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Individual Well Costs from Proposed Rule Changes to Oil and Natural Gas Operations on BLM Lands: Comments and a Monte Carlo Specification

Prepared for:

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Estimating Individual Well Costs from BLM Proposed Rule RIN 1004-AE26: Oil and Gas; Hydraulic Fracturing on Federal and Indian Lands[1]

Summary of Key Findings

A proposed rule governing oil and natural gas operations on BLM managed lands would generate costs to society designed to purchase "useful information to the public" and assurance that "hydraulic fracturing is conducted in a way that adequately protects the environment" (Federal Register Volume 77, Number 92, RIN 1004-AE26). Natural resource economics invokes the basic principles of welfare economics to assess if the benefits to society from such a purchase exceed its cost. This paper contributes to the discussion by first reviewing the key economic principles involved and then estimating through a custom, multi-stage Monte Carlo process the individual well costs imposed by the rule. The design of the Monte Carlo experiment as well as the distributional parameters selected reflect the proprietary process and cost estimates of one of the nation's largest independent oil and natural gas producers and are believed to be representative of industry practices. Among the key findings and points of consideration are the following:

Key Considerations

- The key conclusion of welfare economics in regards to natural resource and environmental management is that social improvements can only occur incrementally. Each proposal must be justified through careful and considered analysis.

- Casual adoption of natural resource and public policy without careful and considered analysis of the costs imposed on society and the benefits generated for society violates the central tenets that form the very foundation of welfare economics.

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Key Findings

- By failing to estimate the reduction in the risks to the environments and assigning values to society's willingness to pay for risk reduction, the analysis reported fails to reach the required level of careful and considered. Even if difficult, monetizing benefits is an essential step in benefit-cost analysis.

- Uncertainty of true costs and benefits complicates optimal natural resource policy. Pindyck (2007) highlights how uncertain benefits combined with irreversible costs (as is the case under the proposed rule) tend to bias traditional benefit-cost analysis towards policy adoption. Both conditions hold in the present analysis. Costs are irreversible and the benefits (of useful information and marginally greater assurance of environmental protection) are so uncertain that no serious attempt has been made to estimate them!

- We use a Monte Carlo Analysis to model uncertainty inherent in the BLM policy and conduct a sensitivity analysis to evaluate the impact of variables that are under BLM's control but have not yet been precisely defined.

- Mean estimates of the various cost components that represent additional costs for a given well include $116,500 for a Surface Cement Evaluation Log (CEL), $174,000 for Intermediate CEL, $360,000 for Surface remediation, $390,000 for Intermediate remediation, and $345,000 for a Type well.

- Since not all wells on BLM lands incur these costs, we calculate the total additional cost averaged across all wells on BLM lands. Our mean estimate of the total additional cost on a per well basis is $129,194 with the high end being $175,654.

- Extrapolated across the 3022 wells started on BLM lands in 2012 suggest industry costs of more than $370 million annually.[2] Competitive capital allocation processes will shift production away from states with large allocations of BLM managed lands effectively shifting the burden of a portion of the costs to local governments and their constituents in the form of foregone sources of non-tax revenue and local employment opportunities.

- Our sensitivity analysis indicates that results are sensitive to BLM's implementation policy, and since this implementation policy has not been precisely defined, this generates additional uncertainty.

- Due to a lower risk adjusted rate of return, these higher additional costs combined with higher uncertainty should lead producers to re-allocate wells from Federal lands to non-Federal lands reducing royalty payments to states and employment in those states which possess a larger fraction of BLM lands.

[2] The BLM reports that 95% of all new wells in Colorado are hydraulically fractured. We apply this rate to the number of new wells started in 2012 and then multiply the number of new hydraulically fractured wells (3022*0.95) by the mean baseline additional cost per well from the proposal ($129,194).

Estimating Individual Well Costs from BLM Proposed Rule RIN 1004-AE26: Oil and Gas; Hydraulic Fracturing on Federal and Indian Lands

Introduction

The focus of natural resource economics is the study of the strategic behavior of economic agents (individually and collectively) in the interactions of nature and society's productive activity. The strategic interactions of individuals and institutions (firms, policy-setting bodies, etc.) determine resource allocations, rates of forest and fishery harvests, national energy portfolios, and rates of mineral extraction among other natural resource economic questions. The recently proposed rule changes governing oil and natural gas extraction on BLM lands presents a ready-made case study in natural resource economics. The regulations would impose new costs to production on BLM lands relative to production on non BLM lands. In a competitive capital allocation industry, which surely characterizes the oil and natural gas exploration and production sector, capital is expected to flow out of BLM production and into competitive alternatives. That is, the rule is expected to reduce the rate of extraction on BLM lands relative to other fields of exploration. The question of natural resource economic analysis is whether such a shift enhances society's well-being.

Conceptualizing the issue is complicated enough and analyzing a specific proposal is no easier. The issue involves assessing the optimality of extraction rates both across fuel sources and across fields of exploration within a given fuel source. If a function existed that expressed social preferences for fuel composition and rates of extraction alongside social preferences for economic production, then the solution that maximized societal well-being would be characterized by the socially optimal rates of extraction and economic activity. Certainly individuals, if given the opportunity to express their preferences, could identify combinations of extraction and economic activity as preferable to or not to a specified alternative. Repeating this exercise across all possible combinations would amount to the individual ranking the extraction/economic activity combinations from most to least preferred.[4] Aggregating the order of preferences across individuals would allow for a specification of social preferences. Kenneth Arrow (1951) investigated rules for aggregating preferences across individuals and thereby generating social

[4] As consumers are able to rank their preferences from most to least preferred, but are unable to measure the degree of satisfaction they receive from a given alternative, preferences are said to satisfy conditions of ordinality but not cardinality.

preferences from individual preferences. His seminal work, known as Arrow's impossibility theorem, found no such rule exists.[5]

In applications such as the proposed BLM rule to be discussed subsequently, and many others central to public policy, the absence of a well-specified social preference function presents a challenge to crafting socially desirable policy. Attempts at socially optimal policy are further confounded by the findings of Lipsey and Lancaster (1956) as they built upon the works of Meade (1955) and others in developing a general theory of second best. The general theory of second best shows that while a socially optimal solution requires the simultaneous satisfaction of all optimal first-order conditions, if constraints (political, institutional, or otherwise) prevent any one of the optimal conditions from being satisfied, satisfying the remaining first-order conditions for optimality is generally no longer socially desirable (in that it does not improve social well-being). Arrow's impossibility theorem and the theory of second best combine to point to a common conclusion – that social improvements can only occur incrementally and require careful analysis on a case-by-case basis to justify their adoption (Wetzstein, 2005). This point merits repeating before proceeding; casual adoption of natural resource and public policy without careful and considered analysis of the costs imposed on society and the benefits generated for society violates the central tenets that form the very foundation of welfare economics.

