

REPORT TITLE

White Rose Field Development
SeaRose Metering
For
140,000 bbls/d Case

SUBMITTED TO

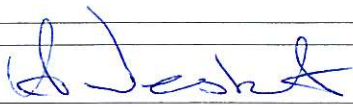
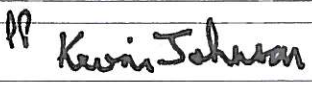
Huntley Nesbit
Husky Energy
235 Water Street, Suite 901
St. John's, NL
A1C 1B6

SUBMITTED BY

Gordon Maxwell
SGS Canada Inc.
215 Water Street, Suite 803
St. John's, NL
A1C 1B6

COMMENTS IF APPLICABLE

Comment – SGS Document Number: WR-702-13-REP-0007-001 Rev 1.

Signature:			
Full Name and Title:	Huntley Nesbit, Study Team Leader	Chris Laing, Field Development Manager	
	Prepared or Reviewed By	Accepted or Approved By	Acceptance or Approval Date

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Husky Energy - White Rose

**Sea Rose Debottlenecking
Study**

WR-702-13-REP-0007-001



Husky Energy - White Rose

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Document Number: WR-702-13-REP-0007-001

Revision Control

Any changes to this document will be issued using the following revisions, which will be identified as follows:

- Rev 0 - Provisional issue for comment
- Rev 1 - Official issue
- Rev 2 to n - Future revisions as necessary

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SGS Canada Inc.
PO Box 5, Atlantic Place, Suite 803, 215 Water Street, St. John's NL, A1C 6C9
Tel: (709) 739-7797 Fax: (709) 739-7798



White Rose

Sea Rose Debottlenecking Study

for

Husky Energy

SGS Canada Inc
PO Box 5
Atlantic Place
Suite 803
215 Water Street
St John's, NL
Canada, A1C 6C9

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1 Executive Summary

SGS Canada Inc. has reviewed the existing Sea Rose FPSO metering systems and deemed that the majority of measurement points can operate satisfactorily within the required measurement and allocation uncertainty in a 140,000 bbls/day facility mean daily production rate (FMDPR) capacity.

In the process of this study, several areas have been highlighted and SGS have included recommendations to ensure that the current flow systems application document fully represents the currently in use White Rose fiscal and allocation metering system and is in full compliance with the C-NLOPB Guidelines/statutory regulations. The main recommendations are summarized below:

- Raise TQ for currently over-sized LP fuel gas orifice flow meter. SGS recommend re-sizing of orifice plate and revision of ICSS flow meter constants/range, and upgrade meter installation during next opportune fuel gas system shutdown.
- Investigate fiscal sampling system low fast loop flow issue and resolve. Note that TQ 0785 is already in the Husky system and ranked at 62.
- Update FSA to reflect use of drill centre ultrasonic meters for allocation purposes.
- Update FSA to reflect upgrade of test separator gas meter from junior to senior orifice carrier and flow transmitter upgrade/re-ranging.
- Investigate flow reading spiking issue with LP flare meter and resolve.
- Investigate 15% over-measurement error with water injection V-cone meters and resolve.
- Investigate Flowatcher over-measurement error and resolve.

Table 1 Tier 1 Measurement Point Summary

Station	✓ / ✗	Comment	Status
Fiscal	✓	No change	Sample loop flow too low
Storage	✓	No change	Good. Confirm line pressure above vapour pressure.
Test Oil	✓	No change to individual well rates	Good
Test Gas	✓	No change to individual well rates	Good
Test Water	✓	No change to individual well rates	Not tested (no water breakthrough)
Water O/B	✓	No change to individual well rates	Not tested (no water breakthrough)
HP Fuel	✓	No change	Good
LP Fuel	✓	No change	Plate oversized, negligible impact on allocation
HP Flare	✓	No change	Good
LP Flare	✓	No change	Meter spiking, suspect cabling.
Production Wells (IDUN)	✓	No change to individual well rates	Good
Water Injection Wells	✓	No change to individual well rates	Tuning vs topsides ongoing
Gas injection	✓	No change	Good
Gas injection wells	✓	No change	Tuning vs topsides ongoing action
Water injection	✓	No change	Good, but FSA requires update to reflect use of drill centre meters
LP Flare	✓	No change	Good
Seawater to process	✓	No change	Good
Lift gas	✓	No change	No increase above design proposed. Still to be commissioned.

2 Acronyms

AOPR	Annualised Output Production Rate
CCO	Chief Conservation Officer (within the C-NLOPB)
C-NLOPB	Canada-Newfoundland Offshore Petroleum Board
DPA	Development Plan Amendment
FPSO	Floating Production, Storage and Offload
FSA	Flow and allocation Systems Application
FMDPR	Facility Mean Daily Production Rate
GVF	Gas Volume Fraction
PFD	Process Flow Diagram
WC	Water Cut

3 Introduction

Husky is in the process of preparing an Amendment to the White Rose Development Plan as approved in the 2001 Decision Report. This Development Plan Amendment (DPA) will be filed pursuant to increasing facility daily oil production limits from 100,000 bbls/day to 140,000 bbls/day (corresponding to an annual rate (AOPR) of 125,000 bbls/day).

As part of Husky's due diligence assurance was sought that the existing flow metering is adequate for this increased throughput and that compliance will be maintained with all relevant regulations related to such systems.

Separate studies have been completed to provide due diligence in terms of reservoir performance and facility capabilities. This check of the metering systems complements these other studies.



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WR-702-13-REP-0007-001	1	14 Sep 06

4 Scope of Work

The focus was upon seeking assurance that the existing metering systems are adequate for a daily oil production (FMDPR) of 140,000 bbls/day (AORP – 125,000 bbls/day). SGS have carried out a study to determine the impact of increased production/flow rates on the existing metering systems. The study examined three main areas as defined below:

- Assure the system as designed and installed is adequate and remains within acceptable accuracy tolerance limits
- Evaluate the impact, if any, on the existing White Rose 'Flow Systems Application'
- Review the systems maintenance status in terms of compliance with design intent

5 Production Data

Table 2 shows the peak production, injection and lift gas rates in sm^3/d and relative increase between the 100 and 140 mbd production scenario.

Table 2 Station Flowrates (Sm^3/d)

Station	100 mbd	140 mbd	Increase %	Design (Flow Meter)
Oil, well	4,200	4,300	2	N/A
Oil, total	16,000	23,000	44	50880
Water production, well	4,500	4,500	0	N/A
Water production, total	23,000	23,000	0	N/A
Gas lift, well	4,500	4,500	0	N/A
Gas lift, total	1,200,000	1,200,000	0	1,200,000
Gas production, well	1,100,000	1,100,000	0	N/A
Gas production, total	3,300,000	4,000,000	22	5,000,000
Water Injection, central	16,400	19,000	16	73,200
Water injection, southern	16,000	16,000	0	N/A
HP Flare	4,296,000	4,296,000	0	N/A
LP Flare	360,000	360,000	0	N/A
HP Fuel	543,360	543,360	0	N/A
LP Fuel	108,000	108,000	0	N/A
Gas lift, total	1,200,000	1,200,000	0	1,200,000

6 Tier 1 Meters

Tier 1 meters are defined to be those that are used for reservoir material balance and were included in the White Rose Flow Systems Application.

6.1 Fiscal Metering Package

The fiscal metering package would be unaffected by any increase in production as the flow rates are determined by the export pump capacity. It is worth noting that the current performance of the fast loop pump 34-P-1440 is well below the original design flow rate of 6 m³/hr (actual indicated flow is in the region of 1.2 m³/hr). Although the fast loop sample probe is located on a vertical section downstream of a dedicated static flow mixer to ensure sample representivity at low watercut values, it is recommended that the low fast loop flow issue be resolved for pump minimum flow protection and improved sample representivity.

6.2 Oil in Storage

The performance of the storage tank wet volume measurement using the Saab radar gauges would be unaffected by any increase in production rates as these measure static volumes only.

