PS Drilling a Downdip Location: Effect on Updip and Downdip Resource Estimates and Commercial Chance*

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Abstract

A common method for choosing the drilling location for an exploration prospect is to simply drill the well on the crest of the structure. The main driver is to maximize the chance of discovering a hydrocarbon accumulation. However, a common situation for a crestal well is that the discovery of productive reservoir full-to-base with hydrocarbons has only proven a limited productive area. So the discovered resource volumes are too small to justify development and further downdip appraisal drilling is required, adding to exploration costs and delaying possible development. An alternative approach is to choose a well location where a discovery would exceed the minimum commercial field size (MCFS) needed to justify development. In practice, the drilling location is often based on a deterministic resource estimate using the mean value from a probabilistic assessment of resource volumes. A downdip discovery smaller than MCFS or even a dry hole with a thick, porous reservoir might tempt decision makers to sidetrack updip since the full probabilistic distribution of the updip resources had not been considered. This paper demonstrates the advantages of trying to choose a location that considers the full probabilistic resource distributions for the updip and downdip volumes relative to the drilling location and the chance of commercial success in the decision making process. The overlap of the two distributions can be significant and what might seem like a good drilling location based on the deterministic estimate exceeding MCFS actually might leave the decision maker with some regrets at the chosen location. Besides modifying the distribution of discovered resources, the chance of geologic success also changes as the location is moved further downdip. The goals are to maximize the chance of a commercial discovery and to choose a drilling location that if a dry hole occurs there will be no regrets or reason to undertake an expensive updip sidetrack or drill another test updip. To accomplish this, multiple drilling locations need to be evaluated with this process and the results plotted to analyze trends. The results are ready to be inputted into a decision tree for expected value calculations and allow answering management questions such as "If we drill 600 acres downdip of crest, what is the probability we make a commercial discovery and what is probability of leaving commercial resource volumes updip? And how does this compare if we drill only 500 acres downdip?"

Drilling a Downdip Location: Effect on Updip and Downdip Resource Estimates and Commercial Chance

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Panel 1: Investigate a Downdip Drilling Location with its Effect on Chance, EUR and EMV

ABSTRACT

Drilling a Downdip Location: Effect on Updip and Downdip Resource Estimates and Commercial Chance

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A common method for choosing the drilling location for an exploration prospect is to simply drill the well on the crest of the structure. The main driver is to maximize the chance of discovering a hydrocarbon accumulation. However, a common situation for a crestal well is that the discovery of productive reservoir full-to-base with hydrocarbons has only proven a limited productive area. So the discovered resource volumes are too small to justify development and further downdip appraisal drilling is required, adding to exploration costs and delaying possible development.

An alternative approach is to choose a well location where a discovery would exceed the minimum commercial field size (MCFS) needed to justify development. In practice, the drilling location is often based on a deterministic resource estimate using the mean value from a probabilistic assessment of resource volumes. A downdip discovery smaller than MCFS or even a dry hole with a thick, porous reservoir might tempt decision makers to sidetrack updip since the full probabilistic distribution of the updip resources had not been considered.

This poster demonstrates the advantages of trying to choose a location that considers the full probabilistic resource distributions for the updip and downdip volumes relative to the drilling location and the chance of commercial success in the decision making process. The overlap of the two distributions can be significant and what might seem like a good drilling location based on the deterministic estimate exceeding MCFS actually might leave the decision maker with some regrets at the chosen location. Besides modifying the distribution of discovered resources, the chance of geologic success also changes as the location is moved further downdip. The goals are to maximize the chance of a commercial discovery and to choose a drilling location that if a dry hole occurs there will be no regrets or reason to undertake an expensive updip sidetrack or drill another test updip. To accomplish this, multiple drilling locations need to be evaluated with this process and the results plotted to analyze trends. The results are ready to be inputted into a decision tree for expected value calculations and allow answering management questions such as "If we drill 600 acres downdip of crest, what is the probability we make a commercial discovery and what is probability of leaving commercial resource volumes updip? And how does this compare if we drill only 500 acres downdip?"

Should I always drill a crestal well to maximize chance of a geologic discovery?

What if the crestal well, if successful, can't prove sufficient volumes for development requiring further appraisal, additional costs and delayed development?

How do I choose a downdip well location so that a discovery will find Estimated Ultimate Recoverable (EUR) oil exceeding the Minimum Commercial Field Size (MCFS)?

What is a downdip well's location impact on chance of geologic and commercial success?

How do I ensure if the downdip well is a dry hole that there will be "no regrets" about potential updip volumes tempting a decision-maker to drill a sidetrack or new well updip?

Can I get additional insights if I consider the entire Updip and Downdip resource distribution relative to the chosen well location?

Is there a downdip well location that maximizes Expected Monetary Value (EMV)?

How does correlation between Area and Net Pay affect Updip and Downdip resources?

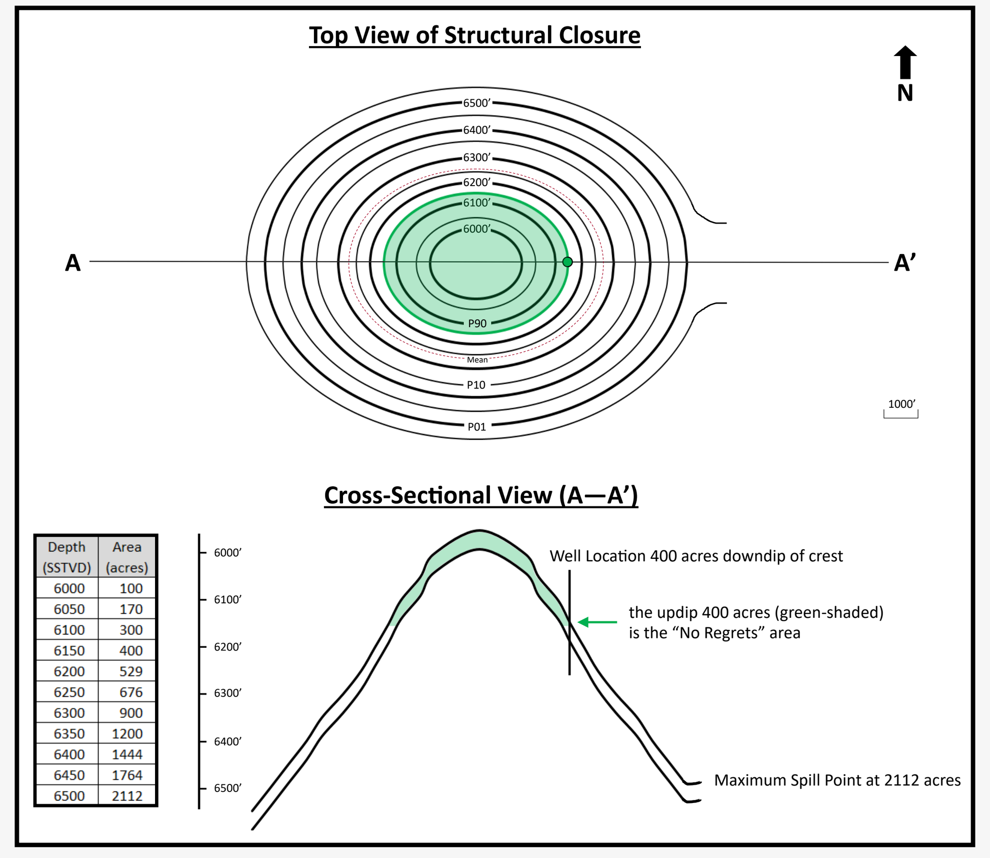

Figure 1: Prospect Structure Map and Cross-Section through Crest. A discovery at the crest with a full column of oil would be too small to justify development without additional appraisal. A discovery at a well location 400 acres downdip, as shown, would have a much higher chance that the discovery would lead to immediate development. The green shaded area ("No Regrets" area) is the updip gross rock volume that is not being tested by the well location in the event of a dry hole.

	Prospect Input Distributions			Prospect EUR Distributions (MMBO)		Updip & Downdip EUR Distributions (MMBO) for Well Location 400 acres downdip of crest		
	Area (ac) (lognormal)	Net Pay (ft) (lognormal)	Oil RY (BO/ac-ft) (simulated)	Geologic EUR Distribution	Commercial EUR Distribution (MCFS = 9.4 MMBO)	Geologic EUR Updip of Drilling Location	Geologic EUR Downdip of Drilling Location	Commercial EUR Downdip of Drilling Location
P99	171	19	230	2.5	9.5	1.7	4.3	9.5
P90	300	36	287	5.3	10.7	3.3	7.6	11.0
P50	600	59	375	13.0	17.1	6.5	15.6	17.7
Mean (P99->P01)	695	62	379	16.4	20.4	7.1	19.2	21.8
P10	1200	92	476	31.9	37.5	11.7	35.7	38.6
P01	2112	178	570	67.1	73.2	20.1	70.9	73.6
"No Regrets" EUR for well drilled 400 acres downdip of crest = 9.4 MMBO (400 ac x 62 ft x 379 BO/ac-ft)								
	Area-Net Pay Not Correlated r = 0		Chance of Success	Pg Chance of Geologic Success (>=P99 EUR)	Pc Chance of Comm Success (>=MCFS)	Pg Chance of Geologic Success (>=P99 EUR)	Pwell Chance of Finding HC at well location	Pc(well) Chance of Finding Comm HC at well location
				50%	34%	50%	43%	35%

Figure 2: Summary of Prospect Input Distributions and Simulated Output EUR Distributions. The Chance of Geologic and Commercial Success for each EUR distribution are also shown. The Prospect EUR distributions represents the entire prospect from crest to spill point (note there is no area-net pay correlation). The new EUR distributions discussed in this poster are the Updip and Downdip accumulation distributions relative to the drilling well location (e.g. 400 acres downdip of crest). The "No Regrets" EUR is defined as the area associated with the well location multiplied by the mean average net pay and mean oil recovery yield). At 400 acres downdip, the "No Regrets" EUR equals 9.4 MMBO (400 ac x 62 ft x 379 BO/ac-ft).

