Taking A Stochastic Approach to Reserve Estimation

OGRE Systems, Inc.

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Give An Estimation

Estimate the number of corn candies?

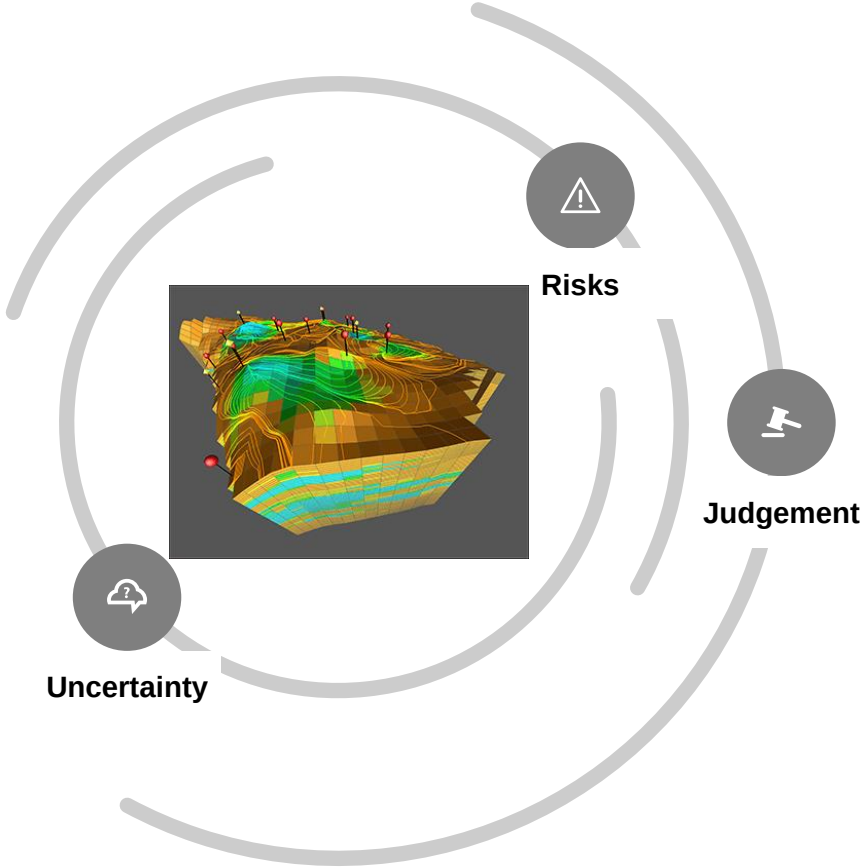
- **A single number?**
- **An estimated range?**

How do you estimate that?

- **“Volumetric” method?**
- **Have you consider the uncertainty?**

762 corn candies

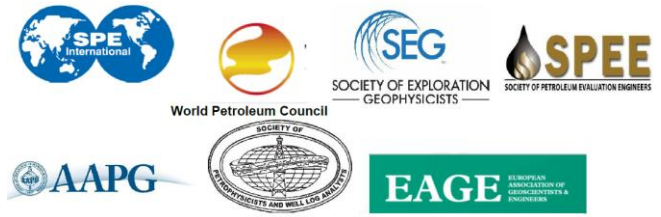
The Problems



- **The Oil & Gas industry is a risk-based business**
- **Reserve Estimation is one of the most essential tasks in the industry**
- **No industry standard exists for stochastic reserve estimation**
- **Industry's "recommended practice"?**

Why Stochastics?

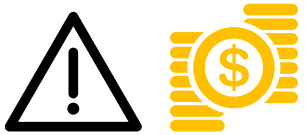
- **Adopted by SEC and PRMS Guideline**
- **The "best-estimate" value from Deterministic Approach**
  - An estimate based on a single value for each parameter (from the geoscience, engineering, or economic data)
  - **"***The temptation to use only the low-case input values for 1P, or only the high-case input values for 3p, should be resisted to prevent gross underestimation and overestimation, respectively***"***



* Quoted from Ferruh Demirmen, Reserve Estimation: The Challenge for the Industry, JPT, May 2007

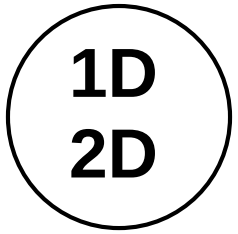
Why Stochastics?

- *"…when the **full range of values** that could reasonably occur from each unknown parameter (from the geoscience and engineering data) is used to generate a **full range of possible outcomes** and their **associated probabilities** of occurrence."**
- **It provides a good understanding of uncertainties and potential rewards.**



* SEC Final Rule: Modernization of Oil and Gas Reporting

Where Are the Uncertainties?

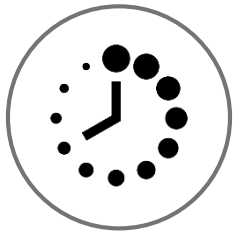


One Dimensional Data

Porosity, S_W, FVF, Logs, etc.

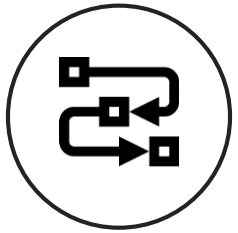
2D and 3D Data

Reservoir Continuity, Seismic Inversion, etc.



Streaming Data

Production Data, Pressure data, etc.



