PRODUCTION DATA PRESENTATION

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&

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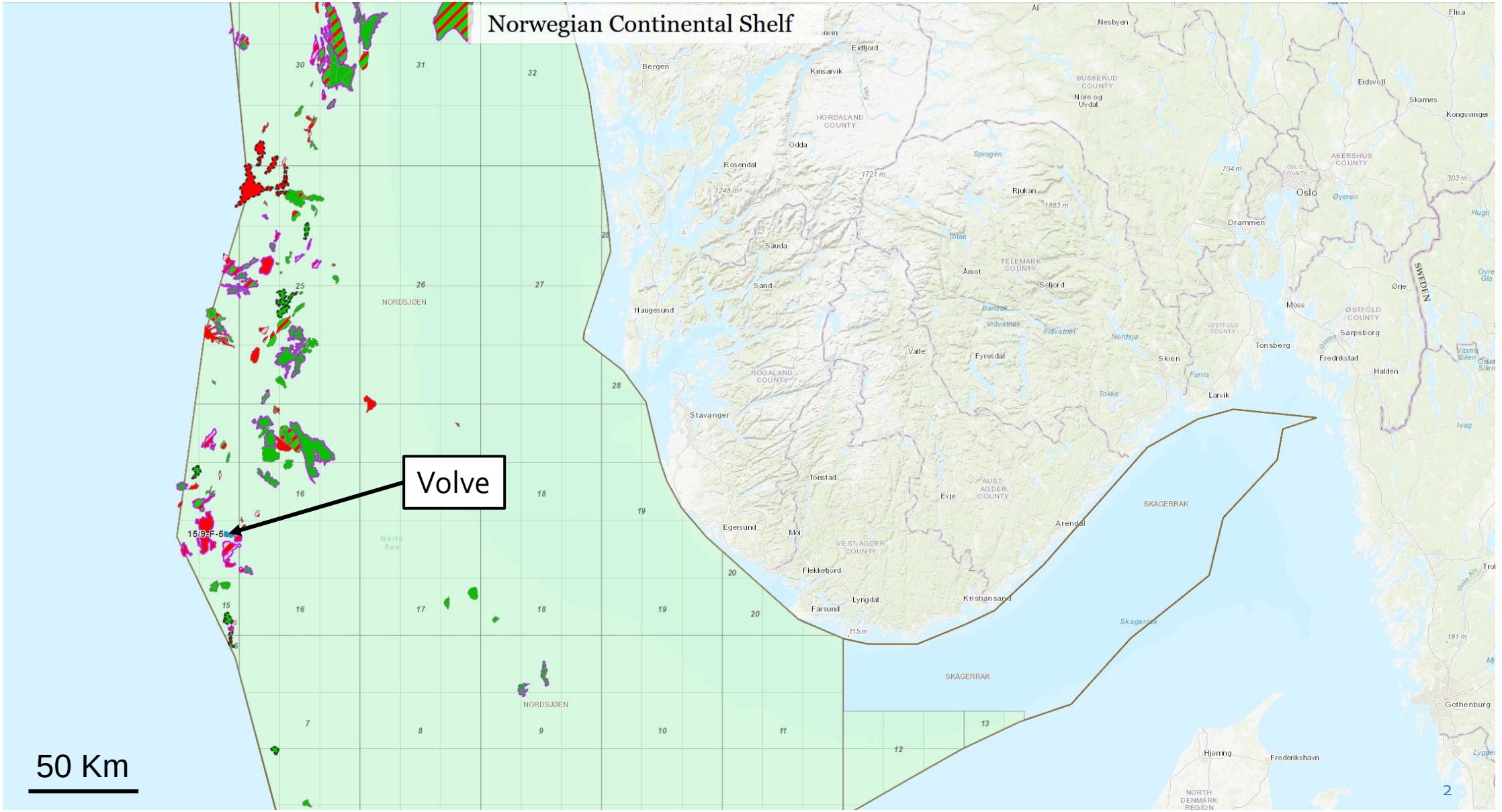
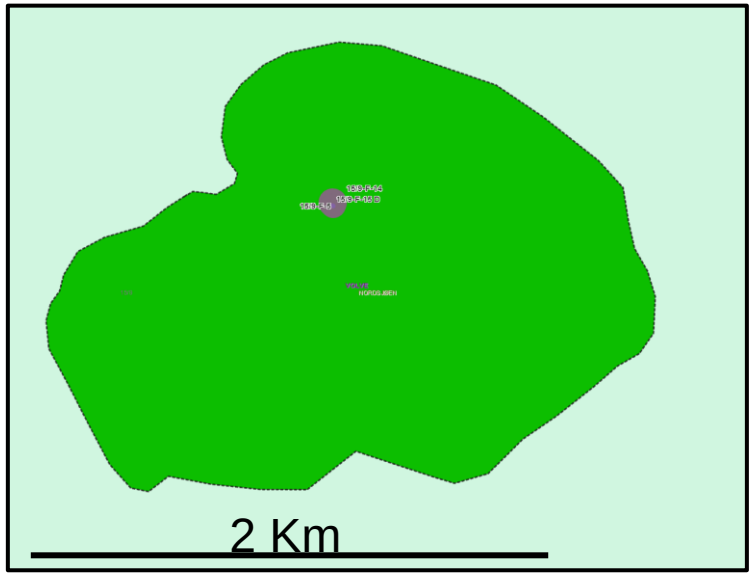
Volve field: maps



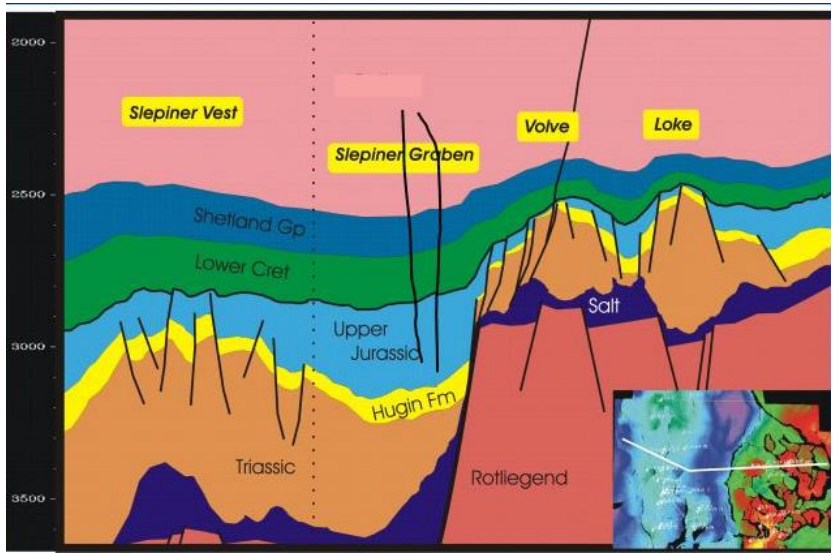
Volve field: maps



- Wells are closely bunched together
- Biggest producers are the F12 and F14 wells
- F-11, F-1C and F-15D are smaller producers
- F-4 and F-5 are injection wells

Volve field: Exploratory phase

- **Structure:**
  - Volve field: 2*3 km
  - Dome-shaped structure formed by the collapse of adjacent salt ridges (turtle back structure?) during the middle Jurassic. It is heavily faulted as a result of this formation process and of the initial extension.
  - The reservoir is thus thicker on the flanks (100m) than on the crest (20m)

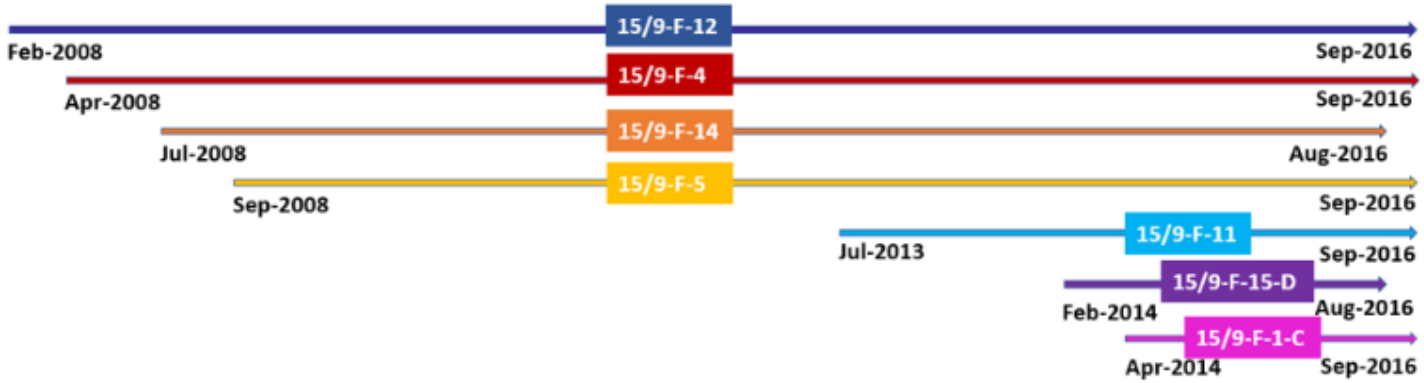


- **Reservoir**
  - Hugin formation (Jura-Trias) is a clean, shallow-water tidal sandstone, laterally expansive.
  - Average reservoir depth : 2750 - 3120 tvdss.
  - PHI = 21% ; K = 1 Darcy; NTG = 93%; Sw = 20% in oil zone
  - Oil-Water contact was estimated to be approximately 3120 m below sea level, but was never found.

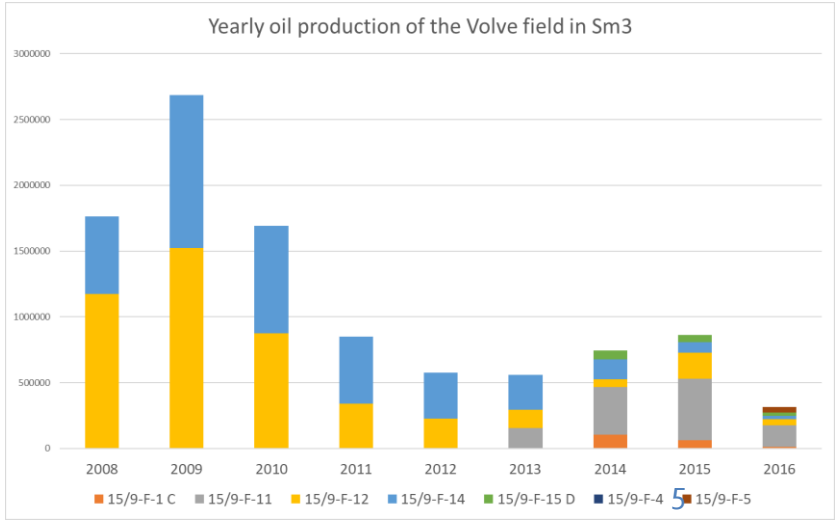
- **Fluids**
  - Studies of fluid indicated that the oil in the Volve field was formed in the Sleipner Graben area, in the NW part of the field, 10 million years ago and later on migrated into the Volve reservoir structure.

Volve field: Exploratory phase

- The initial oil production rate (Exploration well 15/9-19SR) was observed to be 1358 sm3/d with a productivity index of 143 sm3/d/Bar, which allowed to identify a potential prolific reservoir.
- Three main challenges were faced during the production face of Volve field:
  - 1. Formation water with a high content of Barium.
  - 2. Heavy oil features with a significant tendency to develop asphaltenes.
  - 3. Water production from underlying Utsira formation.
- At plateau, Volve produced approximately 8,900 Sm3 per day. It delivered a total of 10 million Sm3 of oil.

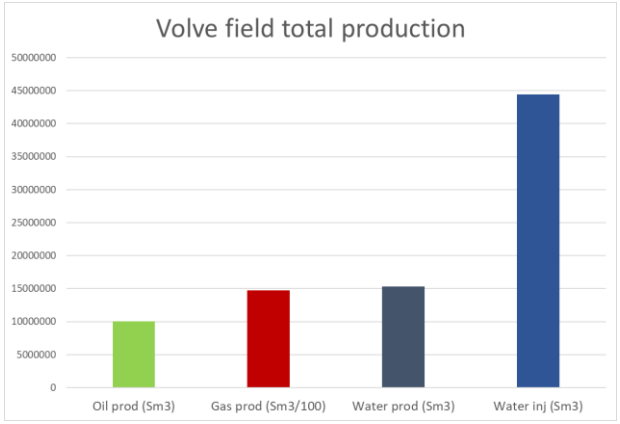


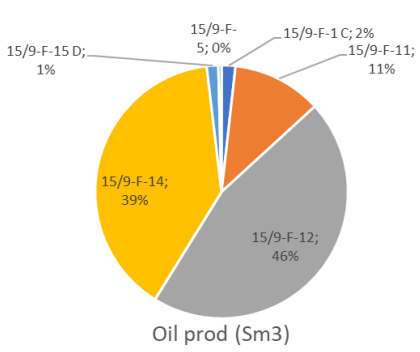
Timeline of operation of the wells of the Volve field (From arcgis website)

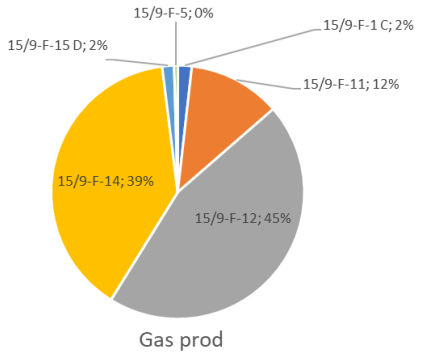


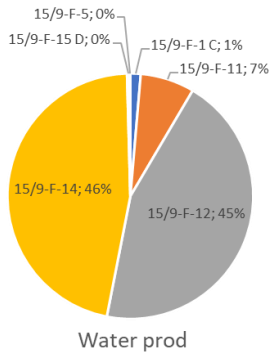
Volve field: Field Production

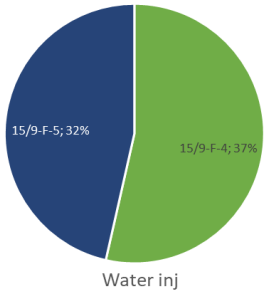
- The oil production actually started in February 2008, after the first producer well, 15/9-F-12 was drilled, and lasted until September 2016. Subsequently, three injector and five oil producer wells were drilled. The following part focuses on the seven wells concerned by the data that was available.
- In total, more than 10 million Sm3 of oil and nearly 1.5 billion Sm3 of gas were produced from the field. The water produced was reinjected as planned.
- In 2013 due to a decrease in the production below the economical limit of 2,100 Sm3/d, three additional producer wells had to be drilled, 15/9-F-11, 15/9-F-15-D, 15/9-F-1-C. This increased the life of the field until 2016.



