Presenting:

Value of Imperfect Information with a Risk Adverse Decision Maker

by Brian Putt

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Value of Imperfect Information with a Risk Adverse Decision Maker

Should we acquire the Roadrunner well data to make a decision on drilling the Coyote Prospect?

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Problem Statement

- We have the option to drill an exploration prospect called Coyote for $8MM. But the probability of success is less than 25%, which is a key value driver for the Decision Maker (DM).
- The DM will only drill wells with a Probability of Success (POS) >= 25% as they have been “burned” with too many wells that have been unsuccessful and must be reported to Corp. Effectively the DM doesn’t value dollars spent on the well the same as spent on other aspects of the project.
- We have the opportunity to acquire some well data from an adjacent discovery - Roadrunner. With this data we believe we can significantly increase our understanding of the Coyote prospect, and therefore better assess the probability of drilling a discovery well.
- If we drill the Coyote well and it is successful, the two discoveries would be unitized making the overall development attractive.
- We do not have to pay for the information if we ultimately drill the exploration well and share the results with the other party. It does not matter whether the well is successful or not. However, if we don’t drill the well then we have to pay a consideration to the other party for looking at their data.

Decisions To Be Made

- Should we acquire the Roadrunner data?
- What should be the maximum consideration paid to look at the data if we don't drill a well?

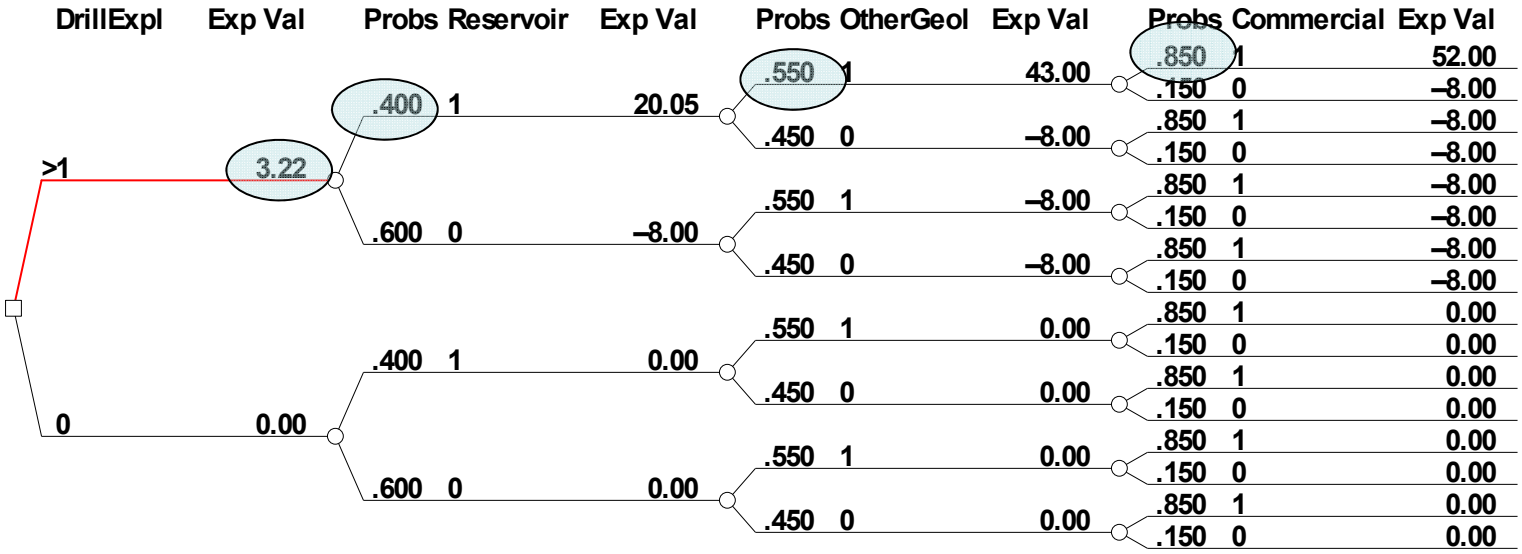
The Dilemma

- Using classical value of imperfect information analysis the maximum consideration is $4.38MM. This assumes that the DM is an expected value decision maker and would drill the well without further information as the NPV is positive.
- However, the Decision Maker is unwilling to drill the well without further information. When the value of imperfect information is compared to doing nothing (not drilling) the maximum consideration increases to $9.58MM.
- But the cost of drilling a well is only $8MM. Why would we pay a consideration above the well cost?

Further Problem Definition

- The well data provides information whether “reservoir” is present but will not impact the probability of other factors required for a successful well.
- The current probability assessment of the reservoir being present is 40%
- Excluding reservoir, the probability of geologic success is 55%
- This yields an overall probability of success of 22%
- The cost of the well is $8MM
- Given the range of reserve assessments there is an 85% chance of being commercial if the well is successful.
- If the well is successful and commercial, development would yield an NPV of $60MM (excluding the exploration well.)

