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14 April 2020

The Honorable Mark Gordon, Governor
State of Wyoming
200 West 24th Street
Cheyenne, WY 82002

RE: Alternative WOGCC Policies as a Proactive Solution for Wyoming Oil & Gas Industry Survival in this Environment of Low Oil Prices & COVID-19

Dear Governor Gordon,

We know that you are actively and completely focused on the impacts to all of Wyoming with respect to the COVID-19 and Saudi/Russian oil price war. The Enhanced Oil Recovery Institute want to proactively assist in any way we can. To that end, we have provided the attached which suggests some immediate, outside-the-box, survival options that we believe the State should consider. While this work has been a collective effort, it has been spearheaded by Steve Whitaker, Technical Manager and Amy Freye, Geologist.

If you or your staff have any questions, would like to discuss this, or require any additional information, please do not hesitate to reach out at your earliest. We stand ready to assist you and the full force of the government of Wyoming to address this unprecedented impact to Wyoming and the oil and gas industry. I can be reached at steven.carpenter@uwyo.edu, at 513-460-0360 (cell), or 307-315-6442 (office).

Respectfully,

Steven M Carpenter

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Director

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Enhanced Oil Recovery Institute

Alternative WOGCC Policies as a Proactive Solution for Wyoming Oil & Gas Industry Survival in this Environment of Low Oil Prices and COVID-19

The current low oil price environment complicated by the COVID-19 pandemic has stressed the Wyoming oil and gas sector such that horizontal wells in unconventional reservoirs will become less important in the foreseeable future and the improved and enhanced recovery methods in conventional reservoirs will be of critical importance to Wyoming's survival. Idle well bonds present a significant financial hurdle and delays and obstructions to gain approval to initiate projects in Wyoming may prevent the recovery of the oil and gas sector. It is imperative that some immediate changes be considered to the WOGCC policies with the sole intention to ensure the Wyoming-based oil producers can survive. This paper identifies, substantiates, and suggests solutions to the issues.

The following narrative describes options to support and maintain survival of the Wyoming conventional oil and gas sector supported by data mostly from the Wyoming Oil & Gas Conservation Commission (WOGCC) and direct experiences/comments from Wyoming operators. For the sake of brevity, layout, and readability; figures and references that document some of the statements are provided at the end of this paper and can be reviewed as desired.

Horizontal Wells in Unconventional Reservoirs are Important to Wyoming but Will Be Much Less So in the Foreseeable Future

Horizontal wells drilled in unconventional reservoirs have increasingly contributed to the state's total oil production since 2010 (Fig. 1). These wells, however, are only economic at relatively high oil prices (Figs. 2 & 3), which means as long as oil prices remain low there will be little if any significant drilling for unconventional reservoirs in the foreseeable future[1]. Without new wells to offset the rapid production declines that are characteristic of these wells (Fig. 4), tax revenues from unconventional reservoirs will decrease substantially. Fortunately for Wyoming, there are ways to encourage production from other hydrocarbon reservoirs (e.g. conventional) even with low oil prices.

Improved and Enhanced Recovery Methods in Conventional Oil & Gas Reservoirs Will be of Critical Importance to Wyoming

Conventional reservoirs make up over 90% of the oil fields in Wyoming and are capable of being economic at much lower oil prices than unconventional ones. Additionally, a much higher percentage of the oil-in-place can be extracted (e.g. higher recovery factor or efficiency) from conventional reservoirs than from unconventionals, making these reservoirs one of the keys to Wyoming's future. Globally, recovery efficiencies from conventional oil reservoirs average between 20% and 40%. With Enhanced Oil Recovery (EOR) methods, between 40% and 70% of the oil-in-

place can be recovered[2]. These numbers are significantly more favorable than the average recovery efficiency in unconventional reservoirs, which are almost universally less than 10%[3].

Remaining recoverable oil reserves in Wyoming from existing conventional reservoirs are about 250 million barrels (mmbo) if the current methods of production are used without alteration. If new water floods were initiated in those fields that have not yet attempted secondary recovery methods, an estimated additional 330 mmbo could be recovered[3,4]. Optimizing existing water floods and polymer floods are likely to yield an additional 460 mmbo in recoverable reserves. Total remaining recoverable reserves from conventional reservoirs in Wyoming are estimated to be over 1 billion barrels.

The key to recovering a bulk of these remaining oil reserves is initiating Improved and Enhanced Oil Recovery (IOR/EOR) methods. These methods include: Water floods, polymer floods, surfactant floods, surfactant/polymer floods (SP), alkaline surfactant polymer floods (ASP), microbial floods, gas floods (e.g. CO_2, methane, ethane, nitrogen), steam, and in-situ combustion. Low oil prices will most likely reduce the options to the less expensive methods, such as optimizing existing water floods, initiating new water floods, and augmenting water floods with polymer.

Total costs incurred by the operators to initiate new water floods or polymer floods average about $16 per barrel of oil produced based on data gathered from the WOGCC covering the past 12 years. The increase in production from a water flood varies greatly depending on reservoir factors but, in Wyoming, it generally produces between 80% and 120% of what was produced on primary recovery[5].

Despite the fact that water flooding is economical in Wyoming, even at low oil prices, there have been relatively few projects approved over the last five years. This downward trend must be reversed if Wyoming is going to at least partly make up for the loss of production from unconventional reservoirs.