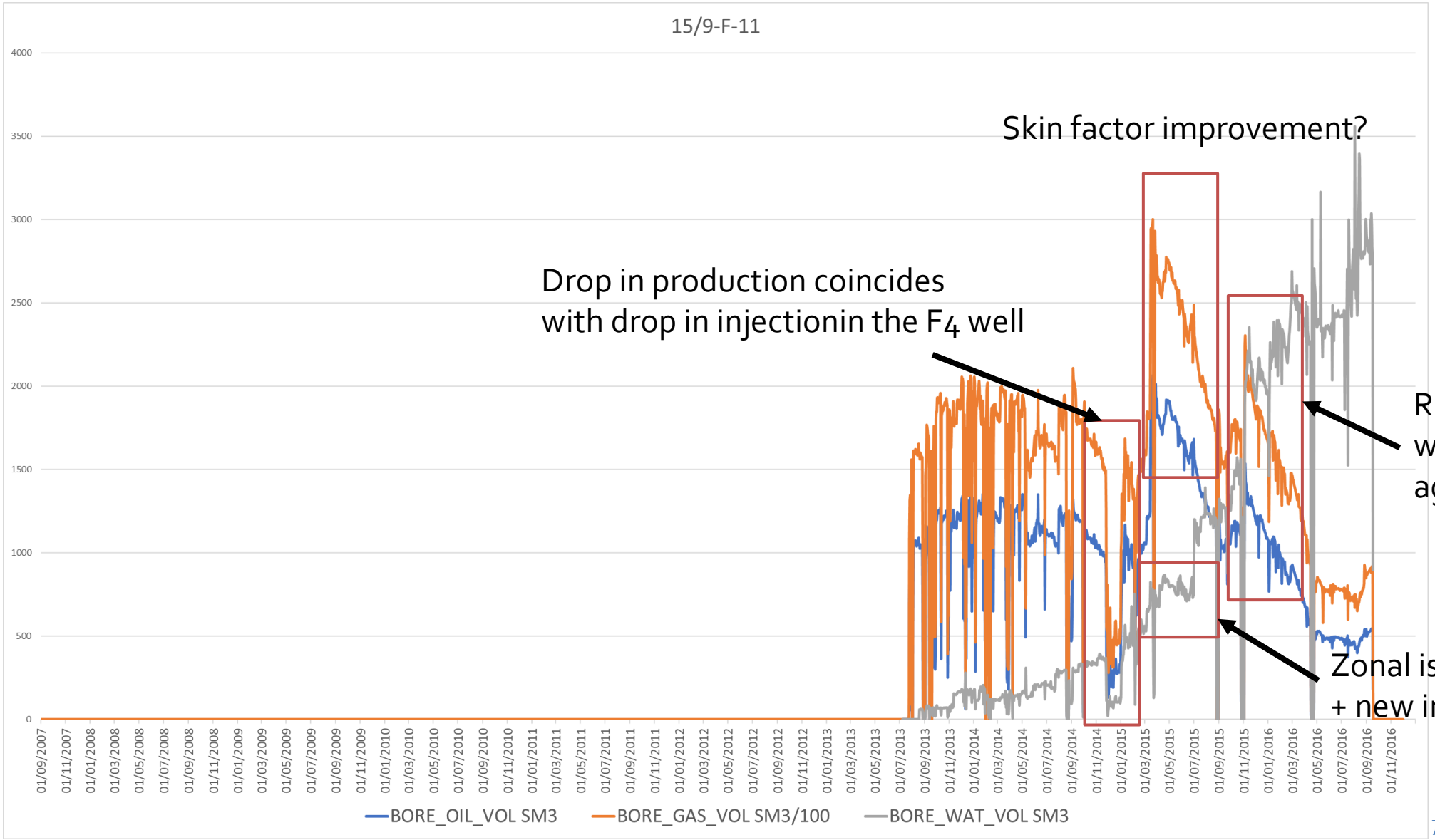




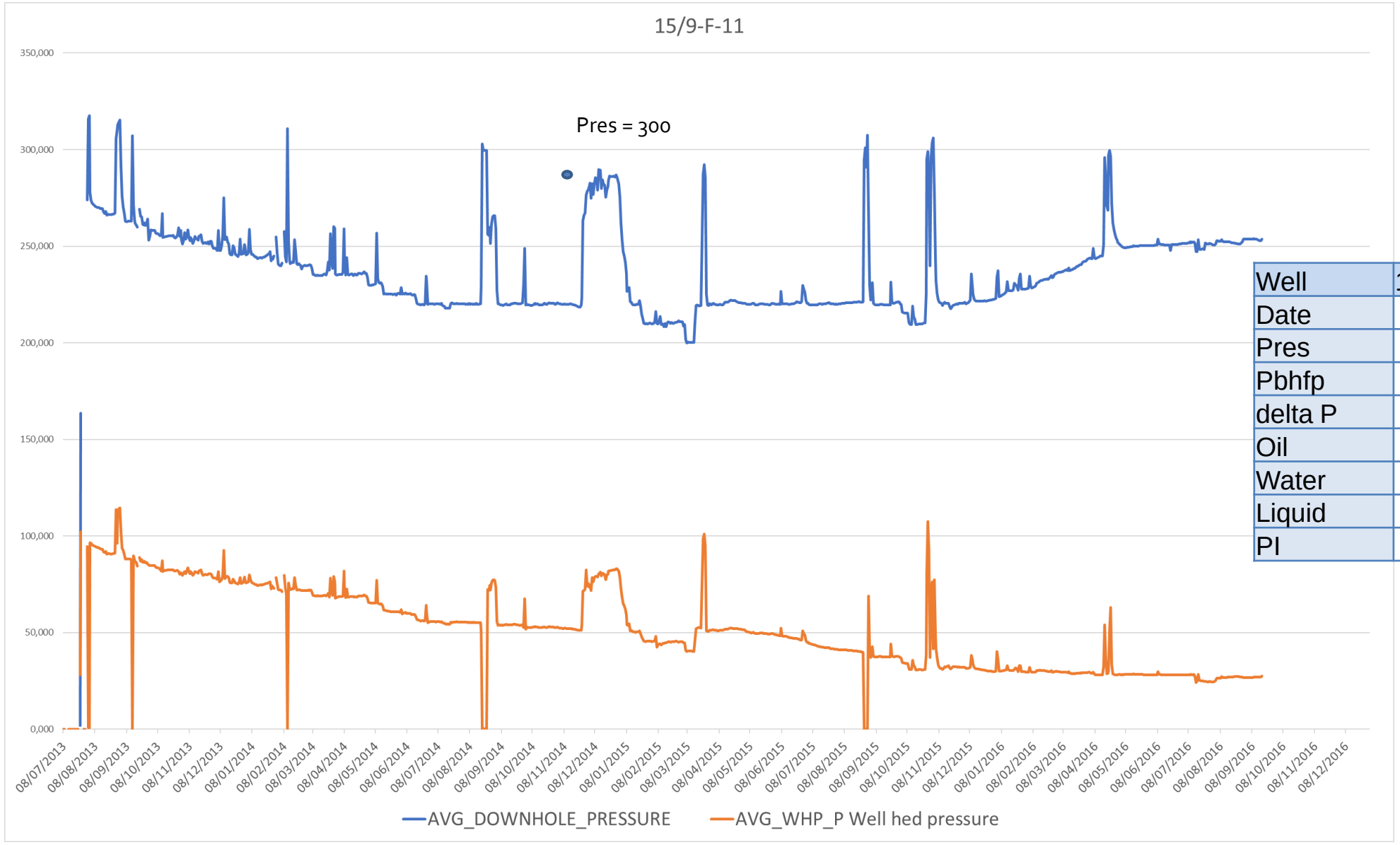




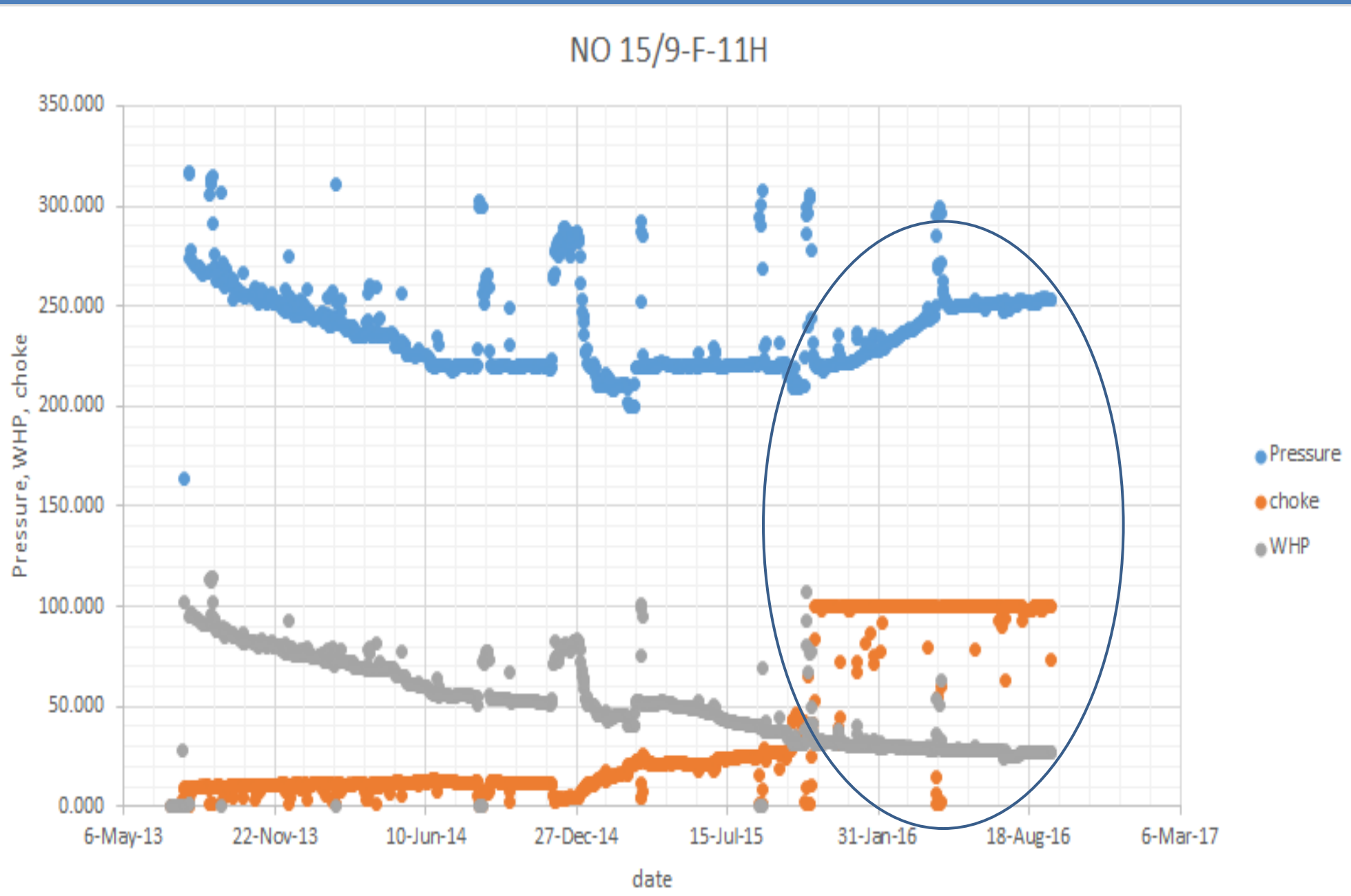
15/9-F-11


15/9-F-11
Skin factor improvement?
Drop in production coincides with drop in injectionin the F4 well
Rise in water cut again
Zonal isolation + new intervals?
BORE_OIL_VOL SM3
BORE_GAS_VOL SM3/100
BORE_WAT_VOL SM3