Without Any Information the EV is $3.22MM with a 22% chance of a successful well and a 18.7% chance of development

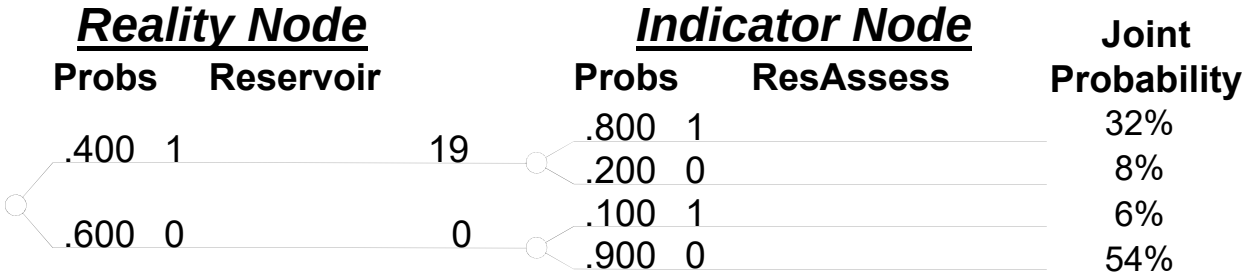


Prob Successful Well = 22% = 40% * 55% which less than the hurdle rate

Prob Development = Prob Successful Well * Prob Commercial = 18.7% = 22% * 85%

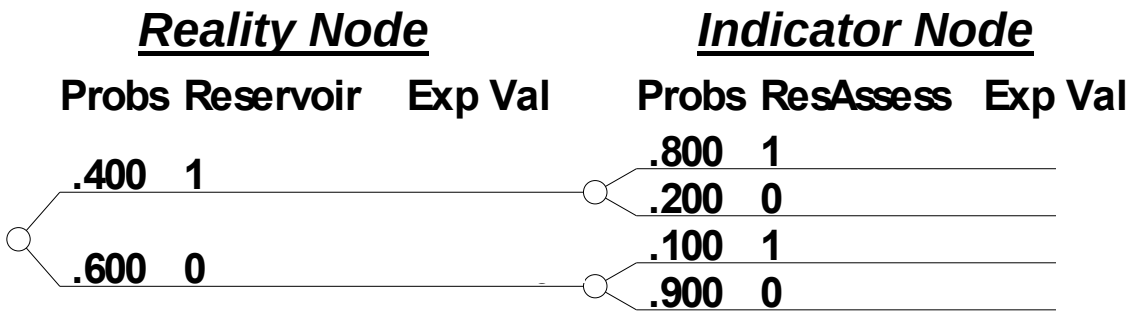
Roadrunner Well Data will provide imperfect information

- If the Coyote reservoir exists then with the Roadrunner data we can predict the reservoir with 80% accuracy.
- There is a 20% probability that we would not predict the Coyote reservoir when it existed.
- If the Coyote reservoir does not exist, then processing the Roadrunner data will indicate that with 90% certainty that the reservoir doesn't exist.