6.3 Oil to Tanks (Rundown Meter)

Tag No	33-FE-1406
Type	Panametrics XMT 868 Clamp-on Ultrasonic Meter (USM)
Line Size	0.25 m: 10 inch
Meter capacity	12 m/s: 2120 m ³ /h: 320,000 bbls/d
Max Process Flowrate	5.2 m/s: 927 m ³ /h: 140,000 bbls/d
Pressure Drop	The pressure head from the separator to meter remains greater than the frictional losses hence no gas breakout expected.
Meter Status	Fully operational
Summary	At the increased rates the meter will be operating at 43% fullscale and is within the unit's optimum range.
Pass / Fail (✓/✗)	✓

6.4 Test Sep Gas

Tag No	33-FE-1166
Type	FMC Senior Orifice Fitting
Line Size	0.25 m: 10 inch
Meter capacity	20 kSm ³ /h (0.48 MSm ³ /d) with 0.38 Beta plate installed
Max Process Flowrate	17.6 m/s: 75 kSm ³ /h (1.8 MSm ³ /d): 63.56 mmscf/d
Pressure Drop	62.5 kPa @ 20 kSm ³ /h (0.48 MSm ³ /d)
Meter Status	Fully operational
Summary	Largest predicted gas flow based on subsea team data is well B07-05 @ 1.12 MSm ³ /d circa. Dec 2008. Current installed orifice plate has a beta ratio of 0.38. Maximum differential pressure for this orifice plate sizing is estimated at 1329 mBarD based on Orifice Plate Buckling: ISO TR12767:1998, which equates to approx. 44.4 kSm ³ /h (1.07 MSm ³ /d). However, for the same time period there is a large variance in projected well test flow rates with the lowest expected to be well B07-02 @ 0.309 MSm ³ /d. SGS recommend performing orifice plate and buckling calculations to encompass complete well test gas flow rate scenarios in order to determine optimum orifice plate sizings to ensure meter uncertainty remains within regulatory limits.
Pass / Fail (✓/✗)	✓

6.5 Test Sep Crude

Tag No	33-FE-1183A/B
Type	E & H Coriolis Meter
Line Size	0.15 m: 6 inch
Meter capacity	Capacity: 800,000 kg/h x 2 = 1,600,000 kg/h 1950 m ³ /h (@ 820 kg/m ³) 295,000 bbls/d (@ 820 kg/m ³) Calibration range: 130,000 kg/h x 2 = 260,000 kg/h 634 m ³ /h @ 820 kg/m ³ 48,000 bbls/d
Max Process Flowrate	264 m ³ /h: 40,000 bbls/d
Pressure Drop	The pressure head from the separator to meter remains

	greater than the frictional losses hence no gas breakout expected.
Meter Status	Operational
Summary	It is not expected that individual wells will produce more than 40,000 bbls/d dry crude. The meter performance is very linear and can be re-ranged if required.
Pass / Fail (✓/✗)	✓

6.6 Test Sep Water

Tag No	42-FE-1180
Type	E & H Coriolis Meter
Line Size	0.15 m: 6 inch
Meter capacity	Capacity 800,000 kg/h 825 m ³ /h (@ 970 kg/m ³) 125,000 bbls/d (@ 970 kg/m ³) Calibration range 130,000 kg/h 134 m ³ /h (@ 970 kg/m ³) 21,000 bbls/d (@ 970 kg/m ³)
Max Process Flowrate	183.5 m ³ /h 27,707 bbls/d
Pressure Drop	N/A
Meter Status	Fully operational
Summary	The <u>total</u> field produced water is expected to remain less than 100,000 bbls/d hence the meter is capable of handling any increased throughput.
Pass / Fail (✓/✗)	✓

6.7 Produced Water Degasser (Water Overboard)

Tag No	42-FE-2149
Type	Panametrics XMT 868 Clamp-on Ultrasonic Meter (USM)
Line Size	0.4 m (16 inch)
Meter capacity	12 m/s, 7,600 m ³ /h (1,141,223 bbls/d)
Max Process Flowrate	663 m ³ /h (100,000 bbls/d)
Pressure Drop	N/A
Pass / Fail	Pass
Meter Status	Not operational, no produced water yet
Summary	Increasing the production rates will not change the peak water production from 100,000 bbls/day which is well within the meter capacity (9% fullscale) leaving substantial spare capacity should this be required.
Pass / Fail (✓/✗)	✓

6.8 Gas Injection

Tag No	36-FE-1950
Type	Panametrics XMT 868 Clamp-on Ultrasonic Meter (USM)
Line Size	0.2 m: 8 inch
Meter capacity	30 m/s: 1,073 ksm ³ /h: 910 mmscf/d @ 362 bara / 70 °C
Max Process Flowrate	5.9 m/s: 212 ksm ³ /h: 180 mmscf/d
Pressure Drop	Increase flow would cause greater pressure drop across fixtures and fittings with ultrasonic noise potential.
Meter Status	Fully operational
Summary	<p>It is not intended to increase the rates of gas production from the field which is limited by the capability of the gas processing plant. The total gas production rates will be maintained within this level by optimising production from low/high GOR wells.</p> <p>Meter capacity is a function of line pressure – increasing line pressure by 20% will increase meter capacity by 20%.</p> <p>The meter is operating at 20% capacity at full injection rates hence will maintain its uncertainty over substantial increases/decreases in flowrate.</p>
Pass / Fail (✓/✗)	✓

6.9 HP Flare

Tag No	48-FE-3024
Type	Roxar RFM Flare Gas Meter
Line Size	0.25 m: 10 inch
Meter capacity	100 m/s: 288 ksm ³ /h: 244 mmscf/d @ 6 bara / 70 °C
Max Process Flowrate	62 m/s: 179 ksm ³ /h: 152 mmscf/d
Pressure Drop	N/A
Meter Status	Fully operational
Summary	<p>It is not intended to increase the rates of gas production from the field which is limited by the capability of the gas processing plant.</p> <p>The total gas production rates will be maintained within this level by optimising production from low/high GOR wells.</p> <p>There will be no change to the process rates to the flare package.</p>
Pass / Fail (✓/✗)	✓

6.10 LP Flare

Tag No	48-FE-3054
Type	Roxar RFM Flare Gas Meter
Line Size	0.45 m: 18 inch
Meter capacity	100 m/s: 92 ksm ³ /h: 78 mmscf/d @ 2 bara / 85 °C
Max Process Flowrate	17 m/s: 15 ksm ³ /h: 13 mmscf/d
Pressure Drop	N/A
Meter Status	Fully operational
Summary	<p>It is not intended to increase the rates of gas production from the field which is limited by the capability of the gas processing plant.</p> <p>The total gas production rates will be maintained within this level by optimising production from low/high GOR wells.</p> <p>There will be no change to the process rates to the flare package.</p>
Pass / Fail (✓/✗)	✓

6.11 HP Fuel

Tag No	43-FE-2246
Type	Daniel Orifice Plate
Line Size	0.1 m: 4 inch
Meter capacity	34.0 ksm ³ /h: 28.8 mmscf/d @ 163.5 kPad
Max Process Flowrate	22.64 ksm ³ /h: 19.2 mmscf/d
Pressure Drop	N/A
Meter Status	The meter is currently considered to be slightly oversized as the HP Fuel Gas KO Drum is sized to provide a combined gas flow of 24,000 kg/h (27,304 Sm ³ /h) to the Main Power Generator gas turbines, compressor seals and the low pressure fuel gas users. Approx. 20,000 kg/h (22,754 Sm ³ /h) of this capacity is allocated to the HP fuel gas users.
Summary	It is not expected that there will be a substantial increase in gas rates to the HP Fuel package. Correspondence with Hari Neth, principal process consultant with Excel Consultants, confirmed that during 2006 performance testing the actual HP Fuel Gas flow during steady oil flow of 125,000 bpd was 11,000 Sm ³ /h, and is estimated to increase to 16,500 Sm ³ /h @ 140,000 bpd. At the increased rates the meter will be operating at 48% fullscale and is within the unit's optimum range.
Pass / Fail (✓/✗)	✓