The Estimation Process itself

Compounded with imperfections in the reservoir model and limited data

What Cause the Uncertainties?

Subjectivity of reference data

Sampling

Inconclusive judgment

Measuring

Principle and Rules

Principle

Clearly understanding what factors contribute to reserves estimation process and reduce the uncertainties to an acceptable level

Rule

Conceptual Framework

Input Distribution
Value Ranges
Raw Data Optimization

Rule

Look-Back Analysis

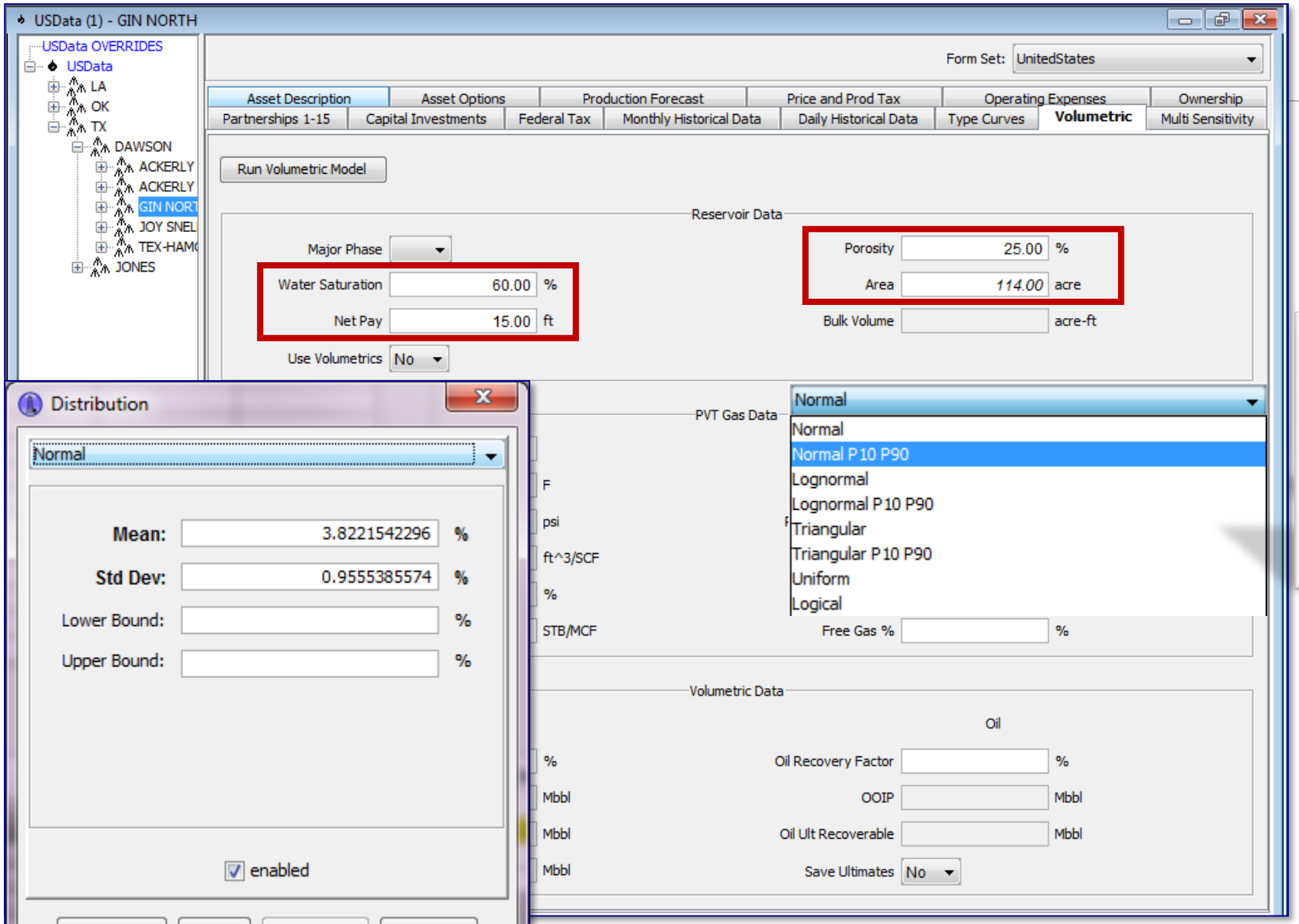
Actual Results vs. Stochastic Results

Assessment of bias

Rule

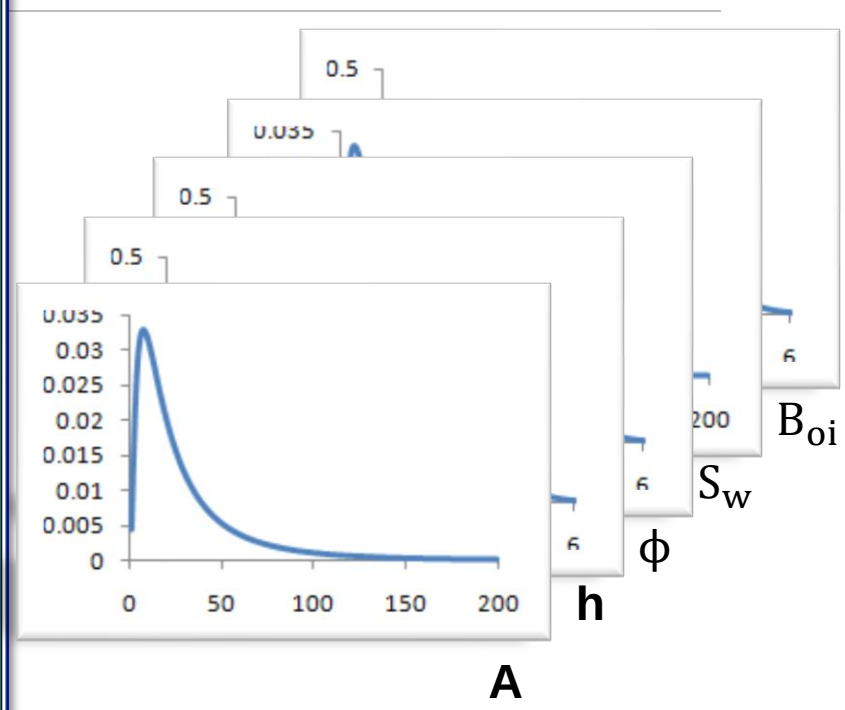
…

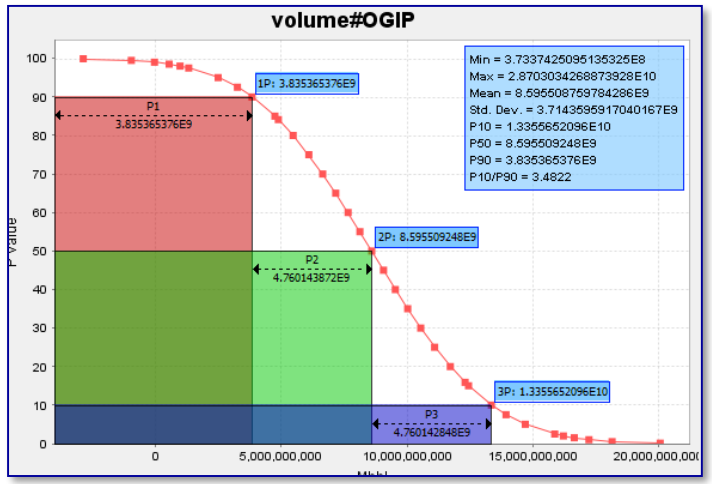
…



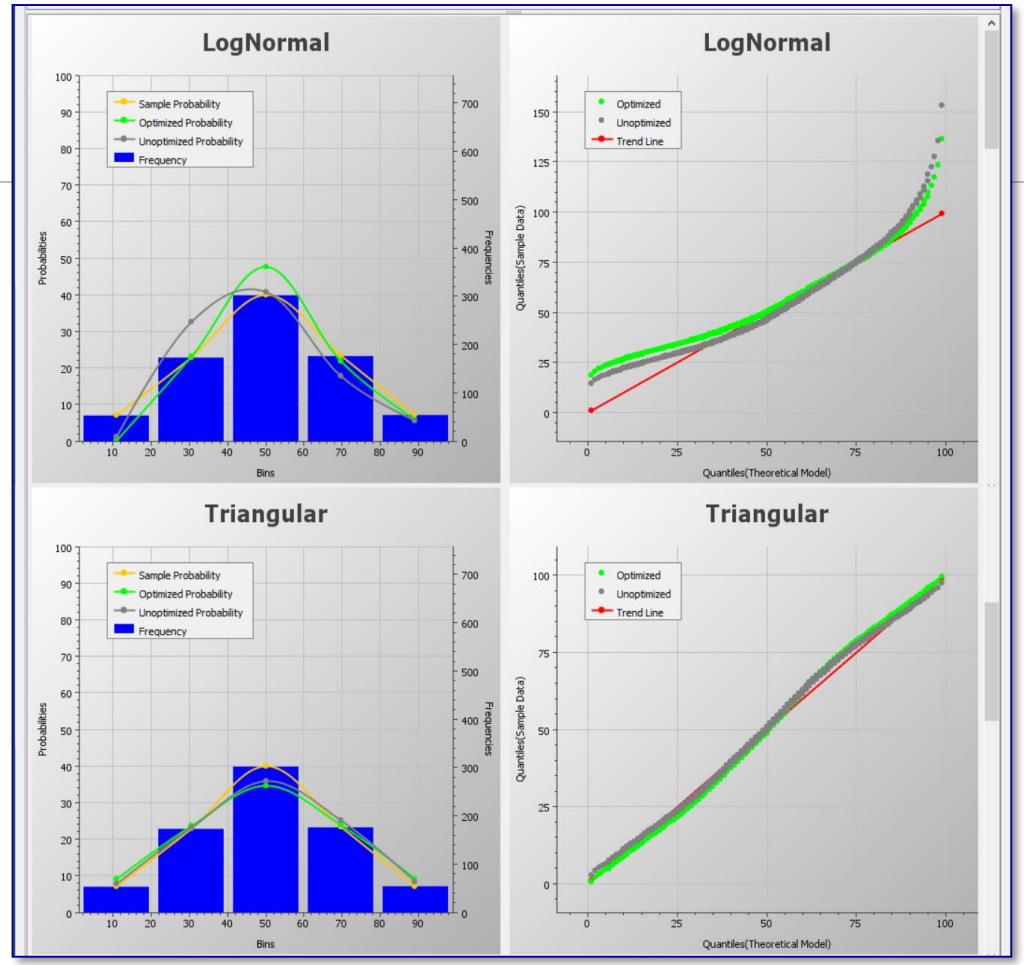
Select distribution for reservoir parameters