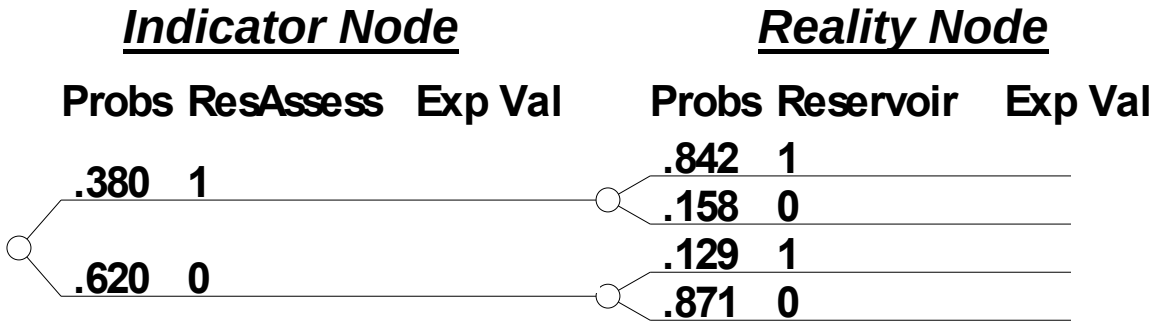


Bayes Law To Invert The Uncertainty Nodes

Natures Order

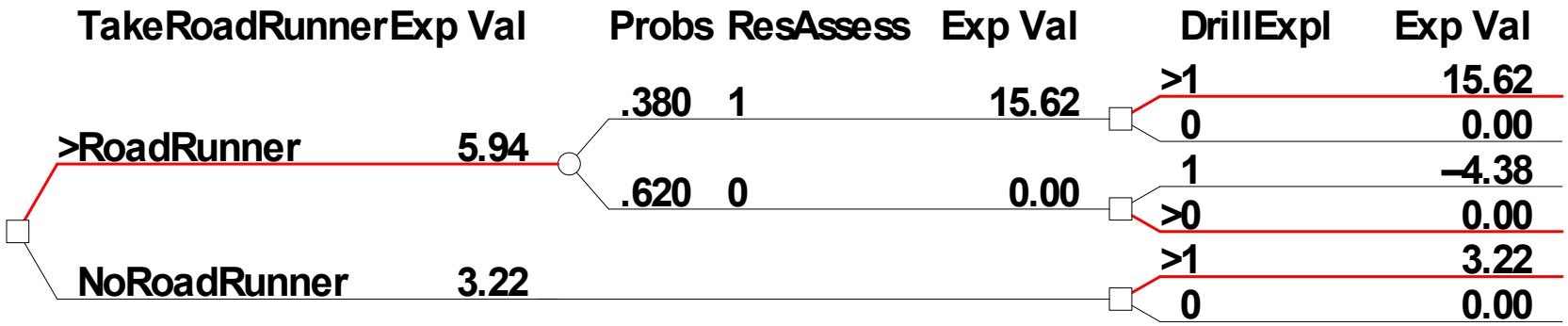


Using Bayes Law the probabilities change when the indicator node is moved in front of the reality node



Access to the Roadrunner Data increases overall value of project to $5.94MM from $3.22M.

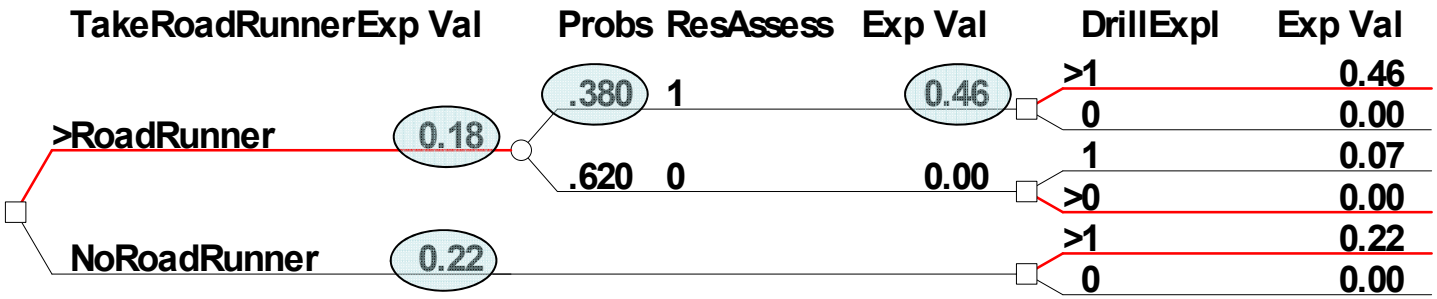
Implied Value of information = 5.94 - 3.22 = $2.72MM



Decision Policy is to drill the well when the reassessment shows a reservoir and not drill the well when it doesn't. By not drilling the well we become obligated to pay the consideration. Here the consideration=0.

Probability of Drilling a Successful Exploration Well Increases Utilizing the Roadrunner Data

- With the Roadrunner data the probability of a successful exploration well increases to 46% IF there is a favorable indication and we drill the well. This exceeds the DM's hurdle rate of 25% that was previously not met.
- However, there is only an 18% probability overall of a geologic success since we only drill 38% of the time. (62% probability of paying the consideration)