Careful and considered analysis requires researchers to overcome many obstacles, two of which merit brief mention. First, many aspects of natural resource policy analysis require the researcher to assign values to considerations where no such natural value exists. Methods for assigning values where well organized markets do not exist are referred to generally as methods of non-market valuation (see Haab and McConnell, 2003 and Champ, Boyle, and Brown, 2003). Because socially desirable policy can only occur incrementally and can only be evaluated on the basis of estimated net benefits generated for society, assigning costs and benefits (even when difficult to do so) is essential. Thus, an entire literature is devoted to rigorous development of models for non-market valuation. Second, many aspects of natural resource policy require the researcher to acknowledge that the costs and benefits under study often do not occur with certainty. Rather,

[5] Arrow would win a Nobel Prize in economics for this and other contributions. Specifically, he found that no rule other than the selection of a dictator whose preferences dominate all other individuals would generate social preferences that satisfied the conditions that social preferences be complete, transitive, independent of irrelevant alternatives, and such that if every individual prefers combination A to combination B, the social preferences also rank combination A as preferred to combination B.

there is a distribution of possible cost and benefit outcomes. Ignoring the uncertainty and performing the analysis using only mean values leads to suboptimal policy decisions (either adopting policies that have net costs to society or failing to adopt policies that have net benefits to society). Pindyck (2007) offers a concise review of the perils of ignoring uncertainty in natural resource and environmental economics.

This paper contributes to the understanding of a proposed BLM rule originally entitled *Oil and Gas; Well Stimulation, Including Hydraulic Fracturing, on Federal and Indian Lands* and published in the federal register under the regulation identifier number RIN 1004-AE26 and proceeds as follows. First, we argue that the internal analysis performed to support the adoption of the rule does not meet the standard set forth previously of "careful and considered" in that it makes no attempt to invoke rigorous methods of non-market valuation to assign values to critical elements of the analysis where no such values exist and ignores the uncertainty inherent in the costs imposed by the rule and the benefits it is designed to secure.

Second, we construct a model of the costs imposed on producers that explicitly recognizes the uncertainty in the distribution of producer costs. Given the distributional assumptions outlined subsequently and reviewed by industry experts, we find mean additional costs to producers of $129,194 with a 90% confidence interval for additional per well costs ranging from $89,186 to $175,654. The cost distribution reflects 200,000 random draws from a multi-stage Monte Carlo process capturing reasonable distributions of the individual cost components reviewed by industry experts. Robustness of the individual well cost estimates are checked against alternative scenarios to investigate the sensitivity of the estimates to changes in the underlying distributional assumptions. Applying the $129,194 additional costs per well just to the 3,022 wells started on BLM designated federal lands in fiscal year 2012 would generate additional industry costs of over $370 million if no actions were taken to avoid the newly levied fees.

In fact, however, drilling and production capital is allocated competitively and the additional costs per well, while modest compared to total drilling costs, are significant enough to impact internal rate of return estimates and therefore generate a new assignment of capital between federal and non-federal lands.[6] While the new assignment of capital succeeds in avoiding some of the cost differentials of drilling on federal BLM lands, it also shifts the distribution of royalty

[6] Note that fees levied on oil and gas extraction and applied specifically to federal BLM lands is equivalent to the levy of a partial factor tax and can be analyzed in the general equilibrium framework pioneered by Harberger, 1962.

payments away from BLM to other royalty owners and these distributional considerations are significant. Reallocating production away from BLM lands to non-federal lands shifts non tax sources of revenue and employment opportunities away from energy states with large allocations of BLM managed lands. This redistribution shifts the burden of some of the costs imposed on society from producers to local governments and the citizen base they serve. To the extent that the lost revenues must be replaced with new tax streams or displace rival appropriations, this effectively shifts a portion of the costs from oil and natural gas producers to consumers at large. The potential of the cost burden to be shifted from the producers to whom the costs are assigned to other sectors of the economy is the expected result from decades of general equilibrium tax incidence analysis (Harberger, 1962; Shoven and Whalley, 1972). The preceding discussion serves to emphasize a key point in this discussion – the assignment of costs very likely differs from the final burden of the costs. Therefore all costs assigned to producers are correctly characterized as societal costs with the ultimate economic burden of the costs undetermined. Following general comments on the analysis reviewed and a formal presentation of the estimated individual well costs under uncertainty, the paper concludes with some final thoughts.

Non-Market Valuation, Risk-Benefit Analysis, and Uncertainty

The original submission of the proposed rule noted in summary that the rule was "necessary to provide useful information to the public and to assure that hydraulic fracturing is conducted in a way that adequately protects the environment." The proposal goes on to elucidate "useful information" as the disclosure of chemicals used in the hydraulic fracturing process and "adequately protects the environment" as increasing construction well-bore oversight to protect underground water sources and increasing oversight of plans to manage flowback waters at the surface. The central concerns are summarized as providing useful information to the public and reducing the risk of a water contamination episode (both surface and subsurface). Therefore the appropriate research questions are twofold. First, do the benefits to society from possessing the additional information on fracturing fluids exceed the costs (opportunity costs) of acquiring the information, and second, do the benefits to society from a marginal reduction in the risk of an adverse environmental episode exceed the costs to society of implementing the new regulations.

Analysis of both of the stated research questions hinges on the appropriate assignment of values to goods (information and risk reduction) where no such market exists. A carefully constructed analysis would begin by rigorously invoking appropriate methods of non-market valuation to construct a baseline value of the benefits to society from possessing additional information and constructing a social marginal willingness to pay curve (demand curve) for risk reduction. Instead, the research note included in the rule proposal notes "because monetization of the reduction of risk…is a difficult issue, this analysis is using avoided cost of remediation as a proxy value." In fact, monetizing the reduction of risk is not particularly difficult, with several recent papers successfully employing contingent valuation methods to monetize risk reduction. The following paragraphs present this idea more fully.

First, the proposed rule presupposes that the risk of water table contamination is not socially optimal. The paper notes that "operators have a vested interest in ensuring that wells are constructed properly to avoid problems that might jeopardize their investment", but the existence of the proposal itself indicates a belief that this "vested interest" alone is not sufficient to drive the risk of an adverse episode to the socially optimal level. This is further emphasized by the implied conclusion that producers don't go far enough to protect their own investment and among the benefits of the rule would be do reduce how often a producer would be required to "shut-in temporarily or plug the well before it may produce all of the mineral resources." Or in other words, some of the benefits from implementing the rule would be enhanced profits accruing to producers. This presentation confuses the key question of whether producers responding to their private profit motives are driven to socially optimal practices (specifically in regards to water table contamination) or if further actions are necessary.

Any risk-benefit analysis (RBA) (or cost benefit analysis (CBA)) should begin by demonstrating that the private market outcome (baseline) is socially undesirable, then propose a policy with clearly defined costs and benefits designed to move to market towards a socially optimal solution, and then conduct a RBA to assess the welfare implication of implementing the policy.

