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SPE 167148-MS
Optimizing Well Completions in the Canadian Bakken: Case History of Different Techniques to Achieve Full ID Wellbores

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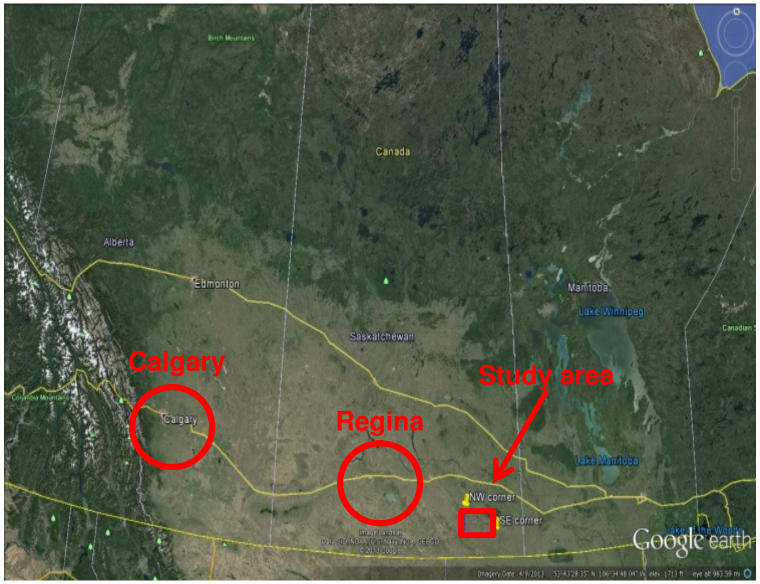
Society of Petroleum Engineers

Agenda

- Introduction
- Geology
- History
- System Descriptions
- Summary of operations
- Time analysis
- Cost analysis
- Production analysis
- Conclusions
- Acknowledgements / Q&A

Introduction

- SE Saskatchewan
- 900 wells by mid 2012
- Interventions needed
- Cost increases for future intervention

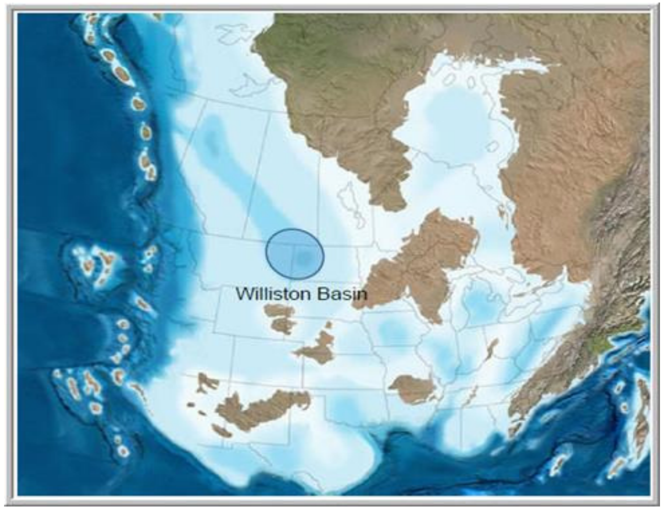


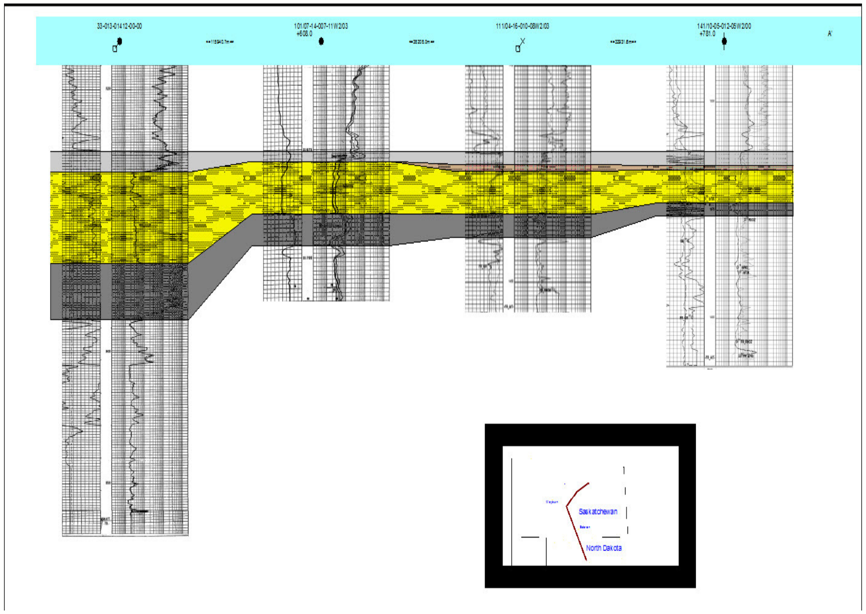
GEOLOGY

Geology

- Williston Basin
- The Bakken
  - Deposited 360 MM y.a. Late Devonian
  - 40m thick

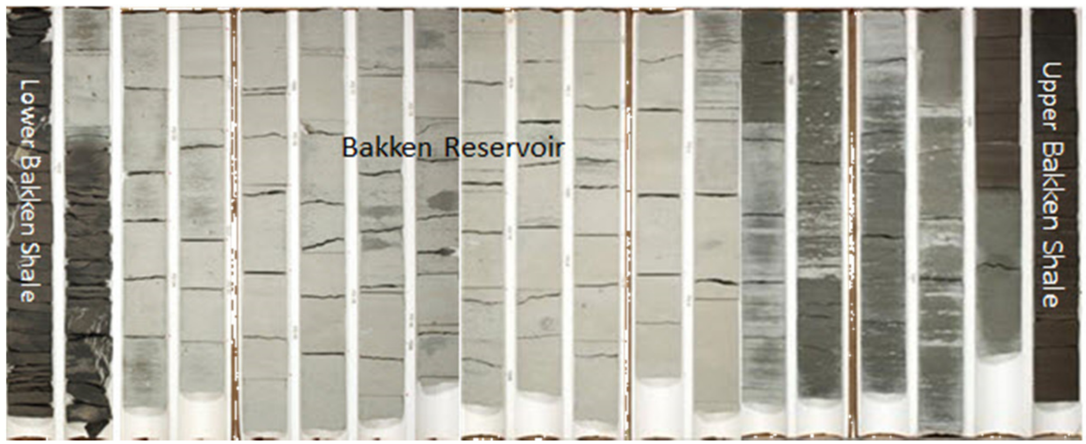
- The Canadian Bakken
  - 4m -12m thick





Geology

- "Oreo Cookie"
  - Lower Bakken black anoxic shale (Exshaw equivalent)
  - Middle Bakken slightly argillaceous, sandy, dolosiltstone
  - Upper Bakken black anoxic shale



