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Lecturer Program



Lunskoye Big Bore Gas Wells - Maximising Gas, Minimising Sand

Mike Gunningham
Sakhalin Energy Investment
Company



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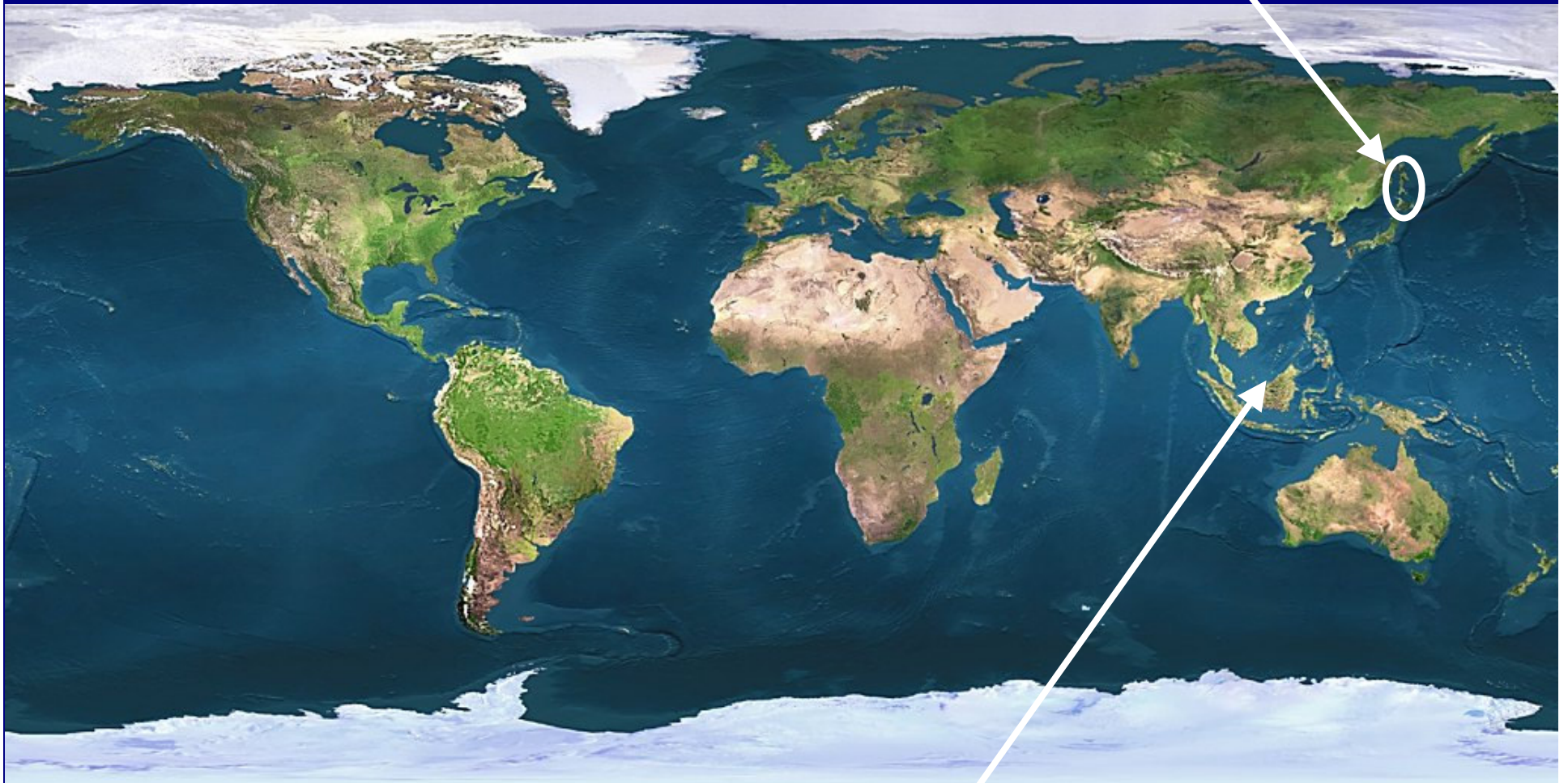
 Mitsubishi Corporation

Presentation Overview

- Introduction Sakhalin II Project
- Lunskoye Field Overview
- Overview of Original Completion Design
- New Sandface Completion Selection
- New Completion Design
- Quantitative Risk Assessment and Sand Management Plan
- Conclusions



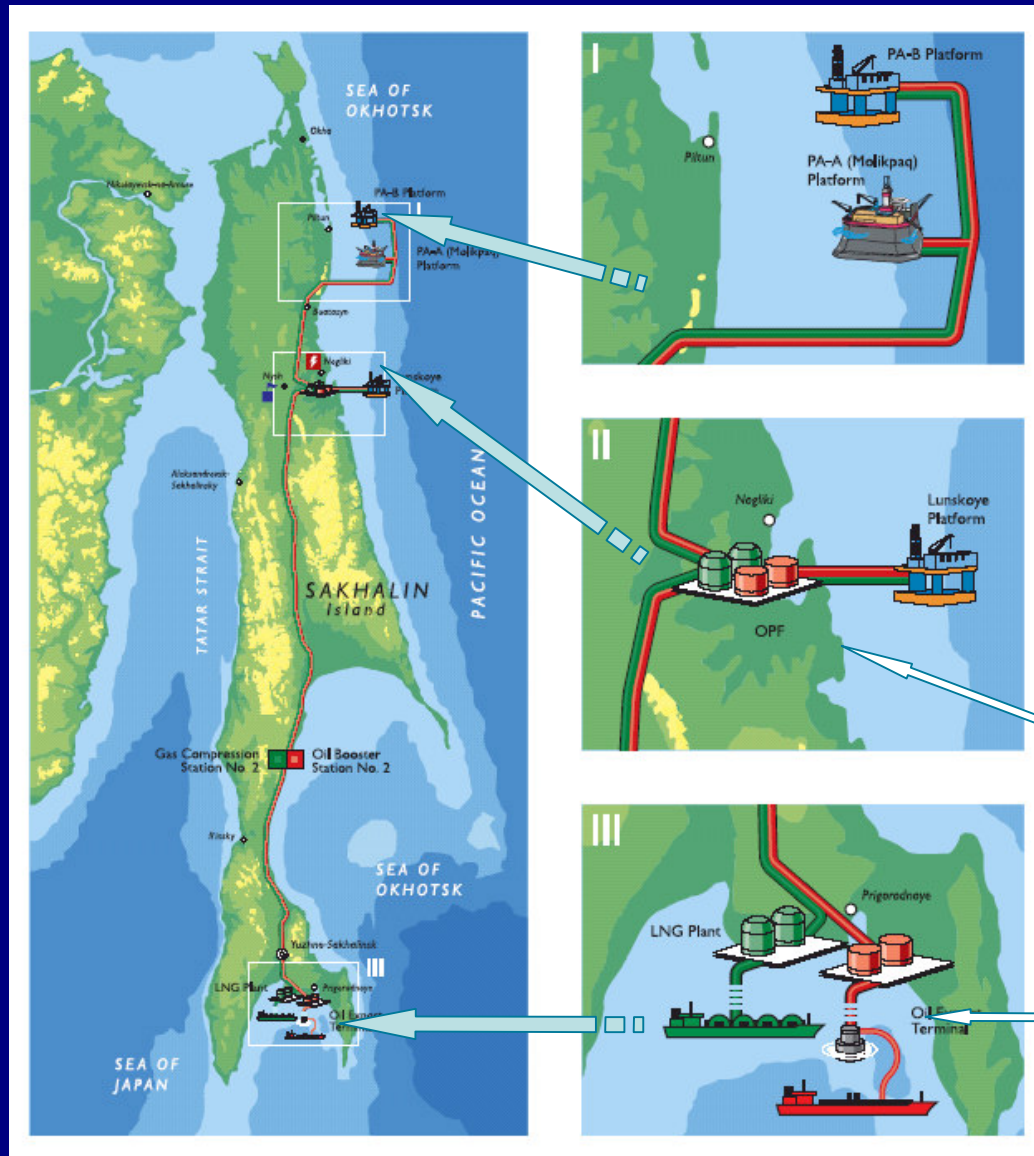
Where is Sakhalin?



Sakhalin

You are here

Sakhalin II Development



- Piltun B platform (70k BOPD)
- Astokh year round production (70k BOPD).
- Lunskeye A platform (1800 MMscf/d & 45k BCPD).
- Onshore processing facility.
- Oil and gas pipelines.
- LNG plant (9.6 MMTPA) & Oil Export Terminal.