In this application, however, much of the cost-benefit analysis seems focused on the cost side of the ledger with the benefits summarized as "non-monetized". For example, consider tables 3 and 4 on pages 117 and 118. Table 3 summarizes costs as estimated and reported in millions of dollars on an annualized basis. Table 4 summarizes non-monetized benefits as the share of hydraulic fracturing plans subject to BLM review, share of hydraulic fracturing plans using unlined pits, etc. The logic becomes almost circular in presenting the costs of implementing the rule as the costs to society and the rule itself as the benefits to society. This is analogous, for example, to arguing that the benefit of random security screenings of luggage is that luggage is screened. In reality, the benefit to society is not that luggage is screened but rather that screening the luggage reduces the risk of an adverse travel event. Similarly, the benefit in question from the proposed rule is really the reduction in the risk of an adverse water contamination event. The risk reduction is not evaluated in the proposal. Instead, table 4 notes the baseline risk of a minor incident is 2.7% and that of a major incident is 0.03%. No attempt to estimate the reduction in this likelihood from implementing the proposed rule is reported - but this is the key question of the analysis. If the intent of the rule is to reduce the risk of a contamination incident and implementing the rule imposes costs on society,[7] we should know what level of risk reduction is effectively secured through society's expenditures. As stated previously, while estimating the monetized value of risk reduction is challenging, it is possible and could provide valuable information.

Before proceeding to our estimates of the social costs of the proposed rule, a few comments on the role that uncertainty plays in natural resource policy are warranted. Multiple references are made to the great deal of uncertainty surrounding the analysis. Lack of certainty about the present and future costs can affect policy design in three ways: the optimal choice of the policy instrument, the optimal policy intensity, and the optimal policy timing (Pyndick, 2007, Review of Environmental Economics and Policy). In this setting it might be appropriate to think about the specific set of regulations as the instrument, the number of wells to which the regulations would be applied as the intensity, and the whether to adopt the instrument at the proposed level of intensity now or wait for further information to clarify potential policy options.

Of particular importance here is the potential combination of irreversibilities and uncertainty. Under uncertainty, situations involving irreversible environmental damage (not the case here given the remediation scenarios) tend to lead to policies that are more conservationist than would otherwise be socially optimal. However, with uncertain costs and benefits – and at least some irreversible costs – cost benefit analysis tends to be biased towards concluding the policy should be adopted. In this case, many of the costs are irreversible (or sunk). For example, once a cement evaluation log is conducted, that cost is sunk. It cannot be recovered at a future period if further information reveals that it offers no additional risk reduction beyond existing pressure tests. Now consider a group of policy proposals, each characterized by uncertain costs and benefits where at least some of the costs are irreversible. Traditional cost-benefit analysis (as employed here) will

[7] Our Monte Carlo simulation results suggest that the BLM's estimate of societal costs of $12 million to $19 million is too low (see table 3: Summary of Costs in the revised rule proposal). Similar to other reports (such as Dunham (2012)), we find that the direct cost to producers is much higher at $370 million, ceteris paribus.

lead to more of the proposals being adopted (on the basis of a positive net present value) than is socially optimal! The key question in such cases is in the policy timing. Socially optimal policy adoptions are more likely as time passes and additional information (in this case, on the level of risk reduction) becomes available.

Estimates of Individual Well Costs - Introduction

Proposed regulation can often create an atmosphere of uncertainty for market participants. While regulators may see this as an unintentional consequence, this uncertainty has real effects that can often be difficult to model. Our Monte Carlo analysis attempts to account for this uncertainty in a reasonable and responsible fashion. Rather than employing individual numbers for our parameters of interest, we use distributions to characterize the spread of outcomes that may occur for a given parameter.

Our Monte Carlo analysis takes 200,000 draws from each of these pre-specified distributions and then combines these draws in a manner specified below to generate a distribution of outcomes for total additional costs on a per well basis. For simplicity's sake, only two types of distributions are employed. Uniform, which assigns equal weight to every point in its domain, is characterized by a beginning and end point. Normal, which assigns less weight to those points located further from the mean, is characterized by a mean and standard deviation. The larger the standard deviation, the flatter the bell curve.

Monte Carlo Analysis- Baseline Scenario[8]

Wells are divided into two distinct categories: Type and non-Type. A Type well is difficult to define and the optimal ratio of Type to non-Type wells is unspecified. To model this uncertainty regarding Type wells, we make the following assumptions. Type wells found in mature plays are uniformly distributed from 0 to 0.1 with an expected value of 0.05 or occurring 5% of the time. Further, wells in mature plays make up 95% of the wells drilled in this current price environment. The other 5% of wells drilled, namely those drilled in exploratory plays, are assumed to be 100% Type wells. Consequently, the expected probability of a Type well being drilled is 9.75%.

All Type wells and some non-Type wells require cement evaluation logs (CEL's) and a certain subset of those wells warrant remediation. It is assumed that the fraction of wells requiring a

[8] Parameterizations were based on input received from experts in the energy industry.

surface CEL is uniformly distributed from 0.1 to 0.3 where the mean implies that 1 out of every 5 wells will require a surface CEL. The ambiguity regarding what constitutes the conditions under which a surface CEL should be performed leads to uncertainty. The process of analysis for the surface CEL and the subsequent remediation, if necessary, are displayed below in Figure 1.

