

CPE 651 :Undergraduate Summer Research

CMG Simulation Modeling Learning

Presenter: Jason Zhang



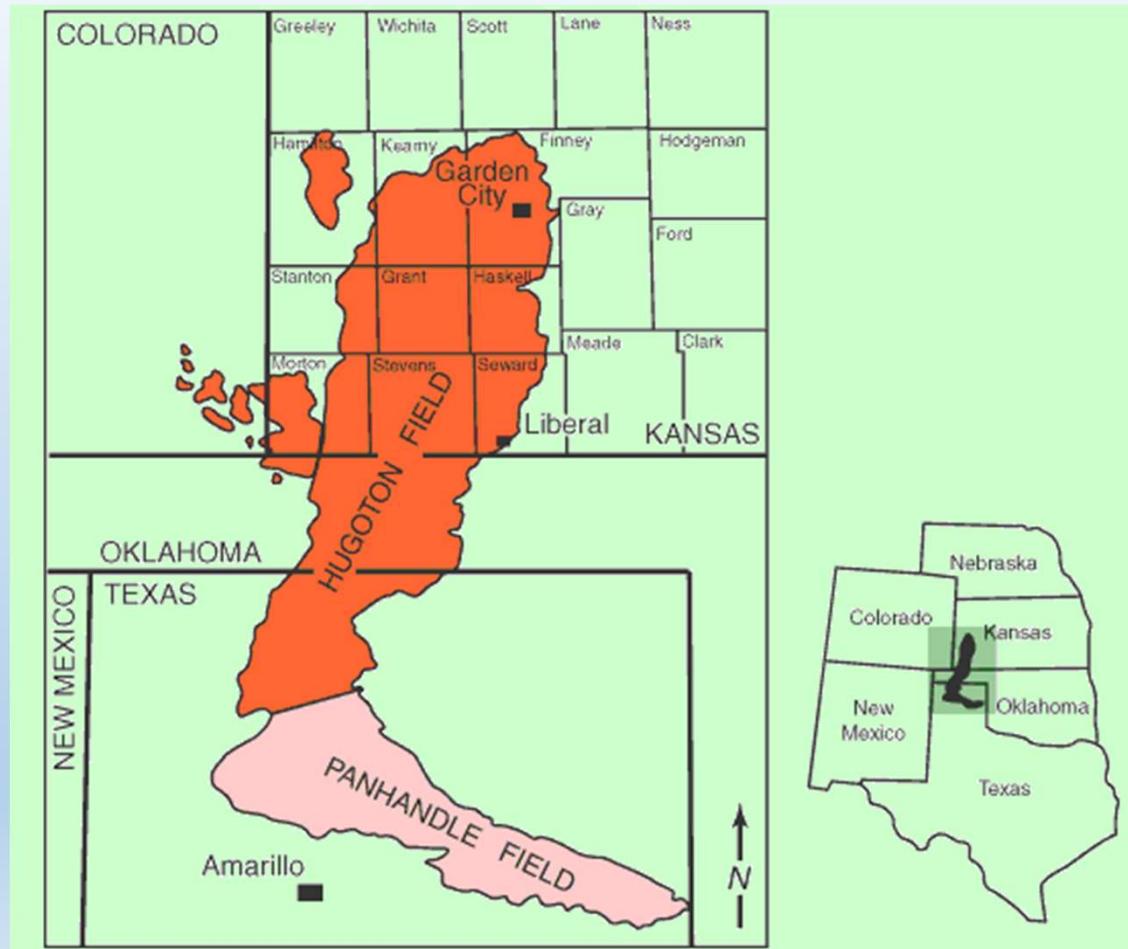
Project Outline

- ❑ Project Objective
- ❑ Raw Data
- ❑ History Matching Procedures and Results
- ❑ Future Forecast
- ❑ Locations of New Wells to Optimize

Project Objective

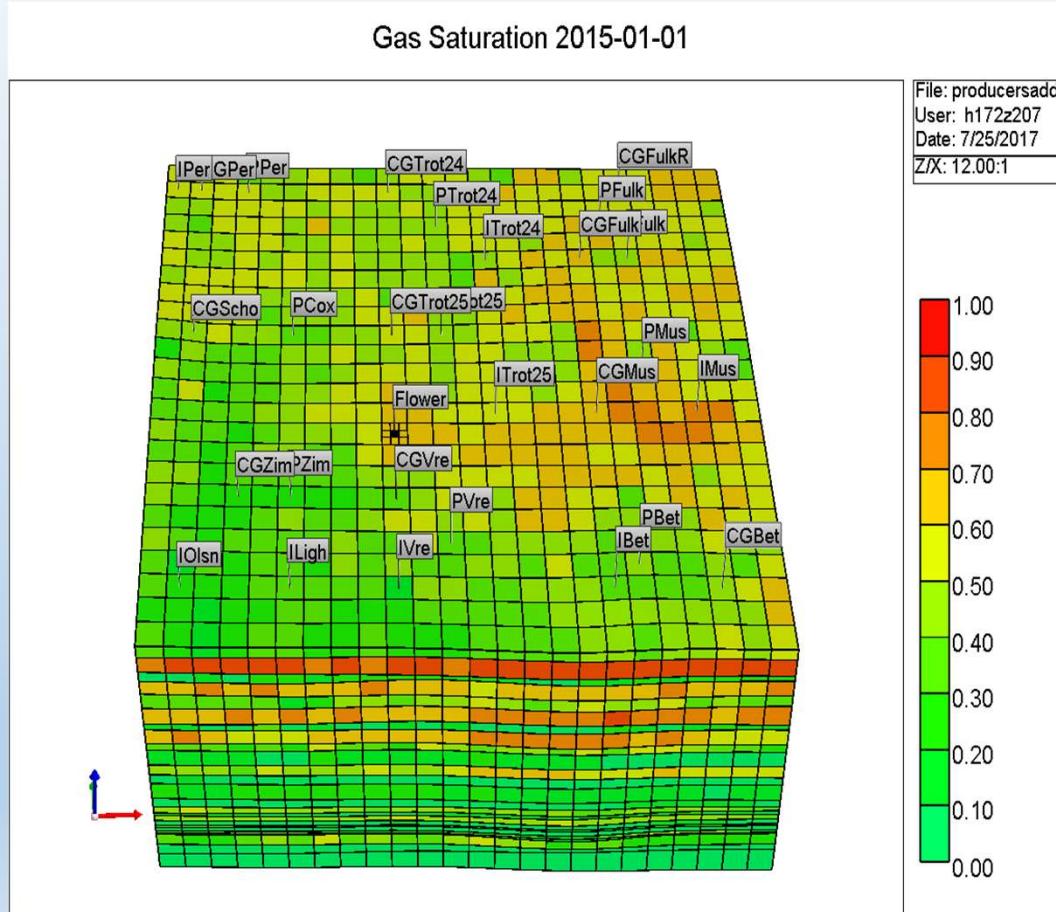
- History Matching for the Gas Field at Kansas Hugoton Flower Area.
- Future Prediction
- Determine the optimum locations for at least two new wells

Hugoton-Panoma Gas Field



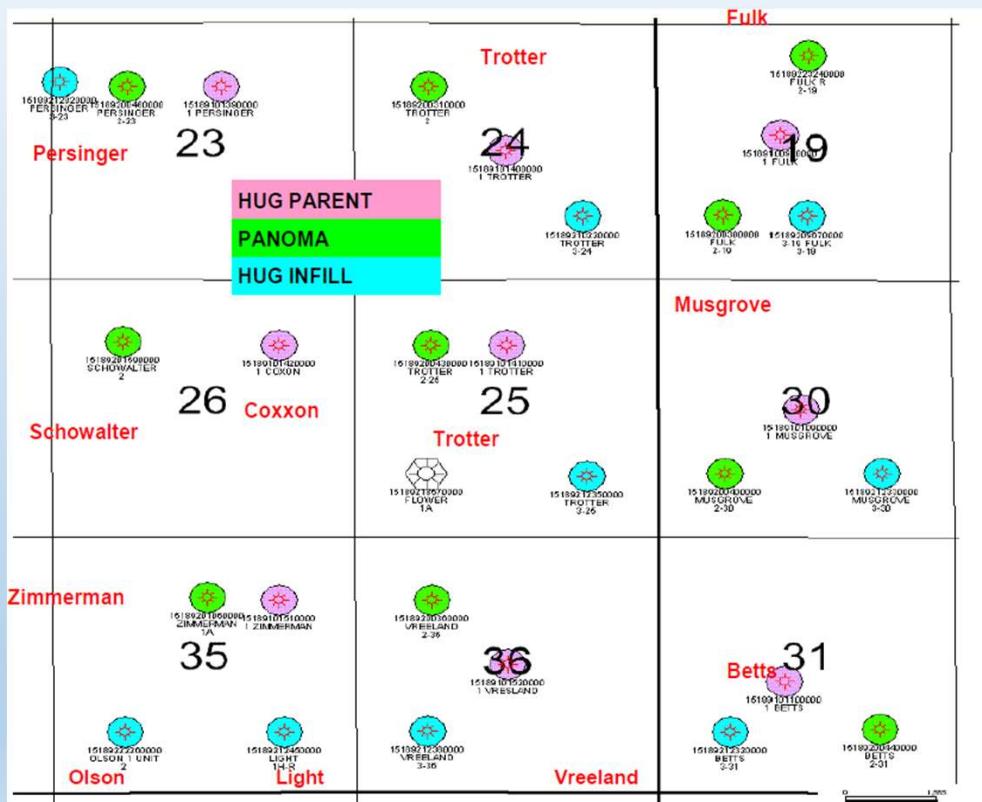
Initial Reservoir Condition

Gas Saturation 2015-01-01



The reservoir interested has 24x24 blocks in the X and Y directions and has 25 layers, single porosity. There are 29 wells and had been perforated at different time.

Well Location



Group	Formation / Member	LAYER
Chase	HRNGTN	1
	KRIDER	2
	ODELL	3
	WINF	4
	GAGE	5
	TOWANDA	6
	HOLMESVILLE	7
	FT RILEY	8
	L/FT RILEY	9
	MATFIELD	10
	WREFORD	11
Council Grove	A1_SH	12
	A1_LM	13
	B1_SH	14
	B1_LM	15
	B2_SH	16
	B2_LM	17
	B3_SH	18
	B3_LM	19
	B4_SH	20
	B4_LM	21
	B5_SH	22
	B5_LM	23
	C_SH	24
	C_LM	25

Table 1: Chase and Council Grove settings

Data Given



Table 2: Rock compressibility

Property	Value	
Reference pressure	465	psi
Rock compressibility	0.000002	1/psi (assumed)

Table 3: PVT properties of the Hugoton gas field

Property	Value	
Reference pressure	465	psi
Max Pressure	500	psi
Reservoir temp	90	F
Gas gravity (Air = 1.0)	0.715	
Water salinity	110,000	ppm

The screenshot shows the "Model Tree View" panel in the Builder software. The tree structure includes nodes for I/O Control, Reservoir, Components, Rock-Fluid, Initial Conditions, Numerical, and Wells & Recurrent. Under the Reservoir node, there are sub-nodes for Grid, Array Properties, Rock-Fluid End-Point Property Modification (with Sectors, Aquifers, Lease Planes), Rock Compressibility (with Compaction/Dilation Regions), Options, and Flux Sectors.

This screenshot shows the same Model Tree View panel, but with the "PVT Region:1" node expanded under the "Component Properties" section. The expanded view shows "Reservoir temperature (TRES)", "PVTG Table", and "Gas phase density (DENSITY GAS)". To the right of the tree, there are two columns of tables: "Ly vs r" and "Rocktype 1" through "Rocktype 6".

Data Given

A.

SW	KRW	KRG
0.25	0.0000	0.40
0.30	0.0000	0.31
0.35	0.0000	0.23
0.40	0.0000	0.16
0.45	0.0002	0.10
0.50	0.0006	0.06
0.55	0.0013	0.02
0.60	0.0024	0.00
0.65	0.0042	0.00
0.70	0.0068	0.00
0.75	0.0103	0.00
0.80	0.0152	0.00
0.85	0.0215	0.00
0.90	0.0296	0.00
0.95	0.0399	0.00
1.00	0.0526	0.00

Rock Type 1)

$K \leq 0.0001 \text{ md}$

B.

SW	KRW	KRG
0.12	0.0000	0.69
0.15	0.0000	0.65
0.20	0.0000	0.54
0.25	0.0000	0.44
0.30	0.0001	0.35
0.35	0.0004	0.27
0.40	0.0010	0.19
0.45	0.0020	0.13
0.50	0.0036	0.08
0.55	0.0060	0.05
0.60	0.0093	0.02
0.65	0.0140	0.00
0.70	0.0202	0.00
0.75	0.0283	0.00
0.80	0.0386	0.00
0.85	0.0515	0.00
0.90	0.0673	0.00
0.95	0.0866	0.00
1.00	0.1096	0.00

Rock Type 2)

$0.0001 < K < 0.001 \text{ md}$

C.

SW	KRW	KRG
0.06	0.0000	0.97
0.10	0.0000	0.88
0.15	0.0000	0.76
0.20	0.0000	0.65
0.25	0.0003	0.54
0.30	0.0009	0.44
0.35	0.0019	0.35
0.40	0.0037	0.26
0.45	0.0065	0.19
0.50	0.0106	0.13
0.55	0.0165	0.08
0.60	0.0244	0.04
0.65	0.0350	0.02
0.70	0.0486	0.00
0.75	0.0658	0.00
0.80	0.0873	0.00
0.85	0.1136	0.00
0.90	0.1455	0.00
0.95	0.1836	0.00
1.00	0.2288	0.00

D.

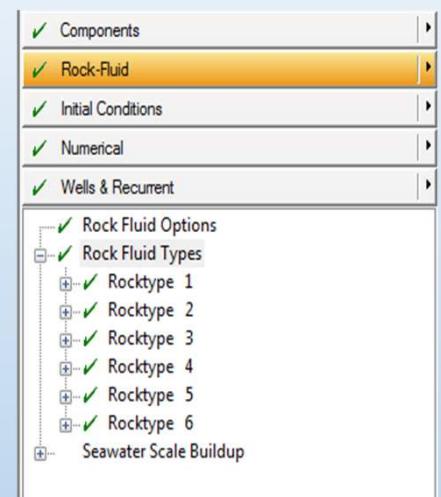
SW	KRW	KRG
0.01	0.0000	0.9803
0.05	0.0000	0.9331
0.10	0.0000	0.8632
0.15	0.0000	0.7913
0.20	0.0000	0.7182
0.25	0.0000	0.6449
0.30	0.0000	0.5723
0.35	0.0000	0.5012
0.40	0.0002	0.4323
0.45	0.0006	0.3666
0.50	0.0015	0.3045
0.55	0.0034	0.2470
0.60	0.0072	0.1944
0.65	0.0140	0.1475
0.70	0.0220	0.1066
0.75	0.0390	0.0721
0.80	0.0667	0.0444
0.85	0.1104	0.0235
0.90	0.1774	0.0095
0.95	0.2780	0.0019
1.00	0.4255	0.0000

SW	KRW	KRG
0.01	0.0000	0.9803
0.05	0.0000	0.9331
0.10	0.0000	0.8632
0.15	0.0000	0.7913
0.20	0.0000	0.7182
0.25	0.0000	0.6449
0.30	0.0000	0.5723
0.35	0.0000	0.5012
0.40	0.0002	0.4323
0.45	0.0006	0.3666
0.50	0.0015	0.3045
0.55	0.0034	0.2470
0.60	0.0072	0.1944
0.65	0.0140	0.1475
0.70	0.0220	0.1066
0.75	0.0390	0.0721
0.80	0.0667	0.0444
0.85	0.1104	0.0235
0.90	0.1774	0.0095
0.95	0.2780	0.0019
1.00	0.4255	0.0000

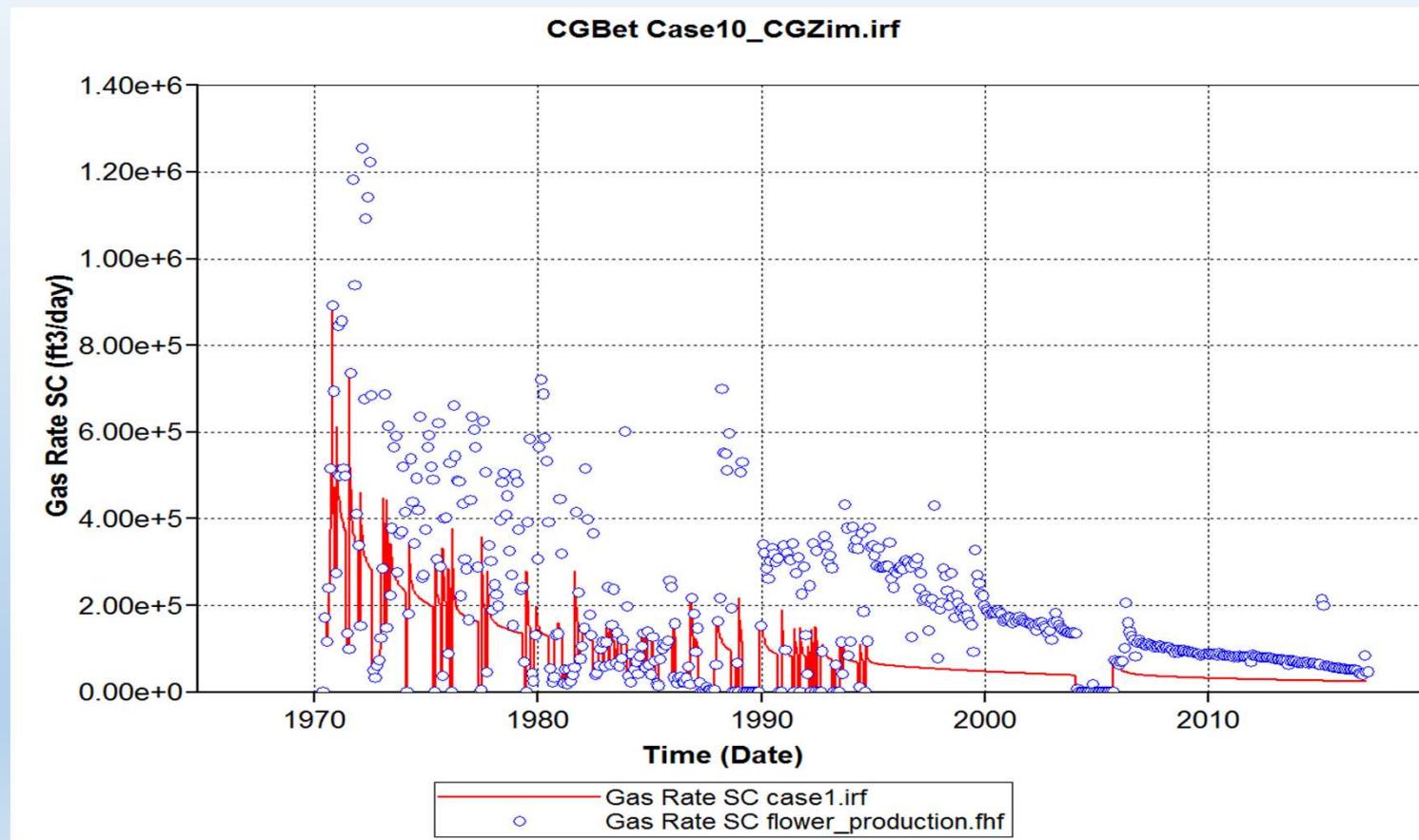
Rock Type 5)