A Mega-Project in a Frontier Environment

Every Aspect is **HUGE!** .. \$22 billion



2 New Platforms

**20,000+ People,
60x10⁶ hrs p.a.**



800km Oil & Gas Pipelines

Environment



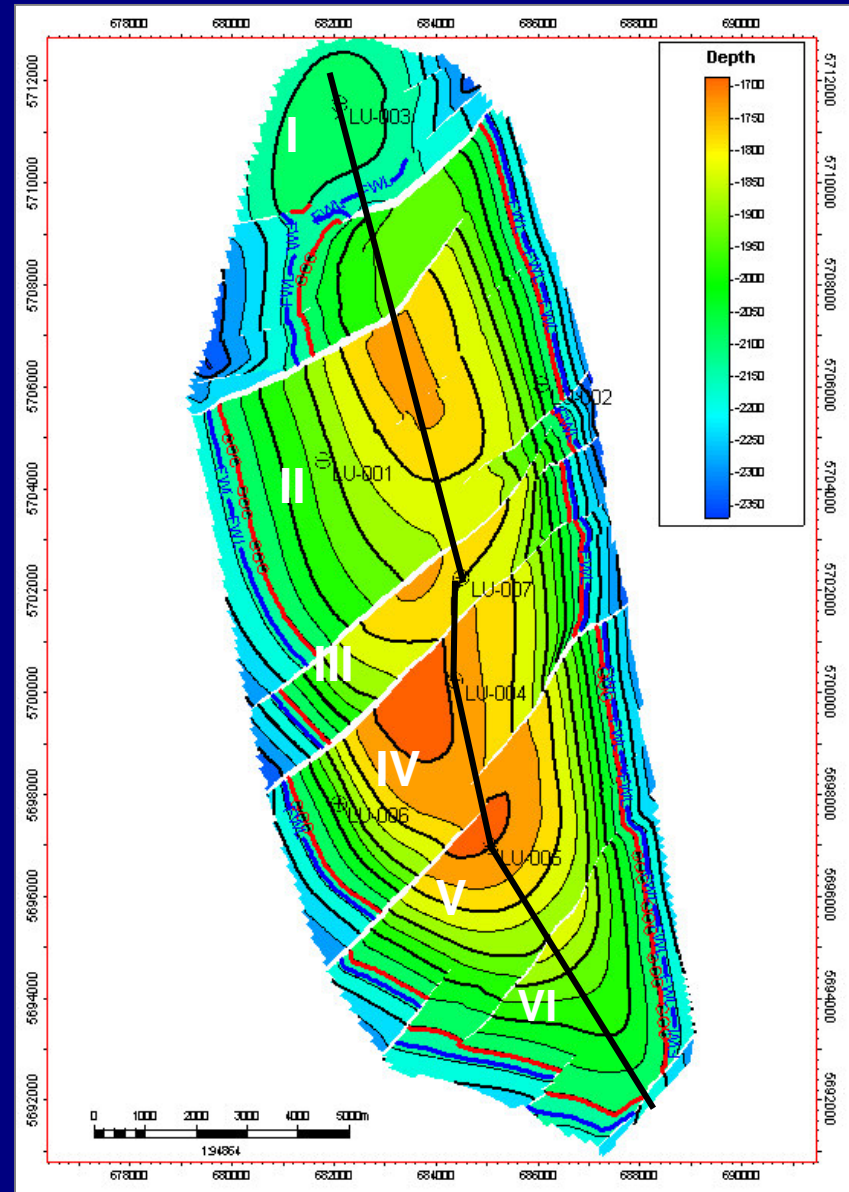
**1st LNG Plant in Russia
2 x 4.8 million tonnes p.a.**

\$100/second Spend



Lunskoye Gas Field

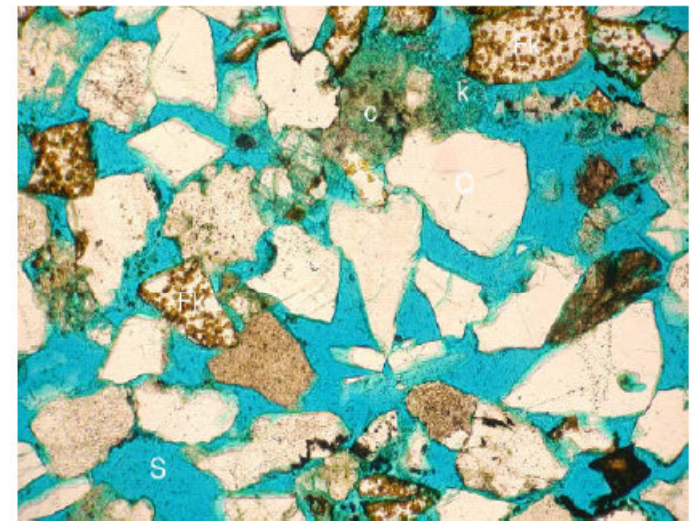
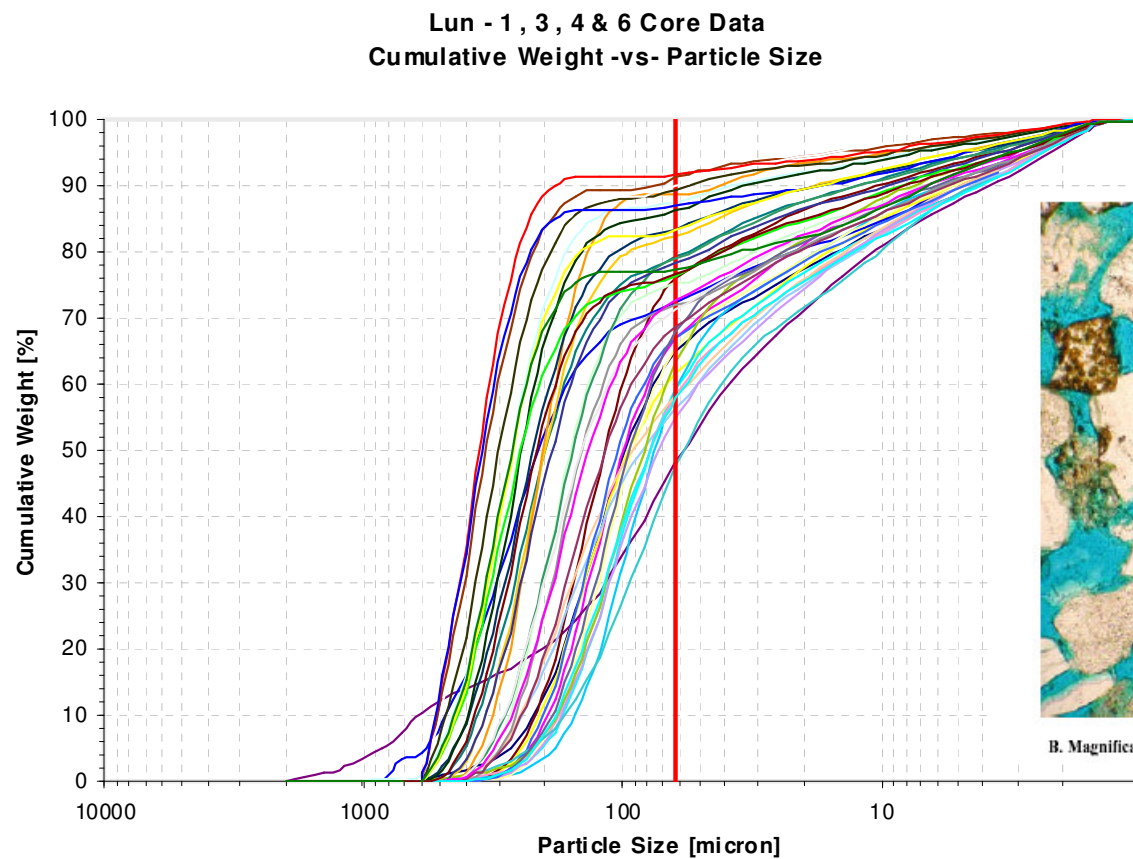
- Discovered in 1984 and appraised with 7 wells
- Excellent gas reservoir with thin oil rim
 - GIIP 18.6 Tcf,
 - STOIIP 931 MMbbl
- One platform (Lun-A) can sustain 20 years production plateau for two LNG trains.



Lunskoye Field – Formation Data

Aver Porosity = 25%,
 $d_{50} = 55-357$ ($A_v = 167\mu\text{m}$)

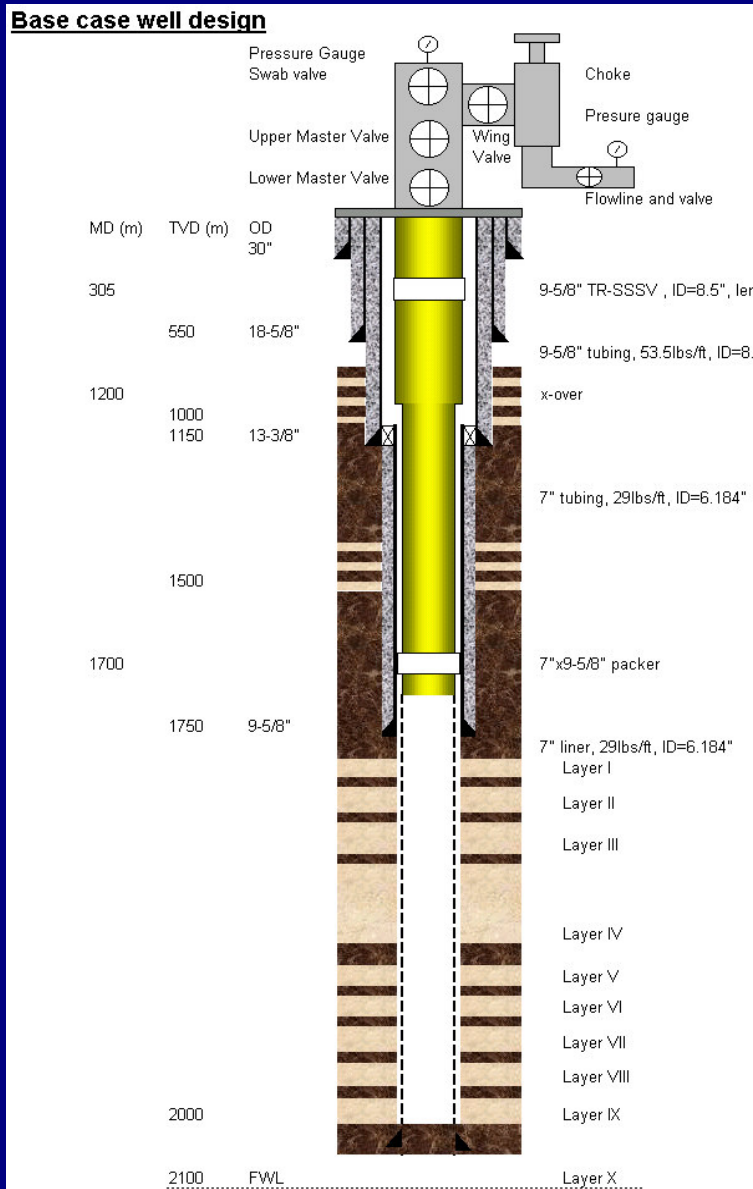
Perm = 150 – 1,200 mD,
Fines = 7-42 (23%)



