging liabilities.

The history of oil and gas development and policy in Pennsylvania underscores the value of such insurance. The Commonwealth has had plugging requirements for both oil and gas wells since the 1920s, and enforcing the requirements became easier in 1955 when the Commonwealth added permitting requirements, which allowed it to establish each well's location and ownership. Despite those policies, an estimated 20 percent of wells drilled between 1955 and 1984 (when bonding requirements were introduced) were abandoned without plugging.[22] Many of these wells will likely become the responsibility of the Commonwealth to plug.

For the Commonwealth and its taxpayers to fully avoid the burden of plugging costs, the bond amount must cover plugging costs on average.[23] Some wells will cost more than the average and others less, but if set correctly, the savings from cheap wells will cover the extra costs of expensive wells. If instead the bond amount is below average plugging costs, the Commonwealth's plugging program will run a deficit and require another revenue source to cover its costs.

Current Bond Amounts

The law governing both conventional and unconventional wells states that bond amounts "may be adjusted by the Environmental Quality Board every two years to reflect the projected costs to the Commonwealth of plugging the well."[24] Moreover, the law governing bond amounts for conventional wells directs the Environmental Quality Board to "undertake a review of the existing bond requirements for conventional oil and gas wells."[25]

[20] Ibid.
[21] This estimate is based on the analysis in Harleman, Weber, and Berkowitz but not reported in the paper.
[22] Weber, McClure, and Simonides, *The Boom, the Bust, and the Cost of Cleanup: Abandoned Oil and Gas Wells in Pennsylvania and Implications for Shale Gas Governance*.
[23] Setting bond amounts equal to average plugging costs would not be appropriate if operators were more likely to leave high-cost wells unplugged. This is possible but hard to establish.
[24] 58 Pa. Con. Stat. § 3225.
[25] 72 P.S. § 1606-E.

Current bond amounts, however, are the unadjusted amounts initially specified by law. The law currently requires a $2,500 bond for each conventional well drilled on or after April 18, 1985.[26] In lieu of the $2,500 per well bond, the law allows operators to post a "blanket bond" of $25,000.[27] This allows operators with more than 10 wells to post a smaller total bond using a blanket bond instead of a per well bond. With 100 wells, for example, an operator would post $250 per well[28] instead of $2,500 per well.

In the late 2000s, operators began drilling more and more wells in the Marcellus and then Utica shale formations. Exploiting the formations required unconventional methods, namely horizontal drilling and hydraulic fracturing, and such wells became known as unconventional wells. In 2012, the Commonwealth adopted laws specific to unconventional wells. The law currently sets a $10,000 bond for each unconventional well, but also caps the total bond amount for an operator with many wells, with the cap acting as a type of blanket bond.[29] The caps vary with operator size. An operator with 50 wells need only post $290,000 in bonds, or $5,800 per well.[30] An operator with more than 150 wells need only post $600,000. Thus, an operator with 240 unconventional wells faces a per well bond amount of $2,500.[31]

Well operators can satisfy bond requirements in different ways, including a corporate surety bond or a deposit of cash, certificates of deposit, or U.S. Treasury bonds.[32] A surety bond acts like an insurance policy. In general, the operator pays an insurer (the surety) a percent of the bond amount each year, and the surety agrees to pay a third party (in this case the Commonwealth) the bond amount if conditions specified in the bond are met (in this case the failure of the operator to plug its well). The rate a surety elects to charge and the bond amount determine the cost of the bond incurred by the operator. At a 5 percent rate, a $10,000 bond costs an operator $500 each year.[33] Rates depend on an operator's financial health, with more financially secure firms facing lower rates and therefore lower costs to satisfy the same bond requirement.

Methods for Projecting Plugging Costs for 2021-2022

The focus of this report is projecting the per well plugging cost that the Commonwealth is likely to incur from plugging wells in the 2021-2022 period. The projection, in turn, is to aid the Environmental Quality Board in adjusting bond amounts to match the projected costs to the Commonwealth of performing well plugging. This section explains the methodology used to project this cost.

Conventional Plugging Costs

To project the cost of plugging a conventional well in the 2021-2022 period, I start by calculating the sample average cost per well for plugging from the 1989–2020 period (in 2020 dollars). This is the

[26] 25 Pa. Code § 78.302.
[27] 72 P.S. § 1606-E.
[28] $25,000/100 wells.
[29] Bond amounts are less for unconventional wells with a total bore length less than 6,000 feet, which applies to few if any unconventional wells since they are generally greater than 6,000 feet in vertical length in addition to several thousand feet in horizontal length.
[30] $5,800 = $290,000/50 wells.
[31] $2,500 = $600,000/240 wells.
[32] 52 Pa. Con. Stat. § 3225.
[33] 0.05 x $10,000.

total cost across all contracts divided by the total number of wells plugged. It would be a reasonable projection of average plugging costs in 2021-2022 if inflation-adjusted costs were constant over time, but they are not—costs have consistently risen over time. To project costs for 2021-2022, I estimate the growth rate in plugging costs using a regression model to account for changes in the location and types of wells being plugged over time. I then apply the estimated growth rate in plugging costs to the sample average well, which was plugged in 2005. See Appendix A for estimation of the growth rate and the calculation of the projected cost.

The key assumption of this approach is that the average well that *has been* plugged by the Commonwealth has characteristics similar to those of the average well that *will be* plugged by the Commonwealth, at least when considering characteristics that affect plugging costs. I test this assumption in two ways. First, I compare the projected cost of plugging a conventional well with the plugging costs incurred over the 2018-2020 period by a large operator of conventional wells in Pennsylvania. Second, I compare the characteristics of wells plugged by the Commonwealth with those of conventional wells drilled over the 2010-2018 period.

Unconventional Plugging Costs

Unlike the case of conventional wells, the Commonwealth of Pennsylvania has plugged no unconventional wells, nor am I aware of other states in the Appalachian basin that have done so. This is because unconventional gas wells, also known as shale gas wells, are relatively new to the region, having only been drilled on a large scale starting in the late 2000s. Private plugging of unconventional wells in Pennsylvania has occurred, but the associated cost data is not publicly available. If collected moving forward, this information could inform future decisions by the Environmental Quality Board.

The cost of plugging conventional wells in Pennsylvania may nonetheless provide a reasonable foundation for estimating unconventional costs. The Commonwealth applies similar plugging regulations to both well types. In coal areas, for example, regulations for both wells require a 200-foot section of cement around the bottom of the surface casing, followed by sections of cement and non-porous material through the rest of the vertical portion of the well bore.[34] Firms plugging both conventional and unconventional wells in Pennsylvania will also face similar material and labor costs.

Given the similarity in plugging regulations and prices for materials and labor, I follow the same methodology for unconventional wells as for conventional wells with one difference. I adjust the sample average plugging cost before applying the growth rate in costs. The adjustment accounts for two large differences between sample conventional wells and unconventional wells. First, unconventional wells are deeper than the average conventional well plugged from 1989 to 2020, which increases costs. Second, essentially all unconventional wells in Pennsylvania are gas wells, which historically have cost more to plug than oil wells. See Appendix B for details on the adjustments and regression model used to assess the effect of depth and well type on plugging costs.

[34] 25 Pa. Code § 78.92(b) and § 78a.92(b). In the case of an unconventional well whose bore extends horizontally, the operator must then place a mechanical plug to block off the vertical part of the well from the horizontal part.

Data

The Pennsylvania Department of Environmental Protection (DEP) provided a dataset with all wells that it has paid to have plugged since 1989, when it plugged its first well, through November of 2020. The dataset contains 3,134 wells and includes, among other variables, the well permit number, the contract number, and the total cost of the contract under which the well was plugged. I put all contract costs in 2020 dollars using the Consumer Price Index (CPI-U). I exclude 35 out-of-scope wells for reasons described in Appendix C, leaving 3,099 wells covered by 255 contracts.

The DEP dataset does not include each well's depth, which is a determinant of plugging costs. To assign depth to each well, I combined an additional DEP-provided dataset of the location of DEP-plugged wells with geospatial data from the Pennsylvania Department of Conservation and Natural Resources (DCNR) on oil and gas fields and pools, which includes each pool's average producing depth.[35] I mapped the DEP-plugged wells over the DNCR pools and assigned to each well the average depth of the pool in which it is located. In doing so, I estimated the depth of 3,060 wells covered by 226 contracts.

Using the well permit number in the DEP plugging data, I added two variables from other state data sources. These were the earliest year when the well appeared in any state records, which is a rough measure of when the well was drilled, and an indicator for whether the well was in a coal region. Older and more deteriorated wells are generally more expensive to plug. Wells in coal regions can also involve different plugging practices, which can affect costs. Incorporating the additional variables improves parts of the analysis by better accounting for differences in well characteristics that can affect cost. For example, it aids in estimating the growth rate in plugging costs apart from changes in the types of wells being plugged over time. The additional variables, along with the depth variable, are available for 3,040 wells from 211 contracts.

The data described above are used to create a contract-level dataset, which is the basis of the analysis. This is a practical necessity because DEP plugging contracts generally only have a total cost for the entire contract, not a unique cost for each well. Because the focus of this report is on the typical well, not the typical contract, I weight contract values by the number of wells in the contract, so that the resulting statistics represent the average well.[36] By comparison, the average of unweighted contract values reflects the average contract.

Values presented in the report reflect the largest sample of wells and contracts possible. Thus, the simple average cost per well is based on the largest sample of 3,099 wells (255 contracts). The average cost per foot of depth is based on the 3,060 wells (226 contracts) for which depth data are available. Analysis involving the two additional well variables uses 3,040 wells (211 contracts).

[35] The oil and gas pool geospatial data can be found by searching the DCNR's elibrary at www.dcnr.pa.gov/ELibrary/Pages/default.aspx.

[36] The well-weighted contract average is equivalent to summing the total costs across all contracts and dividing by the number of wells, which is why the weighted contract average refers to the average well, not the average contract.

Findings: Projected Costs for Conventional Wells

Over the 1989-2020 period the average well plugged cost the Commonwealth $15,118 (Table 1, the "Weighted" column). This does not reflect current plugging costs since the average year of plugging is 2005. The cost per well for the average contract (Table 1, "Unweighted" column) is higher and reflects economies of scale in plugging discussed in detail in a later section. Because most wells are plugged under a large, lower-cost contract, the plugging cost of the average well is lower than for the average contract.

Costs range substantially across contracts, with per well costs ranging from $3,422 to nearly $485,000. The standard error of the weighted average cost, however, is fairly small, at $472. This means that a sample of wells randomly drawn from the same population of previously plugged abandoned wells would likely have an average cost in the range of $14,200 to $16,000.

Table 1. Summary Statistics for Well Plugging Contracts

	Average			
Variable	Weighted	Unweighted	Minimum	Maximum
Plugging Cost Per Well ($)	15,118	49,008	3,422	484,677
Plugging Cost Per Foot ($)	8	20	1	219
Depth Per Well (Feet)	1,925	1,832	450	7,174
Contract Size (Wells)	55	12	1	179
Year Plugged	2005	2005	1989	2020
Emergency Contract (0/1)	0.01	0.08	0.00	1.00
Well Type				
Share Oil Wells	0.83	0.43	0.00	1.00
Share Gas Wells	0.12	0.36	0.00	1.00
Share Oil & Gas Wells	0.04	0.13	0.00	1.00
Share Other	0.01	0.09	0.00	1.00
Share of Wells in Coal Regions	0.06	0.22	0.00	1.00
Estimated Year Drilled	1995	1988	1891	2015
Number of Contracts		211 to 256		
Number of Wells		3,040 to 3,099		

Notes: The data are drawn from various datasets of the Pennsylvania Department of Environmental Protection and Department of Conservation and Natural Resources. All tabulations are by the author. As noted in the text, not all information is available for every well or contract. The weighted average is the contract average weighted by the number of wells in the contract. All monetary values are in 2020 dollars.

As mentioned in the methods section, it is important to adjust the plugging cost of the sample average well for changes in cost over time. Figure 1 shows a scatter plot of plugging costs per foot (in 2020 dollars, log scale) and the year plugging occurred, with the data adjusted for differences in contract and well characteristics (See Appendix A for details). It shows that plugging costs rose over the three-decade

period even after adjusting for inflation. The slope of the best-fit-line line (estimated in log scale) gives the real annual growth rate, which is 3.2 percent.[37] Performing the same analysis but without adjusting for inflation gives a nominal growth rate of 5.6 percent.