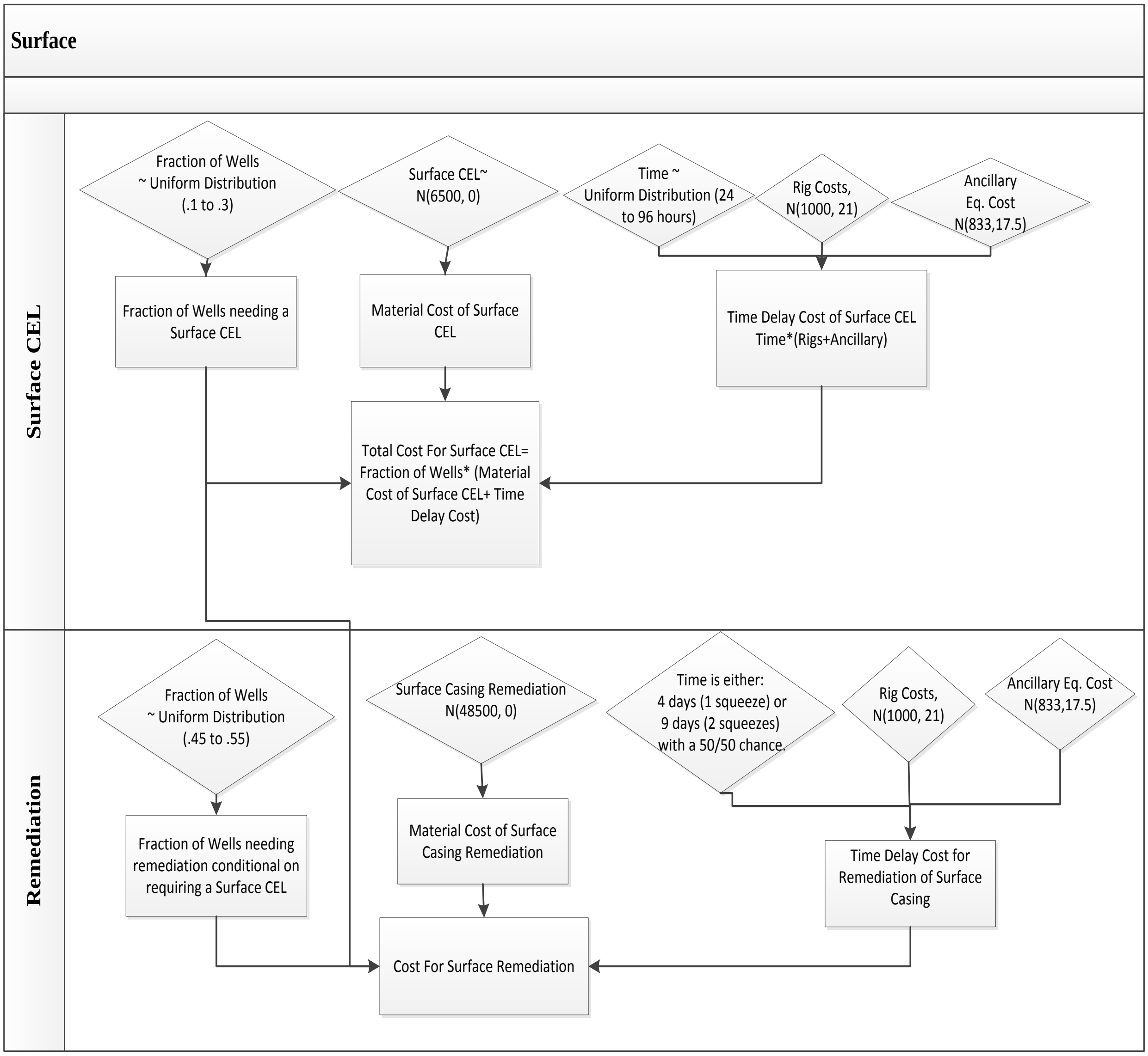

Figure 1: Surface Casing Costs

Surface CEL have both material and time delay costs. Representing the material cost is the surface CEL, which is $6500. Time delay costs are the largest portion of the costs with time being uniformly distributed from 24 to 96 hours. Rigs, that are forced to sit idle during this time, have costs that are normally distributed with mean of $1000/hr and a standard deviation of $21/ hr. Ancillary equipment also incur costs in a similar fashion with a mean rate of $833/hr and a standard deviation of $17.5/hr. For a well that has a surface CEL, this leads to an expected value of nearly $110,000 in time delay costs and $116,500 in overall additional costs. Since only 20% of wells are expected to require a surface CEL, these additional cost spread over all non-Type wells is $23,300.

In distribution plots, such as Figure 2 below, all 200,000 draws are smoothed into a probability density function using a kernel smoothing algorithm. Figure 2 displays the corresponding distribution of possible surface CEL costs.

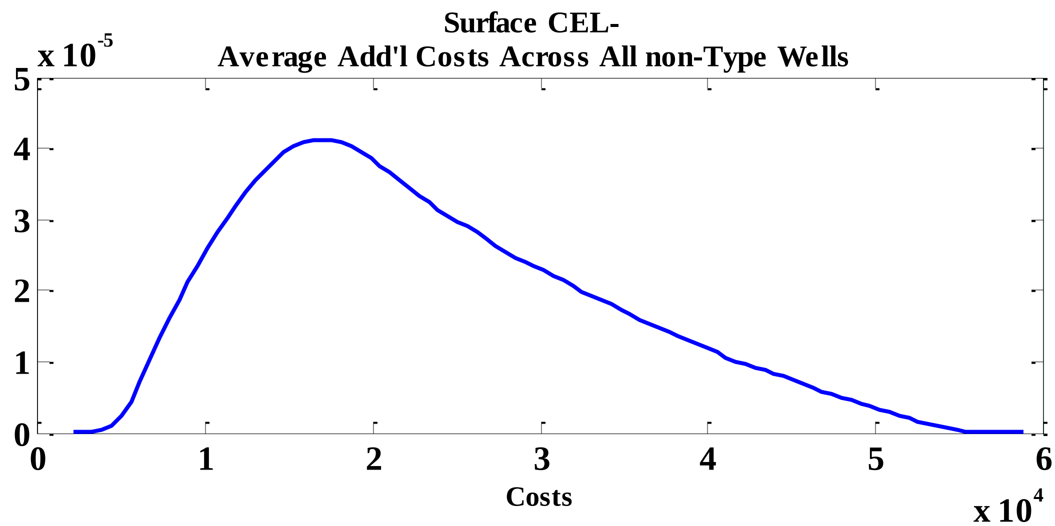

Figure 2: Surface CEL- Additional Costs Across All non-Type Wells

Remediation of wells that have had a surface CEL conducted is expected to ensue about 50% of the time, which represents the mean value of a uniform distribution defined from 0.45 to 0.55. Material costs of remediation for one squeeze include $12,000 for perforating, $30,000 for cementing, and $6,500 for the log for a total of $48,500. If two squeezes are required, this number would double. Remediation time is assumed to be 4 days for one squeeze, 9 days for two squeezes with both outcomes being equally likely. During this time, rig and ancillary equipment costs are incurred on an hourly basis. For a non-Type well that requires surface remediation, the cost is nearly $360,000. If the costs are spread out over all non-Type wells, then the average surface remediation costs incurred on a non-Type well basis is approximately $36,000.

The non-normal distribution of average Surface Casing Remediation spread over all non-Type wells is given in Figure 3 below. The large range and shape of the distribution can be attributed to the fact that there are two distinct possibilities, one squeeze and two squeezes, which have very different time frames and costs.

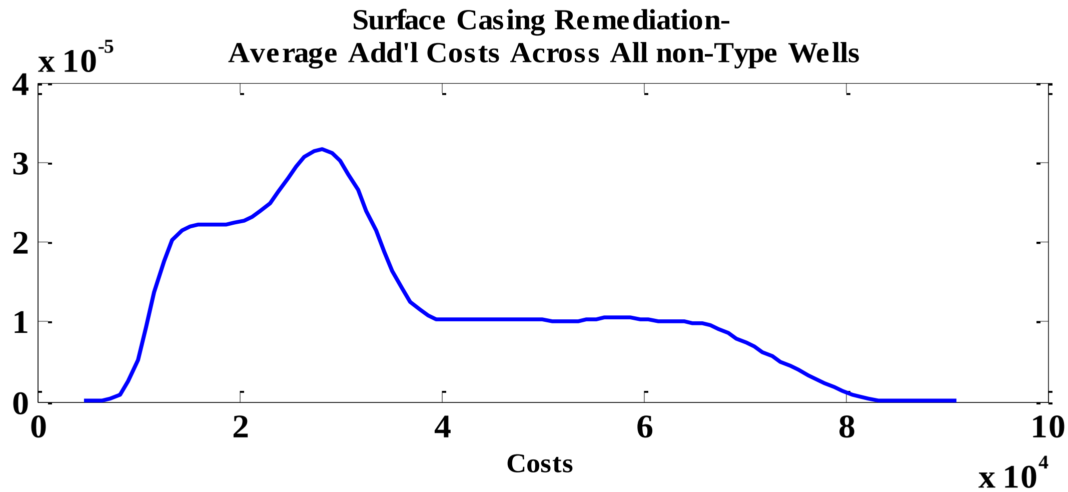

Figure 3: Surface Casing Remediation- Additional Costs Across All non-Type Wells

The set-up for the Intermediate CEL is very similar to the surface CEL with a few modifications where appropriate as displayed in Figure 4 below.