B. Magnification x 113

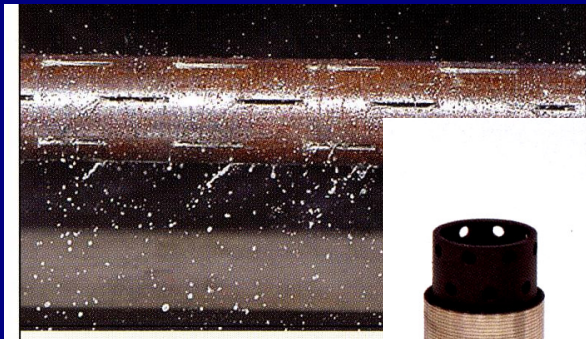
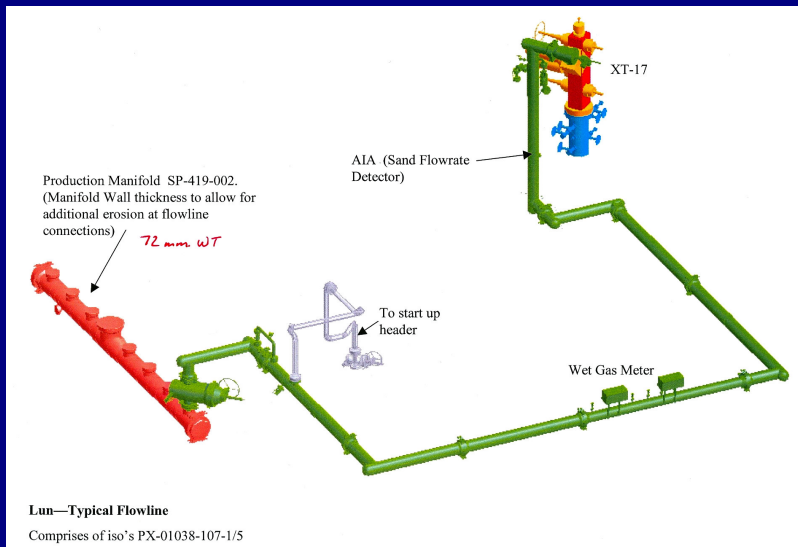
Plane Polarised Light

Initial Gas Well Design, 2002



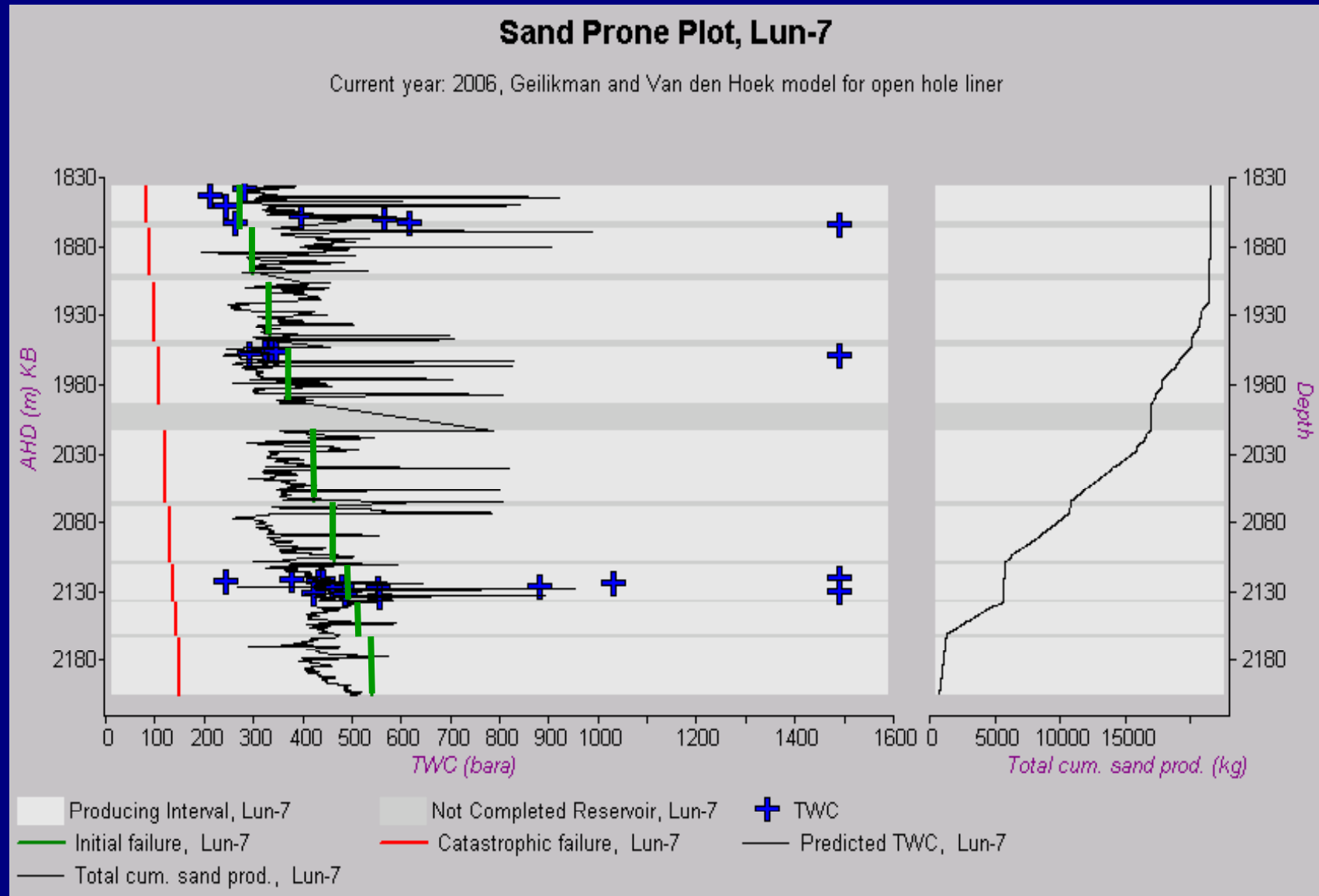
- 9-5/8" x 7" 13Cr tapered tubing, with Pre-Drilled Liner or Slotted Liner completion in open hole.
- Sand expected to be produced and managed, and retrofit sand control as required.
- Topsides designed for sand production (0.5 lbs/MMscf), with 1/2 tonne sand/day expected

Follow-Up Work in 2002-2004

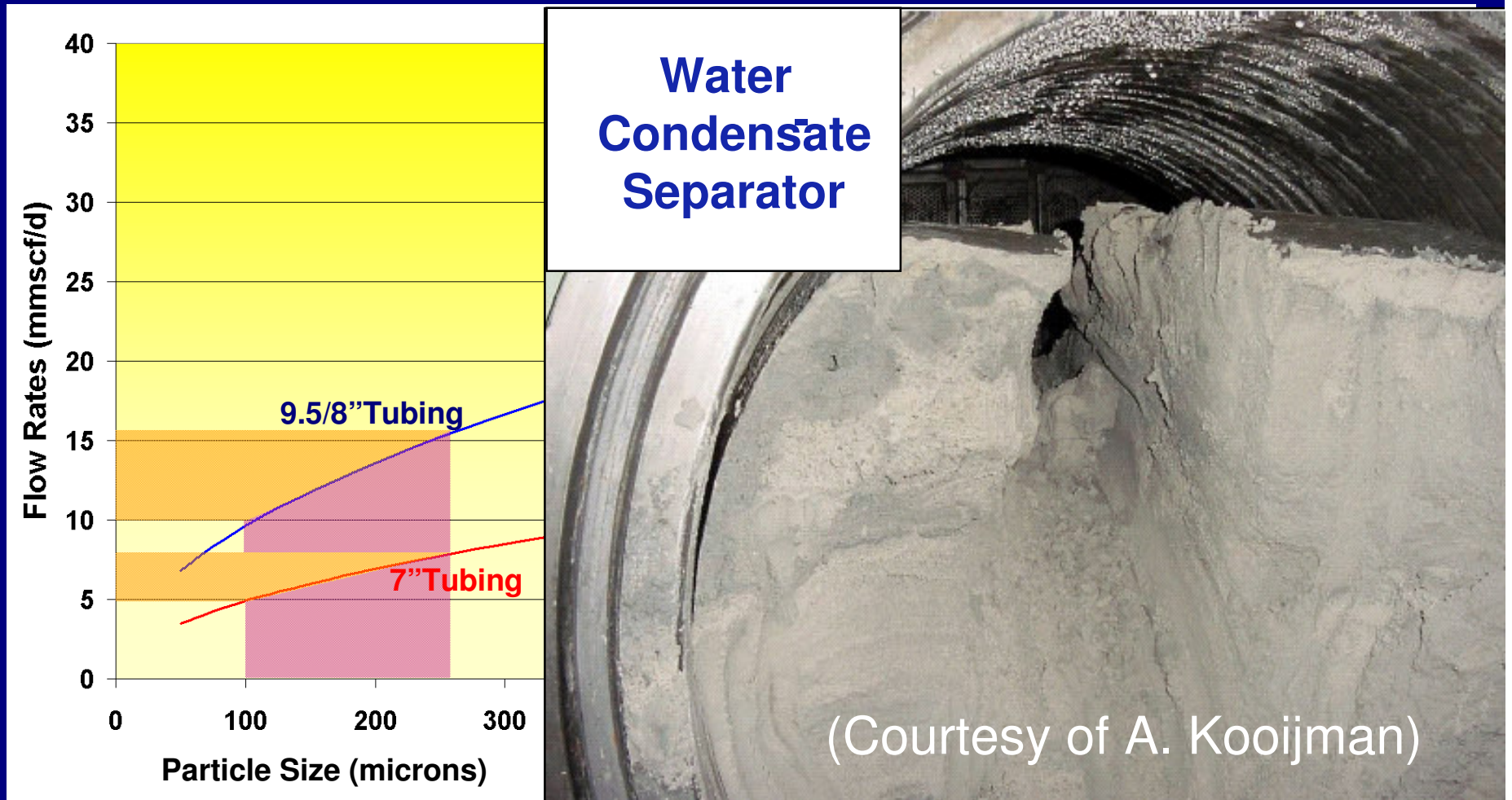


- Value Engineering of Topsides,
 - Sand handling equipment removed
 - Reduced 14" flowlines to 12" (erosion critical)
 - No test separator
- Acceleration of Gas Sales
 - No float in drilling schedule to enable retrofit sand control.
- In 2004: High rate gas wells & sand expected, with:
 - No sand exclusion downhole,
 - Minimal surface sand handling capability.

