Harvey-2 Well Completion Report

South West Hub Carbon Capture and Storage Project

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1. Introduction

In late 2014, DDH1 Drilling Pty Ltd (DDH1), in conjunction with Drilling Contractors Australia (DCA) and RockWater Pty Ltd (RockWater), were awarded a contract by the WA Department of Mines (DMP) to drill and geologically log three wells in the Harvey area of the Perth Basin, approximately 150km south of Perth. The three vertical wells, Harvey-2, -3, and -4, were to be drilled as a part of ongoing investigations in the South West Hub Carbon Capture and Storage (CCS) Project – a joint endeavour by the Federal and WA State Governments, various research institutions and private industry.

DDH1 was appointed as lead contractor with overall site responsibility together with direct responsibility for drilling wells Harvey-2 and Harvey-3, both of which were to be continuously cored to estimated total depths of 1350 and 1550m respectively. DDH1's brief also included mud-rotary drilling an additional shallow (52m) monitoring hole adjacent to the Harvey-4 site.

DCA was subcontracted to drill Harvey-4 to an estimated total depth of 1800m, the bulk of which was to be drilled open hole with only limited core runs in zones of specific interest. DCA also completed a landholder water bore 1.2k from Harvey-2 site prior to commencement of the core drilling program.

RockWater was subcontracted to provide on-site hydro-geological logging services and supervision for all three holes and DDH1 engaged the Australian Mud Company to provide mud engineering services for the entire program.

Local field investigations and earlier drilling at Harvey-1 (Millar and Reeve, 2014) had determined that the strata were highly unlikely to be over-pressured or to yield hydrocarbon flows. However, as a precautionary measure, the drilling programs were undertaken using appropriate well control and mud systems.

This report summarises operational and technical aspects of the drilling program undertaken by DDH1 to complete Harvey-2. In particular, the report captures all drilling intervals and documents the drilling practise and mud engineering responses to the various issues encountered whilst drilling the well.

2. Specifications and Well Design

Well design for Harvey 2 was undertaken by DDH1 in consultation with DMP staff taking account of:

- the project's technical objectives and budgetary constraints,
- prior drilling experience at Harvey-1 (including a review of all drill reports, geophysical logs and inspection of core),
- environmental and safety considerations,
- original hole specifications (DMP Tender 120214 and subsequent revisions).

Hole specifications are shown in Table 1 and the planned *vs* actual well design and timeline is shown diagrammatically in Figure 1.

Table 1: Harvey-2 Well Specifications

Specification	Original (DMP Tender & revisions)	Final (on completion)
Dip:	-90°	-90°
Azimuth:	000°	000°
Total Depth:	1,400 – 1,500m	1350m
Minimum core size	PQ	PQ to 1237m, HQ to 1350m
Hole Orientation	Not required.	Not undertaken
Wireline Logging	To EOH	To 1350m
Casing	3 ½" carbon steel to EOH	3 ½" carbon steel to 440m and cemented
Completion	Plugged at base of casing	Plugged at base of casing

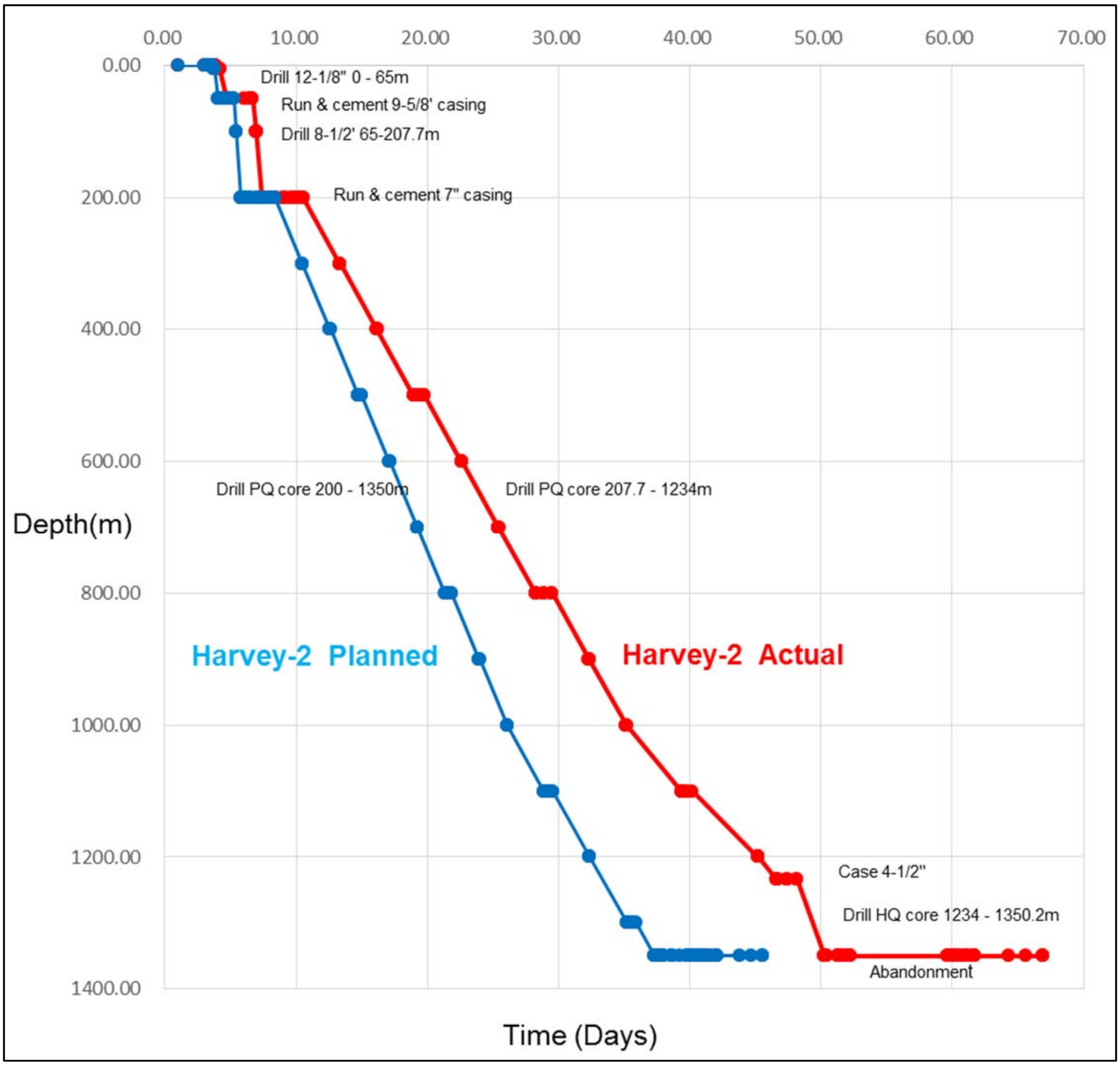

Figure 1: Harvey 2 Well Design and Timeline (Planned vs Actual)

3. Personnel and Equipment

Details of on-site equipment and personnel utilised in drilling Harvey-2 are shown in Table 2.