$K > 0.1 \text{ md}$

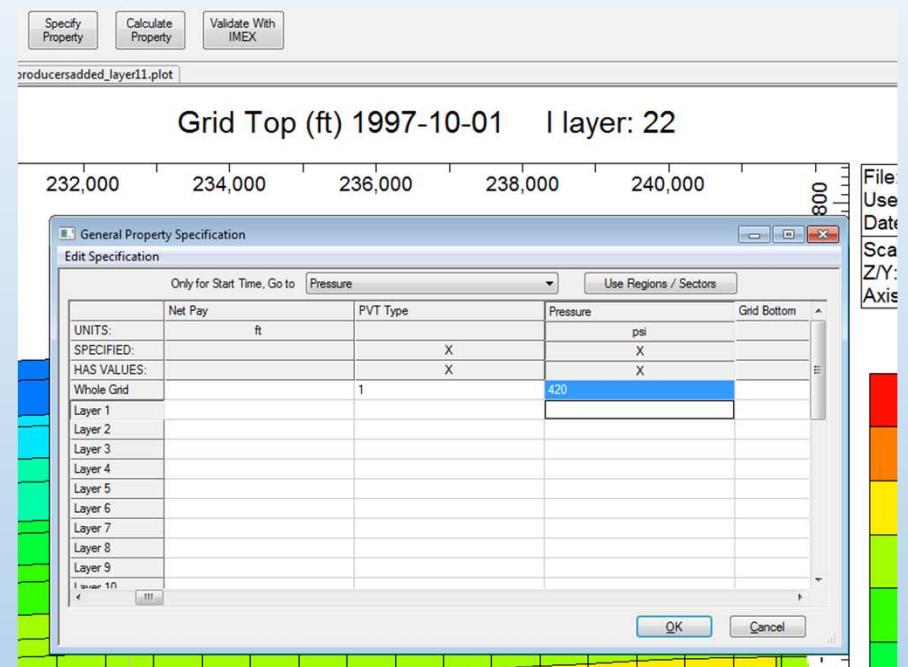
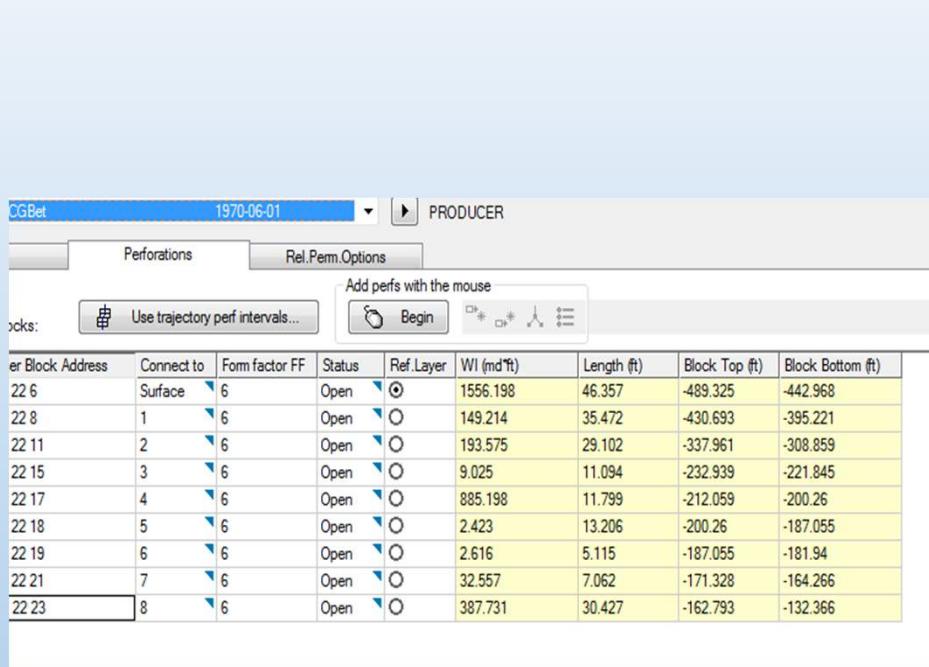
Table 4: Relative-permeability tables for respective rock-types used in single- and multi-section simulation studies.



History Matching

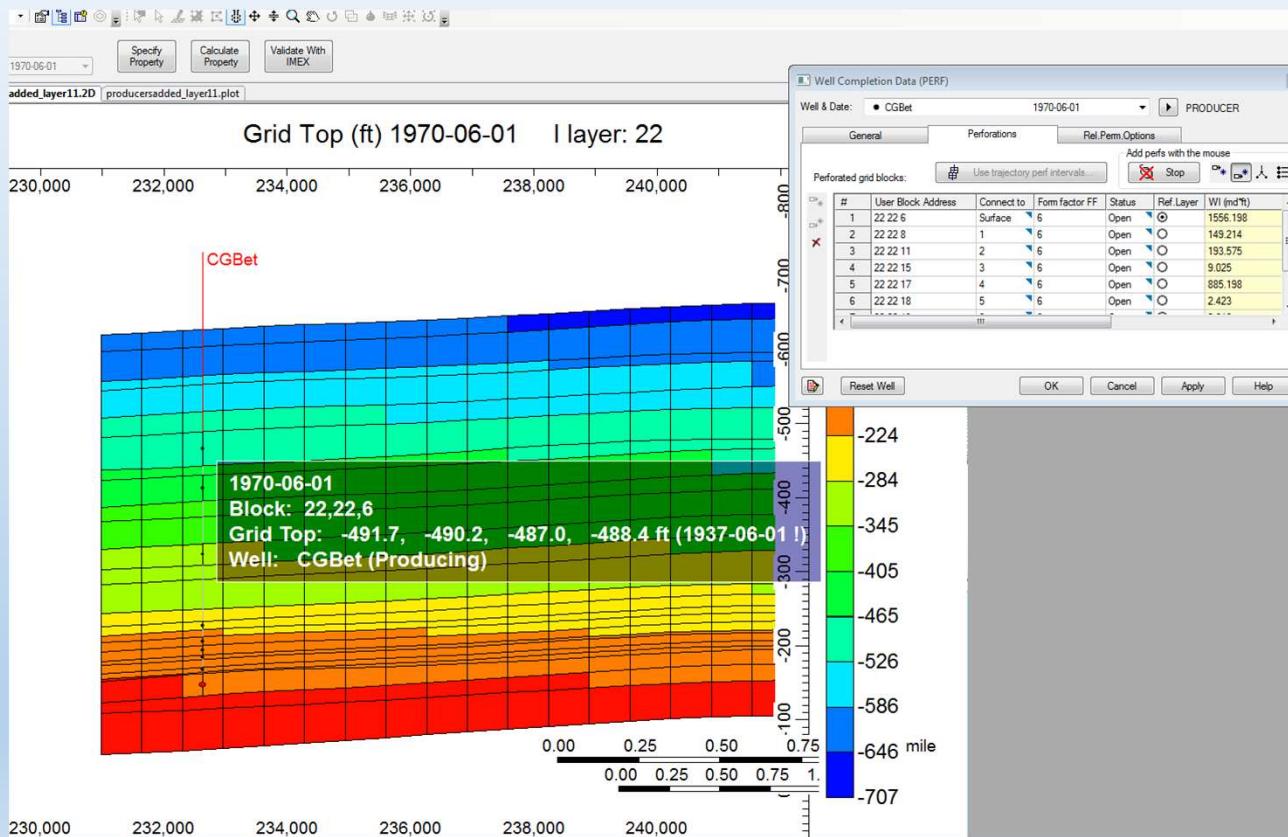


History Matching

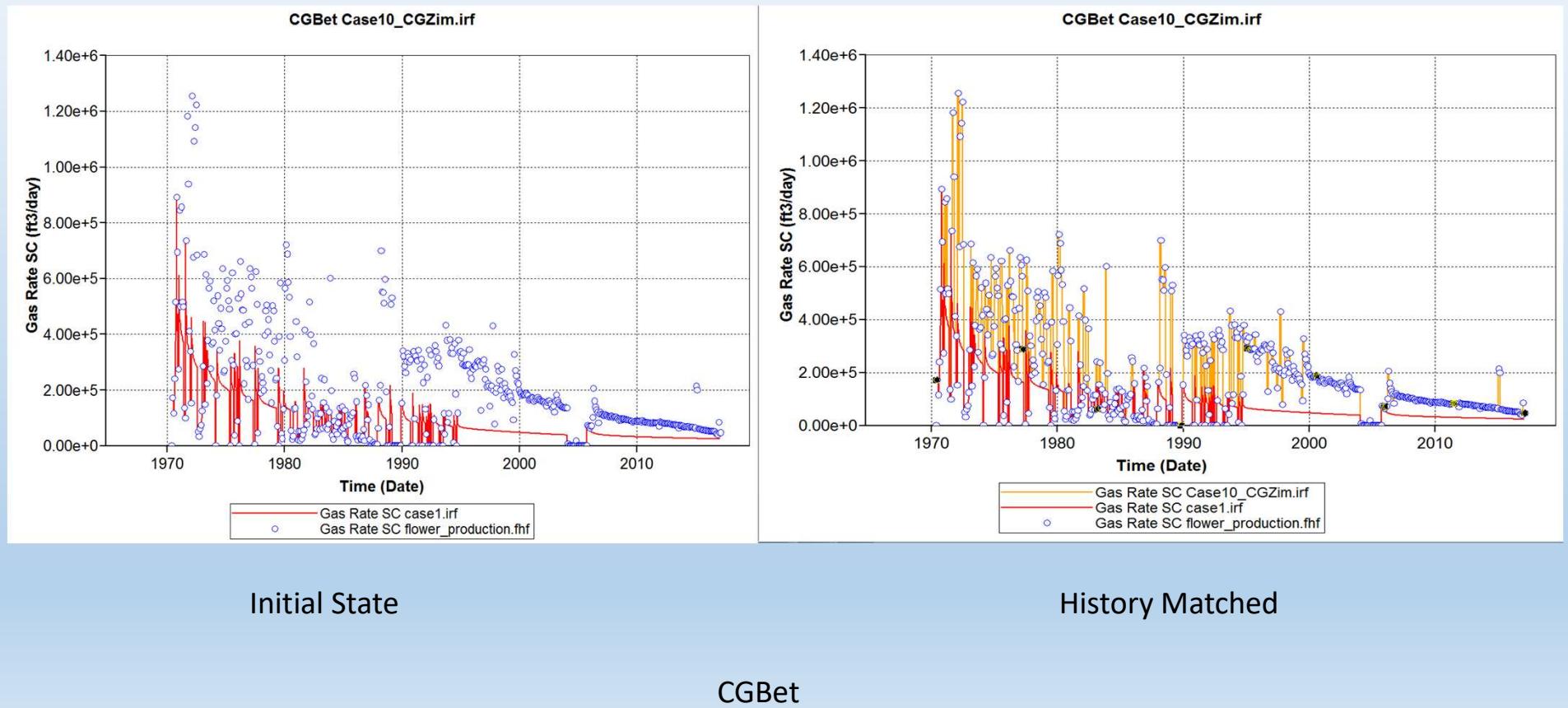


The ff-factor = 1 represents unfractured well and ff>1 represents a well had been hydraulic fractured. the initial reservoir pressure is 460 and can vary between 400-500psi.