- Geological hazards
  - Upper water bearing Lodgepole
  - Thinning Reservoir

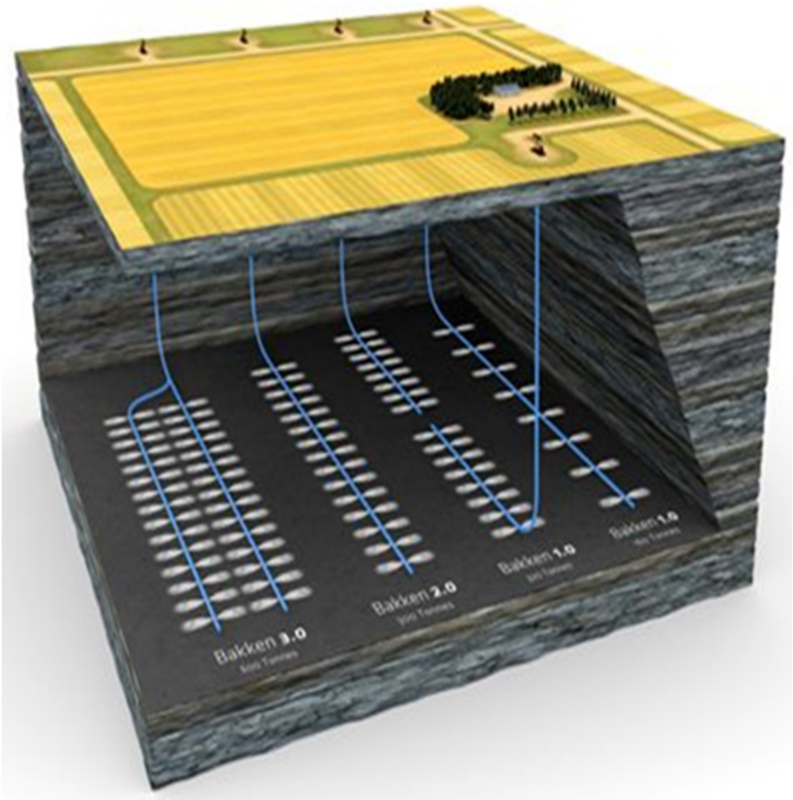
HISTORY

History

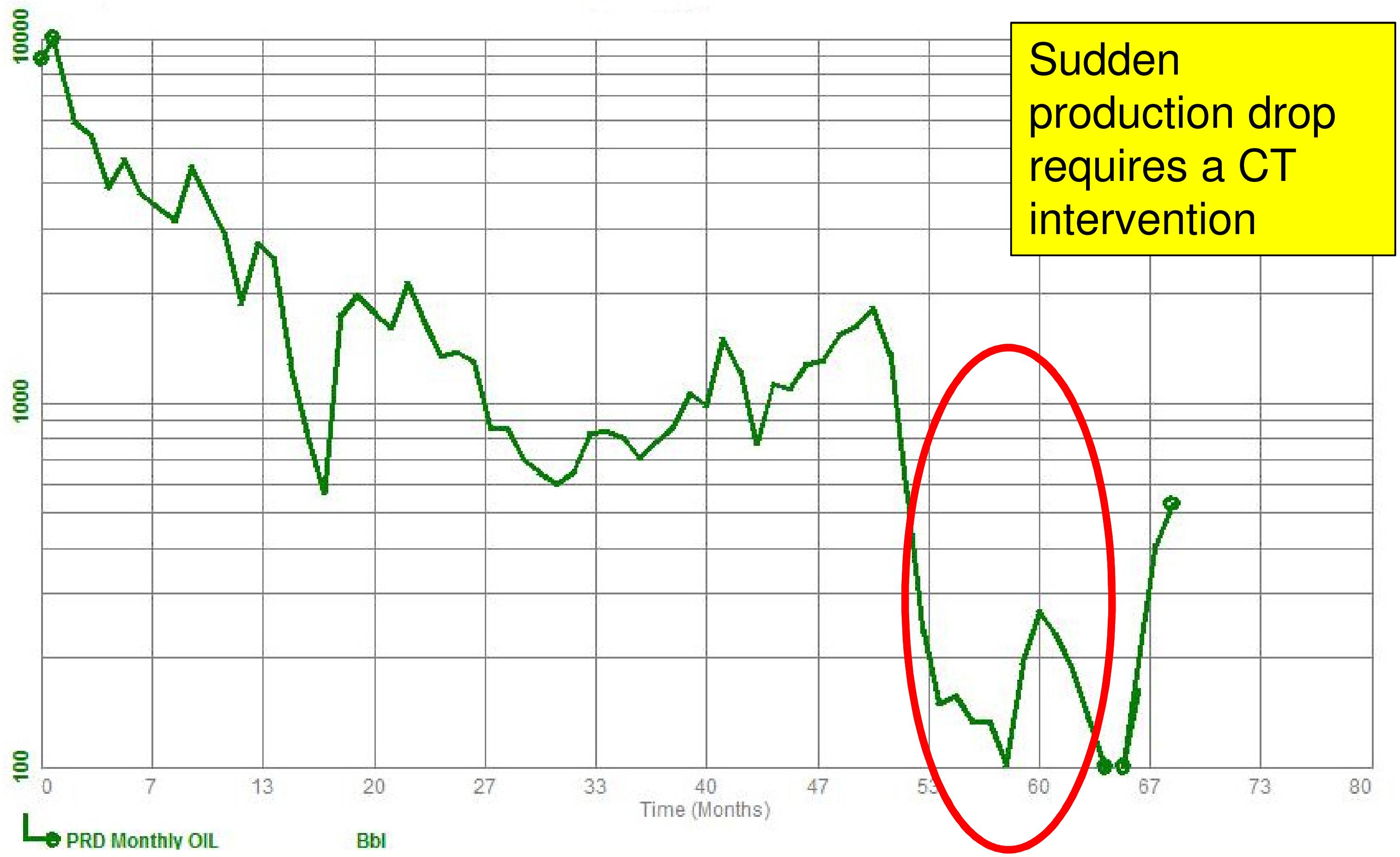
•2006 - Enters play as partner

•2007 to 2009 - Independent drilling program

•2009 to 2013 - Bilateral Wells
Ball drop
16 stages/leg



History



10000
1000
100
0
7
13
20
27
33
40
47
53
60
67
73
80
Time (Months)
PRD Monthly OIL
Bbl
Sudden production drop requires a CT intervention

History

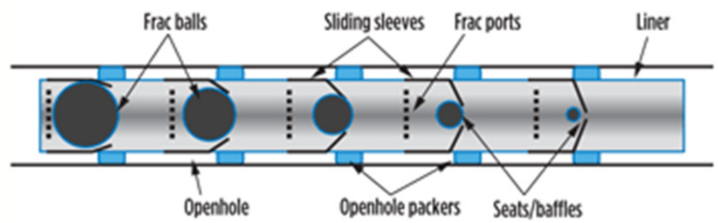
- Milling out summary:

Average cost	$ 289,500
Average cost per stage	$ 23,750
Average months after initial completion	34 months
Average incremental production	22 BOPD
Average fluid lost during milling out	350 m3

SYSTEM DESCRIPTIONS

System Descriptions

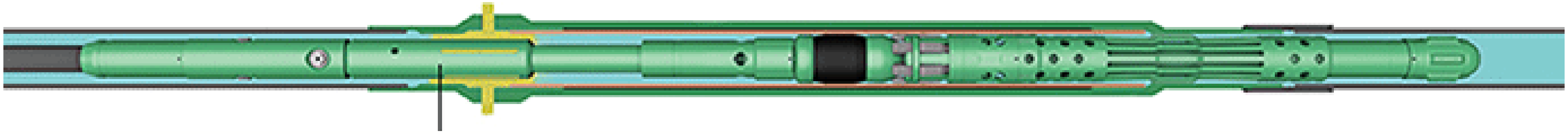
- Ball drop followed by milling out - ball activated sleeves
  - Pros
    - Less time
    - Fewer equipment
  - Cons
    - Limited number of stages*
    - Milling out cost



- Retrievable seats – Ball activated retrievable sleeves
  - Pros
    - Full ID
    - Fewer equipment
  - Cons
    - Post treatment service
    - Retrieval challenges

