CORE LABORATORIES
AUSTRALIA PTY LTD

ROUTINE CORE ANALYSIS REPORT

HARVEY-2

WEST AUSTRALIA

Prepared for
Department of Mines and Petroleum

January 2016

Contract DMP 680714
Core Laboratories file: PRP-15 005

Rock Properties
Core Laboratories
Perth
Australia

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CORE LABORATORIES AUSTRALIA PTY LTD

4th January, 2016

Department of Mines and Petroleum
100 Plain Street
East Perth
WA 6004

Attention : Louise Stelfox

Subject : Routine Core Analysis
Well : Harvey-2
Contract : DMP 680714
File : PRP-15 005

Dear Louise,

Presented herein is the final report of a routine core analysis study conducted on cores from the above well that arrived at our laboratory in July 2015.

We appreciate the opportunity to present this service to Department of Mines and Petroleum. Please contact us should you require any further information or assistance.

Yours sincerely,
Core Laboratories Australia Pty Ltd

James Brown
Senior Core Analyst

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INTRODUCTION

Harvey-2 was cored continuously from 207.7m to 1350.2m (1142.5 metres). The core analysis work conducted on the cores was based on DMP Document "SWH Project, Harvey 2, 3, 4 Core Analysis Program, Routine Core Analysis, Special Core Analysis, Planning Document, Version 9" which is included as an Appendix in this report.

Selected core material from the Wonnerup Member and Yalgorup Member were delivered from the GSWA Core Library to Core Laboratories in July 2015. Sections of core preserved at the well-site had been previously delivered to Core Laboratories from March to May 2015 (during and shortly after the coring phase of the well programme).

Services performed on selected plug samples and presented in the report include:

- Porosity, permeability and grain density at NOBP ("reservoir" samples)
- Fresh state permeability to brine at NOBP ("seal/aquitard" samples)
- Threshold injection pressure to CO_2 at NOBP ("seal/aquitard samples")

The rationale for these tests and the samples selected was as follows:

(A) In the Wonnerup Member and the sandy sections of the Yalgorup Member ("reservoir" samples) to evaluate the storage capacity, injectivity and transmissitivity of these formations with respect to CO_2 injection. A further point to note are:

   a. Porosity and permeability to air data were determined at net overburden pressure (NOBP) on all samples. These data were also generated at 800psi on approximately 20% of the samples so that (i) porosity/permeability data can be generated at any other selected overburden pressure using Stan Jones' 2-point fit equations* (ii) data can be correlated to porosity/permeability data derived from other wells (including Harvey#1, Harvey#2, Harvey#4).

(B) In the claystone rich facies of the Yalgorup Member ("seal/aquitard" samples) to evaluate the seal capacity of these formations (that is, their ability to retain CO_2 injected into the "reservoir" formations).

Please note this quote provided by the DMP:
The GSWA is currently reviewing the stratigraphy of the southern Perth Basin, including the usage of units originally defined in the northern Perth Basin. The formation names and tops quoted in the DMP's Harvey studies are therefore preliminary and may be subject to change following this review.

*SPE 15380, 1986.

SUMMARY

Porosity and permeability measurements in the Yalgorup Member (sand-rich facies) were determined at 1250psi on 25 samples of which 5 were also measured at 800psi. Porosity and permeability measurements in the Wonnerup Member were determined at 1700psi on 20 samples of which 5 were also measured at 800psi. Grain Density was measured on all samples.

	Minimum	Maximum	Average
Yalgorup Member (sand-rich facies)			
Net Confining Pressure of 800psi.			
Porosity (%)	8.8	28.6	18.1
Permeability, Horizontal, K_{inf} (md)	0.347	2560	771
Grain Density (g/cc)	2.608	2.766	2.636
Net Confining Pressure of 1250psi.			
Porosity (%)	7.8	28.0	19.1
Permeability, Horizontal, K_{inf} (md)	0.212	6460	660
Clay-rich Facies Yalgorup Member			
Permeability to brine (md)	No flow		
Threshold Pressure to CO_2 (psi)	No injection		
Wonnerup Member (sand-rich facies)			
Net Confining Pressure of 800psi.			
Porosity (%)	21.4	24.6	22.2
Permeability, Horizontal, K_{inf} (md)	2.79	759	270
Grain Density (g/cc)	2.597	2.701	2.639
Net Confining Pressure of 1700psi.			
Porosity (%)	13.6	24.6	20.9
Permeability, Horizontal, K_{inf} (md)	0.278	750	232

LABORATORY PROCEDURES

Core Preparation:

The core material from the Harvey-2 well was laid out and twenty-one sampling points were marked on the Wonnerup Member. Sampling points in the Yalgorup Member were selected in some of the sandy sections. A proposed listing of samples was forwarded to the Department of Mines and Petroleum on the 23rd July 2015. The final selection of sampling points was determined on the 30th July 2015 while viewing the core.

Sample Preparation:

Horizontal routine core analysis plugs for porosity, permeability and grain density were cut and trimmed from the core to form 1.5" diameter cylinders (in SQ (120mm) core) and 1.0" diameter cylinders (in HQ 63.5mm) core) using 2% potassium chloride as the bit lubricant. Some samples, due to their friable nature, were mounted in Teflon, Nickel foil and screens to avoid grain loss. All samples were then cleaned of residual salts by warm methanol. Complete salt removal was indicated by the methanol, in which the samples were immersed, producing a negative reaction to silver nitrate. After cleaning, the samples were dried in a convection oven at 95°C. To ensure complete drying, each sample was weighed then put back into the oven for twenty-four hours, then reweighed. This process was repeated until consecutive weights were within +/- 0.01 g. After drying, the samples were cooled down in a desiccator to room temperature prior to analysis. The uncleaned, trimmed, plug off-cuts were placed into labelled snap-lock bags.

Grain Volume and Grain Density:

The weight, diameter and length of all samples were measured before they were processed through the Ultrapore™ porosimeter to determine grain volume. As a standard quality control measure, a calibration check plug was run with every ten samples. Grain density data were calculated from grain volume and sample weight data. For mounted samples, corrections were made for Teflon, Nickel and screen weights and volumes.

Porosity and Permeability:

The plug samples were run at the requested confining stresses while determining porosity and permeability. A standard check plug was run with every set of samples. Klinkenberg permeability (K_{inf}) values are obtained directly from the CMS^{TM}300, since it operates by unsteady-state principles. Porosity data was obtained by combining pore volumes from the CMS^{TM}300 data with grain volumes from the Ultrapore porosimeter-corrected for Teflon, Nickel and screen volumes for mounted samples.

Preserved Sample Preparation:

Some sections of preserved clay-rich facies core ("seal/aquitard") were selected for permeability to brine and threshold pressure to CO_2. The end of the PVC tubing was removed and the mineral oil drained out. The core was gently slid out of the tube and inspected for obvious fractures, minor faulting, micro-fractures and other heterogeneity features like sand lenses. The plugs were drilled and trimmed with mineral oil, wrapped in Saran wrap and aluminium foil and placed into snap lock plastic bags and stored in a refrigerator until commencement of analysis.