Table 2: Harvey-2 Site Equipment and Rig Personnel

Item	Detail
Rig	DDH1 Rig 16 (intrinsically safe Evolution 3000 with 70,000lb pullback)
Mud System	GN Solids (13,000l above-ground mud tank incorporating shakers, de-sanders, centrifuge, and mixers)
Mud Auxiliary	3,000l mud storage and mixing tank
Mud Power Supply	90 KVA generator
Water Source	New water bore (completed by DCA prior to commencement)
Water Storage	2 x 10,000l tanks
Well Control	4.5"annular diverter, closing unit and 30m flare line
Pumps	2 x on-rig FMC pumps (65 GPM at 1800 PSI) 1 x Gardner Denver THE pump (300 GPM at 900 PSI)
Site Infrastructure	DDH1 rig office/store caravan DDH1 geological logging / core photography and office unit Site mess and storage unit and site ablutions unit (pump-out) Security fencing and signage
Infrastructure power supply	25 KVA generator
Rig Lighting	2 x Allight lighting towers
Transport / Lifting	1 x 4t Telehandler 1x AWD fuel and crane truck 1 x 8WD site supply truck 1 x LV for crew transport
Site shifts	2 x 12-hour shifts (6.00 – 6.00) per day
Personnel	1 x Rig Supervisor 2 x Drillers (1 per shift) 6 x Drilling Offsiders (3 per shift) 1 x RockWater Geologist (per shift) Safety Officer (regular on-site visits ~80% attendance on site) 1 x Australian Mud Company Mud Engineer (~80% on-site attendance) Mechanic, on-site support as required

4. Daily Drilling Reports

Copies of the Harvey-2 Daily Drilling Reports are provided digitally in Appendix 1. Information from the reports has been utilised in preparation of the drilling summaries provided below.

5. Summary of Pre-Spud and Rig-Up Procedures (December 2 – December 5, 2014)

Drill pad preparation and access works were completed under the supervision of KD1 Pty Ltd (KD1) in November, 2014 and DDH1's drilling crew, rig and ancillary equipment arrived at the site on December 2. All crew underwent site inductions and participated in a review of safe-work procedures for rig-up operations which were completed on December 5. Harvey-2 drilling operations commenced the following morning after a Pre-Spud meeting involving all site personnel.

6. Summary of Drilling Operations (December 6 – March 4, 2015)

Conductor and Surface Casing (Tricone & blade, 12 1/8'' hole, 0 to 65m):

The Harvey-2 conductor hole was drilled with a 14" blade bit and bentonite base mud to a depth of 7.4m and steel 12 ¼" ID conductor casing was subsequently installed. A slight flow of fresh water emanated from the conductor drill hole, however this stopped when the conductor casing was cemented back to surface.

Dual-shift 24hr operations commenced the next day and the hole was progressed from 7.4m to 24m using a 12 ⅛" roller bit. During this interval it became apparent that at the circulation volumes required for such a large-diameter hole, the Solids Control Unit (SCU) could not maintain adequate cleaning of solids. To remedy this situation, the hole was subsequently progressed to the planned surface casing depth of 65m using an 8 ½" bit and reamed to 12 ⅛". A wiper run was then completed in preparation for running casing.

During casing operations, 9 ⅝" buttress casing with float shoe and centralizers was run to 64m and no backfill was encountered. Cementing operations utilised 2000ltrs of 15ppg cement slurry pumped with a displacement plug until cement slurry returns were observed at the surface.

Whilst waiting for the cement to cure, it was noted that the cement slumped and that fresh water started to flow to surface from the annulus between the 9 ⅝" and 12 ¼"ID conductor casing. A top-up cementing job (500ltrs @ 15.6ppg) initially stopped the water. However after some time, additional slumping was observed and water again flowed to the surface (albeit at a much reduced rate relative to the initial egress). A second top-up cement job (500ltrs @ 17.2ppg) was successfully completed with no slumping and the flow was completely contained. Ongoing monitoring for the drilling duration of Harvey-2 failed to find any evidence of renewed groundwater seepage.

Intermediate Casing (Mud rotary, 8 ½" hole, 65 to 206.5m):

The 8 ½" hole continued to plan and the intermediate casing depth of 206.5m was reached on 11/12/2014.

During the wiper run, 2.5m of backfill was encountered and the decision was made to drill a further 1m in order to accommodate the backfill and allow the casing to be landed at the correct height for the well control annular preventer.

The 7" BTC casing was run cleanly to depth and 3500ltrs of cement (@ 15ppg) was pumped and displaced with positive returns observed at surface. The displacement plug was bumped to 800psi and held for 30 minutes. No top-up cement was necessary for the 7" BTC intermediate casing job.

Single shift operations were subsequently implemented until 14/12/2014 when the remaining crew departed site for the Christmas break. The DDH1 crew returned to site 05/01/2015 and double shift operations re-commenced the following day.

The BOP was installed and BOP function tests and pressure tests completed before drilling the 7" shoe.

After successful Leak Off Test results were returned for the intermediate casing (pressures peaked at 400PSI - refer Figure 2), the rod line was reconfigured for subsequent coring.

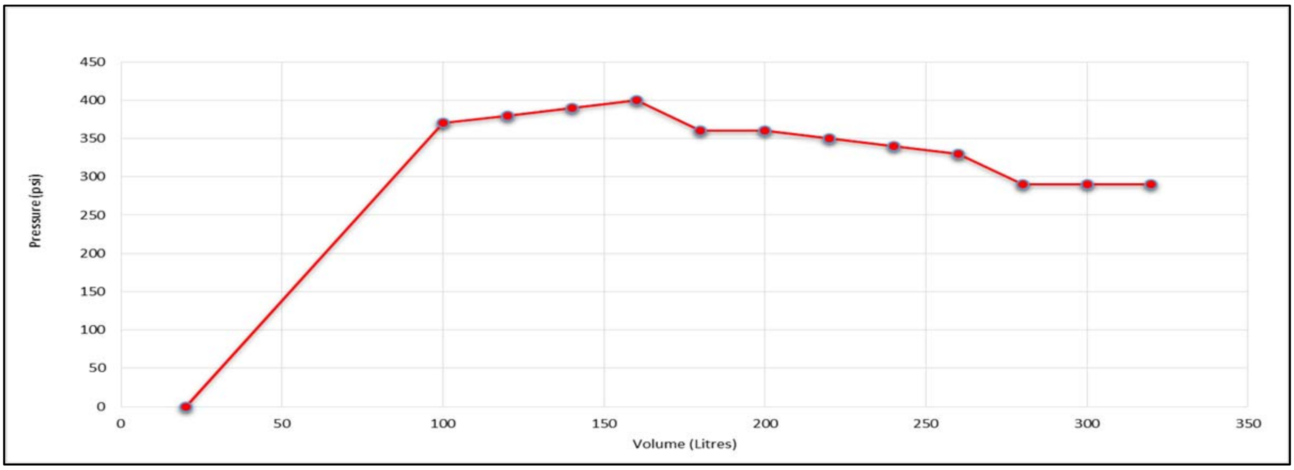

Figure 2: Harvey-2, Intermediate casing Leak Off Test results

PQ3 Coring (206.5 to 255m):

The initial 50m of PQ3 core drilling was in relatively soft and friable sandstone and throughout this interval considerable core-loss occurred. Several different methodologies were trialled including changing bit designs, reamer clearances, inner tube clearances, mud viscosity, pump rates and drilling techniques and core recovery was improved to + 95%.

PQ3 Coring (255 to 410.4m):

During this interval, core recovery was maintained at almost 100%. However a large build-up of filter/wall cake on cores resulted in undersized core and this, together with the amount of scraping and washing required to remove the filter cake, resulted in less-than-optimal core presentation.

Down-hole backfill and deteriorating hole conditions required increasing amounts of back reaming. After some consideration, the mud regime was changed from the initial AMC-recommended Shale Hib /CoreWell system to a more conventional Salt polymer (KCl/Pac R) system. The new formula increased mud weight and immediately improved hole stability, core recovery, core presentation and reduced circulating pressures and drill-string torque.

PQ3 Coring (410.4 to 603.4m):

Excellent core recovery was maintained throughout this section and operations continued to plan. Four bit changes were completed and drill-pipe tripped at 603.4m to run a Carbonaro surface-set step bit.