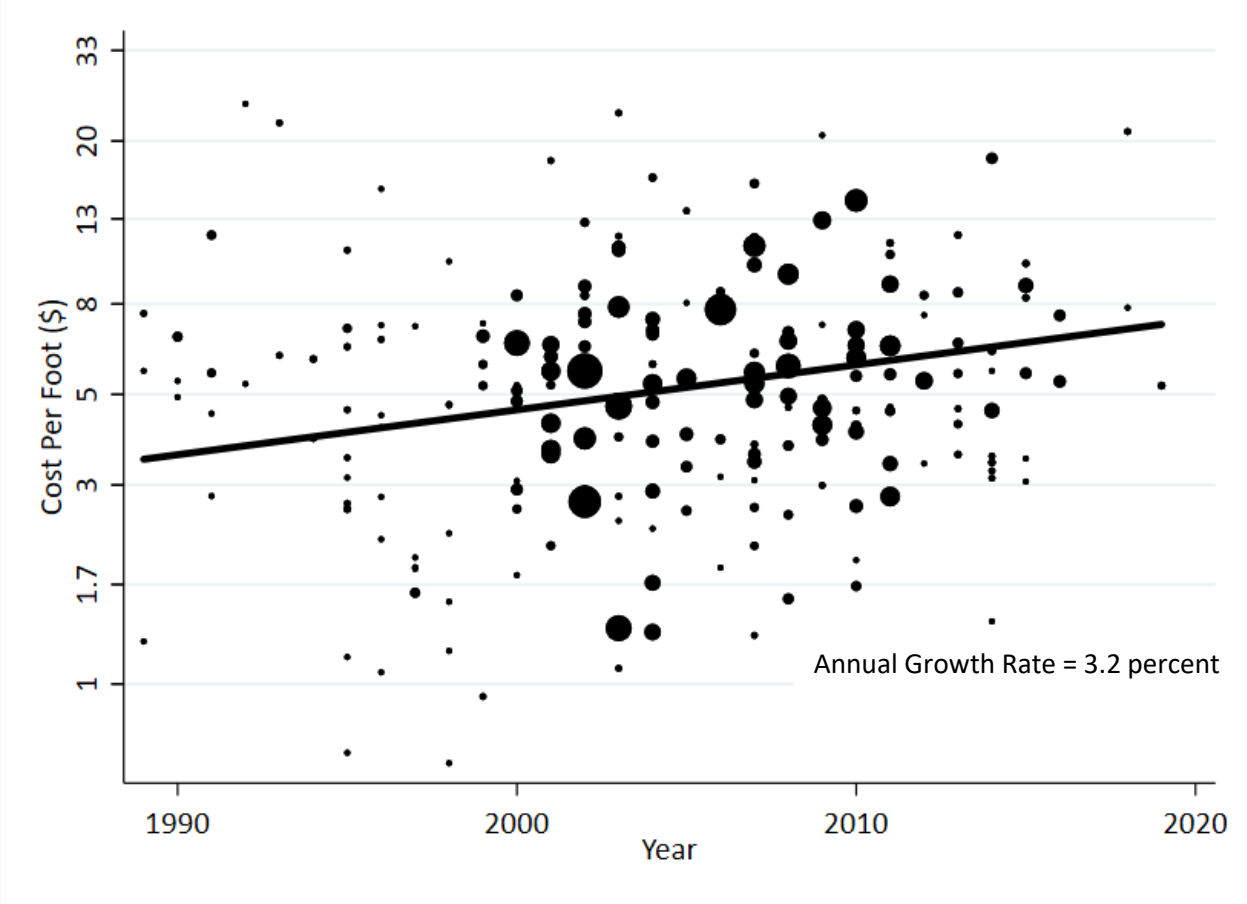

Figure 1. Inflation-Adjusted Plugging Costs Have Grown Over Time

Notes: The vertical axis is plugging cost per foot in 2020 dollars and is shown on a log scale, increasing by increments of roughly 0.5 log points. Each dot represents a well plugging contract. The data shown have been adjusted to account for changes in contract and well characteristics over time. See Appendix A for details. The size of the dots reflects the weight given to the observation (the contract) based on the number of wells in the contract. Larger dots indicate contracts with more wells.

The average plugging cost per well combined with the real and nominal plugging cost growth rates provide what is needed to estimate the plugging cost for 2020 and project the cost for 2021-2022. Doing so gives an estimated 2020 plugging cost of $23,829 per well (in 2020 dollars) and a projected 2021-2022 cost of $25,164 per well (in 2021 dollars).

[37] Plugging and site restoration standards have changed over time, mostly due to Act 13 of 2012. Breaking the study period into before and after Act 13 reveals a growth rate of 3.0 percent before 2012 and 8.5 percent after 2011. That the global average (pooling data from both periods) is 3.2 percent reflects the greater weight given to earlier years when more wells were plugged. I use the global average growth rate as it should better reflect the growth rate moving forward. It is likely that Act 13 caused a temporary increase in the growth rate, with the rate returning to its long-run average after the full incorporation of the changes in plugging practices.

The projected cost for 2021-2022 supports the recommendation of a conventional bond amount of 25,000 per well for the 2021-2022 period. The Environmental Quality Board should revisit the amount every two years, taking into account updated information on plugging costs. The recommended $25,000 amount could become outdated in several years because of inflation and rising real costs. For example, if plugging costs continue to grow at their historical rate, conventional well plugging costs would rise to more than $31,000 by the end of 2025 (in 2025 nominal dollars).[38] In addition, the composition of wells needing to be plugged can change over time, resulting in a higher or lower average cost.

Assessing the Projections

As noted in the methods section, the reliability of the 2021-2022 projection depends in part on whether sample wells are unique in ways that affect plugging costs. One way to gauge their uniqueness is to compare their plugging costs to those of other wells, such as those plugged by the private sector.

A comparison with recent private sector plugging costs suggests that wells plugged by the Commonwealth are not unique in ways that have large effects on plugging costs. Diversified Gas and Oil is a large operator of conventional wells in Appalachia, and in August of 2020 it released a report providing its spending on wells plugged from 2018 through the second quarter of 2020. For the 192 wells that it plugged in the Appalachian region, it reports an average cost of $24,280 per well. Not all of the wells were in Pennsylvania, but Diversified also reports an estimate of per well costs by state, reporting $23,638 for Pennsylvania wells in coal regions and $19,259 for wells outside of them.[39] The costs are similar to the estimated 2020 cost based on wells plugged by the Commonwealth ($23,829).

Another way to gauge the uniqueness of the wells plugged by the Commonwealth is to compare their characteristics with those of conventional wells drilled in recent years. The comparison should reveal how conventional drilling has evolved, which is important because adjusted bond amounts would apply to recently drilled and soon-to-be-drilled wells. To conduct this comparison, I used data from the DEP and analyzed all wells drilled between 2010 and 2018, comparing them to the previously discussed dataset of plugged wells.

On the whole, the comparison also suggests that the plugged well sample is not unique (i.e., is roughly consistent with more recent conventional wells). The average wells of each sample have similar depth and likelihood of being in a coal region. This is notable given the difference in well age across the two samples. The average estimated year drilled is 1995 for plugged wells and 2011 for recently drilled wells. The primary difference between recently drilled wells and wells plugged by the state is the hydrocarbon focus, with the recently drilled wells focused on gas plays, or a mix of oil and gas, and fewer wells in pure oil plays. On the whole, then, the sample of wells plugged by the DEP are likely to provide reasonable estimates of the plugging costs that the Commonwealth is likely to incur in the near future. At the same time, there are some differences between older wells and recently drilled wells, which highlights the value of the Environmental Quality Board periodically revisiting bond amounts with updated cost data.

[38] = $25,000 x (1.056)^4, where 0.056 refers to the nominal growth rate in plugging costs.
[39] Diversified Gas & Oil, *Asset Retirement Supplement for the ARO Liability.*

Table 2. Comparing Plugged Wells and Recently Drilled Conventional Wells

	Average Values		
	Plugged Wells	Recently Drilled Wells	Difference
Depth (Feet)	1,925	2,087	162
Oil Well (0/1)	0.83	0.57	-0.26
Gas Well (0/1)	0.12	0.21	0.09
Oil and Gas Well (0/1)	0.04	0.16	0.12
Other Well (0/1)	0.01	0.08	0.07
Well in Coal Region (0/1)	0.06	0.06	0.00
Estimated Year Drilled	1995	2011	16
Number of Wells	3,040	2,923	

Notes: Data are from various datasets of the Pennsylvania Department of Environmental Protection and Department of Conservation and Natural Resources. All tabulations are by the author. The Estimated Year Drilled refers to the first year that the well appears in state records.

Findings: Projected Costs for Unconventional Wells

I project a plugging cost of $70,000 for an unconventional well in 2021. The number reflects the same methodology used to project costs for conventional wells but with two adjustments to account for differences between unconventional wells and the conventional wells reflected in the DEP plugging data.

The first difference is that unconventional wells are deeper, which increases plugging costs.[40] Plugged wells have an average depth of 1,925 feet compared to an estimated 6,300 feet for unconventional wells.[41] Statistical modeling of the plugging cost data indicates that each foot in depth adds $1.90 in cost, which gives an adjustment of $8,313.[42] The second adjustment is for well type. Most of the conventional wells plugged were oil wells whereas essentially all unconventional wells are gas wells. The same statistical model that relates depth to plugging costs shows that natural gas wells cost an average of $21,376 more to plug than other wells. The resulting adjustment is $18,803.[43] These two adjustments sum to a slightly more than $27,000 increase in cost of plugging from the sample average conventional well.

To arrive at the $70,000 projection, I add the total adjustment to the sample average conventional well cost and then apply the same growth rates in plugging costs as estimated for conventional wells. See Appendix B for details of the calculations and statistical modeling. As with the projected cost for conventional wells, the projection and recommended bond amount for unconventional wells apply to the 2021-2022 period. The Environmental Quality Board should revisit the amount every two years, taking into account updated information on plugging costs. This is especially important in the case of unconventional wells because there is currently no publically available data on the cost of plugging unconventional wells in Pennsylvania.

[40] Ho et al., *Managing environmental liability: an evaluation of bonding requirements for oil and gas wells in the United States.*

[41] Weber, McClure, and Simonides, *The Boom, the Bust, and the Cost of Cleanup: Abandoned Oil and Gas Wells in Pennsylvania and Implications for Shale Gas Governance*.

[42] $8,313 = (6,300 feet – 1,925 feet) x $1.9 per foot. See Appendix B for a discussion of this calculation.

[43] $18,803= (1.0 – 0.12036) x 21,376 per gas well, where .12036 is the weighted contract average share of gas wells (see Table 1).

Assessing the Projection

There is more uncertainty over the projection for unconventional wells than for conventional wells because of the lack of data on unconventional well plugging costs. Yet, the projection is arguably the most well-founded of any projection for unconventional wells in Pennsylvania.

A 2011 study estimated the cost of plugging unconventional wells in Pennsylvania based on well plugging data from Wyoming from 1997 to 2007, and reported that plugging a single unconventional well would cost about $110,000.[44] The authors, however, did not account for differences in terrain and labor and material costs between Wyoming and Pennsylvania. Costs for plugging in Pennsylvania may be different than incurred in other states. For example, one study of plugging costs reports that a drilling rig, which is used to prepare a well for plugging, can cost $85 an hour in Kansas and $240 an hour in Pennsylvania. [45] The estimate of $110,000 also assumed that the horizontal portion of unconventional wells needs to be plugged. Current Department of Environmental Protection regulations cited above make it clear that this is not the case in Pennsylvania—operators need only put a mechanical plug near the bottom of the vertical portion of the well.

A forthcoming study that uses Pennsylvania conventional well plugging data estimates unconventional well plugging costs ranging from about $92,000 to $129,000.[46] These estimates, however, are conditional on wells being plugged in fairly small groups, resulting in small contract sizes. As the next section discusses, per well plugging costs decrease with contract size, and this report's projections are based on the historical average contract size.

The authors of the forthcoming study note that site restoration costs may differ between conventional and unconventional wells.[47] Unconventional wells are found on large pads that host multiple wells whereas conventional wells are more scattered across the landscape. The net effect of the differences on plugging costs (including site restoration) could be positive or negative–larger pads would require more restoration costs but ease of site access and clustering of wells on a pad would reduce it. Because there is no firm way to estimate the impact of this factor, it is not reflected in this report's projection.