System Descriptions

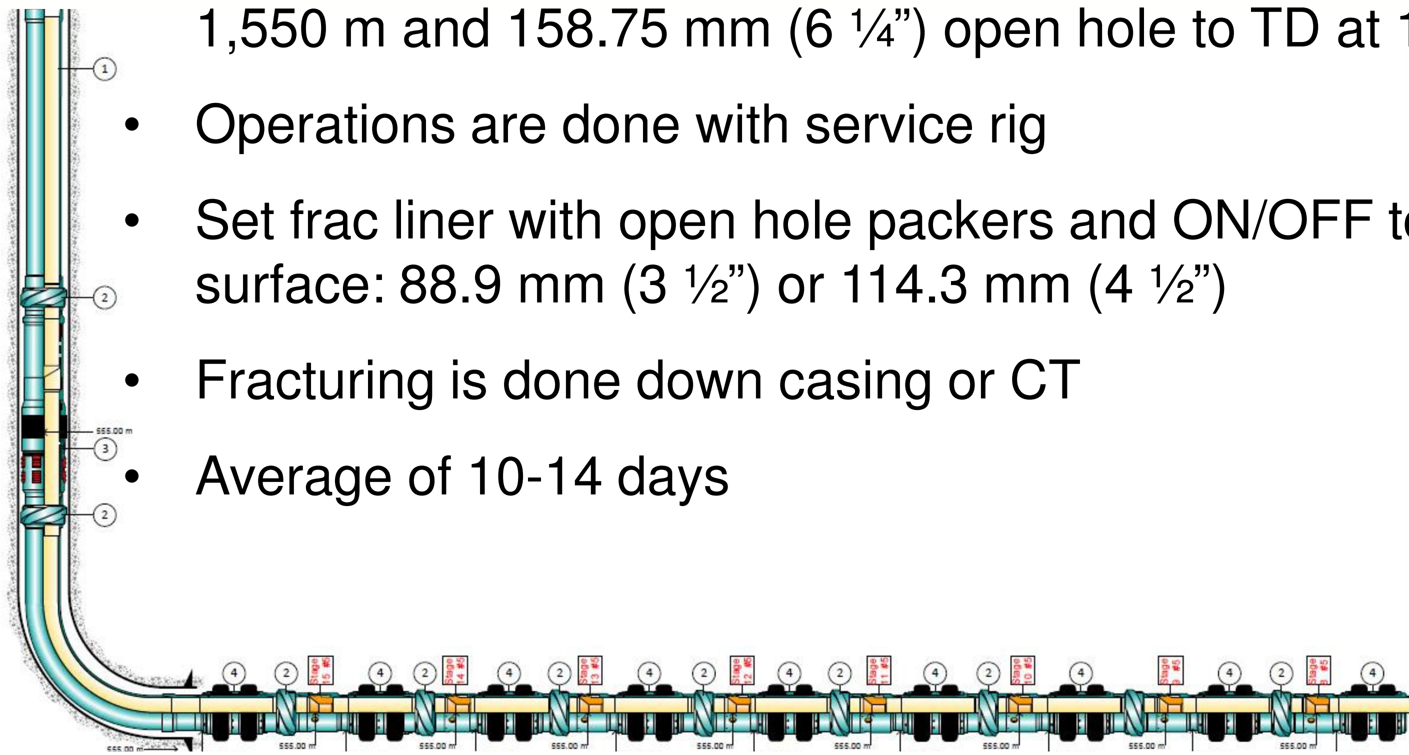
- Hybrid – coiled tubing deployed sleeve shifting tool as well as open hole packers
  - Pros
    - Sleeve shifting with coiled tubing
    - Full ID
    - Contingency options
    - Unlimited stages
  - Cons
    - Longer time
    - More Equipment



OPERATIONAL ANALYSIS

Operational Analysis

- Completions summary:
  - Wells are drilled with 177.8 mm (7”) intermediate casing to +/- 1,550 m and 158.75 mm (6 ¼”) open hole to TD at 1,500 m TVD
  - Operations are done with service rig
  - Set frac liner with open hole packers and ON/OFF tool at heel to surface: 88.9 mm (3 ½”) or 114.3 mm (4 ½”)
  - Fracturing is done down casing or CT
  - Average of 10-14 days



Operational Analysis

- Frac summary
  - Containment is critical!

Number of stages	15-20 stages
Average frac rate	0.6-0.8 m^3/min
Fluid type	Water based synthetic polymer
Proppant Type	20/40 mesh sand
Average volume per stage	25-30 m^3
Average Tonnage per stage	3-5 Tonne

Operational Analysis

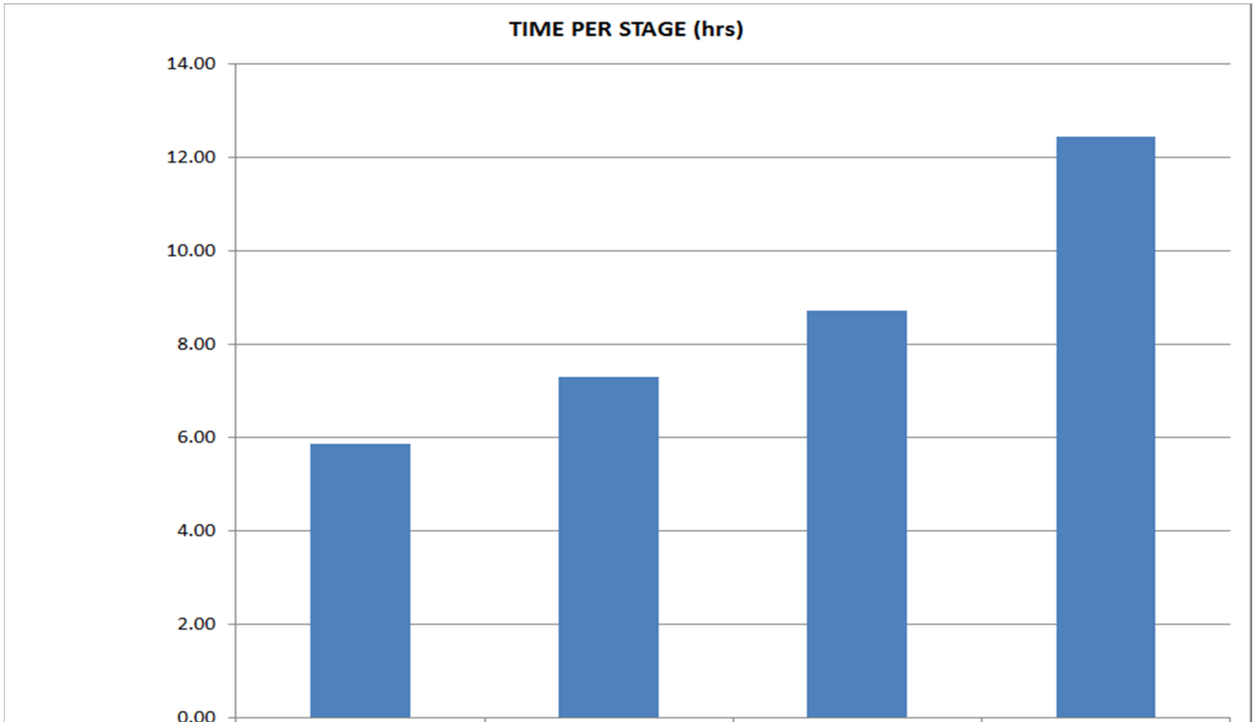
- Operations were done between Jan to Mar 2013
- All three system were tested in the field + one control well (i.e. ball drop without milling out)
- Three variables tracked: time, cost and production

Location	Frac date	Effective number of stages	Stages distribution (xDLL)	System
A	Feb 05 / 2013	26	15x2	Ball drop with MO
B	Feb 09 / 2013	22		Hybrid
C	Feb 21 / 2013	30	15x2	Ball drop with MO
D	Feb 22 / 2013	10		Retrievable
E	Feb 24 / 2013	30	15x2	Ball drop with MO
F	Feb 25 / 2013	20		Ball drop with MO
G	Mar 05 / 2013	30	15x2	Ball drop w/o MO
H	Mar 06 / 2013	18		Hybrid
I	Mar 16 / 2013	32	16x2	Hybrid
J	Mar 20 / 2013	28	16x2	Hybrid
K	Mar 21 / 2013	18		Hybrid
L	Mar 22 / 2013	38	19x2	Hybrid