PQ3 Coring (603.4 to 666.4m):

At 615.1m, a pressurised shear was intersected. The hole was stabilised and progressed to 618m before pumping 180ltr of 14.5ppg cement through the core barrel to successfully stabilise this zone. At 666.4m the 3m core barrel used to drill out the cement was replaced with a 6m core barrel.

PQ3 Coring (666.4 to 922m):

During this interval, coring was maintained at a reasonably steady rate. However lost circulation material (LCM) was required to seal the coarser sandstone horizons that were regularly encountered at the interface of sandstone and mudstone layers. Increased mud weights (to 9.8-10ppg) were found to improve hole stability and minimise the amount of reaming required.

PQ3 Coring (922 to 1233.4m):

No significant issues were encountered in the interval 922 to 1233.4m.

PQ3 Coring (1233.4 to 1233.7m):

After completing a bit change at 1233.4m, difficulties were encountered whilst returning to bottom. Numerous zones (especially at 1032m, 1062.3m, 1138.2m and 1168.3 to 1182.3m) had become unstable and required significant amounts of reaming to allow the string to pass.

Once the barrel was washed to bottom and circulated prior to drilling, the core run was recommenced. However, coring was stopped 300mm into the run due to indications that the inner tube was blocked with backfill. The rods were retracted 6.4m off bottom and the inner-tube was pulled, however, when the head was reconnected the drill pipe was stuck and circulation was limited. The drill-pipe and core barrel became stuck 6.4m off bottom at 1227m.

On 13/02/2015, fishing operations commenced to free the drill-pipe however the crew were unable to work the rods free. An HQ rod line was delivered to site to run inside the PHD drill-string and the PQ inner tube was retrieved by drilling into it with the HQ core barrel. An additional attempt to recover the entire stuck rod line was made using a specialist oil-field actuating jar (recommended and supervised by Weatherfords), but this proved unsuccessful.

<u>HQ Coring (1233.7 to 1350.2m, TD)</u>:

On 16/02/2015, drilling re-commenced using a smaller HQ core barrel and HRQ drill-string (with the stuck PHD drill-string effectively acting as casing for the deteriorated wall rock sections within the hole).

Coring progressed to 1317.8m, at which point the HQ assembly became stuck after retrieving an inner tube of core from the Wonnerup Formation. Circulation was maintained and the likely cause was assessed as differential sticking. After extended flushing, the drill-pipe was freed by the use of dual pull using both the top drive and the main winch in unison.

Drilling was completed on22/02/2015 when Harvey-2 reached the planned total depth of 1350.2m

7. Wireline Logging

Wireline logging operations were undertaken by Haliburton on 22/2/2015 and 23/2/2015. The entire hole to 1350m (including the HQ section) was logged successfully.

8. PQ Rod Line Retrieval

On 23/02/2015, cutting operations commenced to retrieve the stuck PHD string. Six cuts were undertaken as follows:-

- Cut 1, 1180m: Unsuccessful in retrieving any drill pipe.
- Cut 2, 1130m: Although apparently successful (circulation was observed at surface indicating that the casing had been cut), it was still impossible to move the PHD drill pipe (indicating differential sticking further up hole). In an attempt to release the differentially stuck pipe, a hole sweep of Well Clean, Aus-Det, Penetrol and Potassium Chloride was undertaken. The sweep effect was positive and 1 metre of stretch was gained, however the pipe still remained immovable.
- Cut 3, 900m: No improvement or further movement of stuck pipe.
- Cut 4, 720m: No improvement or further movement of stuck pipe.
- Cut 5, 600m: The pipe was freed and was able to be lifted. Freshly weighted mud was circulated and the casing sat back on the cut casing to enable abandonment process to take place. However, after installing the bottom hole (abandonment) cement and connecting back up to the cut, the PHD casing was unable to be moved. It was apparent that once full circulation had been restored, the formation had rapidly deteriorated and the casing had become differentially stuck again.
- Cut 6, 550m: After successful freeing up of the drill pipe, a CWBP Van Ruth plug was placed in the hole at 550m and covered with a 20mtr 14ppg cement plug. The remaining 550m of the PHD string was retrieved on 2/3/2015 using the top drive in conjunction with the main winch.

9. Abandonment

Completion casing (3 ½" BTC) was run with no obstruction to 410m. However, at this point the casing became tight in the hole and was unable to be advanced past 414.6m. The casing was grouted (with grout returns observed at surface) and the hole was finally capped and abandoned on 5/3/2015.

10. Mud Program

As mentioned previously, AMC was contracted to provide product and mud engineering services for the entire Harvey drilling program including:

- Pre-drill test work on historic samples from drill hole Harvey-1 with a view to designing and costing the most appropriate drilling fluids for the current program,
- Ongoing monitoring and technical support during drilling activities at Harvey-2, -3 and -4,
- A review of the effectiveness of the various mud programs with the aim of informing future drilling in the Harvey sequestration project.

AMC's Harvey-2 Drilling Fluid Summary Report is included herein as Appendix 2 and summary comments drawn from it and from DDH1's experience are listed below:

- At Harvey-2, the extended drilling timetable added considerably to drilling fluid costs.
- Fluid shear stress and polymer break down is proportional to total circulation time. The extended drilling timetable required additional product to ensure fluid properties were maintained to specifications.
- The initial program recommended a CoreWell/Shale Hib base which proved less effective than indicated by pre-program testing. The CoreWell/Shale Hib system was replaced with a KCl/PAC R system at 409m.
- The change to KCl was made to offset increasing amounts of backfill during rod pulls, intermittent dropping of core and increasingly poor core presentation (which had become dirty and difficult to remove from the splits). After changing to KCl, the backfill reduced and the core became cleaner. Core recovery was similar with both fluid types. The addition of KCl assisted with sidewall stability via hydrostatic pressure.
- The initial KCl/PAC R system was run at 10% KCl (~50,000 ppm chlorides) with a mud weight SG 1.1 (9.2 – 9.3 lb/gal).
- Chloride concentrations varied 45,000 to 70,000ppm on average. Variations were partly due to individual testing techniques and the timing of sample collection.

- Subsequently the mud weight was increased and kept constant at around SG 1.13 (9.4 – 9.5 lb/gal).
- At approximately 1100 m, the PQ pipes became stuck (14/2) and the hole began to flow which diluted the system.
- To maintain hole stability, mud weight was increased to SG 1.22 (10.2 lb/gal) with chloride content of 110,000 – 127,000ppm and was kept consistent to the end of the hole at 1350.2m.

11. Bit Record

A summary of bit usage throughout the hole is provided in Table 3. Bit changes were particularly frequent at the start of the coring program when attempts were made to determine the optimal bits for drilling progress and for core recovery. Bit changes were also frequent when difficulties were encountered trying to cut particularly hard / abrasive formations and/or when formations were varying rapidly. Maximum cutting performance and core recovery was achieved using surface-set internal discharge step bits with large protruding diamonds.

12. Community Engagement

In consultation with clients, DDH1 seeks to positively engage with community stakeholders on all drilling projects. Working collaboratively with DMP and KD1 staff at Harvey-2, DDH1 sought to:-

- establish and maintain good relations with local land-owners,
- locally source accommodation and messing (rather than bringing the company's camp onto site),
- purchase most non-drilling consumables from local suppliers,
- engage local tradespeople and services whenever possible (e.g. electrical, mechanical, engineering, cementing, some transport, etc.),
- facilitate safe rig site access for client-hosted Open Days and Site Visits,
- minimise traffic, dust, noise, stock disturbance, etc., both at the rig site and on local roads,
- address any concerns promptly and respectfully,
- maintain a clean, tidy, secure and safe work site,
- minimise environmental disturbance at all times.