History Matching



History Matching

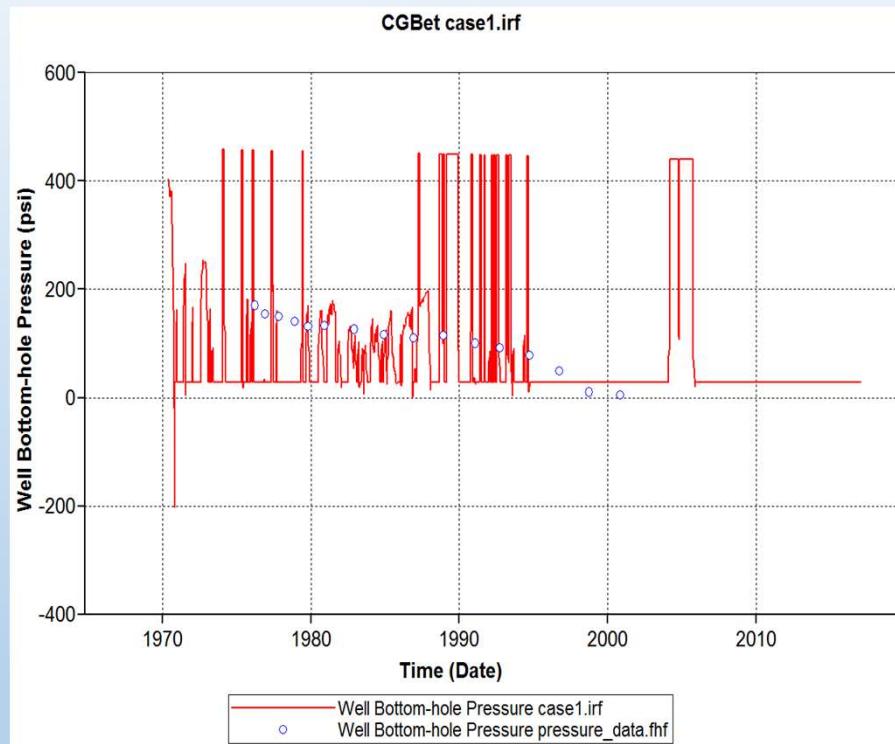


Initial State

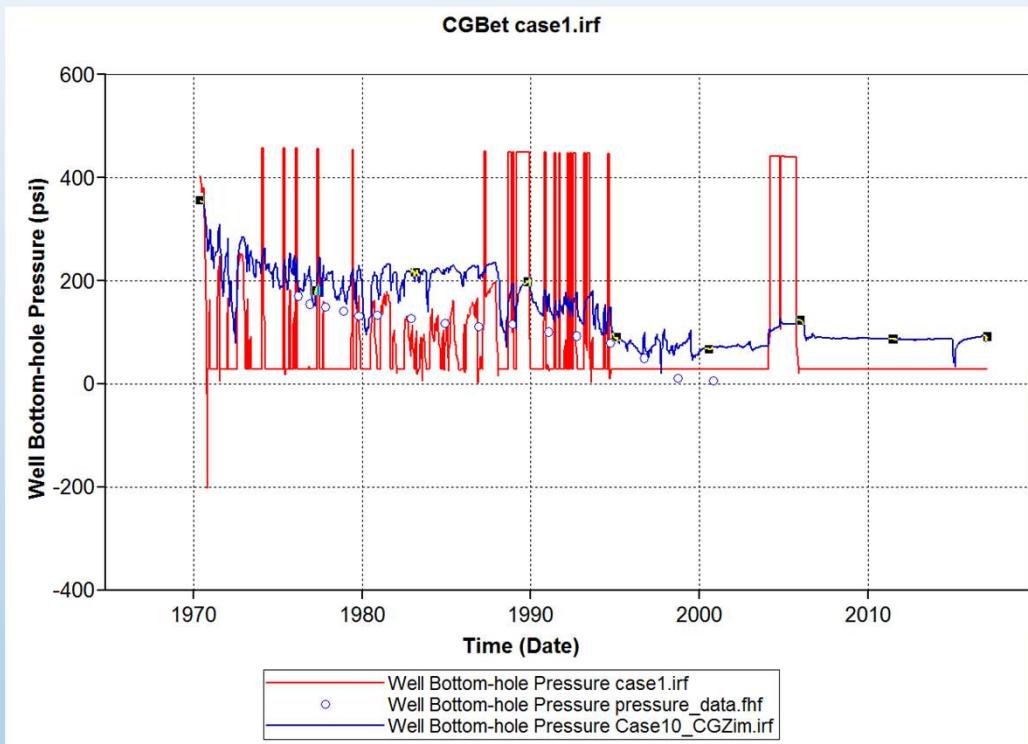
History Matched

CGBet

History Matching

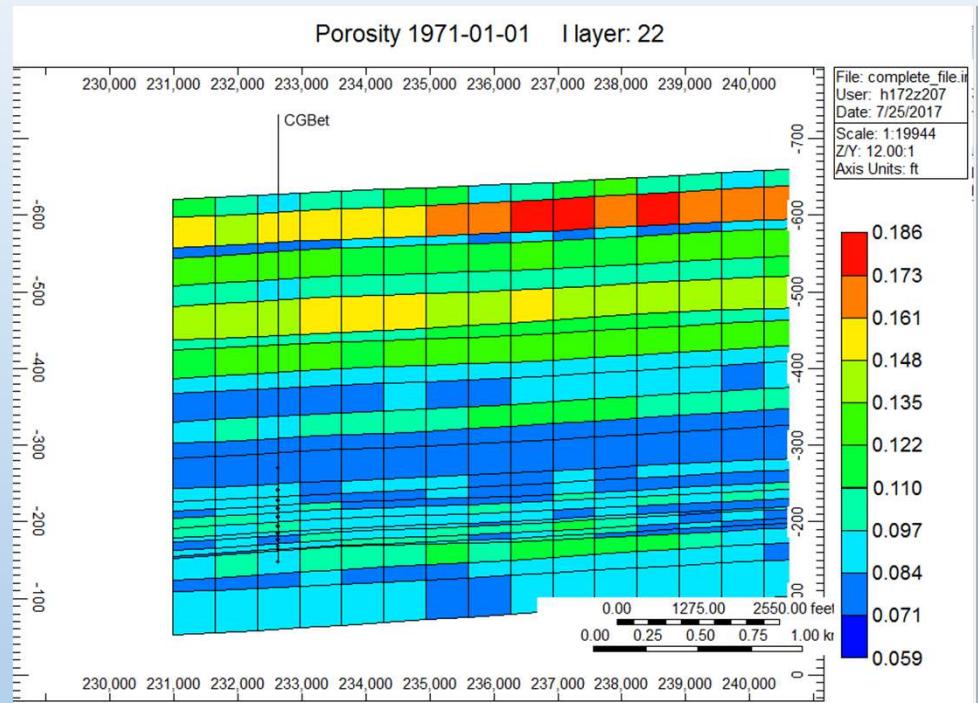
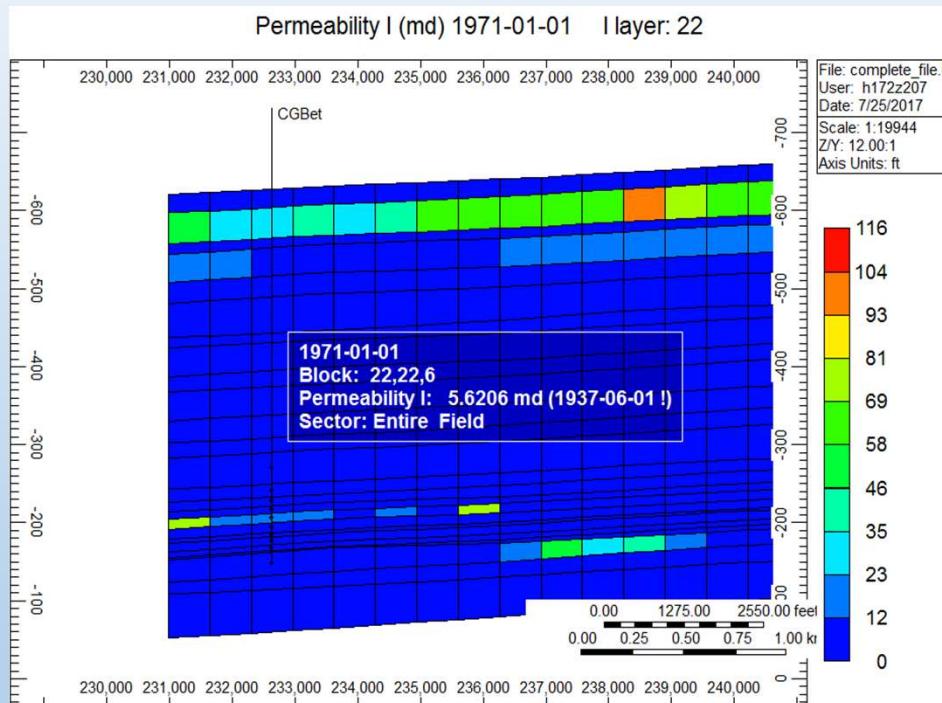


Initial State

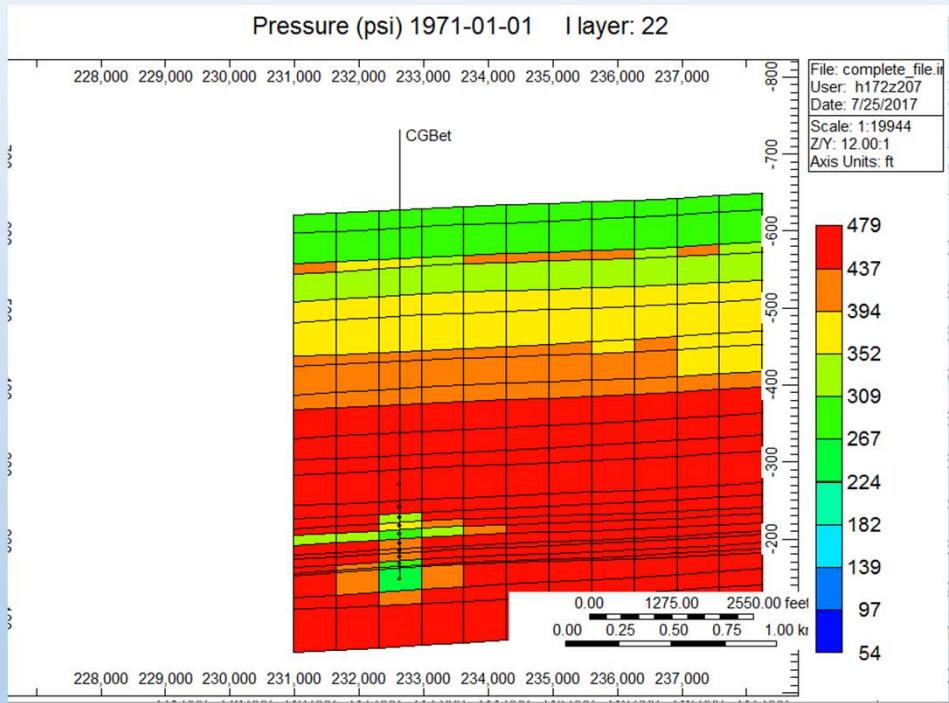
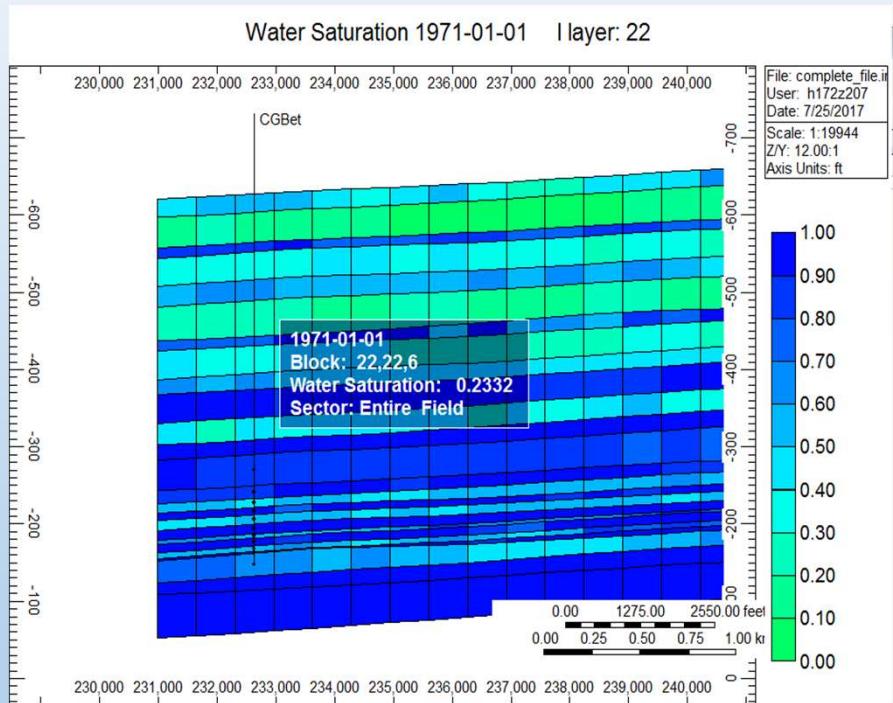


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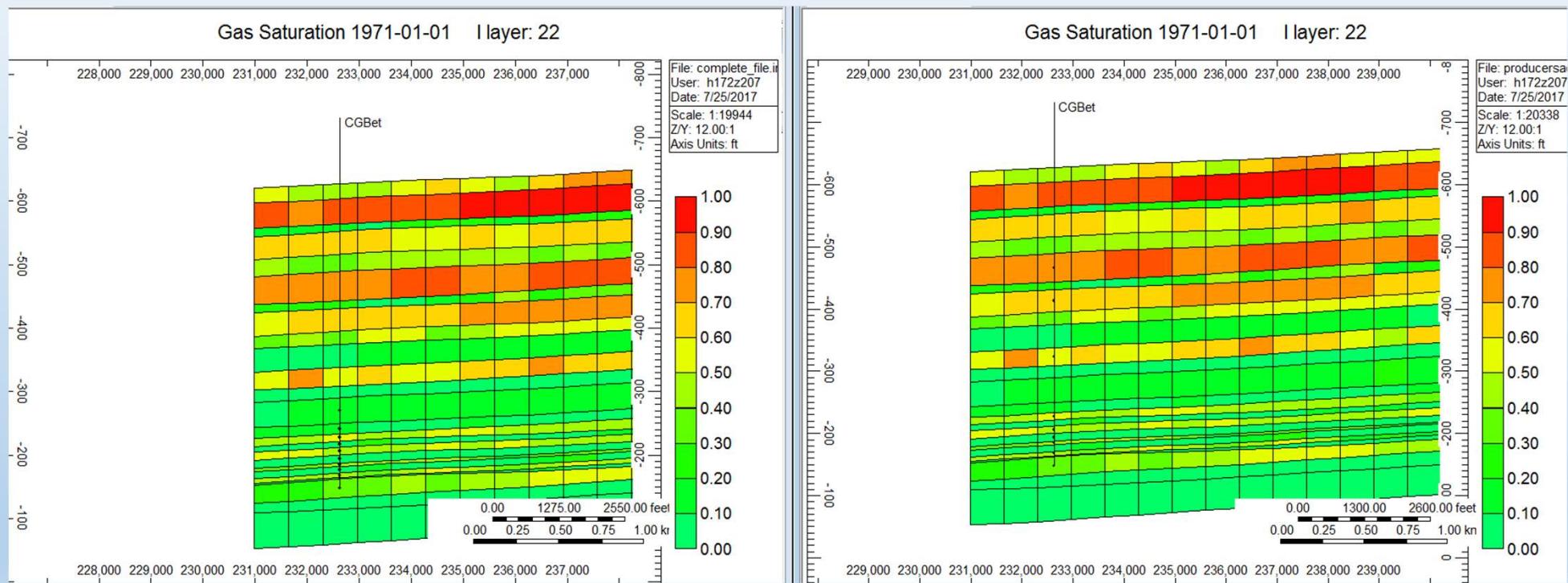
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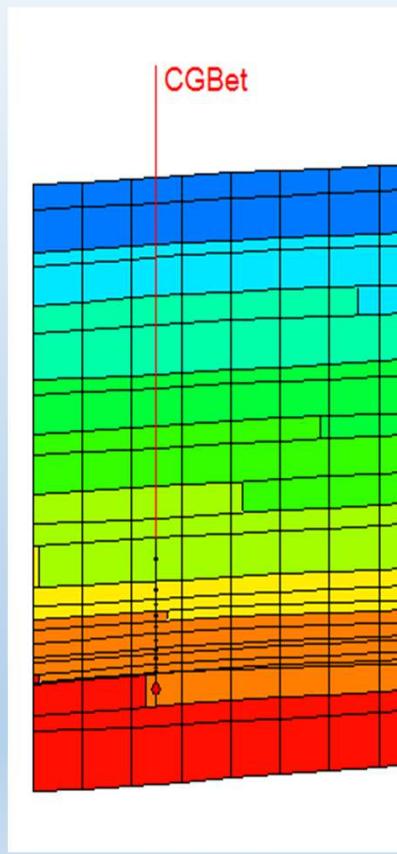
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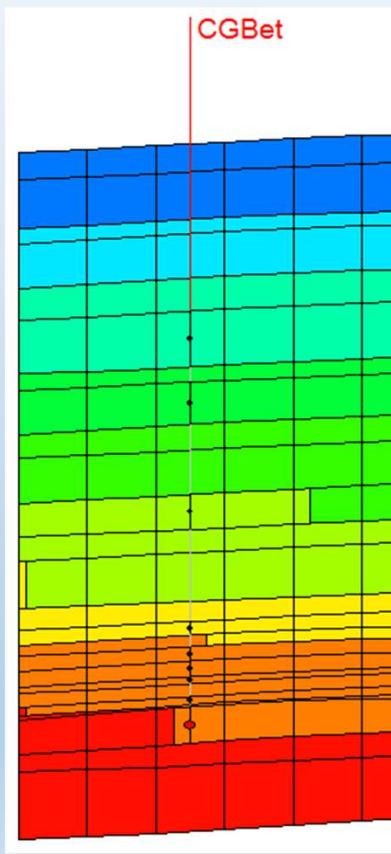
History Matching



History Matching



Before



After

#	User Block Address	Connect to	Form factor FF	Status	Ref.Layer	WI (md ² ft)	L
1	22 22 13	Surface	6	Open	○	1.936	4
2	22 22 14	1	6	Open	○	1.585	1
3	22 22 15	2	6	Open	○	9.025	1
4	22 22 16	3	6	Open	○	0.328	9
5	22 22 17	4	6	Open	○	885.198	1
6	22 22 18	5	6	Open	○	2.423	1
7	22 22 19	6	6	Open	○	2.616	5
8	22 22 20	7	6	Open	○	0.367	1
9	22 22 21	8	6	Open	○	32.557	7
10	22 22 22	9	6	Open	○	0.077	1
* 11	22 22 23	10	6	Open	○	387.731	3

After

Well & Date: • CGBet 1970-06-01 PRODUCER

General Perforations Rel.Perm.Options

Add perfs with the mouse

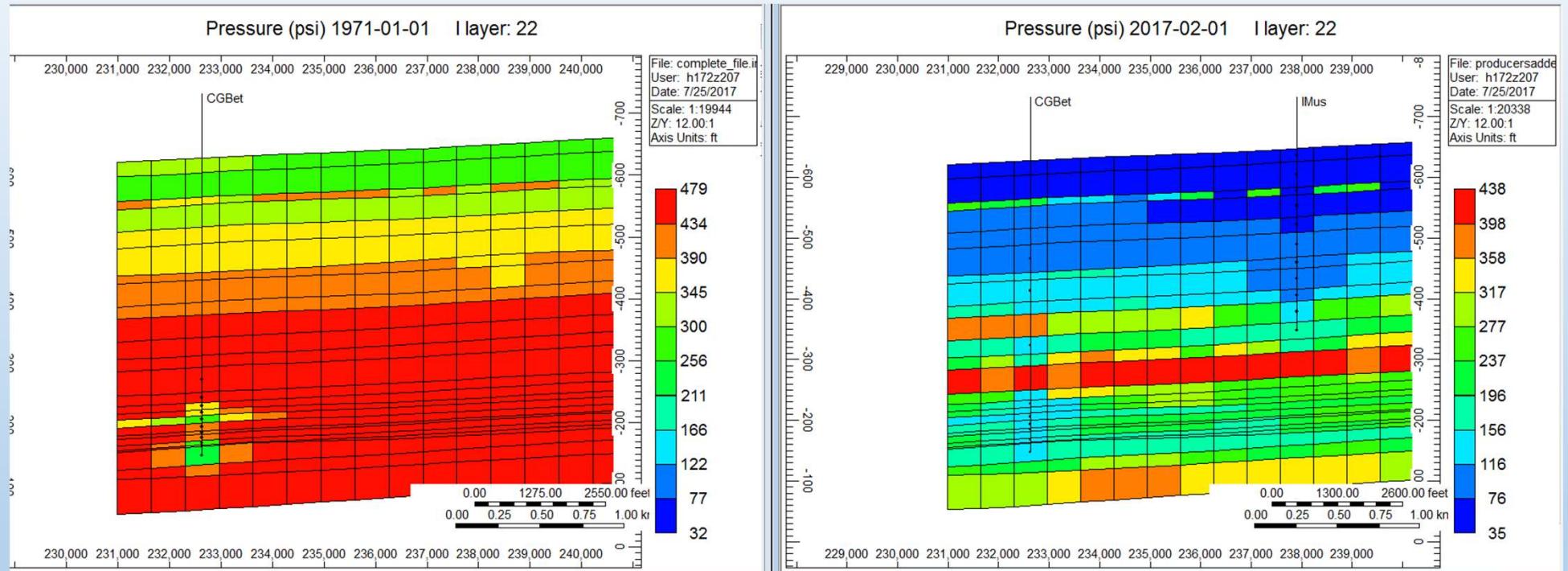
Perforated grid blocks: Use trajectory perf intervals... Begin

#	User Block Address	Connect to	Form factor FF	Status	Ref.Layer	WI (md ² ft)
1	22 22 6	Surface	6	Open	○	1556.198
2	22 22 8	1	6	Open	○	149.214
3	22 22 11	2	6	Open	○	193.575
4	22 22 15	3	6	Open	○	9.025
5	22 22 17	4	6	Open	○	885.198
6	22 22 18	5	6	Open	○	2.423
7	22 22 19	6	6	Open	○	2.616
8	22 22 21	7	6	Open	○	32.557
* 9	22 22 23	8	6	Open	○	387.731