Contract Size and Economies of Scale in Plugging

Both the conventional and unconventional well projections are based upon the average well in the DEP plugged well dataset, which is associated with an average contract size of 55 wells.[48] (The focus on the average well is because the recommended bond amount seeks to match the projected plugging cost for the average well, not the average contract.) The projections, therefore, assume that future wells

[44] Mitchell and Casman, *Economic incentives and regulatory framework for shale gas well site reclamation in Pennsylvania.*
[45] Ho et al., *Managing environmental liability: an evaluation of bonding requirements for oil and gas wells in the United States.*
[46] Weber, McClure, and Simonides, *The Boom, the Bust, and the Cost of Cleanup: Abandoned Oil and Gas Wells in Pennsylvania and Implications for Shale Gas Governance*.
[47] Weber, McClure, and Simonides, *The Boom, the Bust, and the Cost of Cleanup: Abandoned Oil and Gas Wells in Pennsylvania and Implications for Shale Gas Governance*.
[48] The average contract does not have 55 wells. Rather, the average well is plugged under a contract with 55 wells.

will be plugged under similarly sized contracts. The assumption is important because larger contracts have lower average costs. The lower cost stems from at least two sources. First, a large contract provides steady work for well plugging firms, potentially for an entire year. Plugging firms, which tend to be small, value this stability and therefore offer lower bids for larger contracts. Second, wells in the same contract are often near each other, which allows a firm to spread the cost of moving equipment over multiple wells. Clustering can also allow a firm to use the same staging area and access roads for multiple wells, saving labor and equipment time.[49]

Economies of scale in plugging are evident in the data. Figure 2 shows a scatter plot of plugging costs per well (vertical axis) and contract size (horizontal axis), with a best-fit curve shown as a solid black line. Costs decline dramatically as contract size increases from 1 to 15 wells. However, the rate of the decline slows greatly afterward, with contracts of 100 wells having only marginally lower costs per well than contracts of 50 wells.

The declining economies of scale shown in Figure 2 imply that the potential for an overstatement of costs is low since larger-than-expected contracts will bring only marginally lower cost. In contrast, the potential for understatement of costs is large if most wells in the future are plugged under small contracts. Over the entire sample, 1989-2020, the typical well was plugged under a contract covering 55 wells. However, the largest contracts in the data occurred in the 2000-2011 period when the Pennsylvania Department of Environmental Protection had greater funding (through the Growing Greener legislation).[50] Since 2011, a decrease in funding has translated into smaller contracts, with a more recent wells plugged under a contract with 14 wells. This highlights how greater funding for plugging, perhaps through higher bond amounts, could reduce the average plugging cost per well incurred by the Commonwealth.

Contract sizes have varied over time and may increase or decrease in the future. Given uncertainty over future contract sizes, this report's recommended bond amounts are based on the historical contract size for wells plugged by the Commonwealth. However, assuming the more recent contract size of 14 wells would increase the projected plugging cost and recommended bond amount to $38,000 for conventional wells and $83,000 for unconventional wells. The adjustment is based on the estimated non-linear relationship between contract size and per well plugging costs shown in Appendix Table B1.[51]

[49] These details are informed by an interview of an executive of a firm specializing in well plugging in the Appalachian basin.

[50] The level and sources of funding for well plugging can be seen by visiting: www.dep.pa.gov/Business/Energy/OilandGasPrograms/OilandGasMgmt/LegacyWells/Pages/Well-Plugging-Program.aspx.

[51] The adjustment is a $7,711 increase, which I add to the sample average cost per well. The growth rate in plugging costs is then applied to this adjusted average cost as described by equations (A1-A2) and (B1-B2).

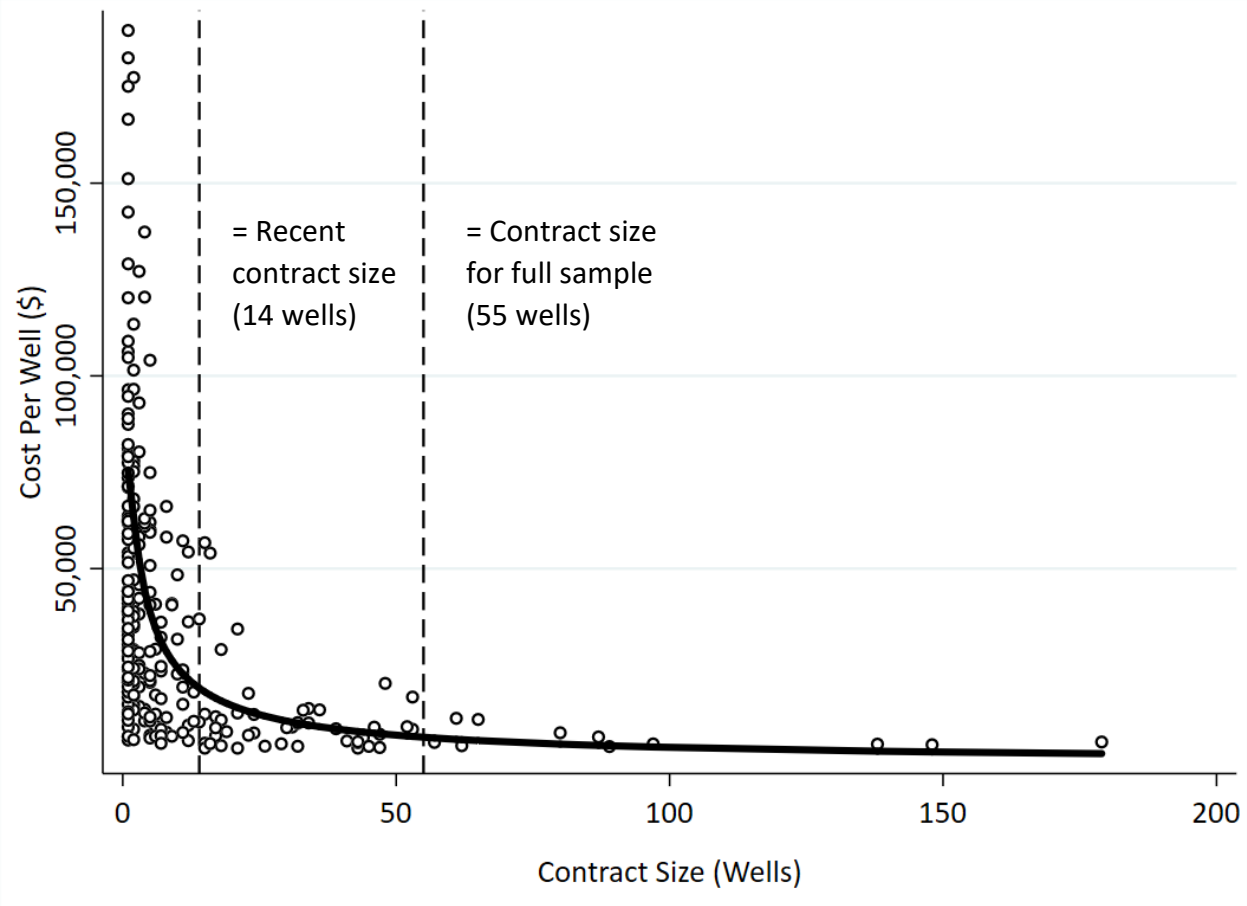

Figure 2. Plugging Costs Decline with Contract Size

Notes: The vertical axis is cost per well in 2020 dollars. Each dot represents a well plugging contract. For clarity of exposition, the vertical axis is limited to a maximum cost of $200,000 per well.

Blanket Bonds

As noted in the section on current bond amounts, blanket bonds (for conventional wells) and bond caps (for unconventional wells) imply that per well bond amounts can be much lower than the commonly cited bond amounts of $2,500 and $10,000 per well. Blanket bonds may have been justified by noting that they limit the total financial burden of bonds on large and financially stable operators. Alternatively, large plugging projects have a lower average cost, also justifying a lower bond amount.

Neither justification is warranted given the bond amounts recommended in this report. With surety bonds, larger—and presumably more financially secure—operators pay less to comply with bonding requirements. This is because sureties base their rates on an operator's finances and the risk that it defaults on its plugging obligations. Thus, a surety bond equal to plugging costs allows lower-risk firms to pay less while also ensuring that the Commonwealth is able to cover the costs of plugging if the operator defaults on its obligations.

Regarding the second potential justification, economies of scale in plugging occur in the range of 1 to 15 wells as shown in Figure 2. There are little, if any, economies of scale in plugging after 50 or so wells, meaning that average plugging costs remain unchanged as contract size increases beyond this size.

Blanket bonds, in contrast, presume that average costs attenuate to zero as contracts grow larger. This is clearly not the case.

If blanket bonds are allowed in their current form, projected plugging costs will exceed, perhaps by a large amount, bond amounts received by the Commonwealth. This report therefore recommends discontinuing the use of blanket bonds or caps and instead recommends that the Commonwealth apply the recommended per well bond amounts to operators of all sizes. Doing so will ensure that the Commonwealth spends, on average, as much on plugging as it receives from forfeited bonds.

To What Wells Should Adjusted Bond Amounts Apply?

Under Pennsylvania statute, bonding requirements apply to all wells in existence after April 17, 1985.[52] Applying adjusted bond amounts in a manner consistent with current law means applying them to new wells and those drilled after the 1985 date, only distinguishing between conventional and unconventional wells as the law does.

This application of adjusted amounts is also consistent with the scope that existing law gives the Environmental Quality Board to adjust bond amounts. The law states that bond amounts "may be adjusted every two years to reflect the projected costs to the Commonwealth of performing well plugging."[53] Because the Board's authority to adjust bond amounts is rooted in projected plugging costs, an uneven application of the adjustment could be justified if there were a basis for expecting new wells to have very different plugging costs than existing wells. The comparison of old and recently drilled wells previously presented in this report suggests no clear basis for the distinction. Thus, if the bond amount were not applied retroactively, the Commonwealth's plugging program would still have insufficient funds to plug the wells that become its responsibility in coming years. Further, this report recommends that the EQB revisit bond amounts every two years, so that it can adjust bond amounts based on any differences in plugging costs between new wells and existing wells that new data may reveal.

The Likely Effect of Bond Adjustments on the Oil and Gas Industry

This section describes the likely effects of adjusted bond amounts on the oil and gas industry based on the experience of Pennsylvania when it introduced its per well Impact Fee for unconventional wells and based on the experiences of Texas and North Dakota when they increased bond amounts. The experiences suggest that the adjustments will improve environmental outcomes, have little effect on aggregate industry activity, and potentially shift wells among operators.

To gauge likely impacts, I first illustrate the potential cost increase associated with adjusted bond amounts. I assume that operators currently post $1,000 for the typical conventional well and $5,000 for

[52] 58 Pa. Con. Stat. § 3225.
[53] 58 Pa. Con. Stat. § 3225.

an unconventional well.[54] I further assume a well life of 30 years, a discount rate of 5 percent, and a bond rate of 5 percent.[55]

The adjusted bond amount would increase annual costs by $3,250 per unconventional well, which has a present value of $50,000 over the life of a 30-year well (Table 3). To put the present value cost in perspective, it is about one-fifth that of the unconventional well Impact Fee. Operators in Pennsylvania pay an Impact Fee of about $50,000 per unconventional well in its first year and about $250,000 over the life of the well.[56]

The industry's response to the introduction of the comparatively more costly Impact Fee suggests that adjusted bond amounts would not affect the number of wells drilled or production. A 2018 study found no systematic change in these outcomes around the introduction of the Impact Fee and compared to areas across the border in West Virginia and Ohio, which did not change their fees or taxes over the same period.[57] The authors did find that leasing declined but attributed this decline primarily to timing of the Fee, which was introduced when natural gas prices were very low and credit lines tight.

Table 3. The Estimated Cost of Bonds at Current and Adjusted Levels

	Well Type	
	Conventional	Unconventional
Assumptions		
Rate on Surety Bond (%)	5	5
Discount Rate (%)	5	5
Current Bond Amount ($ Per Well)	1,000	5,000
Recommended Bond Amount ($ Per Well)	25,000	70,000
Estimates ($ Per Well)		
Current Annual Cost	50	250
Current Present Value of Costs Over 30 Years	769	3,843
New Annual Cost	1,250	3,500
New Present Value of Costs Over 30 Years	19,216	53,804
Change in Annual Cost of Bonding ($ Per Well)	1,200	3,250
Change in Total Cost of Bonding ($ Per Well)	18,447	49,960

[54] Assuming the use of blanket bonds, these per well bond amounts would correspond to a conventional operator with 25 wells ($1,000 = $25,0000 / 25 wells) and an unconventional operator with 120 wells ($5,000 = $600,000 / 120 wells). The cost of current bond amounts would be higher for smaller operators and lower for larger operators.

[55] There is limited data on the bond rates paid by oil and gas operators in Pennsylvania; however, one surety reports on its website that a lower-risk applicant will likely "pay no more than 5% of the bond amount." See www.bryantsuretybonds.com/oil-and-gas-surety-bond. Operators can satisfy bond requirements in different ways (e.g., depositing U.S. Treasury Bonds) and will presumably adopt the lowest cost option. If surety bonds represent the cheapest option, they will provide an accurate indication of actual cost; if not, they will overstate it.

[56] Black, McCoy, and Weber, *When externalities are taxed: The effects and incidence of Pennsylvania's impact fee on shale gas wells.*

[57] Ibid.

Estimates from another recent study show a muted effect of higher bond amounts on unconventional oil and gas activity. The study explored the effect of North Dakota's policy changes, which, among other things, increased per well bond amounts from $20,000 to $50,000 for all existing and new wells.[58] It found that higher bond amounts along with increased regulation had no statistically discernable effect on drilling or production.