The prospect in Figures 1 and 2 is used throughout this poster. Figure 3 shows the Prospect EUR distributions. The productive area versus EUR plot in Figure 4 shows a wide range of area can result in the MCFS = 9.4 MMBO.

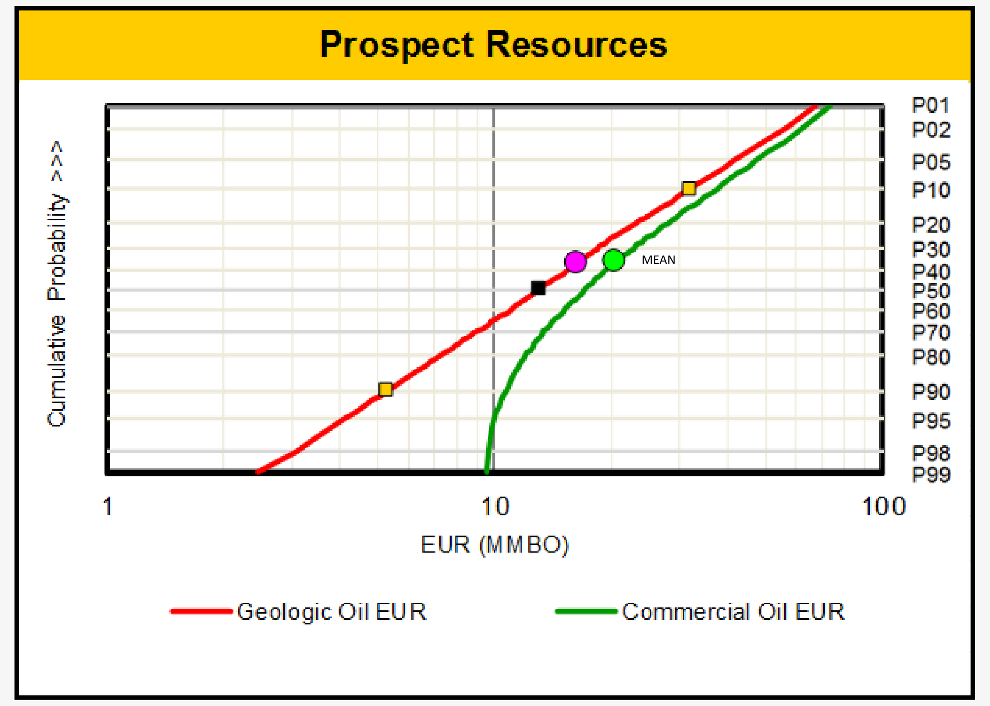

Figure 3: Simulated Prospect Geologic and Commercial EUR Distributions. Commercial resources distribution based on MCFS = 9.4 MMBO.

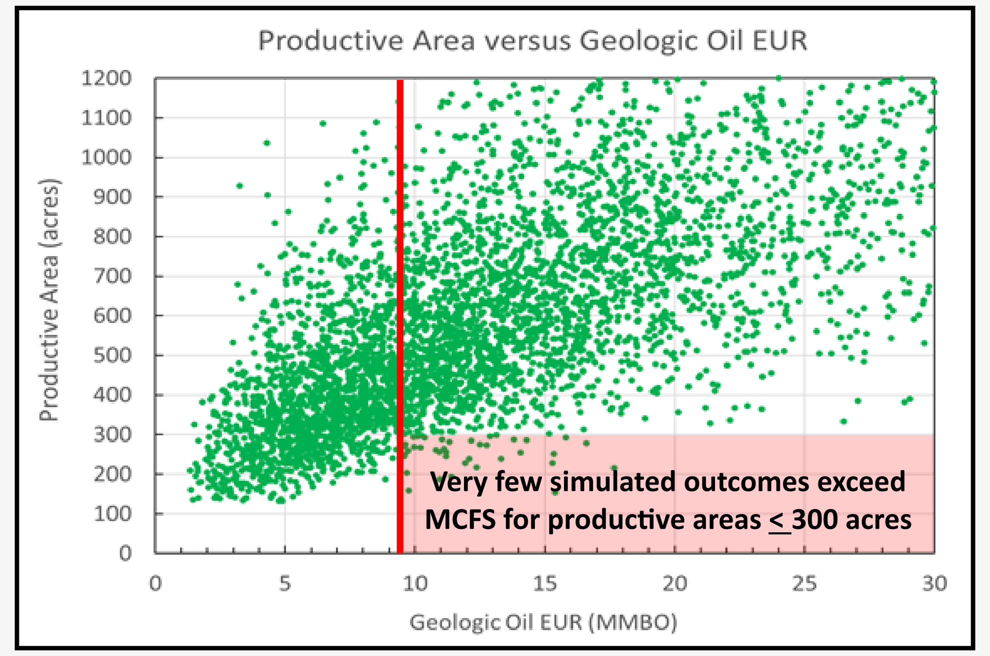

Figure 4: Productive Area samples versus simulated Prospect Geologic Oil Resources. Development is only approved if commercial volumes greater than the MCFS of 9.4 MMBO (the vertical red line) are discovered. The EUR of 9.4 MMBO is associated with productive areas from 200 to 1500 acres. EUR is a function of many parameters, not just area, so that large or small values for pay or porosity contribute to the wide EUR range. Notice there are very few simulated outcomes $\leq$ 300 acres that exceed MCFS. This suggests a well at this location would almost guarantee the need for appraisal.

No single areal well location will validate all possible outcomes of exceeding MCFS. Besides area, the updip resources are a function of many parameters including the reservoir thickness, net-to-gross ratio, porosity, recovery factor and others—any of which can sample large or small values to determine the resources.

The "No Regrets" updip volume (defined as the well location's area multiplied by the mean average net pay and mean oil recovery yield) is useful to the decision-maker, however, it is an oversimplification.

For most downdip well locations, there remains a chance the updip volume will exceed MCFS. So it is important to consider the full probabilistic resource range for the drilling location's Updip and Downdip volumes along with the chances of success in the decision making process.

A decision tree using the oversimplified case of exceeding MCFS or not is shown in Figure 5 to compare the EMV of drilling a well on the crest requiring an appraisal well with drilling a well downdip which, with discovery, leads directly to development without an appraisal well.

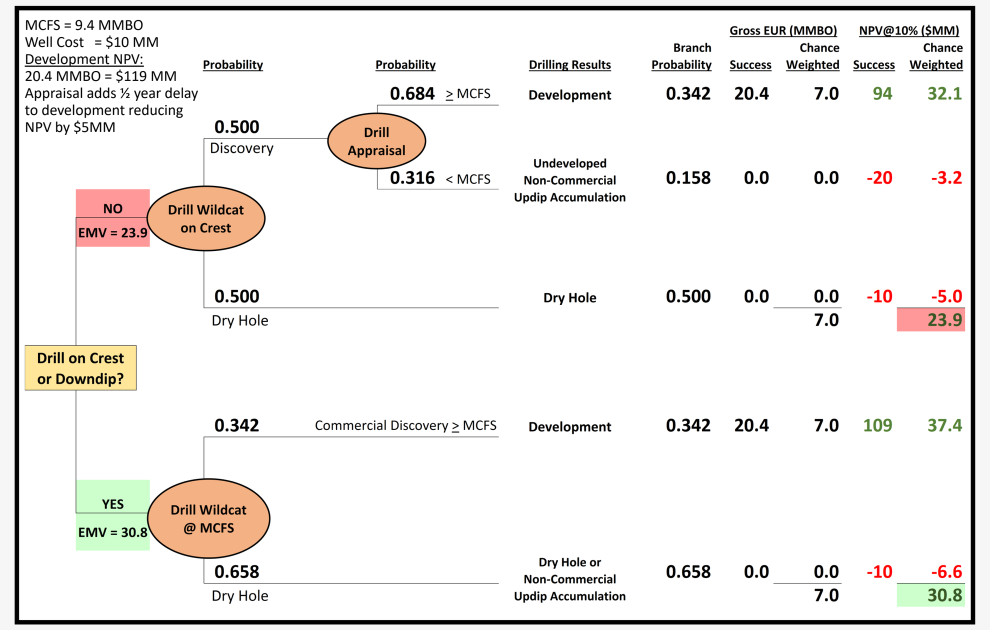

Figure 5: Simple decision tree comparing the EMV for drilling exploration well on crest versus downdip. Upper part of tree shows drilling a crestal well plus an appraisal well versus the lower part of the tree's commercially truncated EUR so that a discovery leads directly to development. The Commercial EUR without an appraisal increases EMV by 29%. The downdip well location is not specified causing this evaluation to be too simplistic.

To answer the questions introduced earlier, we need a probabilistic evaluation for a specified well location analyzing the Updip and Downdip EUR distributions relative to the well location. Figure 6 shows results for a single well location; and Figure 7 shows results for multiple well locations covering a wide range of area.