Table 3: Harvey-2, Summary Bit Record

Date	From (m)	To (m)	Interval* (m)	Size	Type	Style	Serial No.	Brand	Formation (Downhole Interval)
6/12/2014	0.0	7.4	7.4	8½"	Tricone	TCI	710170/8		Leederville Fm (0-135m)
6/12/2014	0.0	7.4	7.4	14"	Blade	4 wing	24111978		
7/12/2014	7.4	65.0	57.6	8½"	Tricone	TCI	710170/8		
7/12/2014	7.4	65.0	57.6	12⅛"	Tricone	Milltooth	10925336		
9/12/2014	65.0	206.5	141.5	8½"	Tricone	Milltooth	3210321		
6/01/2015	206.5	207.7	1.2	4⅞"	Tricone	Milltooth	F209013	AMS	Eneabba Fm (135-419m)
6/01/2015	207.7	208.4	0.7	PQ3 core	Impreg	HA9	31591/05	Hayden	
6/01/2015	208.4	210.8	2.4	PQ3 core	PCD	TSP	1A9015	Dimatec	
7/01/2015	210.8	214.7	3.9	PQ3 core	Impreg	8:10	133886	Hardcore	
7/01/2015	214.7	231.4	16.7	PQ3 core	PCD	TSP	1A9015	Dimatec	
7/01/2015	231.4	234.4	3.0	PQ3 core	PCD		139152	Hardcore	
8/01/2015	234.4	246.1	11.7	PQ3 core	Surf Set		HD0264/3	Hayden	
8/01/2015	246.1	403.7	151.3	PQ3 core	Surf Set	15/25	101-01	AMS	
12/01/2015	403.7	409.1	5.4	PQ3 core	PCD	TSP	1A9015	Dimatec	
13/01/2015	409.1	458.3	49.2	PQ3 core	Surf Set		1132737	Asahi	Yalgorup Mbr (419-1245m)
14/01/2015	458.3	489.6	31.3	PQ3 core	Surf Set		1369173	Asahi	
15/01/2015	489.6	491.5	1.9	PQ3 core	PCD		139154	Hardcore	
16/01/2015	491.5	548.4	57.7	PQ3 core	Surf Set		HD0264.3	Hayden	
17/01/2015	548.4	600.4	52.0	PQ3 core	Surf Set		1416107	Asahi	
19/01/2015	600.4	663.1	62.7	PQ3 core	Surf Set	Carbarna	2B2463	HMI	
23/01/2015	663.1	678.1	15.0	PQ3 core	Surf Set		1010962	Asahi	
24/01/2015	678.1	919.1	241.0	PQ3 core	Surf Set	Carbarna	2B2462	HMI	
1/02/2015	919.1	971.9	52.8	PQ3 core	Surf Set	Carbarna	2B2463	HMI	
4/02/2015	971.9	1233.9	262.0	PQ3 core	Surf Set	Carbarna	2B2460	HMI	
12/02/2015	1233.9	1234.0	0.1	PQ3 core	Surf Set	Carbarna	2B2463	HMI	
16/02/2015	1234.0	1242.3	8.3	HQ core	Impreg	HA9	32104/03	Hayden	
17/02/2015	1242.3	1244.4	2.1	HQ3 core	Surf Set		51313.2	SDS	
17/02/2015	1244.4	1276.2	31.8	HQ3 core	Impreg	SC10.3	1094834	Craelius	Wonnerup Mbr (1245-1351.2m)
19/02/2015	1276.2	1351.2	75.0	HQ3 core	Impreg	4:06	36847/1	Hayden	

*** Bit Interval Colour Code :** 0-5m 5-10m 10-25m 25-50m >50m

13. Discussion of Outcomes

To date, most deep drill holes in the variably consolidated sedimentary rocks of the Perth Basin have been completed for oil and gas targets using large-scale oil-field rigs and rotary mud drilling techniques with only limited core runs in zones of specific interest. The first hole in the South West Hub CCS Project, Harvey-1, was drilled in this manner (Millar and Reeve, 2014).

The requirement for continuous, large-diameter core to depth in Harvey-2, as an integral part of ongoing research in the South West Hub CCS, provided an innovative opportunity for the application of continuous wireline coring drilling techniques using a heavy-duty slim-hole rig of the type more conventionally used in the mineral exploration sector. DDH1’s Rig 16, an intrinsically safe Evolution 3000 with upgraded pull back capacity, in tandem with the GN solids mud system were well suited to this task.

Impressions gained from pre-start inspection of the restricted cored intervals from Harvey-1 formed an integral part of the Harvey-2 well design and drilling plan. However, in practise, lithologies encountered in the Wonnerup and Yalgorup Formations in Harvey-2 were harder and more abrasive than expected. It is not known whether the differences are related to inherent variability in the sedimentary pile or whether they are related to increased secondary silicification – perhaps due to increased faulting /fracturing the vicinity of Harvey-2. Locally intense ferrugunisation effects were also noted throughout much of the core and may have contributed to variabilities in down-hole competency.

Other formation features (essentially confined to the Yalgorup and Wonnerup Members) that presented some drilling issues included:

- at the local scale, porous and permeable very coarse to gritty sandstone beds (requiring sealing with LCM) in contact with significantly finer-grained horizons (with potential for swelling clays),
- more friable horizons with potential for wash-out and caving,
- at the larger scale, the transition from the Yalgorup to Wonnerup Members (with potential for differential sticking largely related to differential clay components).

Formation variability combined with very hard and abrasive characteristics meant that, relative to the original Harvey-2 hole plan, the rate of progress (ROP) was (unavoidably) slower than anticipated (Figure 1) and that more-than-expected bit changes and rod-line trip-outs were required. Extended drilling times and increased down-hole mechanical activity result in lengthened exposure times to drilling fluids and annular pressures which, for time-sensitive formations, can lead to significant deterioration.

In Harvey-2 critical attention to adequately inhibited and correctly weighted drilling mud was largely successful in stabilising the hole. However, after the delays incurred with the irretrievably stuck rod line at 1227m (close to the critical Wonnerup to the Yalgorup Formation interface) and with multiple pipe-cutting attempts, it was obvious that the entire cored section was breaking down and very prone to differential sticking.

Features inherent in wireline coring equipment (e.g., small annulus and a high wall contact area) increase differential sticking potential in susceptible lithologies and once a wireline rod string becomes stuck it is more difficult to free than a conventional drill string. It is unlikely that the formations encountered in Harvey-2 would have posed similar sticking issues if drilled using conventional rotary-drill techniques. In the latter there is no need for stationary drill-pipe or swabbing whilst retrieving wireline core and increased annular clearances and penetration rates reduce the contact and time-exposure of potentially problematical rock types.

Whilst it was disappointing that the entire hole could not be completed in PQ3 core, the inherent flexibility of the wireline coring system and the ability to reduce to HQ core still enabled full core coverage of the rock record in Harvey-2. Destructive rotary-mud drilling techniques could obviously not have achieved this outcome.

Notwithstanding the challenges encountered in drilling Harvey-2, successful completion of the well to target depth endorses slimhole wireline continuous coring as a viable drilling technique in the young and variably-consolidated sediments of the Perth Basin. Harvey-2 demonstrated that the enhanced geological and geotechnical information that only core can provide is achievable in these types of sequences.

The pro-active and collaborative approach by all parties involved in Harvey-2 contributed not only to the technical success of the program but also to the maintenance of good community relations throughout drilling program.

14. References

Millar, AS and Reeve, J, 2014. GSWA Harvey 1 Well completion and preliminary interpretation report, southern Perth Basin, GSWA Record 2014/12.