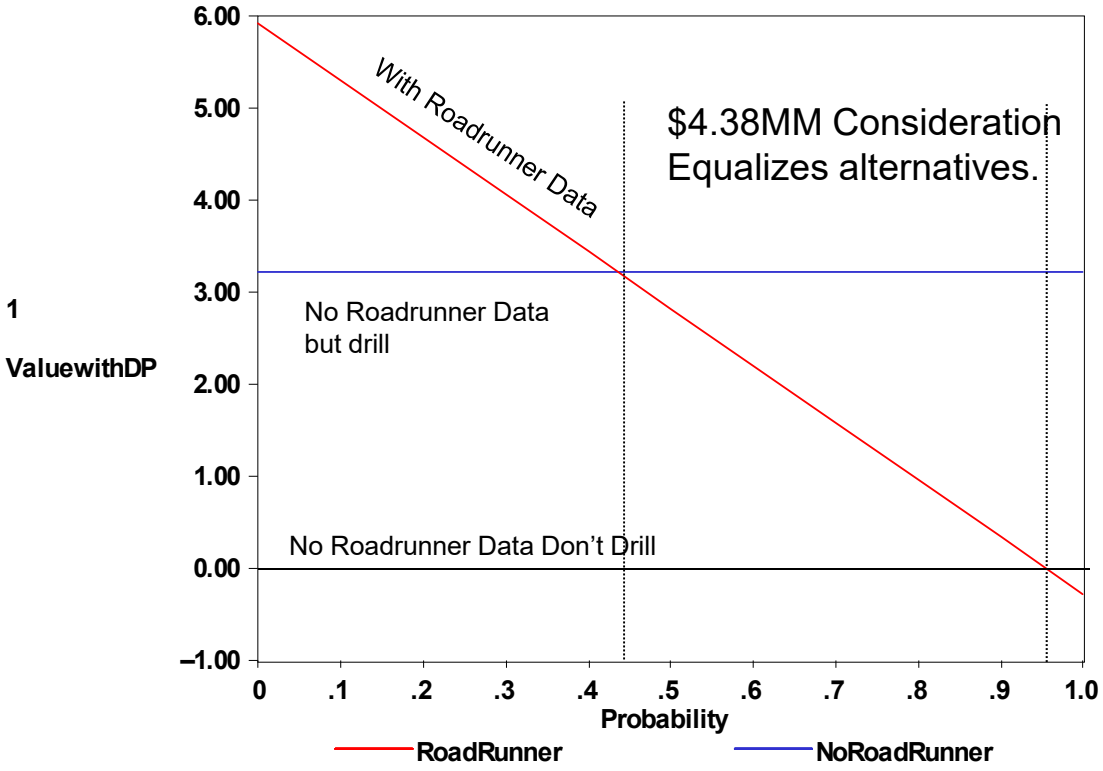


Tree rolled back using NPV as decision criteria but displaying geologic success variable.

Conclusions – Thus Far

- Existing project without Roadrunner data, while attractive from an NPV perspective, does not meet the Business Unit's hurdle rates for a 25% probability of a successful exploration well
- Access to the Roadrunner data would increase both the value of the project and the probability of a successful well if drilled.
- Issue:
  - Should the value of information be measured assuming that we drill the well (even though we would not) or from a base value of zero (i.e. not drilling). Is the value of information = 5.94 or 2.72?
  - How does this translate into the maximum consideration that we could pay if we did not drill the well?

Consideration to Pay -- $4.39 or $9.58



$0MM Consideration

$10MM

Remember that we anticipate paying the consideration only 62% of the time.