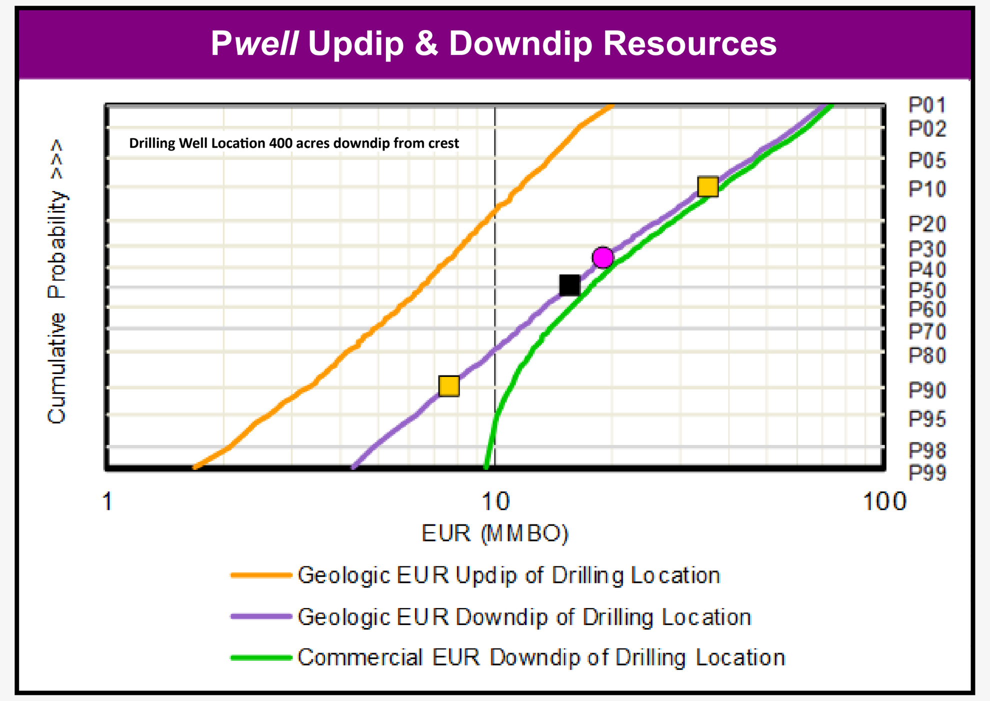

Figure 6: Updip and Downdip Geologic EUR Distributions for a well located 400 acres downdip from crest. The Downdip Commercial EUR distribution (green) is also shown with MCFS = 9.4 MMBO. Note the significant overlap of the Updip (orange) and Downdip (purple) EUR distributions.

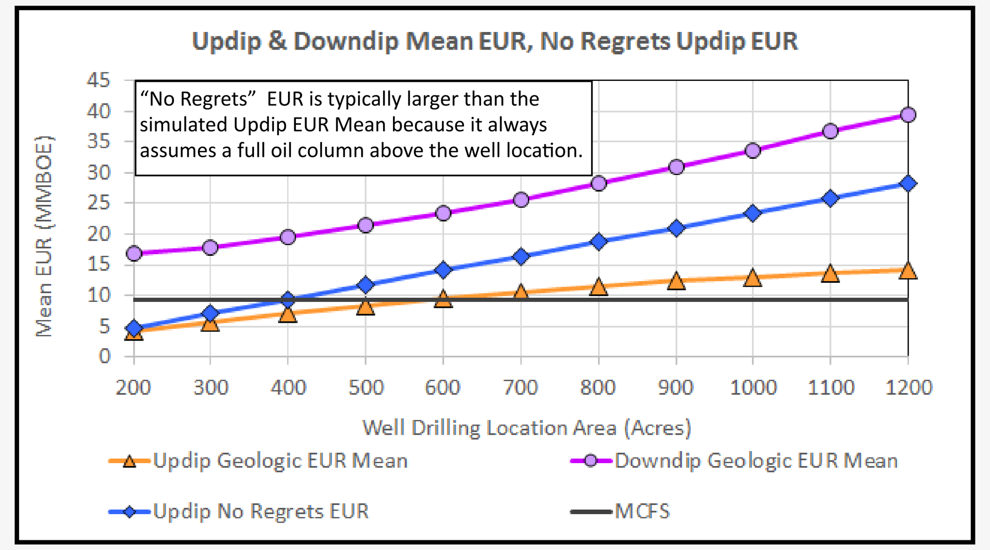

Figure 7: Geologic Updip and Downdip Mean EUR resources and the Updip "No Regrets" EUR as a function of well drilling location. The thick black horizontal line shown is the MCFS of 9.4 MMBO. From this plot, a well at 700 acres is likely too far downdip as the orange Updip Mean EUR > MCFS and the blue "No Regrets" EUR is 16.4 MMBO. A dry hole at 700 acres would likely leave regrets leading to an updip appraisal well.

Drilling a Downdip Location: Effect on Updip and Downdip Resource Estimates and Commercial Chance

Panel 2: Investigate a Downdip Drilling Location of an Uncorrelated Area – Net Pay Prospect Assessment

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Pg, the probability of geologic success, is the chance of an active hydrocarbon system that provides oil and/or gas in quantities sufficient for sustainable flow. For convenience, this is often interpreted to be the P99 EUR. The prospect *Pg* is independent of the well location and commerciality.

The chance of a geologic discovery at the well location (*Pwell*) is given by the equation in textbox to the right. For a well at 400 acres, *Pwell* is equal to Pg (0.50) multiplied by *Ptrap@well* (P77.5 from area distribution for a well located 400 acres downdip of crest) divided by *Ptrap* for the prospect (0.90). Thus, *Pwell* = 0.43 should be reported as the chance of finding oil at the well location.

The chance of commercial success and commercial EUR volumes are required for economic evaluation (i.e. an undeveloped discovery generates no revenue; so Pg alone is insufficient).

Pc, the probability of commercial success, is the chance that a discovery will exceed MCFS and justify development. Pc is equal to the product of Pg and *Pmcfs* as given in the textbox to the right.

The chance that a discovery will be a commercial development at the well location (*Pc(well)*) is also shown to the right. For the prospect, *Pc(well)* is equal to *Pwell* (0.43) multiplied by *Pmcfs(well)* (0.82) for a well located 400 acres downdip of crest. Therefore, *Pc(well)* = 0.35 should be used in the economic evaluation for a well located 400 acres downdip.

Adjusting Pg for a Downdip Well Location:

$$Pwell = Pg \times \frac{Ptrap@well}{Ptrap} = Pg \times \frac{Ptrap@well}{0.90}$$

where:

- *Pwell* = Probability of Discovery at the Drilling Well Location (if area updip of P90 Area, *Pwell* = *Pg*)
- *Pg* = Probability of Geologic Success for the Prospect (i.e. P99 EUR or more)
- *Ptrap* = Percentile used to assess geologic sub-factor for prospect trap (i.e. P90 Area)
- *Ptrap@well* = Percentile from area distribution at well location representing trap with oil column (*Ptrap@well* ≤ *Ptrap*)

Calculating Pc for a Downdip Well Location:

$$Pc = Pg \times Pmcfs$$

$$Pc(well) = Pwell \times Pmcfs(well)$$

where:

- Pc = Probability of Commercial Success for the Prospect
- *Pmcfs* = Probability a Discovery will find EUR ≥ MCFS
- *Pc(well)* = Probability of Commercial Success for a Well drilled Downdip from crest (if the area is updip of P90 Area, *Pc(well)* = Pc)
- *Pmcfs(well)* = Probability a Discovery from a Well drilled Downdip from crest will find EUR ≥ MCFS

Calculating EMV for a Downdip Well Location:

$$EMV = (Pc(well) \times PVs) + (Pf \times PVf)$$

where:

- EMV = Expected Monetary Value (chance-weighted PVs and PVf)
- *Pc(well)* = Probability of Commercial Success for a Well drilled Downdip from crest (if area updip of P90 Area, *Pc(well)* = Pc)
- PVs = Present Value of Commercial Success
- Pf = Probability of Commercial Failure (i.e. *Pf* = 1 - *Pc(well)*)
- PVf = Present Value of Commercial Failure (typically dry hole cost of exploration and appraisal wells)

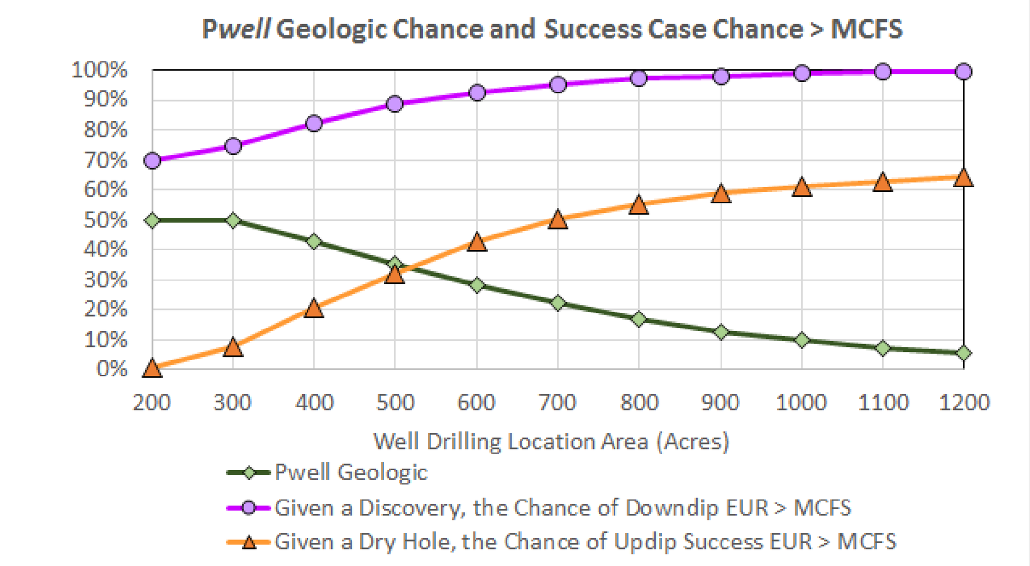

Figure 8: Chance of Geologic Success at Well Location and Chance a Discovery for Updip and Downdip Distributions has EUR exceeding the MCFS as a function of well drilling location. The prospect *Pg* is held constant at 50% for areas less than 300 acres because *Pg* is assessed at the P90 Area (300 acres for this prospect). The green chance of discovery at the well location (*Pwell*) decreases as you go downdip. The purple Downdip curve shows as the well location is moved further downdip, a discovery confirms a larger oil column with the impact being that success case EUR has a greater chance of exceeding the MCFS (approaching 100% chance at 1000 acres downdip from the crest). The orange Updip curve shows if the well location is very near the crest (in this example, 200 acres or less), there is effectively no chance that the updip volumes will exceed MCFS.