The adjusted bond amount would increase annual costs by $1,200 per conventional well, or about $18,000 over the life of a 30-year well (in present value terms). A study of the Texas experience provides insight into what might happen to the conventional well industry. In the early 2000s, Texas introduced a bonding requirement of $2 per foot. In the short term the requirement caused about five percent of operators to exit the market.[59] Exiting operators were small on average and had poor environmental records. Over time, the requirement shifted wells across operators, with about four percent of wells operated by small operators shifting to new operators. As a result, the number of unplugged and abandoned wells decreased by 70 percent and violation of water regulations fell by a quarter. This is a plausible outcome for Pennsylvania—operators unable to pay to the insurance against leaving a well unplugged could exit the market, and their wells could shift to more financially secure operators. Such a shift would protect the Commonwealth from bearing plugging costs since operators unable to pay for insurance (bonds) are probably unable to pay to plug their wells.

It is possible that the adjustment could prematurely shift some existing wells to the responsibility of the Commonwealth. This would happen if the adjustment bankrupts an operator and no other operator wants to acquire the acreage and wells. For such marginal wells and operators, it is likely that the bond adjustment simply changes when the transfer to the Commonwealth happens, not whether it happens. Moreover, with the adjustment the Commonwealth gains financial protection in cases where operators currently can afford the new bonds on existing wells but will eventually fall into financial distress and abandon their wells without plugging them.

It is also worth noting that if Pennsylvania adjusted bond amounts upward it would not be unique among major oil and gas producing states. In addition to North Dakota's bond amount increase referenced above, in 2019 the state increased bond amounts on injection wells from $50,000 to $100,000 and reduced the number of inactive wells that can be covered under a blanket bond.[60] In the same year, Alaska also increased its bond amounts considerably, and Mississippi introduced an annual fee on idle wells.[61]

Conclusion

Thanks to the Pennsylvania Department of Environmental Protection's orderly recording of its plugging activity and costs, much can be said about the well-plugging costs that the Commonwealth has incurred and is likely to incur moving forward. The law prescribing bond amounts appears to anticipate analysis of such data and its consideration by the Environmental Quality Board so that bond amounts can be adjusted to reflect the projected costs to the Commonwealth.

[58] Lange and Redlinger, *Effects of stricter environmental regulations on resource development.*
[59] Boomhower, *Drilling Like There's No Tomorrow*.
[60] Industrial Commission of the State of North Dakota, "Case No. 27828 Order No. 30278". https://www.dmr.nd.gov/oilgas/or30278.pdf
[61] Peltz and Saunders, "How oil & gas states did (and did not) protect land and water in 2019".

Based on analysis of the cost data, this report recommends for the 2021-2022 period a bond amount of $25,000 per conventional well and $70,000 per unconventional well. This adjustment—and subsequent reviews and adjustments by the EQB—will help protect residents and property owners in oil and gas producing areas who would otherwise be harmed or constrained by unplugged abandoned wells. It will also protect the Commonwealth and its taxpayers from shouldering the liabilities of private oil and gas operators that fall into financial distress. By adopting this report's recommendations, the EQB can therefore restore the financial responsibility of well plugging to well operators and remove it from the Commonwealth.

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Appendix A: Conventional Well Plugging Costs

I estimate the plugging cost for a conventional well in the 2021-2022 period by adjusting the sample average plugging cost for changes in costs over time. Let $\bar{c}$ be the sample average cost per well over the 1989-2020 period, $\bar{y}$ the year that the average well was plugged, and $\hat{r}_r$ the estimated real annual growth rate in plugging cost, accounting for any changes in well characteristics over time. The estimated plugging cost for a conventional well in 2020 is then:

$$Estimated\ Cost\ (Con)_{\ 2020} = \bar{c} \cdot (1 + \hat{r}_r)^{(2020-\bar{y})} \quad \text{(A1)}$$

If $\hat{r}_n$is the estimated nominal growth rate in plugging costs (unadjusted for inflation), the projected plugging cost for a conventional well in 2021-2022[62] (in 2021 dollars) is then:

$$Projected\ Cost\ (Con)_{\ 2021-22} = Estimated\ Cost\ (Con)_{\ 2020} \cdot (1 + \hat{r}_n) \quad \text{(A2)}$$

I estimate the real growth rate in plugging costs using the following regression where the unit of analysis is the contract but the regression is weighted by contract size. The dependent variable is the natural log of plugging costs per foot.

$$Ln(Plugging\ Cost\ Per\ Foot_{it}) = \delta Year\ Plugged_{it} + X_{it}\gamma + \delta_c + \varepsilon_{it} \quad \text{(A3)}$$

The term δ_c is a county fixed effect based on the modal county of wells in contract *i* executed in year t. The county fixed effect makes for comparisons of plugging costs within the same county, thereby holding constant factors such as remoteness, terrain, and geology. This accounts for the possibility that plugging costs changed over time because the location of wells being plugged also changed.

The variable Year Plugged is the calendar year (e.g. 2005) when wells in contract *i* were plugged. The vector X includes other variables associated with the contract and its wells and that may affect plugging costs. In its most comprehensive form it includes the natural log of the number of wells in the contract (Contract Size), the shares of wells in the contract of various types (e.g. gas wells), a variable indicating an emergency contract, the share of wells in a coal region, and the average estimated year drilled of contract wells as indicated by the first year the well appears in state records. Their effect on plugging costs is captured by the vector of coefficients in γ. The term ε_{it} captures all variation in the log of plugging costs per foot not captured by the variables in the model.

Multiplying the estimated coefficient on the variable Year Plugged ($\hat{\delta}$) by 100 gives the percent change in per foot plugging costs for each 1-year increase in Year Plugged. Because plugging costs are already adjusted for inflation, this coefficient gives the real annual growth rate in plugging costs over the period holding constant all the other variables in the model. Put differently, $\hat{\delta} = \hat{r}_r$.

Table A1 shows the results from three regressions based on equation A3. The first column includes all the wells in the DEP plugging summary data with depth data, the second includes only wells with additional variables and the third uses this smaller sample and includes two additional control variables. The estimated growth rate—the coefficient on Year Plugged—changes little as the sample is restricted

[62] I consider plugging costs over the 2021-2022 period to equal the cost estimated for the last day of 2021, which is what is given by the formula that applies the nominal annual growth rate to the estimated 2020 plugging cost, assuming that the 2020 cost estimate reflects costs on the last day of 2020.

and more variables are added. The main estimate is 3.2 percent with a 95 percent confidence interval of 2.6 percent to 3.7 percent.

Table A1. Plugging Costs Per Foot (Ln) and Contract and Well Characteristics

	1	2	3
Year Plugged	0.031	0.031	0.032
	(0.002)	(0.003)	(0.003)
Ln(Contract Size)	-0.437	-0.433	-0.399
	(0.012)	(0.012)	(0.013)
Share Oil Wells	-1.116	-1.250	-1.212
	(0.672)	(0.901)	(0.695)
Share Gas Wells	-0.674	-0.803	-1.189
	(0.671)	(0.898)	(0.716)
Share Oil and Gas Wells	-0.944	-1.069	-1.413
	(0.672)	(0.902)	(0.706)
Emergency Contract	-1.064		
	(0.708)		
Share Wells in Coal Region			-0.683
			(0.175)
Estimated Year Drilled			0.011
			(0.001)
Control for County	Yes	Yes	Yes
Number of Contracts	226	211	211
Number of Wells	3,060	3,040	3,040
Adjusted R-Squared	0.51	0.50	0.64

Notes: Robust standard errors are in parenthesis. The regression is based on contract-level data but weighted by the number of wells per contract. The sample of contracts analyzed in columns 2 and 3 does not have any emergency contracts, which is why no results are reported for that variable.

As noted in the main text, the data depicted in Figure 1 are adjusted for changes in contract and well characteristics over time. This is done by excluding the variable Year Plugged from the regression in column 3 of Table A1, in which case the resulting regression error $\hat{\varepsilon}$ reflects variation in plugging costs holding constant factors other than time. Figure 1 then depicts $\hat{\varepsilon}$ on the vertical axis and Year Plugged on the horizontal axis.

Appendix B: Unconventional Well Plugging Costs

I estimate the cost of plugging an unconventional well by adjusting the sample average conventional cost ($\bar{c}$) for differences in the characteristics of the two well types. Let $\bar{X}_{con}$ and $\bar{X}_{un}$ be vectors of the characteristics of the average conventional and unconventional well and let $\hat{\beta}$ be the relationship between a one unit change in a variable in X on per well plugging costs. This adjustment for differences in average well characteristics, such as well depth, can be incorporated into equation (B1) to estimate the cost of plugging an unconventional well in 2020:

$$Estimated\ Cost\ (Un)_{\ 2020} = \bar{c} \cdot \left((\bar{X}_{un} - \bar{X}_{con}) \cdot \hat{\beta}\right) \cdot (1 + \hat{r}_r)^{(2020-\bar{y})} \quad \text{(B1)}$$

Similarly, the projected cost for 2021-2022 (in 2021 dollars) would be:

$$Projected\ Cost\ (Un)_{\ 2021-22} = Estimated\ Cost\ (Un)_{\ 2020} \cdot (1 + \hat{r}_n) \quad \text{(B2)}$$

The real and nominal growth rates ($\hat{r}_r$ and $\hat{r}_n$) are the same as those used for conventional wells and described in Appendix A. I estimate the relationship between per well costs (at the contract level) and well characteristics, given by β, using the regression equation:

$$Plugging\ Cost\ Per\ Well_{it} = Z_{it}\beta + \delta_c + \epsilon_{it} \quad \text{(B3)}$$

where δ_c is a county fixed effect that accounts for any differences in average plugging costs across counties. In its most comprehensive form, the vector Z includes the average depth of wells in the contract, the contract size and the contract size squared (to capture declining economies of scale), the share of contract wells that are gas wells, a variable indicating an emergency contract, the share of wells in a coal region, and the average estimated year drilled of contract wells as indicated by the first year the well appears in state records. The term ϵ_{it} captures all variation in plugging costs per well not captured by the variables in the model.

Table B1 shows the results from two regressions based on equation B3. The unit of analysis is the contract, but the regression is weighted by contract size. Column 1 shows the results of a simple model that only includes depth, contract size, and the year plugged (and no county fixed effect). Column 2's results are based on a model with county fixed effects and the comprehensive version of Z. I use the $\hat{\beta}$ from this more comprehensive model when making the adjustment in equation (B1) because the comprehensive model should more reliably estimate the effects of well depth and type on plugging costs. These are the two characteristics incorporated into the adjustment because they most differ between sample wells and the typical unconventional well.

Based on the short model, an additional foot of depth adds $5.00 to plugging costs. Adding more variables reduces the coefficient on average depth to $1.90, but also shows that contracts with a greater share of natural gas wells have higher costs, suggesting that a contract consisting of all gas wells costs about $21,000 more per well than a contract with no gas wells.

Table B1. Contract and Well Characteristics and Plugging Costs Per Well

	1	2
Average Well Depth (Feet)	5.0	1.9
	(0.5)	(0.5)
Contract Size (Number of Wells)	-681.2	-270.4
	(34.1)	(26.3)
Contract Size Squared	3.1	1.2
	(0.2)	(0.1)
Year Plugged	335.2	278.2
	(132.9)	(105.4)
Share Gas Wells		21,376.1
		(3,545.7)
Share of Wells in Coal Regions		-5,852.3
		(13,524.1)
Estimated Year Drilled		102.0
		(43.9)
Control for County	No	Yes
Number of Contracts	226	211
Number of Wells	3,060	3,040
Adjusted R-Squared	0.27	0.27

Notes: Robust standard errors are in parenthesis. The regression is based on contract-level data but weighted by the number of wells per contract.

Appendix C: Data

The following contracts and wells were removed from the Pennsylvania Department of Environmental Protection's well plugging summary dataset, which left 3,099 wells:

- 1 contract that was in process and had no cost data (7 wells).
- 1 contract where it was noted that site restoration but not plugging occurred (1 well).
- 20 wells across various contracts where instead of a plugging date, it was noted: "not plugged," "not a well," "prev plugged," "stray gas," "unable to locate," "water," "gas drip," or "well not found." Because they were not plugged, these wells were ignored when calculating average values for each contract.

Mapping the DEP wells onto oil and gas pool outlines permitted approximating each well's depth. Some wells could not be mapped onto pools but where other wells in the same contract had depth data, I imputed missing depth data with the contract mean depth. After imputation, depth data were available for 3,060 of the 3,099 wells left after the above exclusions.

I created two additional variables from data not found in the DEP plugging summary dataset. These were an indicator for whether the well was in a coal region and the estimated year the well was drilled as indicated by the first year that the well was observed in state records. Data for both variables were obtained through the Department of Conservation and Natural Resources' EDWIN database. The database is a repository of oil and gas well data from multiple sources, including from various Department of Environmental Protection reports.