$$N = 7758Ah\phi(1 - S_w)B_{oi}$$

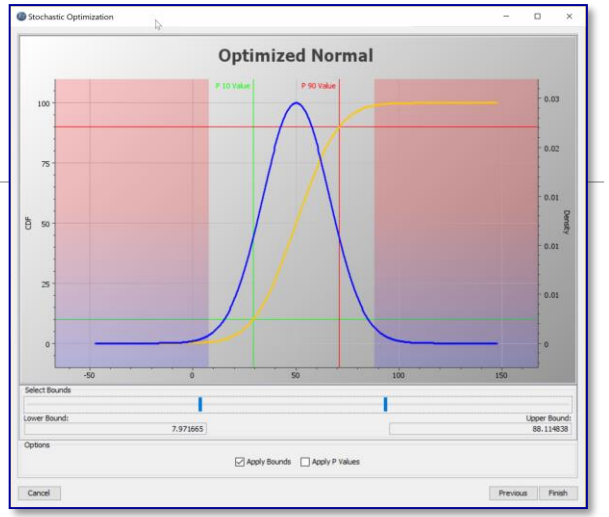


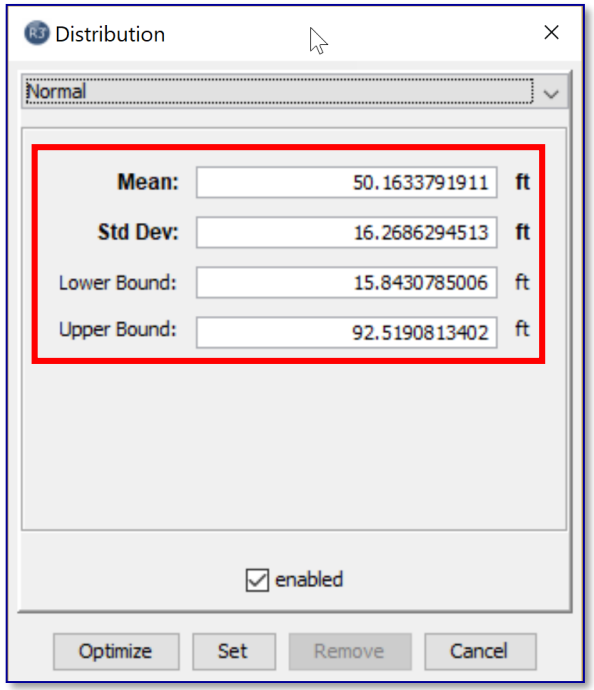


	A	B
1	Poro	Netpay Thickness
2	15.89	37.49
3	33.76	56.59
4	3.58	35.92
5	34.8	47.5
6	29.3	40.28
7	14.66	55.18
8	2.22	48.48
9	43.93	36.29
10	46.31	35.55
11	45.37	53.3
12	6.49	44.58
13	31.11	40.69
14	37.92	58.47
15	15.27	29.6
16	7	33.69
17	46.76	30.84
18	13.18	44.7
19	30.21	42.42
20	6.81	33.34
21	5.2	58.62
22	53.2	27.24
23	22.78	30.22
24	40.12	35.66
25	50.31	23.45
26	34.44	33.62
27	17.4	27.05
28	47.06	38.64
29	38.15	59.09
30	35.68	43.97
31	30.41	45.54
32	33.41	37.04
33	15.84	36.43
34	52.65	48.37
35	13.75	50.18
36	40.64	51.09
37	11.65	36.15
38	36.62	38.35



1. Import raw data
2. Optimize and identify the best fit distribution
3. Auto-generate the distribution parameter
4. Execute the Monte-Carlo Simulation with certain numbers of iterations