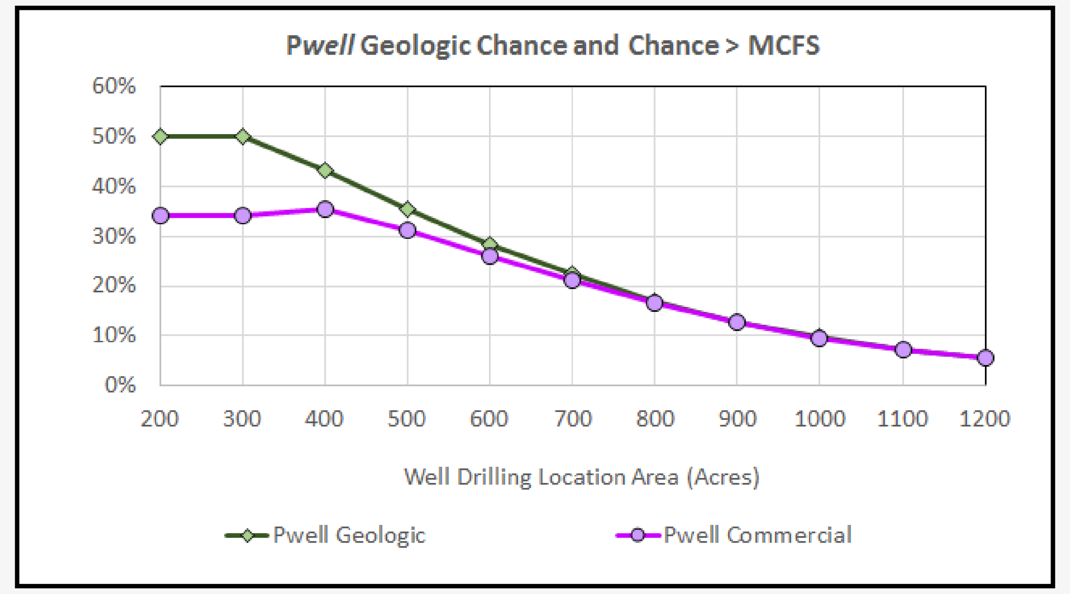

Figure 9: Chance of Geologic and Commercial Success as a function of well drilling location. For reference, the green Chance of Geologic Success at Well Location is the same as in Figure 8. The purple Chance of Commercial Success at the Well Location, *Pc(well)*, is given by the equation in textbox to the left. Notice how the two curves converge as the well location goes further downdip as *Pmcfs(well)* is approaching 100%.

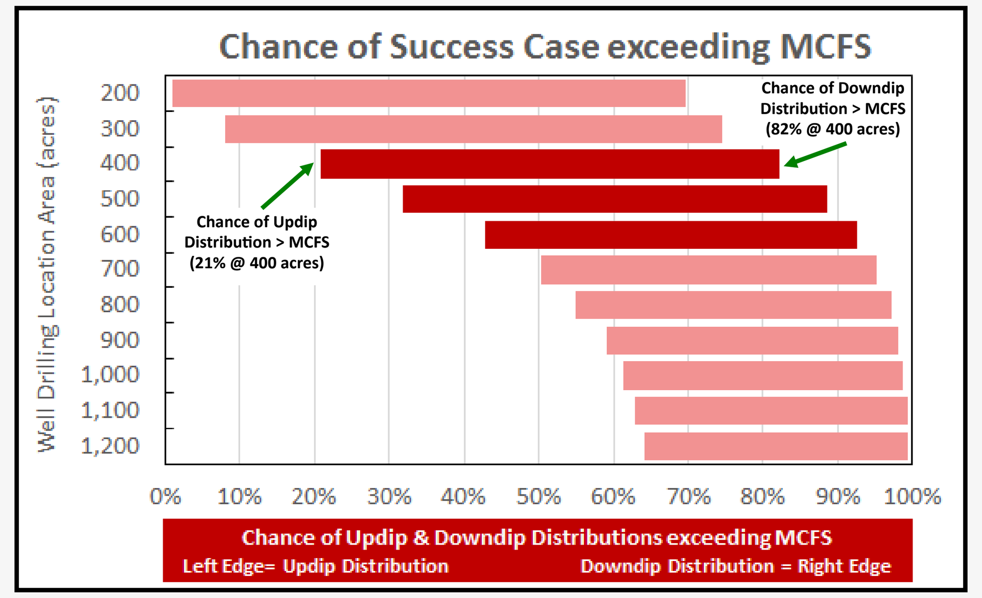

Figure 10: Chance of Success Case exceeding MCFS range for Updip and Downdip Distributions as a function of well drilling location. The bar chart displays the information presented in Figure 8 in a rotated 90° format that may be helpful for decision makers. Dark red histogram bars focus on likely drilling well locations. For a "perfect" well location, a discovery would have 100% chance of exceeding MCFS and a dry hole would leave the updip accumulation with 0% chance of exceeding MCFS. So, wider histogram bars are desired for the drilling well location. This figure does a good job of showing the decision tradeoffs between maximizing the chance of commercial resources in the Downdip resources with minimizing the commercial chance in Updip resources.

A Decision Maker benefits from insightful information gained from a full probabilistic evaluation of both the Updip and Downdip accumulations relative to the proposed drilling well location.

One of the more surprising insights is the large overlap of EUR between the Updip and Downdip distributions. This evaluation shows how to use this information to select a downdip well location that maximizes the chance that a well location will discover EUR ≥ MCFS, but also in event of a dry hole, minimizes the chance the Updip EUR ≥ MCFS so as to have no regrets about not sidetracking or drilling an appraisal well updip. The inherent uncertainties means there is no single "best" well location, but a better informed decision is made.

It is important to adjust the prospect Pg and Pc for the downdip well location and use these adjusted probabilities in the economic calculation of EMV.

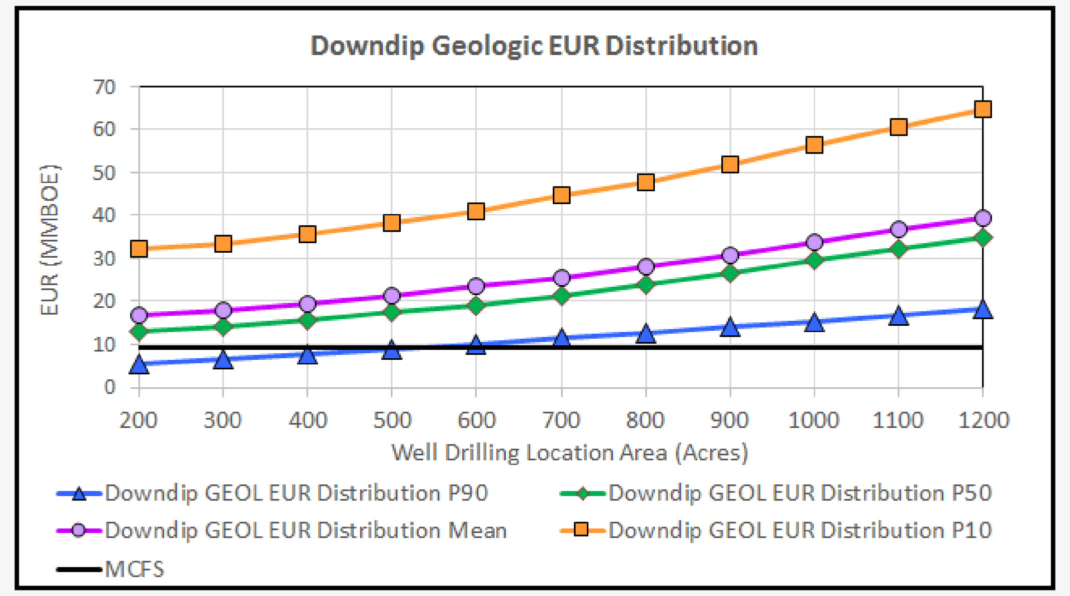

Figure 11: Downdip Geologic EUR distribution key percentiles and Mean EUR as a function of well drilling location. The thick black horizontal line shown is the MCFS of 9.4 MMBO. Figures 11 and 12 reinforce that consideration of the full probabilistic EUR range is critical in understanding consequences of any well drilling location. For example, notice that for a downdip well located between 500 and 600 acres (blue curve), there is about a 90% chance a discovery will exceed MCFS. Wells drilled further downdip have a higher chance of the EUR exceeding MCFS, but is that increased downdip chance warranted given the tradeoff of leaving behind larger Updip Resources as shown in Figure 12?