Permeability to Brine:

- Selected "seal/aquitard" samples were unwrapped and loaded into individual core holders.
- The confining stress was gradually increased from ambient to the requisite net overburden pressure.
- The sample was initially flushed with the simulated formation brine (50,000 mg/L) under back-pressure to eliminate any trapped gas in the pore spaces.
- Brine flow (injection) rates were kept low to ensure laminar flow. For lower permeability samples, the net confining stress was adjusted to account for the increased upstream pressure.
- Brine injection was continued until stabilised flow pressure was attained.
- The effluent was inspected for production of fines. No fines were noticed in the effluent brine collected for any of the samples tested.
- Permeability to brine was calculated at the given injection rate using this equation :

$$Kw = (14700.Q.\mu.L) / \Delta P.A$$

where :

Kw = permeability to brine, md
Q = rate, cm^3/sec
A = cross sectional area, cm^2
L = length, cm
ΔP = differential pressure (inlet-outlet), psi
μ = viscosity, cP
14700 = conversion factor from psi to atmospheres and Darcy to millidarcies

- Since the "seal/aquitard" samples submitted for permeability to brine measurements were clay-rich facies, high flow pressures (>6,000 psi) were often utilised in an attempt to initiate flow. Where no flow was observed after a period of 24 hours, the tests were terminated and reported as "no flow".

Threshold Pressure to Carbon Dioxide (CO_2) Gas:

- Upon completion of the permeability to brine measurement, the sample underwent threshold pressure to CO_2 measurement.
- With the sample still loaded in the core-holder at the applied net overburden pressure, the brine flow line at the upstream-end was removed and any excess brine from the end-stem was syringed out before attaching the CO_2 gas injection line. A graduated pipette was attached at the downstream effluent end.
- Gas injection (displacement) pressure was incrementally increased until effluent brine was first produced in the pipette. This pressure was recorded as the "threshold pressure", sometimes referred to as the "entry pressure", or "displacement pressure".
- The overburden pressure was continuously adjusted to compensate for the increasing CO_2 displacement pressures to maintain the **net** overburden pressure.
- Displacement/injection pressure was increased beyond 5,000 psi in most cases. Where no effluent brine was noted, testing was terminated and reported as "no injection".

Company : Department of Mines and Petroleum

Well: Harvey-2

POROSITY, PERMEABILITY, and GRAIN DENSITY

SAMPLE NUMBER	SAMPLE DEPTH (m)	CONFINING STRESS (800psi)			CONFINING STRESS (1250psi)			GRAIN DENSITY (g/cc)	COMMENTS
		CMS K_{inf} (md)	CMS K_{air} (md)	POROSITY (%)	CMS K_{inf} (md)	CMS K_{air} (md)	POROSITY (%)		
Yalgorup Member									
21	470.00								Failed
22	498.80	2560	2840	28.6	2450	2830	27.9	2.630	Mounted in Ni sleeving
23	572.00				2150	2460	28.0	2.627	Mounted in Ni sleeving
24	674.50				680	736	24.1	2.630	Mounted in Ni sleeving
25	694.00				-	-	-	-	Failed
26	770.20				12.4	14.3	17.6	2.624	Mounted in Ni sleeving
27	789.00	0.347	0.386	11.6	0.212	0.254	11.4	2.663	
28	807.00				506	542	23.9	2.608	Mounted in Ni sleeving
29	831.00				153	167	18.4	2.631	Mounted in Ni sleeving
30	850.00				104	126	18.9	2.625	Mounted in Ni sleeving
31	862.00				128	143	19.6	2.631	Mounted in Ni sleeving
32	882.00	223	239	19.9	201	215	19.3	2.630	Mounted in Ni sleeving
33	905.00				126	140	20.4	2.626	Mounted in Ni sleeving
34	958.30				-	-	-	-	Failed
35	1041.00				-	8810	27.2	2.623	Poor sample
37	1088.00				497	534	21.5	2.625	Mounted in Ni sleeving
38	1105.00	-	-	-	-	-	-	-	Failed
39	1110.00				-	-	-	-	Failed
40	1121.40				157	168	17.3	2.622	Mounted in Ni sleeving
41	1126.00				425	445	22.0	2.625	Mounted in Ni sleeving
42	1140.50				-	-	-	-	Failed
43	1142.00	1070	1100	21.7	1030	1090	21.5	2.619	Mounted in Ni sleeving
44	1159.50				6460	6520	27.6	2.617	Mounted in Ni sleeving
45	1164.00				6.75	8.02	13.4	2.692	Mounted in Ni sleeving

Company : Department of Mines and Petroleum

Well: Harvey-2

POROSITY, PERMEABILITY, and GRAIN DENSITY

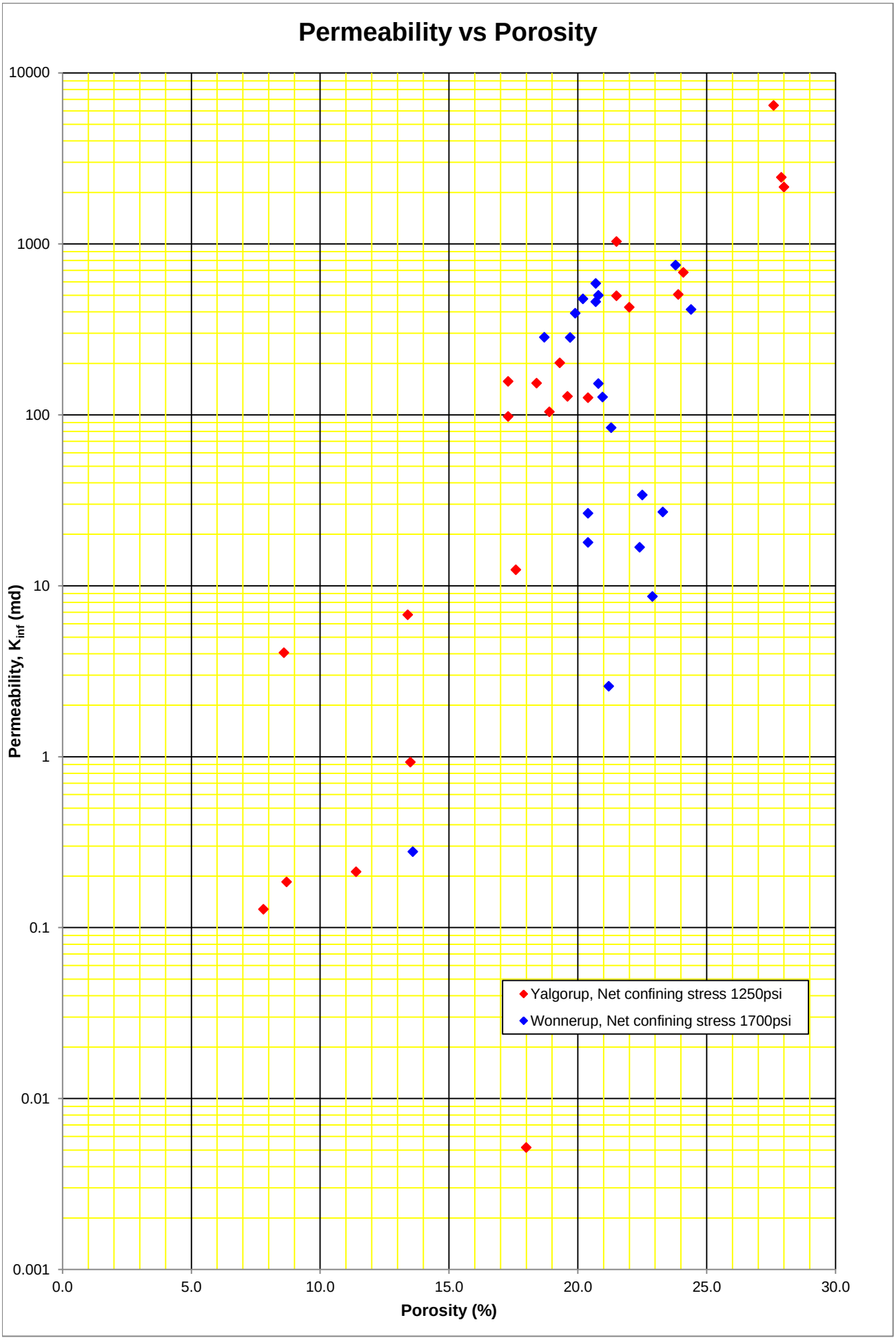
SAMPLE NUMBER	SAMPLE DEPTH (m)	CONFINING STRESS (800psi)			CONFINING STRESS (1250psi)			GRAIN DENSITY (g/cc)	COMMENTS
		CMS K_{inf} (md)	CMS K_{air} (md)	POROSITY (%)	CMS K_{inf} (md)	CMS K_{air} (md)	POROSITY (%)		
46	1171.60				0.928	1.20	13.5	2.632	
48	1181.30				97.8	105	17.3	2.615	
50	1208.50	4.62	5.37	8.8	4.05	4.69	8.6	2.628	
51	1209.00				0.128	0.204	7.8	2.657	
53	1224.00				0.185	0.262	8.7	2.634	
54	1227.80				0.005	0.018	18.0	2.766	
55	1233.00				-	1170	23.6	2.625	Poor sample