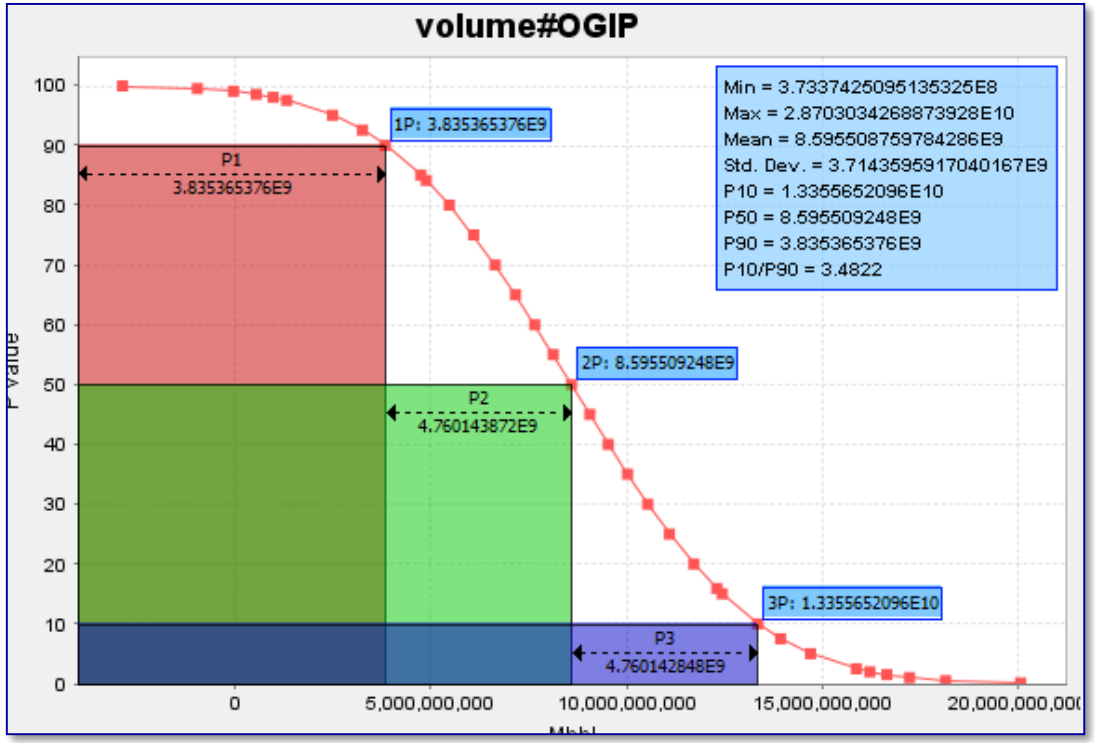


Example in Volumetric

- Conducting Monte-Carlo Simulation on optimized range of data
- Probability Density Function allows the visualization of the full range of possible results

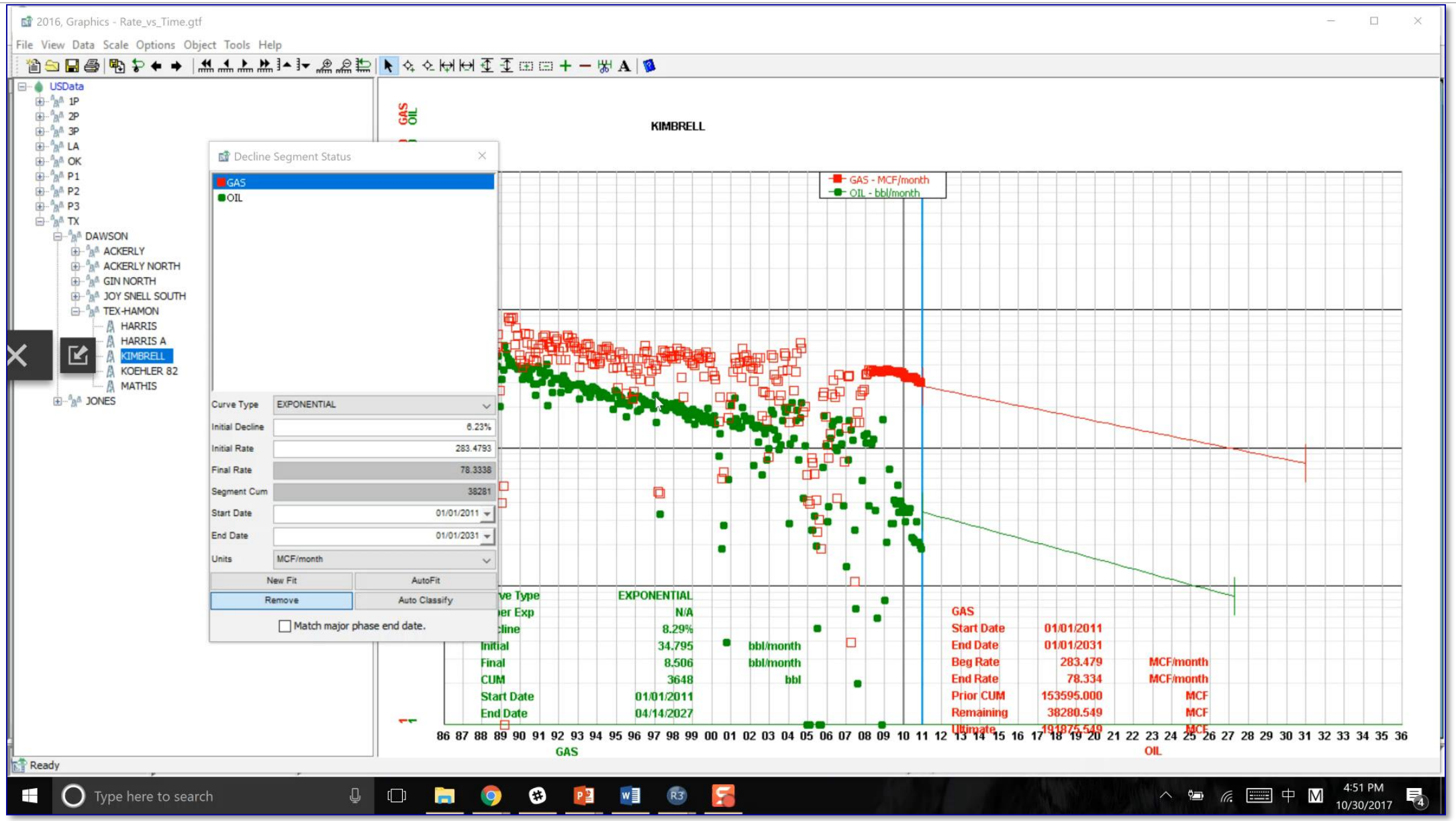
Summary:

- **Distribution** of parameters can be picked manually - Triangle, Uniform, Normal, and **Lognormal** are supported.
- Raw data can be **optimized** with an auto-generated Mean, Std Dev, Upper and Lower Bounds in order to mitigate **bias.**



Reverse Cumulative Probability Function Chart

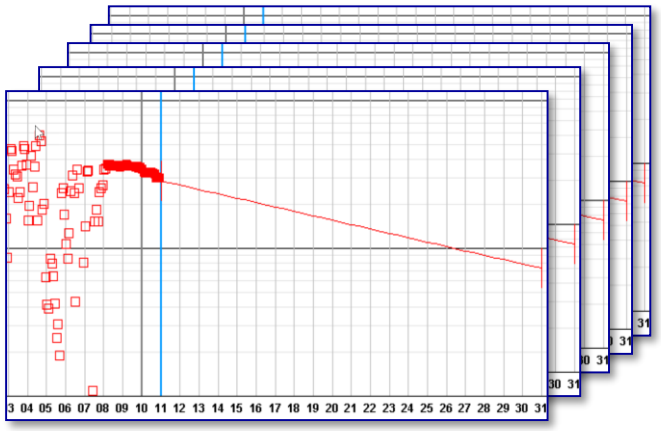
Example of Stochastic in DCA



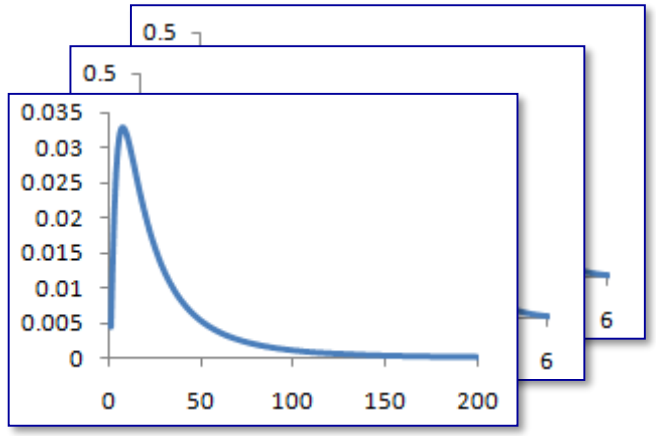
Example of Stochastic in DCA

The general practice in this specific DCA is

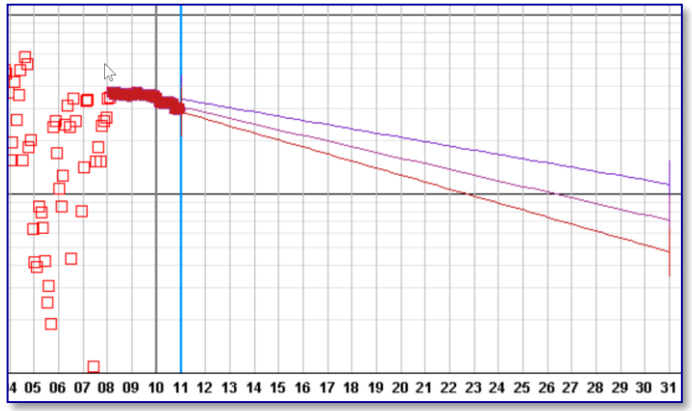
- Select the recent/relevant data – ***User selects the data***
- Program uses this data and under a guided-methodology to perform curve fitting
- Program will perform numerous iterations and utilizes the continuous probability density function to generate the P10, P50 and P90 reserve estimation.