2004, Openhole Sand Estimate



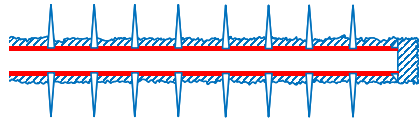
What happens if a well produces sand?



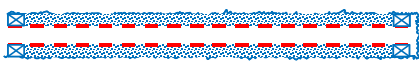
If this happens on Lunskeye: A delay in the time to reach Plateau production would be 4-6 months minimum.

Back to the Drawing Board: Sand Face Completion Selection

Cased & Perforated



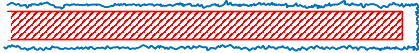
Open Hole Gravel Pack



Expandable Sandscreen



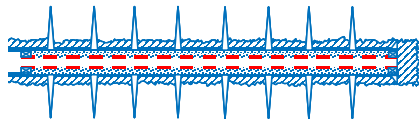
Standalone Screen



Slotted Liner



Internal Gravel pack



Predrilled Liner



Barefoot



SPE 88493

← But C&P has no screen/filter to stop sand ...
.... so how much sand will be produced?
.... how much gas production?

	Barefoot	Pre-drilled liner	Slotted Liner	Stand Alone Screen	Cased and Perforated	OH ESS	OH Gravel Pack
Overall Score	Red	Red	Red	Red	Green	Yellow	Red
Reliability	Red	Red	Red	Red	Yellow	Yellow	Yellow
Installation / Do-ability	Red	Red	Red	Red	Green	Yellow	Red
Capacity	Red	Red	Red	Red	Yellow	Yellow	Yellow
Cost	Red	Red	Red	Red	Yellow	Red	Red
HSE	Red	Red	Red	Red	Green	Green	Green

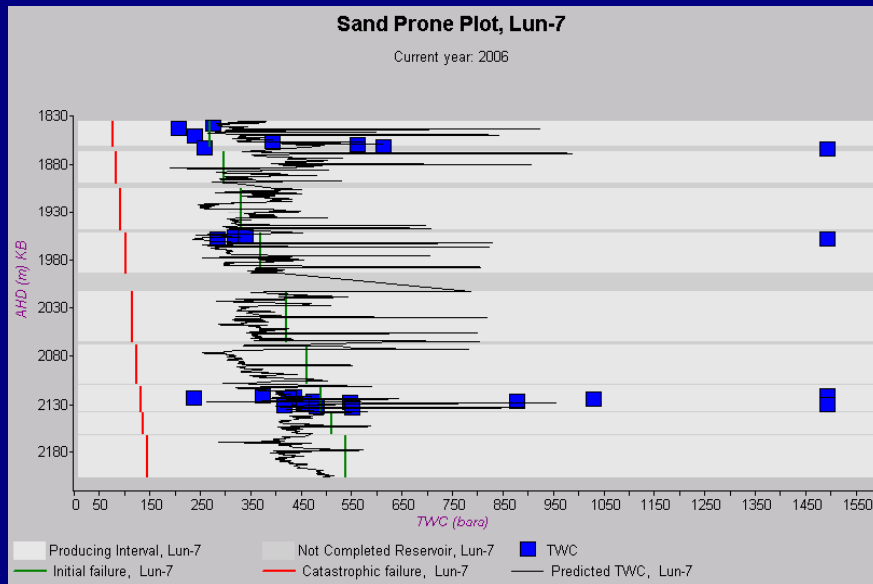
Good Option

Possible Option

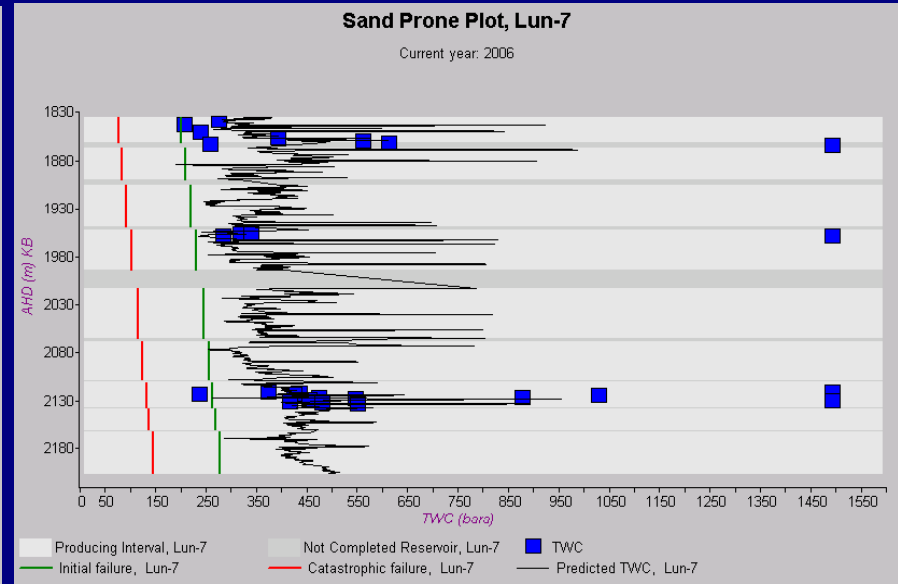
Worst Option

Openhole Vs Cased and Perforated: Sand Prediction

Openhole

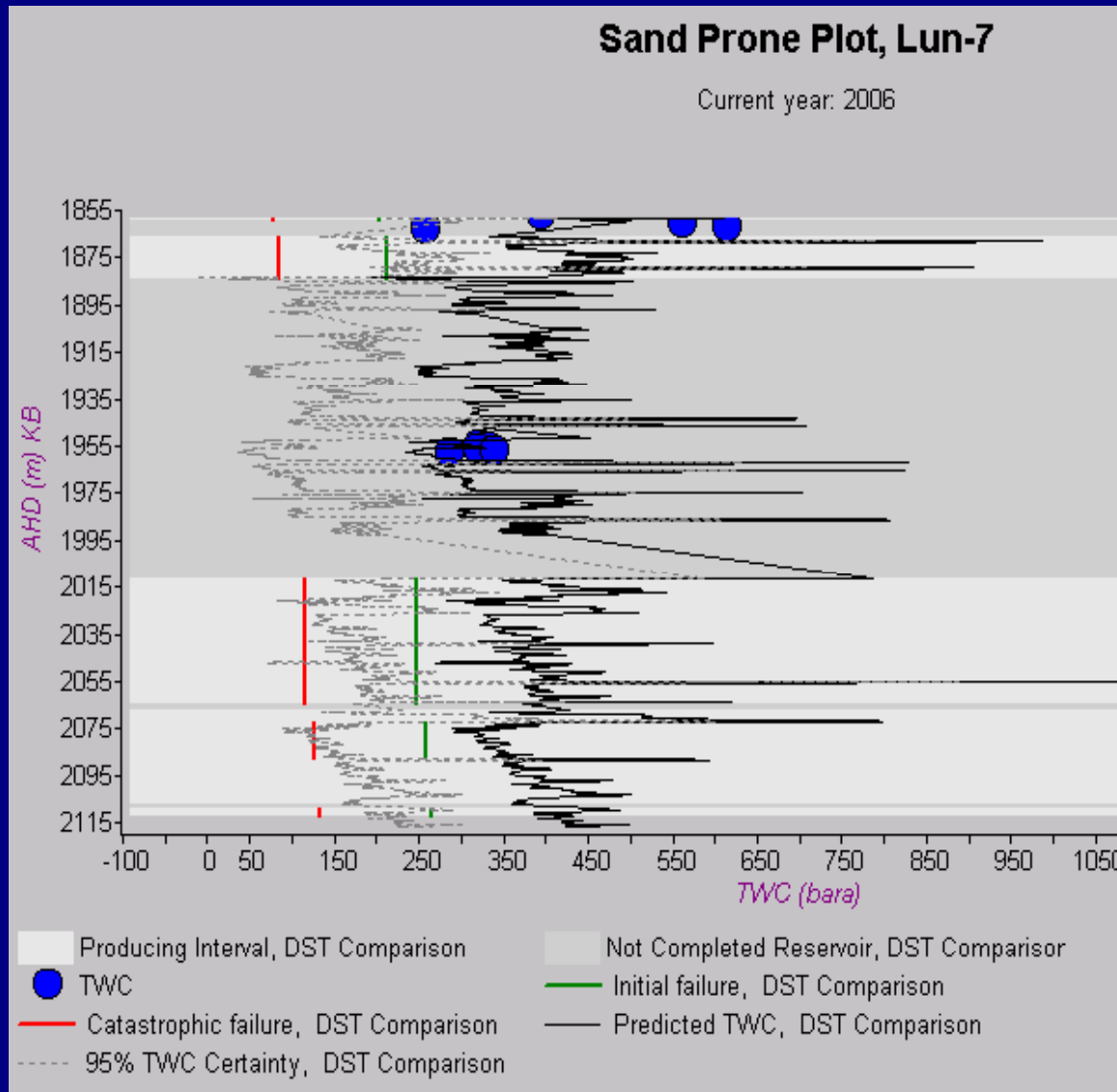


Cased & Perforated



Sand Production is expected to be delayed (with smaller volumes) with cased and perforated completions compared to openhole completions