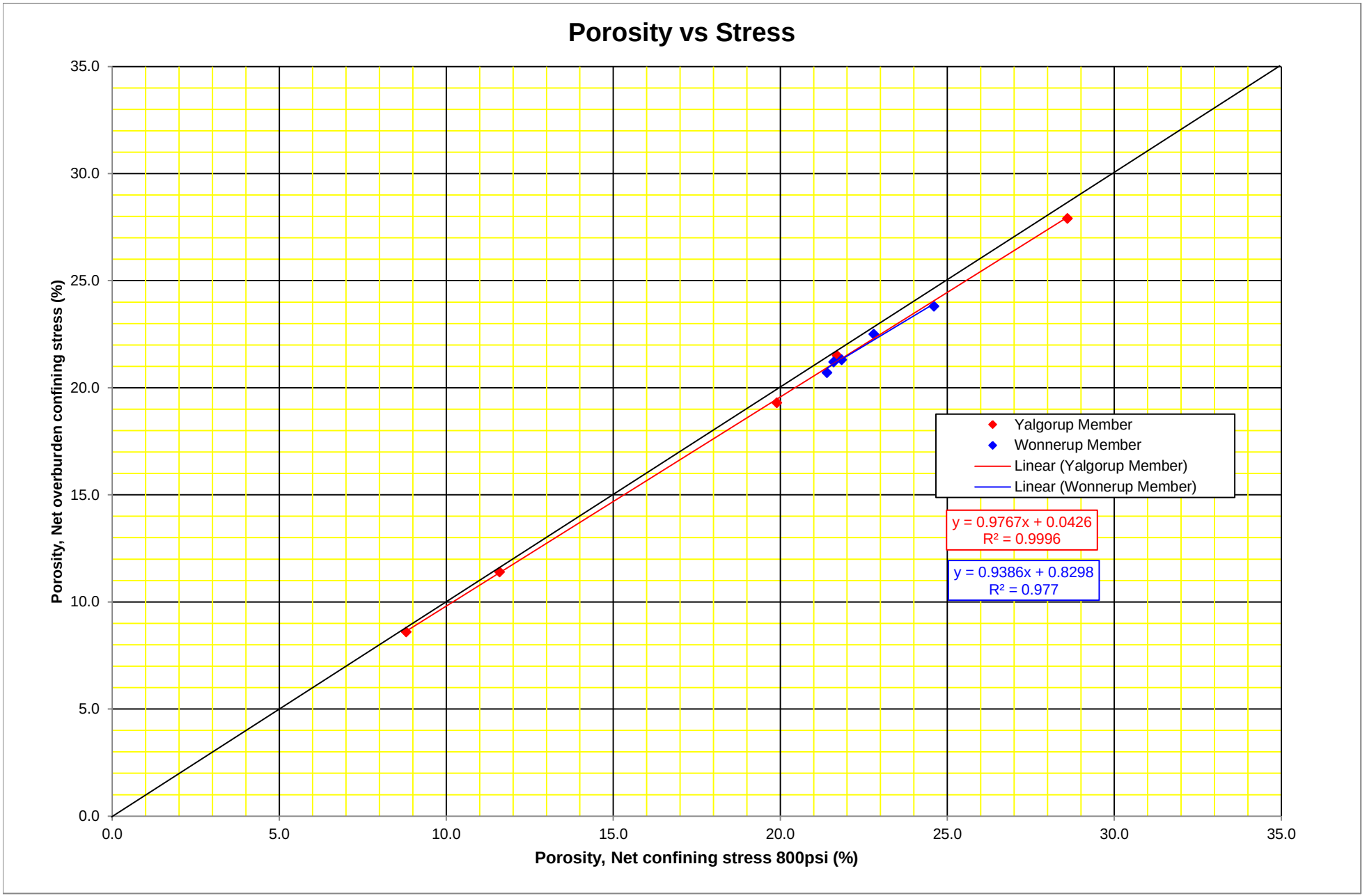
Company : Department of Mines and Petroleum