Reset Well OK Cancel Apply Help

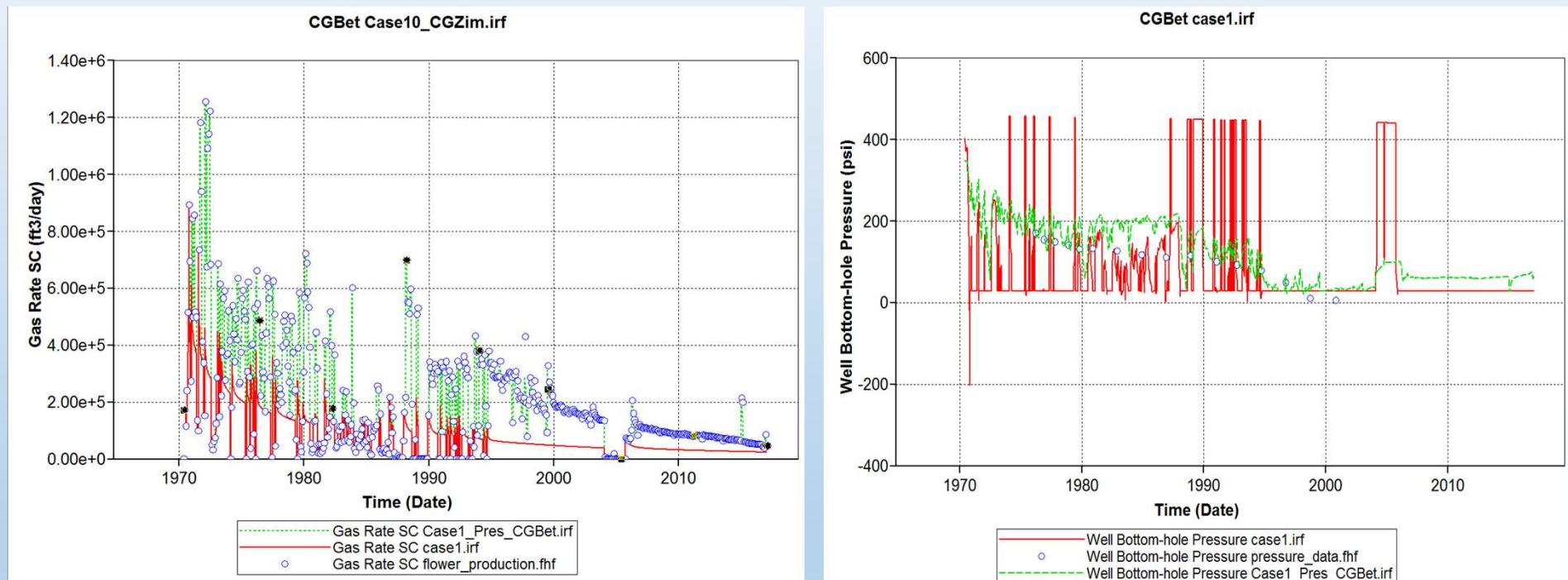
Before

History Matching

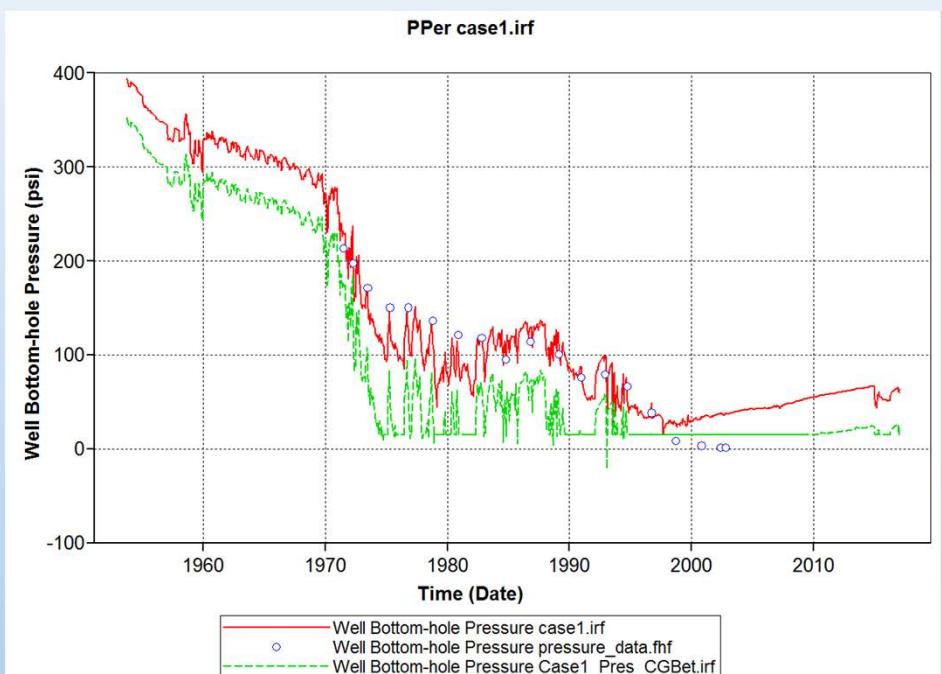
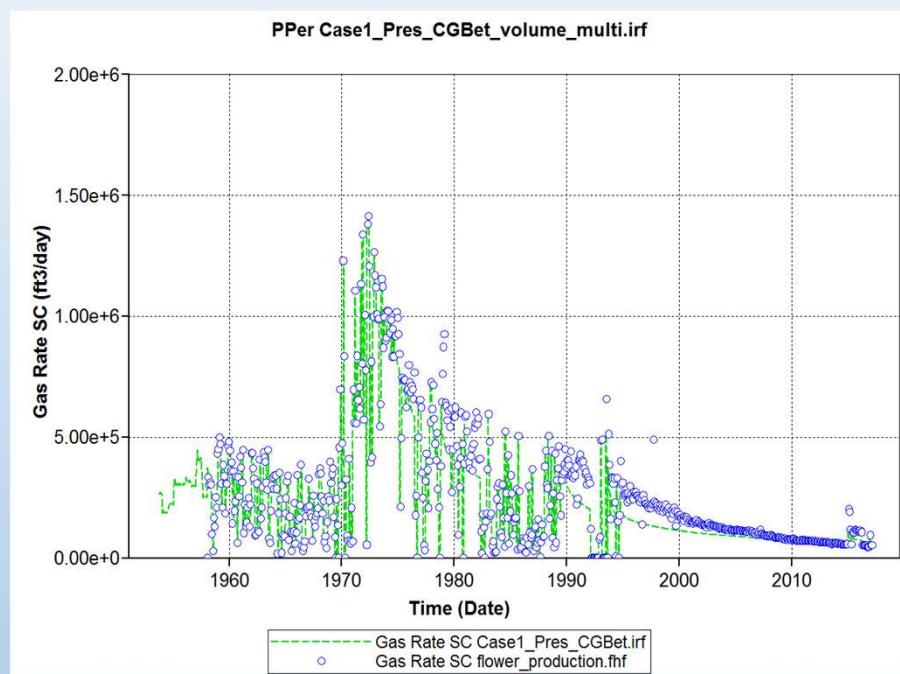
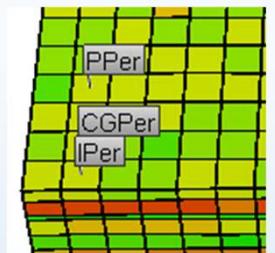


Decrease in Pressure

History Matching

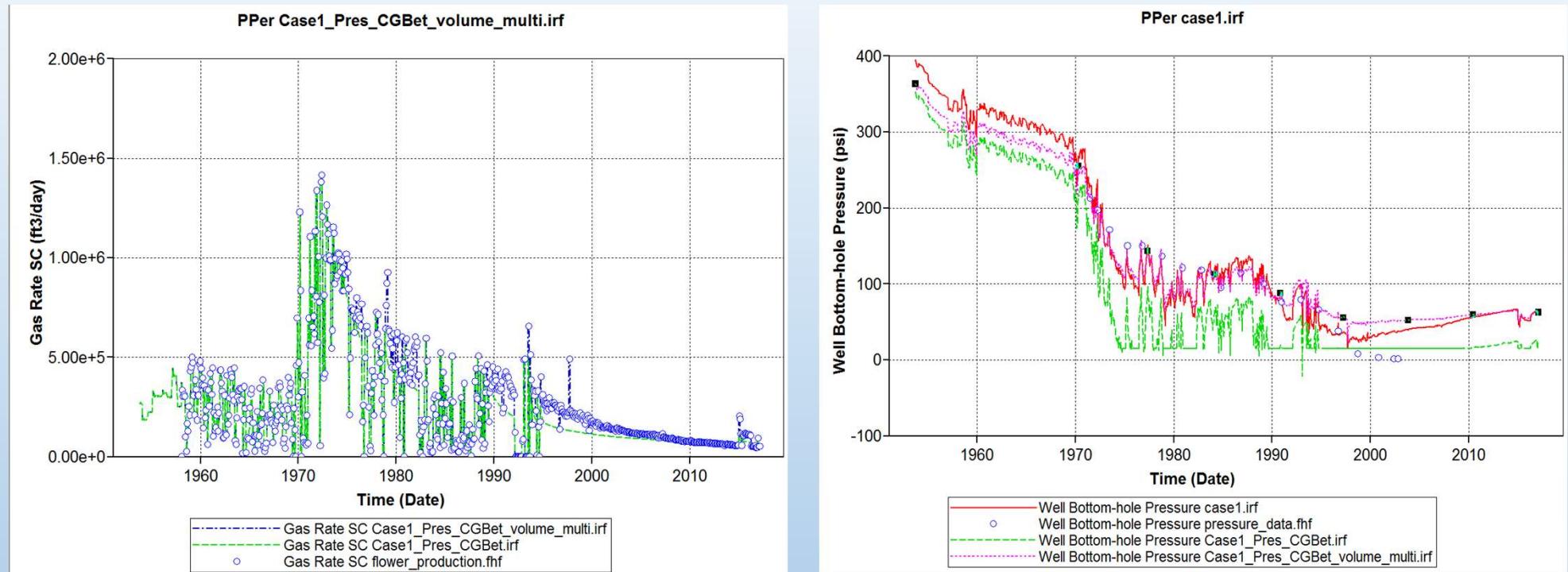


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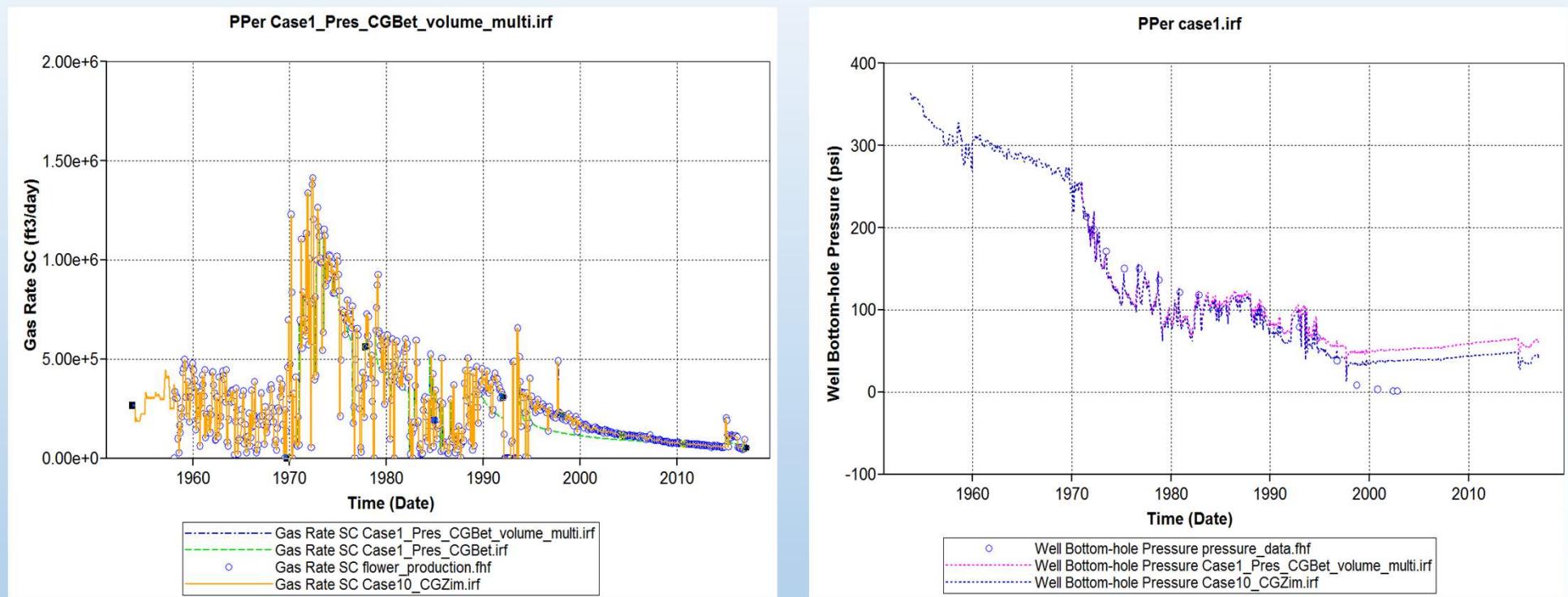


Boundary Well PPer

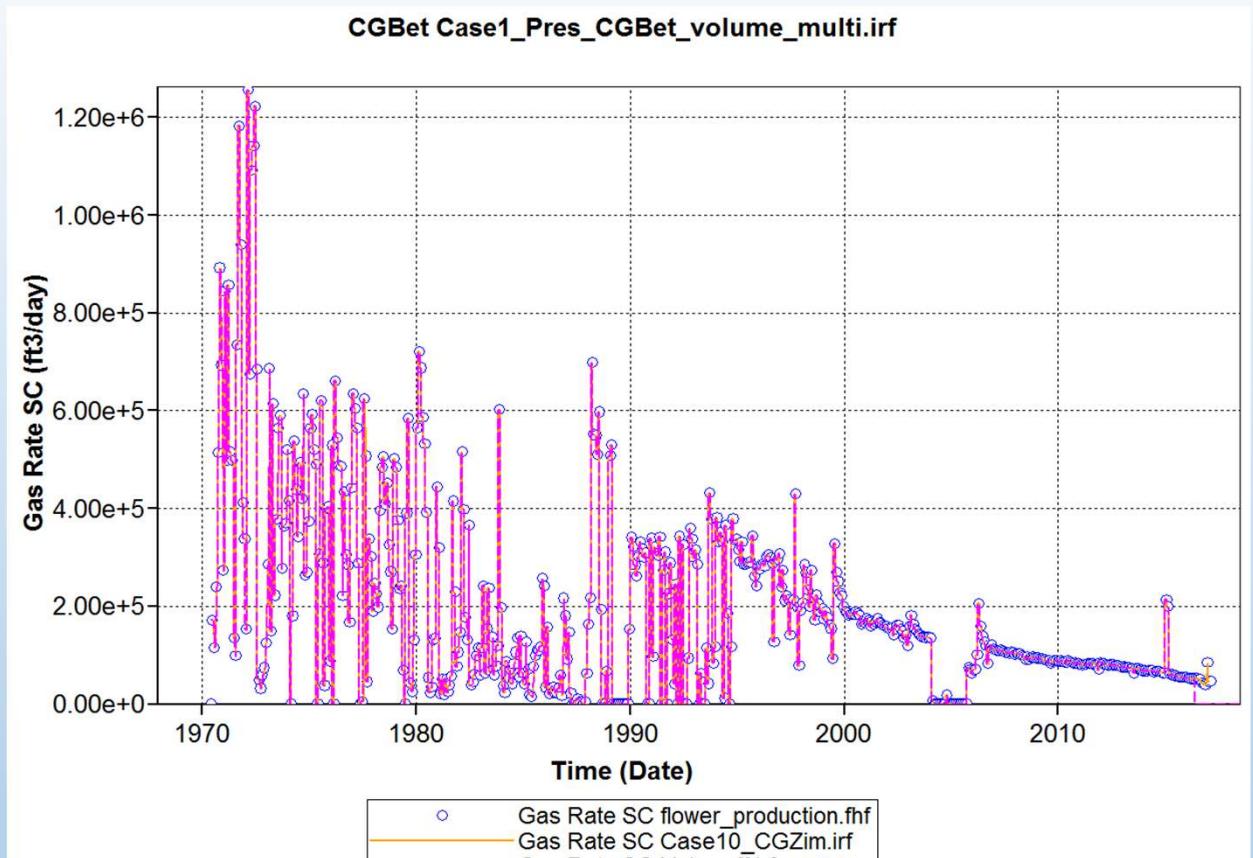
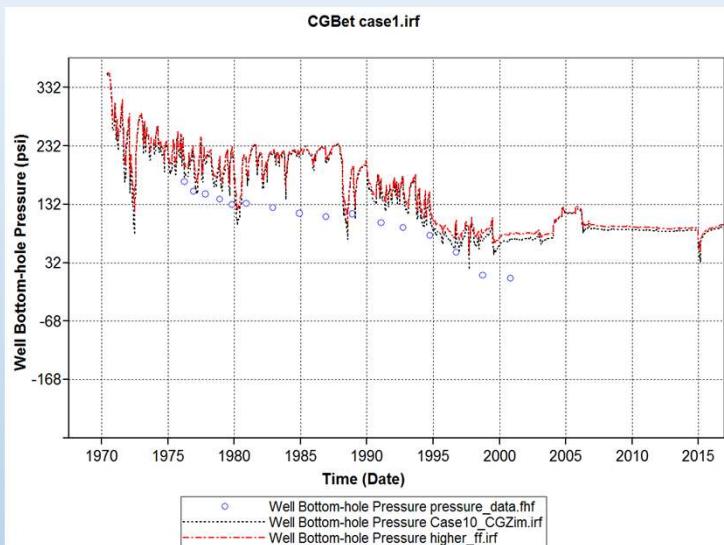
History Matching