Attachment D

Well Bond Amounts
by State

<table>
<tr><th>State</th><th>Program</th></tr>
<tr><td>Federal (Bureau of Land Management)</td><td>Any operator that seeks to drill wells on federal land must sign a lease to do so with the Bureau of Land Management (BLM). 43 C.F.R. Part 3100 describes the process of obtaining a lease from BLM to drill a well. Prior to commencing drilling on the leased land, the operator must submit a bond to BLM whose return is conditioned on the operator following all lease requirements, including plugging of the well and restoration of the land after production has ceased. 43 C.F.R. Subpart 3104 governs the bond requirements.

For individual wells, an operator shall provide a bond of not less than $10,000 for each well, or

For multiple wells, an operator shall provide one of the following blanket bonds:
a. Not less than $25,000 to cover all wells in any one state;
b. Not less than $150,000 to cover all wells nationwide, and

BLM state offices have the authority to increase (or decrease) individual bond amounts as the office feels necessary, provided that the new bond amount does not exceed “the total of the estimated costs of plugging and reclamation, the amount of uncollected royalties due to the Service, plus the amount of monies owed to the lessor due to previous violations remaining outstanding.” 43 C.F.R. § 3104.5.

BLM has adopted a policy of reviewing bond amounts for all statewide and nationwide bonds every five years, and increasing or decreasing the bond amount based on a set formula (with some discretion to disregard the formula). Memorandum from the Assistant Dir., Energy, Minerals, and Realty Mgmt., Bureau of Land Mgmt., to all Field Officials (Nov. 15, 2018), https://www.blm.gov/policy/im-2019-014#_ftn7.</td></tr>
<tr><td>Alabama</td><td>The State Oil and Gas Board of Alabama is a regulatory agency that promotes protection and conservation of the environment. The board enforces the state rules and regulations through oversight of oil and gas drilling, operation, exploration, and production; Class II injection wells; and underground storage of gas in reservoirs in Alabama. The Oil and Gas Board of Alabama Administrative Code 400-1-1-.01 thru 400-7-1-.23 defines the regulations process for oil and gas permits. Chapter 400-1-2 details the process of well permitting, and Section 400-1-2-.03 explains the bond requirement.

<table><tr><td>Measured Depth (ft)</td><td>Amount of bond req’d</td></tr><tr><td>0 - 5,000</td><td>$5,000</td></tr><tr><td>5,001 - 10,000</td><td>$10,000</td></tr><tr><td>10,001 - 15,000</td><td>$15,000</td></tr><tr><td>15,001 - 20,000</td><td>$30,000</td></tr><tr><td>Greater than 20,000</td><td>$50,000</td></tr><tr><td colspan="2">The Board may, however, accept a blanket bond in the amount of one hundred thousand</td></tr></table></td></tr>
</table>

<table>
<tr><td></td><td>dollars ($100,000.00).</td></tr>
<tr><td>State</td><td>Program</td></tr>
<tr><td>Alaska</td><td>Alaska oil and gas operators that drill, produce, and maintain oil, gas, and geothermal wells must obtain a Permit to Drill from the Alaska Oil and Gas Conservation Commission (AOGCC). The Commission manages certain oil and gas operations in the state, whether it is federally owned, state owned, or privately owned. The permit covers operators of exploratory, stratigraphic test, development wells, injection, and other service wells related to oil, gas and geothermal activities. A part of the permit process includes obtaining a single well or blanket surety bond.

Alaska Admin. Code tit. 20, § 25.025.

<table><tr><td># Permitted Wells</td><td>Bond Amount</td></tr><tr><td>1 - 5 wells</td><td>$400,000 per well</td></tr><tr><td>6-20 wells</td><td>$2,000,000 plus $250,000 per well</td></tr><tr><td>21 - 40 wells</td><td>$6,000,000 blanket bond</td></tr><tr><td>41 - 100 wells</td><td>$10,000,000</td></tr><tr><td>101 - 1,000 wells</td><td>$20,000,000</td></tr><tr><td>Over 1,000 wells</td><td>$30,000,000</td></tr></table></td></tr>
<tr><td>State</td><td>Program</td></tr>
<tr><td>Arizona</td><td>The Arizona Department of Environmental Quality, Oil and Gas Conservation Commission is responsible for the issuing of permits and operator compliance with state laws and regulations for oil and gas new well operations, re-entering an abandoned well, drilling, and production. The Department requires a performance bond before drilling of new wells, re-entering an abandoned well, or assuming the responsibility of an existing well.

Arizona Administrative Code (A.A.C.) R12-7-103

<table><tr><td>For individual wells, an operator shall provide a $10,000 bond for each well drilled to a total depth of 10,000 feet or less or a $20,000 bond for each well drilled deeper than 10,000 feet, or</td></tr><tr><td>For multiple wells, an operator shall provide one of the following blanket bonds to cover all wells:
a. $25,000 for 10 or fewer wells;
b. $50,000 for more than 10 but fewer than 50 wells; or
c. $250,000 for 50 or more wells.</td></tr></table></td></tr>
</table>

<table>
<tr><th>State</th><th>Program</th></tr>
<tr><td>California</td><td>Oil and gas well operators in California are regulated by the Department of Conservation‘s (DOC) Division of Oil, Gas, & Geothermal Resources. The Division oversees the drilling, operation, maintenance, plugging and abandonment of oil, gas, and geothermal wells. Oil and gas operators in California must file individual or blanket bonds with the Department.

CA PRC 3204

<table><tr><td>Twenty-five thousand dollars ($25,000) for each well that is less than 10,000 feet deep.</td></tr><tr><td>Forty thousand dollars ($40,000) for each well that is 10,000 or more feet deep.</td></tr></table></td></tr>
<tr><th>State</th><th>Program</th></tr>
<tr><td>Colorado</td><td>The Colorado Department of Natural Resources, State Land Board, Oil & Gas Conservation Commission (COGCC) is responsible for the issuing of permits and operator compliance with state laws and regulations for oil and gas well drilling, exploration, operation and plugging. The Commission requires a surety bond prior to the assignment or permit to drill new wells, deepening of wells, and the plugging of wells.

2 CO ADC 404-1 - 700 Series (Rule 706)

<table><tr><td>Individual</td><td>$10,000 for wells less than 3,000 feet deep and $20,000 for wells equal to or more than 3,000 feet deep</td></tr><tr><td>Blanket</td><td>A $60,000 blanket bond for less than 100 wells, or a $100,000 blanket bond for more than 100 wells</td></tr><tr><td colspan="2">The Commission may increase the required assurance under special circumstances, per Rule 702.a (2 CCR 404-1:702(a))</td></tr></table></td></tr>
<tr><th>State</th><th>Program</th></tr>
<tr><td>Florida</td><td>The State of Florida Department of Environmental Protection, Oil and Gas Program is the permitting authority for mining and minerals regulation programs. The oil and gas program details can be found in Chapter 377 of the Florida Statutes and Rules 62C-25 through 30 of the Florida Administrative Code. FS 377.22(f) gives the Department the authority to require bonds, and Rule 62C-26.002 details the requirement.

Rule 62C-26.002, F.A.C.
or
Fla. Admin. Code r. 62C-26.002

<table><tr><td>Well Depth (Feet)</td><td>Security Required</td></tr></table></td></tr>
</table>

<table>
<tr><td></td><td>
<table>
<tr><td>0 - 9,000</td><td>$50,000</td></tr>
<tr><td>9,001 or more</td><td>$100,000</td></tr>
<tr><td colspan="2">In lieu of furnishing a separate security for each particular well, an owner or operator may file with the Department a blanket bond for multiple operations within the State in the amount of $1,000,000.00. Each blanket bond may cover up to ten wells.</td></tr>
</table>
</td></tr>
<tr><td>State</td><td>Program</td></tr>
<tr><td>Georgia</td><td>In order to work on oil and gas wells in Georgia, operators need to obtain a permit from the state Department of Natural Resources. One of the main criteria that you have to fulfill to get a permit is to post a surety bond. It serves as a protection mechanism for the state that you will operate the oil and gas well drilling in accordance with state regulations.

Ga. Code Ann., § 12-4-47 (sets the maximum)

Ga Comp. R. & Regs. 391-3-13-.04

<table>
<tr><td>Permit Depth</td><td>Amount of Bond</td></tr>
<tr><td>Less than 5,000 feet</td><td>$20,000</td></tr>
<tr><td>5,000 - 10,000 feet</td><td>$40,000</td></tr>
<tr><td>10,000 - 15,000 feet</td><td>$60,000</td></tr>
<tr><td>Over 15,000 feet</td><td>$80,000</td></tr>
<tr><td colspan="2">“[A] blanket bond in the amount of $100,000 may be substituted. . . . The Director may require that the blanket bond not be applicable for any well left open after rig removal.”</td></tr>
</table>
</td></tr>
<tr><td>State</td><td>Program</td></tr>
<tr><td>Idaho</td><td>The Idaho Department of Lands, Oil & Gas Conservation Commission regulates drilling, explorations, and production of oil and gas wells. The Commission requires a surety bond before any drilling of new wells, plug back, or deepening of an existing well.

IDAPA 20.07.02.220.

<table>
<tr><td>Individual</td><td>“[N]ot less than ten thousand dollars ($10,000) plus one dollar ($1) for each foot of planned well length . . . .”</td></tr>
<tr><td>Blanket</td><td>- $50,000 (up to 10 wells)
- $100,000 (11 to 30 wells)
- $150,000 (over 30 wells)</td></tr>
</table>
</td></tr>
<tr><td>State</td><td>Program</td></tr>
</table>

<table>
<tr><td>Illinois</td><td>The Illinois Department of Natural Resources, Office of Oil and Gas Resource Management, regulates the permitting, drilling, operating, and plugging oil and gas production wells. The Department requires surety bonds or another form of security from oil and gas drillers to help protect Illinois' oil and gas resources, the environment, land, and water resources.

62 Ill. Adm. Code 240.1500.

<table><tr><td>Individual</td><td>- $1,500 for a well < 2000 ft
- $3,000 for a well > 2000 ft</td></tr><tr><td>Blanket</td><td>- $25,000 for up to 25 wells
- $50,000 for up to 50 wells
- $100,000 for all wells</td></tr><tr><td>Other</td><td>- $10,000 before a permit is issued, authorizing a person to operate
- $2,500 for each individual permit (or $25,000 blanket bond) to be filed before a permit is issued to drill a test hole or monitoring of a well</td></tr></table></td></tr>
<tr><td>State</td><td>Program</td></tr>
<tr><td>Indiana</td><td>The Indiana Department of Natural Resources requires a permit for drilling, deepening, operating, or converting a well for oil and gas purposes. The Department requires a security from well operators to ensure compliance with respect to plugging of the well, filling in of all excavations, the removal of concrete bases, discarding machinery and materials, cutting off of the surface casing, and restoration of the surface as nearly as possible to its former condition prior to drilling.

Indiana Code (IC) 14-37-6

<table><tr><td>Individual</td><td>$2,500</td></tr><tr><td>Blanket</td><td>$45,000</td></tr></table></td></tr>
<tr><td>Iowa</td><td>The Iowa Department of Natural Resources oversees the administration of the state’s laws and regulations governing oil, gas, and metallic mineral exploration and production. The Department requires a conformance bond from any operators in this field.

Iowa Admin. Code 561-17.5(458A)

<table><tr><td>Individual</td><td>$15,000</td></tr><tr><td>Blanket</td><td>$30,000</td></tr></table></td></tr>
<tr><td>State</td><td>Program</td></tr>
<tr><td>Kansas</td><td>The Kansas Corporation Commission, Conservation Division regulates oil and gas</td></tr>
</table>

<table>
<tr><td></td><td>production in the state, including exploration and production activities and intrastate gas storage.The Division requires a form of financial assurance before any drilling of new wells, deepening, repairing, re-drilling, or plugging and abandoning of an existing well.

K.S.A. 55-155, K.A.R. 82-3-120

<table>
<tr><td>$.75 times the total aggregate depth (in feet) of all wells</td></tr>
<tr><td>OR

< 2,000 feet in depth:
- 1 to 5 wells $7,500
- 6 to 25 wells $15,000
- Over 25 wells $30,000

> 2,000 feet in depth:
- 1 to 5 wells $15,000
- 6 to 25 wells $30,000
- Over 25 wells $45,000</td></tr>
</table>
</td></tr>
<tr><td>State</td><td>Program</td></tr>
<tr><td>Kentucky</td><td>KRS 353.590 governs bond requirements in Kentucky.