Note that (5.94-3.22)/.62=4.38

And (5.94-0)/.62 = 9.58

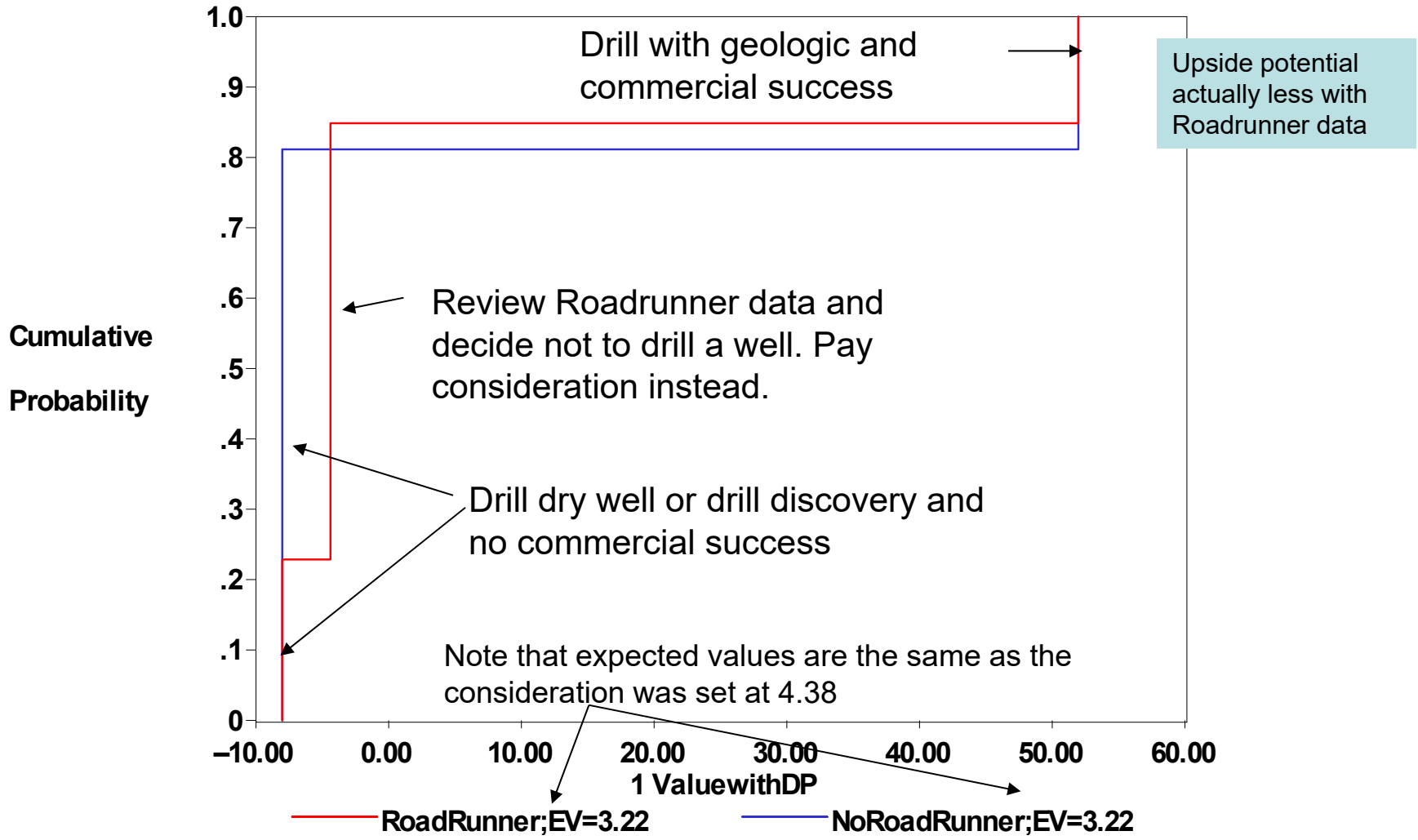
Sensitivity to Probability

Present order of nodes: 1 2 3 4 5 6 7 8
New order of nodes: 1 2 3 4 5 6 7 8
Sensitivity to probability for node: 8
There are 4 endpoint measures: ValuewithDP;ValuewithoutDP;POSGwDP;POSGwoDP
Measure displayed: 1 ValuewithDP
Measure for decision criterion: 1 ValuewithDP

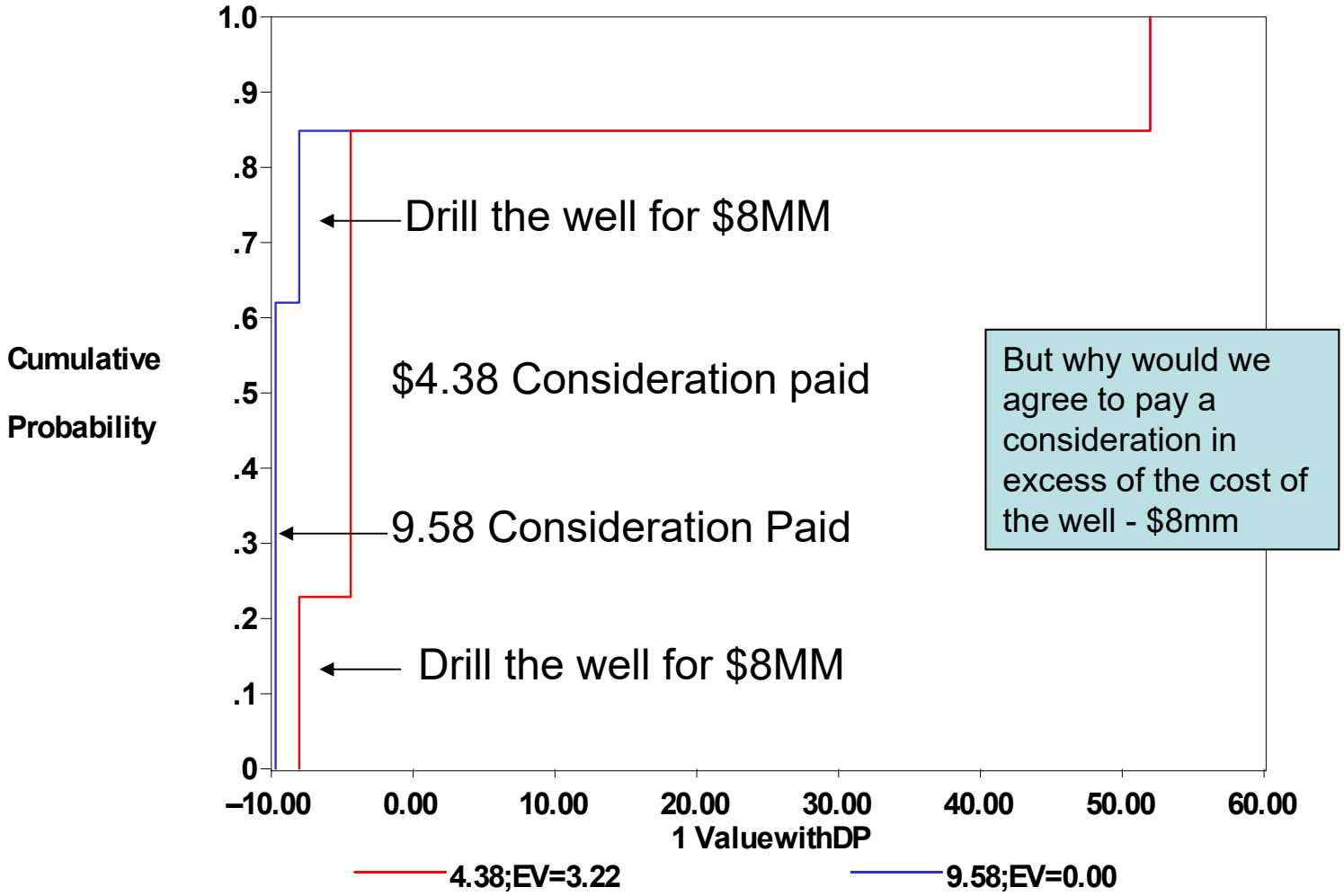
Probability Sensitivity 4/23/03 9:34 Roadrunner Exploration Well