Idle Well Bonds Are A Significant Hurdle to IOR/EOR Programs in Wyoming

According to the WOCGG Rules and Regulations: Chapter 3, Section 4 (b), (ii), there is no definition of when a well is deemed “idle”. The current practice at the WOGCC is to deem a well “idle” if it has not produced or injected fluid in the past 12 consecutive months. An Idle Well Bond is assessed to each idle well at the rate of $10 for each foot of open borehole. Costs for these bonds are commonly in excess of $60,000 per well. When the status of “idle” is applied to a well, the operator must either pay the Idle Well Bond or plug and abandon (P&A) the well. If an operator has paid a bond and then P&A’d the well, the operator is to be refunded the Idle Well Bond money. Many operators, however, have stated that they have not received any refunds after plugging subject wells.

A list provided by the WOGCC in October 2019 identified 121 operators who had idle wells. According to the WOGCC website during the same month, however, there were 599 operators identified. It is unclear why there is a discrepancy of 478 operators. If one excludes Coalbed Methane (CBM) wells, the list noted 10,980 idle oil and gas wells.

An examination of the list of idle oil and gas wells revealed that over 30% of the so-called idle wells did not meet the WOGCC's criteria to be deemed idle. These errors included wells that had recorded production or injection within the 12-month period or were never drilled. As a consequence of these errors, operators are being assessed Idle Well Bonds for wells that should not be on the list, needlessly depleting capital that could otherwise be deployed to improve production and save jobs.

Additionally, wells that are temporarily idle due to limited access caused by factors such a weather, road conditions, or sage grouse habitat are on the idle well list. There is no policy of providing "consideration" for these extenuating circumstances, which would then remove such wells from the list. These practices create additional hardship (e.g. cost of bonds, P&A of wells) for oil and gas operators.

Companies that purchase old fields containing idle wells with the intention of initiating IOR/EOR methods, reactivating the wells, and improving production, are required to pay Idle Well Bonds on those wells. In practice, this policy is a strong deterrent to reactivate old oil fields and is thereby hindering attempts to improve production. As an example, recently an operator purchased some fields in the Powder River Basin with the intention of improving existing water floods and initiating new ones, was assessed more than $30 million in Idle Well Bond fees. This cost was substantially more than the cost to purchase the fields. The loss of some $30 million in capital was a major factor contributing to the company's inability to complete their Wyoming project. Other operators have confided that they will not purchase any fields in Wyoming due to the current Idle Well Bond policy.

When faced with having to pay an Idle Well Bond at $10/ft for the depth of the well or plug the well, many operators opt to plug the well because it is less costly. The WOGCC does not consider whether or not the idle wells still have remaining recoverable reserves. By requiring wells to be plugged that still provide access to recoverable hydrocarbon reserves, the WOGCC is failing to uphold its primary mission of properly managing the mineral resources of the state. Thus, Wyoming is losing oil reserves as well as many millions of dollars in future tax revenue because of this practice.

The Idle Well Bond policy relies on the erroneous assumption that every idle well is going to become an orphaned well and will ultimately be the State's responsibly to plug. Based on figures from the WOGCC (11/20/2019), the total footage of all 3,026 orphan wells in the state equals 2,631,178; with the vast majority (88%) being from CBM wells.

The state's figures show that instead of costing $10/ft to plug these orphan wells, the actual plugging cost to the state is $4.90/ft. At this average cost, the state would need $12,892,771 to plug 100% of the orphan wells. In a worst-case scenario where the plugging costs were actually $10/ft, the state would need $26,333,780 to plug all of the orphan wells. In fact, based on the March 2020 WOGCC supervisor's report, the total bond amount held by the state is $224,002,324, of which $158,001,719 was from Idle Well Bonds.

None of the operators who have paid into this bond are responsible for any of the current orphaned wells. The capital tied up by the Idle Well Bond policy is a severe strain on oil and gas companies, particularly small Wyoming-based operators, and prevents more constructive actions, such as implementing IOR or EOR programs.

Delays and Obstructions in Gaining Approval to Initiate IOR/EOR Projects in Wyoming

As previously mentioned, initiating EOR projects such as water flooding in Wyoming will help improve production beyond the status quo. According to data from the WOGCC, over 80% of water flood applications were approved by the WOGCC prior to 2015. Since 2015 that percentage has plummeted to about 35% (Fig. 5). The length of time it takes the WOGCC to render a decision on a water flood application has increased significantly since 2014 from under 60 days to over 90 days (Fig. 6).

Disposal well applications have seen a similar delay in the approval process. Based on data from the WOGCC, applications for disposal wells have been turned down much more frequently since 2015 (Fig. 7), dropping from an 80% approval rate to about 35%. The time it takes the WOGCC to make a decision on an application for a disposal well has increased from under 60 days to over 80 (Fig. 8).

Imperative and Immediate changes to WOGCC Policies that May Help Improve Production in Wyoming

Wyoming is in competition with all other hydrocarbon producing states regarding attracting investment. Oil and gas operators are going to concentrate their activity in regions where they have the best chances of maximizing their return on investment. A basic and imperative question that Wyoming should consider is how to make hydrocarbon exploration and production attractive to investors?