<table>
<tr><td>Individual</td><td>Shallow Wells - $2/foot
Vertical Deep Wells - $25,000
Horizontal Deep Wells - $40,000</td></tr>
<tr><td>Blanket</td><td>Shallow Wells
- 1 - 25 Wells = $20,000
- 26 - 100 = $50,000
- 101 - 500 = $200,000
- 501 - 1000 = $300,000
- 1001 - 1025 = $320,000
- 1026 - 1100 = $350,000
- 1101 - 1500 = $500,000
- 1501 - 2000 = $600,000
- 2001 - 2025 = $620,000
- 2026 - 2100 = $650,000
- 2101 - 2500 = $800,000
- 2501 - 3000 = $900,000
- 3001 - 3025 = $920,000
- 3026 - 3100 = $950,000
- 3101 - 3500 = $1,100,000
- 3501 - 4000 = $1,200,000
- 4001 - 4025 = $1,220,000
- 4026 - 4100 = $1,250,000
- 4101 - 4500 = $1,400,000</td></tr>
</table>
</td></tr>
</table>

<table>
<tr><td></td><td>
<table>
<tr><td></td><td>- 4501 - 5000 = $1,500,000
Vertical Deep Wells
- $200,000 for every ten wells
Horizontal Deep Wells
- $320,000 for every ten wells</td></tr>
</table>
</td></tr>
<tr><td>State</td><td>Program</td></tr>
<tr><td>Louisiana</td><td>The Louisiana Department of Natural Resources, Office of Conservation, regulates oil and gas production in the state, including exploration and production activities and intrastate gas storage. The Office requires a form of financial assurance before any new drilling of wells, deepening, operation, plugging and abandoning of an existing well.

La. Admin Code. tit. 43, Pt XIX, § 104.

Individual Well by Footage
<table>
<tr><td>Depth</td><td>Land</td><td>Coastal</td><td>Offshore</td></tr>
<tr><td><3,000 ft</td><td>$2 ft</td><td>$8 ft</td><td>$12 ft</td></tr>
<tr><td>3,001 – 10,000 ft</td><td>$5 ft</td><td>$8 ft</td><td>$12 ft</td></tr>
<tr><td>>10,000 ft</td><td>$4 ft</td><td>$8 ft</td><td>$12 ft</td></tr>
</table>
Blanket Bond – Prior to August 12, 2016
<table>
<tr><td># Wells</td><td>Land</td><td>Coastal</td><td>Offshore</td></tr>
<tr><td><10</td><td>$25,000</td><td>$250,000</td><td>$500,000</td></tr>
<tr><td>11-99</td><td>$125,000</td><td>$1,250,000</td><td>$2,500,000</td></tr>
<tr><td>>100</td><td>$250,000</td><td>$2,500,000</td><td>$5,000,000</td></tr>
</table>
Blanket Bond – After August 12, 2016
<table>
<tr><td># Wells</td><td>Land</td><td>Coastal</td><td>Offshore</td></tr>
<tr><td><10</td><td>$50,000</td><td>$250,000</td><td>$500,000</td></tr>
<tr><td>11-99</td><td>$250,000</td><td>$1,250,000</td><td>$2,500,000</td></tr>
<tr><td>>100</td><td>$500,000</td><td>$2,500,000</td><td>$5,000,000</td></tr>
</table>
</td></tr>
<tr><td>State</td><td>Program</td></tr>
<tr><td>Maryland</td><td>Applicants for a permit to drill a well must file a financial assurance with the Maryland Department of the Environment in order to receive their permit. Md. Code Ann., Env’t § 14-111 (West) and COMAR 26.19.01.06 set the requirements for bond amounts.
<table>
<tr><td>Individual</td><td>$50,000 per well, but “not less than the most recent closure cost estimate provided by the permit holder . . . .” The amount, however, cannot exceed $100,000 per well</td></tr>
</table>
</td></tr>
</table>

<table>
<tr><td></td><td><table><tr><td>Blanket</td><td>$500,000</td></tr></table></td></tr>
<tr><td>State</td><td>Program</td></tr>
<tr><td>Michigan</td><td>The Michigan Department of Environmental Quality, Oil, Gas and Minerals Division is responsible for the issuing of permits and operator compliance with state laws and regulations for oil and gas well operations, plugging, deepening, converting, and drilling. The Department requires a conformance bond prior to the drilling of any new wells, deepening of wells, and the plugging of wells.

MCL 324.61525 and Mich. Admin. Code R 324.212 set the bond requirements

<table><tr><td>Individual</td><td>- < 2000 ft deep - $10,000
- 2,000 - 4,000 ft - $40,000
- 4,000 - 7,500 ft - $50,000
- > 7,500 ft - $60,000</td></tr><tr><td>Blanket
(100 well max)</td><td>- < 2,000 ft deep - $100,000
- 2,000 - 4,000 ft - $200,000
- > 4,000 ft deep - $250,000</td></tr></table></td></tr>
<tr><td>State</td><td>Program</td></tr>
<tr><td>Mississippi</td><td>The Mississippi Oil and Gas Board regulates oil and gas production in the state. The Board issues operator permits; collects and tracks inactive and active well data and maintains well field maps; conducts inspections for new wells, plugging and abandoning of wells; and provides a financial responsibility element in the event an operator fails to perform the duties to meet the state requirements. The Board requires a form of financial responsibility before new drilling of wells, operation, plugging and abandoning of an existing well.

26 Miss. Admin. Code Pt. 2, R. 1.4
(Formerly cited as MS ADC 26-2:1.4)

Individual Well

<table><tr><td>Depth in Feet</td><td>Bond Required</td></tr><tr><td>Zero to 10,000 ft</td><td>$20,000</td></tr><tr><td>10,001 to 16,000 ft</td><td>$30,000</td></tr><tr><td>16,001 or more ft</td><td>$60,000</td></tr><tr><td>Blanket Bond</td><td>$100,000</td></tr></table>
Submerged Offshore Lands

<table><tr><td>Number of Wells</td><td>Bond Required</td></tr><tr><td>Each Well</td><td>$100,000</td></tr><tr><td>Blanket Bond</td><td>$200,000</td></tr></table></td></tr>
</table>

<table>
<tr><th>State</th><th>Program</th></tr>
<tr><td>Missouri</td><td>The Missouri Department of Natural Resources, Oil and Gas Council regulates oil and gas production including drilling, deepening, plug-back, or recomplete well operations. The Department requires a form of financial assurance before the drilling of wells, deepening, operation, plug-back, and recomplete of an existing well.

10 Mo. Code of State Regulations 50-2.020

Individual
<table>
<tr><td>Well Depth</td><td>Bond Amount</td></tr>
<tr><td>0 - 500 ft</td><td>$1,100</td></tr>
<tr><td>501 - 1,000 ft</td><td>$2,200</td></tr>
<tr><td>1,001 - 2,000 ft</td><td>$3,300</td></tr>
<tr><td>2,001 - 5,000 ft</td><td>$4,400</td></tr>
<tr><td>5,000 ft</td><td>$5,500 + $2 for each additional foot</td></tr>
</table>
Blanket
<table>
<tr><td>Well Depth</td><td>Bond Amount</td></tr>
<tr><td>0 - 800 ft</td><td>$22,000 for up to 40 wells</td></tr>
<tr><td>800 - 1,500 ft</td><td>$25,000 for up to 10 wells</td></tr>
<tr><td colspan="2">Wells with a depth greater than 1,500 ft must be bonded individually</td></tr>
</table></td></tr>
<tr><th>State</th><th>Program</th></tr>
<tr><td>Montana</td><td>The Montana Board of Oil and Gas Conservation regulates oil and gas production including drilling, re-entering, well operations, deepening, plugging, and restoration. The Board requires a form of financial responsibility before the drilling of wells, deepening, operation, or re-entering and plugging of an existing well.

Mont.Admin.R. (ARM) 36.22.1308

Individual
<table>
<tr><td>Well Depth</td><td>Bond Requirement</td></tr>
<tr><td>< 2,000 ft</td><td>$1,500</td></tr>
<tr><td>2,500 - 3,501 ft</td><td>$5,000</td></tr>
<tr><td>> 3,501 ft</td><td>$10,000</td></tr>
</table></td></tr>
</table>

<table>
<tr><td></td><td>
<table><tr><td>The Board has the option to increase surety bond amounts for an individual well from:
$1,500 to $3,000;
$5,000 to $10,000;
$10,000 to $20,000</td></tr></table>

Blanket
<table><tr><td>$50,000 - May be increased to $100,000 at the discretion of the Board</td></tr></table>
</td></tr>
<tr><td>State</td><td>Program</td></tr>
<tr><td>Nebraska</td><td>The Nebraska Oil and Gas Conservation Commission regulates oil and gas production including drilling, producing, well operations, re-entering, plugging, and land restoration. The Commission requires a form of financial responsibility before drilling of new wells, deepening, operation, or re-entering and plugging of an existing well.

Neb. Admin. R. & Regs. Tit. 267, Ch. 3, § 004

<table>
<tr><td>Individual</td><td>$10,000</td></tr>
<tr><td>Blanket</td><td>$100,000</td></tr>
</table>
</td></tr>
<tr><td>Nevada</td><td>The Nevada Commission of Mineral Resources, Division of Minerals regulates oil, gas and geothermal production or injection including re-drilling, deepening, drilling, abandoning, and production of minerals at well sites. The Division requires a form of financial responsibility in order to obtain a permit for oil, gas, or geothermal drilling.

NAC 522.230

<table>
<tr><td>Individual</td><td>$10,000</td></tr>
<tr><td>Blanket</td><td>$50,000</td></tr>
</table>
</td></tr>
<tr><td>State</td><td>Program</td></tr>
<tr><td>New Mexico</td><td>The New Mexico Energy, Minerals, and Natural Resources Department, Oil Conservation Division requires a surety bond prior to the drilling of new wells, deepening of wells, and the plugging of wells.

19.15.8.9 NMAC

<table>
<tr><td>Individual</td><td>$25,000 + $2/ft</td></tr>
<tr><td>Blanket</td><td>1-10 wells - $50,000
11-50 wells - $75,000
51-100 wells - $125,000
100+ wells - $250,000</td></tr>
</table>
</td></tr>
</table>

<table>
<tr><th>State</th><th>Program</th></tr>
<tr><td>New York</td><td>The New York Department of Environmental Conservation, Division of Mineral Resources is responsible for the issuing of permits and operator compliance of state laws and regulations for oil and gas well operations and solution mining, plugging, deepening, converting, drilling, and surface restoration. The Division requires a plugging and surface restoration bond prior to the drilling of any new wells, deepening of wells, and converting and the plugging of wells.

6 CRR-NY 551.4; 551.5; 551.6

<table>
<tr><td>< 2,500 ft deep</td><td>- 1 - 25 Wells = $2,500 per well, not exceeding $25,000
- 26 - 50 = $25,000, plus $2,500 per well in excess of 25 wells, not exceeding $40,000
- 51 - 100 = $40,000, plus $2,500 per well in excess of 50 wells, not exceeding $70,000; or
- 100 + wells = $70,000, plus $2,500 per well in excess of 100 wells, not exceeding $100,000</td></tr>
<tr><td>2,500 - 6,000 ft</td><td>- 1 - 25 Wells = $5,000 per well, not exceeding $40,000
- 26 - 50 = $40,000, plus $5,000 per well in excess of 25 wells, not exceeding $60,000
- 51 - 100 = $60,000, plus $5,000 per well in excess of 50 wells, not exceeding $100,000; or
- 100 + wells = $100,000, plus $5,000 per well in excess of 100 wells, not exceeding $150,000</td></tr>
<tr><td>> 6,000 ft</td><td>- The Division is empowered to set an amount for each well “based upon the anticipated costs of plugging and abandoning that well” up to $250,000
- Or a blanket bond of $2,000,000</td></tr>
</table>
</td></tr>
<tr><th>State</th><th>Program</th></tr>
<tr><td>North Carolina</td><td>The North Carolina Department of Environmental Quality’s Oil and Gas Commission is responsible for adopting rules on oil and gas exploration in North Carolina. The Commission requires financial assurance to be filed with the state prior to any drilling operation.

N.C.G.S.A. § 113-378 and 15A NCAC 05H.1402

<table>
<tr><td>Plugging & Abandonment Bond</td><td>$5,000 + $1/ft</td></tr>
<tr><td>Environmental Damage Bond</td><td>$1,000,000, but the Commission may set a higher bond amount if it determines the well would be cited in an “environmentally sensitive area.”</td></tr>
</table>
</td></tr>
</table>

<table>
<tr><td></td><td>The bonds may be aggregated.</td></tr>
<tr><td>State</td><td>Program</td></tr>
<tr><td>North Dakota</td><td>The North Dakota Industrial Commission, Department of Natural Resources, Oil and Gas Division regulates drilling, exploration, and production of oil and gas wells. It is also responsible for the issuing of permits and operator compliance, well completion, drilling, and production. The Division requires a form of security before any drilling of new wells, plugging, or deepening of an existing well.