15/9-F-11

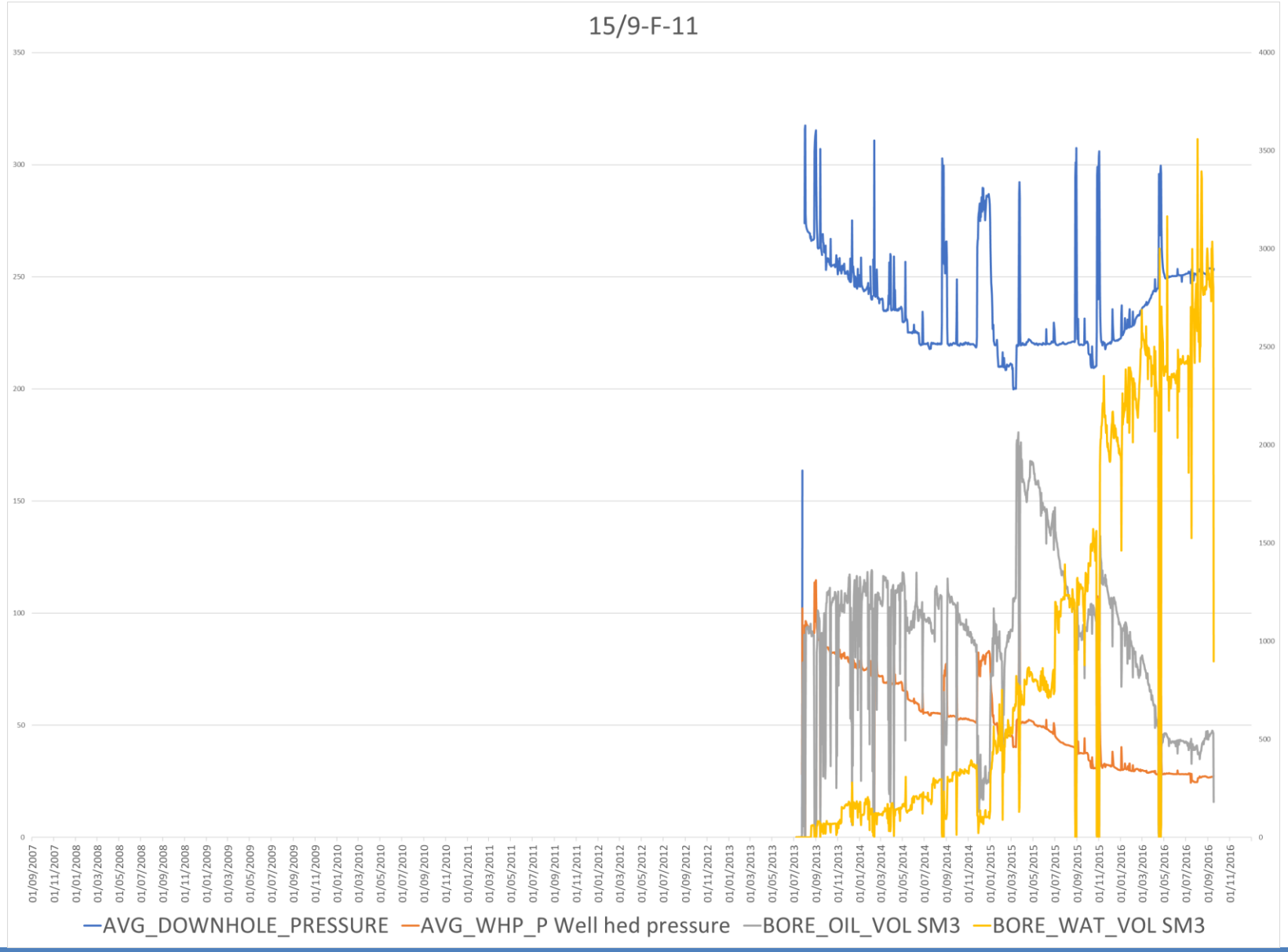


Well	15/9-F-11
Date	13/11/2014
Pres	300
Pbhfp	220,026
delta P	79,974
Oil	1 001
Water	362
Liquid	1 363
PI	17,04



Gradual rise of downhole pressure is not associated to the increase in choke size, as it would cause decrease in Downhole pressure. It would also cause an increase in Well head pressure, which is not observed.

15/9-F-11


15/9-F-11
350
300
250
200
150
100
50
0
4000
3500
3000
2500
2000
1500
1000
500
0
01/09/2007
01/11/2007
01/01/2008
01/03/2008
01/05/2008
01/07/2008
01/09/2008
01/11/2008
01/01/2009
01/03/2009
01/05/2009
01/07/2009
01/09/2009
01/11/2009
01/01/2010
01/03/2010
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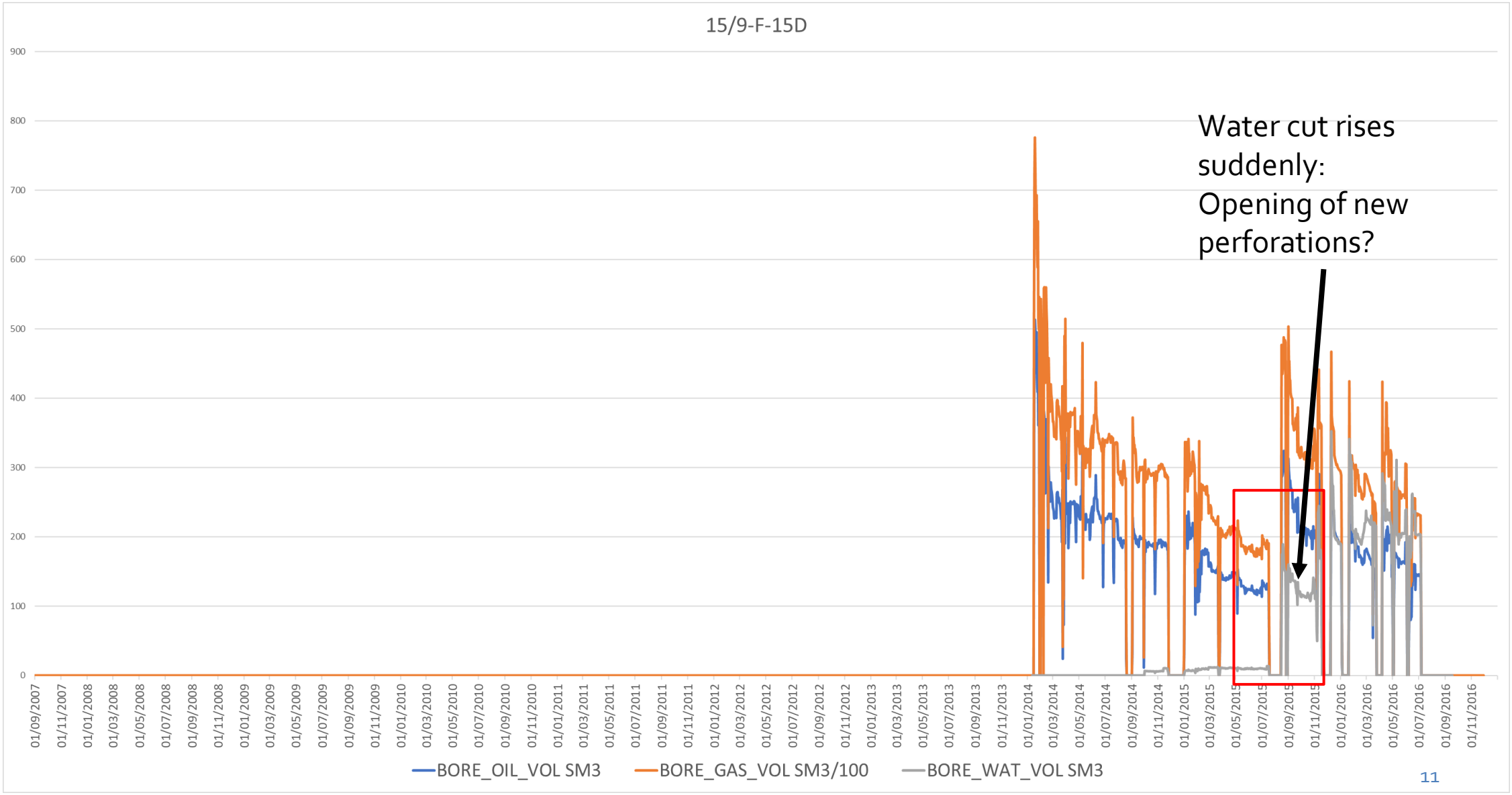
01/03/2014
01/05/2014
01/07/2014
01/09/2014
01/11/2014
01/01/2015
01/03/2015
01/05/2015
01/07/2015
01/09/2015
01/11/2015
01/01/2016
01/03/2016
01/05/2016
01/07/2016
01/09/2016
01/11/2016
AVG_DOWNHOLE_PRESSURE
AVG_WHP_P Well hed pressure
BORE_OIL_VOL SM3
BORE_WAT_VOL SM3

15/9-F-15D


15/9-F-15D
900
800
700
600
500
400
300
200
100
0
01/09/2007
01/11/2007
01/01/2008
01/03/2008
01/05/2008
01/07/2008
01/09/2008
01/11/2008
01/01/2009
01/03/2009
01/05/2009
01/07/2009
01/09/2009
01/11/2009
01/01/2010
01/03/2010
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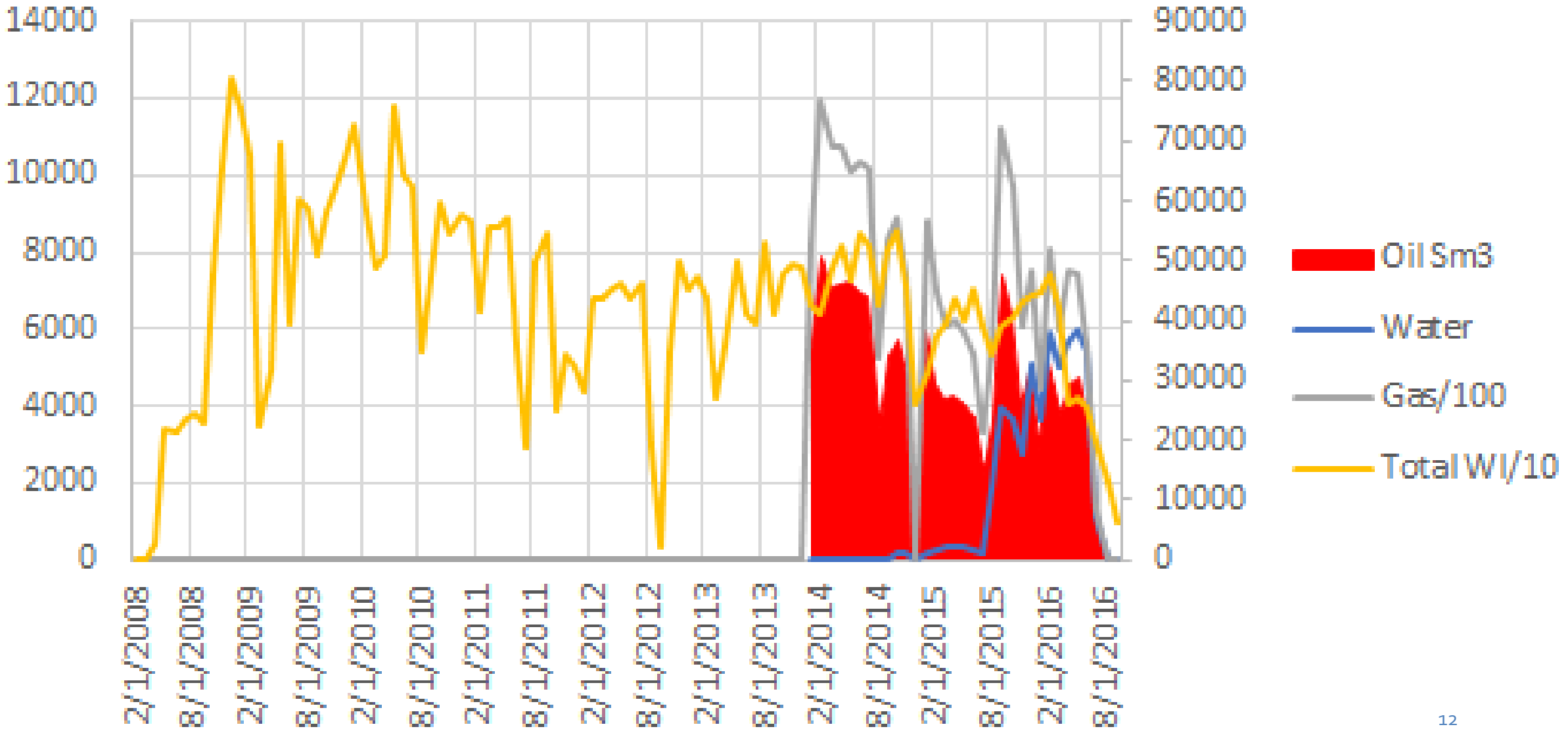
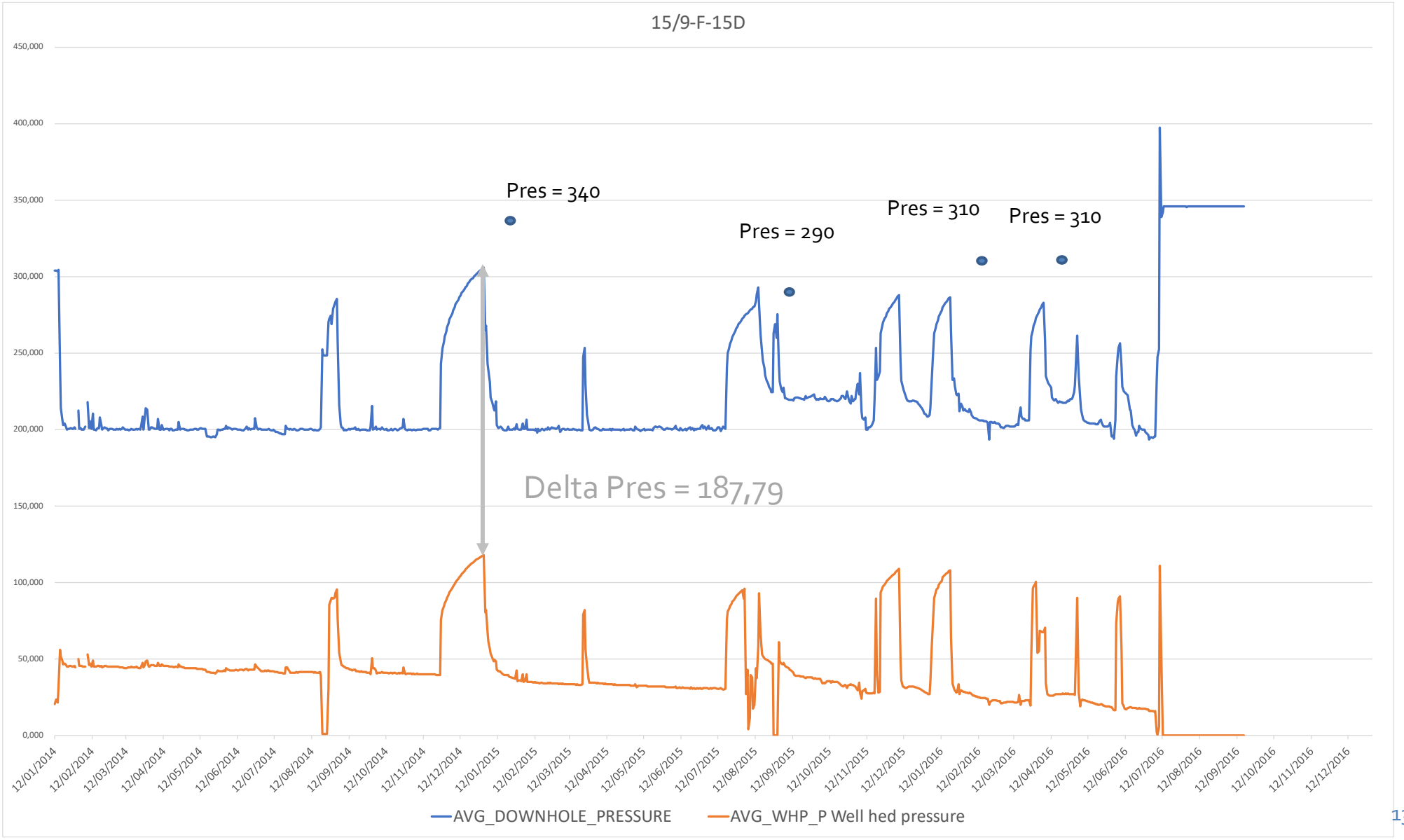
01/03/2014
01/05/2014
01/07/2014
01/09/2014
01/11/2014
01/01/2015
01/03/2015
01/05/2015
01/07/2015
01/09/2015
01/11/2015
01/01/2016
01/03/2016
01/05/2016
01/07/2016
01/09/2016
01/11/2016
BORE_OIL_VOL SM3
BORE_GAS_VOL SM3/100
BORE_WAT_VOL SM3
Water cut rises suddenly: Opening of new perforations?