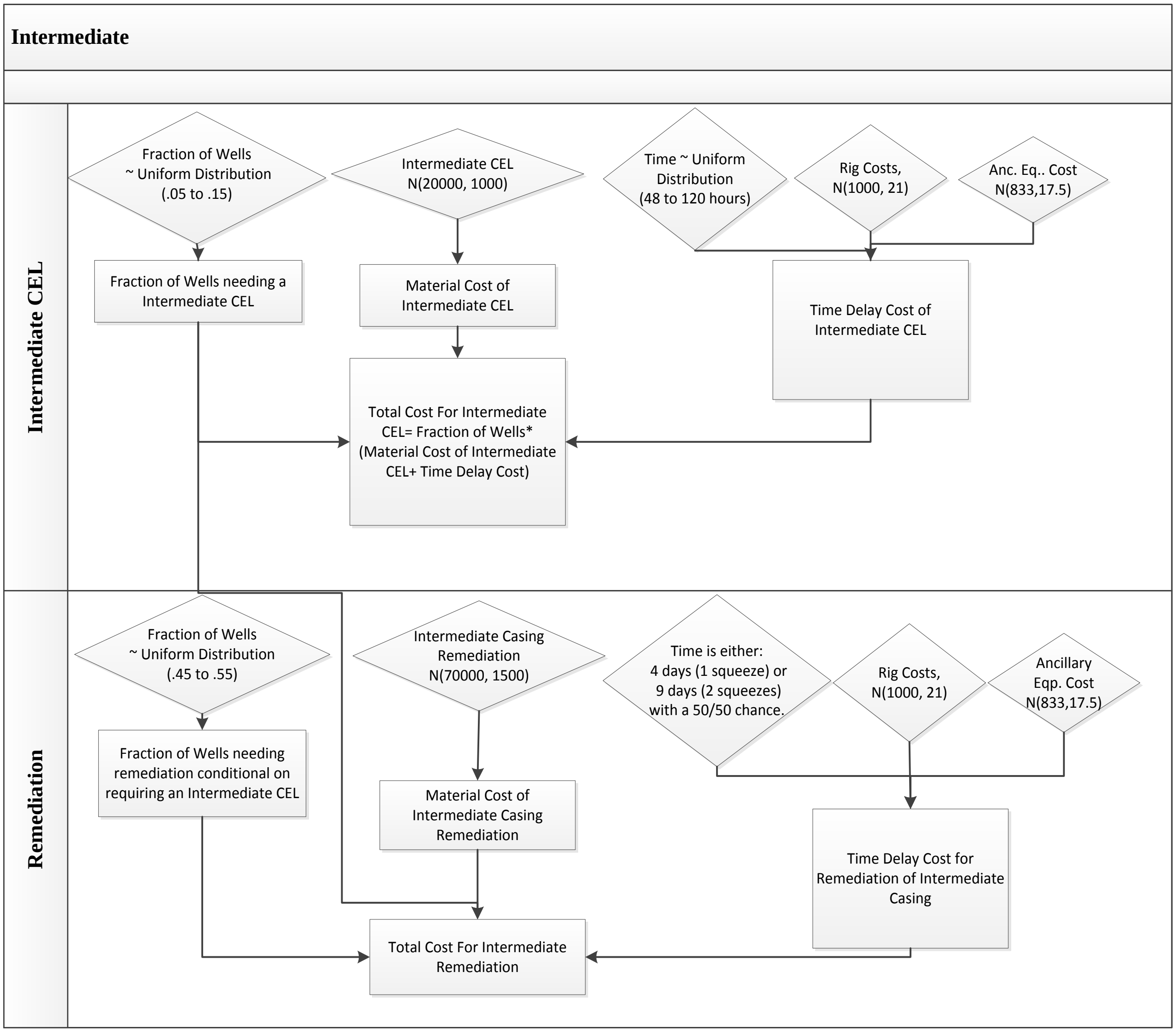

Figure 4: Intermediate

The fraction of non-Type wells requiring an intermediate CEL is reduced to 10% with a range from 0.05 to 0.15. However, the mean intermediate CEL is higher at $20,000 and more uncertain with a standard deviation of $1,000. The log time distribution has increased by 24 hours with a range from 48 hours to 120 hours and a mean expected value of 84 hours. For an individual well having an intermediate CEL, the expected cost is approximately $174,000. Since only 10% of non-Type wells are expected to have an Intermediate CEL, this implies an average increase of $17,400 on a per well basis. The distribution is depicted below in Figure 5.

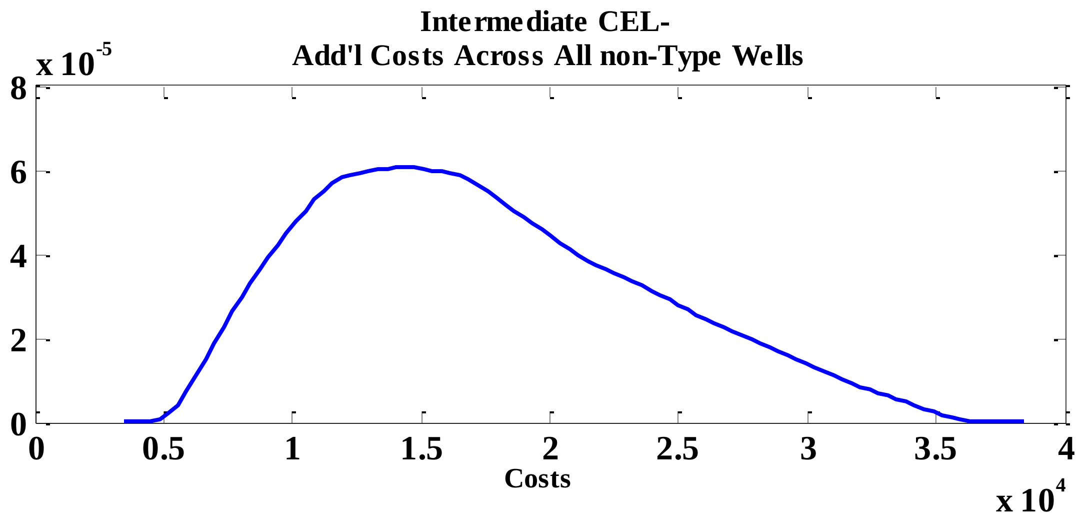

Figure 5: Intermediate CEL- Additional Costs Across All non-Type Wells

Remediation costs for the intermediate casing are assumed to be $20,000 for perforating, $30,000 for cementing and $20,000 for second bond log for a total of $70,000. Like surface remediation, this cost will be incurred twice if two squeezes are required. Intermediate remediation time is assumed the same as surface remediation, with 4 days required for 1 squeeze and 9 days required for 2 squeezes with each outcome being equally likely. The expected cost of intermediate remediation of a non-Type well is over $390,000 which, if distributed over all non-Type wells, is $19,500 per non-Type well, bringing the average intermediate CEL and remediation to nearly $37,000 per non-type well.