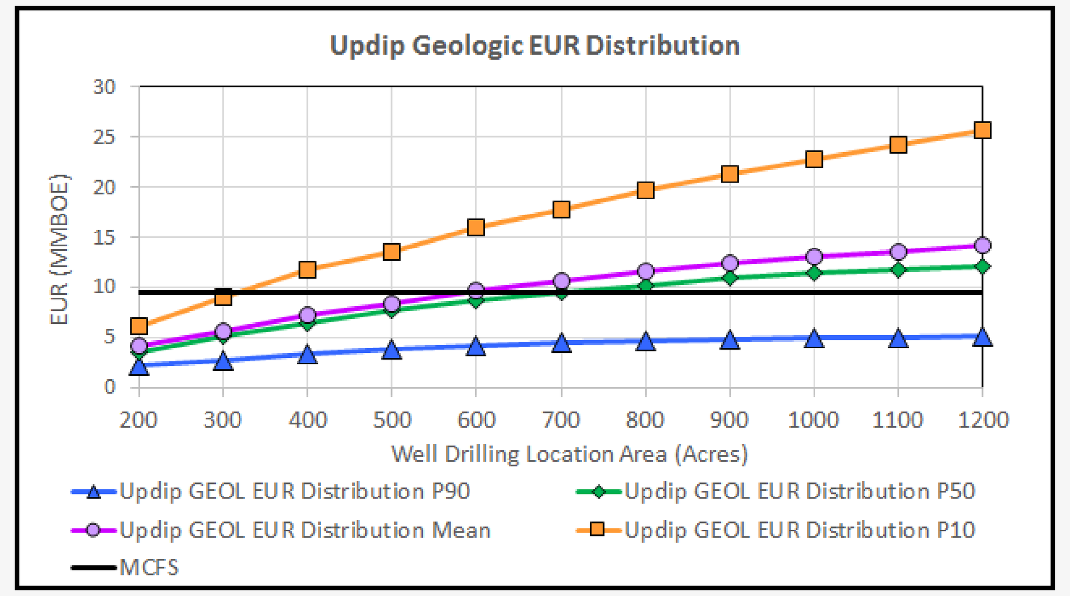

Figure 12: Updip Geologic EUR distribution key percentiles and Mean EUR as a function of well drilling location. The thick black horizontal line shown is the MCFS of 9.4 MMBO. At about 600 acres, the Updip Mean EUR (purple) is a little larger than the MCFS. Can the decision maker tolerate a 40% (the percentile associated with the mean EUR) chance of commercial volumes in an updip position if the downdip well was a dry hole or would there be regrets resulting in an appraisal well and increased costs?

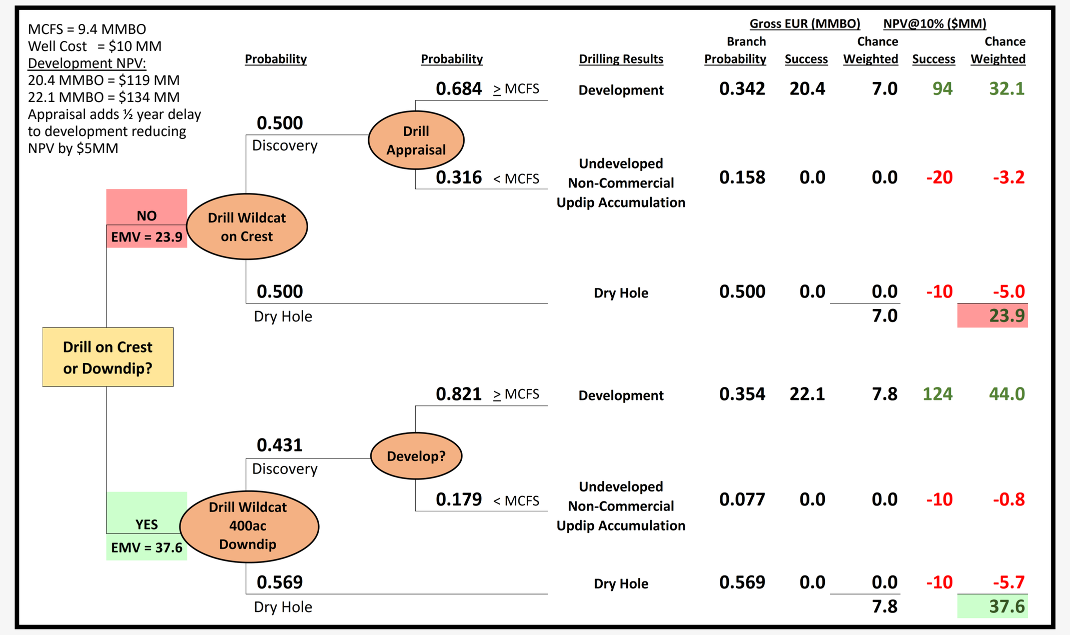

Figure 13: Decision tree using the drilling well location at 400 acres downdip from crest to determine *Pwell* (*Pg* adjusted to the well location), *Pmcfs(well)* given success at well location, the corresponding *Pc(well)* (i.e. *Pwell* * *Pmcfs(well)*) and the Commercial Downdip Mean EUR. This more rigorous evaluation gives stronger support to drilling the downdip well than the overly simplified Figure 5 decision tree since there is greater uplift in EMV drilling downdip versus the crestal well. This EMV calculation can be prepared for the full range of productive area associated with possible drilling well locations.

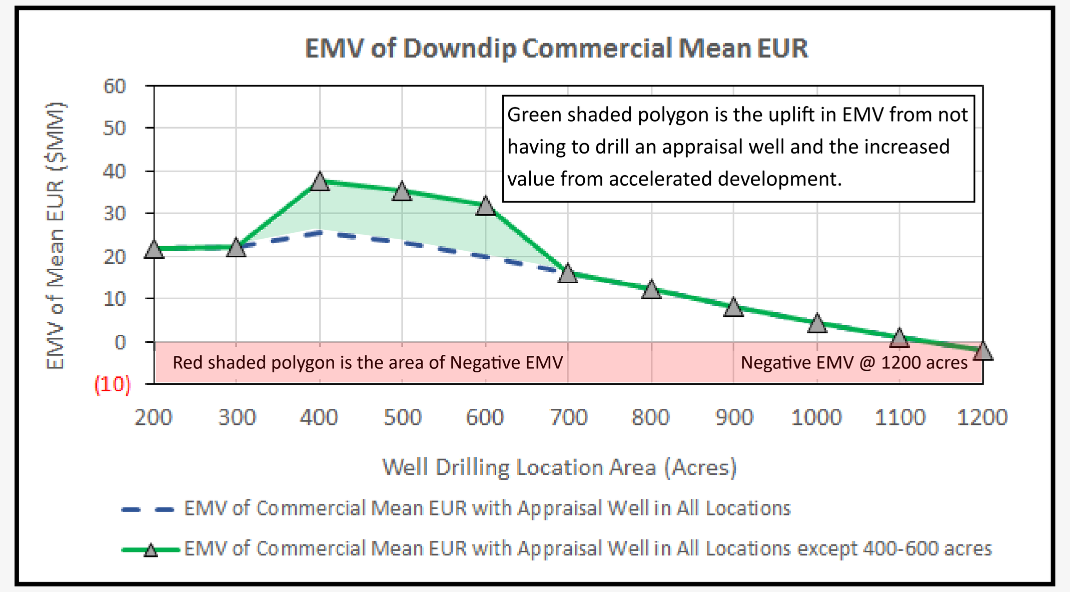

Figure 14: Expected Monetary Value (EMV) as a function of well drilling location. This plot shows the EMV of a decision tree for each drilling location (e.g. the Figure 13 400 acre EMV of $37.6MM without appraisal is shown on the green curve). The green curve assumes appraisal is required if the exploration well is drilled ≤ 300 acres from crest (downdip appraisal) or ≥ 700 acres (a dry hole leads to updip sidetrack). A well location from 400 to 600 acres would not require appraisal. These assumptions maximize EMV at 400 acres and need to be consistent with the decision-making process and need to be verified as reasonable as would all other assumptions made for accurate economic evaluation.

Observations

Observations from the prospect evaluation presented on these first two panels for selecting a drilling well location include:

1) The maximum Pc occurs at 400 acres (Figure 9).

2) A well location at 400-500 acres would decrease the chance of a geologic discovery from 50% to about 40% with about 30% commercial chance (Figure 9).

3) What level of risk is tolerable for leaving Updip resources that would not be drilled? A maximum 20-30% chance of leaving behind Updip commercial resources suggests a 400-500 acre well location is appropriate. The tradeoff is that a discovery at these locations provide only an 80-90% chance of a commercial accumulation (Figure 10).

4) The Mean Updip resources for 500-700 acres is very close to the MCFS volume which is balanced by a P90 Downdip volume near or in excess of the MCFS (Figures 11 and 12). Drill further updip if this is too much to leave behind.

5) The maximum EMV occurs at 400 acres assuming that no appraisal well is drilled (Figure 14). *Maximizing EMV is always a key metric.*

Area-Net Pay Correlation Observations

The prospect presented on these first two panels has no Area-Net Pay correlation. Independence between Area and Net Pay is not always a good assumption. Area versus Depth rock volume assessments often show a positive Area-Net Pay correlation since the oil column increases in height as you go further downdip in area. Using the same prospect, but with an assumed strong Area-Net Pay correlation, is discussed on the next panel showing the importance of always including correlations in the evaluation when justified.