COMPLETION TIME ANALYSIS

Completions Time Analysis

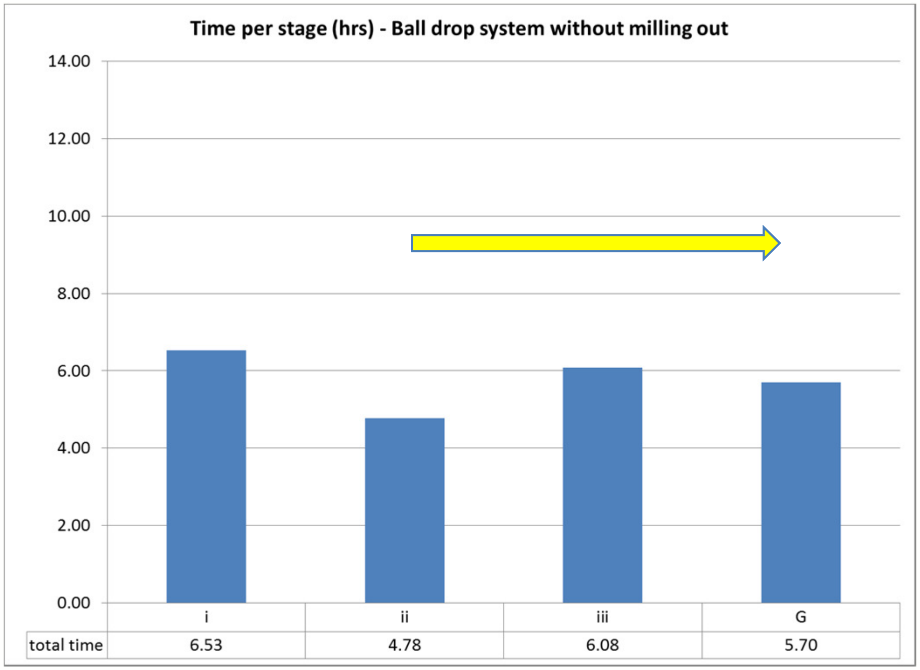
- Time was normalized by the total number of stages
- Ball drop without milling out is the quickest method
- Hybrid took less time than the ball drop with milling out

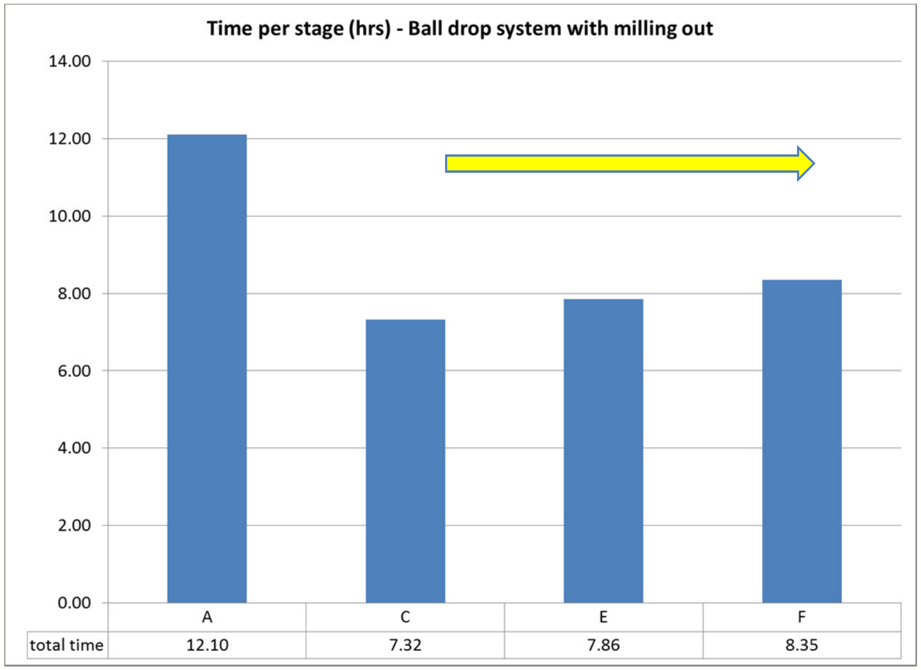


	ball drop w/o milling out	hybrid	ball drop with milling out	retrievable
TIME PER STAGE (hrs)	5.87	7.31	8.72	12.45

Completions Time Analysis

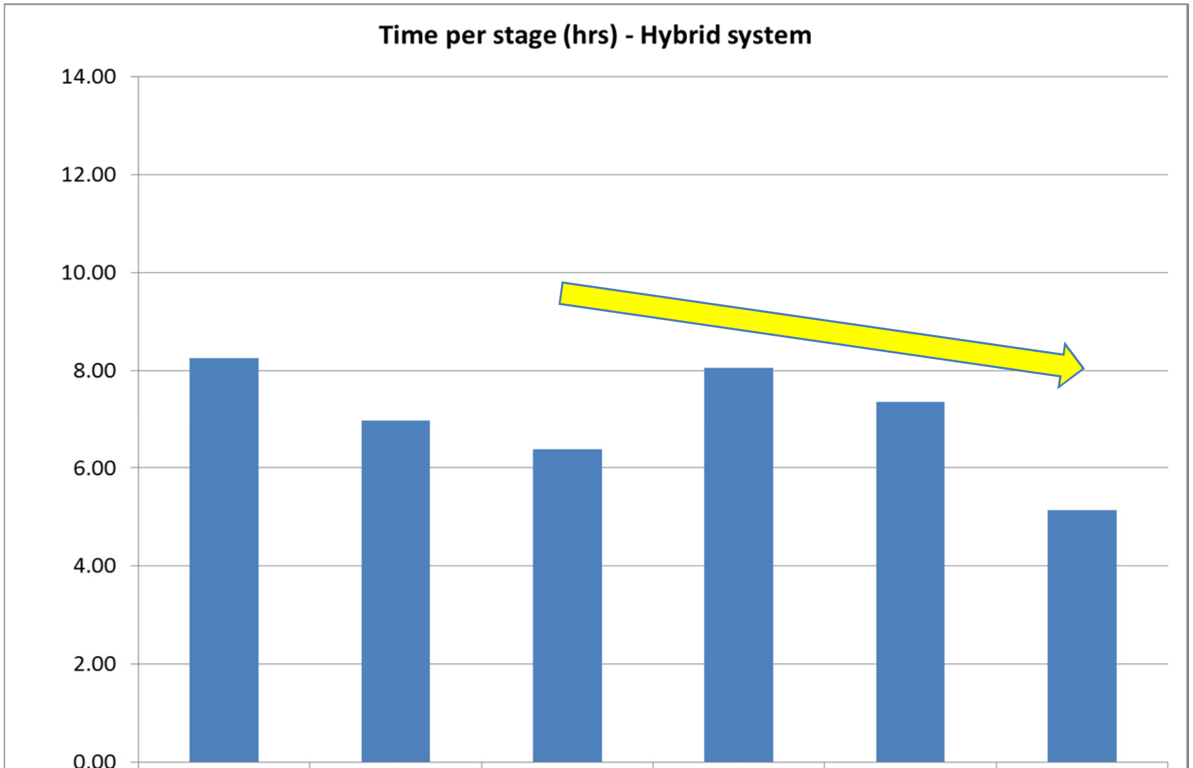
- Ball drop system
- Time stabilized around 5.5 hrs/stg without milling out and 8 hrs/stg with milling out
- 128 m^3 fluid lost with immediate milling out compared with 350 m^3