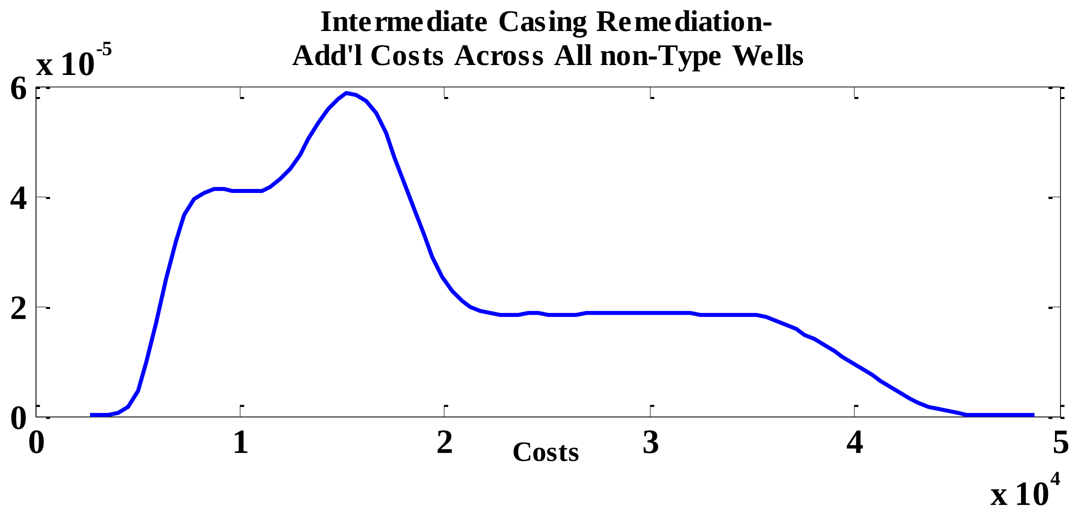

Figure 6: Intermediate Casing Remediation- Add'l Costs Across All non-Type Wells

The calculation of Type wells are shown below in Figure 7. Each Type well is assumed to have a surface CEL (expected value is $116,500) and intermediate CEL ($174,000). Further each Type well requires a frac model (mean $4500, standard deviation ($765)) and horizontal casing ($50,000). The total additional cost of a Type well has an expected value of $345,000 and its distribution is depicted in Figure 8.

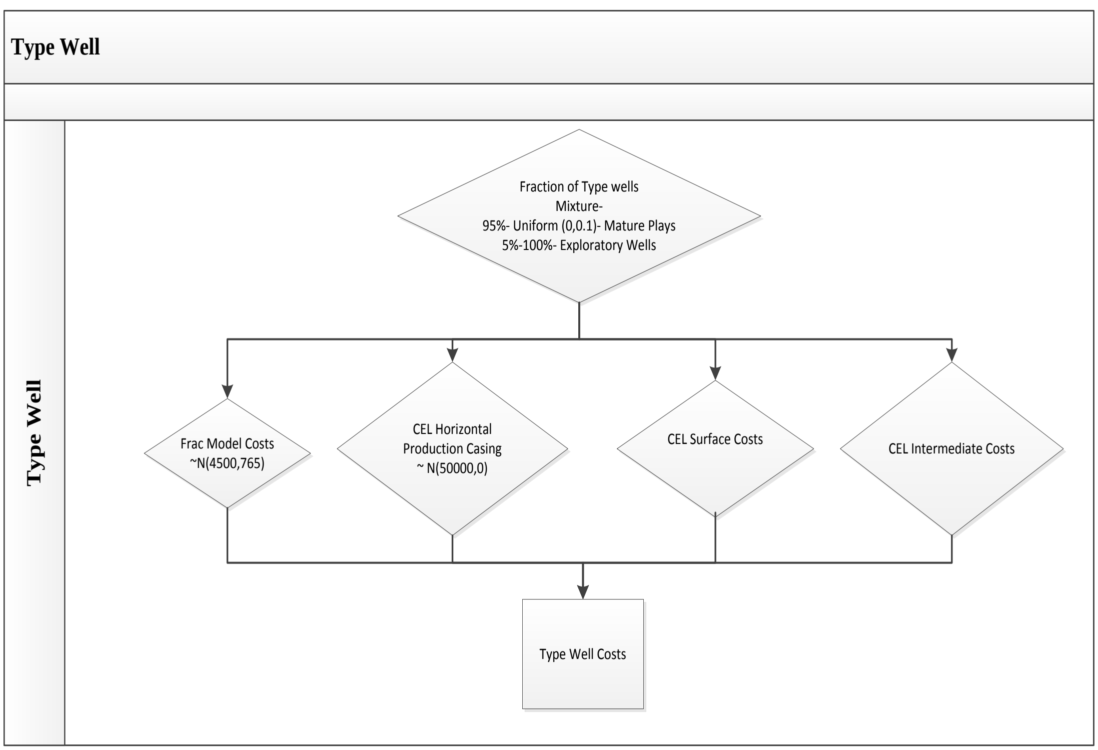

Figure 7: Type Well

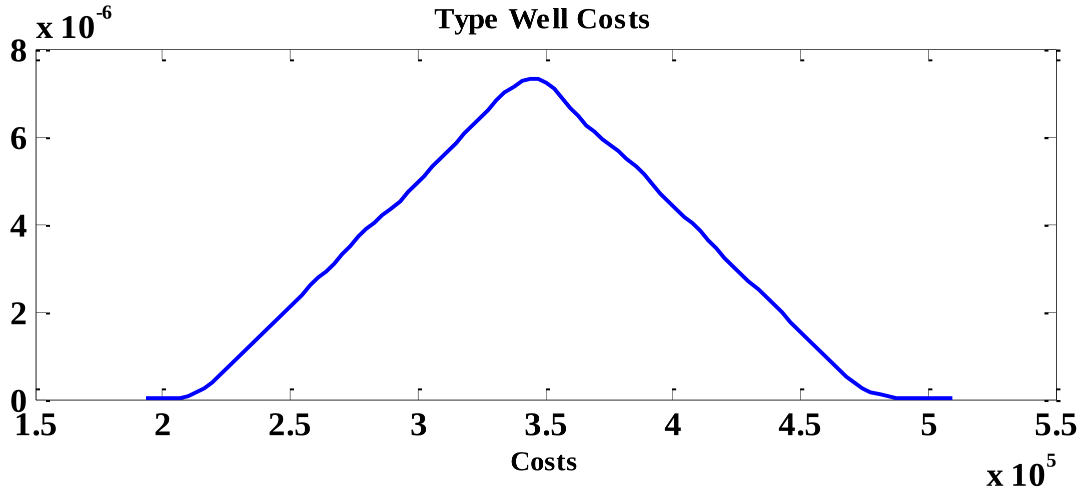

Figure 8: Type Well Costs

Average total additional costs on a per well basis are depicted below in Figure 4. Additional costs incurred by producers for both Type and non-Type wells are personnel costs, which are expected to be $8,750 on a per well basis with a standard deviation $1,488. Consequently, the average cost increase on a per well basis is approximately $129,000 per well.