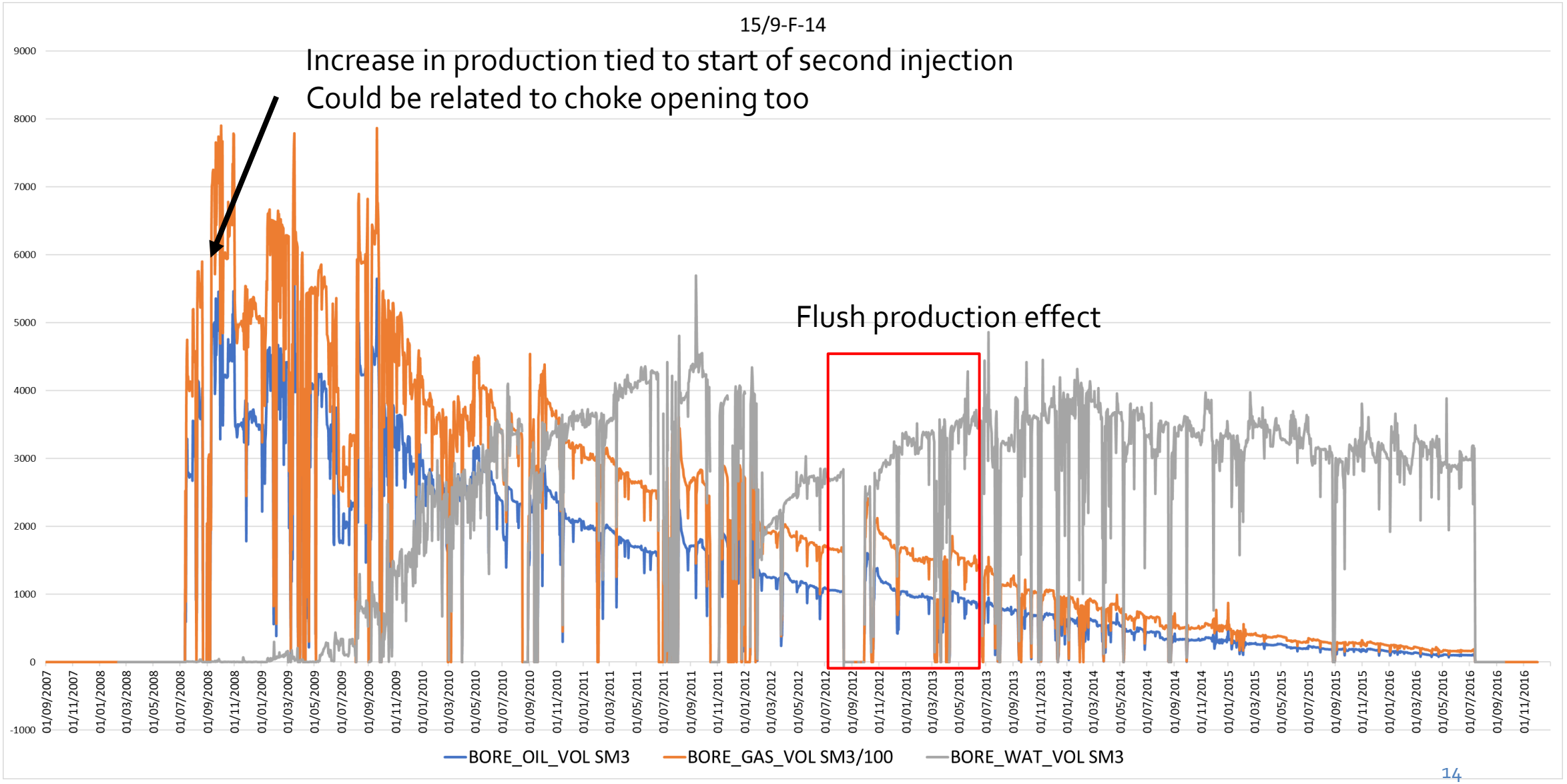
15/9-F-15 D

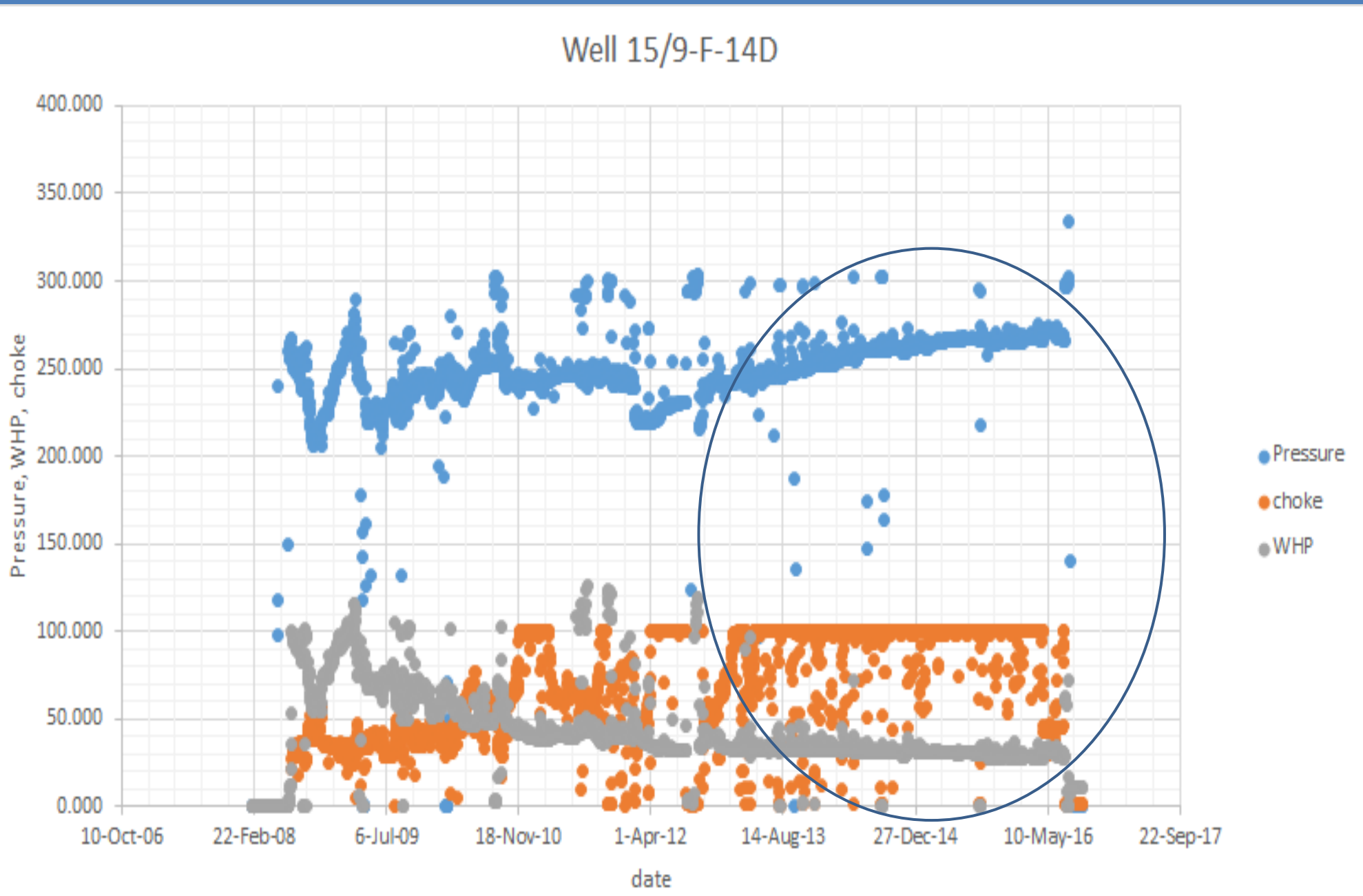

14000
12000
10000
8000
6000
4000
2000
0
90000
80000
70000
60000
50000
40000
30000
20000
10000
0
2/1/2008
8/1/2008
2/1/2009
8/1/2009
2/1/2010
8/1/2010
2/1/2011
8/1/2011
2/1/2012
8/1/2012
2/1/2013
8/1/2013
2/1/2014
8/1/2014
2/1/2015
8/1/2015
2/1/2016
8/1/2016
Oil Sm3
Water
Gas/100
Total WI/10

15/9-F-15D


15/9-F-15D
Pres = 340
Pres = 290
Pres = 310
Pres = 310
Delta Pres = 187,79
AVG_DOWNHOLE_PRESSURE
AVG_WHP_P Well hed pressure