Taxes on the oil industry in Wyoming are the highest in the United States (Fig. 9), yet the industry has been cognizant of the fact that the state relies on this revenue for its survival and has been willing to operate here under certain conditions. Additional financial burdens demanded by the state over and above those taxes, however, prove to be a significant deterrent to operating in Wyoming. The following recommendations are put forth for consideration:

1. **Eliminate the Idle Well Bond Policy** and refund all of the Idle Well Bond money to the respective operators. The infusion of capital to the operators, capital that is stagnating in

the Idle Well Bond fund, would have obvious positive ramifications to the operators involved. As a replacement to the Idle Well Bond, setting aside a small amount from the production taxes already levied on the oil industry and putting that money in an Orphan Well Fund would serve two purposes: (a) it would offer better financial conditions for operators who are trying to reinstate production in old fields and (b) it would provide a safeguard for the state by having funds to plug orphan wells in a more equitable manner than the present Idle Well Bond policy.

Example economic models run by the EORI (Fig. 10) indicate that without altering the present production tax amount, a fund allocating between 0.35% and 0.5% of the production revenue that the state is already collecting would provide sufficient funds to offset annual plugging programs for present and potential future orphan wells. The amount the state uses from the production taxes could be adjusted depending on actual plugging demands.

2. **Consider establishing a tiered Blanket Bond** to supplement revenue to the state. One example of such a bond would be to have a $100,000 bond for operators who have up to 50 wells; $250,000 for 50-100 wells; $500,000 for over 100 wells.

3. **Incentivize EOR activity** by expanding the policy of a tax break already in statute (§39-14-205 (d)) to include a variety of EOR methods, including water floods, not just for CO_2. An increase in oil production, and oil reserves, will increase state revenue compared to what will happen without such incentives. This tax break could be tied to a threshold crude oil purchase price such as $50/barrel net actual price (not WTI).

4. **Establish a maximum 60-day time limit for reviewing and actioning water flood and disposal well applications**. Presently there is no time limit and some operators have experienced delays of over 3 years, which essentially eliminates their plans.

5. **Extend the time period of inactivity before a well is considered "Idle" to consecutive 24 months**. Consider extenuating circumstances such as weather, access, and sage grouse issues before classifying a well as idle.

6. **Before the state demands that a well should be plugged, it should be evaluated to determine if it has any remaining recoverable reserves.** The state should never needlessly abandon or sacrifice hydrocarbon reserves. The EORI would be one candidate agency that could assist the WOGCC in this matter if WOGCC does not have resources to do the analysis.

7. **Orphan wells should likewise be evaluated** to ensure they do not contain any remaining recoverable reserves. Those few orphan wells that are viable for future production or injection could be put into a fund, administered by the state, and offered for sale to operators at timely periods as opposed to being permanently plugged.

All of these options come at no out-of-pocket cost to the State. None of these suggestions require any additional spending by any agency. These options provide survivability options and can greatly assist the Wyoming oil industry. The net result of enacting these suggested options would be a more appealing environment for oil and gas operators to initiate improvements to production and provide an increase in recoverable reserves. Wyoming jobs will be preserved and tax revenue to the state can be maintained or improved during these unprecedented low oil price and COVID-19 driven times.

References Noted

1. Petroleum Association of Wyoming letter to Governor Gordon, April 6,2020
2. Muggeridge, A.; Cockin, A.; Webb, K.; Frampton, H.; Colllins, I.; Moulds, T.; and Salino, P. (2013). Recovery rates enhanced oil recovery and technological limits, Philosophical Transactions A Math Phys Eng Sci, Royal Publishing Society.
3. National Energy Technology Laboratory. (2019). Unconventional Resources, U.S. Department of Energy. https://netl.doe.gov/sites/default/files/2019-04/Program-130
4. Whitaker, Stephen and Freye, Amy. (2018). Potential for future water flood projects in Wyoming, EORI Bulletin #1801/2018, Casper, WY: Enhanced Oil Recovery Institute
5. Standard Handbook of Petroleum and Natural Gas Engineering (Third Edition). (2016) Table 5.9.1.