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Panel 3: Investigate a Downdip Drilling Location of a Correlated Area – Net Pay Prospect Assessment

All previous discussion was for a prospect with no correlation between area and average net pay. This panel uses the same prospect, but with assumption of a strong Area - Net Pay correlation to highlight the impact correlation has on the decision making process for the well location.

Figure 15 compares the prospect EUR distributions with no area-net pay correlation (r = 0.0) in red and a positive area-net pay correlation (r = +0.8) in blue. The positive correlation increases the Mean EUR and the P10/P90 uncertainty.

Figures 16 and 17 show the prospect uncorrelated and correlated EUR distributions for the drilling location at 400 acres. Each figure displays the Updip (orange) and Downdip (purple) Geologic EUR distributions and the Downdip Commercial EUR (green) distribution.

Figure 16 with no area-net pay correlation highlights the 68% overlap (tan rectangle) of the Updip and Downdip EUR distributions (P100 to P32 of Downdip Distribution). This significant EUR overlap is often surprising. A decision maker selecting a downdip well location to prove up MCFS, with the intention of not sidetracking if the well is a failure is probably not aware that the Updip EUR Distribution has a 21% chance of exceeding MCFS and the Updip P01 EUR = 20 MMBO. The insight from this makes for a better informed decision with all of the uncertainty quantified.

Figure 17 with the positive area-net pay correlation highlights how the EUR overlap (tan rectangle) is significantly reduced to only 26% (P100 to P74 of Downdip distribution). As always, this reinforces that strong correlations must be included in the assessment only when they are justified. The positive correlation's increased prospect mean EUR and overlap reduction enables a more definitive decision on the well location.

Figure 18 compares the impact of correlation by showing the chance of success as a function of the drilling well location for the Updip and Downdip EUR distributions with both no area-net pay correlation and a strong correlation. The chance at 400 acres that Updip EUR exceeds MCFS has reduced from 21% to 5% when considering the strong correlation.

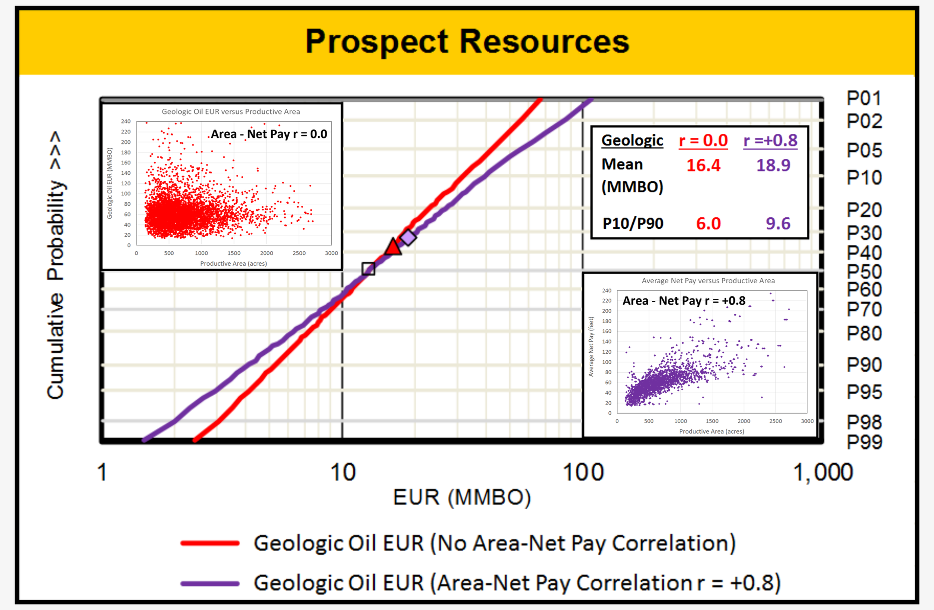

Figure 15: Geologic EUR Distributions showing impact of area – net pay correlation for r = 0.0 and r = +0.8.

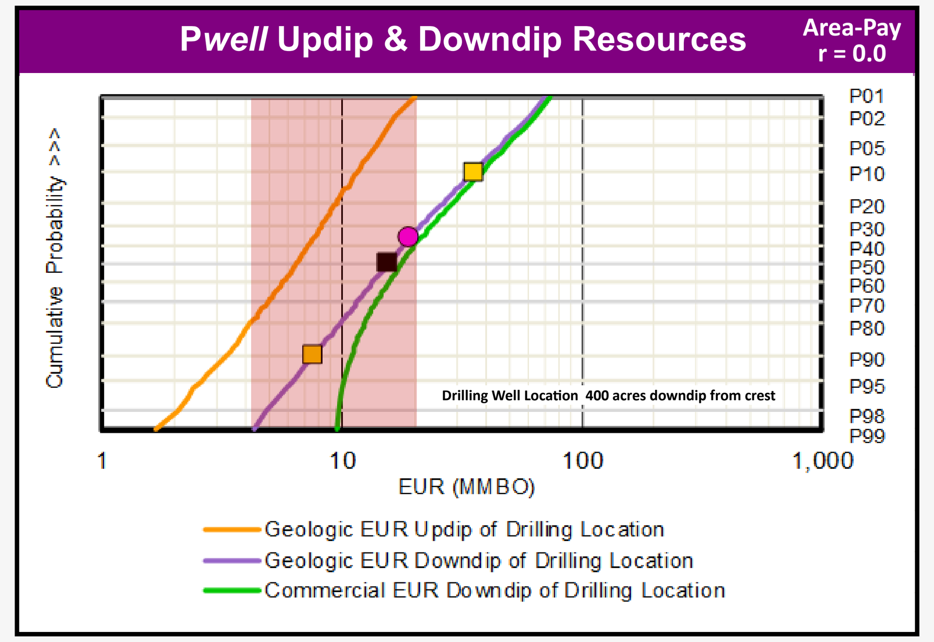

Figure 16: Updip & Downdip Geologic and Commercial distributions with well location at 400 acres with no area - net pay correlation. Downdip distribution has 68% of its EUR distribution overlapping with Updip.

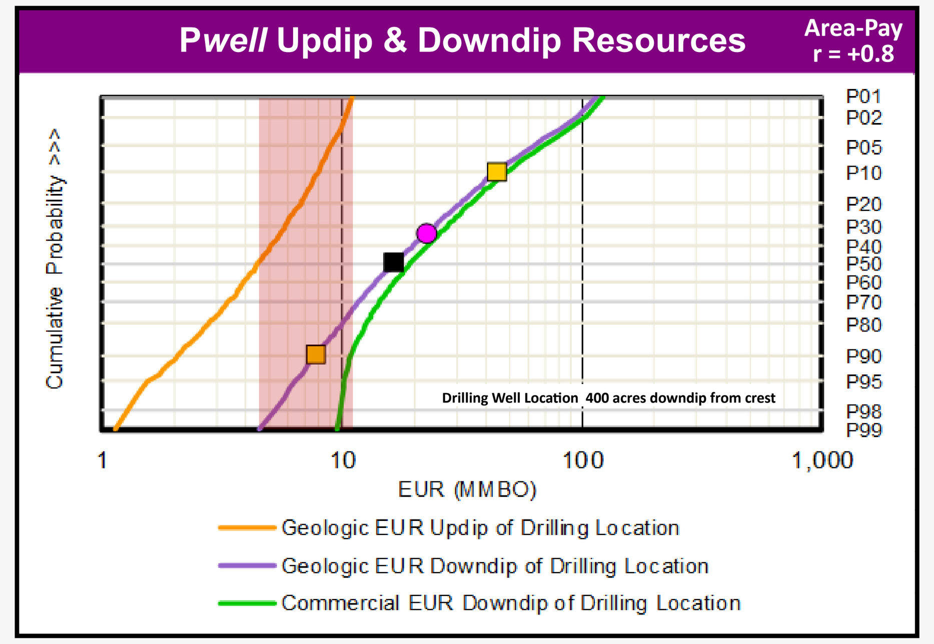

Figure 17: Updip and Downdip Geologic and Commercial distributions with well location at 400 acres with area - net pay correlated with r = +0.8. Downdip distribution overlap with the Updip EUR is reduced to 26%.

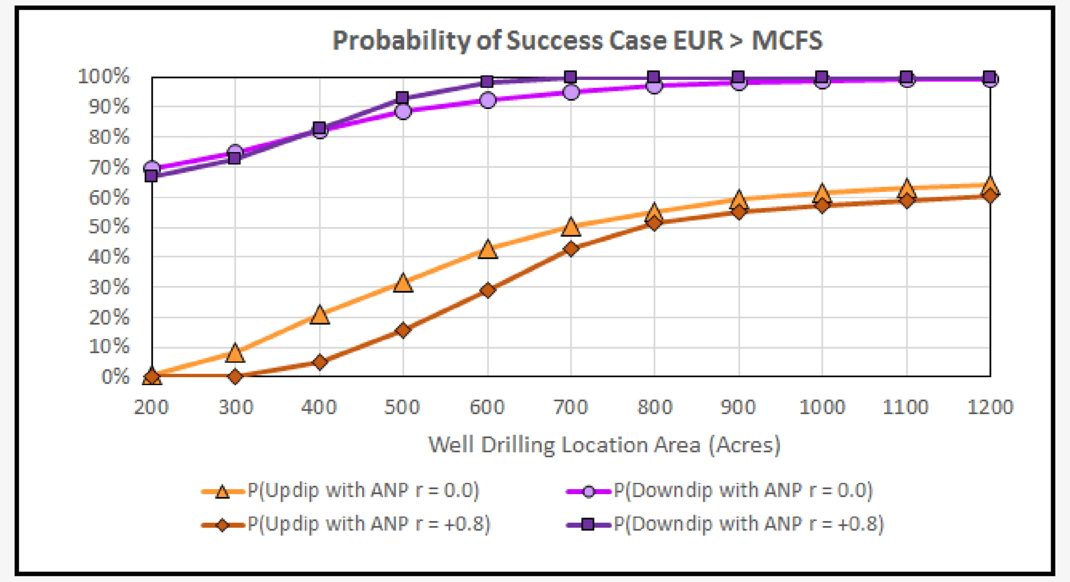

Figure 18: Effect on Success Case Chance of a Positive Area-Net Pay Correlation. The positive area-net pay correlation shows the greatest impact on the Updip chances (brown) drilled near the crest where a 0% chance of exceeding MCFS is extended from 200 to 300 acres and the chance of exceeding MCFS is significantly reduced up to 700 acres (for example, at 400 acres from 21% to 5%) because of the shorter updip column and thinner net pay. For the purple Downdip distribution, the chance of exceeding MCFS approaches 100% faster because of the thicker correlated pay with increasing oil column height.