Completions Time Analysis

- Hybrid system
- Downward trend for time per stage

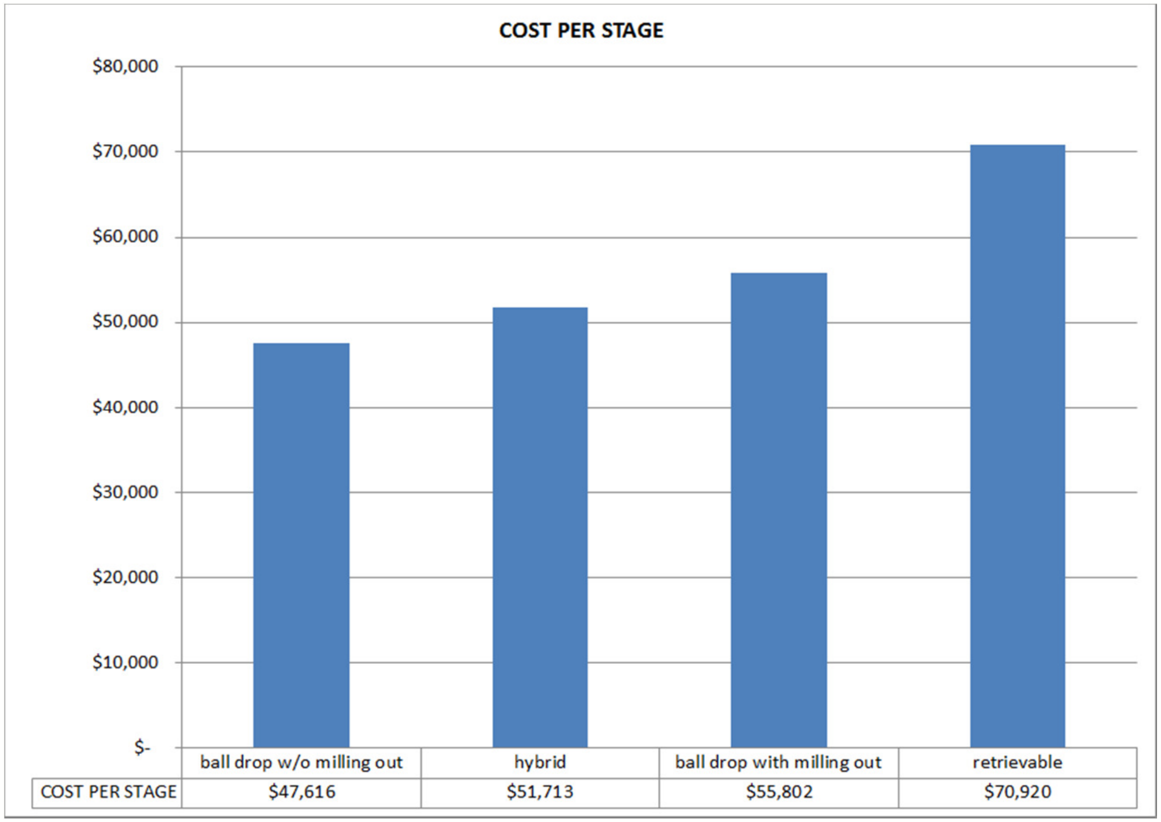


	B	H	I	J	K	L
total time	8.25	6.97	6.38	8.05	7.36	5.14

COMPLETION COST ANALYSIS

Completions Cost Analysis

- Cost was normalized by the total number of stages
- Similar trend as time per stage: ball drop w/o milling is less expensive



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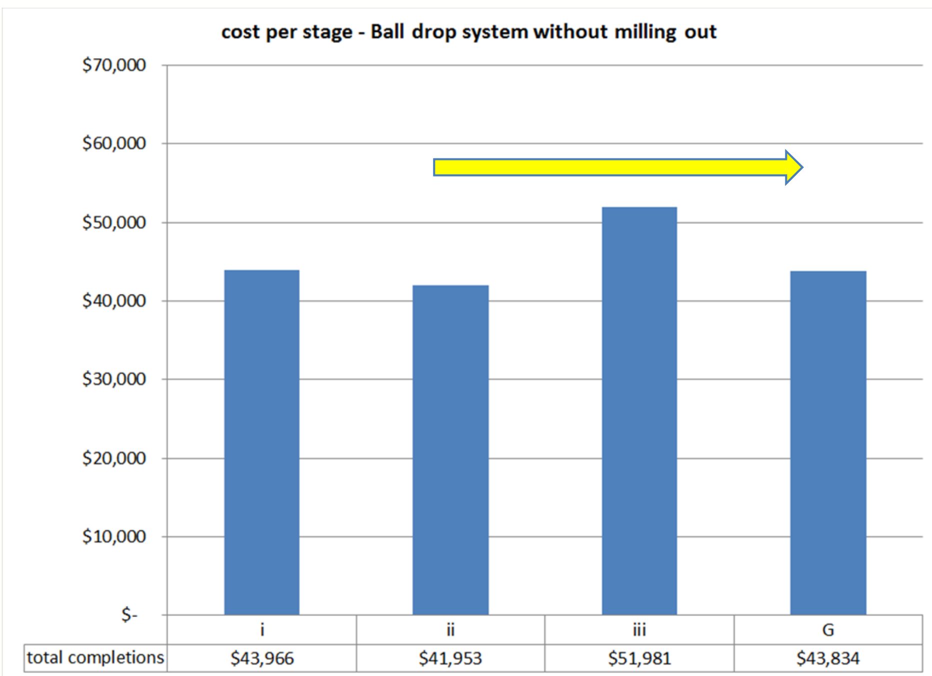