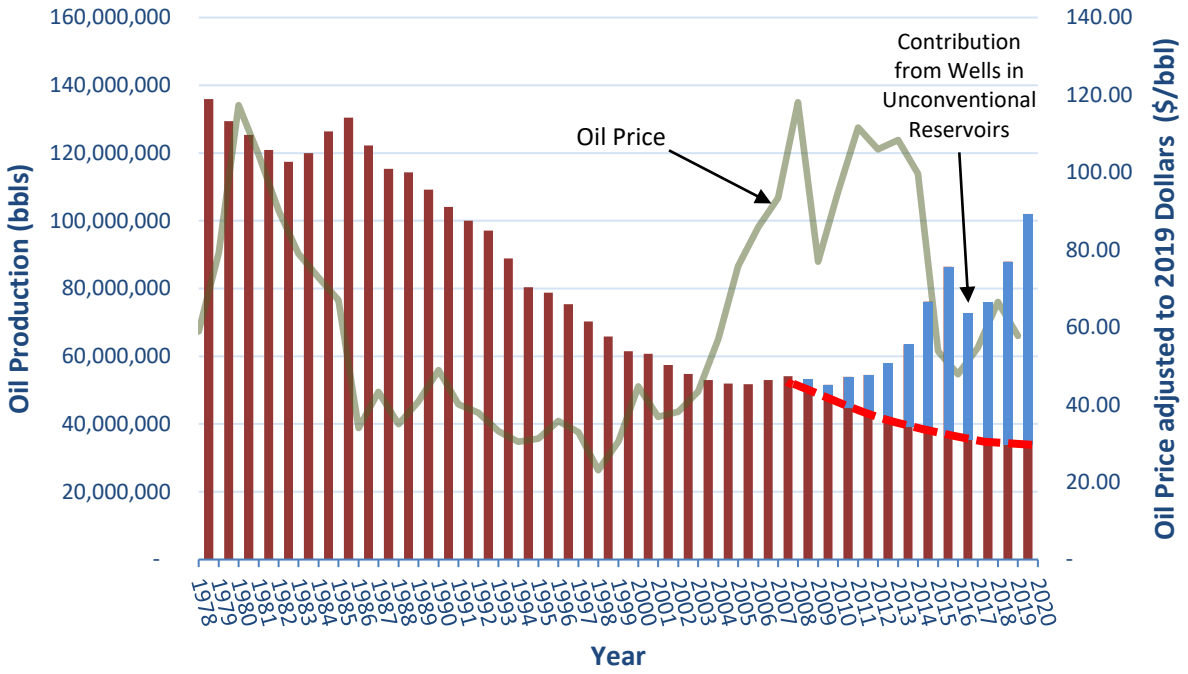
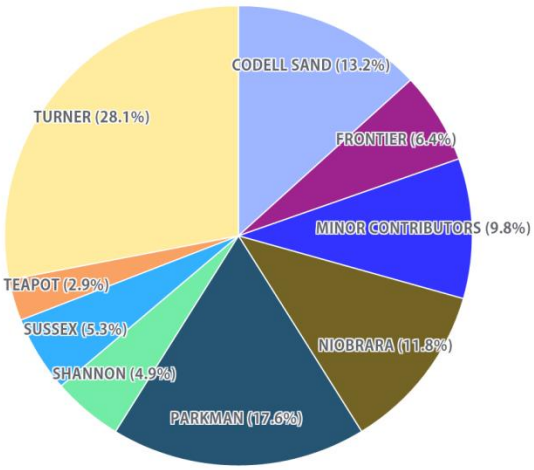


Figure 1. Annual Wyoming Oil Production



Total horizontal production since 2010:
294,830,516 bbl Oil
1,476,374,937 mcf Gas
1,009,821,523 bbl Water

Formation	Oil EUR (bbls)	Gas EUR (mcf)	$/bbl to produce
Turner	306,917	1,033,966	30.63
Parkman	256,139	152,515	34.00
Codell	351,429	268,975	28.11
Niobrara	167,068	461,141	87.70
Frontier	400,709	713,955	Not enough data
Sussex	212,044	1,164,502	61.64
Shannon	193,683	80,551	74.63
Teapot	183,899	108,207	39.18
Lewis	247,128	4,848,311	46.36
Mowry	151,747	2,489,968	89.48

Break-Even costs average $53.64 from all formations
EUR= Estimated Ultimate Recovery