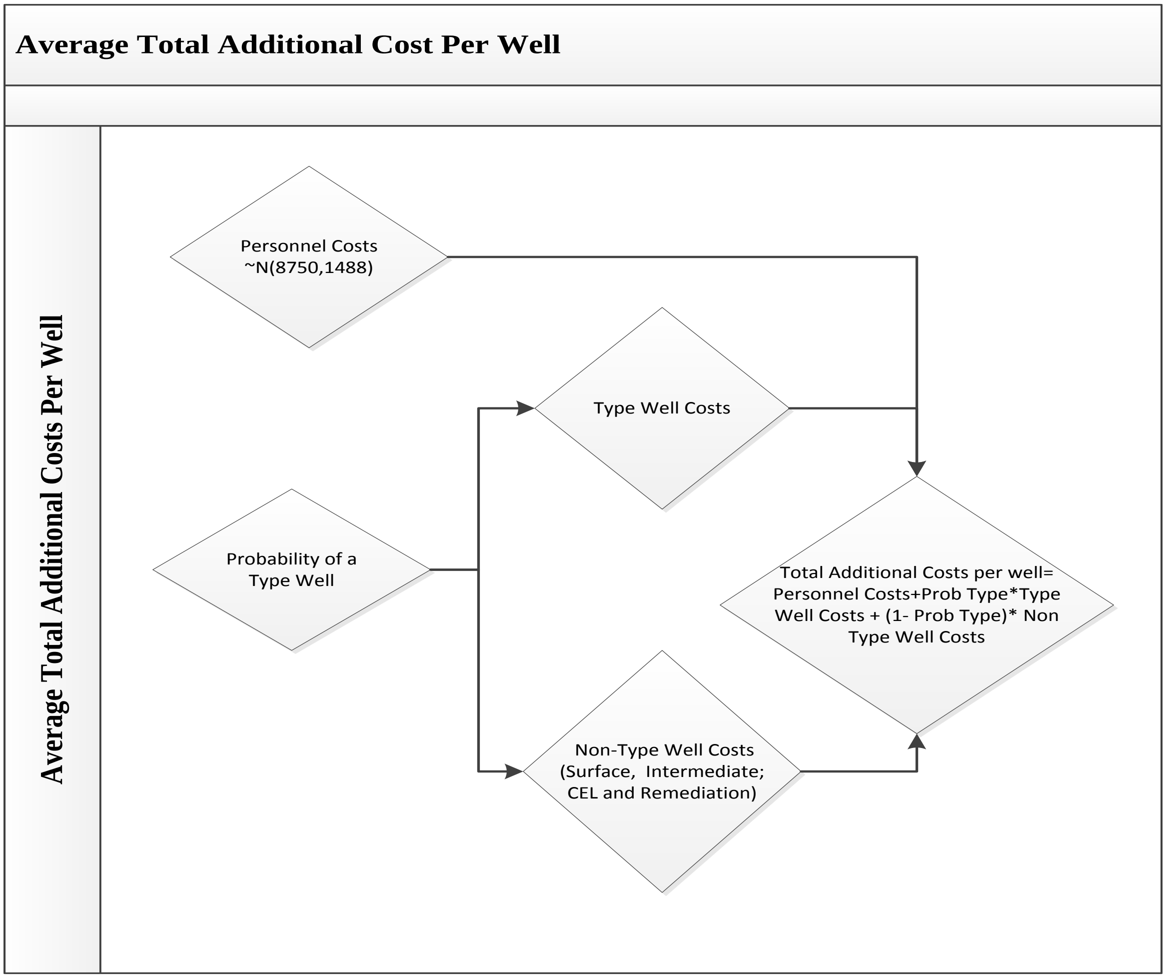

Figure 9: Average Total Additional Costs Per Well.

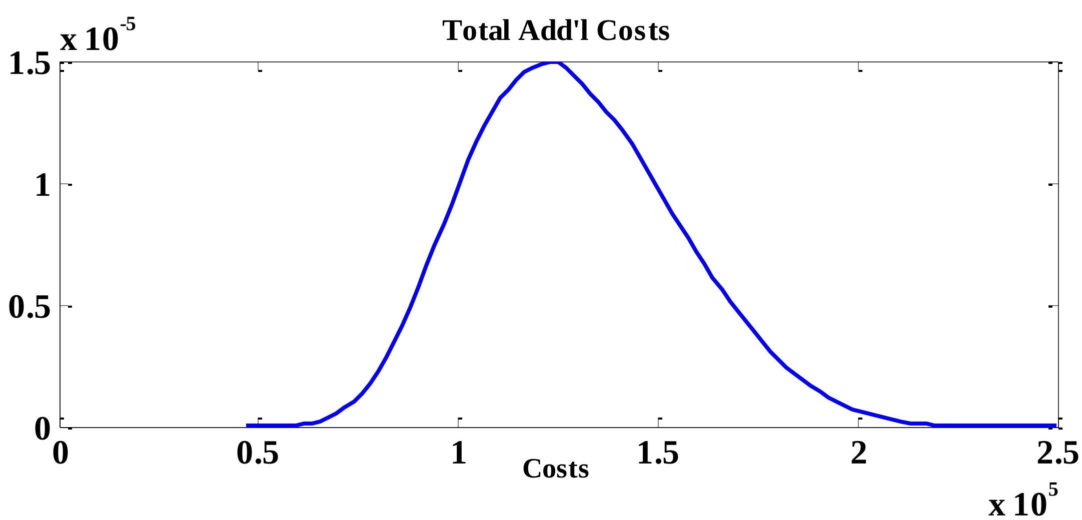

Figure 10: Total Additional Costs per Well

Baseline Scenario Summary

To summarize how the 200,000 random draws[9] characterize the additional costs by cost component, we provide the following summary statistics in Table 1. While the mean value of total additional costs is $129,000, the worst case scenario indicated by these draws is over $240,000 additional dollars on a per well basis.

Table 1: Baseline Scenario, Summary Statistics				
Cost Component	**Mean**	**Standard Deviation**	**Minimum Draw**	**Maximum Draw**
CEL Surface	$23,340	$10,408	$5,011	$55,954
Surface Casing Remediation	$35,926	$17,585	$9,436	$86,336
CEL Intermediate	$17,403	$6,404	$5,296	$36,541
Intermediate Casing Remediation	$19,524	$9,513	$5,210	$46,201
Type	$345,077	$54,036	$209,770	$493,859
Total Costs	*$129,194*	*$26,193*	*$54,485*	*$242,375*

Since many of these resulting distributions fail the tests for normality, they cannot be fully characterized by a mean and standard deviation. Consequently, Table 2 shows the percentiles generated by the kernel smoothing algorithm describing the tails of the distribution.