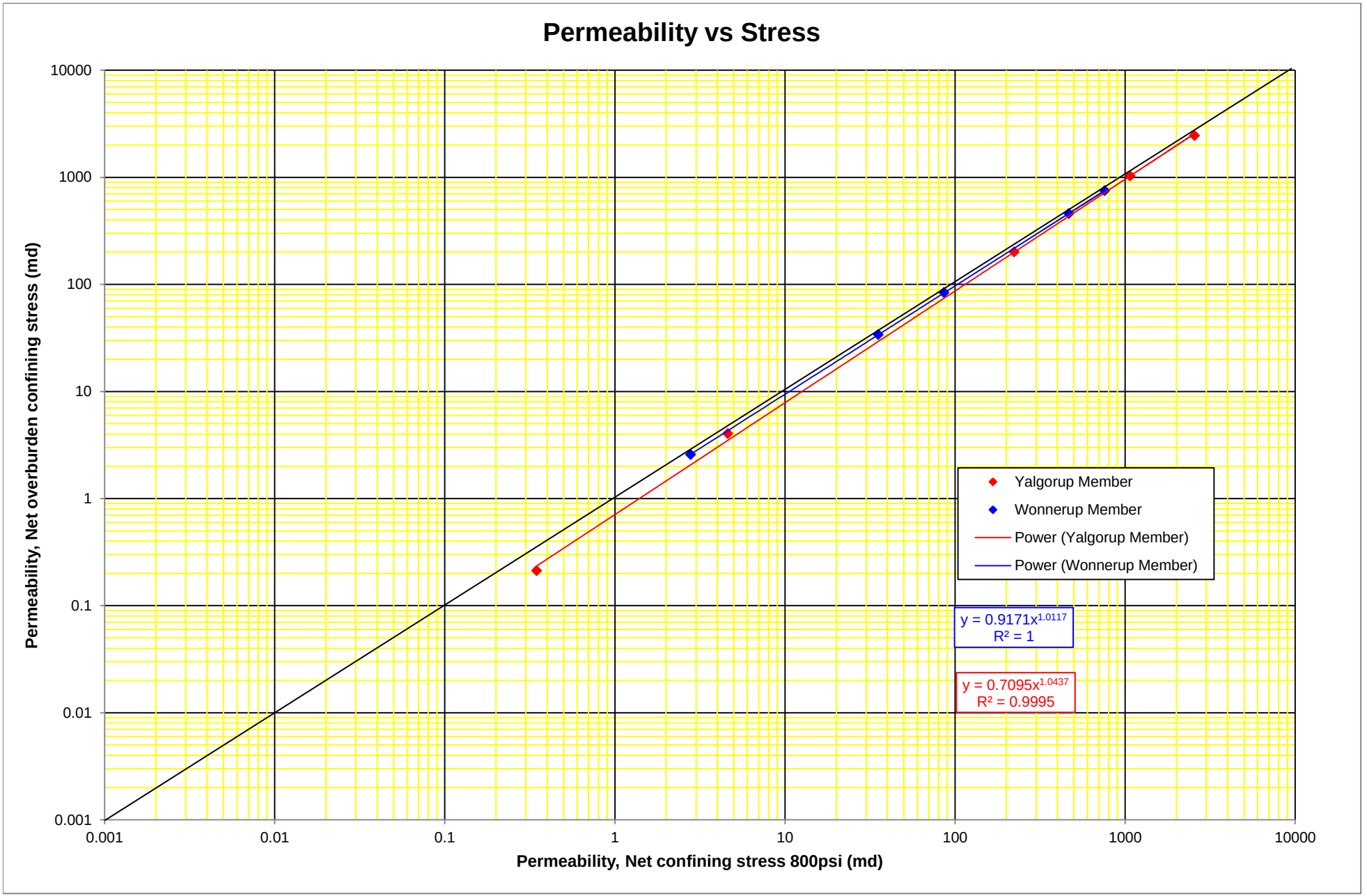
Well: Harvey-2

POROSITY, PERMEABILITY, and GRAIN DENSITY

SAMPLE NUMBER	SAMPLE DEPTH (m)	CONFINING STRESS (800psi) CMS K_{inf} (md)	CMS K_{air} (md)	POROSITY (%)	CONFINING STRESS (1700psi) CMS K_{inf} (md)	CMS K_{air} (md)	POROSITY (%)	GRAIN DENSITY (g/cc)	COMMENTS
Wonnerup Member									
1	1239.00	35.4	40.9	22.8	33.9	39.3	22.5	2.652	Mounted in Ni sleeving
2	1241.00				0.278	0.370	13.6	2.597	Carbonaceous fragments
3	1244.00				283	463	19.7	2.632	Mounted in Ni sleeving
4	1255.00				284	470	18.7	2.661	Mounted in Ni sleeving
5	1264.50				152	228	20.8	2.627	
6	1267.50	466	745	21.4	458	734	20.7	2.638	Mounted in Ni sleeving
7	1274.00				393	601	19.9	2.628	Mounted in Ni sleeving
8	1275.00				27.0	35.4	23.3	2.626	
56	1278.00				-	-	-	-	Failed
9	1280.00				413	527	24.4	2.642	Mounted in Ni sleeving
10	1286.00	759	942	24.6	750	934	23.8	2.631	Mounted in Ni sleeving
11	1296.00				26.5	31.7	20.4	2.701	
12	1296.80				17.9	21.4	20.4	2.640	
13	1314.60				16.8	20.6	22.4	2.649	
14	1315.00				8.64	10.8	22.9	2.675	
15	1316.60	2.79	3.91	21.6	2.58	3.66	21.2	2.644	
16	1328.50				127	181	21.0	2.626	Mounted in Ni sleeving
17	1335.00				500	781	20.8	2.630	Mounted in Ni sleeving
18	1344.00				587	913	20.7	2.622	Mounted in Ni sleeving
19	1348.00				476	492	20.2	2.615	Mounted in Ni sleeving
20	1349.00	86.2	101	21.8	84.0	97.8	21.3	2.634	


Permeability vs Porosity
10000
1000
100
10
1
0.1
0.01
0.001
Permeability, K_inf (md)
0.0
5.0
10.0
15.0
20.0
25.0
30.0
Porosity (%)
Yalgorup, Net confining stress 1250psi
Wonnerup, Net confining stress 1700psi


Porosity vs Stress
Porosity, Net overburden confining stress (%)
Porosity, Net confining stress 800psi (%)
0.0
5.0
10.0
15.0
20.0
25.0
30.0
35.0
Yalgorup Member
Wonnerup Member
Linear (Yalgorup Member)
Linear (Wonnerup Member)
y = 0.9767x + 0.0426
R² = 0.9996
y = 0.9386x + 0.8298
R² = 0.977


Permeability vs Stress
Permeability, Net overburden confining stress (md)
10000
1000
100
10
1
0.1
0.01
0.001
0.001
0.01
0.1
1
10
100
1000
10000
Permeability, Net confining stress 800psi (md)
Yalgorup Member
Wonnerup Member
Power (Yalgorup Member)
Power (Wonnerup Member)
y = 0.9171x^1.0117
R² = 1
y = 0.7095x^1.0437
R² = 0.9995

Permeability to Brine and threshold Pressure to CO_2 at NOBP

Yalgorup -1250psi Net Confining Stress

Well name	Sample no.	Depth (m)	Permeability To water (md)	CO2 threshold Pressure (psi)
Yalgorup	PSH6	464.82	no flow	no injection
Yalgorup	PSV3	464.92	no flow	no injection
Yalgorup	PSH7	492.06	no flow	no injection
Yalgorup	PSH8	511.04	no flow	no injection
Yalgorup	PSV4	511.10	no flow	no injection
Yalgorup	PSH9	742.78	no flow	no injection
Yalgorup	PSH10	754.93	no flow	no injection
Yalgorup	PSV5	755.05	no flow	no injection
Yalgorup	PSH11	790.68	no flow	no injection
Yalgorup	PSH12	815.90	no flow	no injection
Yalgorup	PSV6	816.03	no flow	no injection