Figure 2. Horizontal Unconventional Targets in Wyoming

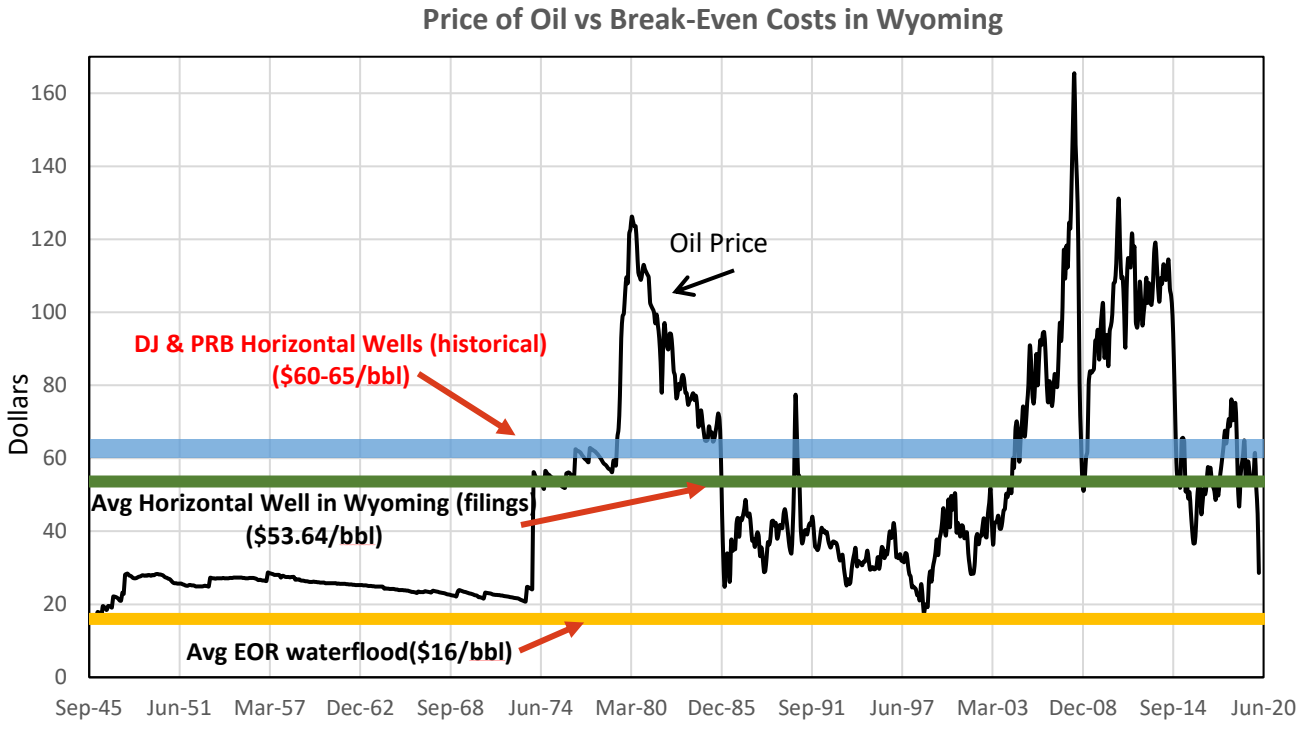


Figure 3. Break-Even costs in Wyoming compared to crude oil price

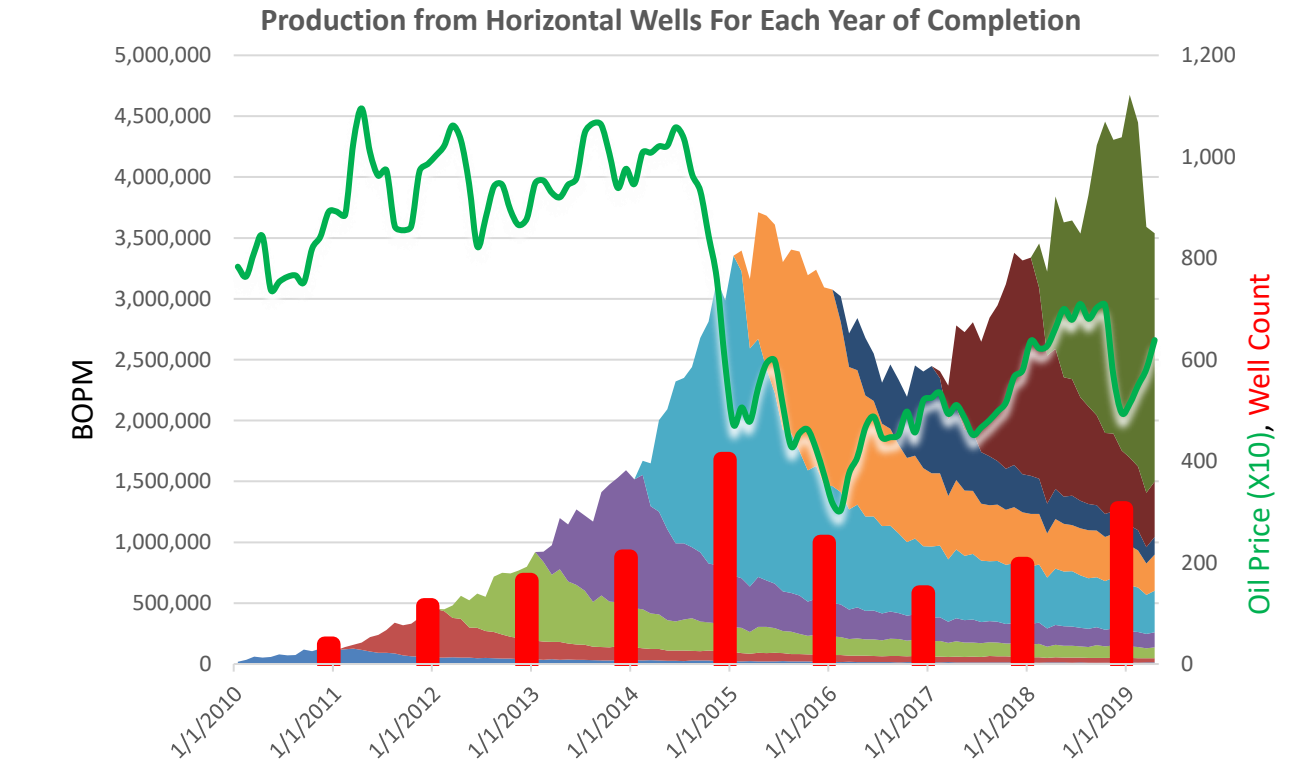


Figure 4. Unconventional reservoirs exhibit rapid declines in production