North Dakota Administrative Code 43-02-03-15.2

<table><tr><td>Individual</td><td>$50,000, but if < 2,000 ft, may be approved with a smaller bond

$100,000 for wells used for “commercial injection operations”</td></tr><tr><td>Blanket</td><td>$100,000, so long as it meets certain requirements</td></tr></table></td></tr>
<tr><td>State</td><td>Program</td></tr>
<tr><td>Ohio</td><td>The Ohio Division of Oil and Gas Resources Management is responsible for the issuing of permits and operator compliance of state laws and regulations for oil and gas well drilling, operation, exploration, and plugging. The Division requires a surety bond prior to the drilling of any new wells, deepening of wells, and the plugging of wells.

OAC 1501:9-1-03

<table><tr><td>Individual</td><td>$5,000</td></tr><tr><td>Blanket</td><td>$15,000</td></tr></table></td></tr>
<tr><td>Oklahoma</td><td>The Oklahoma Corporation Commission, Oil & Gas Conservation Division regulates oil and gas drilling, re-drilling, deepening, abandoning, and production at well sites, commercial pits, seismic operations, and commercial soil farming. The Division requires a form of financial security in order to obtain a permit for oil or gas drilling, deepening, re-entering, plugging, and abandoning of wells.

Okla. Admin. Code 165:10-1-12

“An operator may file a blanket surety bond in the principal amount of $25,000.00 in U.S. dollars. . . as surety. In the alternative, the operator may file a surety bond of a lesser amount but that is sufficient to cover the total estimated cost of properly plugging and abandoning each and every well . . . .”</td></tr>
<tr><td>State</td><td>Program</td></tr>
<tr><td>Oregon</td><td>The Oregon Department of Geology and Mineral Industries oversees mining operations</td></tr>
</table>

<table>
<tr><td></td><td>within the state. The Department requires every person who engages in the drilling, redrilling, or reworking of any well to file a bond prior to the approval of any drilling application.

OAR 632-010-0205

<table><tr><td>< 10,000 feet deep</td><td>$25,000</td></tr><tr><td>> 10,000 feet deep</td><td>$50,000</td></tr><tr><td>Blanket</td><td>$150,000</td></tr></table></td></tr>
<tr><td>State</td><td>Program</td></tr>
<tr><td>South Carolina</td><td>The South Carolina Water Resources Commission regulates bond amounts in the state. Before any person shall be granted a well drilling permit, such person shall file with the Commission a reasonable performance bond.

S.C. Code of Regulations R. 121-8.6

<table><tr><td>Up to 10,000 ft</td><td>$20,000</td></tr><tr><td>10,000 - 15,000 ft</td><td>$30,000</td></tr><tr><td>15,000 - 20,000 ft</td><td>$40,000</td></tr><tr><td>20,000+ ft</td><td>$50,000</td></tr><tr><td>Submerged Land</td><td>$100,000</td></tr><tr><td>Blanket</td><td>$100,000</td></tr></table></td></tr>
<tr><td>South Dakota</td><td>The South Dakota Department of Environment and Natural Resources, Minerals & Mining Program Board requires that a performance surety bond be obtained for wells drilled or permitted after July 1, 2013.

SDCL § 45-9-15

<table><tr><td>Individual</td><td>$50,000</td></tr><tr><td>Blanket</td><td>$100,000</td></tr></table></td></tr>
<tr><td>State</td><td>Program</td></tr>
<tr><td>Tennessee</td><td>The Tennessee Department of Environment and Conservation, Division of Water Resources, Oil and Gas Program is responsible for the issuing of permits and operator compliance with state rules and regulations for oil and gas well drilling, re-drilling, operations, plugging, and abandonment. The Program requires a surety bond for the plugging of each well and maintaining and restoring well sites.</td></tr>
</table>

<table>
<tr><td></td><td>
Tenn. Comp. R. & Regs. 0400-52-01-.01 and .02

Individual
<table>
<tr><td>Up to 2,500 ft</td><td>$2,000</td></tr>
<tr><td>2,500 - 5,000 ft</td><td>$3,000</td></tr>
<tr><td>Over 5,000 ft</td><td>$3,000 + $1/ft over</td></tr>
</table>

Blanket
- $20,000 up to 10 wells with a maximum depth of 5,000 feet
- $30,000 for up to 10 wells with a maximum depth of 10,000 feet
- If well depth exceeds 10,000 feet, the well is not eligible to be included in a blanket bond.
</td></tr>
<tr><td>State</td><td>Program</td></tr>
<tr><td>Texas</td><td>
The Texas Oil and Gas Railroad Commission is responsible for the permitting, compliance, enforcement, and environmental cleanup programs for the state. Operators of wells are required to obtain either a bond or other form of financial assurance or financial guarantee depending on the number of wells the operator has.

16 TAC § 3.78(a)(4) and (g)

Individual
<table>
<tr><td>$2 / ft</td></tr>
</table>

Blanket
<table>
<tr><td>10 or fewer wells</td><td>$25,000</td></tr>
<tr><td>11 - 99 wells</td><td>$50,000</td></tr>
<tr><td>100 or more wells</td><td>$100,000</td></tr>
</table>
</td></tr>
<tr><td>State</td><td>Program</td></tr>
<tr><td>Utah</td><td>
The Utah Department of Natural Resources, Division of Oil, Gas, and Mining is responsible for issuing permits and ensuring operator compliance with state rules and regulations for oil and gas well drilling, re-drilling, operations, plugging and abandonment, deepening, and repairing. The Division requires a surety bond for the plugging of each dry or abandoned well, repairs to wells, and maintaining and restoring well sites.

U.A.C. R649-3-1
</td></tr>
</table>

<table>
<tr><td></td><td>
Individual
<table>
<tr><td>Up to 1,000 ft</td><td>$1,500</td></tr>
<tr><td>1,000 - 3,000 ft</td><td>$15,000</td></tr>
<tr><td>3,000 - 10,000 ft</td><td>$30,000</td></tr>
<tr><td>More than 10,000 ft</td><td>$60,000</td></tr>
</table>
Blanket
<table>
<tr><td>Less than 1,000 ft</td><td>$15,000</td></tr>
<tr><td>More than 1,000 ft</td><td>$120,000</td></tr>
</table>
</td></tr>
<tr><td>State</td><td>Program</td></tr>
<tr><td>Virginia</td><td>
The Commonwealth of Virginia, Department of Mines, Minerals, and Energy, Division of Gas and Oil is responsible for the issuing of permits and operator compliance with state rules and regulations for oil and gas well drilling, operations, plugging, and abandonment. The Division requires a surety bond for the plugging of each well and maintaining and restoration of well sites.

Senate Bill 1453, § 45.2-1633, passed in March 2021, goes into effect on October 10, 2021 and repeals and replaces VA Code Ann. § 45.1-361.31
<table>
<tr><td>Individual</td><td>$10,000/each well
+ $2,000/acre of disturbed land
The statute is ambiguous on whether the Department can increase this bond amount if it believes the cost of plugging the well is higher; the Department unambiguously has this authority in the Tidewater region of Virginia</td></tr>
<tr><td>Blanket</td><td>- Up to 10 wells - $25,000
- 11 wells to 50 wells - $50,000
- 51 wells to 200 wells - $100,000
- 200 or more wells - $200,000
The Department may choose not to allow an operator to submit a blanket bond and require individual bonds</td></tr>
</table>
</td></tr>
<tr><td>State</td><td>Program</td></tr>
<tr><td>Washington</td><td>
The Washington Department of Natural Resources, Division of Geology and Earth Resources requires the filing of a bond with the state before drilling.

WAC 344-12-060
</td></tr>
</table>

<table>
<tr><td></td><td><table>
<tr><td>Individual</td><td>Not less than $50,000 each</td></tr>
<tr><td>Blanket</td><td>Not less than $250,000</td></tr>
</table></td></tr>
<tr><td>State</td><td>Program</td></tr>
<tr><td>West Virginia</td><td>The West Virginia Department of Environmental Protection, Office of Oil and Gas is responsible for the issuing of permits and operator compliance with state laws and regulations for oil and gas well operations, exploration, drilling, storage, and production. The Office requires a performance bond prior to the drilling of any new wells, deepening of wells, and the plugging of wells.

W. Va. Code, § 22-6-26

<table>
<tr><td>Individual</td><td>$5,000</td></tr>
<tr><td>Blanket</td><td>$50,000</td></tr>
</table></td></tr>
<tr><td>State</td><td>Program</td></tr>
<tr><td>Wyoming</td><td>The Wyoming Oil and Gas Conservation Commission, Office of State Oil and Gas regulates drilling, re-drilling, repairing, operating, deepening, plugging, and abandoning of wells. It is also responsible for the issuing of permits. The agency requires a bond to ensure the plugging of wells.

WY Rules and Regulations 055.0001.3 § 4(b)

<table>
<tr><td>Individual</td><td>$10/foot</td></tr>
<tr><td>Blanket</td><td>$100,000</td></tr>
</table></td></tr>
</table>

Attachment E

Gillian Graber
Affidavit

AFFIDAVIT OF GILLIAN GRABER

Pursuant to 18 Pa. Cons. Stat. § 4904, I, Gillian Graber, state as follows:

1. I have personal knowledge of the statements contained herein and could competently testify to them if called as a witness.

2. I live with my family in Trafford Borough in Westmoreland County, Pennsylvania. We have lived here for eight years. We moved here with the intention of raising our children in a healthy environment and neighborhood.

3. We chose Trafford because it is still a close drive to Pittsburgh but is more of a residential suburban community with great schools, parks, a quaint ice cream shop on the corner, and a semi-private road where my kids could learn how to ride their bikes safely. This working-class community fits our needs perfectly as it is also close to my in-laws, who are our source of child care. When looking for a home we intentionally steered clear of other locations like Plum Borough in Allegheny County because it was upwind from the Cheswick Power Plant. Having previously lived on a busy road, we were concerned about the air our children breathe and wanted to ensure their access to clean air.

4. I am a member of the Sierra Club. I support the Sierra Club's mission and goals to encourage the public to explore, enjoy, and protect the wild places of the earth; to practice and promote the responsible use of the earth's ecosystem and resources; to educate and enlist humanity to protect and restore the quality of the natural environment; and to use all lawful means to carry out these objectives.

5. I also currently serve as the Executive Director of Protect PT (Penn-Trafford). I founded the organization, along with other Penn-Trafford community members, in December

2014 to fight a fracking well pad that was proposed in the community less than a half-mile from my home. My husband and I were particularly concerned about air quality living near unconventional gas development. The more we learned about fracking, and the health impacts and detriment to our community that it poses, the more we wanted to fight this proposal for a well pad near our home. Additionally, this well pad was the closest we had ever seen to such a densely populated suburban neighborhood like ours. This means that hundreds of children would be exposed to this pollution in addition to our children. As a mother and home owner, I worried that this idyllic neighborhood would soon become an industrial zone. While the operator is still attempting to move the project forward, until now we have successfully stopped that well pad from being constructed.

6. However, there are hundreds of conventional wells scattered across my community that were drilled before I moved to Trafford. This includes both actively producing wells and wells that are legally abandoned, but are not plugged. Based on a Sierra Club analysis I saw, there are three wells within two miles of my home that the Pennsylvania Department of Environmental Protection ("DEP") has listed as abandoned but not plugged, and nineteen wells within five miles of my home that DEP has listed as abandoned but not plugged. In addition, there are two wells within two miles of my home that are listed as active but that have not produced any oil or gas for at least a year, which means they are legally abandoned and must be plugged, and twenty-one of these wells within five miles of my home. This mean that in total, there are forty-six wells that are not plugged, but should be, within a five-mile radius of our home. I believe, and am very concerned that, there are dozens to even hundreds of additional abandoned wells that DEP does not even have records for within five miles of my home.

7. In addition, based on a Sierra Club analysis I have reviewed, I am aware that there are five wells within five miles of the Protect PT office that DEP has listed as abandoned but not plugged; one well within two miles of my office that is listed as active but has not produced for over three years; and six such wells within five miles of my office. Additional orphan wells that have not been identified by DEP are likely located within five miles of my office, based upon neighbor accounts.

8. Because there are so many conventional wells in my community, I have no doubt that there are also numerous abandoned and active wells near areas where I recreate and spend time with friends and family. In fact, there are so many abandoned wells in the community that with every new proposed well pad, the operators must survey the neighbors about what abandoned wells are on their property. In one case, while taking a walk two Protect PT members found that at the location of a proposed well pad there was at least one abandoned well that the operator had not identified in their survey.

9. I did not realize the extent to which these oil and gas wells are impacting the health of my family until we participated in a study with Environmental Health News ("EHN") in 2019. Because we do not live extremely close to any fracked wells, my family was supposed to be part of the control group that did not have contact with dangerous fracking chemicals. EHN analyzed the pollutants we had been exposed to against people who live closer to fracked wells. However, our reports showed alarming amount of dangerous pollutants in our bodies. My daughter, particularly, had a very high rate of dangerous pollutants in her body.