Value of Alternatives with Consideration of $4.38MM

Think of the consideration $4.38MM as being paid in lieu of drilling a dry well for $8MM



Comparison of Alternative Considerations
($4.38MM vs $9.58MM)



Conclusions

- Being able to correlate the Roadrunner data to our seismic allows us to make a better decision whether to drill
  - When we drill a well, the probability of drilling a geologic discovery well increases to 46% from 22% without the data.
  - NPV increases to 5.94 from either 3.22 or Zero.
- We would anticipate paying the consideration only 62% of the time so the EV consideration paid is $2.72MM which is less than paying $8MM for the well without information.
- On the one hand we should not pay more than $4.38MM consideration, but relative to what we would actual do (not drill) the analysis suggest we could pay up to $9.58MM

What should be our recommendation to the negotiation team on the upper limit to pay for the consideration?

Other supporting slides

Assumed BU Assessments

Structure	85%
Seal	80%
Reservoir	40%
Hydrocarbon Charge	80%
Overall Prob of Success (POS)	22%

Probability of Success with Roadrunner Data

• Probability of a positive indication	38%
• Probability of discovery and positive indication	32%
• Probability of discovery given positive indication	32%/38%= 84%
• Probability of discovery for other factors	55%
• Overall probability of discovery	84% * 55% = 46%

Input Section of Model

Roadrunner - Coyote Model

	Default	Used	Options -->>	
Decisions				
TakeRoadrunner	Roadrunner	Roadrunner	TakeRoadr	Roadrunne NoRoadrunner
Consideration	0	0	Consideration	
DrillExpl	1	1	DrillExpl	1=Yes, 0=No
DrillExplConditioned			1	
Subsurface Variables				
Reservoir	1	1	Reservoir	1=Yes, 0=No
ResAssess	1	1	ResAsses	1=Yes, 0=No
OtherGeol	1	1	OtherGeol	1=Success, 0=dry
Commercial	1	1	Commercia	1=Yes, 0=No
Costs				
WellCost	8	8	WellCost	
Appraisal	0	0	Appraisal	
Development Value	60	60	ValueDev	unrisked

Results Section

Results	With Imbedding Decision Policy	Without Imbedded Decision Policy
Consideration	0	0
Well Cost	-8	-8
Incur Appraisal Cost	0	0
Value of Successful Proj	60	60
	52	52
	ValuewithDP	ValuewithoutDP
Successful Expl Well	1	1
	POSGwDP	POSGwoDP
Commercial Development (Yes/No)	1	1
		POSG (Exclude Commercial)

Tree Used for Sensitivity to Probability

Show Tree Structure

Tree name: Roadrunner Exploration Well

STRUCTURE	NAMES	OUTCOMES	PROBABILITIES
1D2 3	TakeRoadRunner	RoadRunner NoRoadRunner	
2C3 3	ResAssess	1 0	Depends on 4
3D4 4	DrillExpl	1 0	
4C5 5	Reservoir	1 0	0.4 0.6
5C6 6	OtherGeol	1 0	.55 .45
6C7 7	Appraisal	8 0	0 1
7C8 8	Commercial	1 0	.85 .15
8C13 13	Consideration	10 0	1 0
13E	E$c:\wpdata\training\daa& g\expl voi roadrunner.xl& s$ValuewithDP;Valuewitho& utDP;POSGwDP;POSGwoDP$DA	Depends on 1 2 3 4 5 6& 7 8	