APPENDIX A

Preserved Core Inventory

Well Name: Harvey-2

Client: Department of Mines and Petroleum

Job No.: PRP-15 005

Core	Barrel	Top Depth	Btm Depth		Selected	Plugs	Comments
							Eneabba basal shale
N/A	1	402.10	402.45	F10 fault	RCA-1	PSH1	Packed in PVC can
N/A	2	411.75	412.10	F10 fault	RCA-1	PSH2, PSV1	Packed in PVC can
N/A	3	417.60	417.95	F10 fault	RCA-1	PSH3	Packed in PVC can
							Top Yalgorup Member
N/A	4	424.70	425.05	F10 fault	RCA-1	PSH4, PSV2	Packed in PVC can
N/A	5	433.00	433.35	F10 fault	RCA-1	PSH5	Packed in PVC can
N/A	6	452.10	452.45				Packed in PVC can
N/A	7	464.70	464.95		RCA-1	PSH6, PSV3	Packed in PVC can
N/A	8	484.40	484.75				Packed in PVC can
N/A	Below samples Recieved on 28-01-15						
N/A	9	492.00	492.30		RCA-1	PSH7	Packed in PVC can
N/A	10	501.95	502.30				Packed in PVC can
N/A	11	510.95	511.30		RCA-1	PSH8, PSV4	Packed in PVC can
N/A	12	725.20	725.55				Packed in PVC can
N/A	13	742.75	743.00		RCA-1	PSH9	Packed in PVC can
N/A	14	748.10	748.35				Packed in PVC can
N/A	15	754.90	755.20		RCA-1	PSH10, PSV5	Packed in PVC can
N/A	Below samples Recieved on 05-02-15						
N/A	16	767.05	767.30				Packed in PVC can
N/A	17	775.90	776.25				Packed in PVC can
N/A	18	790.65	790.95		RCA-1	PSH11	Packed in PVC can
N/A	19	815.90	816.25		RCA-1	PSH12, PSV6	Packed in PVC can
N/A	20	835.35	835.65				Packed in PVC can
N/A	21	961.25	961.60				Packed in PVC can
N/A	22	968.25	968.55		RCA-1	PSH13	Packed in PVC can
N/A	Below samples Recieved on 09-02-15						

Preserved Core Inventory

Well Name: Harvey-2

Client: Department of Mines and Petroleum

Job No.: PRP-15 005

Core	Barrel	Top Depth	Btm Depth		Selected	Plugs	Comments
N/A	23	979.10	979.40		RCA-1	PSH14, PSV7	Packed in PVC can
N/A	24	988.00	988.25				Packed in PVC can
N/A	25	1036.40	1036.70		RCA-1	PSH15	Packed in PVC can
N/A	26	1107.85	1108.15				Packed in PVC can
N/A	27	1119.15	1119.40				Packed in PVC can
N/A	28	1132.05	1132.40				Packed in PVC can
	Below samples Recieved on 20-02-15						
N/A	29	1145.25	1145.55				Packed in PVC can
N/A	30	1166.05	1166.36				Packed in PVC can
N/A	31	1190.75	1191.05				Packed in PVC can
N/A	32	1228.55	1228.80				Packed in PVC can
							Top Wonnerup Member
Radioisotope-1		464.30	464.55				
Radioisotope-2		512.40	512.75				
Radioisotope-3		975.90	976.20				
Radioisotope-4		?	1085.55				

PLUGGING LIST

Date: 15/10/2015

Client: DMP

Well: Harvey-2

Job No: **PRP - 15005**

Sample No.	PREPOSED Depth (m)	Depth Check	Revised Depth	Comments
21	470.00	Failed		Top Yalgorup (419m)
22	498.80	√	498.85	
23	572.00	√		
24	674.50	√		
25	694.00	Failed		
26	770.20	√		
27	789.00	√		
28	807.00	√	806.9	
29	831.00	√		
30	850.00	√		
31	862.00	√		
32	882.00	√	882.02	
33	905.00	√		
34	958.30	Failed		
35	1041.00	√		
36	1065.00			Removed 30-7-15
37	1088.00	√		
38	1105.00	Failed		
39	1110.00	Failed		
40	1121.40	√	1121.44	
41	1126.00	√		
42	1140.50	Failed		
43	1142.00	√		
44	1159.50	√	1159.4	
45	1164.00	√		
46	1171.60	√		
47	1180.00			Removed 30-7-15
48	1181.30	√		
49	1186.30			Removed 30-7-15
50	1208.50	√		
51	1209.00	√		
52	1218.00			Removed 30-7-15
53	1224.00	√		
54	1227.80	√		
55	1233.00	√	1233.08	
1	1239.00	√		Top Wonnerup (1245m)
2	1241.00	√		
V1	1241.00			Postponed 30-7-15
3	1244.00	√		
4	1255.00	√		

PLUGGING LIST

Date: 15/10/2015
Client: DMP
Well: Harvey-2
Job No: **PRP - 15005**



Sample No.	PREPOSED Depth (m)	Depth Check	Revised Depth	Comments
V2	1255.00			Postponed 30-7-15
5	1264.50	√		
6	1267.50	√		
V3	1267.50			Postponed 30-7-15
7	1274.00	√		
8	1275.00	√		
V4	1275.00			Postponed 30-7-15
56	1285.00	Failed		Additional 30-7-15
9	1280.00	√		
10	1286.00	√		
V5	1286.00			Postponed 30-7-15
11	1296.00	√		
12	1296.80	√		
V6	1296.80			Postponed 30-7-15
13	1314.60	√		
14	1315.00	√		
V7	1315.00			Postponed 30-7-15
15	1316.60	√		
16	1328.50	√		
V8	1328.50			Postponed 30-7-15
17	1341.50	√		
18	1344.00	√		
V9	1344.00			Postponed 30-7-15
19	1349.00	√		
20	1351.00	√		
V10	1349.00			Postponed 30-7-15
				Preserved Samples
PSH1		Failed		402.10-402.45
PSH2		Failed		411.75-412.10
PSH3		Failed		417.60-417.95
PSH4		Failed		424.70-425.05
PSH5		Failed		433.00-433.35
PSH6	464.82	√		
PSH7	492.06	√		
PSH8	511.04	√		
PSH9	742.78	√		
PSH10	754.93	√		