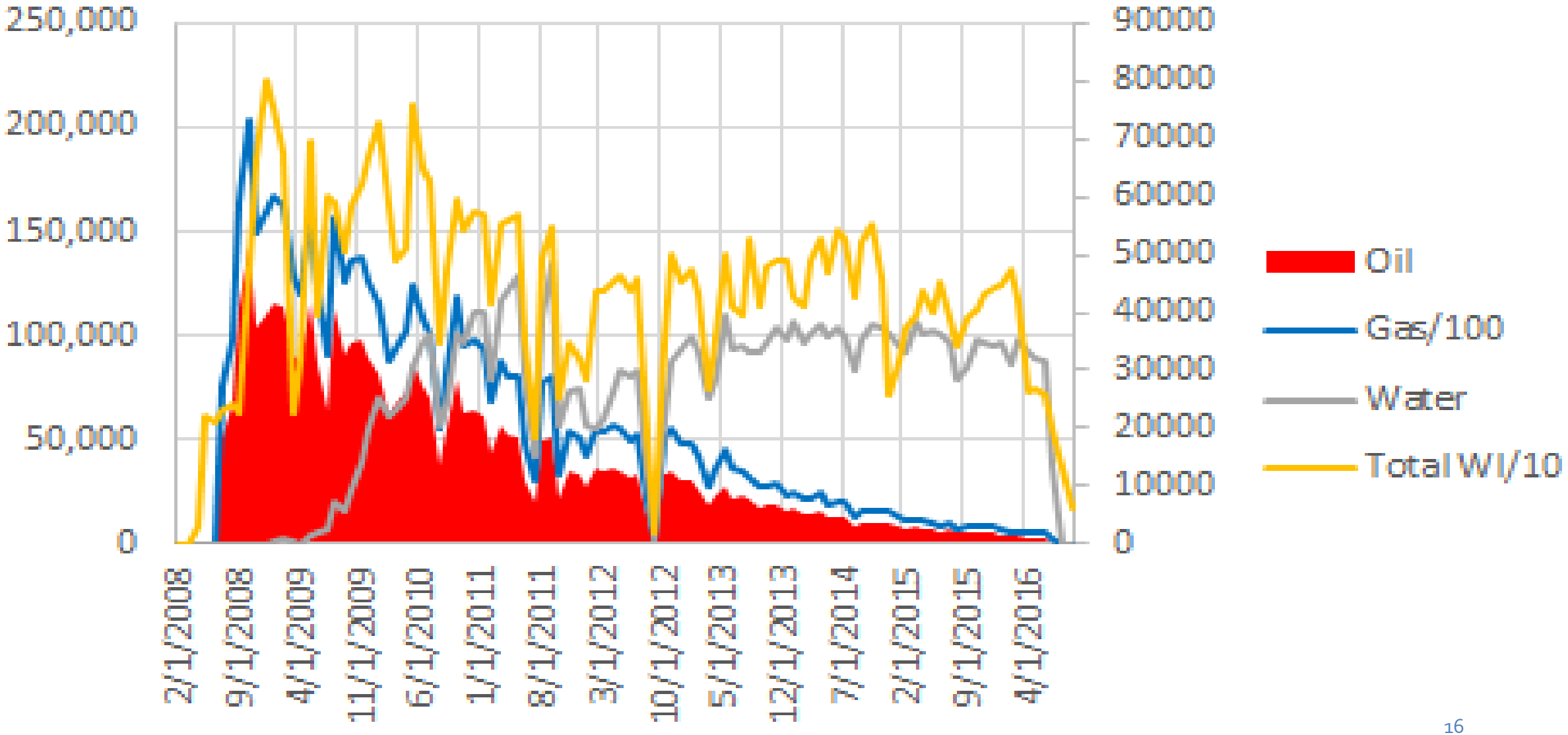
15/9-F-14


15/9-F-14
Increase in production tied to start of second injection
Could be related to choke opening too
Flush production effect
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
-1000
01/09/2007
01/11/2007
01/01/2008
01/03/2008
01/05/2008
01/07/2008
01/09/2008
01/11/2008
01/01/2009
01/03/2009
01/05/2009
01/07/2009
01/09/2009
01/11/2009
01/01/2010
01/03/2010
01/05/2010
01/07/2010
01/09/2010
01/11/2010
01/01/2011
01/03/2011
01/05/2011
01/07/2011
01/09/2011
01/11/2011
01/01/2012
01/03/2012
01/05/2012
01/07/2012
01/09/2012
01/11/2012
01/01/2013
01/03/2013
01/05/2013
01/07/2013
01/09/2013
01/11/2013
01/01/2014
01/03/2014
01/05/2014
01/07/2014
01/09/2014
01/11/2014
01/01/2015
01/03/2015
01/05/2015
01/07/2015
01/09/2015
01/11/2015
01/01/2016
01/03/2016
01/05/2016
01/07/2016
01/09/2016
01/11/2016
BORE_OIL_VOL SM3
BORE_GAS_VOL SM3/100
BORE_WAT_VOL SM3

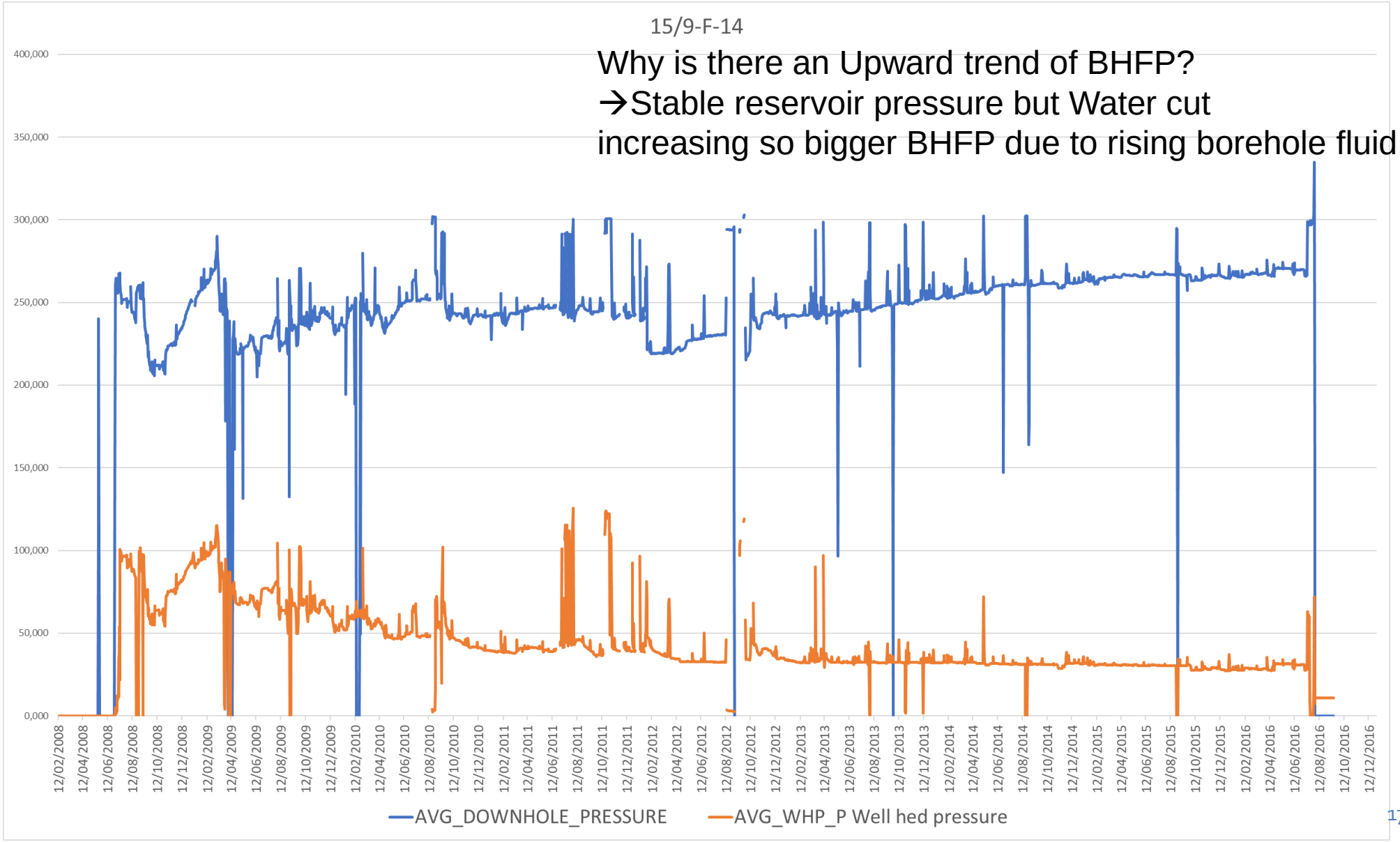


Gradual rise of downhole pressure is associated to the rise of borehole fluid density. Increase in choke size would have inverse effect

15/9-F-14


250,000
200,000
150,000
100,000
50,000
0
90000
80000
70000
60000
50000
40000
30000
20000
10000
0
2/1/2008
9/1/2008
4/1/2009
11/1/2009
6/1/2010
1/1/2011
8/1/2011
3/1/2012
10/1/2012
5/1/2013
12/1/2013
7/1/2014
2/1/2015
9/1/2015
4/1/2016
Oil
Gas/100
Water
Total WI/10

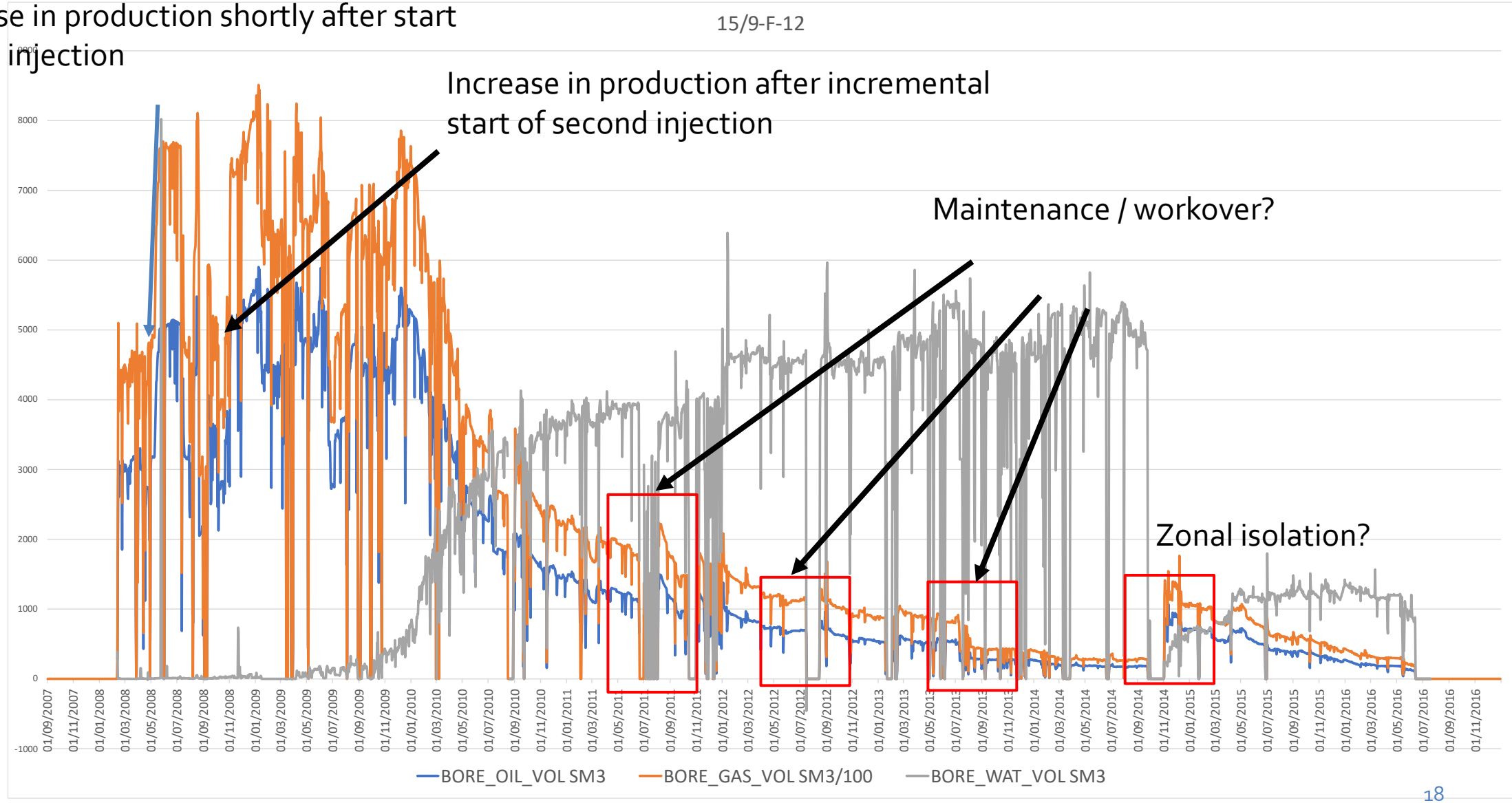
15/9-F-14



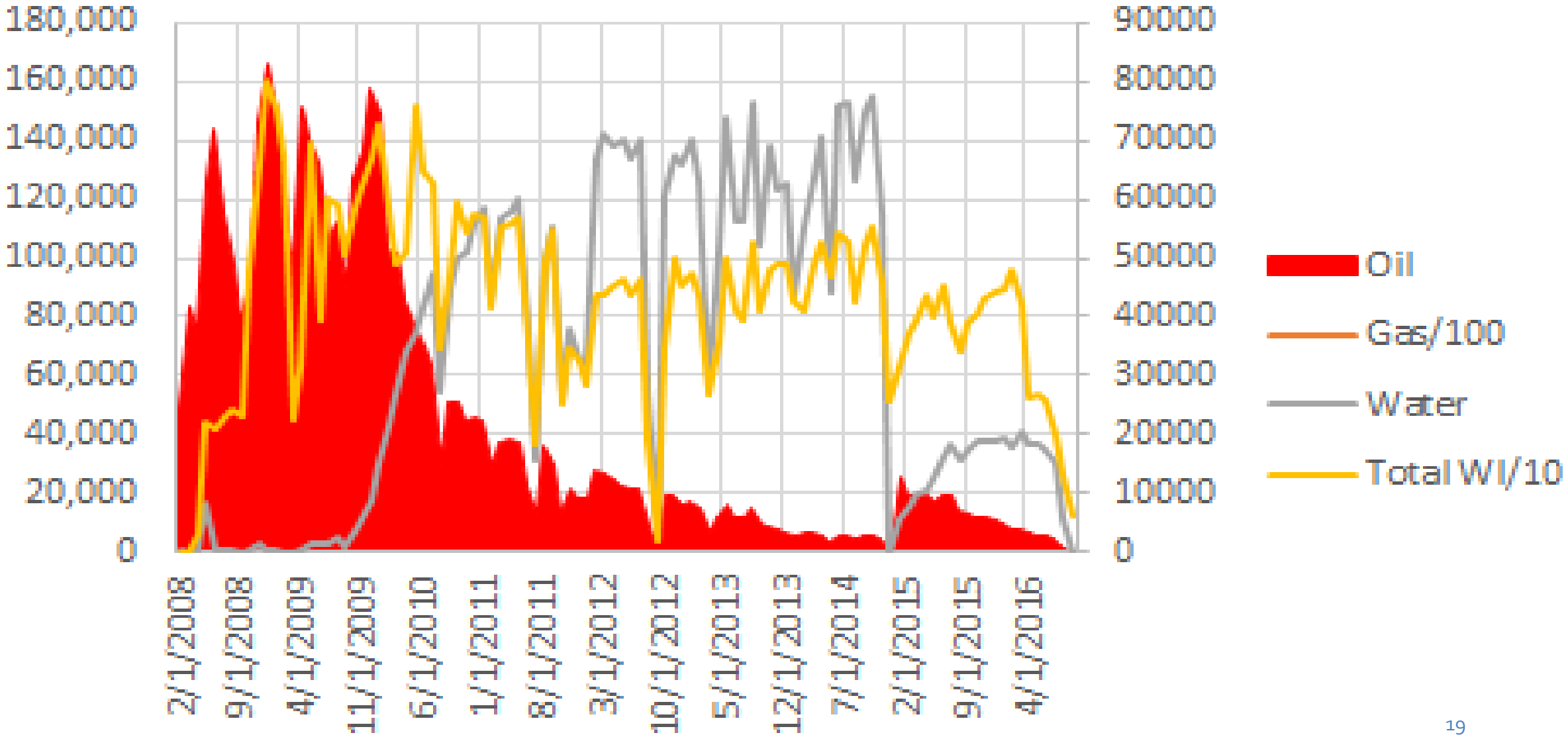
Why is there an Upward trend of BHFP?
→Stable reservoir pressure but Water cut increasing so bigger BHFP due to rising borehole fluid density