Iterations and populate IP, D_i parameters



Create distributions for IP, D_i, etc. and find P90, P50, P10 value of them



Based on the statistical results and create P10, P50 and P90 cases

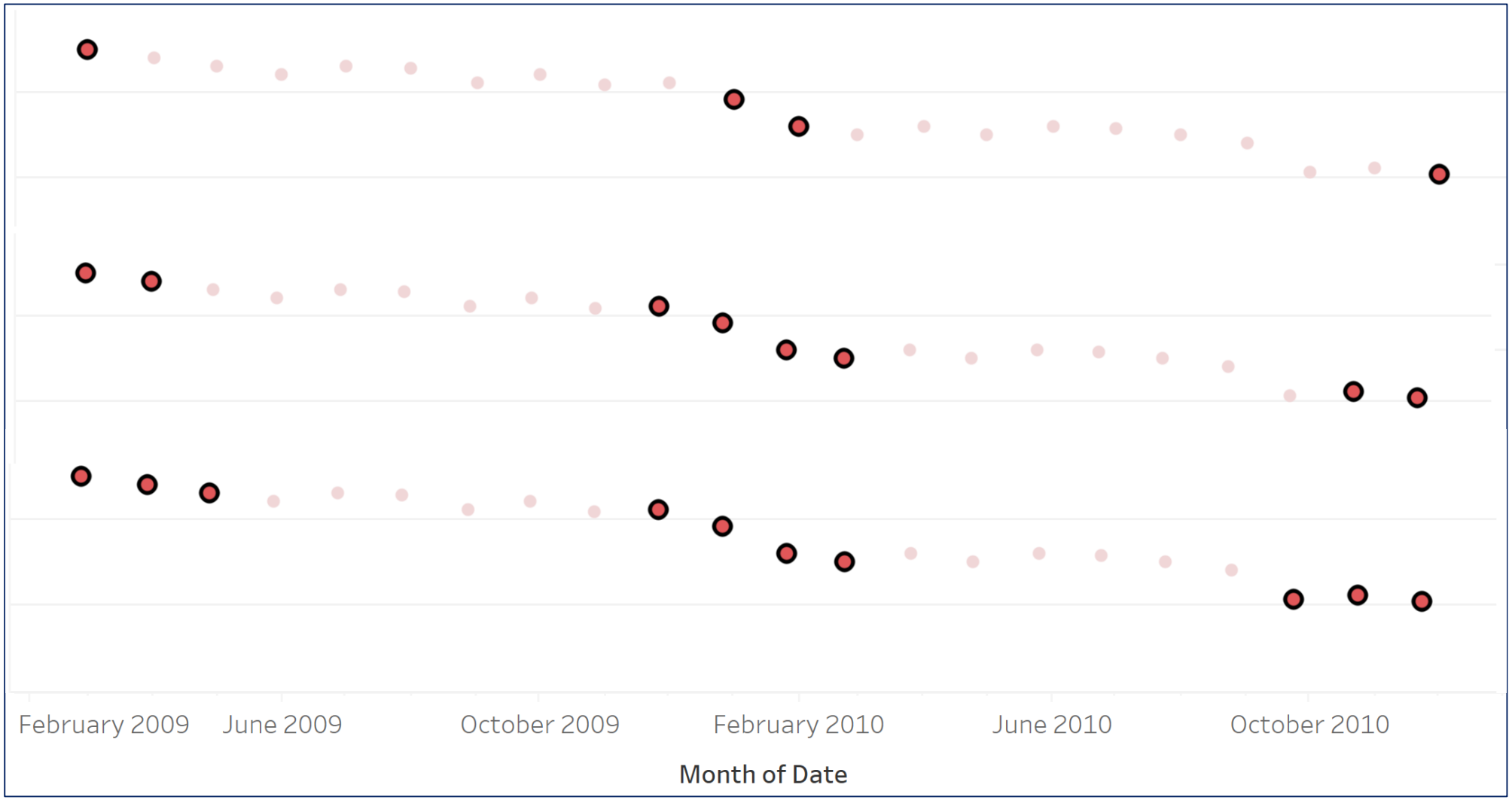
Production Data Picking Examples

#1

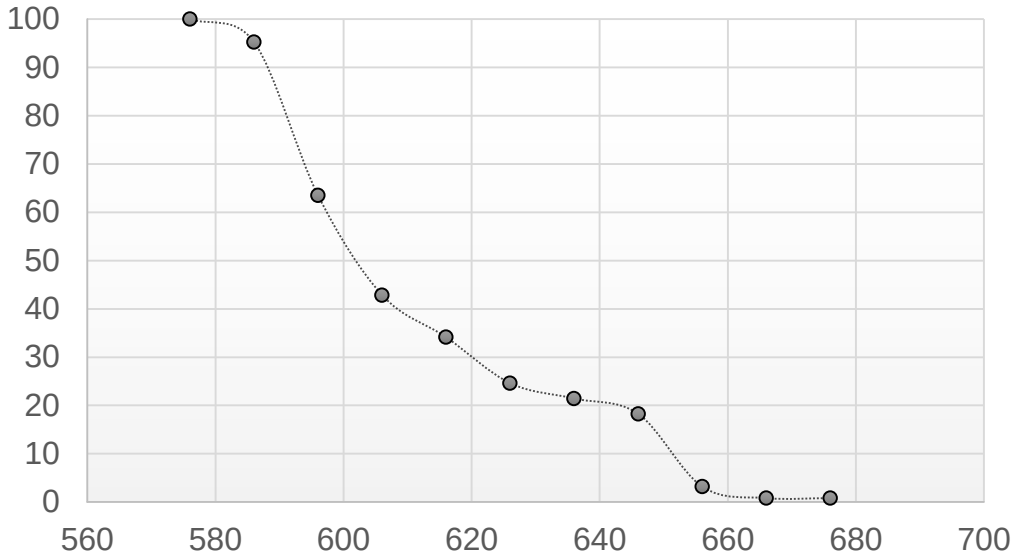
#2

#3

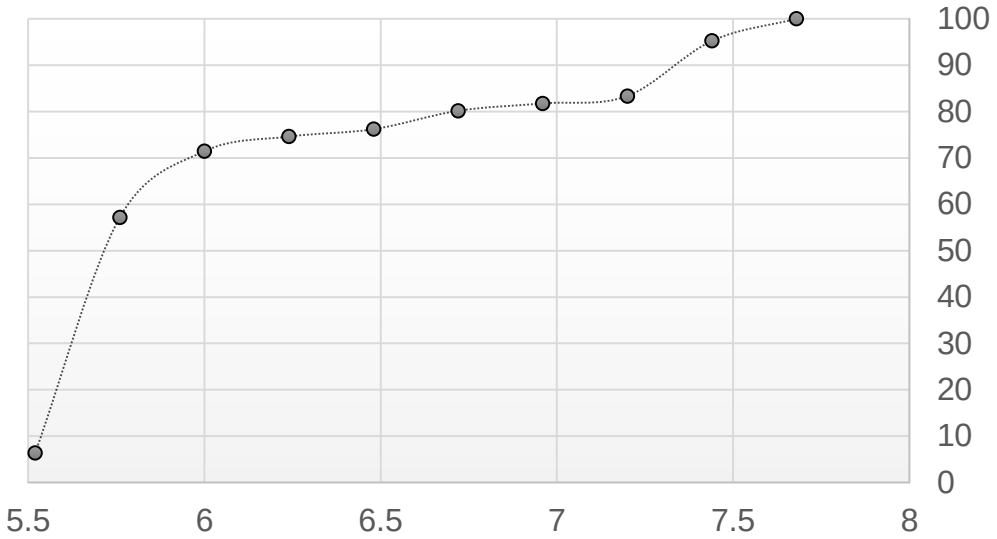
…



Approach Procedures



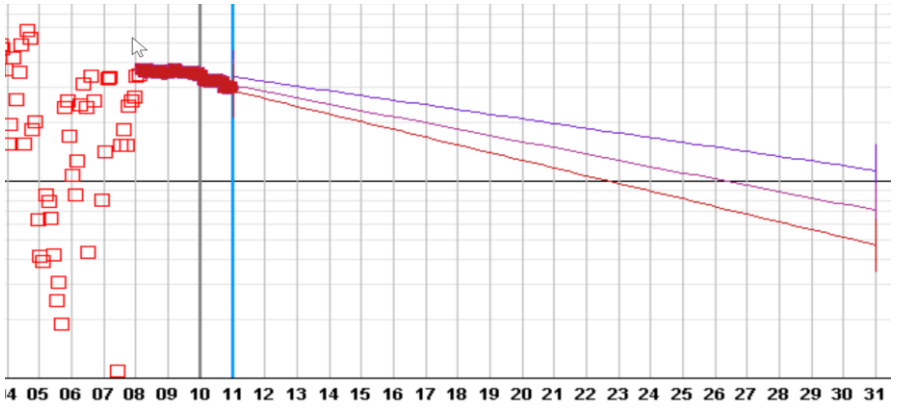
Reverse Cumulative Probability Function for IP



Cumulative Probability Function for D_i

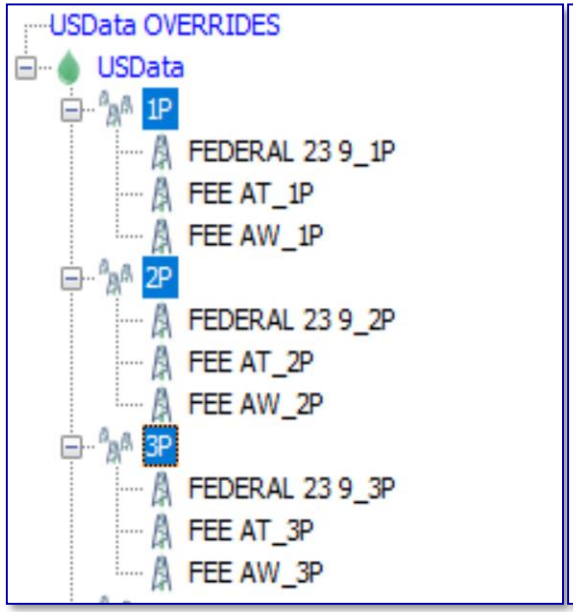
Probability	IP	D_i
%	bbl/day	%
P90	584	7.3
P50	600	5.7
P10	650	5.54

Statistical Results for IP and D_i



P10 P50 P90 Case for Single Assets

Evaluate the Economics



Giant Corp
Smart Reservoir
Tight Field

Reserves and Economics

As of January 01, 2010

Date Oct 31, 2017
Time 02:42 PM
Study USData

Asset	Gross Production Oil MBBL	Gross Production Gas MMCF	Net Production Oil MBBL	Net Production Gas MMCF	Oper. Cash Flow, M$	DDA M$	Taxable Income, M$	Taxes Payable, M$	Cash Flow ATAX, M$	10.0 Pct. Cum. Disc. ATAX, M$
FEDERAL 23 9_1P	2.042	0.000	1.787	0.000	-237.420	0.000	0.000	0.000	-686.520	-475.213
FEDERAL 23 9_2P	8.011	0.000	6.642	0.000	237.090	0.000	0.000	0.000	-212.010	-262.441
FEDERAL 23 9_3P	18.452	0.000	12.865	0.000	858.170	0.000	0.000	0.000	409.070	15.738

Report generated by OGRE Systems, Inc.

- **Batch processing of wells into 1P, 2P and 3P scenarios**
- **Conduct economic analysis and generate reports**
- **Economic parameters can be assigned with distribution and value ranges as well**

Summary

This stochastics approach allows you to

- **Clearly understand what factors contribute to reserves estimation and reduce the uncertainties to an acceptable level**
- **Provide a good understanding of uncertainties and potential rewards.**
- **Utilize a reliable technology to create reasonable certainty in your reserve estimation process**

THANKS

Questions?

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