APPENDICES

APPENDIX 1: Harvey-2 DDH1 Daily Drilling Reports (provided as digital copy only)

APPENDICES

APPENDIX 2: Australian Mud Company Harvey-2 Drilling Fluid Summary Report

Harvey-2
Drilling Fluid Summary Report

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ATTACHMENTS

1. Introduction

In September, 2014, the Australian Mud Company (AMC) was engaged by DDH1 Drilling to provide technical support and ongoing mud supplies for deep drill holes Harvey-2, -3 and -4 in the South West Hub Carbon Capture and Storage (CCS) Project.

AMC's brief was to provide:-

- Pre-drill test work on historic samples from drill hole Harvey-1 with a view to designing and costing the most appropriate mud program(s) for Harvey 2, 3 and 4,
- Ongoing monitoring and technical support for holes Harvey-2 and -3 (to be cored by DDH1 Drilling) and Harvey-4 (to be rotary drilled by Drilling Contractors Australia with limited coring intervals),
- Mud product supply,
- A review of the effectiveness of the various mud programs with the aim of informing future drilling in the Harvey sequestration project.

This report describes AMC's input into those programs.

2. General Design Principles for the Drilling Fluids Program

In designing the Harvey Project mud programs, AMC considered the following issues:

- Geotechnical characteristics of likely down-hole formations including formation integrity,
- Choice of the most effective fluid(s) to stabilise down-hole conditions with appropriate parameters to address encapsulation, inhibition and filtration control,
- Analysis of on-site "make-up" water,
- Ease of use of the selected fluid(s),
- The need to minimise costs (without adversely impacting fluid effectiveness),
- The need to minimise any potential environmental impacts of the fluids used,
- Ease of disposal of mud products at the completion of the program.

3. Harvey-1, Data Review and Geotechnical Testwork

A review of the well completion report for Harvey -1, drilled in 2012, showed that the well was initially drilled with a basic Gel / PHPA system. It was evident from the recap that the integrity of the hole had been compromised due to the fact no inhibitive fluid was used.

To further address these issues, samples from some of the more challenging sections in Harvey-1 were collected from the GSWA Perth Core Library and forwarded to AMC' Perth Laboratory for further analysis. The sampling program encountered some difficulties in finding cutting samples that could be could be considered truly representative of the broader formation intervals and were also sufficiently stable and of sufficient volume to conduct meaningful laboratory tests.

Immersion and integrity tests of the samples were conducted in two stages in September and November, 2014. Sample intervals and test fluid combinations for the programs are shown in Table 1 and Attachments A and B provide photographic records of the test work observations over zero, 3-hour and 72-hour intervals.

Table 1: Sample intervals and fluid combinations selected for Phase 1 and Phase 2 test work on historic Harvey-1 cuttings and core

	AMC Test 1 (cuttings only) (September, 2014)	AMC Test 2 (sectioned core samples) (November, 2014)
Sample Interval	H1 1269 to 1270m H1 1270 to 1272m H1 1276 to 1278m H1 1333 to 1334m Box 4, 5, 13, 14, 15, 16, 17.	495 to 510m 675 to 690m 1210 to 1215m 1225 to 1230m 1270.7m 1277m 1333.3m 1340 to 1345m
Test Fluid Combinations	Solution 1: 1.5kg COREWELL + 3kg PAC L + 1% SHALEHIB ULTRA Solution 2: 2.5kg PAC R + 3kg PAC L + 3kg CLAY DOCTOR + 1% SHALEHIB ULTRA	Blank: (Water) Mud 1: 20kg Aus-Gel +3kg PAC R +4kg PAC L + 4%KCl Mud 2: 20kg Aus-Gel +3kg PAC R +4kg PAC L + 8%KCl Mud 3: 2.5kg PAC R +3kg PAC L + 8kg Clay doctor + 3%KCl Mud 4: 2.5kg PAC R +3kg PAC L + 8kg Clay doctor + 1% SHALEHIB Mud 5: 1.5kg COREWELL + 1% SHALEHIB + 3kg PAC L

Results from both phases of test work (refer Attachments A and B) showed that the clays encountered in Harvey-1 were more dispersive than swelling in nature. The best containment results came from AMC's CORE-WELL based system, which is a premium encapsulating agent.

4. "Make-Up" Water Analysis

In addition to formation integrity testing, the "make-up" water to be used in the mud program from the on-site, purpose-drilled water bore was analysed with results as follows:

- pH 6 - 7,
- Total Hardness: 250 mg/l,
- Chlorides: 1900 mg/l.

5. Drilling Fluid Proposal

AMC's final drilling fluid proposal envisaged a two component program as follows:

- For the rotary pre-collar section - a conventional gel/polymer mix was recommended to give the best hole cleaning characteristics and to allow good filtrate control as well as hole stabilisation
- From the start of coring, utilisation of the CORE-WELL based clay-inhibiting system were recommended with KCl included as an ancillary item (at lower properties that used in Harvey 1). The rationale was that the proactive approach to protecting the formation would reduce the percentage of KCl required to control the formation. A contingency was also allowed in the mud program for adding a weighting agent (Sodium Chloride) to the system to obtain a mud weight similar to that of Harvey-1 if needed.

Mud 5 from the second geotechnical test program (i.e., 1.5kg COREWELL + 1% SHALEHIB + 3kg PAC-L) was selected as the drilling fluid of choice for the cored section of the well.

In addition to the system's superior encapsulating properties, it also had potential environmental benefits of limiting of chloride addition to ground-water. The lower chloride content would also result in greater ease and reduced costs of disposal at conventional refuse facilities.

Although the COREWELL (powder), SHALEHIB (fluid) and PAC-L (powder) mud system was a three-part mix, reduced product volumes and reduced corrosive character were considered advantageous and less onerous to mix than to chloride-based system.

After completing Harvey-2, the fluid system would be reassessed and, if necessary, revised for the Harvey-3 well.

6. Mud Program Operations

6.1 Pre-Collar Section (0-208m)

Depth / Hole Size/ Date	:	0-65m / 12⅛" (6/12/14 - 7/12/14) & 65-208m / 8½" (9/12/14 - 12/12/14)	
Mud Type	:	Gel/Polymer (as per AMC proposal)	
Fluid system used	:	Soda Ash	0.5 kg/m³
		AUS GEL XTRA	15 – 20 kg/m³
		AMC PAC L	2.0 – 3.0 kg/m³
		AMC PAC R	1.5 – 2.0 kg/m³
		SODIUM BICARBONATE	2.0 kg/m³ pre-treatment

The 12⅛" and 8½" sections were completed successfully with no anomalies recorded (refer Table 2). Both cemented sections were drilled out with as per the proposed fluid system that was pre-treated with sodium bicarbonate.

The mud weight started to increase towards the end of the 8½" section due to an increase of solids being incorporated into the fluid system. This was controlled by dumping 4000 litres of fluid and then diluting with water.

Once the intermediate casing was cemented, the fluid system was dumped and the solids control unit cleaned.

Table 2: Fluid Properties for Harvey-2 Pre-Collar Section, 0-208m

Date	Bit Diam. (")	Depth (m)	Viscosity	Mud Weight		PV	YP	pH	Filtrate	Chlorides
				SG	PPG					
6-Dec	8½	34	38	1.05	8.7	12	6	8	14	1900
7-Dec	12⅛	64	40	1.06	8.9	12	8	9	10.4	1900
10-Dec	8½	102	38	1.11	9.2	13	4	11	10.8	2000
10-Dec	8½	118	41	1.14	9.5	15	10	10	12	2100
11-Dec	8½	189	42	1.1	9.2	14	12	9	7.6	2100

6.2 Cored Section (208-409m)

Depth / Hole Size/ Date	:	208-409m/PQ (6/01/15- 13/01/15)	
Mud Type	:	Amine/PHPA, PAC/KCl (as per AMC proposal)	
Fluid system	:	Soda Ash	0.5 kg/m³
		AMC PAC L	3.0 – 4.0 kg/m³ (Filtration control)
		COREWELL (PHPA)	1.0 – 1.5 Kg/m³ (Encapsulation)
		SHALEHIB ULTRA (Amine)	10 – 20 lt/m³ (Inhibition)

Once coring commenced, early drilling progress was encumbered by the process of determining the optimum bit, reamer and barrel combination for drilling in the type of formations encountered (Table 2). At the same time, there was evidence of formation de-stabilisation and less-than-optimal hole clearing.