6.12 LP Fuel

Tag No	43-FE-2291
Type	Daniel Orifice Plate
Line Size	0.1 m: 4 inch
Meter capacity	4.5 ksm ³ /h: 3.8 mmscf/d @ 25 kPad
Max Process Flowrate	4.5 ksm ³ /h: 3.8 mmscf/d
Pressure Drop	N/A
Meter Status	The meter is currently considered to be oversized for the normal process flowrates 400 Sm ³ /h.
Summary	<p>It is not expected that there will be a substantial increase in gas rates from the LP Fuel package. Correspondence with Hari Neth, principal process consultant with Excel Consultants, confirmed that during 2006 performance testing the maximum expected LP fuel gas demand was approx. 740 Sm³/h</p> <p>It is recommended that the orifice plate 43-FE-2291 be re-</p>

	sized by reducing the orifice plate diameter to the minimum ISO 5167 0.3 β ratio (29.154mm). This will re-range the flow meter to 870 Sm ³ /hr. This equates to a DP of 49.8 mbar @ 400 Sm ³ /hr which is well within the DP transmitter's range. It is worth noting that this orifice plate can only be changed out during an LP fuel gas system outage as it is a flanged orifice plate.
Pass / Fail (✓/✗)	✓

6.13 Injection Water to Southern Drill Centre

Tag No	44-FT-9011
Type	Panametrics XMT 868 Clamp-on Ultrasonic Meter (USM)
Line Size	0.3 m: 12 inch
Meter capacity	12 m/s: 3050 m ³ /h: 461,000 bbls/d
Max Process Flowrate	2.7 m/s: 691 m ³ /h: 104,360 bbls/d
Pressure Drop	Increase flow would cause greater pressure drop across fixtures and fittings with ultrasonic noise potential.
Meter Status	Fully operational
Summary	It is worth noting that this meter is currently in use as the primary allocation meter for the Southern drill centre metering application due to the originally-designated water injection pump v-cone meters installation performance being deemed out with acceptable uncertainty limits due to installation effects/design. At the increased rates the meter will still only be operating at 23% fullscale and is within the unit's optimum range, based on a peak predicted drill centre injection rate circa. Dec 2008 from current Husky subsurface team GG200 model.
Pass / Fail (✓/✗)	✓

6.14 Injection Water to Central Drill Centre

Tag No	44-FT-9021
Type	Panametrics XMT 868 Clamp-on Ultrasonic Meter (USM)
Line Size	0.3 m: 12 inch
Meter capacity	12 m/s: 3050 m ³ /h: 461,000 bbls/d
Max Process Flowrate	3.1 m/s: 784 m ³ /h: 118,387 bbls/d
Pressure Drop	Increase flow would cause greater pressure drop across fixtures and fittings with ultrasonic noise potential.
Meter Status	Fully operational
Summary	It is worth noting that this meter is currently in use as the primary allocation meter for the Central drill centre metering application due to the originally-designated water injection pump v-cone meters installation performance being deemed out with acceptable uncertainty limits due to installation effects/design. At the increased rates the meter will still only be operating at 26% fullscale and is within the unit's optimum range, based on a peak predicted drill centre injection rate circa. Dec 2007 from current Husky subsurface team GG200 model.
Pass / Fail (✓/✗)	✓

6.15 Gas Lift to Southern Drill Centre

Tag No	37-FT-9011
Type	Daniel Senior Orifice Carrier M-0148C
Line Size	0.1 m: 4 inch
Meter capacity	1200000 Sm ³ /d with 0.66 beta ratio plate installed
Max Process Flowrate	1190000 Sm ³ /d per glory hole, 1600000 Sm ³ /d total lift gas
Pressure Drop	N/A
Meter Status	Not commissioned, estimated not online until June 2009
Summary	Unit not commissioned, SBM data sheet states that carrier was supplied with 3 different orifice plate sizes; the largest plate range is stated as the meter capacity. Note that the flow transmitter data sheet specifies a square root extraction output; this is not required as Siemens PCS mode 5 has a linear differential pressure signal input. Recommend changing 37-FIT-9011/21 analogue output signal to linear during commissioning. Preliminary data from subsea team indicates maximum total lift gas rate of 1150000 Sm ³ /d circa. April 2019, this is within the current largest orifice plate range per drill centre.
Pass / Fail (✓/✗)	✓

6.16 Gas Lift to Central Drill Centre

Tag No	37-FT-9021
Type	Daniel Senior Orifice Carrier M-0148C
Line Size	0.1 m: 4 inch
Meter capacity	1200000 Sm ³ /d with 0.66 beta ratio plate installed
Max Process Flowrate	1190000 Sm ³ /d per glory hole, 1600000 Sm ³ /d total lift gas
Pressure Drop	N/A
Meter Status	Not commissioned, estimated not online until June 2009
Summary	Unit not commissioned, SBM data sheet states that carrier was supplied with 3 different orifice plate sizes; the largest plate range is stated as the meter capacity. Note that the flow transmitter data sheet specifies a square root extraction output; this is not required as Siemens PCS mode 5 has a linear differential pressure signal input. Recommend changing 37-FIT-9011/21 analogue output signal to linear during commissioning. Preliminary data from subsea team indicates maximum total lift gas rate of 1150000 Sm ³ /d circa. April 2019, this is within the current largest orifice plate range per drill centre.
Pass / Fail (✓/✗)	✓

6.17 Water Injection to MP Crude Heater (Seawater to Process)

Tag No	44-FT-1225
Type	Daniel Orifice Plate Model CAT520
Line Size	0.1 m: 4 inch
Meter capacity	35 m ³ /h with 0.569 beta ratio plate installed
Max Process Flowrate	35 m ³ /h
Pressure Drop	N/A
Meter Status	Not operational
Summary	Unit currently not operational, however the flow transmitter differential pressure transmitter is currently ranged 0-25 kPad, but the Rosemount 3051S has a CD2 range sensor which is capable of 62.3 kPad if re-ranging is required with the currently installed orifice plate.
Pass / Fail (✓/✗)	✓

7 Flow Systems Application Impact

With reference to the Flow Systems Application submitted to the C-NLOPB, Husky document reference WR-O-99-J-RP-00001-001 Rev E1, the following sections require to be revised to accurately reflect the current operating mode of the White Rose fiscal and allocation metering systems in conjunction with a 140,000 bbls/day operational regime:

Section 1.3.1.1 – Field Production - description requires revision

Section 1.4.1.5 – Main System Capacities - values requires revision

Section 2.4.9 – Water Injection V-cone Installation – this section requires replacement with a detailed installation description of the Central and Southern drill centre meters. This is due to the design failure of the v-cone meter installation/location for allocation purposes due to the downstream unallocated flow path to produced water overboard dump via the water injection pump minimum flow pump protection recycle valves. The drill centre meters have been used for allocation purposes since start-up and should be identified as the primary allocation meters in the FSA.

Section 2.5.5 – Rundown/Water Overboard - this section requires the additional of the drill centre water meters

Section 2.5.6 – this section requires deletion as it refers to the water injection pump v-cone meters

Section 2.5.6.1 – this section requires deletion as it refers to the water injection pump v-cone meters

Section 2.5.7.1 – this section requires amendment to reflect the change out of the junior-type FMC OrificeMaster to the senior-type FMC MeasureMaster orifice carrier.

Section 2.6.1 – this section requires updating to reflect the use of the drill centre ultrasonic meters for allocation purposes and the removal of references to the water injection pump v-cone meters and secondary instrumentation.

Section 2.6.2 – this section requires updating to reflect the upgrade of the test separator gas differential pressure transmitters from 3051S to 3051S Ultra for Flow.

Section 3.4.1.4 – this section requires clarification as it states that the lift gas DP transmitter output is square-rooted, however Siemens PCS function block mode 5 is designed for a linear DP input signal. It is recommended that 37-FIT-9011/21 analogue output signal be changed from square root to linear output during commissioning.

Tables 5 and 8 – these tables requires updating to reflect the use of the drill centre ultrasonic meters for allocation purposes and the removal of references to the water injection pump v-cone meters and secondary instrumentation.

Section 4.3.1.8 - this section requires updating to reflect the use of the drill centre ultrasonic meters for allocation purposes and the removal of references to the water injection pump v-cone meters and secondary instrumentation.