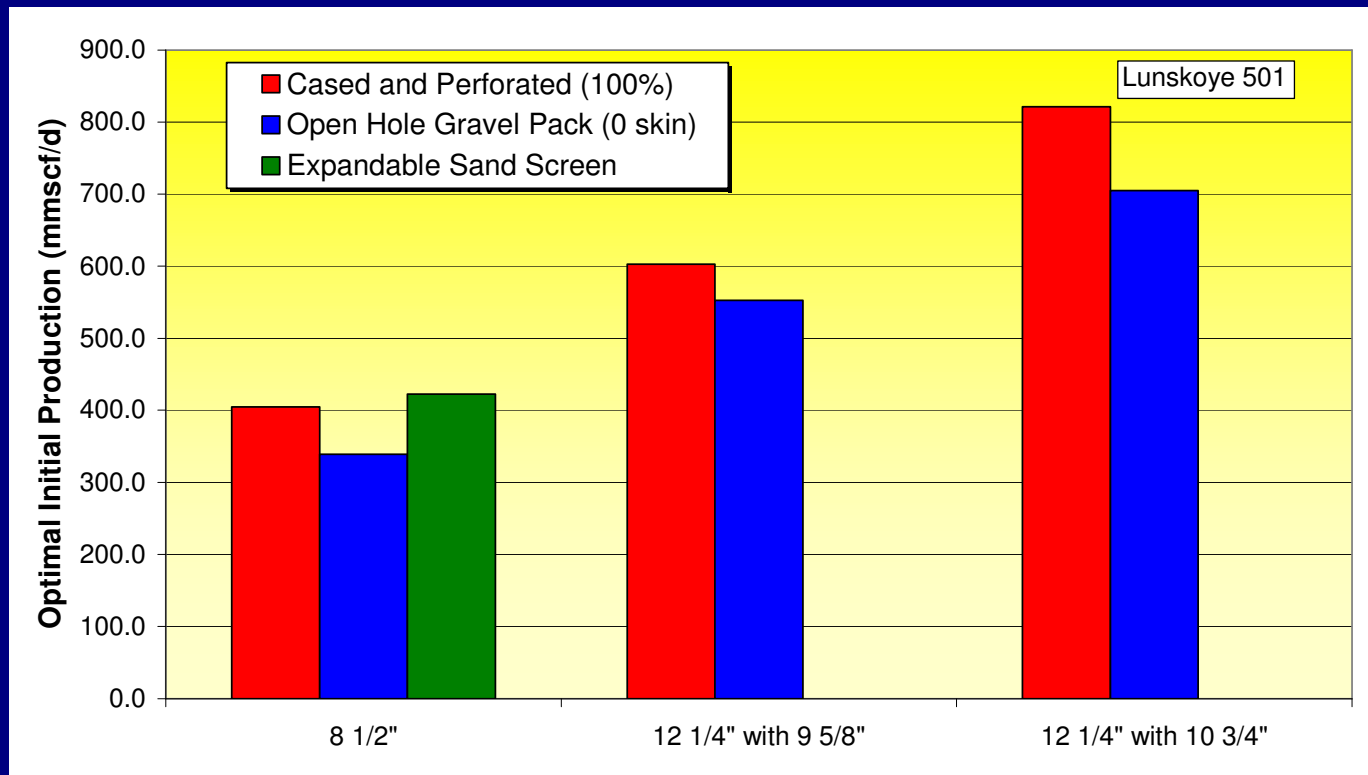
2004 Prediction Calibrations: Cased & Perforated



- **Drill Stem Tests from Lun-7 observed no sand**
- **Successfully predicted (Blind)**
- **Sand failure predictions also showed sand would not be expected in the DSTs performed on other wells – consistent with the observations.**

Productivity Predictions: Lun-501

- Development well trajectories changed from vertical to inclined to increase reservoir exposure
- Completion sizes 8 1/2" and 12 1/4" open hole considered



Downhole: Sandface Completion Comparison

Sand face completion	Pros	Cons
Cased & Perforated	Robust, Productive Water Shut Off capability	Sand production later in field life
Openhole Gravel Pack	Downhole sand control	Very difficult to achieve in winter Lower Productivity Costly & Complex installation No Water Shut Off capability
Expandable Sand Screen	Downhole sand control	Limited track record for high rate gas wells No Water Shut Off capability 8 1/2" hole only

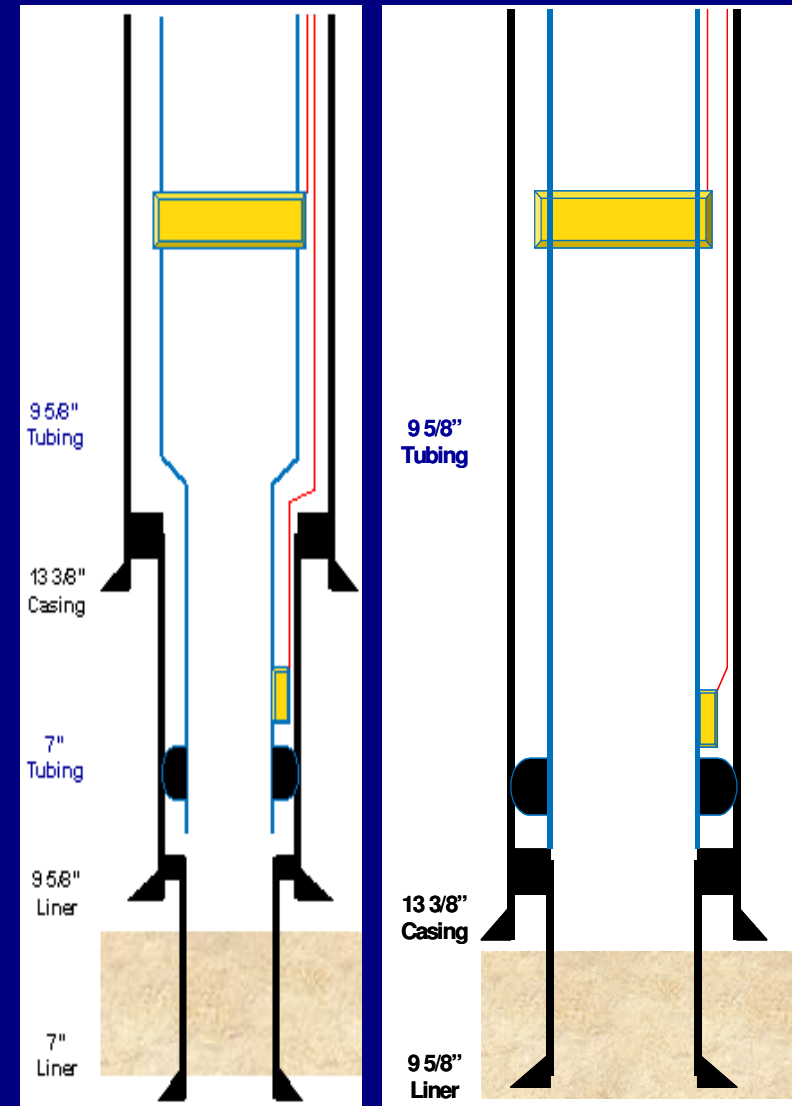
Conclusion of sand study - use C&P and make detailed contingency design for ESS/OHGP.

Optimising Cased & Perforated Completion

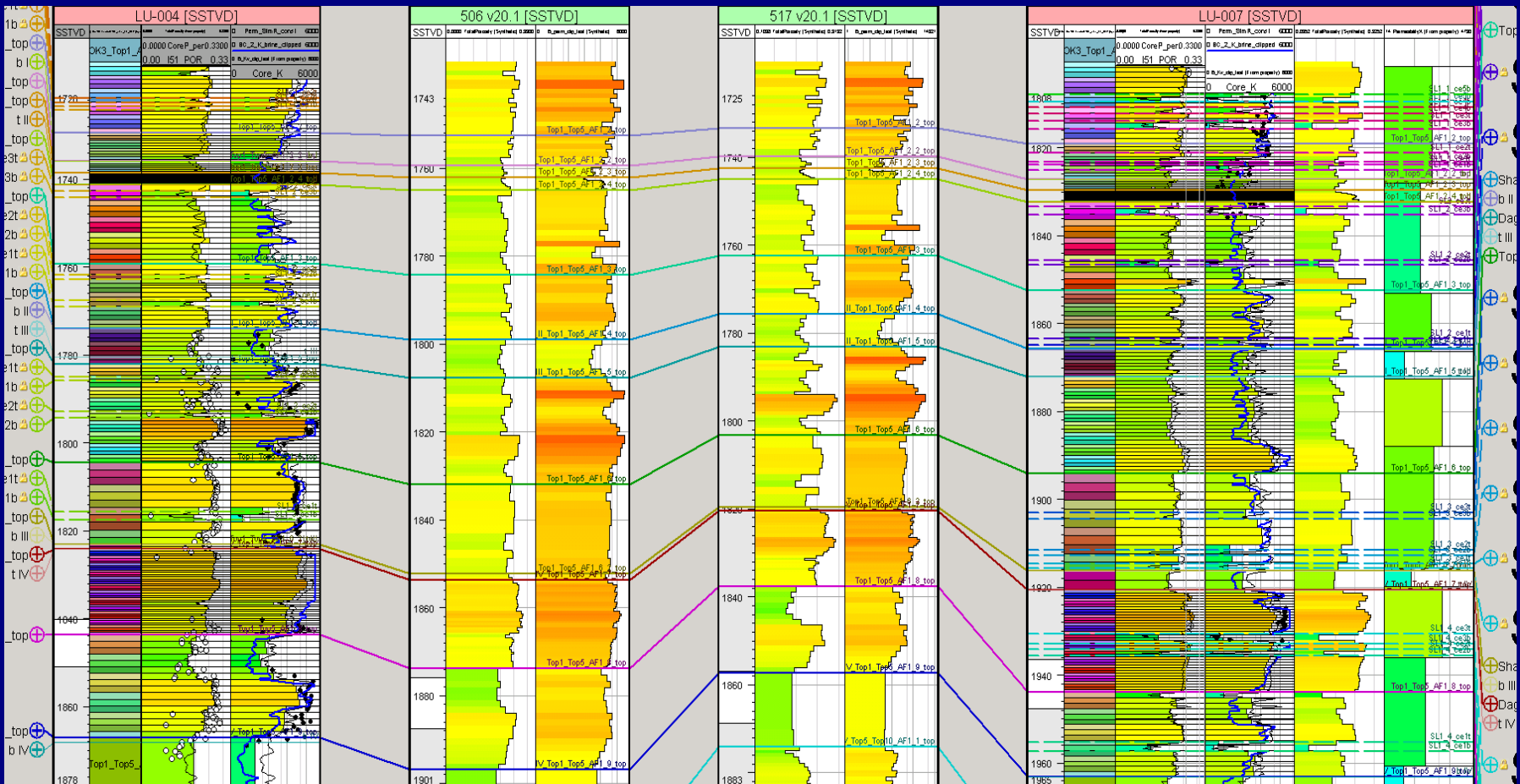
- Development well geology estimated for 2m AHD intervals discretisation.
- 400 inflow intervals/well (~2 to 3m AHD).
- Sand Prediction gives failed intervals: these are not perforated.