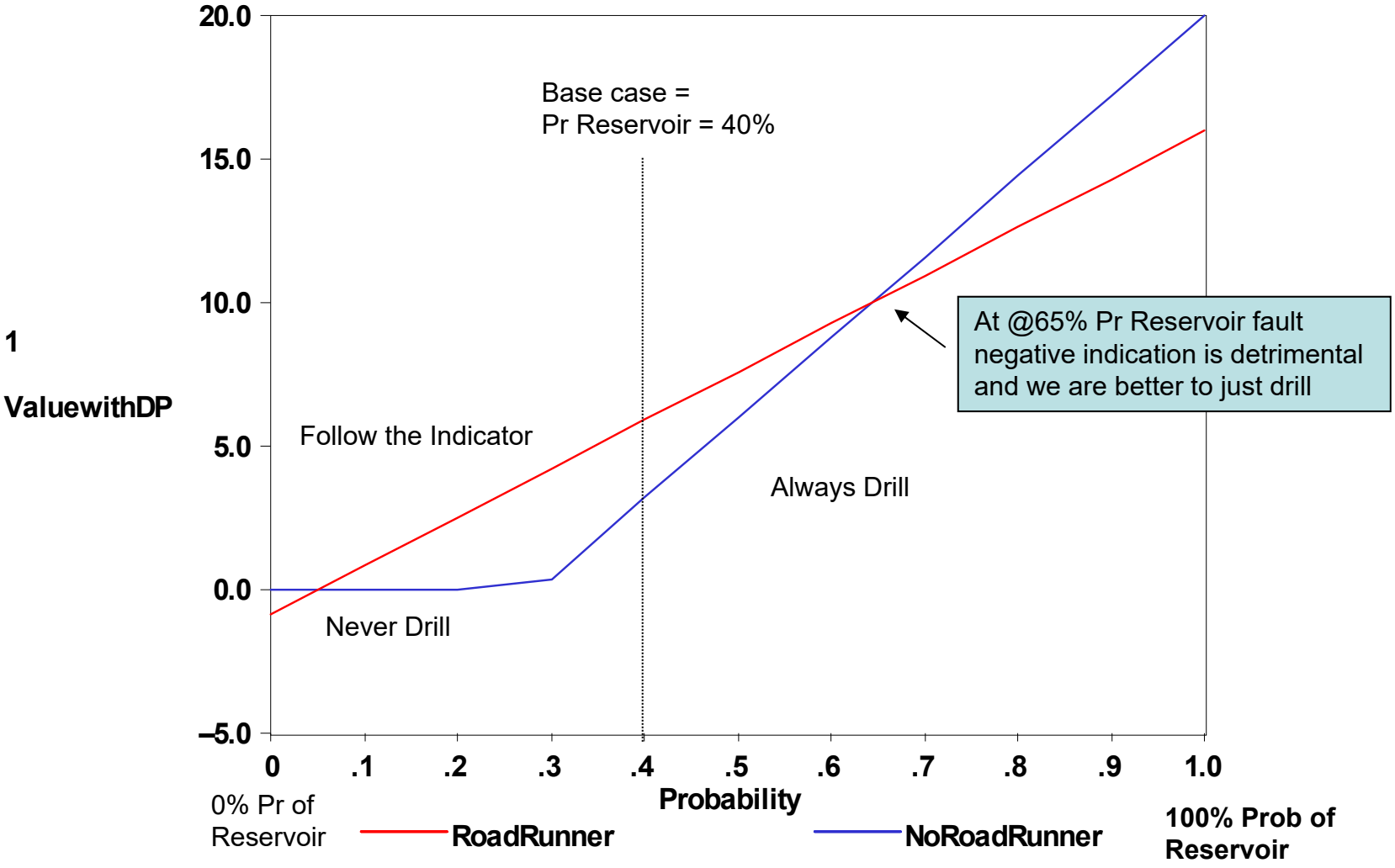
Reservoir	PROBABILITY, NODE 2
1	0.8 0.2
0	0.1 0.9

Excel options:

Open linked spreadsheets.

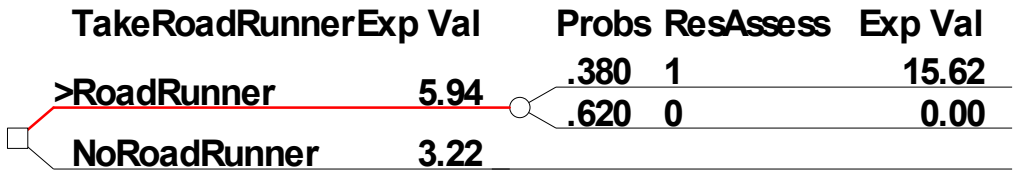
Iterate with 100 maximum iterations and 0.001 maximum change.

Sensitivity to Probability of Reservoir
(No Consideration)



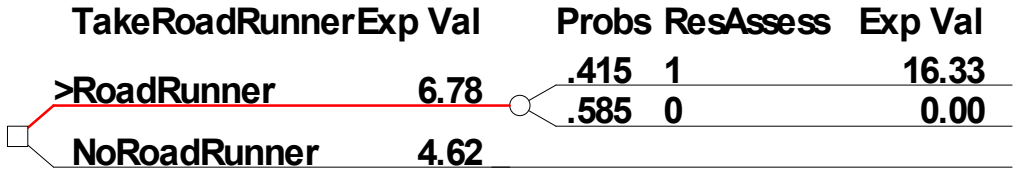
Sensitivity to Probability of Resource
(No Consideration)

40% Reservoir



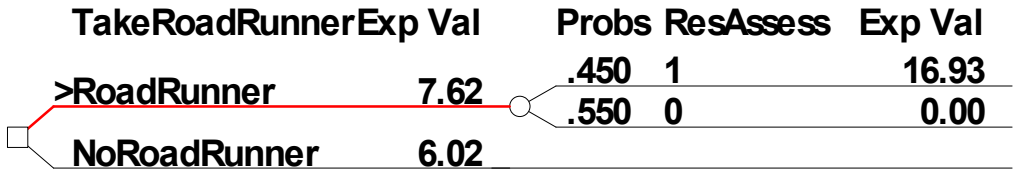
VOI = 2.72
Consideration = 4.38=2.72/.62