History Matching

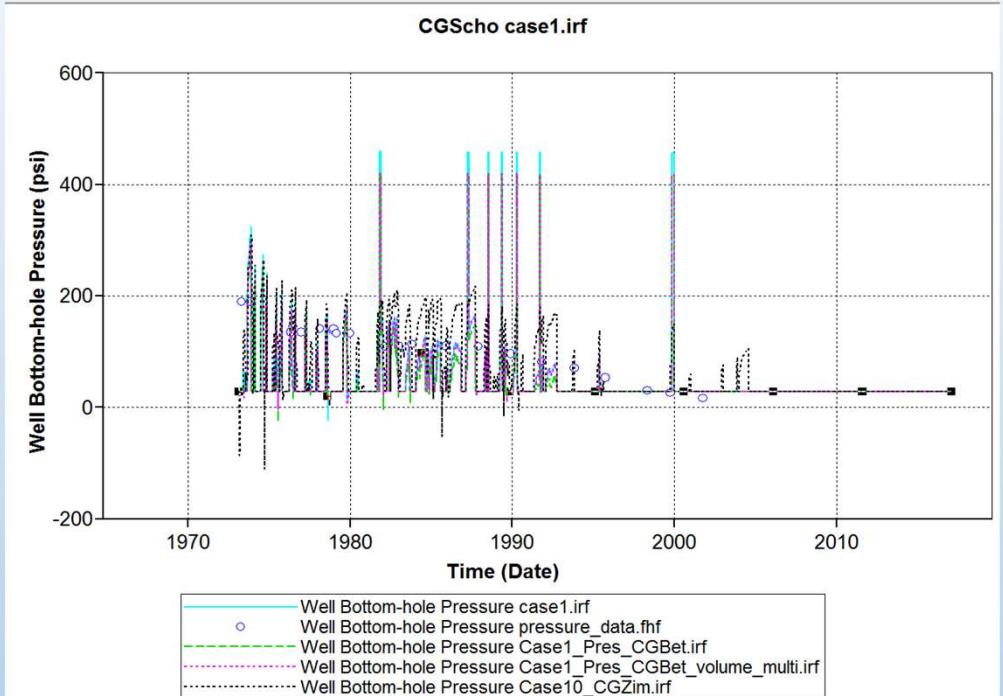
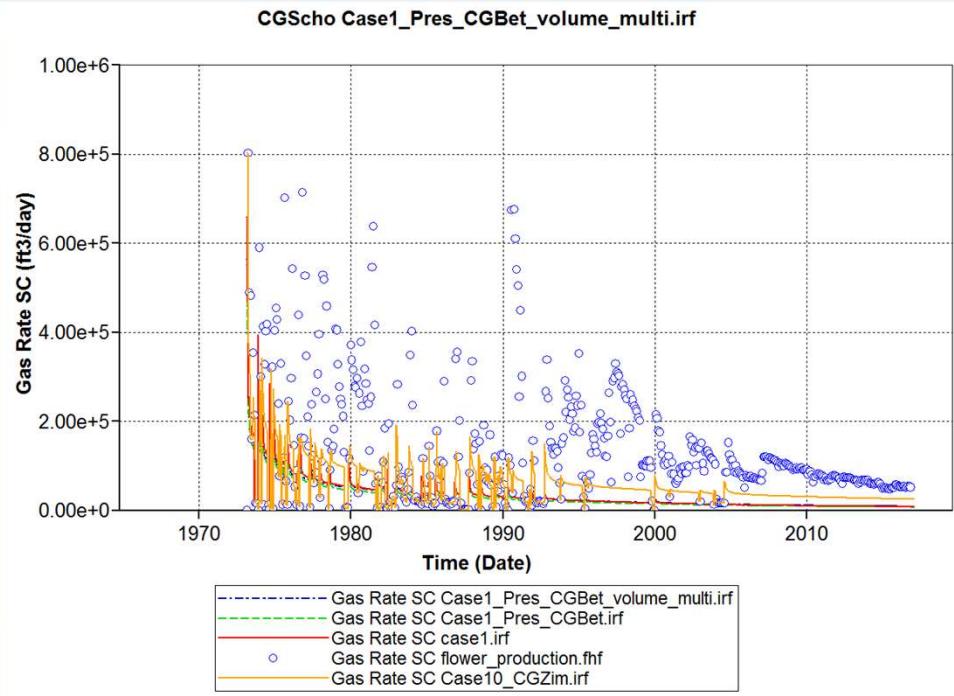


History Matching



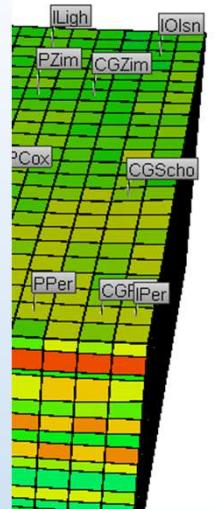
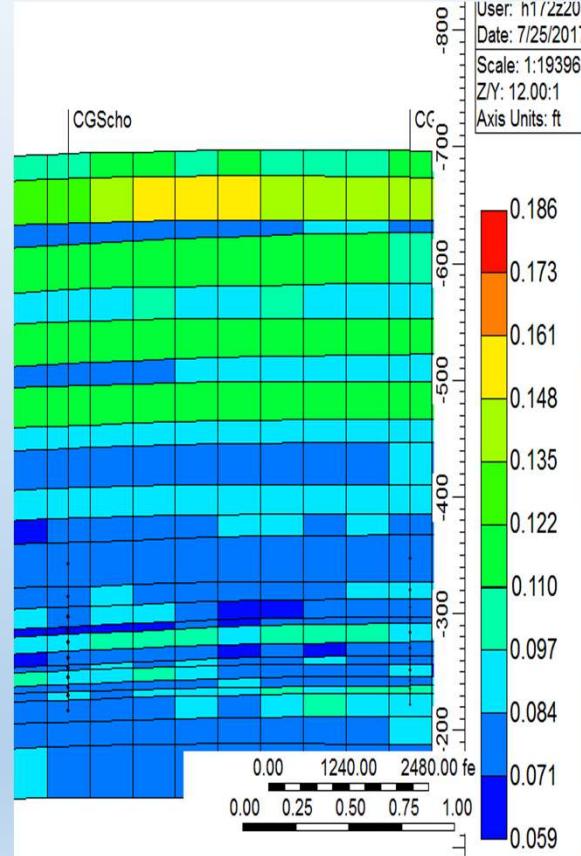
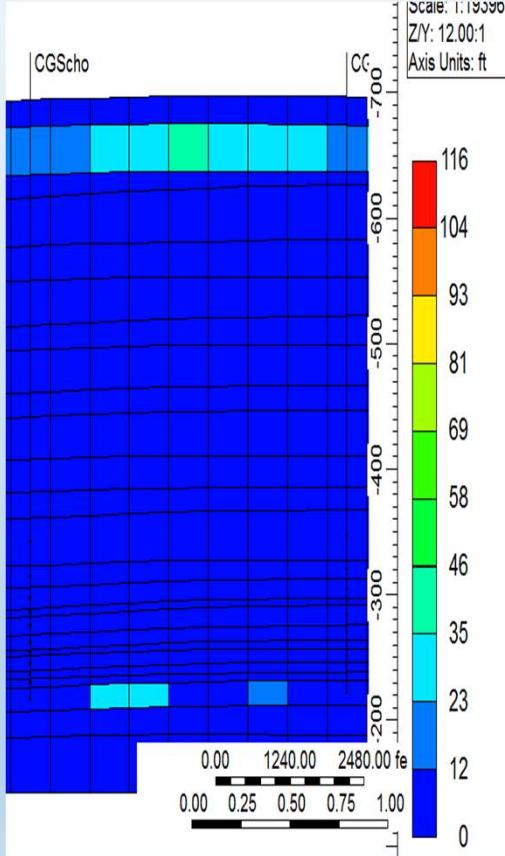
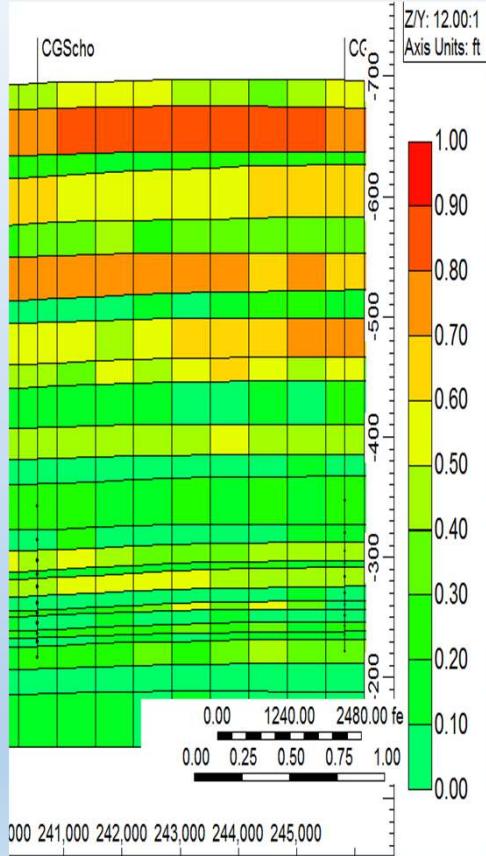
Higher ff, better results?

History Matching



Error

History Matching



Future Prediction

Simulation Dates

* - no keyword data exists on this date (it can be deleted)

#	Date & Time (day)	set STOP	Comments
913	2015-10-01 (28611.00)	<input type="checkbox"/>	
914	2015-11-01 (28642.00)	<input type="checkbox"/>	
915	2015-12-01 (28672.00)	<input type="checkbox"/>	
916	2016-01-01 (28703.00)	<input type="checkbox"/>	
917	2016-02-01 (28734.00)	<input type="checkbox"/>	
918	2016-03-01 (28763.00)	<input type="checkbox"/>	
919	2016-04-01 (28794.00)	<input type="checkbox"/>	
920	2016-05-01 (28824.00)	<input type="checkbox"/>	
921	2016-06-01 (28855.00)	<input type="checkbox"/>	
922	2016-07-01 (28885.00)	<input type="checkbox"/>	
923	2016-08-01 (28916.00)	<input type="checkbox"/>	
924	2016-09-01 (28947.00)	<input type="checkbox"/>	
925	2016-10-01 (28977.00)	<input type="checkbox"/>	
926	2016-11-01 (29008.00)	<input type="checkbox"/>	
927	2016-12-01 (29038.00)	<input type="checkbox"/>	
928	2017-01-01 (29069.00)	<input type="checkbox"/>	
929	2017-02-01 (29100.00)	<input checked="" type="checkbox"/>	

Add a new date:

Add a range of dates:

Delete selected empty dates:

Delete all empty dates:

To limit output file size, limit grid output (with WSRF) to:

Do not limit grid output

Remove existing keywords (WSRF) to limit grid output

Well Events

displayed wells 29 of 29

2016-06-01 Well: 'CGBet' at 2016-06-01 (28855.00 day)

Name / Date	Event	ID & Type	Constraint definition	previous date: 1970-06-01
2015-07-01	ALTER			
2015-08-01	ALTER			
2015-09-01	ALTER			
2015-10-01	ALTER			
2015-11-01	ALTER			
2015-12-01	ALTER			
2016-01-01	ALTER			
2016-02-01	ALTER			
2016-03-01	ALTER			
2016-04-01	ALTER			
2016-05-01	ALTER			
2016-06-01	ALTER			
2016-07-01	ALTER			
2016-08-01	ALTER			
2016-09-01	ALTER			
2016-10-01	ALTER			
2016-11-01	ALTER			
2016-12-01	ALTER			
2017-01-01	ALTER			
2017-02-01	ALTER			
CGFulk				
1970-05-01	WELL PRODUCER			

Sort by: Name Date

Constraint definition previous date: 1970-06-01

Change current primary constraint (ALTER) Set new or change old constraint (TARGET)

STG 51763.19922 ft³/day # Parameter Value

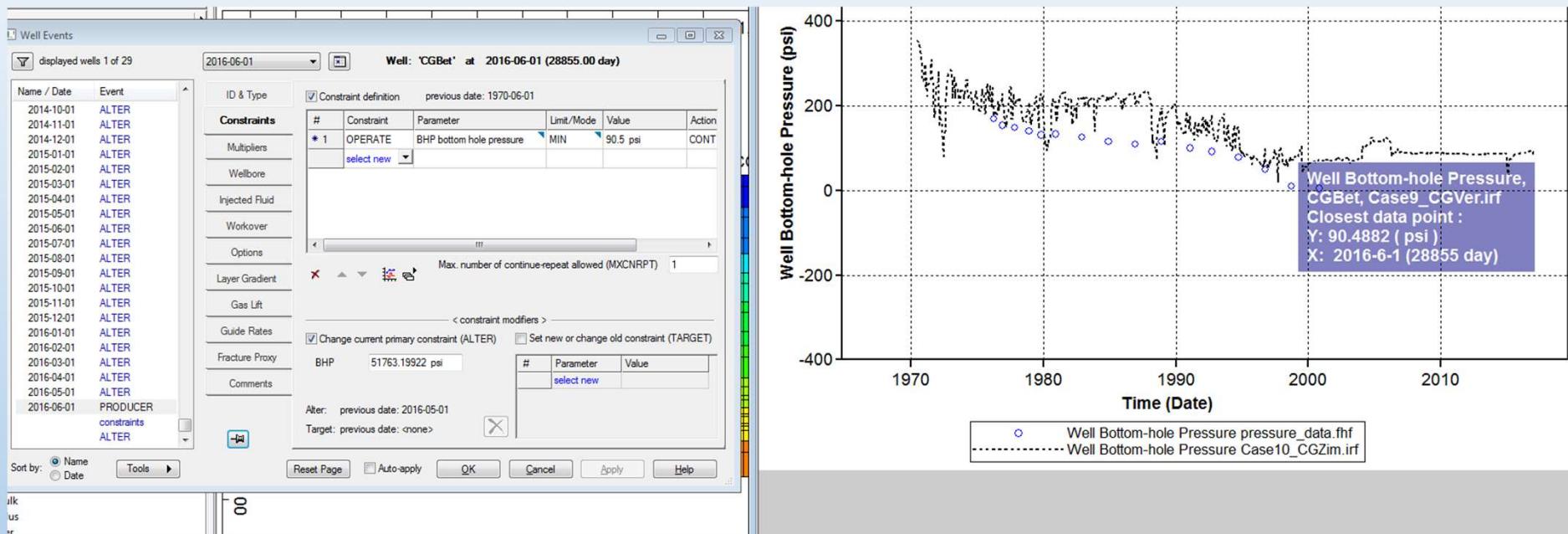
select new

Alter: previous date: 2016-05-01 Target: previous date: <none>

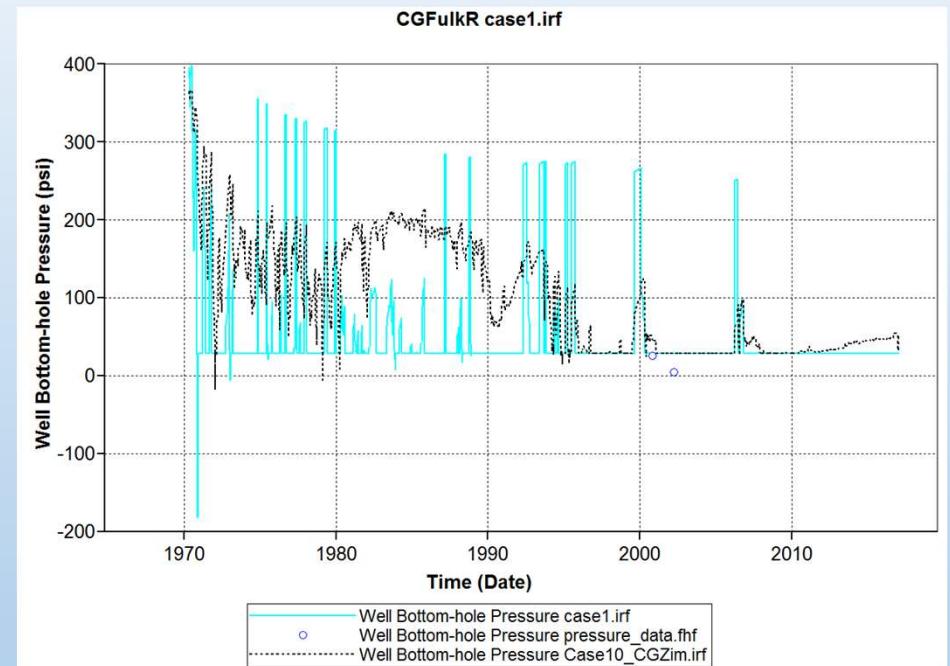
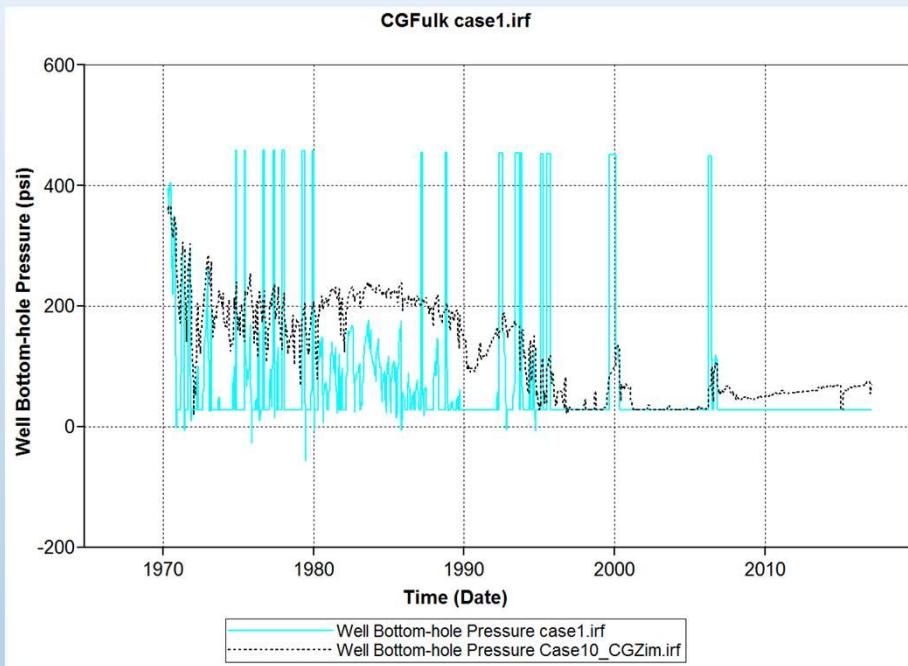
Auto-apply

1365	* 2050-04-01 (41212.00)	<input type="checkbox"/>
1366	* 2050-05-01 (41242.00)	<input type="checkbox"/>
1367	2050-06-01 (41273.00)	<input checked="" type="checkbox"/>