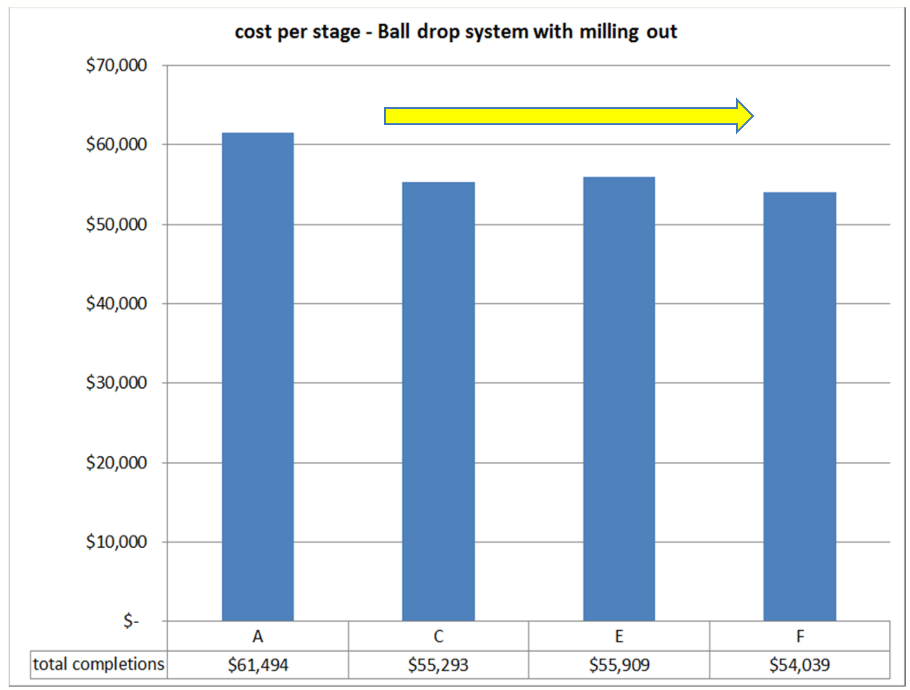

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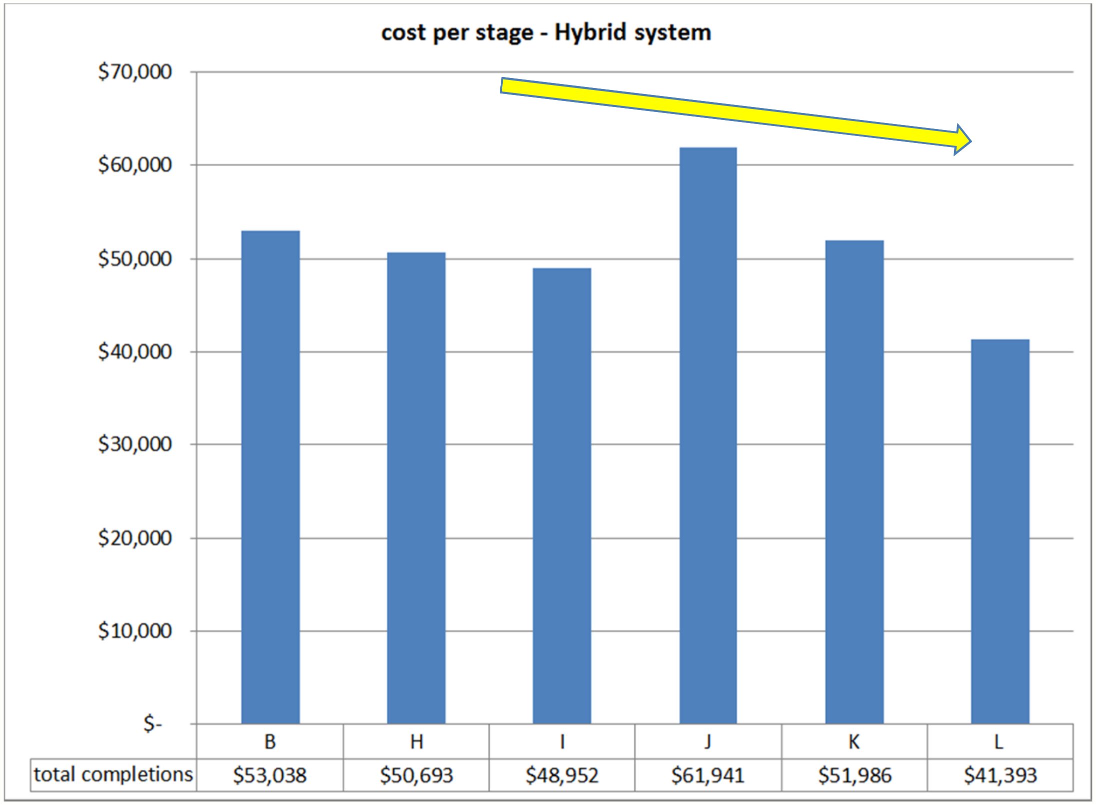
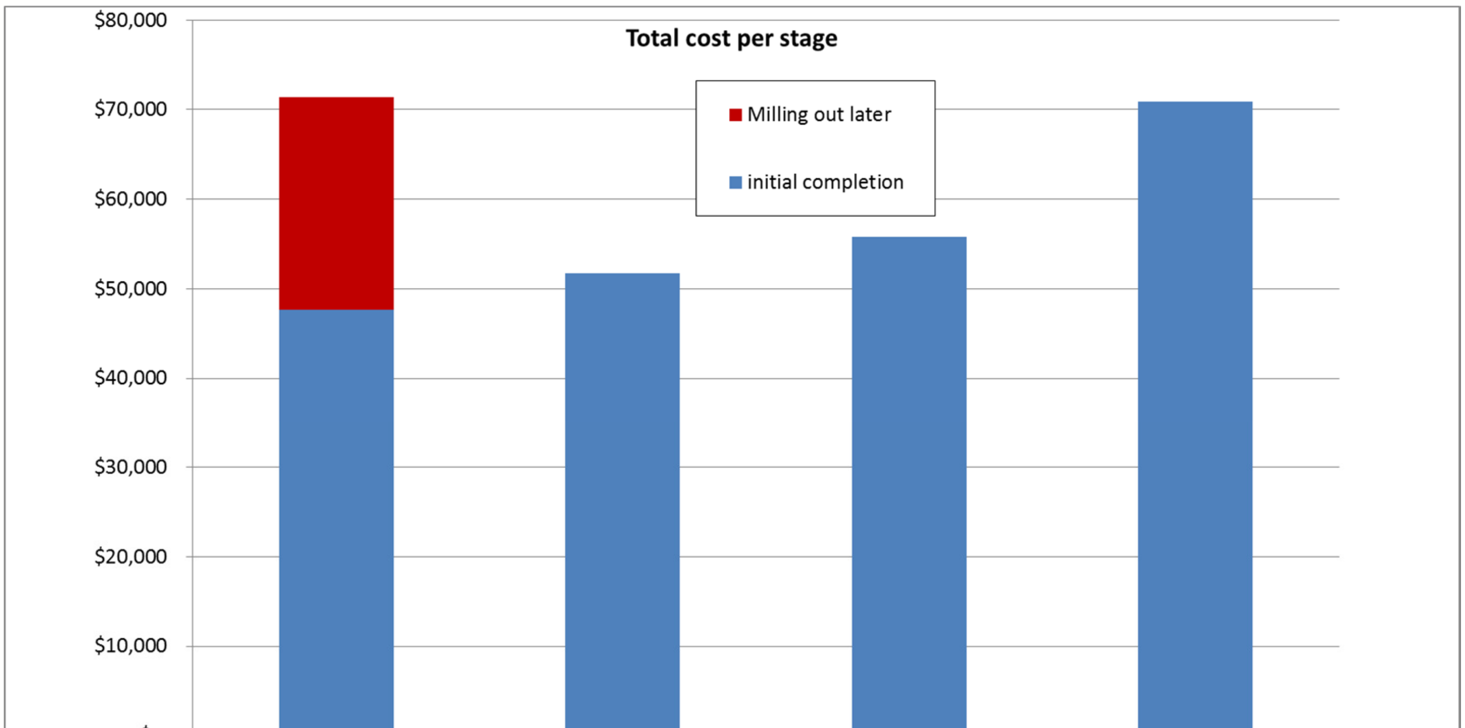