Section 5.3.7 - this section requires updating to reflect the use of the drill centre ultrasonic meters for allocation purposes and the removal of references to the water injection pump v-cone meters and secondary instrumentation.

Table 11 – this table requires updating to reflect the use of the drill centre ultrasonic meters for allocation purposes and the removal of references to the water injection pump v-cone meters and secondary instrumentation.

Section 6.4.5 - this section requires updating to reflect the removal of references to the water injection pump v-cone meters and secondary instrumentation for allocation purposes.

Appendices – All appendices require updating to reflect the upgrade of the test separator gas orifice carrier and flow transmitters, use of the drill centre ultrasonic meters for allocation purposes and the removal of references to the water injection pump v-cone meters and secondary instrumentation.

General comment – it may be worth considering revising all process stated parameters throughout the document to more closely reflect current/anticipated process parameters at 140,000 bbls/day operation.

8 Systems Maintenance Status

As no modifications are considered required to the existing Tier 1 metering systems, then no changes are considered required to the currently approved planned maintenance system schedule.

9 Supporting Data

Figure 1 Production Sensitivity Cases - South Avalon Pool Only

Fluids	Case 1 (Base Case)	Case 2	Case 3	Case 4	Case 5	Comments
Oil Flow Rate bbls/d [m ³ /d]	100,000 [15,900]	120,000 [19,080]		140,000 [22,260]		
Gas mmscf/d [sm ³ /d]	142 [4.01x10 ⁶]	150 [4.2x10 ⁶]	180 [5x10 ⁶]	150 [4.2x10 ⁶]	180 [5x10 ⁶]	<ul style="list-style-type: none"> Includes FG & Lift Gas Gas injection rate will reduce as head requirement increases
Lift Gas mmscf/d [sm ³ /d]	42 [1.6x10 ⁶]					<ul style="list-style-type: none"> Limit / glory hole of 1.19x10⁶ sm³/d
Water Injection bbls/d [m ³ /d]	189,000 each Glory Hole [30,000 / Glory Hole]					Total Limit of 44,000 m ³ /d
Produced Water Handling	176,400 bwpd [28,000 m ³ /d]					
Total Liquids	207,900 [33,000]					