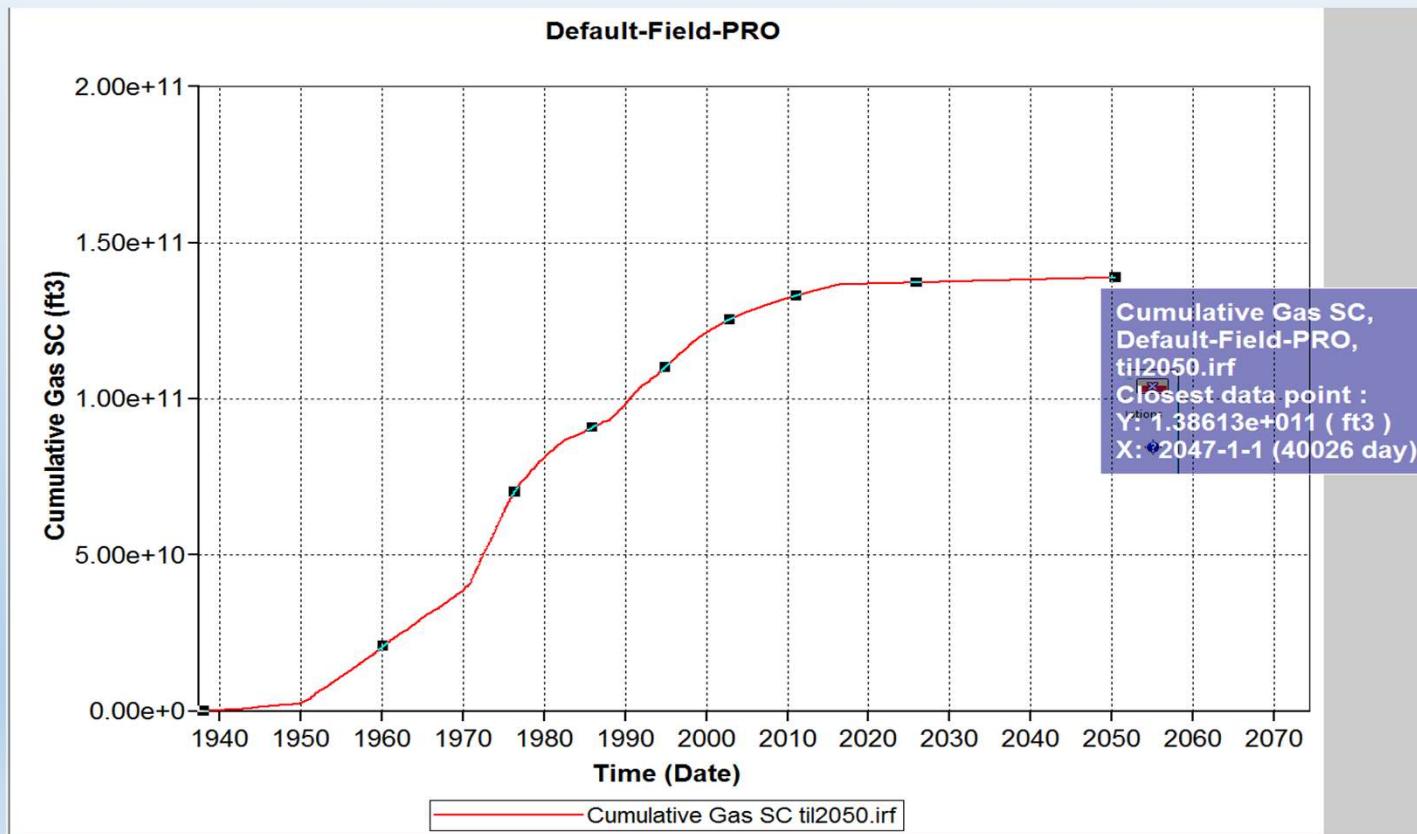
Future Prediction



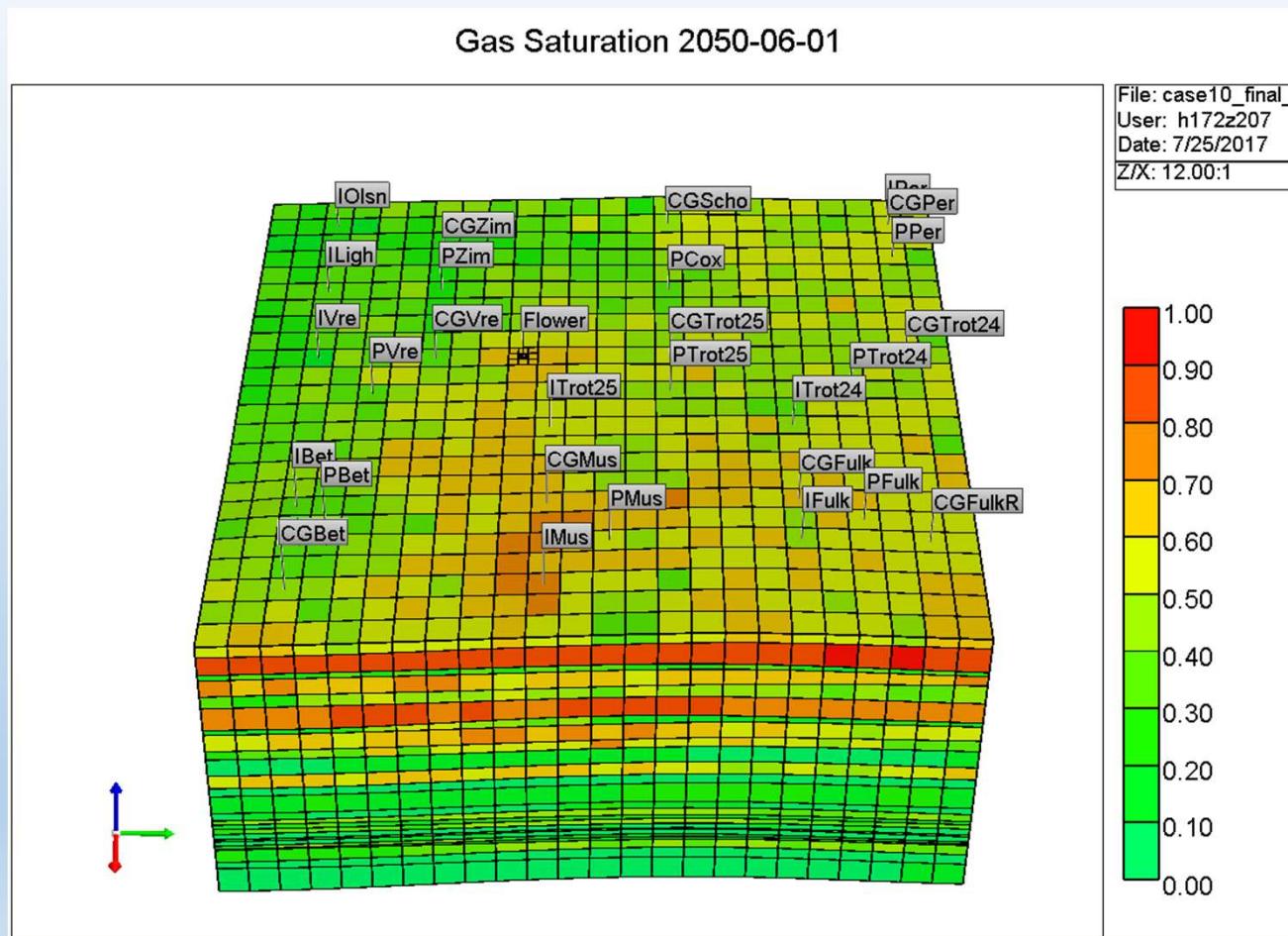
Future Prediction



Future Prediction

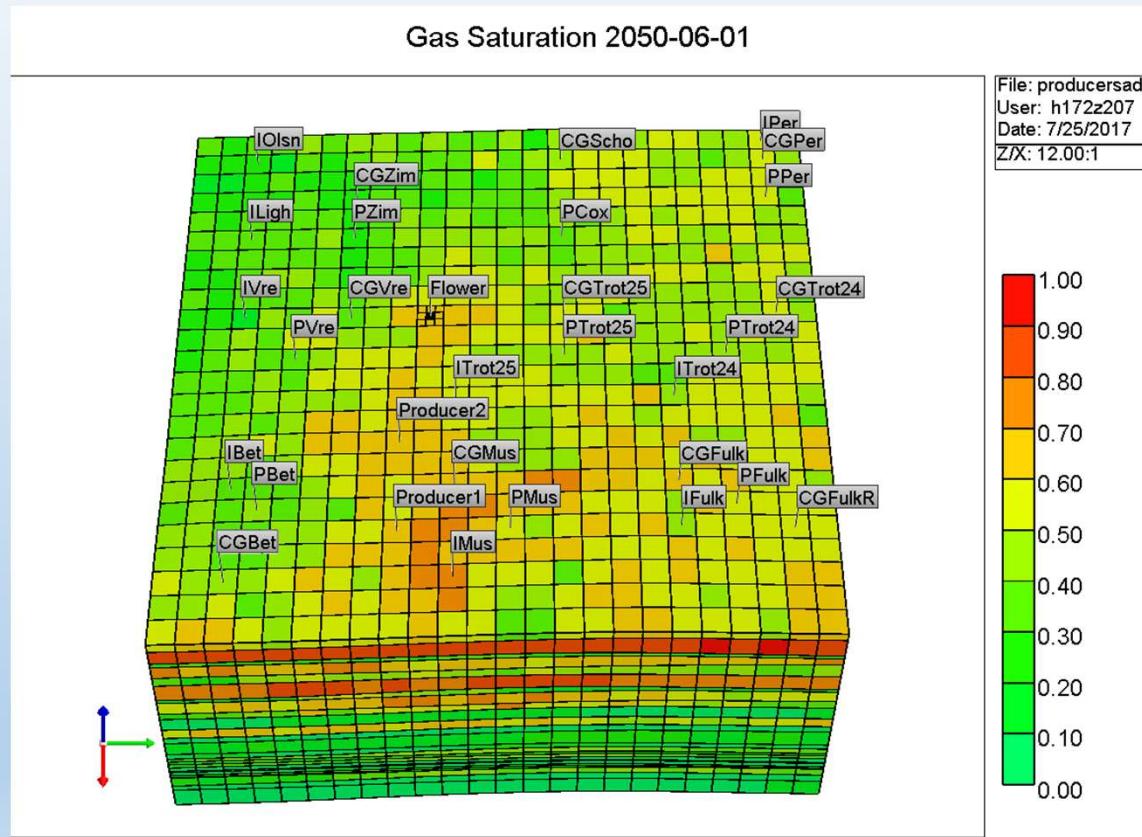


Future Prediction

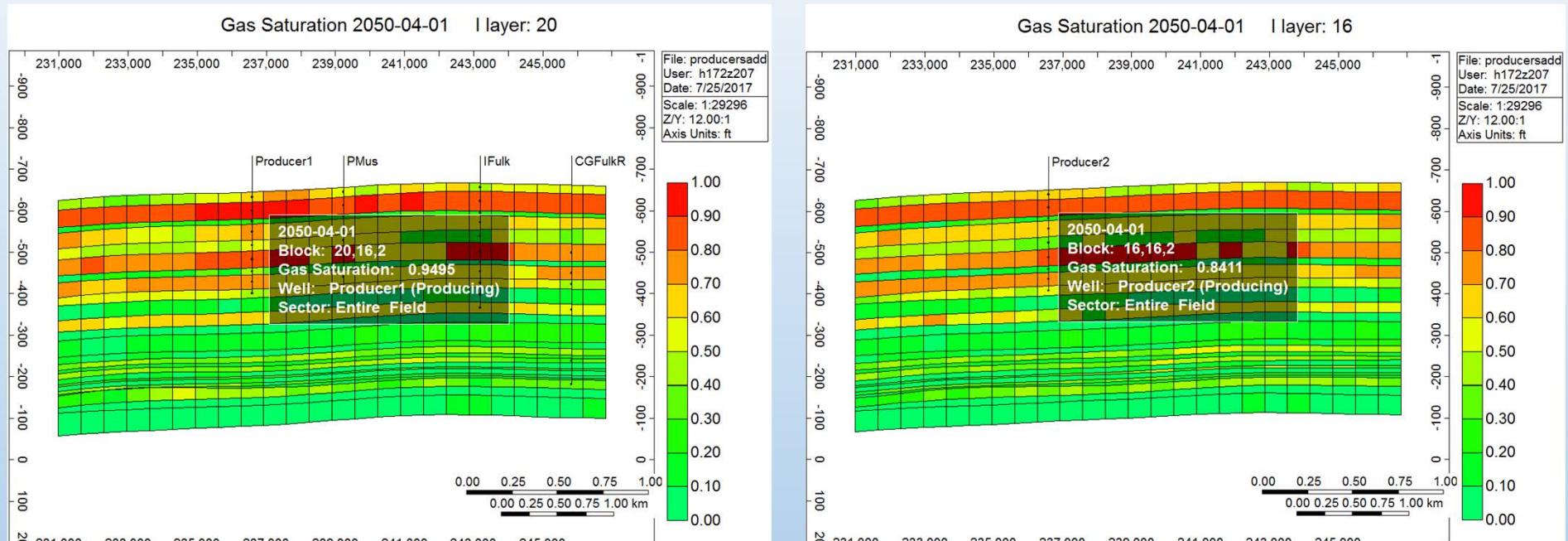


From CMG result 3D

New Wells Optimum Locations

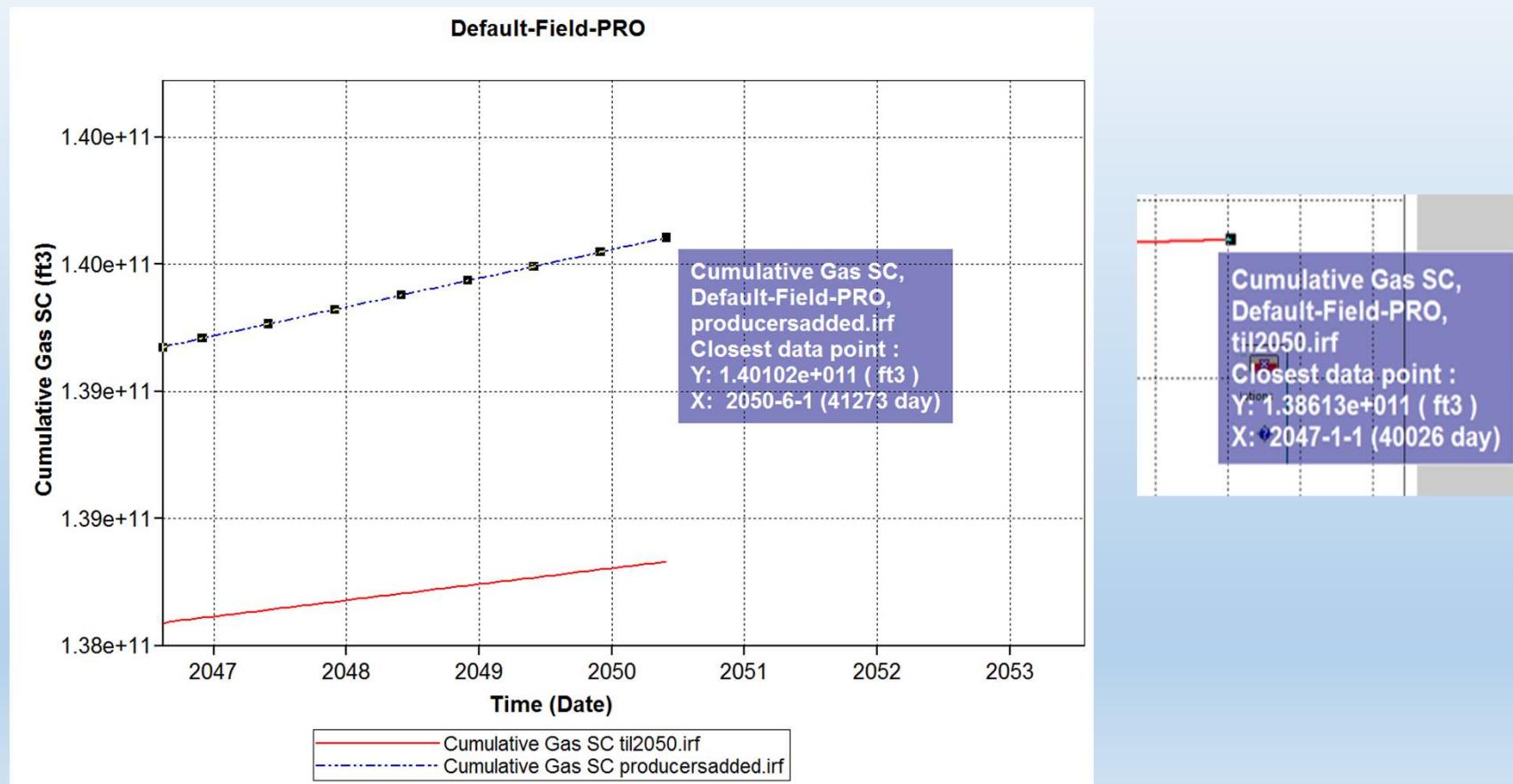


New Wells Optimum Locations

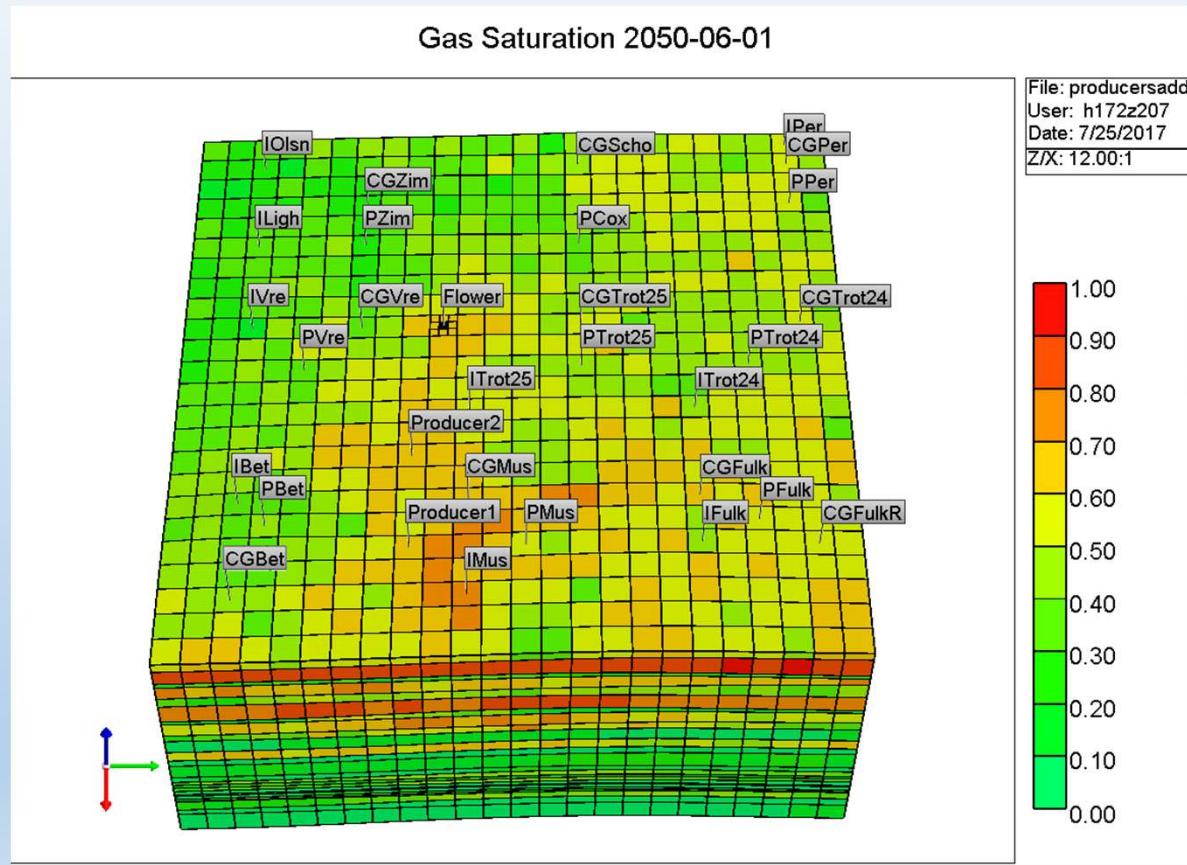