15/9-F-12

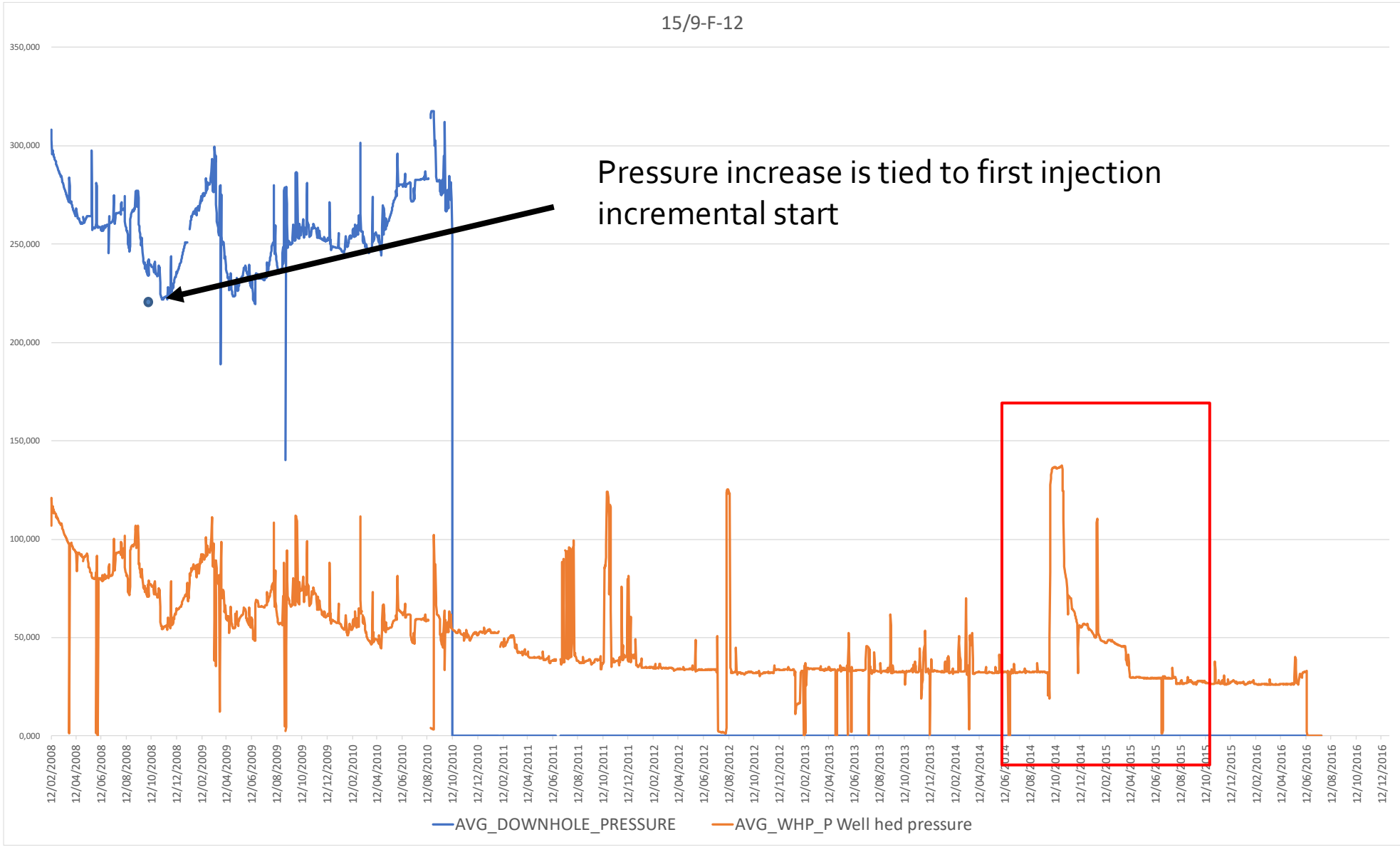
Increase in production shortly after start of first injection



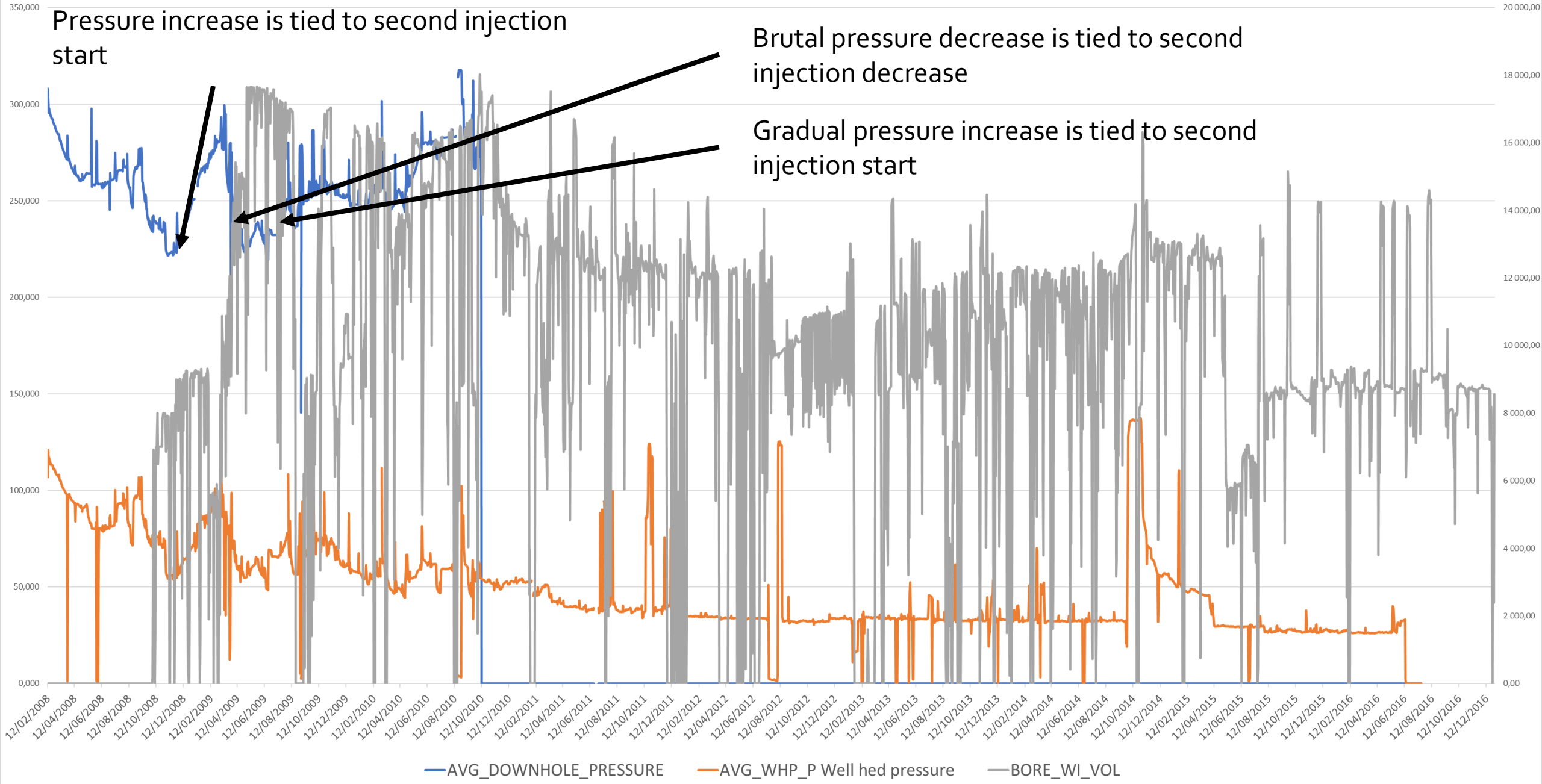
15/9-F-12


180,000
160,000
140,000
120,000
100,000
80,000
60,000
40,000
20,000
0
90000
80000
70000
60000
50000
40000
30000
20000
10000
0
2/1/2008
9/1/2008
4/1/2009
11/1/2009
6/1/2010
1/1/2011
8/1/2011
3/1/2012
10/1/2012
5/1/2013
12/1/2013
7/1/2014
2/1/2015
9/1/2015
4/1/2016
Oil
Gas/100
Water
Total WI/10

15/9-F-12


15/9-F-12
350,000
300,000
250,000
200,000
150,000
100,000
50,000
0,000
Pressure increase is tied to first injection incremental start
12/02/2008
12/04/2008
12/06/2008
12/08/2008
12/10/2008
12/12/2008
12/02/2009
12/04/2009
12/06/2009
12/08/2009
12/10/2009
12/12/2009
12/02/2010
12/04/2010
12/06/2010
12/08/2010
12/10/2010
12/12/2010
12/02/2011
12/04/2011
12/06/2011
12/08/2011
12/10/2011
12/12/2011
12/02/2012
12/04/2012
12/06/2012
12/08/2012
12/10/2012
12/12/2012
12/02/2013
12/04/2013
12/06/2013
12/08/2013
12/10/2013
12/12/2013
12/02/2014
12/04/2014
12/06/2014
12/08/2014
12/10/2014
12/12/2014
12/02/2015
12/04/2015
12/06/2015
12/08/2015
12/10/2015
12/12/2015
12/02/2016
12/04/2016
12/06/2016
12/08/2016
12/10/2016
12/12/2016
AVG_DOWNHOLE_PRESSURE
AVG_WHP_P Well hed pressure

15/9-F-12


Pressure increase is tied to second injection start
Brutal pressure decrease is tied to second injection decrease
Gradual pressure increase is tied to second injection start
350,000
300,000
250,000
200,000
150,000
100,000
50,000
0,000
20 000,00
18 000,00
16 000,00
14 000,00
12 000,00
10 000,00
8 000,00
6 000,00
4 000,00
2 000,00
0,00
12/02/2008
12/04/2008
12/06/2008
12/08/2008
12/10/2008
12/12/2008
12/02/2009
12/04/2009
12/06/2009
12/08/2009
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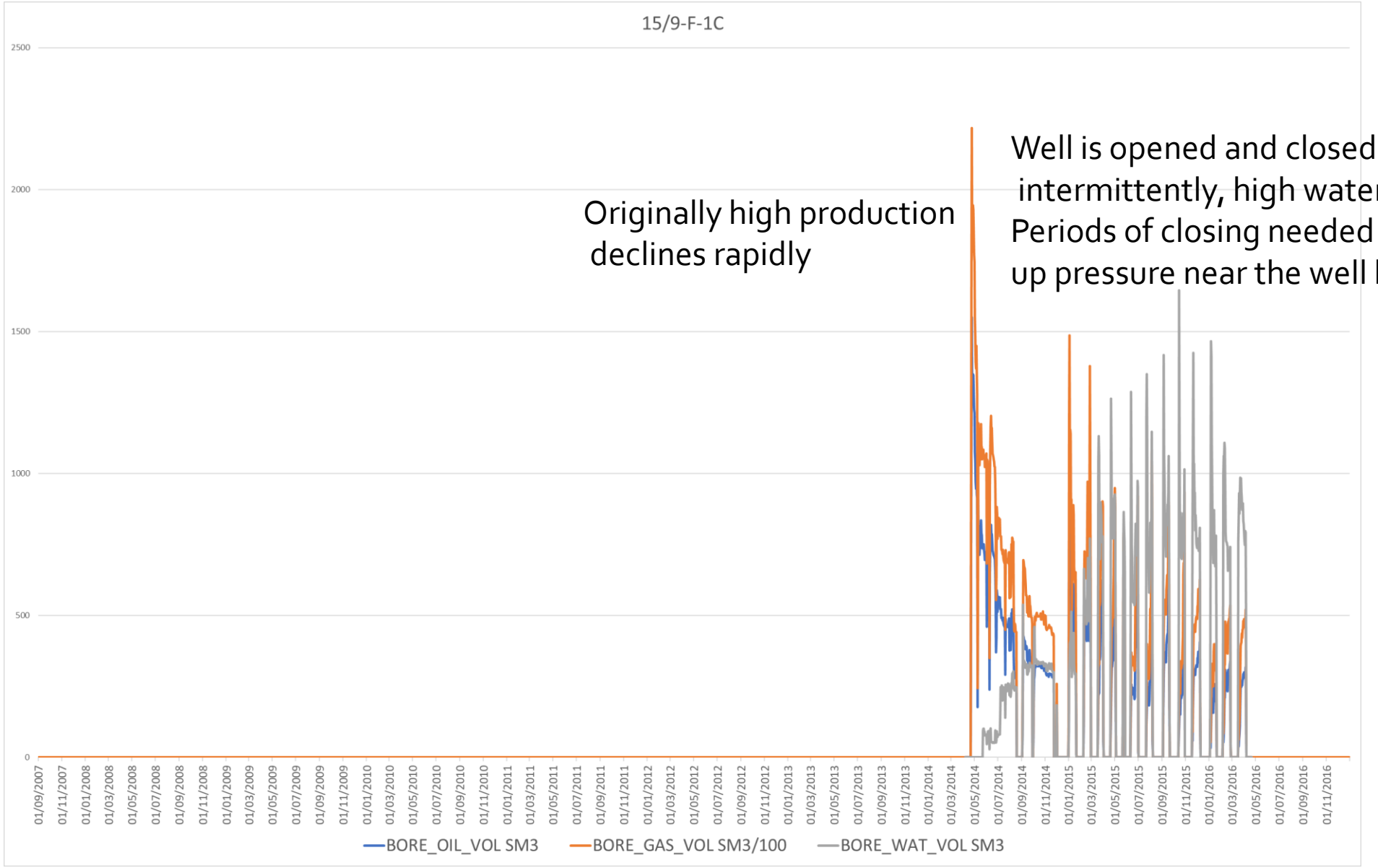
12/02/2015
12/04/2015
12/06/2015
12/08/2015
12/10/2015
12/12/2015
12/02/2016
12/04/2016
12/06/2016
12/08/2016
12/10/2016
12/12/2016
AVG_DOWNHOLE_PRESSURE
AVG_WHP_P Well hed pressure
BORE_WI_VOL