Figure 2 Projected Well Oil Production 100 mbd

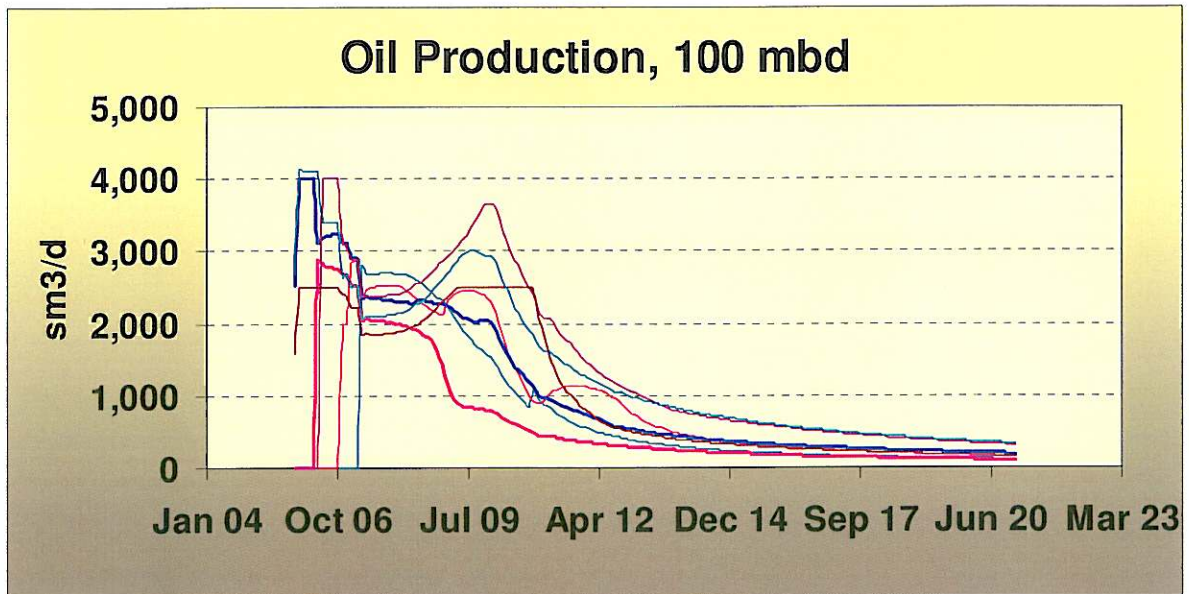


Figure 3 Projected Total Oil Production 100 mbd

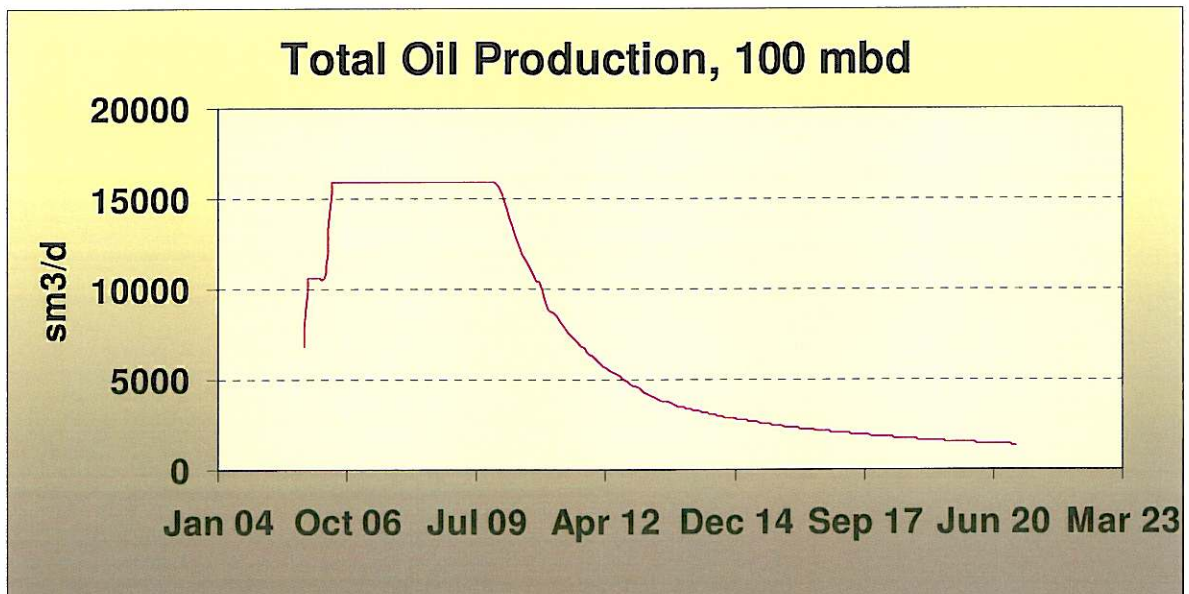


Figure 4 Projected Well Oil Production 140 mbd

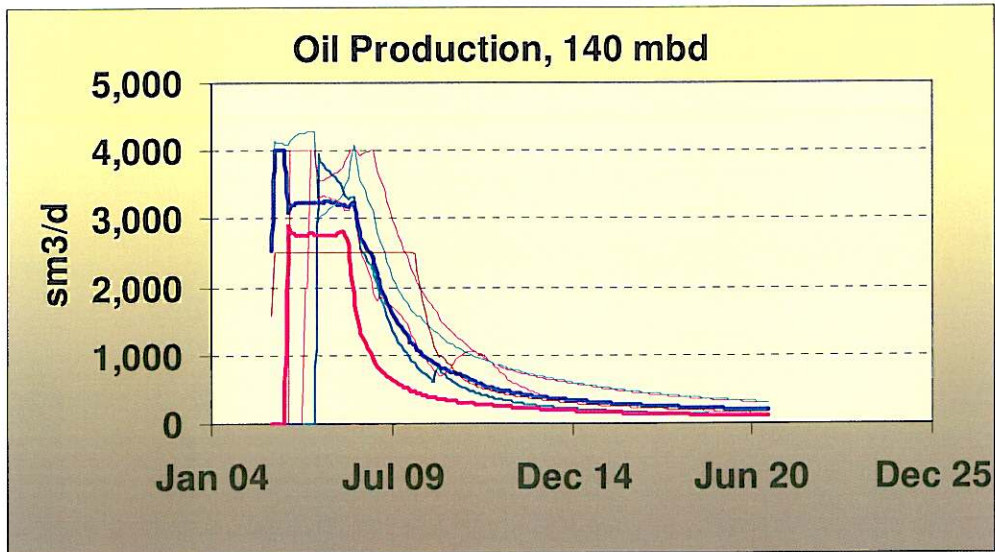


Figure 5 Projected Total Oil Production 140 mbd

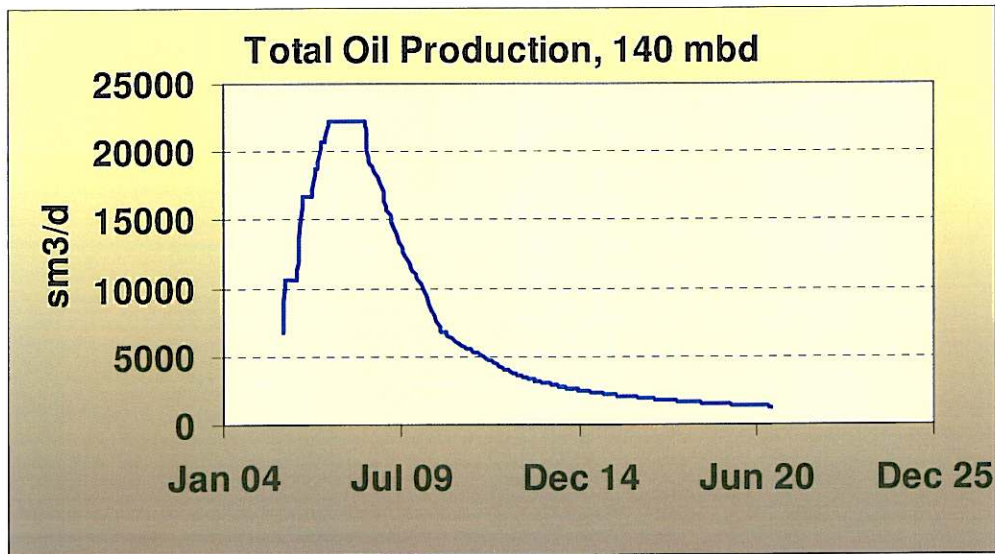


Figure 6 Projected Well Water Production 100 mbd

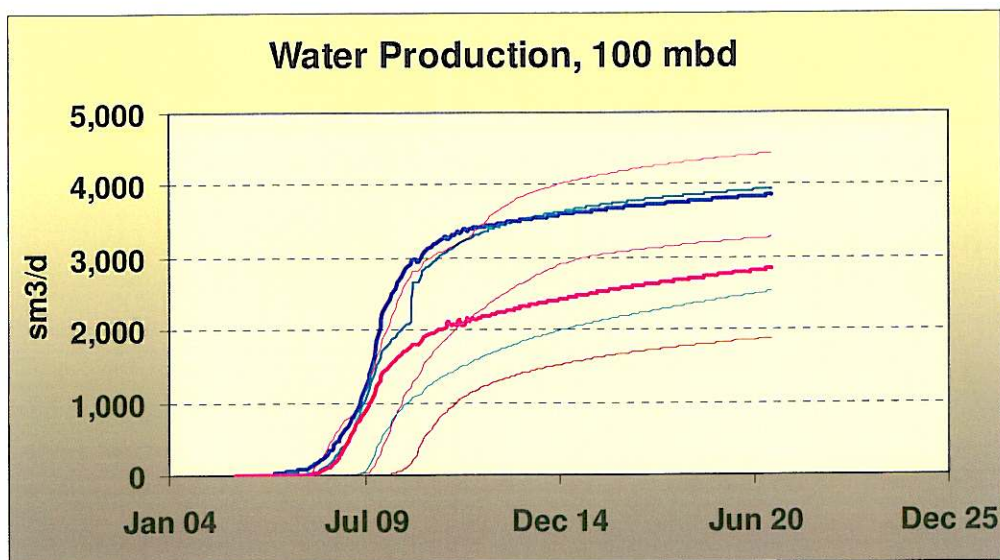


Figure 7 Projected Total Water Production 100 mbd

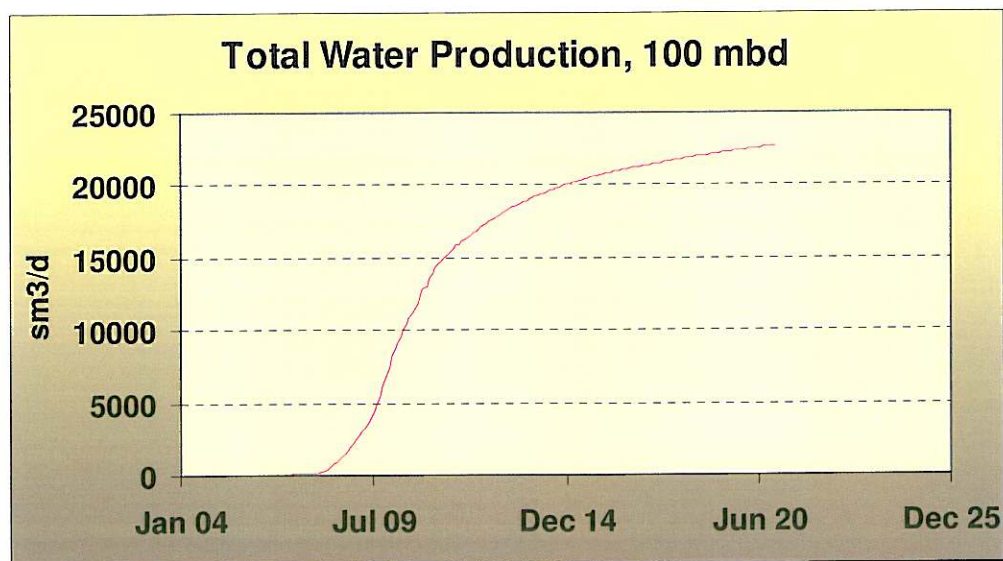


Figure 8 Projected Well Water Production 140 mbd

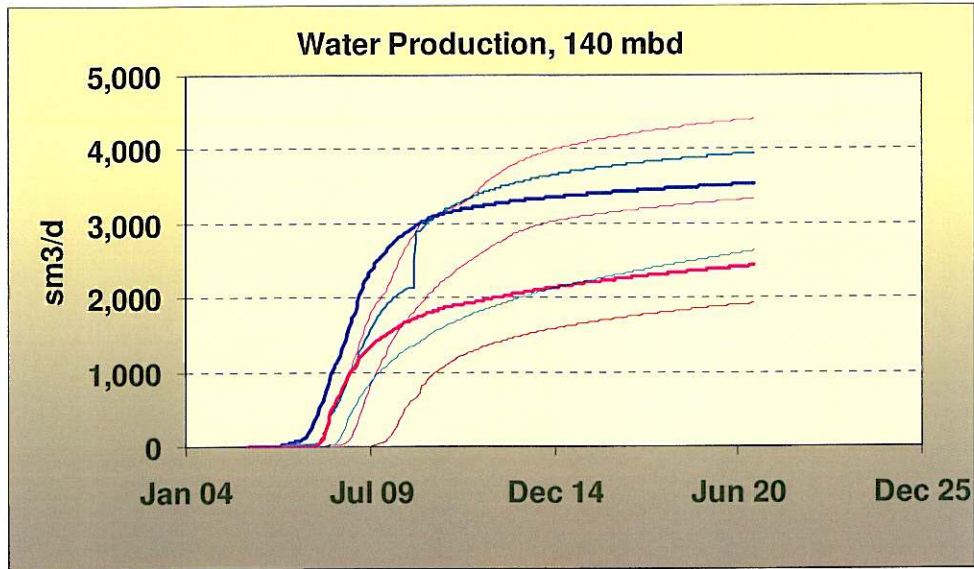


Figure 9 Projected Total Water Production 140 mbd

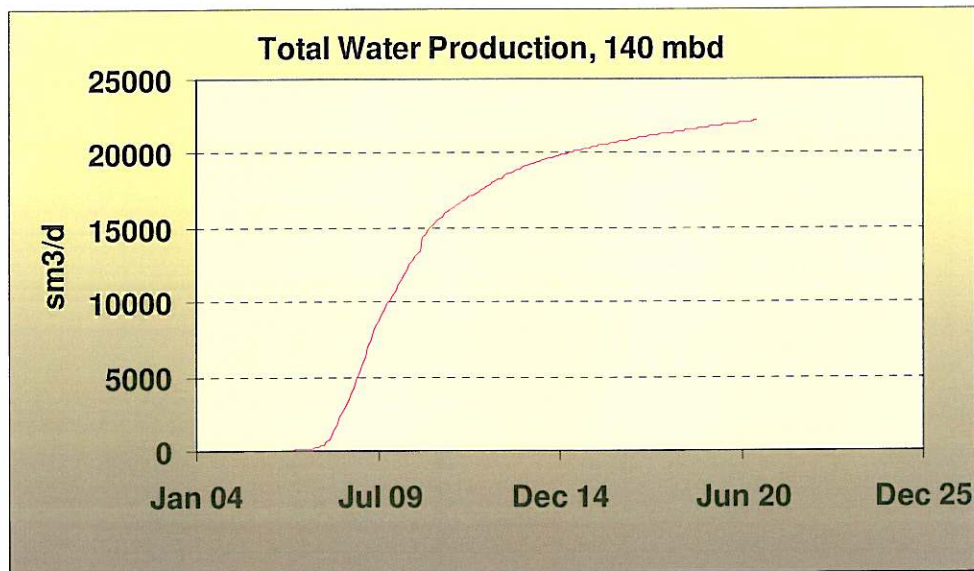


Figure 10 Anticipated Total Gas Lift 100-140 mbd

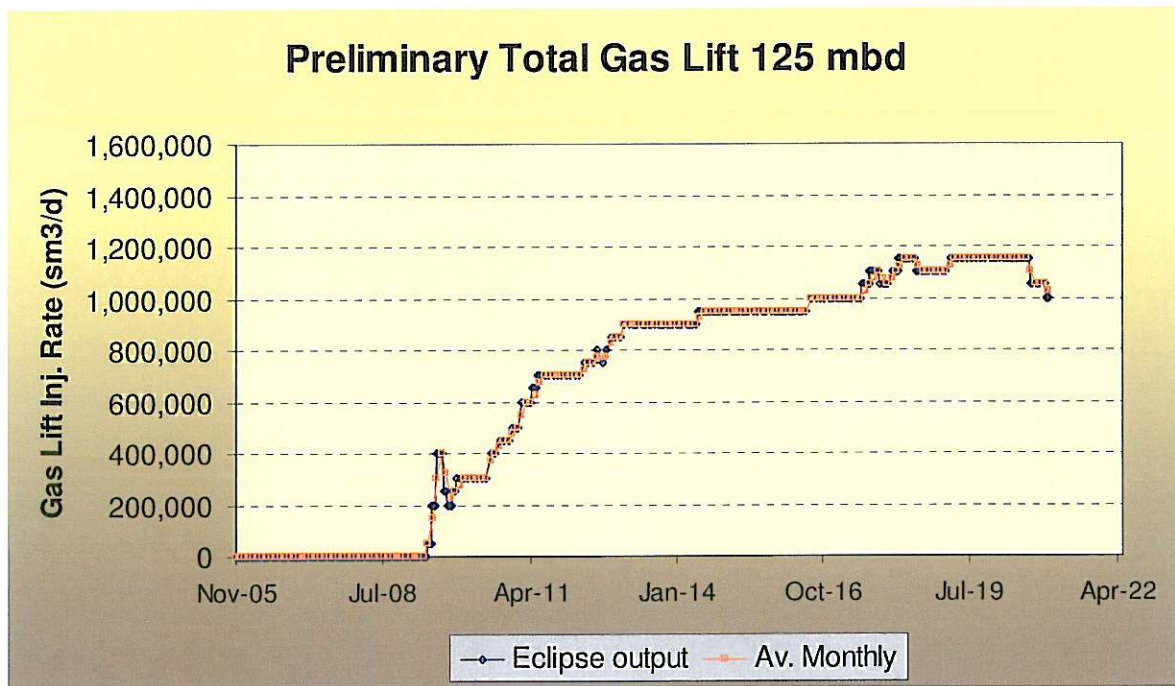


Figure 11 Projected Well Gas Production 100 mbd

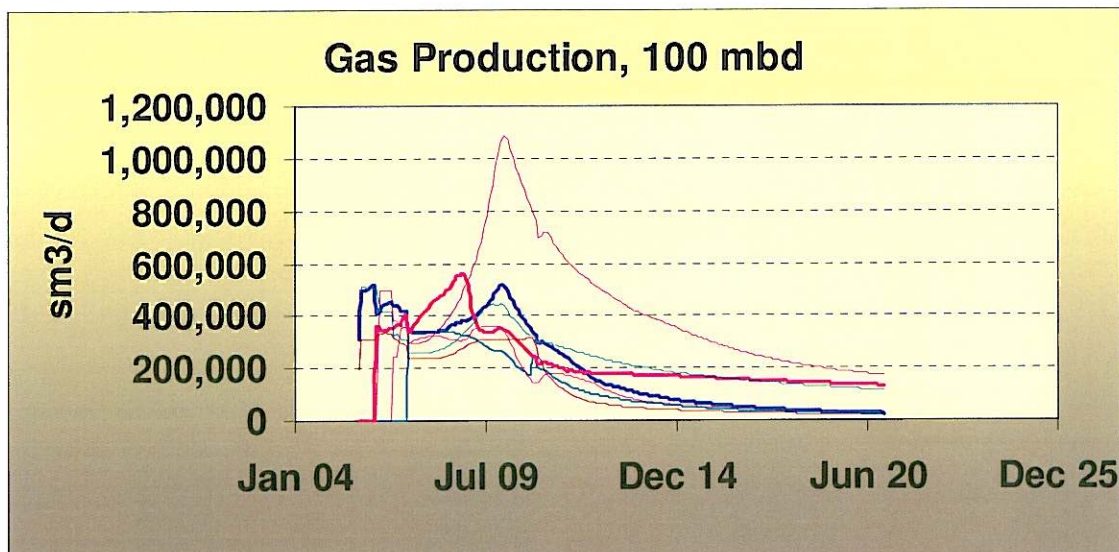


Figure 12 Projected Total Gas Production 100 mbd

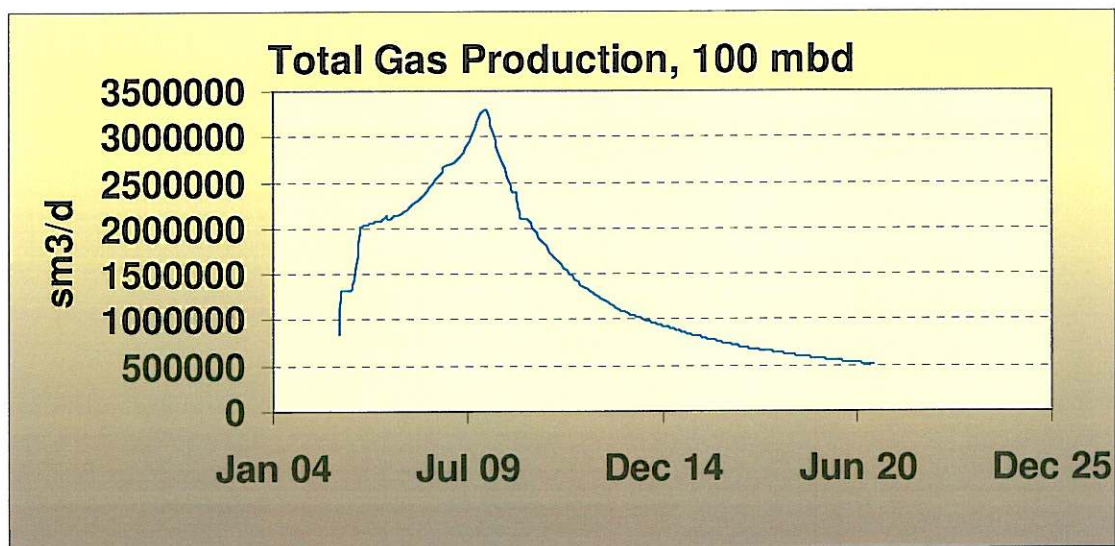


Figure 13 Projected Well Gas Production 140 mbd

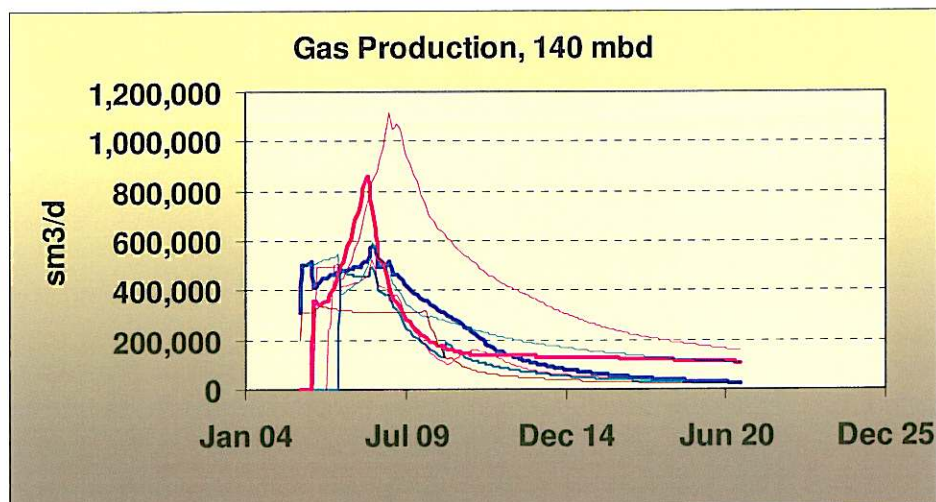


Figure 14 Projected Total Gas Production 140 mbd

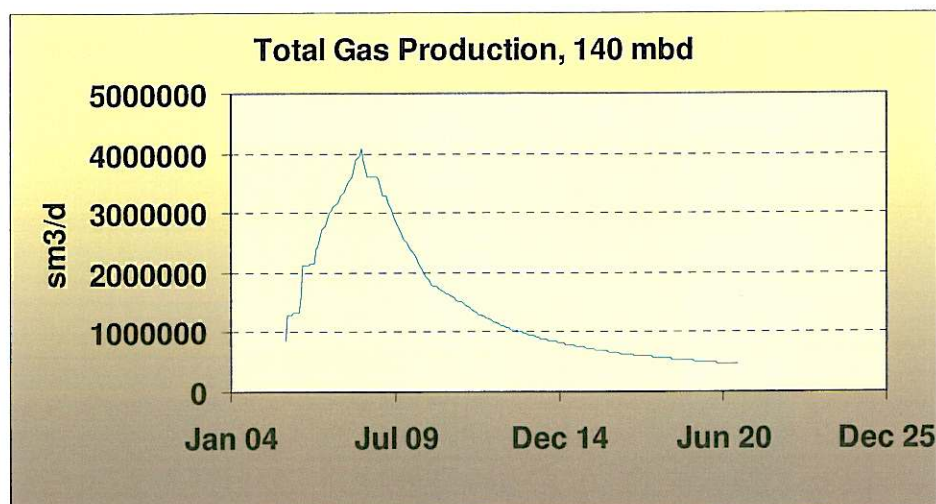


Figure 15 Projected Central Drill Centre Water Injection 100 mbd

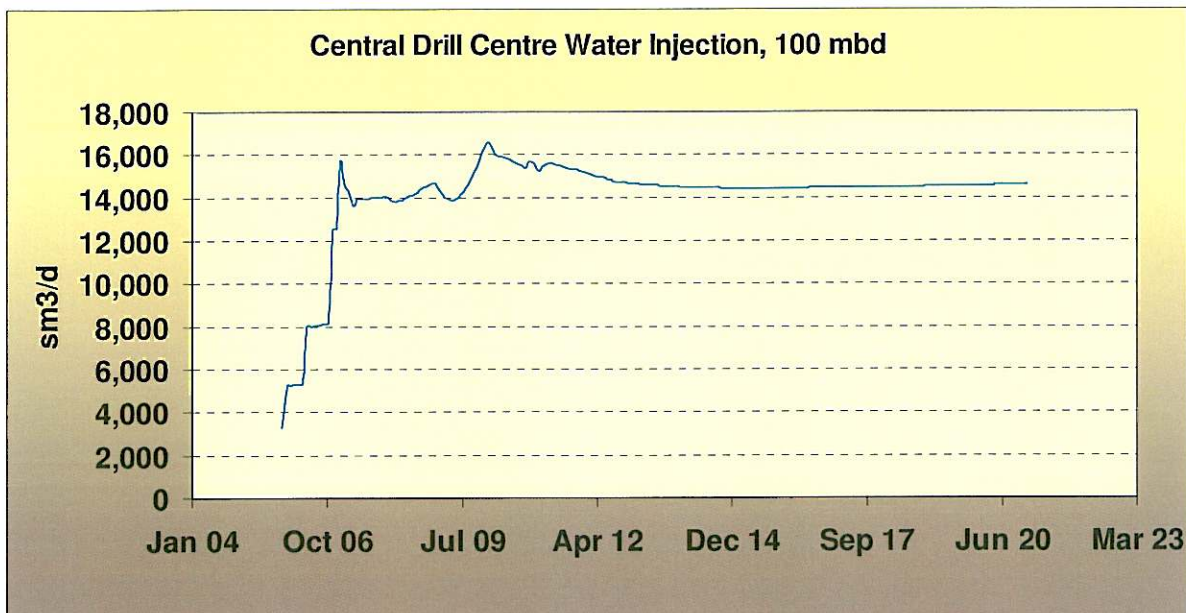