Table 3: Summary of Drilling Activity, Harvey-2 PQ Core Interval, 208-409m

Depth (m)	Date & Shift	Action / Hole Conditions
219	7/1 Day	Pull out and changed bit
231	7/1 Night	Pull out and changed bit
240	8/1 Day	Pull out and changed bit
252	8/1 Night	Pull out and reconfigured barrel
276	9/1 Day	Changed reamer and encountered 0.9 backfill on re-entry
300	9/1 Night	Pulled out, Stuck tube 0.6m backfill on re-entry
369	11/1 Night	Slight sludging occurred; decision was made to dump 3000 litres of fluid to reduce solids. PHPA reintroduced to system
404	12/1 Night	Pulled out to change bit, rods hung up at 270 metres. Pipes were reamed to 282m.
409	13/1 Day	Pulled out to change bit. On re-entry the rods hung up at 150m from bottom and the inner tube was full of cuttings. Reamed BHA 100m to bottom. Fluid system changed.

After the initial mix, DDH1 requested that AMC PAC R was used instead of COREWELL. The PAC R was used at the same mixing ratios as the PHPA. Due to the slight rise in the mud weight and the concerns of sludging (end of day shift, January 11), COREWELL was re-introduced into the system to try and improve the cutting integrity. The addition rates were at 1kg over an hour period. This was done so that the flocculation of the colloidal particles already in the system was kept to a minimum.
A summary of drilling fluid properties in the interval 208 to 209m is shown in Table 4.

Table 4: Fluid Properties for Harvey-2 PQ Core Interval, 208-409m

Date	Bit Diam. (")	Depth (m)	Viscosity	Mud Weight		PV	YP	pH	Filtrate	Chlorides
				SG	PPG					
8-Jan	PQ		42	1.01	8.4	10	4	8.5	20.8	2200
8-Jan	PQ	231	45	1.01	8.4	13	9	9	20	2200
9-Jan	PQ	250	41	1.01	8.4	10	4	9	13	2100
10-Jan	PQ	310	40	1.02	8.5	9	1	9	11	2530
10-Jan	PQ	316	43	1.02	8.5	11	2	9	7.8	2300
10-Jan	PQ	325	44	1.02	8.5	10	1	9	10.4	2300
11-Jan	PQ	351	42	1.03	8.6	11	3	9	7.8	2300
11-Jan	PQ	358	42	1.03	8.6	9	2	9	9	2500
11-Jan	PQ	369	43	1.01	8.4	9	1	9	10	2500
12-Jan	PQ	398	40	1.01	8.4	9	1	9	12	2500
13-Jan	PQ	400	40	1.02	8.5			9	9	2400
13-Jan	PQ	406	42	1.02	8.5	9	4	9	8.4	2500

The stability of the hole continued to be an issue and there were concerns raised about the "eroded" nature of the core presentation. It was also noted that the formation in this portion of the well was "stickier" than anticipated and not as hard as had been expected from the original inspection of Havey-1 samples.

At end of day shift on January 13, after consultation between AMC and DDH1 site representatives, DDH1 requested that the fluid system be changed to a more conventional weighted mud system with KCl as the principle weighting agent. Operations using the revised mud system are discussed below.

6.3 Cored Section (409-1350m)

Depth / Hole Size/ Date	:	409 - 1234m/PQ (13/01/15 - 15/02/15),	
	:	1234 - 1350.2m/HQ (16/02/15 - 21/02/15).	
Revised Mud Type	:	Weighted PAC/KCl (initially 9.2 lb/gal in the PQ section but later increased to 10.2 lb/gal in the HQ section).	
Revised Fluid system	:	Soda Ash	0.5 kg/m^3
		AMC PAC L	3.0 – 4.0 kg/m^3
		AMC PAC R	2.0 – 2.5 kg/m^3
		KCl	100.0 kg/m^3

Table 5: Revised Mud System Fluid Properties for Harvey-2 Core Interval, 409-1350.2m

Date	Bit Diam. (")	Depth (m)	Viscosity	Mud Weight		PV	YP	pH	Filtrate	Chlorides
				SG	PPG					
14-Jan	PQ	412	44	1.1	9.2	13	4	9	7.2	64000
14-Jan	PQ	429	40	1.1	9.2	9	2	9	6.8	53500
15-Jan	PQ	458	42	1.1	9.2	10	2	9	6	50000
16-Jan	PQ	489	42	1.11	9.25	12	2	9	6	65000
16-Jan	PQ	490	42	1.11	9.25	12	1	9	7.2	54000
16-Jan	PQ	495	42	1.12	9.3			9	5.4	65000
17-Jan	PQ	522	43	1.12	9.3	11	3	9	5.6	59000
18-Jan	PQ	545	43	1.12	9.3	19	5	9	5.2	58000
19-Jan	PQ	582	43	1.12	9.3	23	7	9	4.2	54000
20-Jan	PQ	606	43	1.11	9.25	21	2	9	4.6	54000
22-Jan	PQ	626	42	1.1	9.2	21	7	9	7.8	58000
23-Jan	PQ	680	43	1.1	9.2	17	7	9	6.8	66000
24-Jan	PQ	664	44	1.11	9.25	18	6	9	7	54000
25-Jan	PQ	676	43	1.11	9.2	21	8	9	5.8	64000
26-Jan	PQ	700	45	1.14	9.5	22	8	9	6	54000
29-Jan	PQ	815	43	1.13	9.4	17	5	9	5.2	51000
2-Feb	PQ	919	43	1.13	9.4	17	4	9	5.6	45000
4-Feb	PQ		43	1.15	9.6	21	4	9	4	47000
5-Feb	PQ	989	42	1.15	9.6	20	7	9	5.2	44000
6-Feb	PQ	1007	43	1.15	9.6	20	2	9	4.8	45000
7-Feb	PQ	1046	43	1.16	9.65	20	6	9	4.4	47000
8-Feb	PQ	1090	42	1.16	9.7	20	6	9	5	45000
9-Feb	PQ		44	1.16	9.7	20	6	9	4.4	40000
10-Feb	PQ	1175	45	1.17	9.8	22	4	9	5	40000
11-Feb	PQ	1203	43	1.17	9.8	23	4	9	4	43000
12-Feb	PQ	1228	43	1.16	9.7					
13-Feb	PQ		44	1.16	9.7	20	4	9	4	49000
16-Feb	HQ		42	1.2	10	17	7	9	4.2	91000
17-Feb	HQ	1242	43	1.22	10.2					
18-Feb	HQ	1256	46	1.22	10.2	20	5	9	3.6	110000
19-Feb	HQ		44	1.22	10.2	23	10	9	3.8	111000
20-Feb	HQ	1293	44	1.22	10.2	23	7	9	4.4	113000
21-Feb	HQ		44	1.23	10.25	22	10	9	4	127000

Fluid properties of the revised KCl mud mix over the rest of the Harvey-2 hole are shown in Table 5. The change in mud led to the increased use of AUS DET XTRA in place of PENETROL XTRA; at an addition rate of 25 litres/ 12hr period or as needed.