Table 2: Distribution Percentiles; Kernel Smoothed Estimates, 200,000 Draws*						
Cost Component	**1**	**5**	**10**	**90**	**95**	**99**
CEL Surface	$6,500	$9,041	$11,002	$38,699	$43,274	$49,680
Surface Casing Remediation	$10,613	$13,326	$15,659	$63,864	$69,212	$76,330
CEL Intermediate	$6,492	$8,231	$9,554	$26,736	$29,344	$33,085
Intermediate Casing Remediation	$5,835	$7,309	$8,572	$34,704	$37,631	$41,401
Type	$230,658	$254,381	$271,755	$418,355	$435,886	$460,020
Total Costs	*$77,099*	*$89,186*	*$96,466*	*$164,926*	*$175,654*	*$194,614*

[9] Due to the random nature of the draws these values can differ slightly from the calculated expected values.

Sensitivity Analysis

In the baseline case, we have made certain assumptions regarding the parameterization of these distributions. In this section, we check the sensitivity our results to some of these assumptions. In particular, we check the following cases:

1) Increase the baseline probability that a surface CEL is performed.
    a. Move from a lower and upper bounds of 0.1 and 0.3 to a lower and upper bounds of 0.2 and 0.4.
2) Increase the baseline probability that a surface casing remediation is performed.
    a. Move from a lower and upper bounds of 0.45 and 0.55 to a lower and upper bounds of 0.7 and 0.8.
3) Increase both the surface CEL probability and the surface casing remediation probability.
    a. Move from a lower and upper bounds of 0.1 and 0.3 to a lower and upper bounds of 0.2 and 0.4.
    b. Move from a lower and upper bounds of 0.45 and 0.55 to a lower and upper bounds of 0.7 and 0.8.
4) Increase the baseline probability that an intermediate CEL is performed.
    a. Move from a lower and upper bounds of 0.05 and 0.15 to a lower and upper bounds of 0.15 and 0.25.
5) Increase the baseline probability that an intermediate casing remediation is performed.
    a. Move from a lower and upper bounds of 0.45 and 0.55 to a lower and upper bounds of 0.7 and 0.8.
6) Increase both the intermediate CEL probability and the intermediate casing remediation probability.
    a. Move from a lower and upper bounds of 0.05 and 0.15 to a lower and upper bounds of 0.15 and 0.25.
    b. Move from a lower and upper bounds of 0.45 and 0.55 to a lower and upper bounds of 0.7 and 0.8.

These particular scenarios have been selected as important as the conditions upon which they depend have yet to be defined by the BLM. This ambiguity allows the BLM the freedom to apply

CEL and Remediation to a much broader set of cases than would otherwise be considered normal by the majority of stakeholders. The distribution of mean additional individual well costs for each scenario outlined above is reported in Table 3 below.

Table 3: Individual Well Cost - Sensitivity Analysis

		Cost by Type					
		CEL Surface	Surface Casing Remediation	CEL Intermediate	Intermediate Casing Remediation	Type Well	Total Costs
Scenario 1	Mean	34,962	53,754	17,405	19,522	345,082	155,777
	Std. Dev.	13,433	23,217	6,412	9,514	54,023	30,465
Scenario 2	Mean	23,253	53,841	17,387	19,539	344,930	145,284
	Std. Dev.	10,395	26,200	6,412	9,514	54,165	32,339
Scenario 3	Mean	34,964	80,736	17,408	19,590	344,904	180,220
	Std. Dev.	13,431	34,752	6,402	9,537	54,071	38,989
Scenario 4	Mean	23,323	35,864	34,777	39,109	345,085	162,504
	Std. Dev.	10,406	17,570	9,193	15,912	54,105	29,006
Scenario 5	Mean	23,307	35,925	17,396	29,322	344,968	138,002
	Std. Dev.	10,414	17,593	6,412	14,204	54,166	28,281
Scenario 6	Mean	23,319	35,862	34,790	58,762	345,018	180,250
	Std. Dev.	10,420	17,574	9,182	23,727	54,073	33,335

For Scenario 1, when the probability of running a Surface CEL is increased by 10 percentage points, expected surface CEL costs increase by 50% and total additional costs increase by 21%. For Scenario 2, when the expected probability of remediating the surface casing is increased from 50% to 75%, expected additional total costs increase by 12%. When the probabilities of a surface CEL and surface casing remediation increase, we observe a 40% increase in expected total additional costs. Consequently, to the extent that we have underestimated any of the surface probabilities, our total additional costs will be even higher.

Raising the probability of an intermediate CEL by 10 percentage points produces nearly 100% increase CEL Intermediate costs and raises the total additional costs by 26%. Increasing the probability of remediation by 25 percentage points raises intermediate remediation costs by 50% and total additional costs by nearly 7%. Increasing the probability of an intermediate CEL and remediation increases the additional cost by 39%. Similar to surface probabilities, increasing intermediate probabilities leads to greater additional total costs on a per well basis.

Conclusion

The BLM proposes to impose additional oversight and costs on producers of oil and natural gas on BLM Federal and Indian lands in an effort to secure for the public "useful information" and greater assurance that "hydraulic fracturing is conducted in a way that adequately protects the environment" (Federal Register, RIN 1004-AE26). In support of the rule, no attempt is made to monetize the value of the additional information. More concerning, no attempt is made to estimate the reduction in the probability of an environmental incident from their baseline levels of 2.7% for a minor incident and 0.03% for a major incident nor monetize the benefits to society from such a reduction (if it were achieved). The absence of a careful consideration of the benefits generated from implementation of the proposed rule violates the central tenets of welfare economics in regards to natural resource management – that social improvements occur incrementally, with careful and considered evaluation required of every proposed change to determine its social desirability.

We contribute modestly to the analysis by examining in more detail the costs to society of implementing the rule. Recognizing the inherent uncertainty, we construct a custom, multi-stage Monte Carlo process to estimate the average additional costs per well imposed on producers. The process flow of the model as well as the cost distribution parameters are informed by reported practices and costs of one of the nation's largest independent producers. We find average additional costs per well for the rule of $129,194. A sensitivity analysis of the baseline case compared to alternative reasonable scenarios finds average additional costs per well as high as $180,250. Given our baseline scenario, this additional per well cost would imply $370 million in total costs from 2012 alone from operations on BLM lands.

Given the competitive allocation of capital that characterizes oil and gas exploration, the distributional impacts are expected to differ from the assignment of costs to producers. Shifting production capital away from BLM energy states to alternative fields of production (to equalize after tax rates of return) shifts non-tax sources of revenue and employment opportunities away from BLM energy states. The shift may be greater than would be expected from the increase in average well costs as significant uncertainty still remains as to how the rule will be implemented and enforced over time. This uncertainty will be priced into allocation decisions causing a second layer of capital allocation away from BLM energy states to ensure equalized risk-adjusted rates of returns across competitive investment opportunities.

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