PLUGGING LIST

Date: 15/10/2015

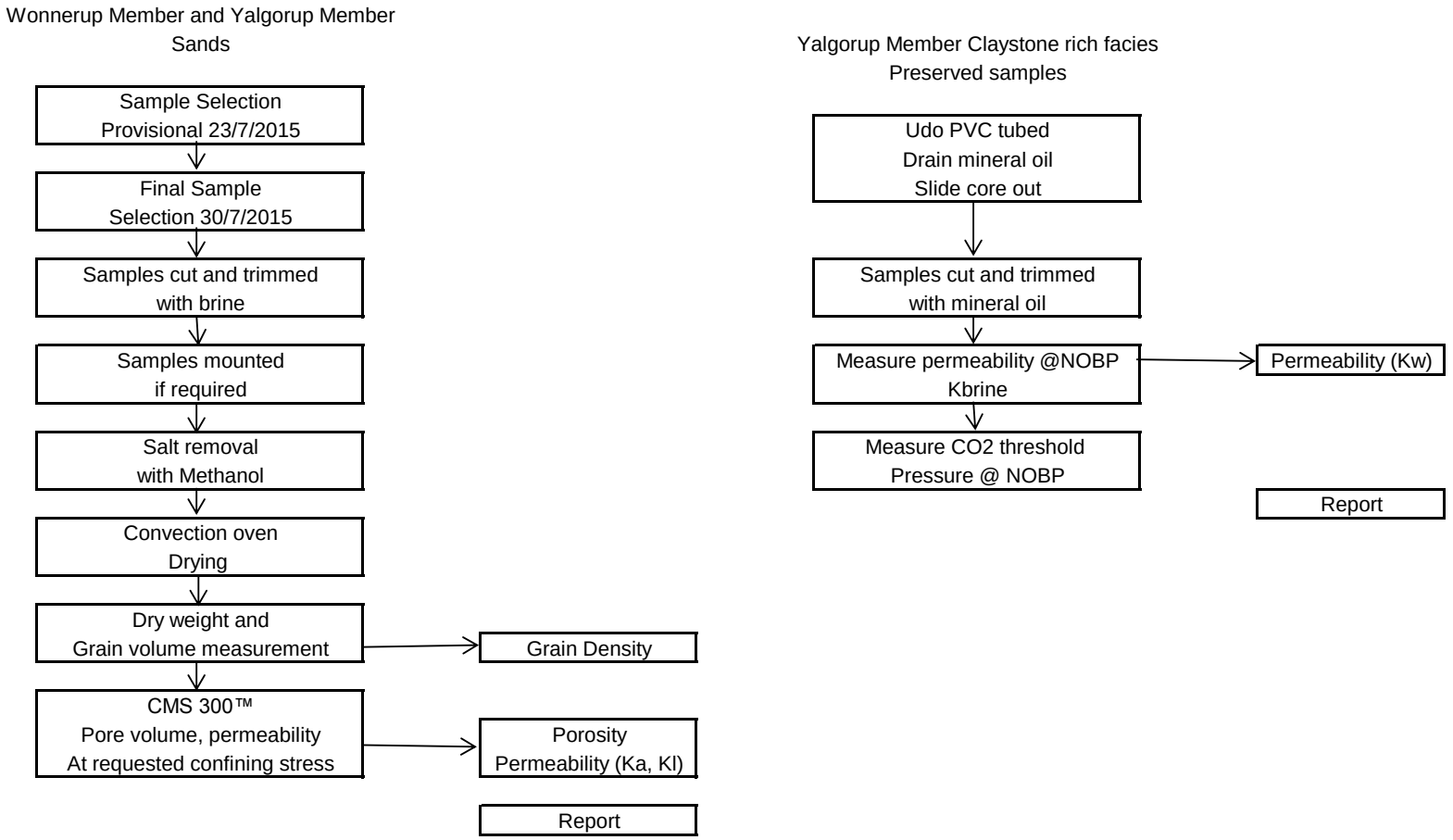
Client: DMP

Well: Harvey-2

Job No: **PRP - 15005**

Sample No.	PREPOSED Depth (m)	Depth Check	Revised Depth	Comments
PSH11	790.68	√		
PSH12	815.90	√		
PSH13		Failed		968.25-968.55
PSH14		Failed		979.10-979.40
PSH15		Failed		1036.40-1036.70
PSV1		Failed		411.75-412.10
PSV2		Failed		424.70-425.05
PSV3	464.92	√		
PSV4	511.10	√		
PSV5	755.05	√		
PSV6	816.03	√		
PSV7				

Analysis Flow Chart



APPENDIX B

SWH Project
Harvey 2, 3, 4 Core Analysis Program
Routine Core Analysis
Special Core Analysis

Planning Document

Version	Date	Done by	Reviewed by	Approved by
Update 9	June 24, 2015	TK	LS	
Update 8	June 16, 2015	LS		
Update 7	May 26, 2015	SS	LS	
Update 6	May 20, 2015	SS/LS		
Update 5	May 18, 2015	SS/LS	LS	
Update 4	May 11, 2015	SS/LS		
Update 3	April 20, 2015	SS/LS		
Update 2	28 Feb 2015	SS	LS	DVG
Update 1	24 Feb 2015	SS	LS	
RFT Scope	Oct 2014	SS/LS	DVG	

1 SUMMARY OF APPROACH TO CORE ANALYSIS

The DMP RFT scope was discussed and adapted based on the project objectives through discussions with Core Lab (Core Analysis Consultants), ODIN (Modelling and Interpretation consultants) and GSWA. The finalised scope is outlined below and the rationale defined in the subsequent sections.

In terms of classification the core analysis terminology for cap rock refers to the Eneabba basal 'shale' and the Yalgorup paleosols. The reservoir refers to the Wonnerup sands and the Yalgorup sandy facies.

While normally TRA analysis would not be done on cap-rock, in the case of the Lesueur as these are dominated by paleosols a few TRA tests are worth performing in addition to special MICP (SCAL) work.

A specific learning from the Harvey 1 exercise is to perform a CT scan of plugs for SCAL so that the plugs tested are representative.

A certain number of plugs will be required for the ANLEC research projects. Around 5 plugs per well will likely be needed for the paleo-salinity while the requirements for the others is yet to be defined.

Tabulation of Strata tops: predicted vs preliminary actual (updated 16/06/15).

16/06/2015

Depth to strata tops

Harvey 2 DDH1 Rig 16 (RT = 0.6m)

	Odin's 3-D seismic depth prognosis (m AHD)	Approx. actual depth interpretation (m depth)	Approx. strata elevation (m AHD) from Core	Diff between prognosed & prelim actual (m)
X : 392052.65 Y : 6347141.74				
G.L (m AHD)	15.40			
Rig table datum (m AHD)	16.00			
Driller's datum (m AHD)	16.00			
Base of Leederville unconformity (m sub sea)	-145	135	-119	-26
Eneabba basal shale (m sub sea)	-425	393	-377	-48
Top Yalgorup Member (m sub sea)	-491	419	-403	-88
Top Wonnerup Member (m sub sea)	-1,237	1,245	-1,229	-8
Final depth	~ 1,350 m	1,351	-1,335	-15
Completion depth (m)		414.6	-399	

Harvey 3 DDH1 Rig 16 (RT = 0.6m)

	Odin's 3-D seismic depth prognosis (m AHD)	Approx. actual depth interpretation (m depth)	Approx. strata elevation (m AHD) from Core	Diff between prognosed & prelim actual (m)
X : 387392.24 Y : 6343895.95				
Lat and Long				
Ground elevation, as surveyed (m AHD)	20.20			
Rig table datum (m AHD)	20.80			
Driller's datum (m AHD)	20.80			
Base of Leederville unconformity (m sub sea)	-226	cased	tentatively from GR log ?	
Eneabba basal shale (m sub sea)	-628	655	-634	6
Top Yalgorup Member (m sub sea)	-713	741	-720	7
Top Wonnerup Member (m sub sea)	-1,426	1,418	-1,398	-28
Final depth	~ 1,550 m			
Completion depth (m)		HQ coring to TD		

Installing casing to TD, approx.

1,462 m (16/6/14)

Harvey 4 DCA Rig (RT = 4.0m)

	Odin's 3-D seismic depth prognosis (m AHD)	Approx. actual depth interpretation (m depth)	Approx. strata elevation (m AHD) from Cuttings	Diff between prognosed & prelim actual (m)
X : 389946.08 Y : 6343842.51				
Ground elevation, as surveyed (m AHD)	15.89			
Rig table datum (m AHD)	19.89			
Driller's datum (m AHD)	15.89			
Base of Leederville unconformity (m sub sea)	-154	165	-149	-5
Eneabba basal shale (m sub sea)	-837	808	-792	-43
Top Yalgorup Member (m sub sea)	-1,016	1,020	-1,004	-12
Top Wonnerup Member (m sub sea)	-1,665	1,617	-1,601	-64
Final depth	~ 1,800 m	1,802	-1,786	-14
Completion depth (m)		1,802	-1,786	

Drilling finished 21/04/15

Notes

Well sites surveyed by DMP's surveyor in Nov 14 and again on 25 April 2015.

Actual strata tops are preliminary pending palynology results and wireline logging data

There is difficulty in defining transition between the Eneabba Formation and

Yalgorup Member.