GF&A, 2019

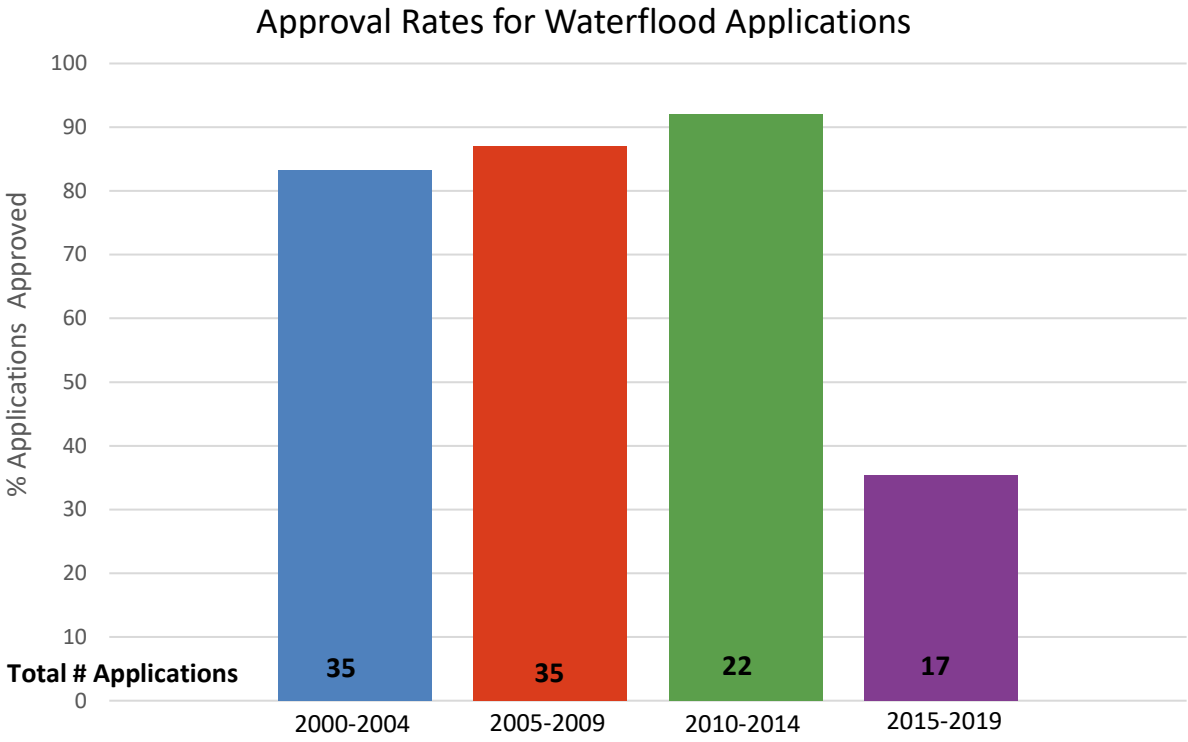


Figure 5. Approval rates for water flood applications have plummeted since 2015

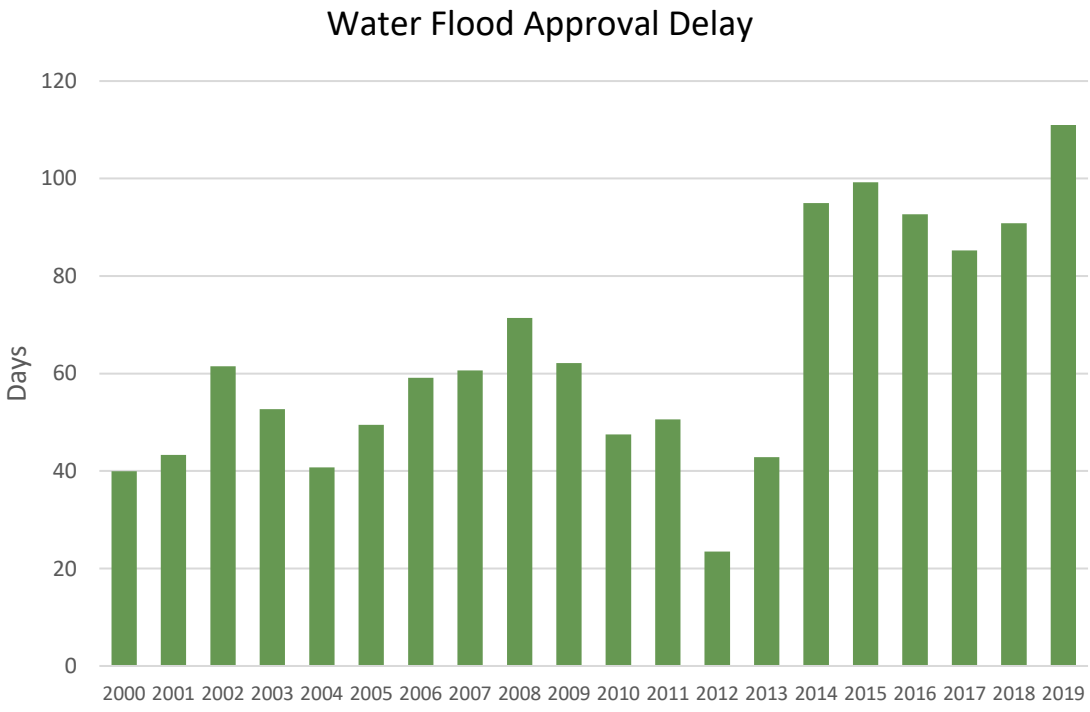


Figure 6. Time it takes to approve water flood application has increased since 2014