Perforated to layer 9

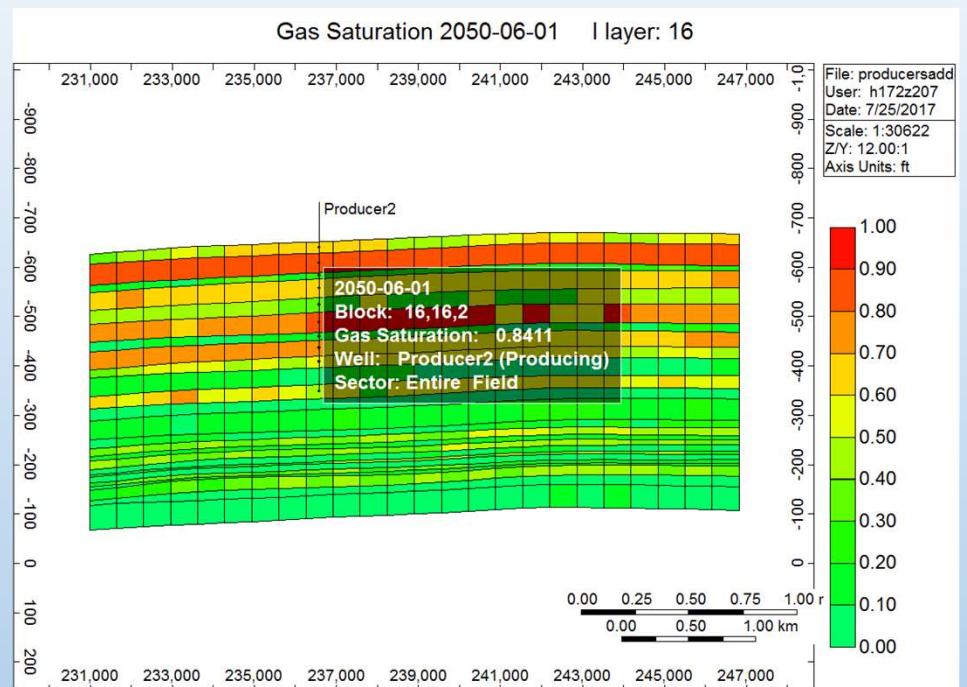
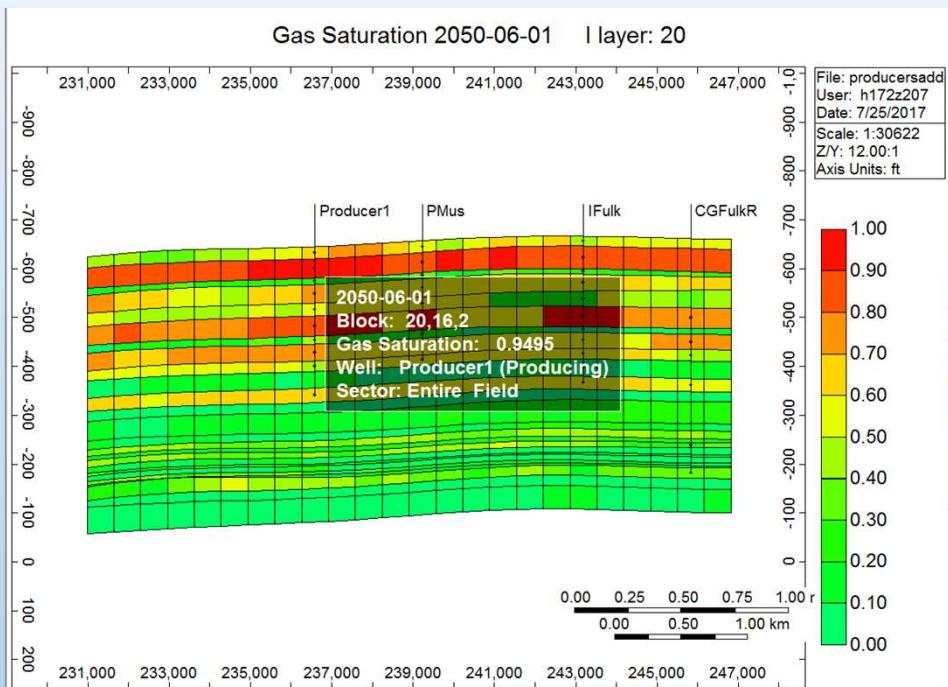
New Wells Optimum Locations



New Wells Optimum Locations

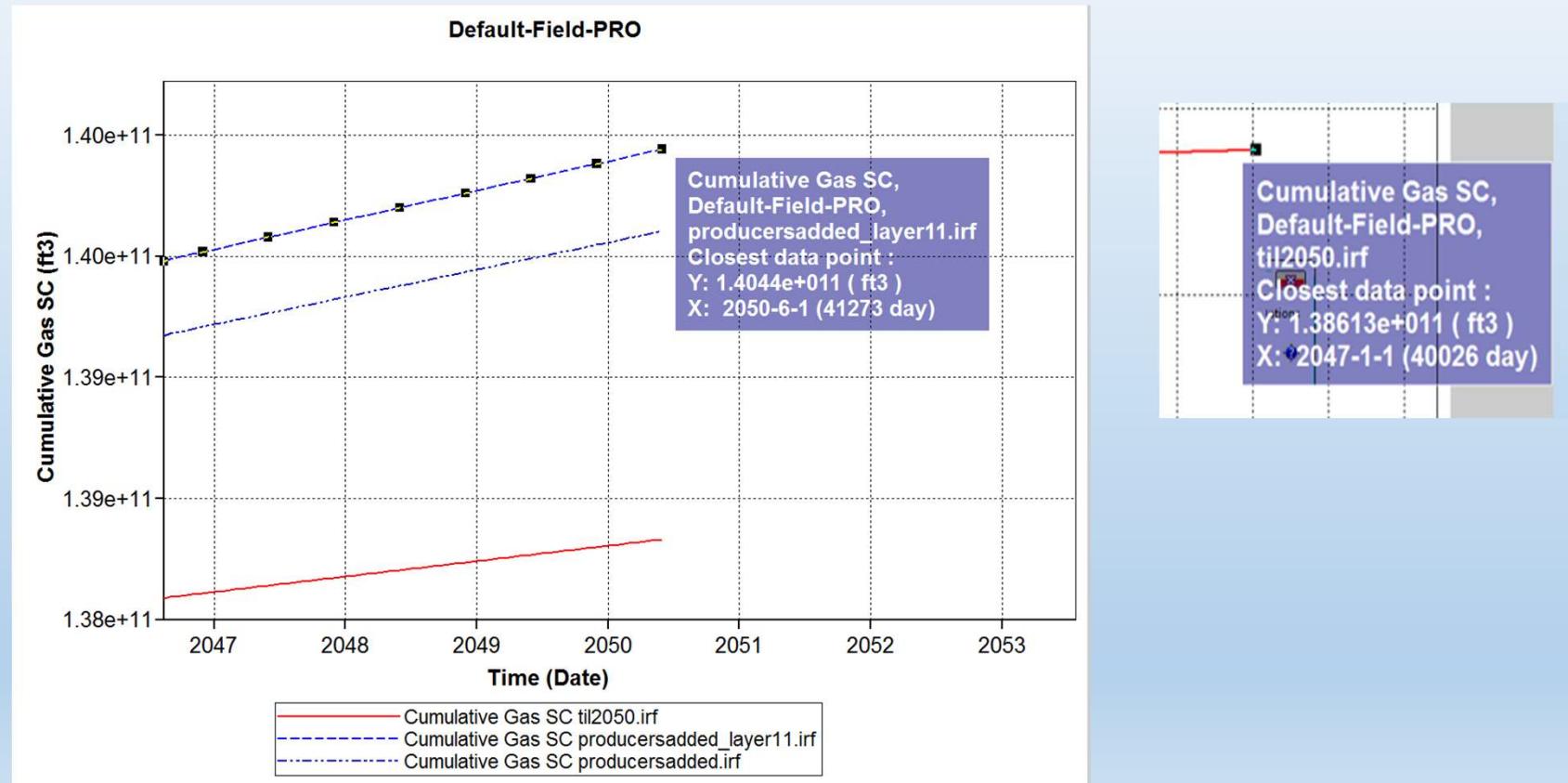


New Wells Optimum Locations

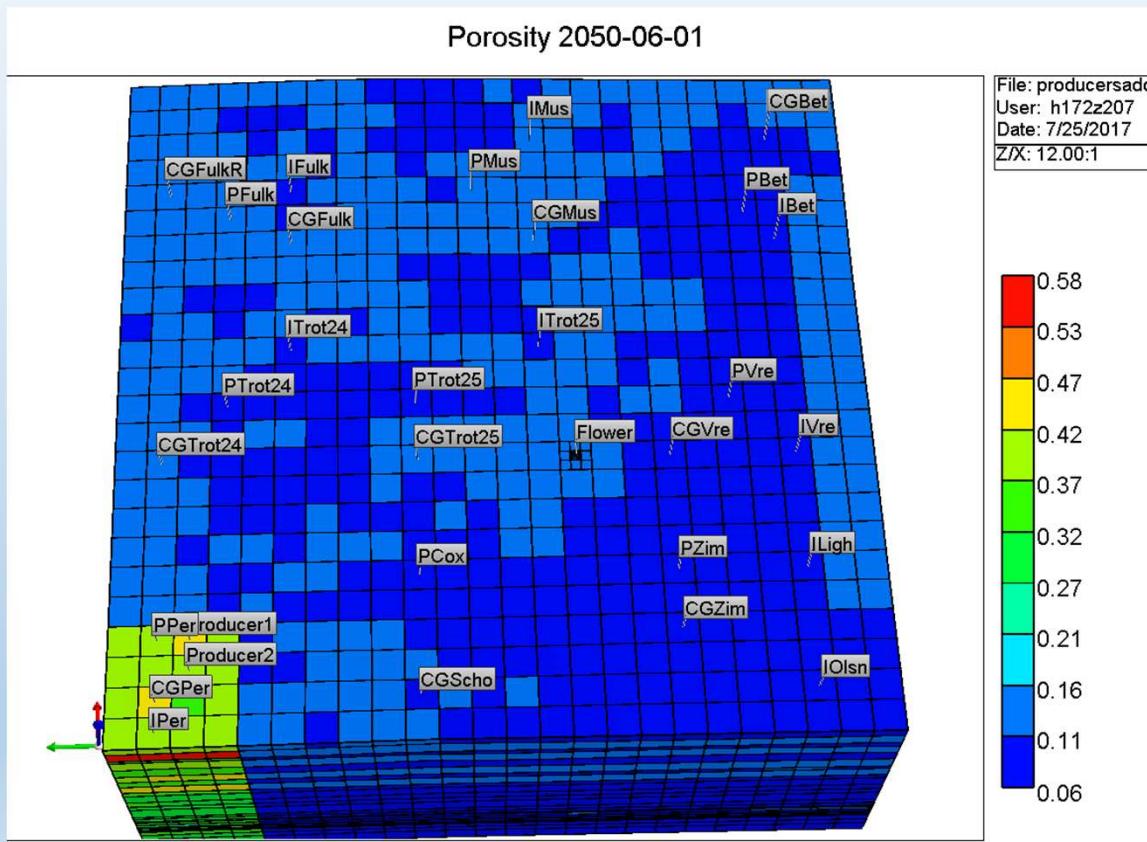


Perforated to layer 11

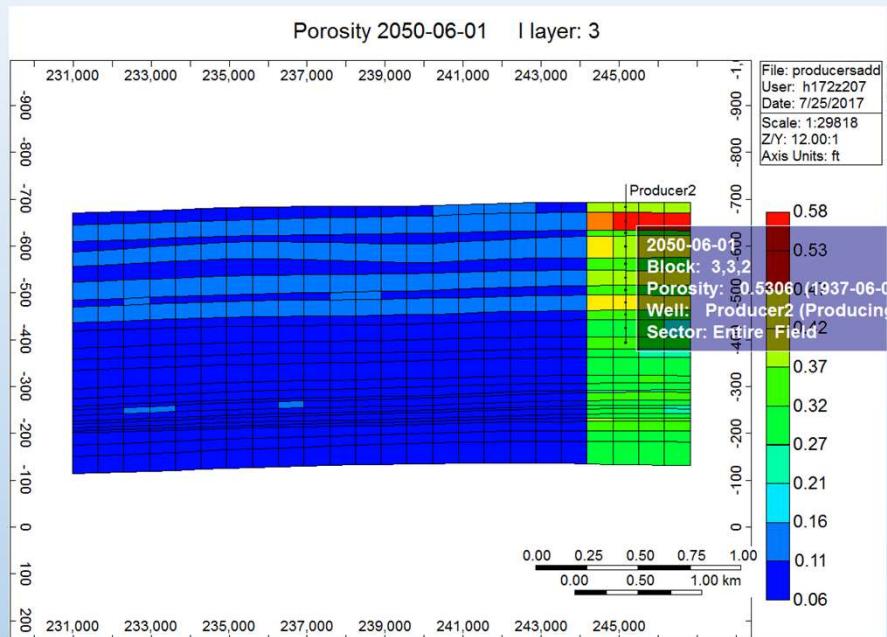
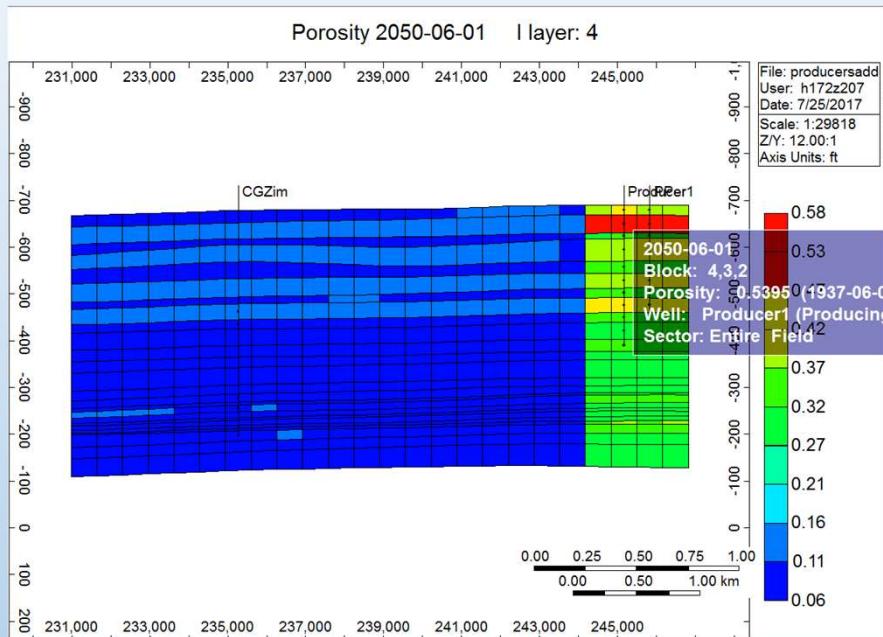
New Wells Optimum Locations