Intervals Cored

Harvey 2 was fully-cored. Core samples preserved in mineral oil (claystone and/or siltstone- rich facies):

Sample Number	Depth (m)		Date
	Start	End	
1	402.1	402.45	12/01/2015
2	411.75	412.1	14/01/2015
3	417.6	417.95	14/01/2015
4	424.7	425.05	14/01/2015
5	433	433.35	14/01/2015
6	452.1	452.45	14/01/2015
7	464.7	464.95	15/01/2015
8	487.4	487.75	15/01/2015
9	492	492.3	16/01/2015
10	501.95	502.3	16/01/2015
11	510.95	511.3	17/01/2015
12	725.2	725.55	27/01/2015
13	742.75	743	27/01/2015
14	748.1	748.45	27/01/2015
15	754.9	755.2	27/01/2015
16	767.05	767.3	28/01/2015
17	775.9	776.25	28/01/2015
18	790.65	790.95	28/01/2015
19	815.9	816.25	29/01/2015
20	835.35	835.65	30/01/2015
21	961.25	961.6	04/02/2015
22	968.25	968.55	04/02/2015
23	979.1	979.4	05/02/2015
24	988	988.25	05/02/2015
25	1036.4	1036.7	07/02/2015
26	1107.85	1108.15	08/02/2015
27	1119.15	1119.4	08/02/2015
28	1132.05	1132.4	09/02/2015
29	1145.25	1145.55	09/02/2015
30	1166.05	1166.35	10/02/2015
31	1190.75	1191.05	10/02/2015
32	1228.55	1228.8	12/02/2015

Radio-isotope samples

Sample Number	Depth (m)		Date
	Start	End	
R1	464.3	464.55	15/01/2015
R2	512.4	512.75	17/01/2015
R3	975.9	976.22	05/02/2015
R4	1085.25	1085.55	08/02/2015

Harvey 3 was fully-cored.

Core samples preserved in mineral oil (claystone and/or siltstone- rich facies):

Sample Number	Depth (m)		Date
	Start	End	
1	604.25	604.65	27/03/2015
2	647.55	647.9	28/03/2015
3	657	657.2	28/03/2015
4	662.7	663.05	28/03/2015
5	664.55	664.9	29/03/2015
6	673.25	673.55	29/03/2015
7	696.70	697.00	31/03/2015
8	717.50	717.80	01/04/2015
9	716.25	716.45	01/04/2015
10	720.15	720.45	01/04/2015
11	725.05	725.35	01/04/2015
12	728.60	728.90	02/04/2015
13	740.50	740.80	02/04/2015
14	743.75	743.95	02/04/2015
Harvey 3A			
15	765.55	765.85	09/04/2015
16	778.35	778.65	09/04/2015
17	888.05	888.35	17/04/2015
18	914.7	915	19/04/2015
19	1171.1	1172	03/05/2015
20	1226.3	1226.65	08/05/2015

Radio-isotope samples

Sample Number	Depth (m)		Date
	Start	End	
R1	688.55	688.85	30/03/2015
R2	725.05	725.35	01/04/2015
R3	735.3	735.6	02/04/2015

Yalgorup Member Sandstone (Glad wrapped)

Sample Number	Depth (m)		Date
	Start	End	
YS1	1250.95	125195	11/05/2015

Harvey 4 was interval-cored (four times), with a special large barrel use to retrieve a broken TCI roller bit in the Yalgorup Member.

Run 1		
893.00-894.00 m	placed in oil in PVC tubes	exposed to air for ~ 3 hours, transported to CoreLab on 19/02
894.00-895.00 m	placed in oil in PVC tubes	exposed to air for ~ 3 hours, transported to CoreLab on 19/02
895.00-895.96 m	placed in oil in PVC tubes	exposed to air for ~ 3 hours, transported to CoreLab on 19/02
895.96-896.00 m	dropped	-
896.00-896.30 m	wrapped in plastic, refrigerated	???
896.3	zipped plastic bag	transported to Core Library on 23/04/2015
896.30-897.30 m	placed in oil in PVC tubes	exposed to air for ~ 6.5 hours, transported to CoreLab on 19/02
897.30-898.30 m	placed in oil in PVC tubes	exposed to air for ~ 6.5 hours, transported to CoreLab on 19/02
898.30-899.25 m	placed in oil in PVC tubes	exposed to air for ~ 6.5 hours, transported to CoreLab on 19/02
899.25-899.30 m	zipped plastic bag	transported to Core Library on 23/04/2015
899.30 m	zipped plastic bag	transported to Core Library on 23/04/2015
Run 2		
898.40-898.60 m	zipped plastic bag	transported to Core Library on 23/04/2015
898.60-899.60 m	placed in oil in PVC tubes	exposed to air for ~ 2 hours, transported to CoreLab on 20/02
899.60-900.60 m	placed in oil in PVC tubes	exposed to air for ~ 2 hours, transported to CoreLab on 20/02
900.60-901.60 m	placed in oil in PVC tubes	exposed to air for ~ 2 hours, transported to CoreLab on 20/02
901.60-901.75 m	wrapped in glad wrap, alfoil, refrigerated	transported to CoreLab on 20/02
901.75-902.75 m	placed in oil in PVC tubes	exposed to air for ~ 2.75 hours, transported to CoreLab on 20/02
902.75-903.75 m	placed in oil in PVC tubes	exposed to air for ~ 2.75 hours, transported to CoreLab on 20/02
903.75-904.80 m	placed in oil in PVC tubes	exposed to air for ~ 2.75 hours, transported to CoreLab on 20/02
904.80-905.05 m	wrapped in glad wrap, alfoil, refrigerated	transported to CoreLab on 20/02
905.05-905.15 m	zipped plastic bag	transported to Core Library on 23/04/2015
905.15-906.15 m	placed in oil in PVC tubes	exposed to air for ~ 3.75 hours, transported to CoreLab on 20/02
906.15-907.15 m	placed in oil in PVC tubes	exposed to air for ~ 3.75 hours, transported to CoreLab on 20/02
907.15-908.05 m	placed in oil in PVC tubes	exposed to air for ~ 3.75 hours, transported to CoreLab on 20/02
908.05-908.35 m	2 x zipped plastic bags	transported to Core Library on 23/04/2015
Run 3		
1665.05-1666.65 m	wrapped in glad wrap and kept in tray	transported to Core Library on 29/4/2015
Run4		
1792.70-1802.55	kept in tray (except samples below)	transported to Core Library on 29/4/2015
1795.10-1795.60	Long term preservation sample - glad wrapped and placed in tubes	transported to Core Labs on 23/04/2015
1797.60-1798.10	Long term preservation sample - glad wrapped and placed in tubes	transported to Core Labs on 23/04/2015
1800.65-1801.15	Long term preservation sample - glad wrapped and placed in tubes	transported to Core Labs on 23/04/2015

The two samples from Run 1 in zip lock bags were crumbled core from the lifter and barrel join. These are estimated to be 0.05 – 0.10 m long.