Gas Wells 1-3

Gas Wells 4-7

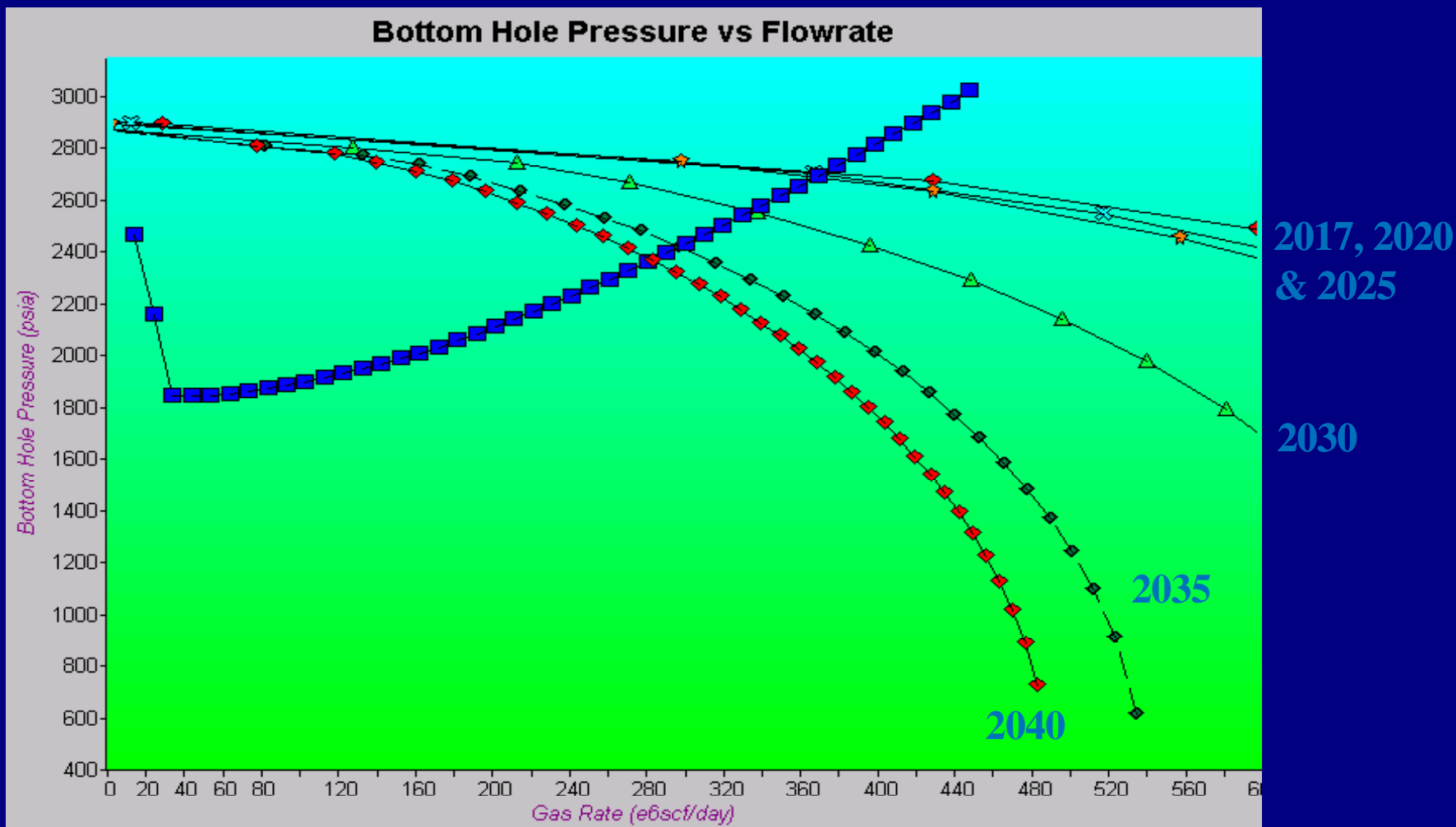


Example of Petrel Discretisation of Daghinsky



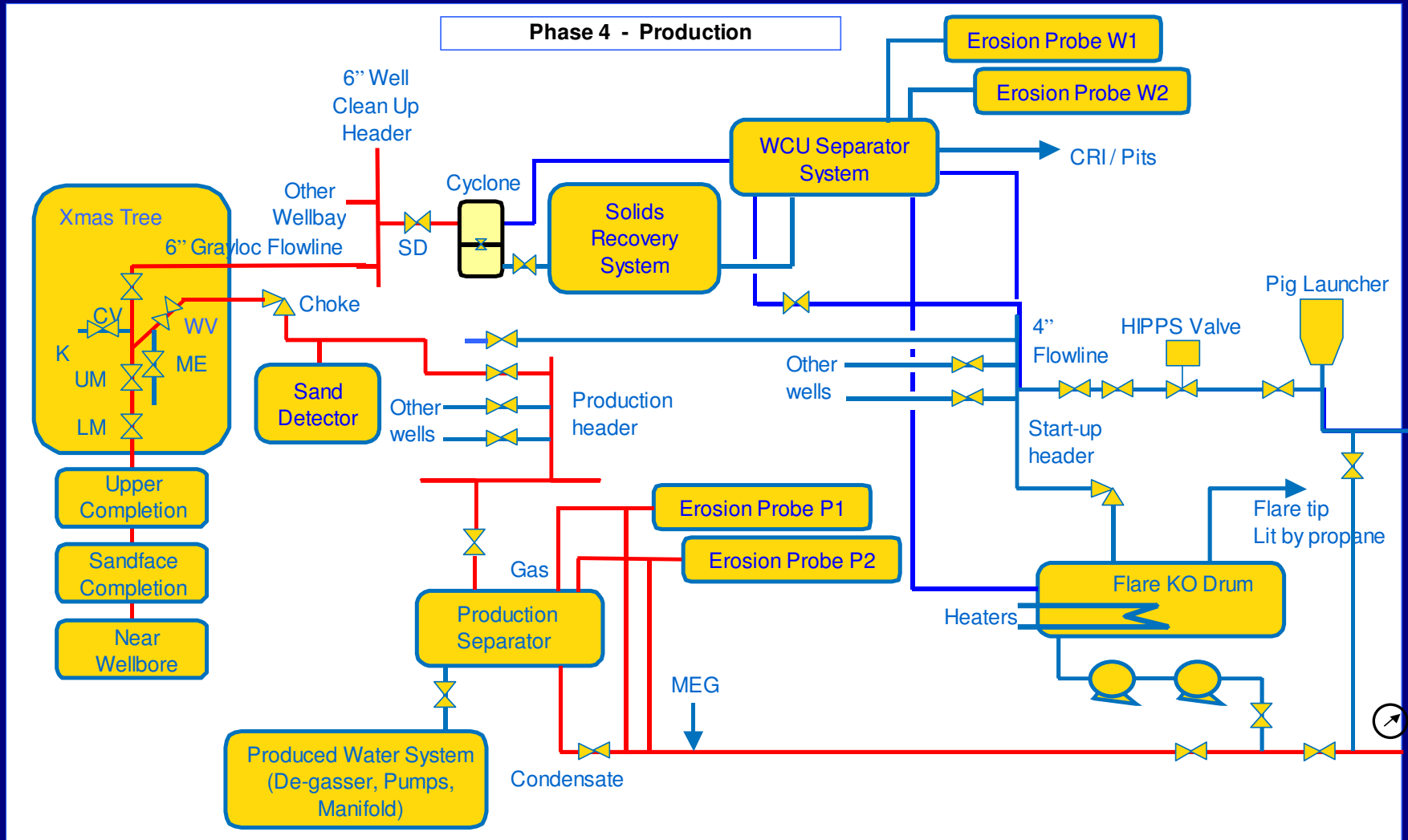
2m Intervals

Impact on Initial Production with Selective Perforation



- Selective perforating based on sand free production until 2025

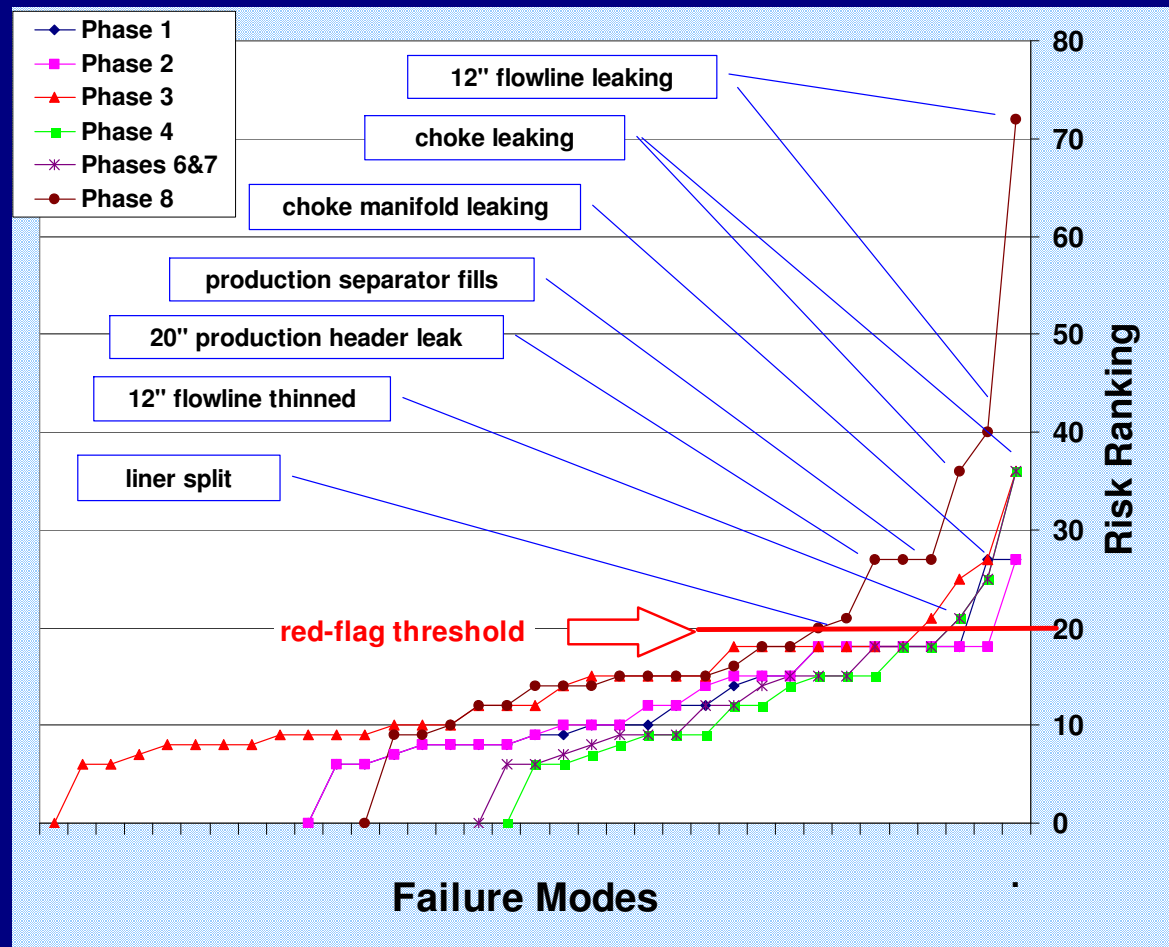
QRA: Quantitative Risk Analysis



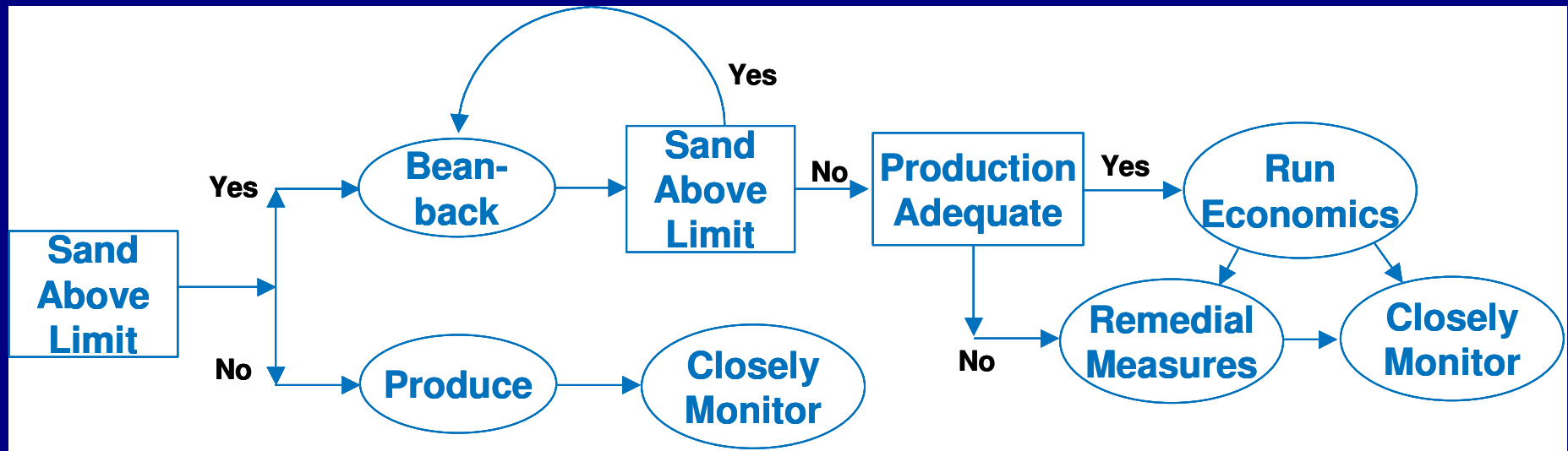
Mitigation Measures to Reduce Impact of Sand Production

Example

- 12" Flowline
- Erode until detected
- Remedial Options
 - Maximise use Well Clean Up Unit
 - Small bean Up steps
 - Use clamp on sand detector
 - Non destructive testing



Remedial Completion Options



Remedial Measures Selection Matrix

	Re-Perforate	Sand Consolidation/Polymer Shut-off	Cement squeeze & drill out	Cement Plug	Mechanical Plug	Inflatable Plug	Straddle Packers	Cased Hole ESS (WCS)	Wireline Conveyed Screen	Patch (Generic) (W/L & CT)
Selection criteria										
Through Tubing										
Max Running OD-5.75"										
ID restriction post deployment										
Metallurgy CRA, 13Cr or higher										
Deployment (W/L, CT, DP, W/O)	W/L & CT	CT + SPT	CT	W/L & CT	W/L blanks 4-5m	W/L blanks 4-5m	W/L & CT & Blank	DP	W/L	
Length Range		3m/treatment					100m???			
Live Deployment? (Y/N)										
Collapse Rating (psi)										
Mid interval sand production										
Bottom sand production										
Sand location unknown										
Whole section sanding										

Sand Management Plan

- **Lunskoye Sand Management Plan:**

- Completion Design
- Quantitative Risk Assessment
- Monitoring
- Roles & Responsibilities
- Contingency Planning