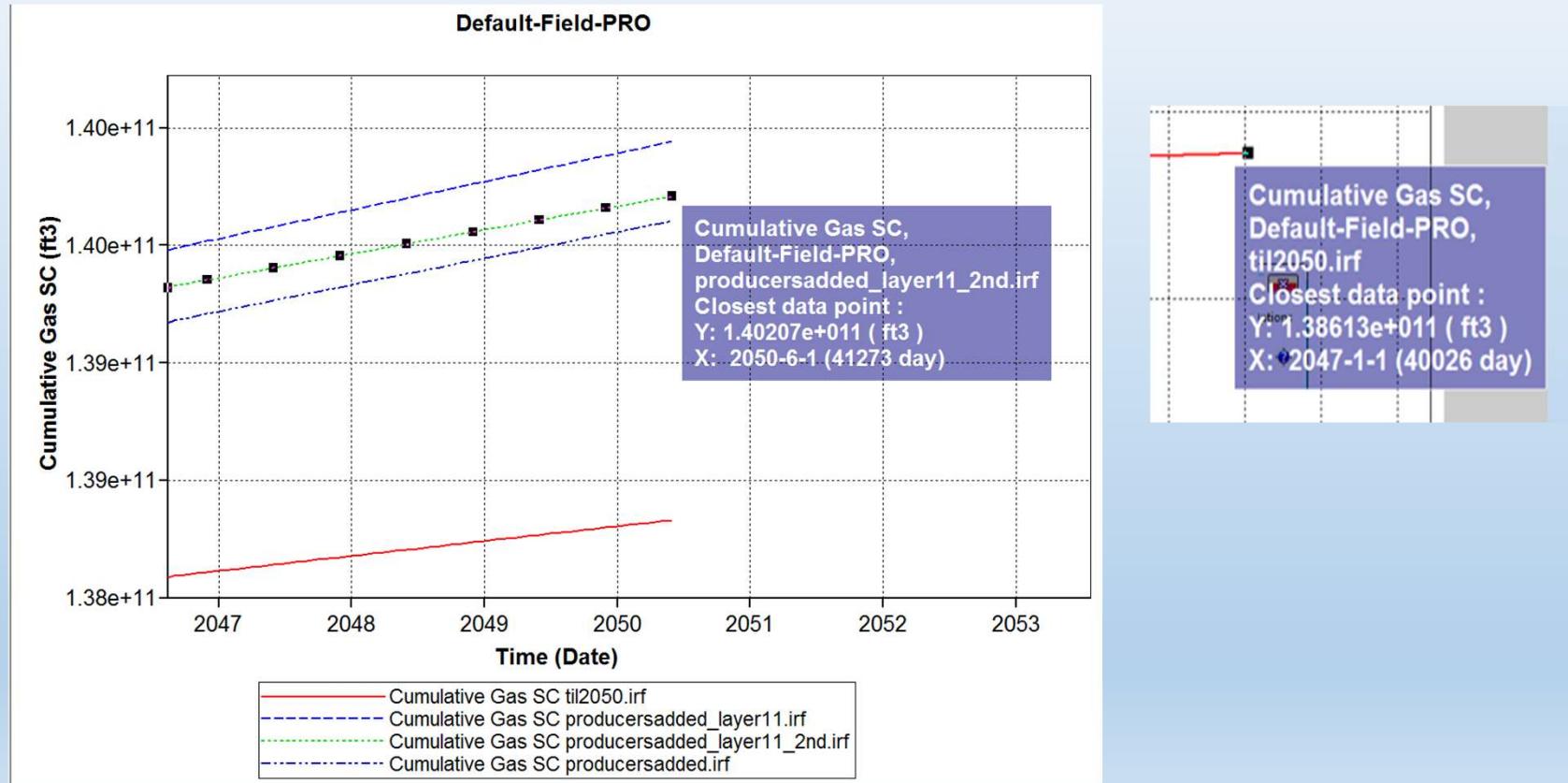
New Wells Optimum Locations



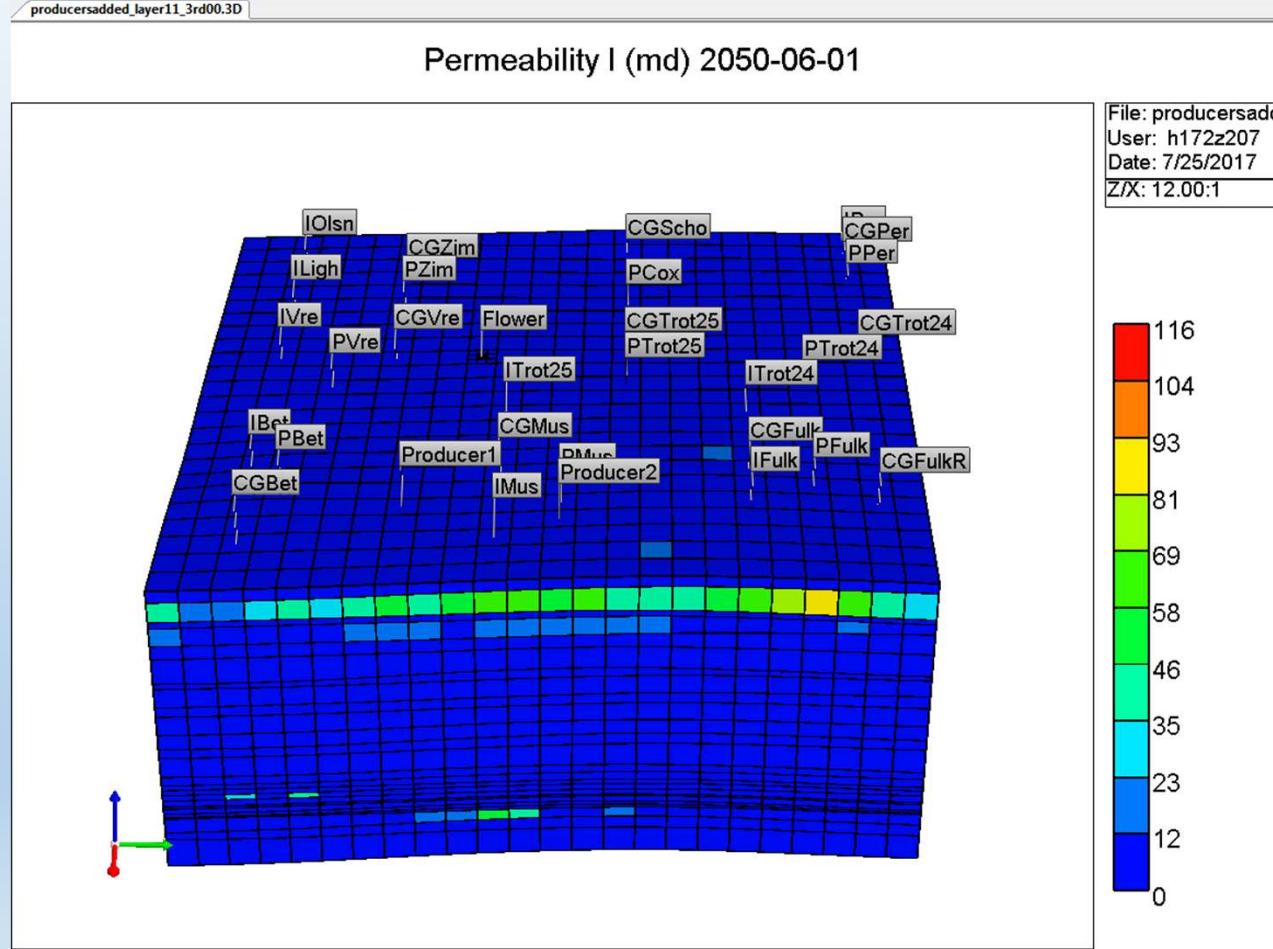
New Wells Optimum Locations



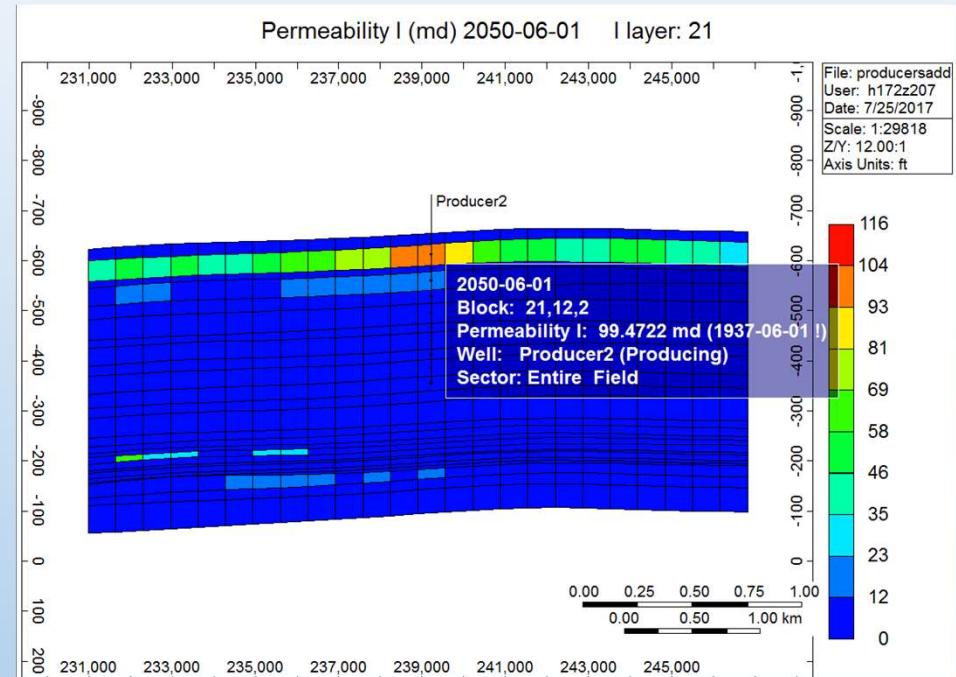
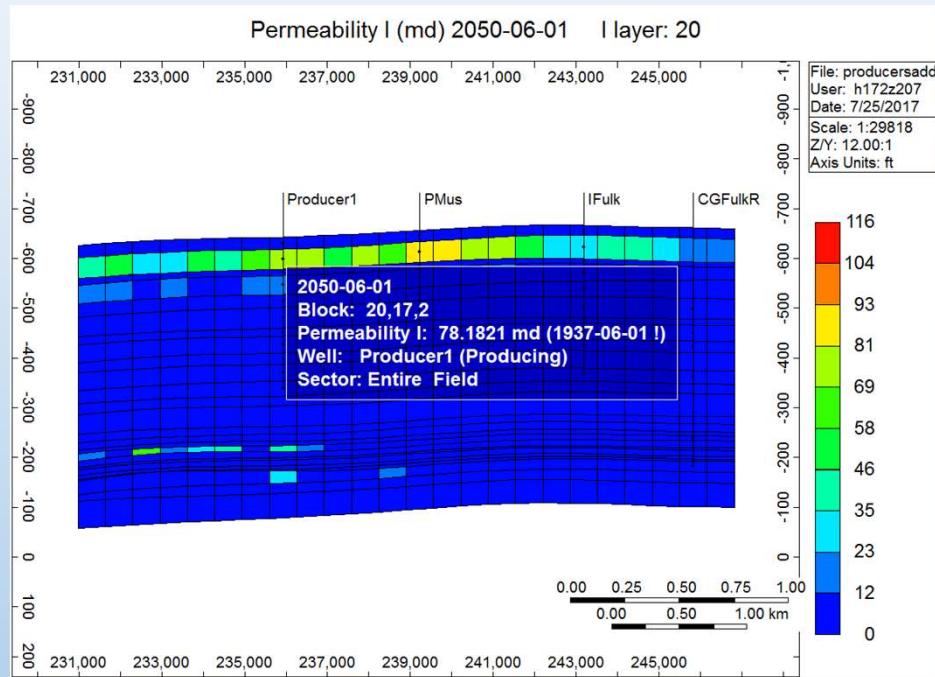
New Wells Optimum Locations



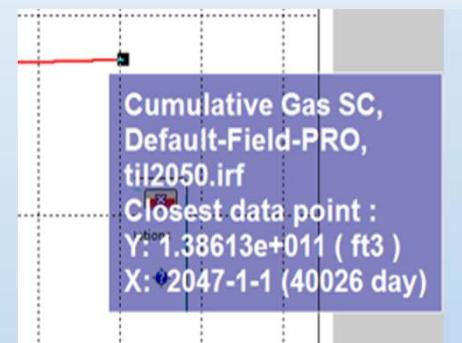
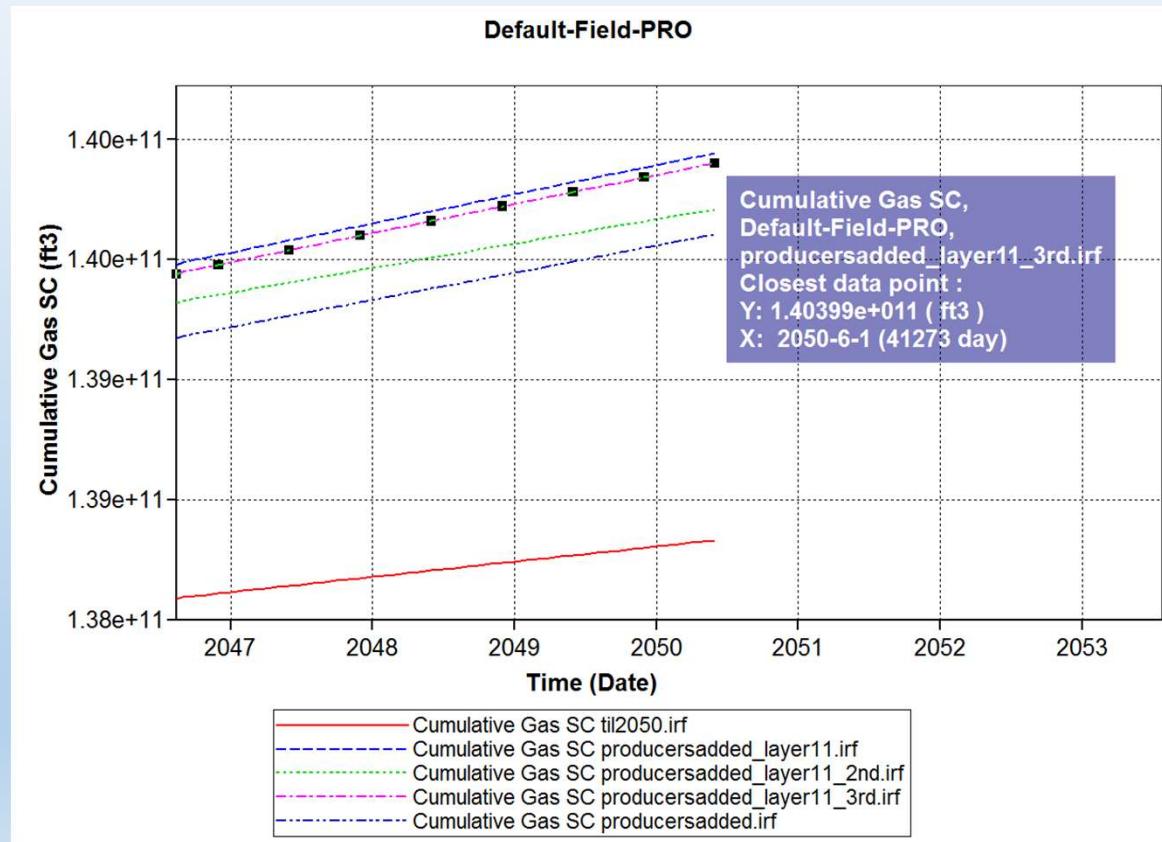
New Wells Optimum Locations



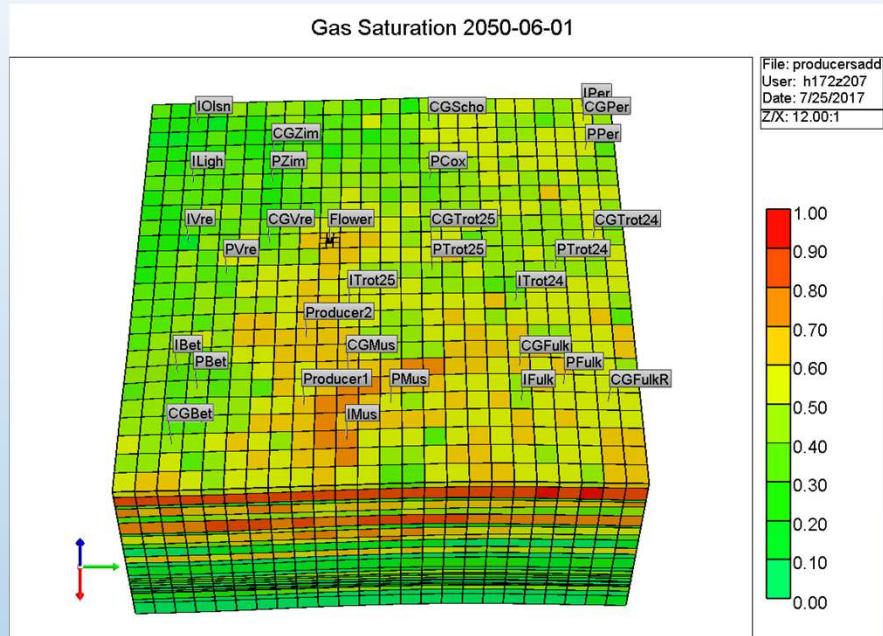
New Wells Optimum Locations



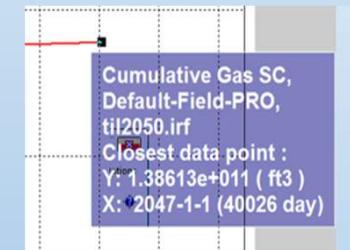
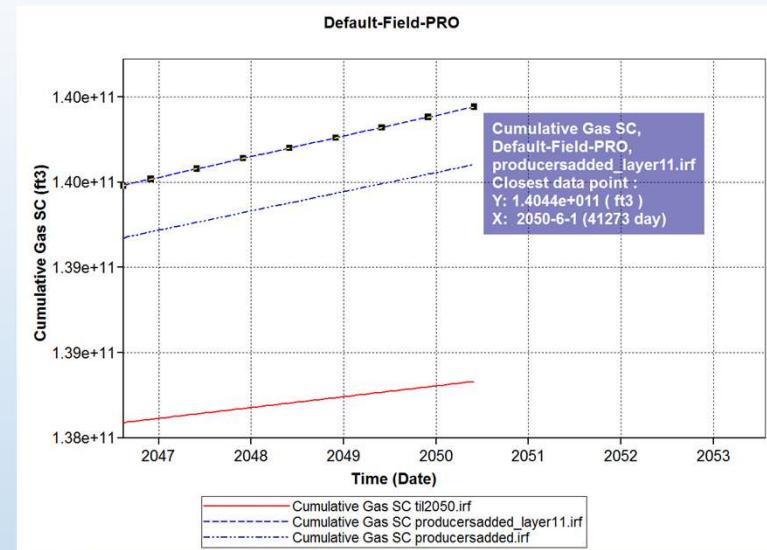
New Wells Optimum Locations



Conclusion



Perforated to layer 11



Total Production Increased: **0.01827 e+11 ft^3**

Total percent of Production Increased: **1.3009%**

Thank You for Watching



Especially thanks for Dr. Esmail Ansari for instructing the course during the summer.

Wish you all have a good rest of your Summer.