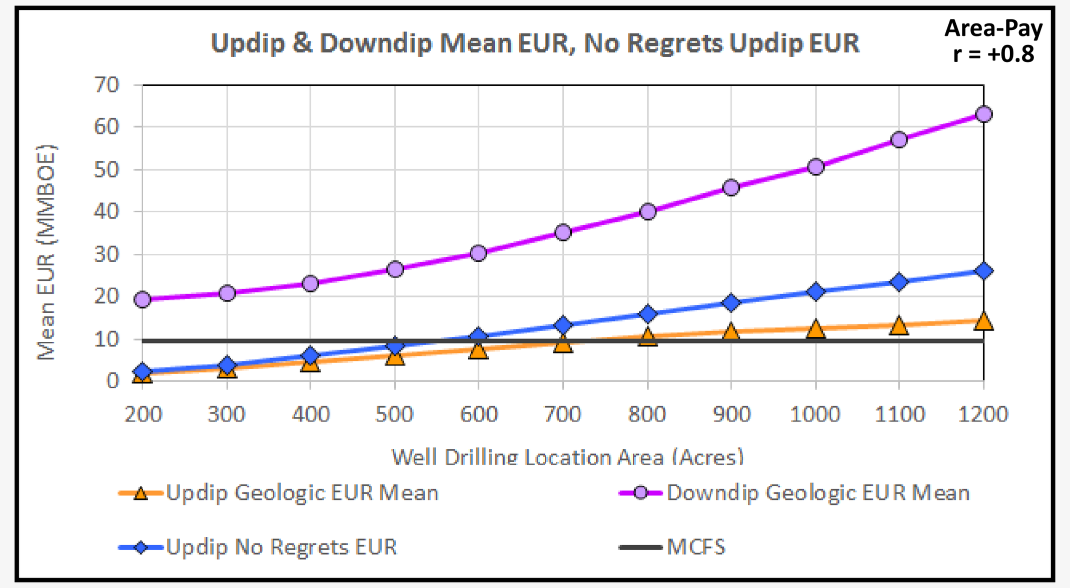

Figure 19: Geologic Updip and Downdip Mean EUR and the Updip "No Regrets" EUR as a function of well drilling location. The thick black horizontal line is the MCFS of 9.4 MMBO. Recall in Figure 7 at 700 acres, the uncorrelated Mean Updip EUR was greater than the MCFS, while here with the positive correlation the Mean Updip (orange) is less than MCFS. The correlated Mean Downdip EUR (purple) increases faster with area due to the correlation with net pay. Note the chance the Downdip EUR exceeds MCFS approaches 100% at 700 acres in Figure 20, while it is 1000 acres in Figure 8 for uncorrelated Downdip EUR.

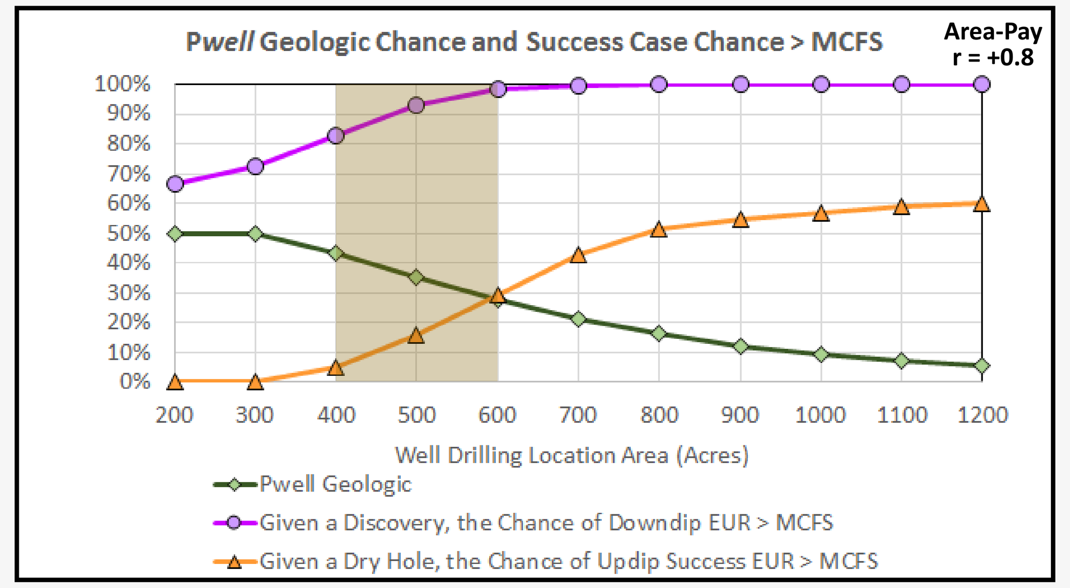

Figure 20: Chance of Geologic Success and Chance a Discovery has EUR exceeding the MCFS. Along with Figures 18 and 21, this figure highlights how the positive correlation reduces the well location decision to the range from 400 to 600 acres with less potential for commercial regrets.

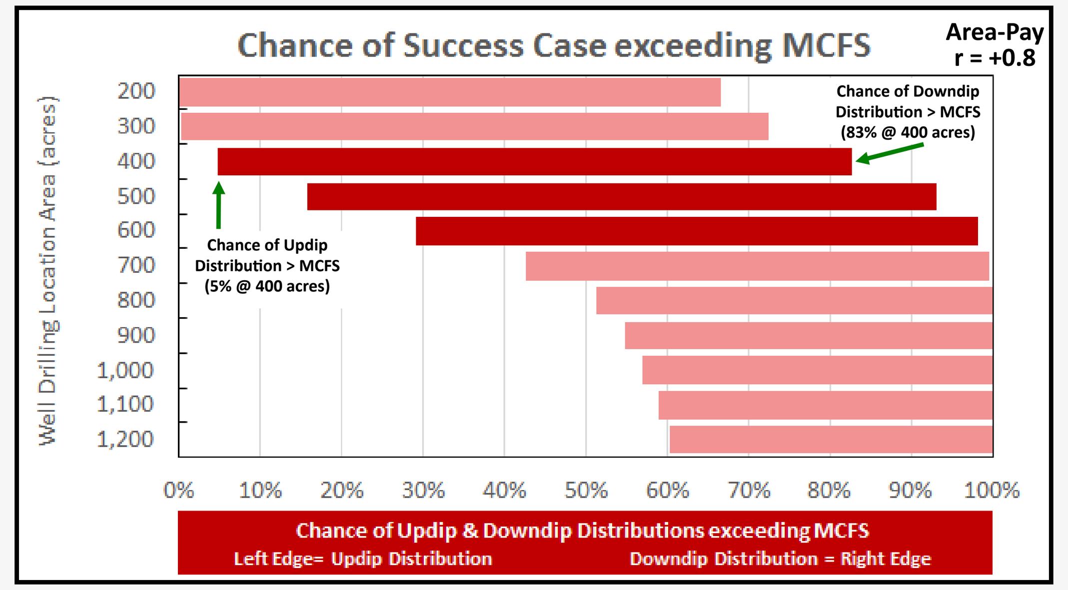

Figure 21: Chance of Success Case exceeding MCFS range for Updip and Downdip Distributions. Compared to Figure 10, the choice of 400 - 600 acres is more definitive with the correlation.