As drilling progressed, fluid losses beyond that of hole volume became apparent and Magma Fibre (lost circulation material) was slowly incorporated into the system at a feed rate of 25lb over a 3 shift period. Additional fluid was also being added at a rate of 1500 to 4000 litres/shift, depending on the fluid losses (Table 6). The added fluids comprised either water or a light concentration of 6% KCl with a view to maintaining consistent viscosity, mud weight parameters and to controlling the increasing levels of colloidal solids. When it was considered that the solids content was increasing beyond a safe operating level, the volume on the surface was dumped and replaced with fresh fluid. This ranged from 8 to $20m^3$ of fluid.

Table 6: Fluid Additions whilst Drilling with the Revised Mud System

Fluid Additions		
Fluid Added (litres)	Water Added (litres)	Fluid Dumped (litres)
80150	10300	38000

At 1234m the PQ pipe became stuck and after several attempts to remove the pipe, the hole was reduced to HQ. Coincident with the core size reduction, DDH1 requested that the mud weight be increased to 10.2 lb/gal, running a 22% KCl system. This mud system was maintained for the remainder of the drilling program until successful completion at TD 1350.2m.

7. Materials Consumption and Cost Analysis of the Harvey-2 Drilling Fluid Program

A review of programmed vs actual materials consumption in Harvey-2 is presented in Table 7 and overall variance in costs for the original (un-weighted) and revised (weighted) programs is shown in Table 8. The overall increase in hole costs can be attributed to:

- The increased length of time on the hole, which increased fluid consumption through losses (approximately 2000 litres/day throughout the hole),
- Higher than expected formation pressure which was likely to have accentuated fluid losses in more permeable zones.

- Increased pressurisation which necessitated the change from the initial un-weighted mud system to a weighted mud system. Mud weights were increased from 8.5 lb/gal to 9.2 lb/gal from 406 metres and then again at 1234m to 10.2 lb/gal.

- The change from Sodium Chloride to more expensive Potassium Chloride as a weighting agent.

- A higher retention of solids than expected which caused an increase in product usage through depletion and additional fluid dumping (38,000 litres)

*Table 7: Harvey-2, Programmed vs Actual Materials Consumption and Costs**

Product	Unit Size	Unit Cost	Programmed Units	Programmed Costs	Actual Units	Actual Costs	Cost Variance
SODA ASH	25kg	$22.95	3	$68.85	6	$137.70	$68.85
AUS GEL XTRA	25kg	$17.50	38	$665.00	10	$175.00	-$490.00
PAC R	25kg	$157.50	8	$1,260.00	34	$5,355.00	$4,095.00
PAC L	25kg	$157.50	28	$4,410.00	53	$8,347.50	$3,937.50
COREWELL	15kg	$185.40	14	$2,595.60	6	$1,112.40	-$1,483.20
SHALEHIB ULTRA	25kg	$ 153.00	32	$4,896.00	43	$6,579.00	$1,683.00
PENETROL XTRA	25L	$79.20	4	$316.80	11	$871.20	$554.40
SODIUM BICARBONATE	25kg	$24.19	3	$72.57	2	$48.38	-$24.19
POTASSIUM CHLORIDE	25kg	$24.50	167	$4,091.50	820	$20,090.00	$15,998.50
SODIUM CHLORIDE	25kg	$12.46	884	$11,014.64	0	$0.00	-$11,014.64
AUS DET XTRA	25L	$76.39	10	$763.90	47	$3,590.33	$2,826.43
MAGMA FIBRE	40lb	$98.50	5	$492.50	21	$2,068.50	$1,576.00
LIQUISPERCE	25kg	$137.54	10	$1,375.40	0	$0.00	-$1,375.40
AUSPLUG	8kg	$76.39	5	$381.95	0	$0.00	-$381.95
Totals				**$32,404.71**		**$48,375.01**	**$15,970.30**

NB: Programmed quantity includes weighting agent (NaCl) and inhibitor (KCl) from the weighted program)

*Table 8: Harvey-2, Summary of Cost Variance for the Original (Un-Weighted) and Revised (Weighted) Mud Programs**

Cost Base	Original (Unweighted) Mud Program	Revised (Weighted) Mud Program
Programmed	$ 17,604.55	$ 28,727.02
Actual	$ 48,341.07	$ 48,341.07
Variance	$ 30,736.52	$ 19,614.05

** Costs relate to only the products that were used on site during the drilling process.*

8. Conclusions and Recommendations

Based on the results of the Harvey-2 drilling program, the following recommendations are made in relation to drill fluid support for future core drilling programs in the Harvey Carbon Sequestration Project:-

- Use an inhibitive system from the start of the hole, either KCl or an amine based product,
- If possible include a PHPA in the fluid system to assist with cutting integrity and to assist with the removal of excess fines,
- Run a weighted system from the start of the coring section and to reduce costs NaCl could be used.
- Monitor seepage losses and correlate to increases in mud weight to assist in controlling over-pressurization and use lost circulation material accordingly,
- Make allowances for running an additional intermediate casing string.

9. References

Millar, A S and Reeve, J, 2014. GSWA Harvey 1 Well completion and preliminary interpretation report, southern Perth Basin, GSWA Record 2014/12.

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GSWA Harvey-1 Immersion Testing Program 1, September, 2014

Introduction

11 samples from GSWA Harvey-1 were sent to AMC R&D lab to be evaluated and to provide visual observations on the clays' dispersion properties and advise on the optimal mud system to stabilise these types of formations.

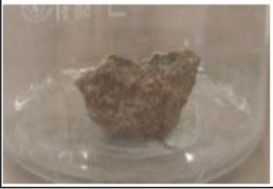
System 1: The first system was to evaluate samples marked H1 1269-1270m, H1 1270-1272m, H1 1276-1278m and H1 1333-1334m using a Core-Well, PACL and Shalehib system.

System 2: The second system was to evaluate samples marked Box 4, 5, 13, 14, 15, 16 and 17 using a Pac-R, Pac-L, Clay-Doctor and Shalehib system.

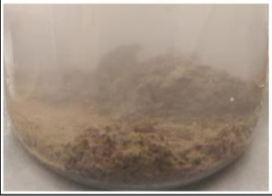
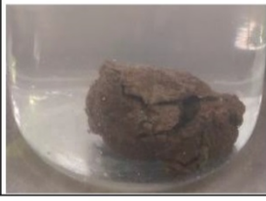
Observations

System 1 (1.5kg,1000L Core-Well, 3kg,1000L Pac-L a 1% Shalehib)

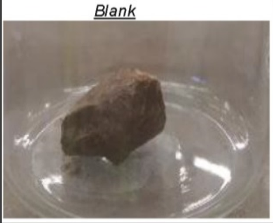
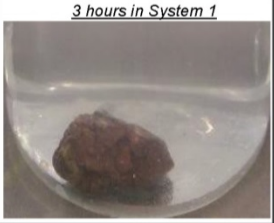
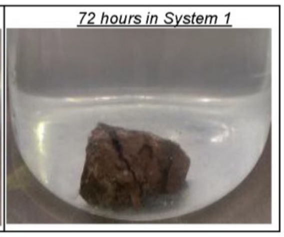
H1 1269-1270 = Firm piece of core, very little dispersion in water

Blank	*Water*	*3 hours in System 1*	*72 hours in System 1*
			

H1 1270-1272 = Brittle, dispersive clay, however System 1 provides the encapsulation required to stabilise this formation

Blank	*Water*	*3 hours in System 1*	*72 hours in System 1*
			

H1 1276-1278 = Brittle, dispersive clay, however System 1 provides the encapsulation required to stabilise this formation

Blank	*Water*	*3 hours in System 1*	*72 hours in System 1*
			

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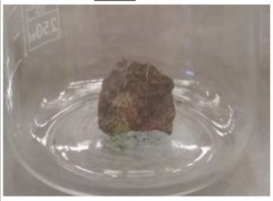
H1 1333-1334 = Brittle, dispersive clay, however System 1 provides the encapsulation required to stabilise this formation