Figure 16 Projected Central Drill Centre Water Injection 140 mbd

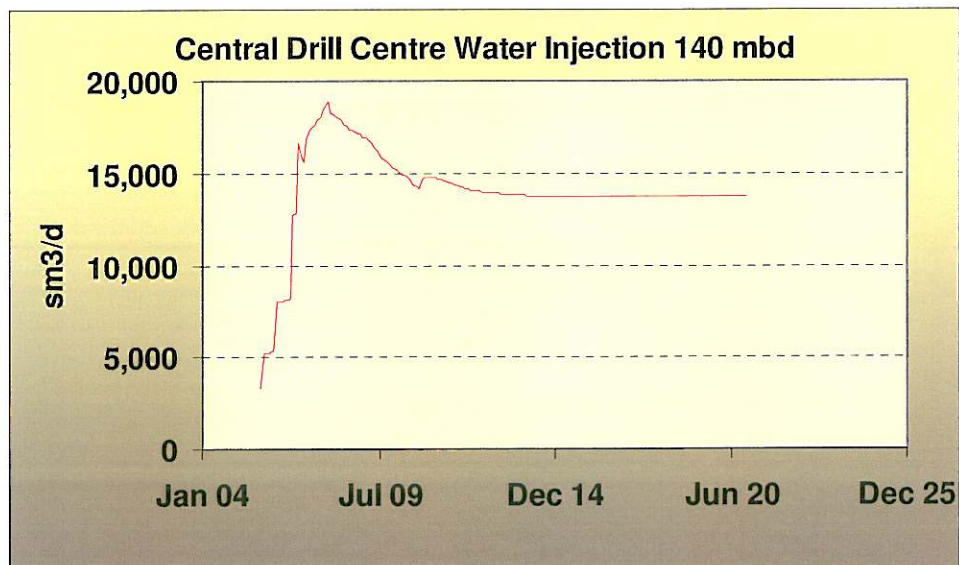


Figure 17 Projected Southern Drill Centre Water Injection 100 mbd

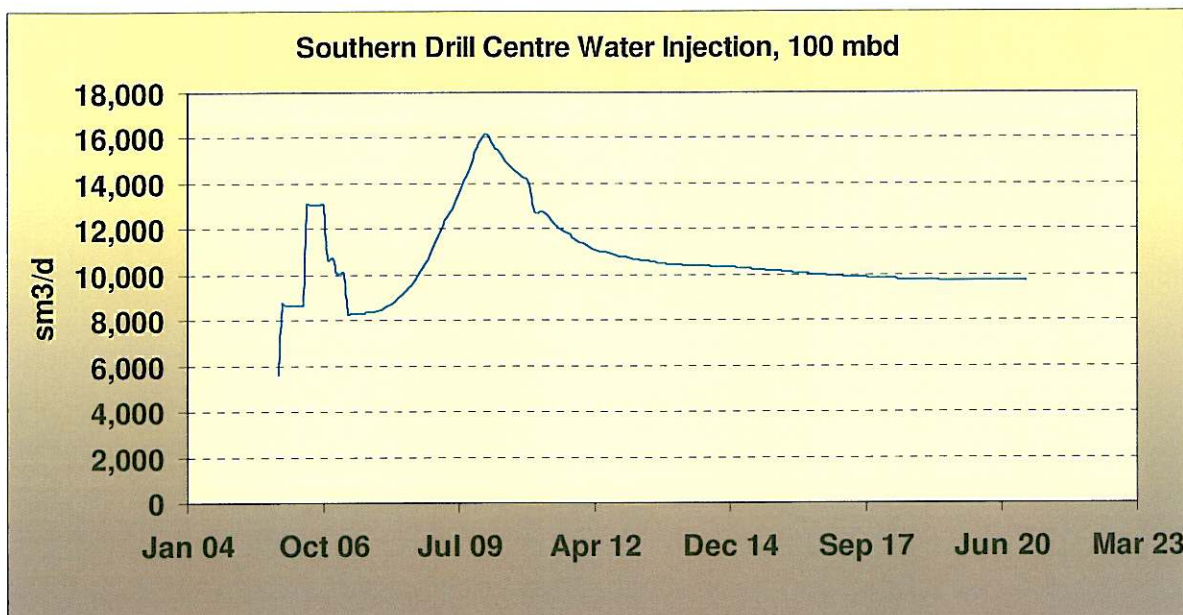
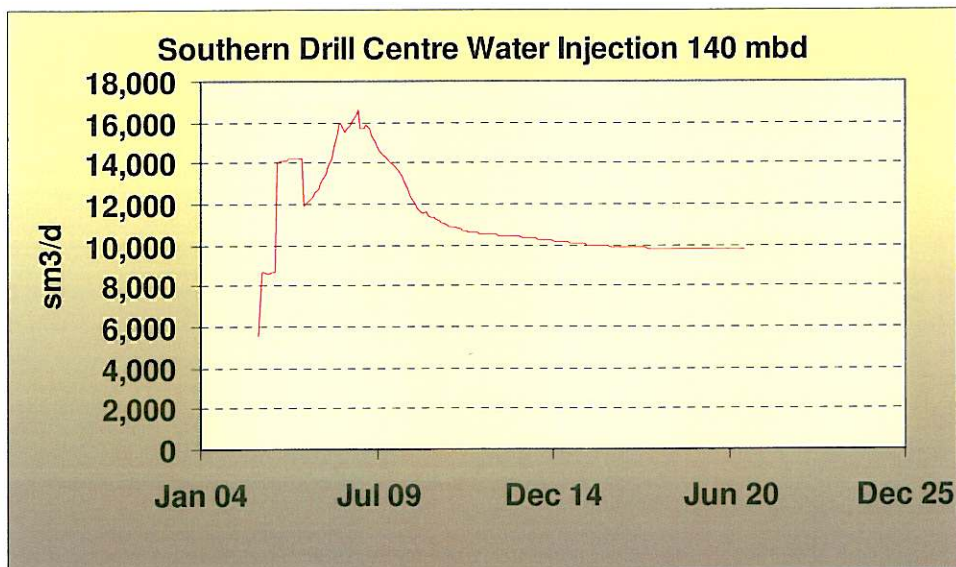


Figure 18 Projected Southern Drill Centre Water Injection 140 mbd



10 Tier 2 Meters

Tier 2 meters are defined to be those that are used for plant monitoring requirements and were not included in the White Rose Flow Systems Application, but were initially reviewed by SGS as part of the Siemens PCS meter constants calculation workscope.

Table 3 Tier 2 Measurement Point Summary

Station	✓ / ✗	Comment	Status
HP Separator Off Gas 33-FE-1108	✓	No change	No known issues *
Flowline Recirc Pump 33-FE-1207A	✓	No change	No known issues *
MP Separator Off Gas 33-FE-1255	✓	No change	No known issues *
LP Separator Off Gas 33-FE-1315	✓	No change	No known issues *
1 st Stage Flash Gas Compressor 35-FE-1558	✓	No change	No known issues *
2 st Stage Flash Gas Compressor 35-FE-1628	✓	No change	No known issues *
LP Compressor Feed 36-FE-1698A/B	✓	No change	No known issues *
IP Compressor Feed 36-FE-1848A/B	✓	No change	No known issues *
HP Compressor Feed 36-FE-1918A/B	✓	No change	No known issues *