10. We were tested three times, and each time every member of my family had levels of mandelic acid (a metabolite of ethylbenzene and styrene) detected in our urine that exceeded

the 95th percentile for the general U.S. population. Ethylbenzene and styrene can cause liver, kidney, or circulatory system problems and increase the risk of cancer. We also all had levels of hippuric acid (a metabolite of toluene and cinnamaldehyde), 2-Methylhippuric acid (a metabolite of xylene), phenylglyoxylic acid (a metabolite of ethylbenzene and styrene), and trans, trans-muconic acid (a metabolite of benzene) above the U.S. median. We often far exceeded the U.S. median for these chemicals. In several instances we even exceeded the 95th percentile for these chemicals in at least one family members' urine sample. These chemicals can cause health effects such as nervous system damage, kidney damage, nausea, circulatory system problems, anemia, and an increased risk of cancer.

11. Additionally, as part of this study we wore air sampling monitors for periods of six to eight hours. We wore these monitors on two separate occasions. The air monitor results indicated that we were all exposed to benzene, ethylbenzene, and naphthalene levels that are above the risk limit set by the California Office of Environmental Health Hazard Assessment; a risk limit that indicates an increased cancer risk of at least one in a million. At high enough exposures, these chemicals can also cause conditions such as anemia, liver and kidney problems, neurological damage, and eye damage.

12. Water from our hose and bathtub were also tested. Only five of the 40 chemicals tested have regulatory limits, and our water samples did not exceed those regulatory limits. However, our water samples did exceed the median among the other nineteen samples analyzed in the study for several pollutants, including heptane, 1,2,3-trimethylbenzene, and naphthalene. While we use reverse osmosis to purify our drinking water, we do not have that system set up for

our showers or our hose, and it is unclear what the consequences will be from our higher exposure to these chemicals.

13. I cannot know for certain how these pollutants got in my body, especially since the oil and gas industry refuses to give us data on the kinds of chemicals they use in their operations. However, I believe a lot of this pollution comes from the conventional wells, both abandoned and actively producing, all around us. Many of these wells are very old and have limited reserves left, so the owners have fracked the wells to stimulate production. It is known that the pollutants that were found in our bodies are carcinogenic and are associated with oil and gas drilling. I believe specifically that the use of the dangerous chemicals employed in fracking has resulted in harmful pollutants migrating into our water supply and into the air.

14. The operators of these wells also store the condensate from drilling in condensate tanks that vent pollutants into the atmosphere, and these tanks are often not properly maintained. Recently, the DEP charged an operator near my office with multiple violations because they kept a condensate tank on the well pad for years and did not maintain it. As a result, the condensate overflowed and spilled into a nearby stream.

15. I believe that my family and I are also being exposed to methane, benzene, toluene, and other pollutants as a result of leaks from both active and abandoned wells. Methane can turn into ozone, which can damage the heart and lungs; benzene can cause anemia, increase cancer risk, and can have significant harmful developmental effects in children; and toluene can cause nervous system or liver problems and increase cancer risk. We worry about living around these wells that have constant, low, ambient-level leaks because we just do not know if the leaks are infiltrating our air or water.

16. I am incredibly worried about how the pollution my family and I have been exposed to will impact our long-term health. My fear is that I'm going to get cancer and that my kids are going to get cancer. It is shocking how often we hear about kids and adults that have been diagnosed with cancer in our area. It is the same types of cancer too—types of leukemias, Ewing's sarcomas, and osteosarcomas—that are usually very rare. For example, one of my friend's grandmothers died several years ago from a very rare form of leukemia, and research shows that one of the ways that form of leukemia can manifest is from exposure to fracking chemicals. My friend is certain that this is how her grandmother developed leukemia, and because of it they became interested in supporting our work at Protect PT. Another friend that knows the kind of work I do a has contacted me on two separate occasions to tell me that someone they grew up with in this area was either diagnosed with cancer or that their child was. Last year, he even sent me a picture of a fundraising poster for a third grader in Norwin School District that was diagnosed with cancer.

17. It is hard to overstate the fear you are forced to live with when you and your family are exposed to these kinds of chemicals every day that you know are incredibly dangerous, and that you see are already sickening your friends and neighbors. It takes an incredible mental toll. No one should have to fear exposing their children to an increased risk of cancer just because of the place they choose to live. No mother should have to go through this, but so many are and no one is doing anything about it.

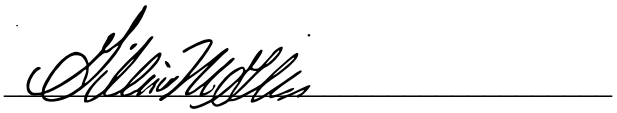
18. It's not just our health that these wells impact. They also impact our ability to enjoy the natural environment. Now that I know what the big, green condensate tanks are and what negative consequences rusty well pipes can cause, it worries me every time I see them,

which is all the time; they are all over the place. There is a well in a stream next to a nearby park, for example. I cannot walk in the woods near my home without seeing a gas well. I often wonder, "Am I being exposed just by walking along this path?" I get out in nature to avoid pollution, but that's where many of these wells are.

19. I believe if abandoned wells are properly plugged, some portion—and perhaps a very large portion—of the pollution that I am currently exposed to would be mitigated. The abandoned wells that are currently spewing chemicals into the groundwater and air would stop emitting pollutants, including the dangerous fracking chemicals with which many of these wells have been stimulated. The operator or state also must remediate the well pad when they close an abandoned well, which includes removing the condensate tanks and other polluting aspects of the drilling operation. This would greatly reduce the pollution my family and I are exposed to and reduce our risk of long-term disease. For this reason, I believe properly incentivizing and funding the closure of abandoned wells would reduce the harms I have described throughout this affidavit. It also would prevent me, and other taxpayers, from paying for the clean-up because it would make it less likely that operators leave plugging responsibilities to the state. I do not want these abandoned wells in my area polluting my air and water, and I absolutely do not want to have to pay for the cleanup. I do not want to see what happened with the mining industry, which caused hundreds of red creek beds from mine drainage that will never be remediated, happen again.

The foregoing is true and correct to the best of my knowledge, information and belief. I understand that any false statements made are subject to the penalties of 18 Pa. Cons. Stat. § 4904 relating to unsworn falsification to authorities.

Executed on this 9th day of September 2021.



Gillian Graber

Attachment F

Ann Lecuyer
Affidavit

AFFIDAVIT OF ANN LECUYER

Pursuant to 18 Pa. Cons. Stat. § 4904, I, Ann Lecuyer, state as follows:

1. I have personal knowledge of the statements contained herein and could competently testify to them if called as a witness.

2. I live with my family—my husband and four children—in Trafford Borough in Westmoreland County, Pennsylvania. We have lived here for five years. I grew up in Plum Borough, about ten miles away from my current home.

3. We decided to move to Trafford because it has a small school, the neighborhood has sidewalks, and there are a lot of playgrounds, so it's nice for young children. It seemed like a wonderful, idyllic community.

4. I am a member of the Sierra Club. I also was on the staff of the organization Protect Penn-Trafford (Protect PT) from 2017 to 2020.

5. I met Gillian Graber, the Executive Director of Protect PT, through my kids' school. My kids and her children went to the same school. I was very worried about a proposed fracking well in our community that Protect PT was fighting, so I ended up getting hired part-time to work with the organization. I eventually became the Project Outreach Coordinator, planning the programming, writing grants, and doing anything else the organization needed.

6. Today I work as a birth doula, coaching moms through their pregnancy. I have been doing this work in some capacity for the past twenty-two years.

7. My community is covered in oil and gas wells—there are numerous abandoned and active conventional wells near my home. Based on a Sierra Club analysis I have seen, there are four wells within a three-mile radius of my home that the Pennsylvania Department of

Environmental Protection ("DEP") has listed as abandoned but not plugged, and sixteen such wells within five miles of my home. In addition, there are ten wells within a three-mile radius of my home that are listed as active but that have not produced any oil or gas for at least a year (which means they are legally abandoned and must be plugged), and twenty-two such wells within five miles of my home. When I researched the issue in 2019, I learned that there are scores of wells listed as active within five miles of my home and over fifty active wells within a mile of my home--many that have not been inspected in the last ten years. Given how many abandoned wells there are across the state that DEP does not have records for and how many abandoned and active wells there are in my area, I believe there are likely hundreds of additional abandoned wells within five miles of my home.

8. In 2019, I participated in a study run by Environmental Health News ("EHN") that was intended to examine the health impacts of oil and gas drilling in the region. The results showed that all three times we were tested, every member of my family had levels of mandelic acid (which is a metabolite of ethylbenzene and styrene) detected in our urine that exceeded the ninety-fifth percentile for the general U.S. population. Eighty-seven percent of our family's samples also exceeded the ninety-fifth percentile for phenylglyoxylic acid (a metabolite of ethylbenzene and styrene); and more than half of our samples exceeded the ninety-fifth percentile for trans, trans-muconic acid (a metabolite of benzene). These chemicals can cause health effects such as liver, kidney, and circulatory system problems; anemia; and an increased risk of cancer. We also all had levels of several additional pollutants, such as hippuric acid (a metabolite of toluene and cinnamaldehyde) that exceeded the U.S. median.

9. As part of the study my family also wore air sampling monitors for several hours two separate times. Nine out of ten of those air monitor results showed that we were exposed to levels of benzene, ethylbenzene, and naphthalene that increased our risk of cancer by at least one in a million. This is based on a benchmark set by the California Office of Environmental Health Hazard Assessment, assuming that the person is consistently exposed to this level of a chemical over the course of their lifetime. These chemicals, at high enough exposures, can also cause (among other things) anemia, liver and kidney problems, and neurological damage.

10. I always wondered how living next to so many wells was impacting my family's health. Finding out just how many toxic chemicals we had in our bodies was extremely stressful. I am concerned these pollutants will increase our risk of cancer or some other dangerous disease. I have considered moving to protect myself and my family from the pollution we are being exposed to living in this area. But I don't know where we would go. My family is here in Pennsylvania and it feels like much of the state is dealing with the same problem our community is. And this is a problem in a lot of other areas in the country too. So, I've stayed put. But I'm always wondering in the back of my mind about what pollutants we are being exposed to that we cannot see and how I can protect my kids from that exposure. Now, every time I see a well, it is stressful for me because it makes me think about the air pollution I'm exposing myself and my family to. And I see wells all the time—pretty much every time I leave my house. To be exposed to this level of air pollution every day, both at home and, for my kids, at school, is very dangerous.

11. Since moving to Trafford, I have also noticed that my asthma has gotten much worse. I have always had asthma, but it was never this severe. I had to go to the emergency room

by ambulance once in November of 2018 because of an asthma attack, and that had never happened before. My doctor has since prescribed me additional maintenance medication for my asthma that has made the situation better, but I still have more problems with my asthma now than I did before moving to Trafford. Having to go to the emergency room because of difficulty breathing was very scary, and it is frustrating to have to deal with additional difficulties with my asthma on a regular basis.

12. We live in a valley between two hills, and I believe that this traps air pollution in and makes it worse. I am concerned that whatever pollutants are coming up from these wells are sitting in the air and we are breathing it in, increasing our cancer risks and exacerbating my asthma. I don't know how else these dangerous pollutants could have entered our body but from the oil and gas wells. The wells are all around us and the pollutants found in our body are known to be emitted by oil and gas wells.

13. As a birth doula I think all the time about how to ensure healthy births. I have seen the literature on the especially large impact that pollution from oil and gas wells can have on prenatal development. It can cause preterm birth, low birth weight and heart complications, among other problems. I am concerned for the pregnant moms that have to deal with this and for the health of their children.

14. After I got the results from the EHN study, I researched the wells around me to see if I could find any evidence of problems that could have caused the pollution my family and I experienced. I looked at the inspection dates and production reports for every well within a few miles of my house (I do not remember the exact distance). I found out there were numerous wells that no one had inspected in a long time, and several that also had no production reports

associated with them so, to my understanding, were legally required to be plugged. I called DEP and told them about what I had found. They told me they would look into it and get back to me. They never got back to me, and I had to call two or three more times until they finally told me that they had sent an inspector out to a few of the wells I identified and the inspector had found that the wells were fine and were not leaking. They did not say anything about the wells that were not producing and were supposed to be plugged. In my opinion, DEP just does not have the resources to properly enforce the laws regulating oil and gas wells and their plugging.

15. I believe that plugging abandoned oil and gas wells will reduce the pollution my family and I are exposed to. It is known that unplugged abandoned wells leak, and plugging them would stop this leakage. This should lower the health risks my family and I face living next to these abandoned wells. Because of my observations of DEP's inability to ensure operators plug wells, I believe the best way to ensure the abandoned wells in my community are plugged is a higher bond amount that would incentivize operators to plug their abandoned wells themselves. I believe ensuring abandoned wells are plugged should be a top priority for the state.

The foregoing is true and correct to the best of my knowledge, information and belief. I understand that any false statements made are subject to the penalties of 18 Pa. Cons. Stat. § 4904 relating to unsworn falsification to authorities.

Executed on this 13th day of September 2021

Ann Lecuyer