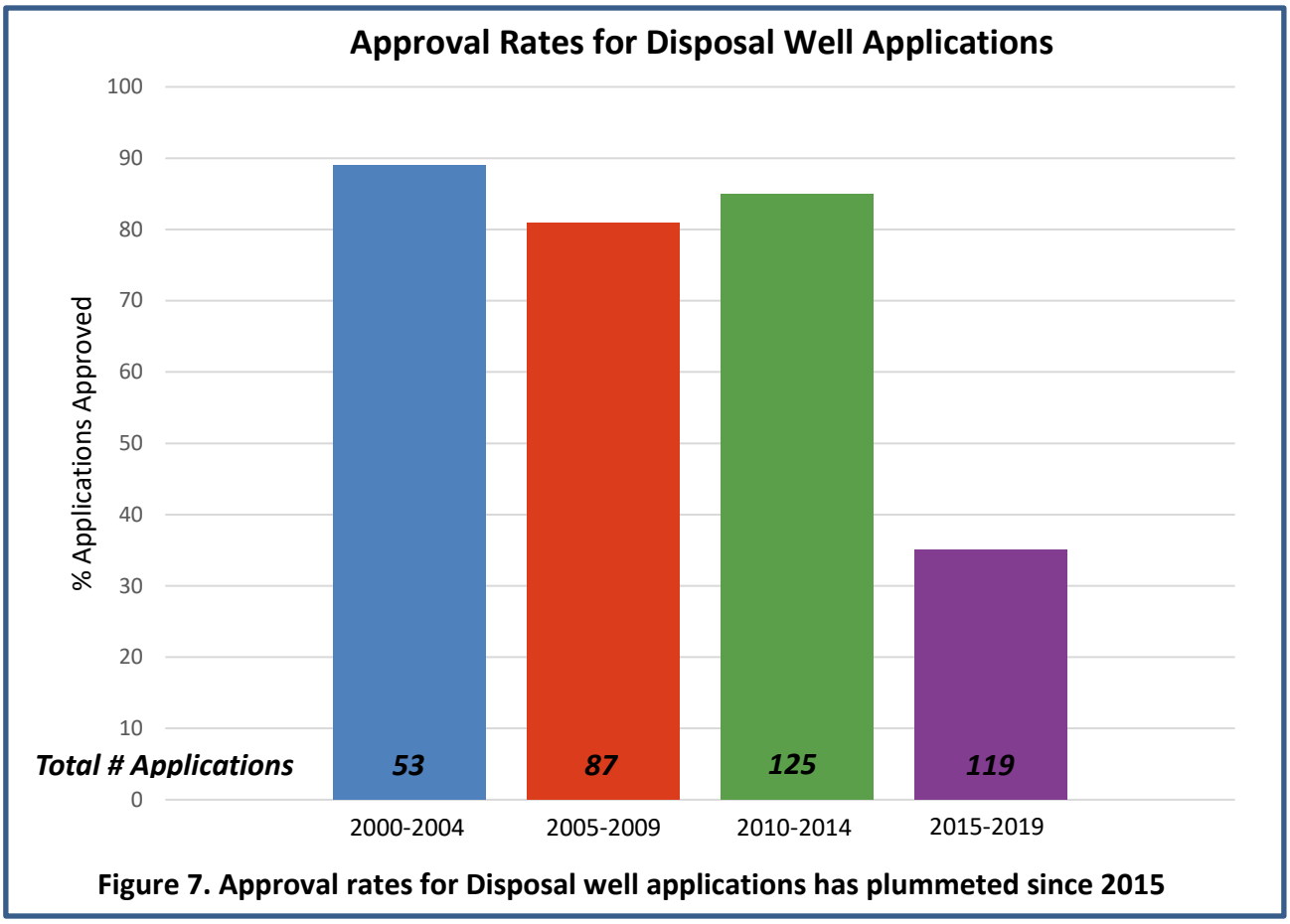


Figure 7. Approval rates for Disposal well applications has plummeted since 2015

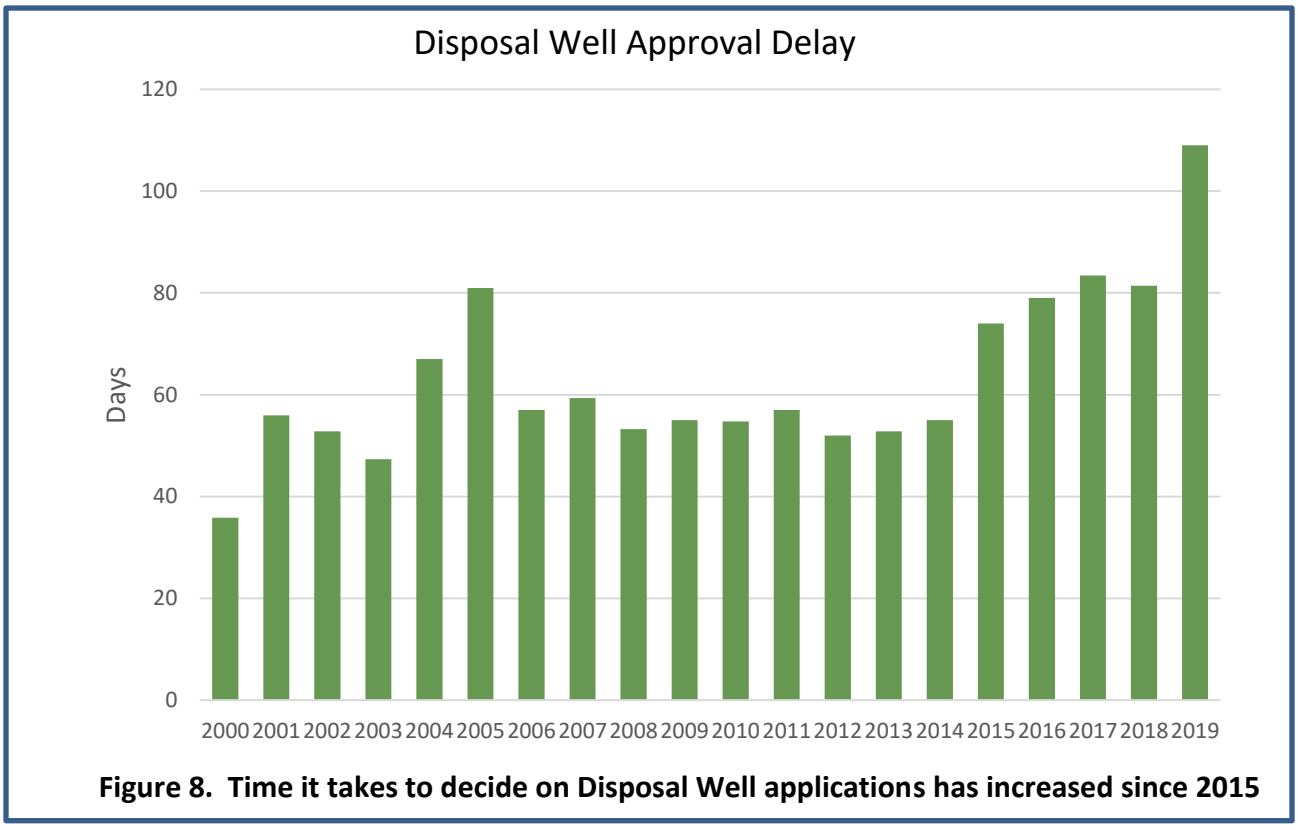


Figure 8. Time it takes to decide on Disposal Well applications has increased since 2015

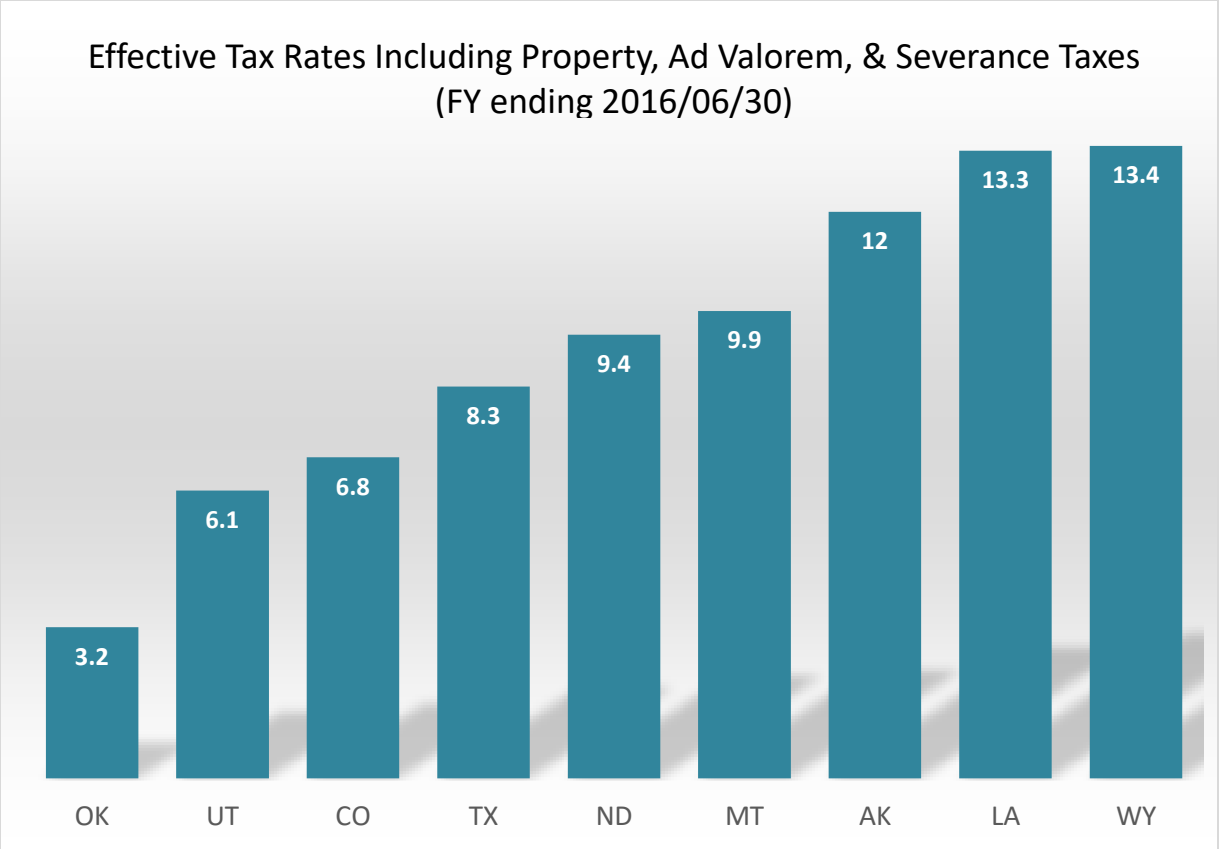


Figure 9. Wyoming has the highest tax rate on the oil & gas industry in the USA

Orphaned Well Variables	Value	Unit
Orphan Well Fund Tax Deduction	0.50%	%
Total Idle Wells	10,980	#
Average Orphan Well Depth	870	ft
Idle Well Plug Cost (Worst-Case)	$10	$/ft
Idle Well Plug Cost (Average)	$4.90	$/ft
Orphaned Well Chance	3.5%	%
Est. Orphaned Wells/year	500	
Oil & Gas Severance & Property Taxes	$700,000,000	
Total Well-Feet to Plug	435,000	
Total Plugging Cost (Worst-Case)	$4,350,000	
Total Plugging Cost (Average)	$2,131,500	
Value of Orphan Well Fund Deduction	$3,500,000	
Surplus (Shortfall) [Average]	$1,368,500	

Figure 10. Projected revenue from an orphan well fund deducted from production tax