45% Reservoir (Overall probability of success = 25%)



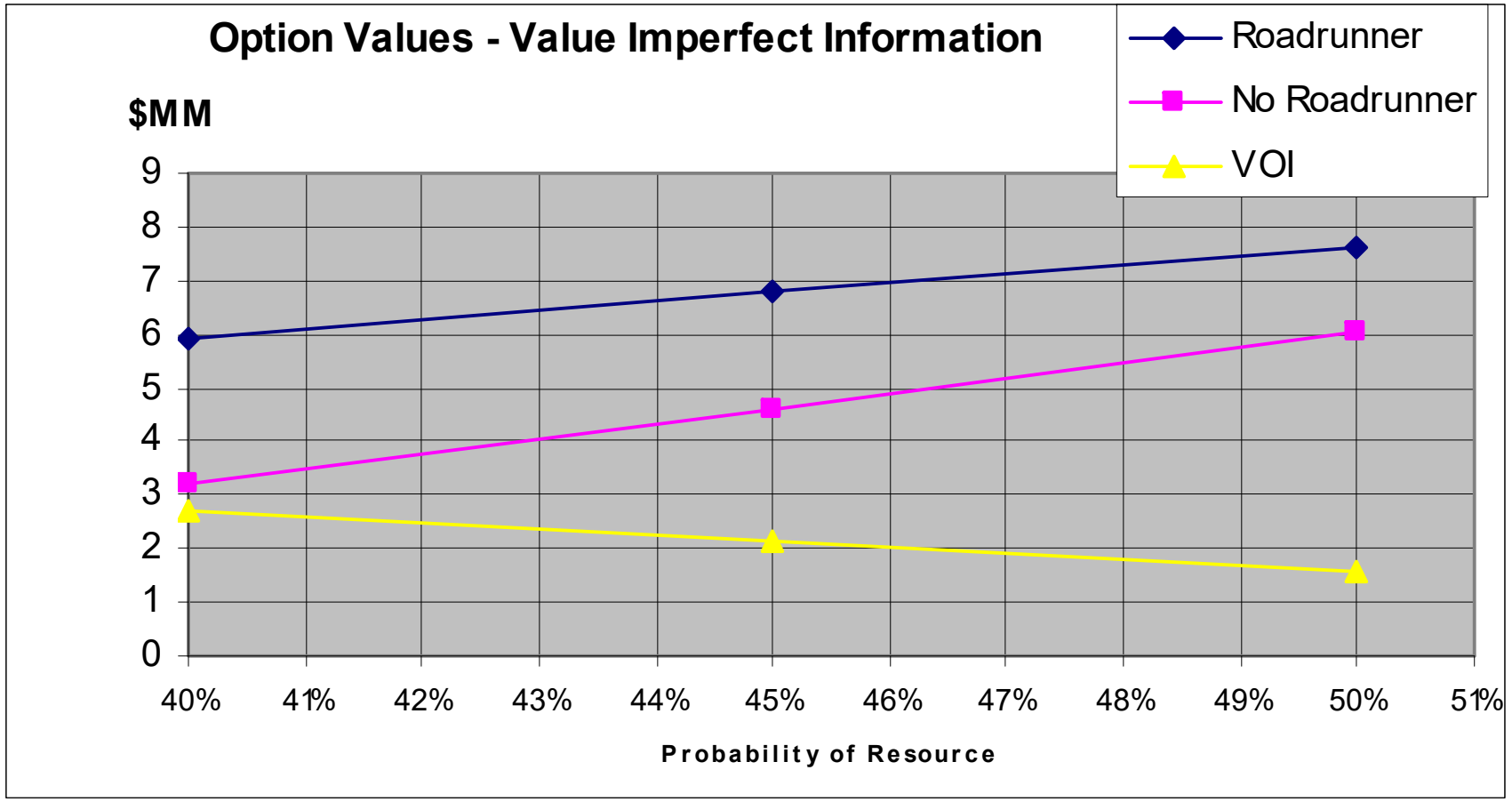
VOI = 2.16
Consideration = 3.69=2.16/.585

50% Reservoir



VOI = 1.60
Consideration = 2.91 = 1.60/.55

As our assessment of resource increases the value of imperfect information decreases



Tree with 40% Prob of Resource and $3.69MM Consideration

There is an argument that we should not pay more than the value of information justifies if we were willing to drill the well. If the probability of resource were increased to 45% the overall probability of success would be 25%. A maximum consideration of $3.69 would then be appropriate. Utilizing our original 40% probability of reservoir (this hasn't changed), the project value is $3.65MM which is greater than the current project value of $3.22MM.