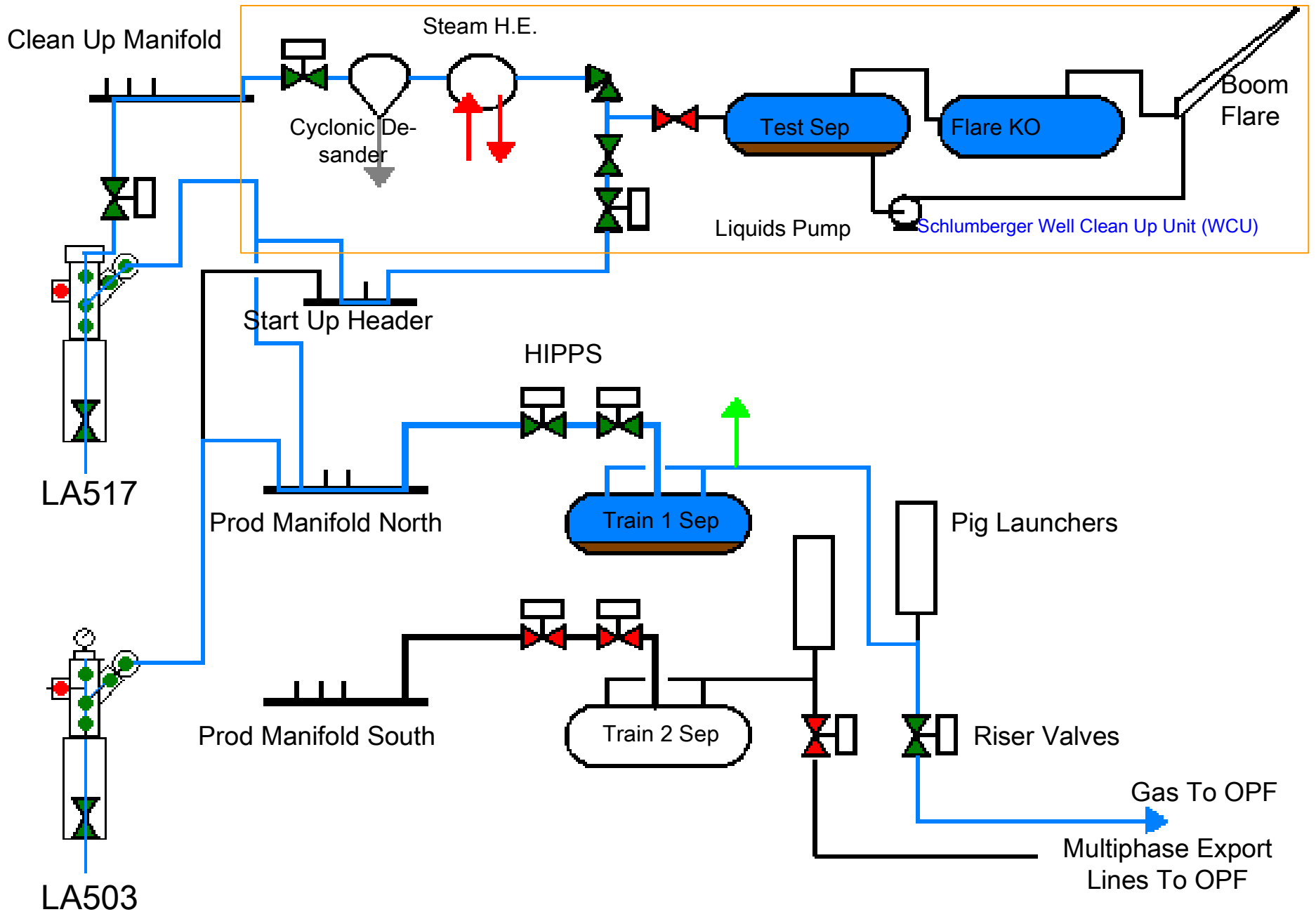
- Apply other operator's experience

Lunskoye Sand Management Plan		Rev 01
TABLE OF CONTENTS		
1	SEIC SAND MANAGEMENT POLICY.....	6
1.1	The Hazards and Effects Management Process (HEMP)	6
1.2	Geology and Structure of the Lunskoye Field	7
1.2.1	Impact of the Lunskoye Structure on the Sand Production Risks.....	8
1.3	Sand Management Team	8
2	BACKGROUND TO SAND PRODUCTION ON THE LUNSKOYE FIELD.....	9
2.1	Production from the Lunskoye Field	9
2.1.1	Secondary production: Compression.....	9
2.2	Sand Transport from the Well	10
2.3	Properties of the sandstone formations – Particle Size Distribution	11
2.4	Daghinsky Formation Sand Quality	12
2.5	Sand Angularity	13
3	SAND PREDICTED FOR THE LUNSKOYE WELLS: INITIAL GAS WELL SEQUENCE	13
3.1	Initial well clean-up and bean-up	13
3.2	Sand production at plateau production	14
4	QUANTITATIVE RISK ANALYSIS:	15
4.1	Framework for the QRA	15
4.1.1	Probability of Occurrence.....	15
4.1.2	Consequences of Failure.....	15
4.2	Erosion Summary	15
4.2.1	Facility layout.....	15
4.2.2	Erosion risk.....	15
4.3	Sand Production.....	15
4.4	QRA.....	21
5	OPERATIONAL PROCEDURES.....	21
5.1	Well clean-up and bean-up phase.....	21
5.2	Monitoring.....	31
5.3	Well integrity/sand production.....	32
5.3.3	Well testing: Sand Influx.....	32
6	DESIGN AND OPERATIONAL STRATEGY.....	32
6.1	Well design.....	33
6.2	Well completion.....	34
6.3	Well completion: Should we perforate for selective perforating?	34
6.3.1	Well completion: Should we perforate for selective perforating?	35
6.3.2	Well completion: Should we perforate for selective perforating?	35
6.3.3	Well completion: Should we perforate for selective perforating?	38
6.3.4	Well completion: Should we perforate for selective perforating?	38
6.3.5	Well completion: Should we perforate for selective perforating?	39
6.3.6	Well completion: Should we perforate for selective perforating?	39
6.3.7	Well completion: Should we perforate for selective perforating?	39
6.3.8	Well completion: Should we perforate for selective perforating?	39
6.3.9	Well completion: Should we perforate for selective perforating?	39
6.3.10	Well completion: Should we perforate for selective perforating?	39
6.3.11	Well completion: Should we perforate for selective perforating?	39
6.3.12	Well completion: Should we perforate for selective perforating?	39
6.3.13	Well completion: Should we perforate for selective perforating?	39
6.3.14	Well completion: Should we perforate for selective perforating?	39
6.3.15	Well completion: Should we perforate for selective perforating?	39
6.3.16	Well completion: Should we perforate for selective perforating?	39
6.3.17	Well completion: Should we perforate for selective perforating?	39
6.3.18	Well completion: Should we perforate for selective perforating?	39
6.3.19	Well completion: Should we perforate for selective perforating?	39
6.3.20	Well completion: Should we perforate for selective perforating?	39
6.3.21	Well completion: Should we perforate for selective perforating?	39
6.3.22	Well completion: Should we perforate for selective perforating?	39
6.3.23	Well completion: Should we perforate for selective perforating?	39
6.3.24	Well completion: Should we perforate for selective perforating?	39
6.3.25	Well completion: Should we perforate for selective perforating?	39
6.3.26	Well completion: Should we perforate for selective perforating?	39
6.3.27	Well completion: Should we perforate for selective perforating?	39
6.3.28	Well completion: Should we perforate for selective perforating?	39
6.3.29	Well completion: Should we perforate for selective perforating?	39
6.3.30	Well completion: Should we perforate for selective perforating?	39
6.3.31	Well completion: Should we perforate for selective perforating?	39
6.3.32	Well completion: Should we perforate for selective perforating?	39
6.3.33	Well completion: Should we perforate for selective perforating?	39
6.3.34	Well completion: Should we perforate for selective perforating?	39
6.3.35	Well completion: Should we perforate for selective perforating?	39
6.3.36	Well completion: Should we perforate for selective perforating?	39
6.3.37	Well completion: Should we perforate for selective perforating?	39
6.3.38	Well completion: Should we perforate for selective perforating?	39
6.3.39	Well completion: Should we perforate for selective perforating?	39
6.3.40	Well completion: Should we perforate for selective perforating?	39
6.3.41	Well completion: Should we perforate for selective perforating?	39
6.3.42	Well completion: Should we perforate for selective perforating?	39
6.3.43	Well completion: Should we perforate for selective perforating?	39
6.3.44	Well completion: Should we perforate for selective perforating?	39
6.3.45	Well completion: Should we perforate for selective perforating?	39
6.3.46	Well completion: Should we perforate for selective perforating?	39
6.3.47	Well completion: Should we perforate for selective perforating?	39
6.3.48	Well completion: Should we perforate for selective perforating?	39
6.3.49	Well completion: Should we perforate for selective perforating?	39
6.3.50	Well completion: Should we perforate for selective perforating?	39
6.3.51	Well completion: Should we perforate for selective perforating?	39
6.3.52	Well completion: Should we perforate for selective perforating?	39
6.3.53	Well completion: Should we perforate for selective perforating?	39
6.3.54	Well completion: Should we perforate for selective perforating?	39
6.3.55	Well completion: Should we perforate for selective perforating?	39
6.3.56	Well completion: Should we perforate for selective perforating?	39
6.3.57	Well completion: Should we perforate for selective perforating?	39
6.3.58	Well completion: Should we perforate for selective perforating?	39
6.3.59	Well completion: Should we perforate for selective perforating?	39
6.3.60	Well completion: Should we perforate for selective perforating?	39
6.3.61	Well completion: Should we perforate for selective perforating?	39
6.3.62	Well completion: Should we perforate for selective perforating?	39
6.3.63	Well completion: Should we perforate for selective perforating?	39
6.3.64	Well completion: Should we perforate for selective perforating?	39
6.3.65	Well completion: Should we perforate for selective perforating?	39
6.3.66	Well completion: Should we perforate for selective perforating?	39
6.3.67	Well completion: Should we perforate for selective perforating?	39
6.3.68	Well completion: Should we perforate for selective perforating?	39
6.3.69	Well completion: Should we perforate for selective perforating?	39
6.3.70	Well completion: Should we perforate for selective perforating?	39
6.3.71	Well completion: Should we perforate for selective perforating?	39
6.3.72	Well completion: Should we perforate for selective perforating?	39
6.3.73	Well completion: Should we perforate for selective perforating?	39
6.3.74	Well completion: Should we perforate for selective perforating?	39
6.3.75	Well completion: Should we perforate for selective perforating?	39
6.3.76	Well completion: Should we perforate for selective perforating?	39
6.3.77	Well completion: Should we perforate for selective perforating?	39
6.3.78	Well completion: Should we perforate for selective perforating?	39
6.3.79	Well completion: Should we perforate for selective perforating?	39
6.3.80	Well completion: Should we perforate for selective perforating?	39
6.3.81	Well completion: Should we perforate for selective perforating?	39
6.3.82	Well completion: Should we perforate for selective perforating?	39
6.3.83	Well completion: Should we perforate for selective perforating?	39
6.3.84	Well completion: Should we perforate for selective perforating?	39
6.3.85	Well completion: Should we perforate for selective perforating?	39
6.3.86	Well completion: Should we perforate for selective perforating?	39
6.3.87	Well completion: Should we perforate for selective perforating?	39
6.3.88	Well completion: Should we perforate for selective perforating?	39
6.3.89	Well completion: Should we perforate for selective perforating?	39
6.3.90	Well completion: Should we perforate for selective perforating?	39
6.3.91	Well completion: Should we perforate for selective perforating?	39
6.3.92	Well completion: Should we perforate for selective perforating?	39
6.3.93	Well completion: Should we perforate for selective perforating?	39
6.3.94	Well completion: Should we perforate for selective perforating?	39
6.3.95	Well completion: Should we perforate for selective perforating?	39
6.3.96	Well completion: Should we perforate for selective perforating?	39
6.3.97	Well completion: Should we perforate for selective perforating?	39
6.3.98	Well completion: Should we perforate for selective perforating?	39
6.3.99	Well completion: Should we perforate for selective perforating?	39
6.3.100	Well completion: Should we perforate for selective perforating?	39
6.4	Well completion: Should we perforate for selective perforating?	40
6.4.1	Well completion: Should we perforate for selective perforating?	40
6.4.2	Well completion: Should we perforate for selective perforating?	40
6.4.3	Well completion: Should we perforate for selective perforating?	40
6.4.4	Well completion: Should we perforate for selective perforating?	40
7	RESPONSE TO OBSERVED EXCESSIVE SAND PRODUCTION	41
7.1	Decision Trees: Short, Medium and Long term operational responses	42
8	REMEDIAL COMPLETION OPTIONS FOR CASED AND PERFORATED COMPLETIONS	46

Lunskoye Sand Management Plan

The \$22 Billion Question?

Did it work?



LUN-A Start Up Configuration



Lunskoye Clean Up, Dec 2008

Bean Up Summary

- No incidents or accidents
- Each well delivers:
 - 350 MMscf/d or 10 Mln.m³/d gas
 - Practically no sand seen (half a cup)
- Lunskeye gas wells are:
 - Russia's largest gas wells
 - Largest offshore gas wells in the world

Conclusions

- Pre-Drilled Liner produced too much sand
- New Sand Failure Prediction Tool predicts onset of sand & quantifies volumes
- Preferred new completion design is Cased and Selectively Perforated
 - Defer sand production to 2025+
 - Sand levels lower and more manageable
- Quantitative Risk Assessment to address risk
- Lunskeye Sand Management Plan to manage risk

Final Words

- Cased & Selectively Perforated Wells deliver World Class Performance
 - Maximise gas production
 - Minimise sand production



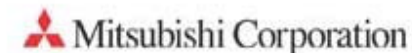
Acknowledgements

To those that did the work...

- David Brown, Jeroen Webers, Christoph Zerbst (Sakhalin Energy), Philippe Brassart, Hamed Subhi & Tony Addis (Shell)

And to those that paid for it....the Shareholders

- Gazprom
- Shell
- Mitsui
- Mitsubishi



Questions?



References

- SPE 116713: Sand Quantification: The Impact on Sandface Completion Selection and Design, Facilities Design and Risk Evaluation
- SPE 112099: Applying Sand Management Process on the Lunskeye High Gas-Rate Platform Using Quantitative Risk Assessment
- SPE 114805: The Integrated Use of New Technology in the Development of the Sakhalin II Project