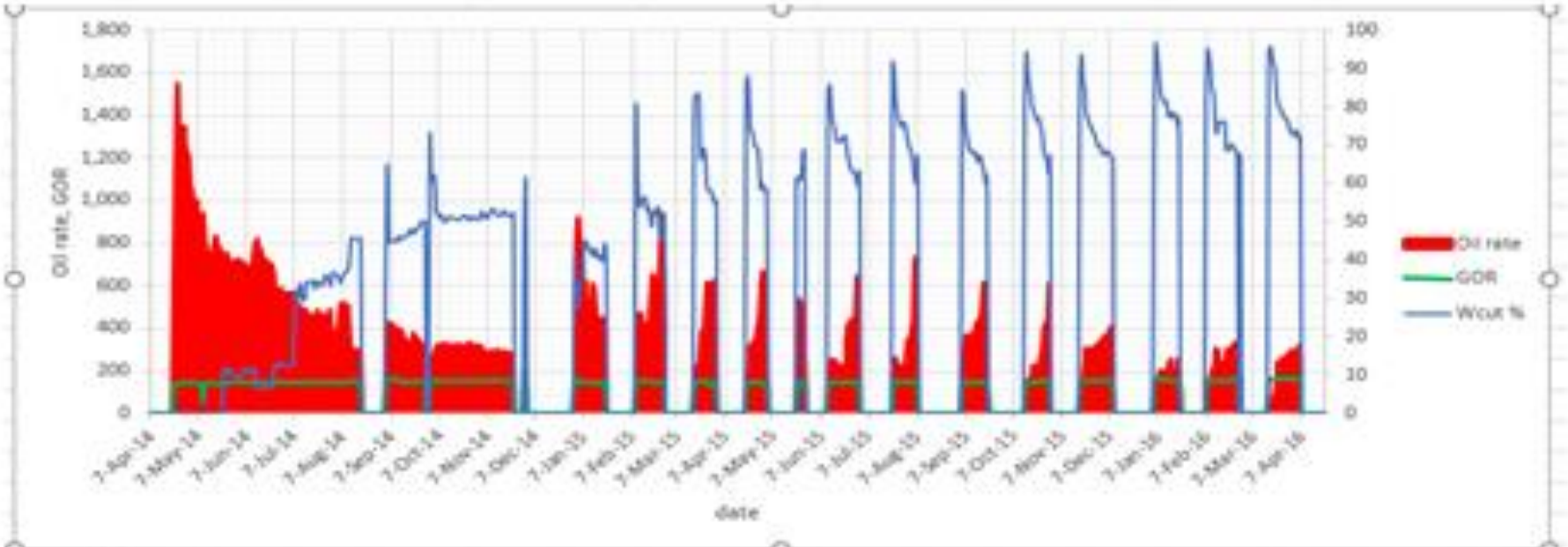
15/9-F-1C

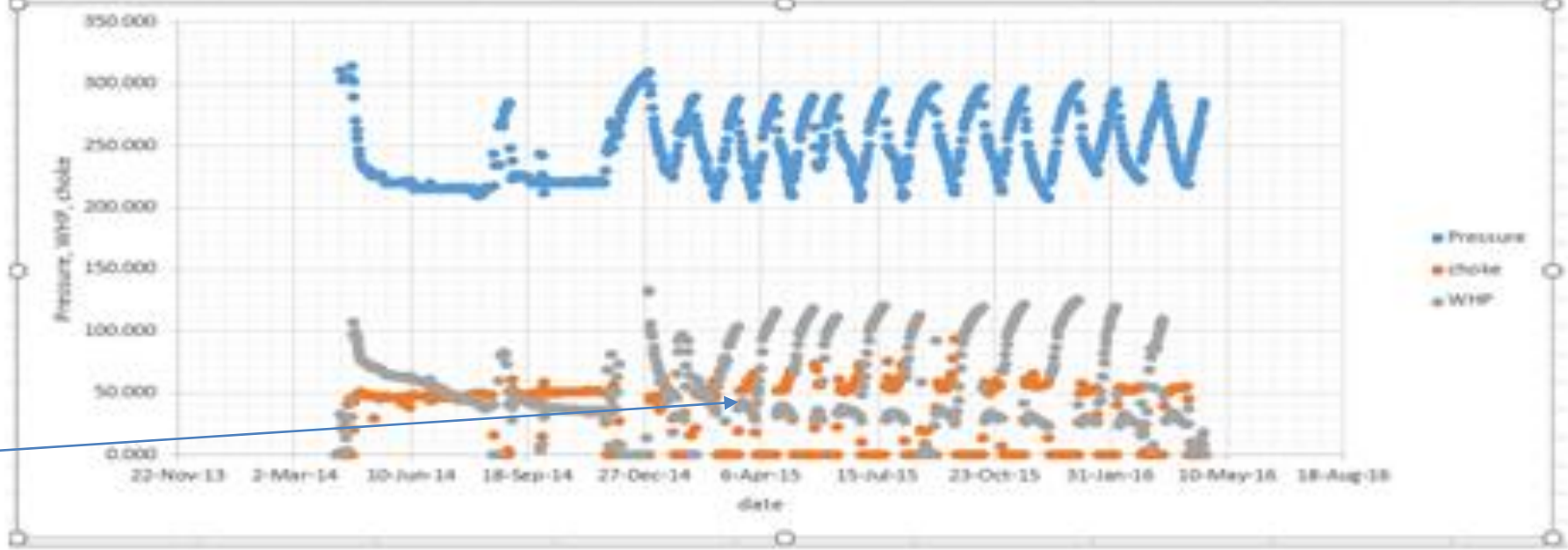


Originally high production declines rapidly

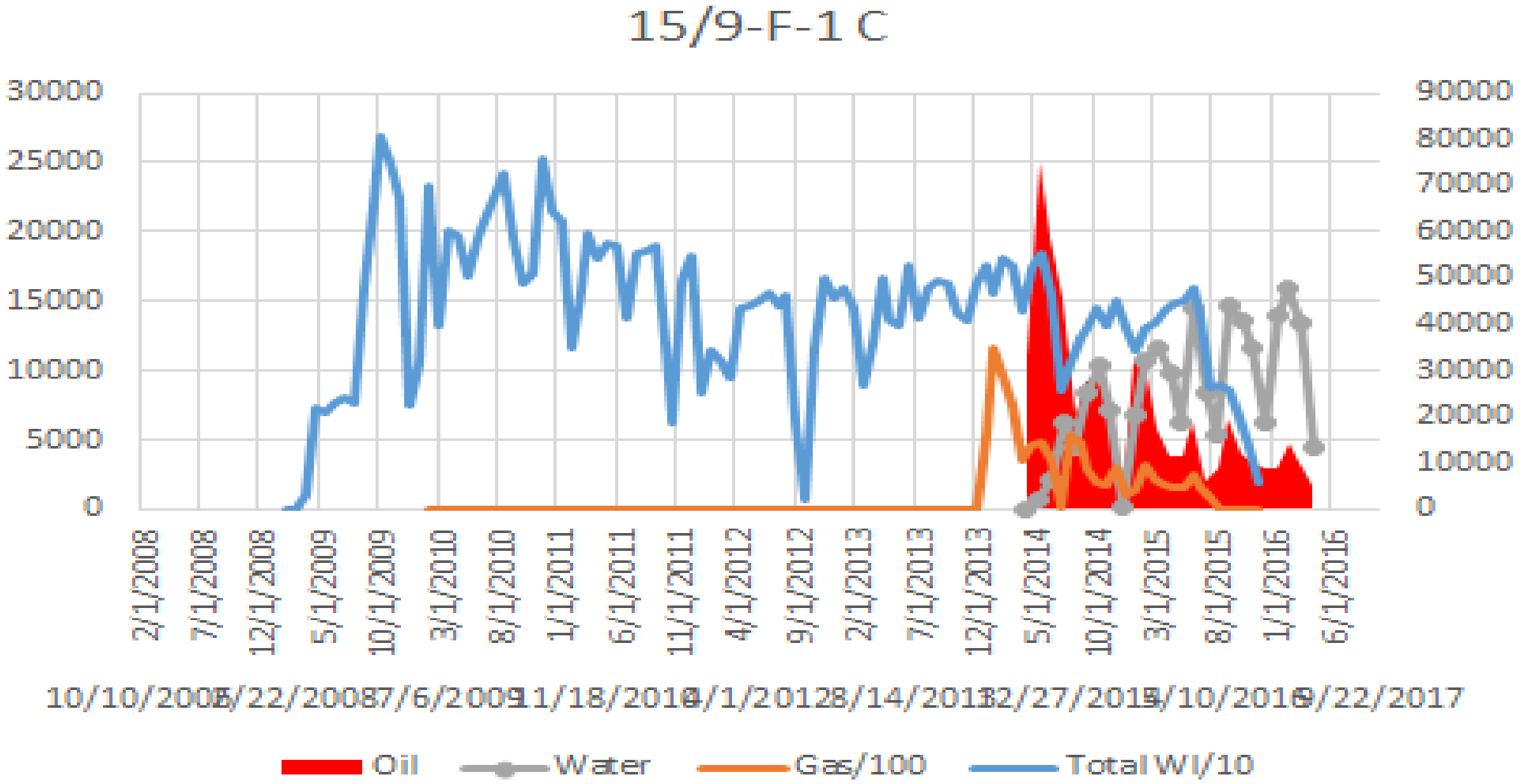
Well is opened and closed intermittently, high watercut. Periods of closing needed to build up pressure near the well bore?

NO 15/9-F-1 C

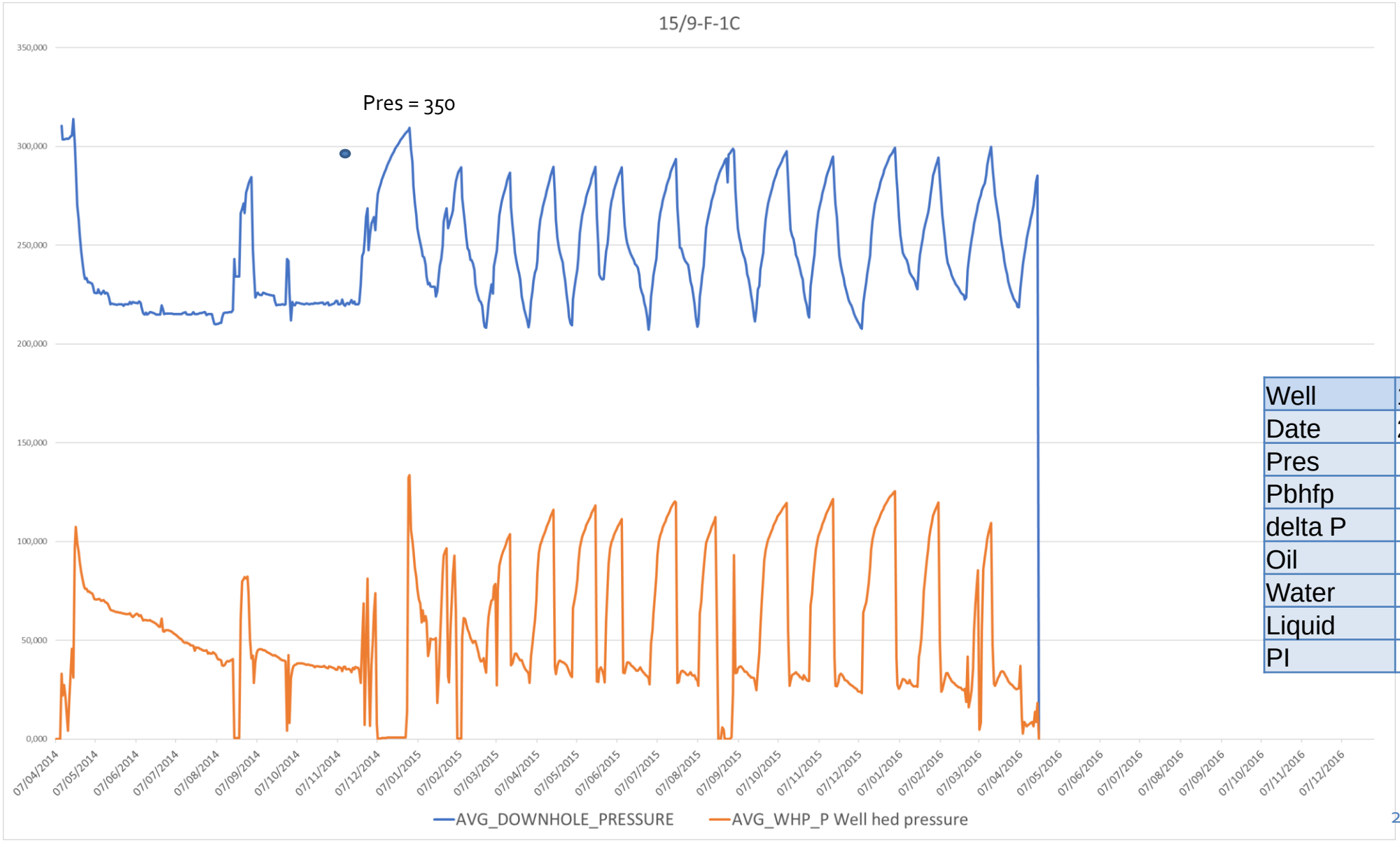




The intermittent opening of the well is confirmed was from the choke size.