MP Separator Produced Water 42-FE-1269A	✓	No change	No known issues *
LP Separator Produced Water 42-FE-1375A	✓	No change	No known issues *
Deaerator Chemical Injection Carrier 44-FE-2497	✓	No change	No known issues *
Water Injection Pump Discharge 44-FE-2541A/B/C	✗	No change	Reading approx. 15% high
Deaerator Oxygen Scavenger 45-FE-2498	✓	No change	No known issues *

Station	✓ / ✗	Comment	Status
Methanol to HP Fuel Gas Cooler 45-FE-2807	✓	No change	No known issues *
Methanol to Glycol Contactor Inlet Cooler 45-FE-2809	✓	No change	No known issues *
HP MeOH Injection Pump Manifold 45-FE-2825	✓	No change	No known issues *
HM Circulation Pump Minimum Flow 46-FE-2887	✓	No change	No known issues *
WHRU Heating Medium Outlet 46-FE-2915A/B/C	✓	No change	No known issues *
Cooling Medium Circulation Pump Discharge Manifold 47-FE-2979	✓	No change	No known issues *
Deaerator Feed 53-FE-2483	✓	No change	No known issues *
Vacuum Pump Seawater Supply 53-FE-2521A/B	✓	No change	No known issues *
Cooling Medium Coolers 53-FE-2951A	✓	No change	No known issues *
Water Inj Choke Valve Calculated Flow XWX-FI-0007	✓	No change	No known issues *
Gas Inj Choke Valve Calculated Flow XWX-FI-0020	✓	No change	No known issues *
Smart Well Venturi Flow NGX-FI-0007	✗	No change	Performance testing ongoing

* No known issues have been communicated to SGS Canada Inc. with regard to the tier 2 meters, therefore it is assumed that all are operating within original design. SGS recommend confirmation of tier 2 meter status with offshore/SAP system if further supporting data is required.



10.1 Exceptions to Tier 2 Pass Status

The only tier 2 meters known at this time to be not performing to design are the three v-cone meters 44-FE-2541A/B/C. Note that these meters were originally classified as Tier 1, however due to the meter installation upstream of the pump discharge minimum flow recycle valve to overboard dump, these meters were de-classified as Tier 1 meters as there is no Tier 1 meter installed to measure overboard dump water. Additionally, during extensive offshore performance trials the meters were found to be reading approx. 15% higher when compared to the drill centre meters, which were verified using a portable clamp-on ultrasonic meter during the trials, during confirmed full-forward flow from the online pumps.

The smart well venturi flow meters are also suspect over-reading and are currently under investigation by the Husky subsea team. Initial findings point to the LVDT accuracy and/or effect of the Flowatcher venturi sealing properties when installed in the reverse flow direction.