Well Name	Sample type	Depth from (m)	Depth To (m)	Sampling and Preservation method	Comments
Harvey 4	6" Core from Yalgorup	1325.50	1326.60	Washed, placed in tray	Core was recovered during core operations to retrieve metals pieces from the bottom of the hole. Sent to Core Library 13/05/15.
Harvey 4	6" Core from Yalgorup	1324.00	1325.25	In PVC tube in mineral oil	Core was recovered during core operations to retrieve metals pieces from the bottom of the hole. Sent to Core Labs 13/05

1,324	1,327	Sandstone	Pale grey with thin purple mottled bands. Very fine to very coarse grained - occasional granular grains, moderately to poorly sorted, angular to sub-rounded, predominantly quartz (clear to frosted with grey and purple grains in purple bands), feldspar (white, pink); minor black heavy minerals, trace garnet and glauconite (increasing in purple band). Well cemented with trace argillic (pale green, dark purple) cementation. (Note: core samples are very different from drill cuttings either side, where siltstone/mudstone predominates - possible wash out from hole above, Steve Bolton, 2015).

Notes

- Plug selections to be referenced from Harvey 3 as the well has whole cores over the entire area of interest
- Horizontal Plugs to be taken every 1 m and Vertical Plugs every 3 m (close to 3rd horizontal plug) in wells Harvey 3 and Harvey 4.
- Harvey 4 has fewer plugs as the wells have been interval cored.
- Plug frequency reduced in Harvey 2 as it is not in the fairway of interest.
- The number of plugs has been increased from the original plan of 280 plugs (165 H, 105V).
- SCAL plugs to be CT scanned to check for consistency.
- No provision as yet for additional plugs for R&D. Researchers to advise.
- The well H-2 intercepts the F0 fault. This provides an opportunity to collect some plugs and do some tests in the fault zone. Whilst not visibly obvious, approximate depth of the intercept is between 340 and 440 m. This is largely based on Hylogger data where some distinct markers are seen – amorphous silica (348-385 m), gypsum (from 420 m), wet core signature (430-440 m). Cap rock type tests are planned here with 6 H and 2 V plugs.

2 FINAL SCOPE: ROUTINE CORE ANALYSIS (RCA)

No	Sample	Program	Requirement with estimated volumes	Comments
1.	Caprock (Eneabba and Yalgorup)	Preparation	Harvey 2: F10 investigation 6 horizontal plugs and 2 vertical plugs (normal to bedding) Harvey 2: 10 horizontal plugs and 5 vertical plugs (normal to bedding) Harvey 3: 30 horizontal and 10 vertical plugs (normal to bedding) Harvey 4: 10 horizontal plugs and 5 vertical plugs (normal to bedding)	V plugs should be cut adjacent to relevant H plugs. From original plan number of V plugs reduced. V plugs taken every 2nd or 3rd H plug.
2.	Reservoir Yalgorup and Wonnerup)	Preparation	Harvey 2: 20 H and 10 V in Wonnerup Harvey 3: 140 Hand 50 V in Wonnerup Harvey 3: 20 H and 5 V in Yalgorup	. V plugs should be cut adjacent to relevant H plugs.

No	Sample	Program	Requirement with estimated volumes	Comments
			Harvey 4: 10 H and 5 V in Wonnerup	
3.	Caprock (Eneabba and Yalgorup	Routine rock properties: Caprock analysis	Harvey 2: F10 investigation 5 horizontal plugs and 1 vertical plugs (normal to bedding) Harvey 2: 8 horizontal plugs and 4 vertical plugs (normal to bedding) Harvey 3: 27 horizontal and 9 vertical plugs (normal to bedding) Harvey 4: 8 horizontal plugs and 4 vertical plugs (normal to bedding) Use selected plugs from Item 1	Kw and threshold pressure for CO2 injection to understand the paleosol properties for containment. Some vertical plugs to include the tree root systems in the Yalgorup
4.	Reservoir Yalgorup and Wonnerup)	Routine rock properties: Porosity and permeability (P&P) to gas and water (Kg and Kw) at NOBP	Harvey 2: 20 horizontal and 10 vertical plugs Harvey 3: 140 H + 50 V plugs—Wonnerup Harvey 3: 20H + 5 V--Yalgorup Harvey 4: 10 horizontal and 5 vertical plugs Use plugs from Item 2	For evaluating porosity, Ka, Kw and grain density. Kw on 20% of plugs or more to be able to draw a correlation No Kw measurements in Harvey 2. Plugs to be taken in Wonnerup and Yalgorup sands.
5.	Reservoir Yalgorp and Wonnerup)	As in Item 4 but at a different pressure	Use selected plugs from Item 4	To evaluate the properties in 4 at a different pressure for estimation of KPhi at any NOBP using 2-point fit
6.	Core: Caprock and reservoir	Petrographic analysis: thin section (TS), X-Ray diffraction (XRD) and Scanning electron microscopy (SEM)	Use end-trims from the Caprock and P&P plugs. Caprock – F10 test – 6 samples Caprock: 14 representative samples Reservoir: 20 representative samples (4 Yalgorup and 16 Wonnerup)	For reservoir, plugs to be taken in Wonnerup and Yalgorup sands. For caprock samples, consider in Yalgorup and Eneabba paleosols. Select from those that undergo MICP/Pc tests in the SCAL programme. For the F10 confirm mineralogy particularly Gypsum
7.	Fluid	Fluid compositional analyses	Consider a total of 6 Modular Formation Dynamics Tester (MDT) samples	3 samples from H4 and possibly 3 from H3. Use 50% of the samples or less for baseline dissolved CO2 in the formation water in addition to the planned tests (10 ions etc.).

3 FINAL SCOPE: SPECIAL CORE ANALYSIS (SCAL)

No	Sample	Program Name	Details	CoreLabs Discussions
1.	Caprock	Kw and threshold capillary pressure	Capillary Pressure for supercritical CO2 brine: 1) capillary pressure H2 fault—1H + 1V H2 shale—2H+1V H3 shale—3H +1V H4 shale—2H+1V	On *samples from Eneabba Formation/Yalgorup Member.* 10 plugs selected from RCA item 1. 7H and 3V. 2 plugs from the F10 fault set in H2 (1H and 1V) 12 plugs in total
2.	Caprock and Reservoir	Capillary pressure: mercury injection capillary pressure (MICP)	Will provide pore size distribution curves, capillary entry pressure and to establish seal capacity (not suitable in heterogeneous seal)	On *samples from Eneabba Formation/Yalgorup Member.* Trim ends of 10 plugs from SCAL item 1. This is a destructive test. 2 plugs from the F10 fault set in H2 (trim-ends from SCAL item 1). Trims of 6 Krel samples (SCAL item 4). 18 samples in total
3.	Caprock and Reservoir	Geomechanical testing: Triaxial compression test with ultrasonic velocities (TXC)	The parameters measured are static/dynamic Young's Modulus, Bulk Modulus, Shear Modulus and Poisson's Ratio for rock stability	Use V plugs from P&P for the Wonnerup reservoir. This is a destructive test but the materials will still be available for other uses.
4.	Reservoir	Relative permeability	Drainage and imbibition and end point measurements for CO_2/water (brine) under high pressure and temperature	End point measurement for 4 horizontal plugs. Drainage and imbibition for 2 horizontal plugs. Plugs from porosity and permeability (P&P) testing will be used if suitable (RCA item 4)

Note: Versions 7 & 8 of this document include input from ODIN Consulting.

Document developed by Sandeep Sharma, in consultation with Tony Kenniard, Core Lab, 26 May 2015.

Reviewed by Louise Stelfox, 16 June 2015

Update to sample numbers (in yellow) advised by Tony Kenniard, Core Lab, 24 June 2015.