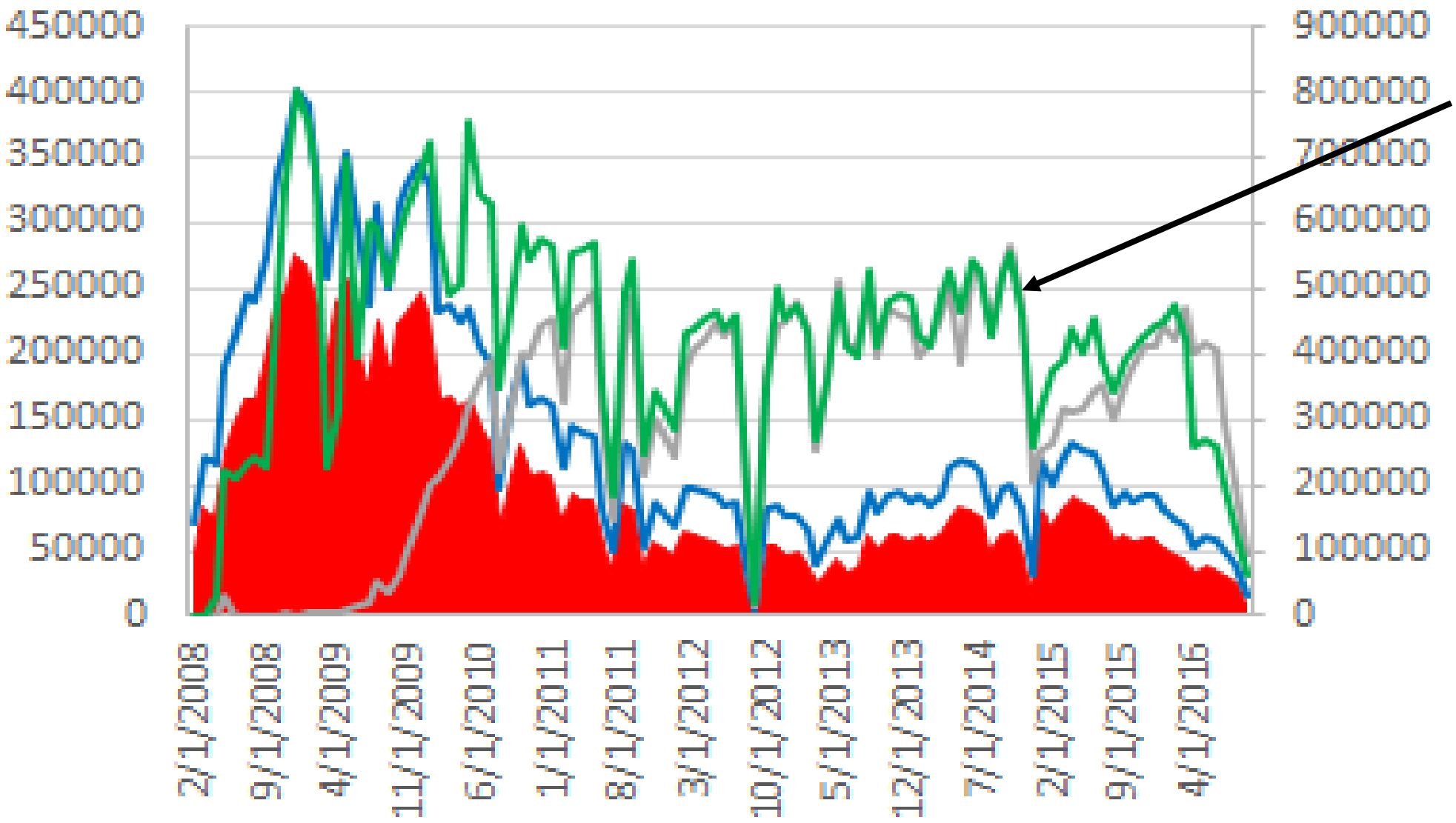

15/9-F-1 C
30000
25000
20000
15000
10000
5000
0
90000
80000
70000
60000
50000
40000
30000
20000
10000
0
2/1/2008
7/1/2008
12/1/2008
5/1/2009
10/1/2009
3/1/2010
8/1/2010
1/1/2011
6/1/2011
11/1/2011
4/1/2012
9/1/2012
2/1/2013
7/1/2013
12/1/2013
5/1/2014
10/1/2014
3/1/2015
8/1/2015
1/1/2016
6/1/2016
10/10/2008
5/22/2008
7/6/2009
11/18/2010
4/1/2012
8/14/2013
12/27/2015
5/10/2016
9/22/2017
Oil
Water
Gas/100
Total WI/10

15/9-F-1C



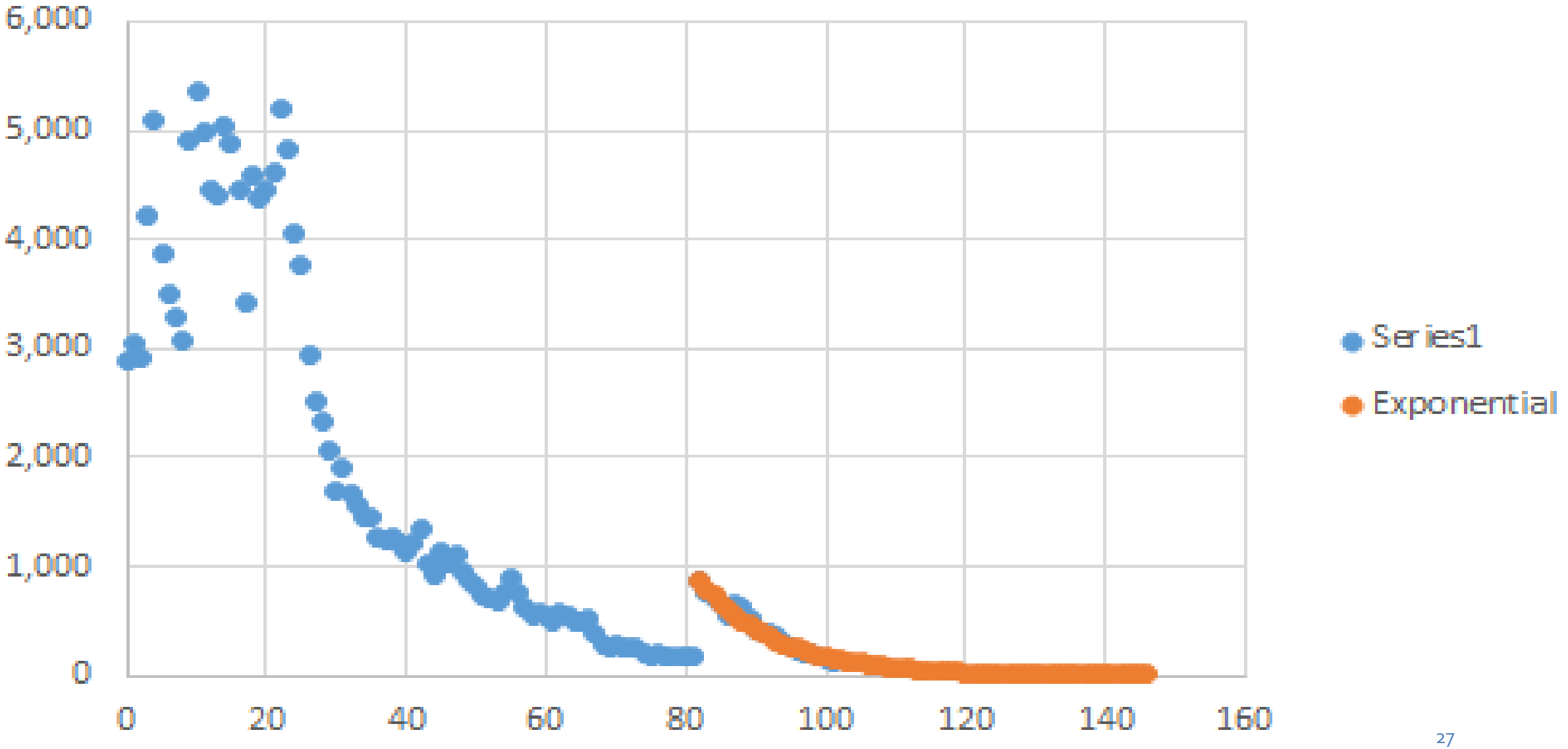
Well	15/9-F-1C
Date	20/11/2014
Pres	350
Pbhfp	222,000
delta P	128,000
Oil	285
Water	303
Liquid	588
PI	4,59

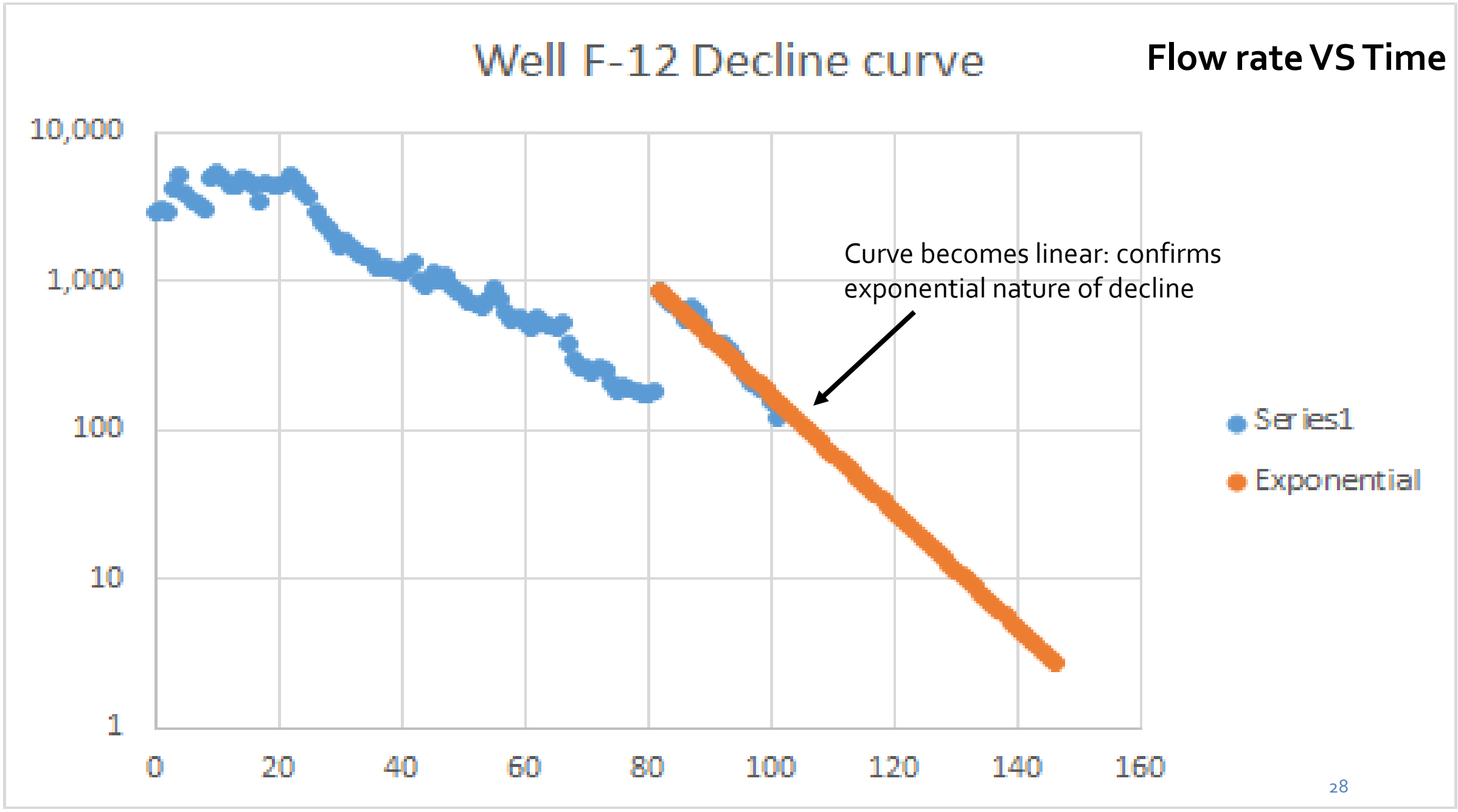
Fluid Production VS Water Injection



Injected water trend follows production trend perfectly
Produce more fluids than they inject.
Underlying acquifer helping?

Well F-12 Decline curve




Well F-12 Decline curve
Flow rate VS Time
10,000
1,000
100
10
1
0
20
40
60
80
100
120
140
160
Curve becomes linear: confirms exponential nature of decline
Series1
Exponential

Sources

Arcgis.com website:
https://www.arcgis.com/apps/Cascade/index.html?appid=c69d228730e2460da9c67cde26121020