Completions Cost Analysis

- Total wellbore cost
- Hybrid system provides the best economic proposition

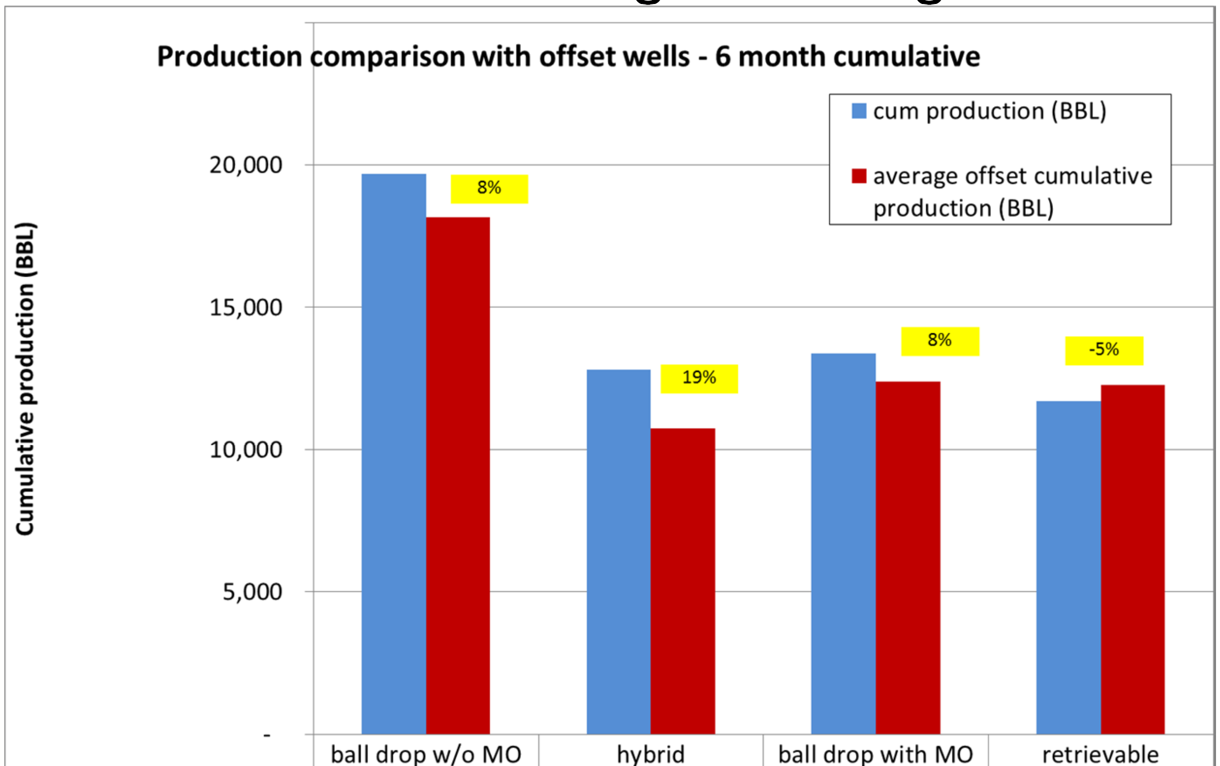


	ball drop w/o milling out	hybrid	ball drop with milling out	retrievable
Milling out later	$23,750			
initial completion	$47,616	$51,713	$55,802	$70,920

PRODUCTION ANALYSIS

Production Analysis

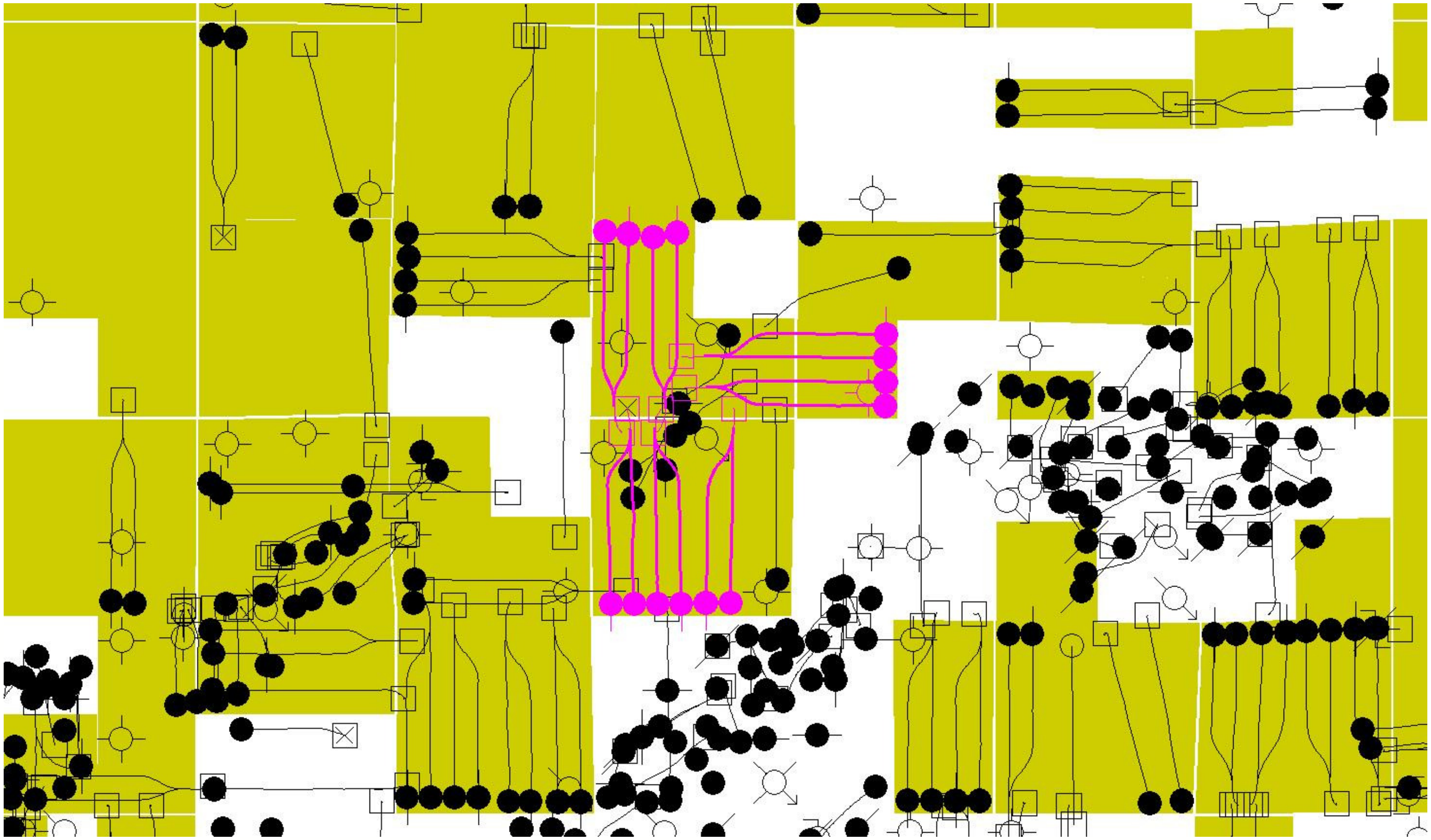
- Cumulative production for 6 months
- Offsets were comparable in terms of # stages and age with 5 wells on average
- Higher than average offset production in most cases



	ball drop w/o MO	hybrid	ball drop with MO	retrievable
cum production (BBL)	19,675	12,821	13,396	11,726
average offset cumulative production (BBL)	18,174	10,747	12,393	12,283