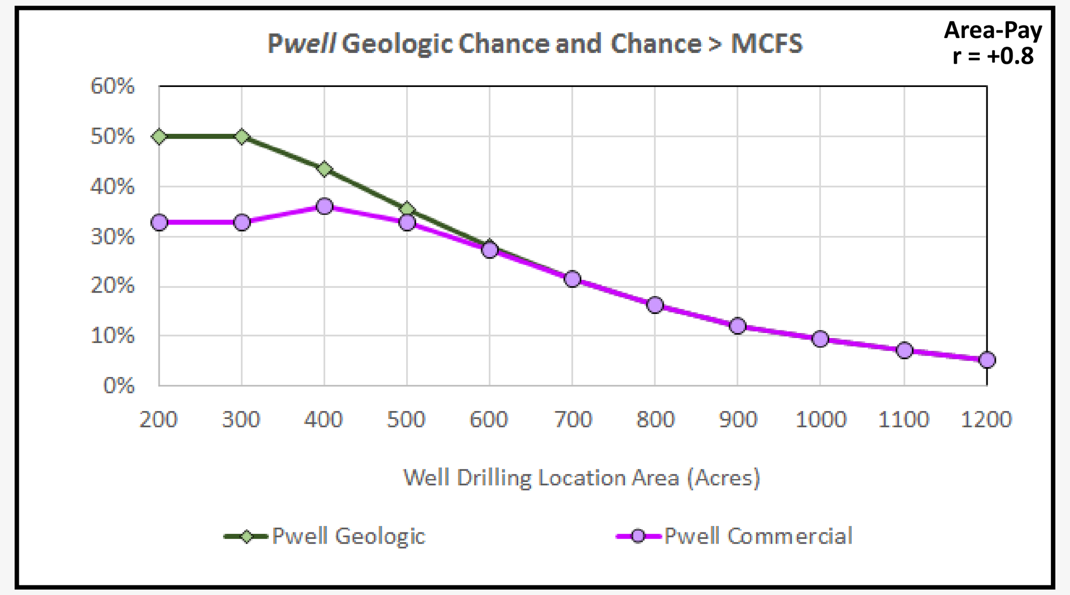

Figure 22: Chance of Geologic and Commercial Success as a function of well drilling location. The impact on Pg and Pc due to area – net pay correlation is small compared to Figure 10.

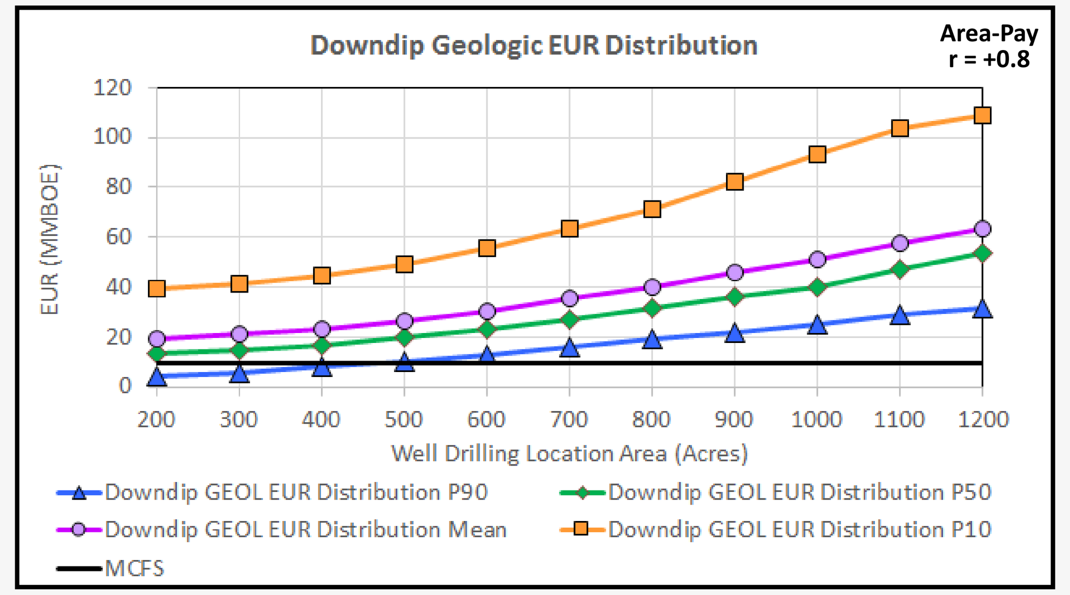

Figure 23: Downdip Geologic EUR distribution key percentiles and Mean EUR as a function of well drilling location. For a well located 400-500 acres downdip (smaller area than the no correlation model in Figure 11), the blue P90 curve shows there is about a 90% chance a discovery will exceed MCFS.

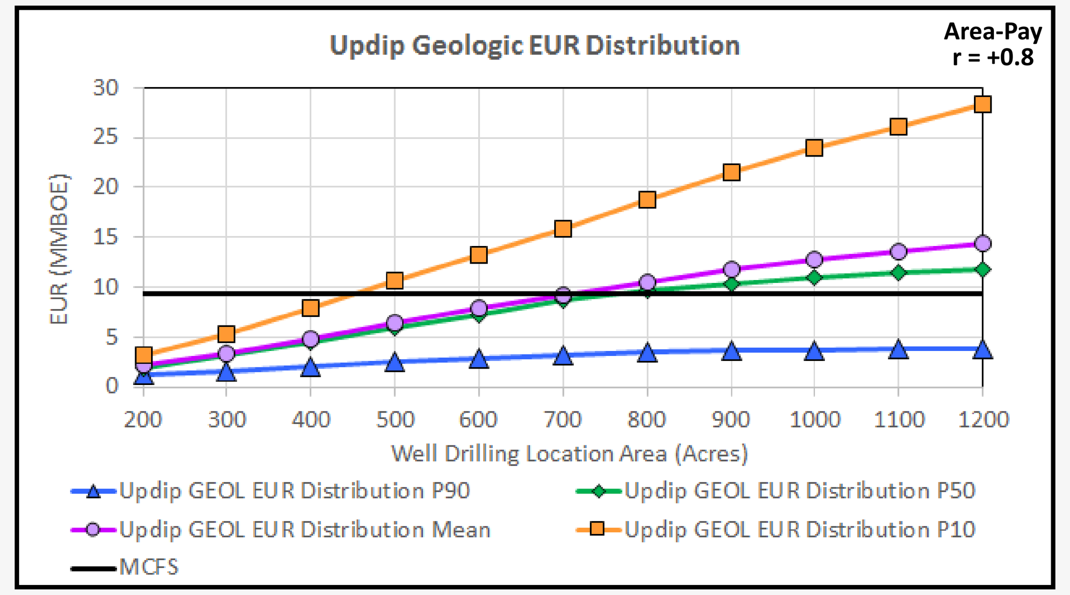

Figure 24: Updip Geologic EUR distribution key percentiles and Mean EUR as a function of well drilling location. For a well located at 400-500 acres, the orange P10 curve shows there is about a 10% chance a discovery will exceed MCFS (much less chance of updip regrets than if no correlation).

Figure 25: Decision tree using the drilling well location at 400 acres with area – net pay correlation. EMV for the correlated model is 43% higher than the uncorrelated model in Figure 13 with a similar uplift versus the crestal well. The increased EMV is mainly due to the larger Commercial Mean EUR.

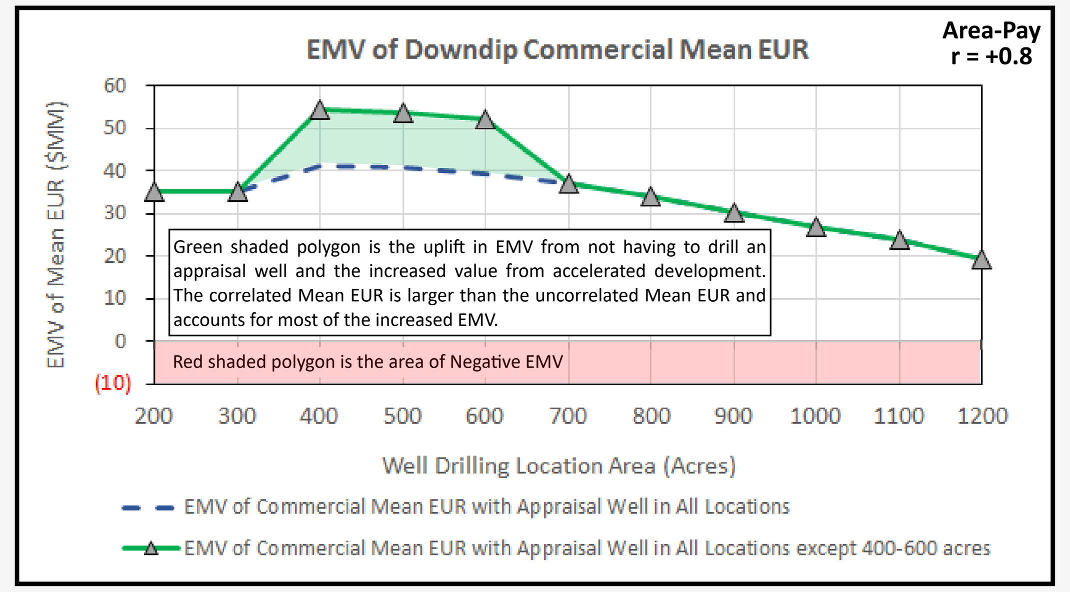

Figure 26: Expected Monetary Value (EMV) as a function of well drilling location with area – net pay correlation. Same assumptions apply as in Figure 14. Note at drilling well locations ≥ 800 acres, the EMV is less than drilling on crest due to the negative impact for Pg adjustment to the well location.

Conclusions

While other issues (e.g. seismic data quality, shallow drilling hazards, surface location, reservoir compartmentalization, testing for oil and gas columns, block boundary, well cost) impact the downdip well location decision and the required number of appraisal wells — taking into account the Updip and Downdip chance of geologic and commercial success and the full range of EUR are critical for the decision maker to understand the benefits and risks of drilling at downdip locations.

The broad uncertainty of the input parameters and simulated output must always be taken into account. With these uncertainties in mind, there may not be a single "best" well location because of 1) risk tolerance of the decision makers , 2) different metrics to be taken into account and 3) impact of changes based on the input assumptions. With the additional insights provided here, more informed decisions can be made.

Drilling at a location where EMV is maximized – due to ability to eliminate an appraisal targeted downdip to confirm commerciality or targeted updip to chase potential left-behind resources – can be a winning strategy.