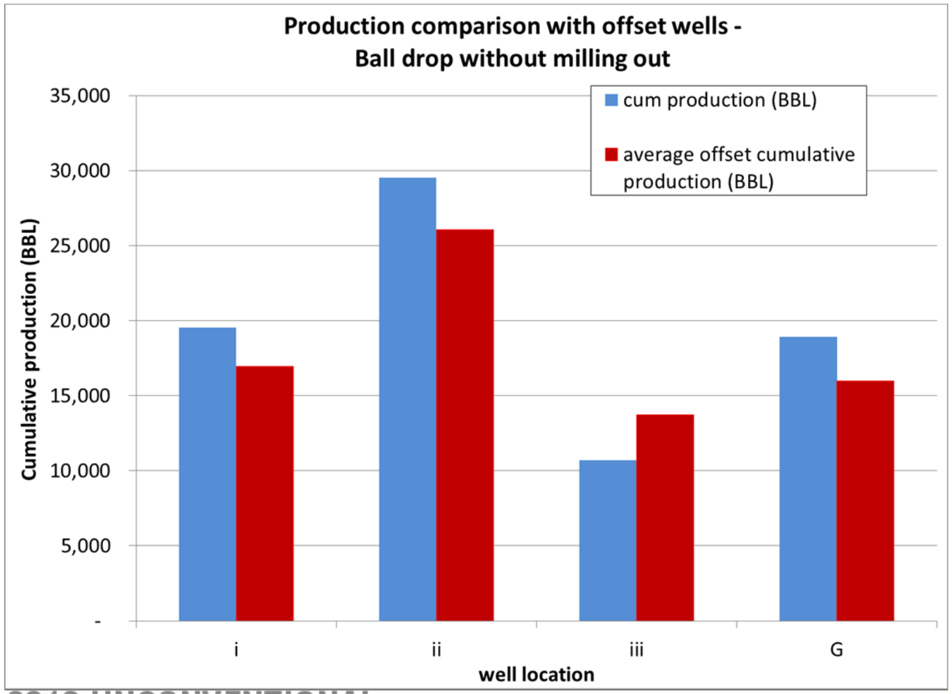
Production Analysis

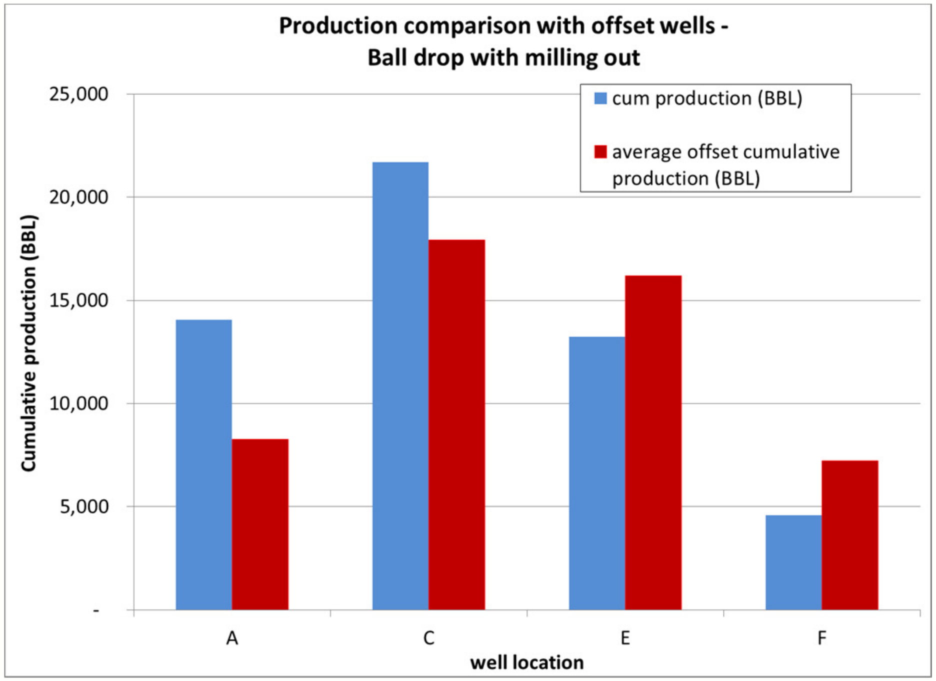
- Offset wells example



Production Analysis

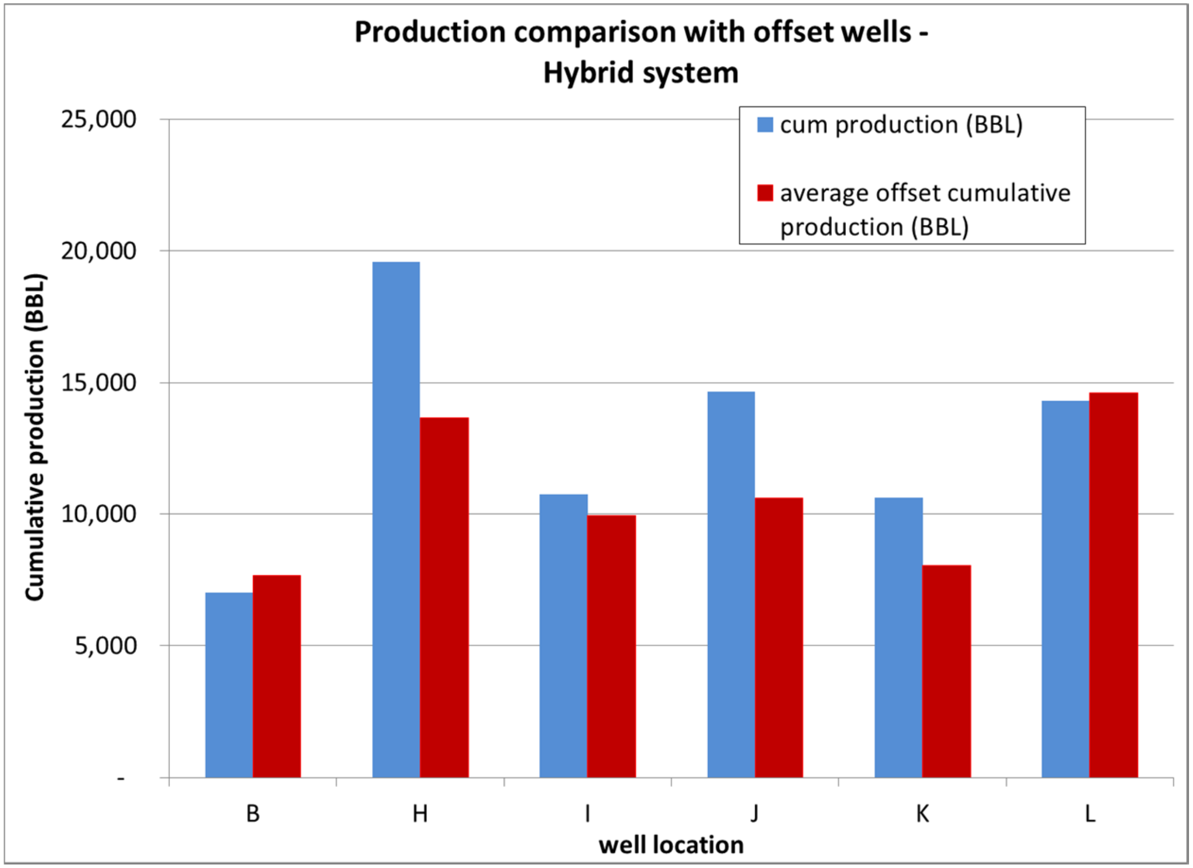
- Mixed production results for ball drop system with or without milling out compared with offset wells
- Ball drop with milling out wells presented more variability





Production Analysis

- Hybrid wellbores consistently delivered wellbores with higher production in most cases compared with their offsets



CONCLUSIONS

Conclusions

- The ball drop without milling system out was the quickest, but the time added for future milling out makes the hybrid system quicker overall.
- The ball drop without milling system out was the least expensive during initial completions, but it left restrictions behind.
- It is better to milling out frac seats immediately after the initial completions rather than later, considering economical perspective and lower fluid losses.
- Production was above offset wells in all the system tested.

Conclusions

- Proper engineering and design were the driving factors in the selection of the wellbore completion, this completion method may not be the ideal solution for all cases.
- The hybrid system was the most cost effective method to achieve a full wellbore ID considering the total capital cost
- The hybrid system provided additional operational benefits:
  - Lower treating volume
  - Quick recover from screen out
  - Capability for post operation bottomhole data analysis
  - Unlimited number of stages

LATEST UPDATES

Latest Updates

- Inter-stage pressure communication was observed with the "hybrid" system, about 20% of cases
- Risk of overstimulation into the same stage
- Cemented liners (CL) were tried during Q4 2013 and Q1 2014
- Some initial results
  - Lower water cut
  - Lower cost: cementation cost is independent of number of stages
  - Similar production level
- Paper to be presented at the SPE Western North America Meeting in Denver, CO on April 16-18th (SPE # 169574)

Acknowledgements

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Questions & Answers