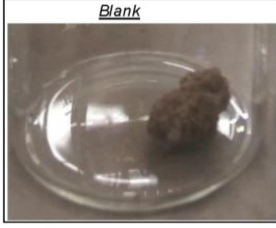
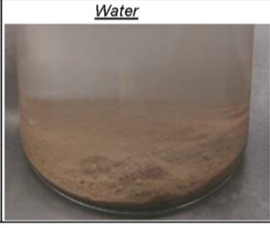
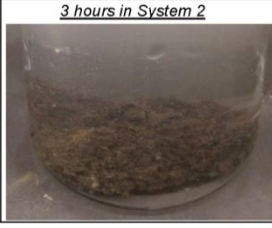
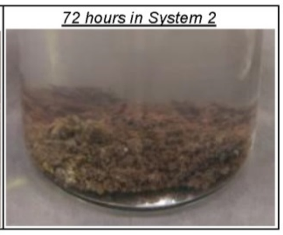
Blank	*Water*	*3 hours in System 1*	*72 hours in System 1*
			

System 2 (2.5kg,1000L PAC-R, 3kg,1000L Pac-L, 3kg,1000L Clay-Doctor and 1% Shalehib)

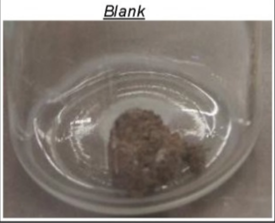
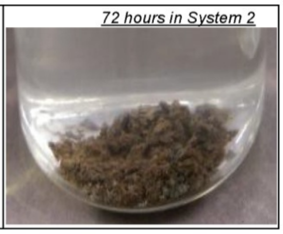
BOX 4 = Brittle, dispersive clay, System 2 provides some encapsulation however nowhere as well as System 1 to stabilise this formation

Blank	*Water*	*3 hours in System 2*	*72 hours in System 2*
			

BOX 5 = Brittle, dispersive clay, System 2 provides some encapsulation however nowhere as well as System 1 to stabilise this formation

Blank	*Water*	*3 hours in System 2*	*72 hours in System 2*
			

BOX 13 = Brittle, dispersive clay, System 2 provides some encapsulation however nowhere as well as System 1 to stabilise this formation

Blank	*Water*	*3 hours in System 2*	*72 hours in System 2*
			

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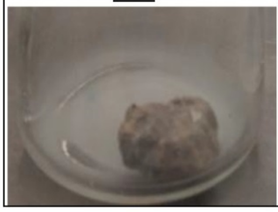
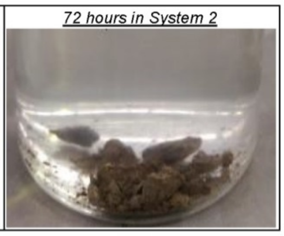
BOX 14 = Brittle, dispersive clay, System 2 provides some encapsulation however nowhere as well as System 1 to stabilise this formation

Blank	*Water*	*3 hours in System 2*	*72 hours in System 2*
			

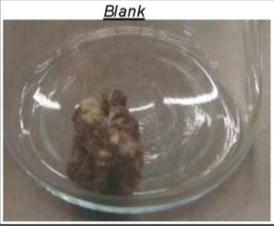
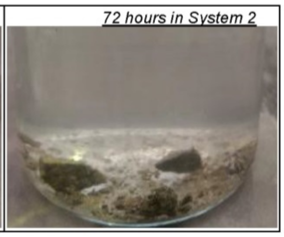
BOX 15 = Firm piece of core, very little dispersion in water

Blank	*Water*	*3 hours in System 2*	*72 hours in System 2*
			

BOX 16 = Brittle, dispersive clay, with System 2 providing initial encapsulation and stabilising the formation, however it breaks down over a longer period of time.

Blank	*Water*	*3 hours in System 2*	*72 hours in System 2*
			

BOX 17 = Brittle, dispersive clay, with System 2 providing initial encapsulation and stabilising the formation, however it breaks down over a longer period of time.

Blank	*Water*	*3 hours in System 2*	*72 hours in System 2*
			

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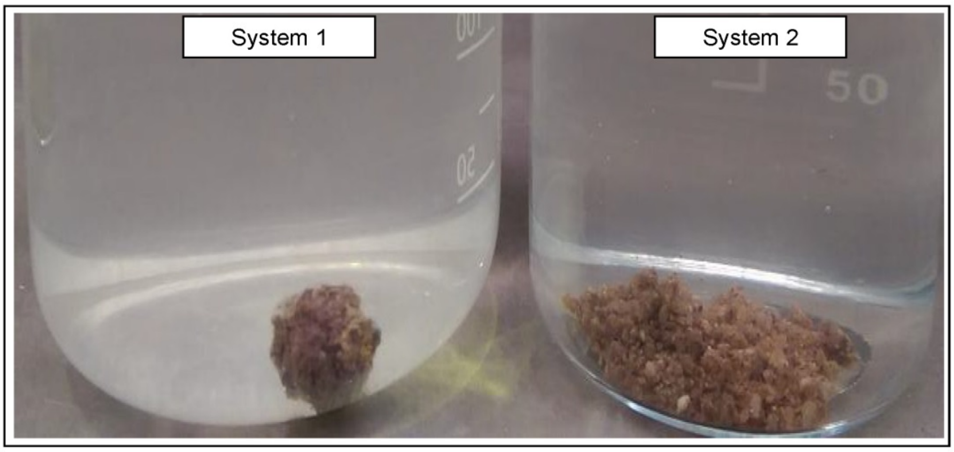
Conclusions

The majority of the samples supplied from Harvey-1 were more dispersive clays rather than swelling clays.

Mud System 1 containing AMC CORE-WELL is more effective in these types of formation as its crossed linked (web like) structure encapsulates the clay better and therefore provides better formation stability. With the added Shalehib for inhibition, it provides the perfect combination to controlling reactive, dispersive clays.

Below is an example comparing the benefits of System 1 vs System 2 on the same sample ("Box 4") over a 72 hour period.



08/09/14 Analysed by: Justin Bergh

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GSWA Harvey-1 Immersion Testing Program 2, November, 2014

Introduction

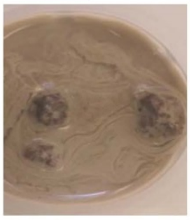
8 samples from GSWA Harvey-1 were sent to AMC R&D lab for a second time to be evaluated and provide a visual observation on the clays dispersion properties and advise on the optimal mud system to stabilise these types of formations.

The Mud Systems tested were as follows:-

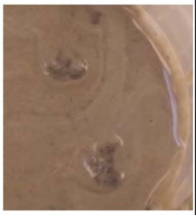
- Blank (Water)
- Mud 1 (20kg Aus-Gel +3kg PAC R +4kg PAC L + 4%KCL)
- Mud 2 (20kg Aus-Gel +3kg PAC R +4kg PAC L + 8%KCL
- Mud 3 (2.5kg PAC R +3kg PAC L + 8kg Clay doctor + 3%KCL)
- Mud 4 (2.5kg PAC R +3kg PAC L + 8kg Clay doctor + 1% Shalehib)
- Mud 5 (1.5kg COREWELL + 1% Shalehib + 3kg PAC L)

Observations

Harvey 1 (495m-510m) G32721)

Blank	*Mud 1*	*Mud 2*	*Mud 3*	*Mud 4*	*Mud 5*
					

Harvey 1 (675m-690m) G32721)

Blank	*Mud 1*	*Mud 2*	*Mud 3*	*Mud 4*	*Mud 5*
					

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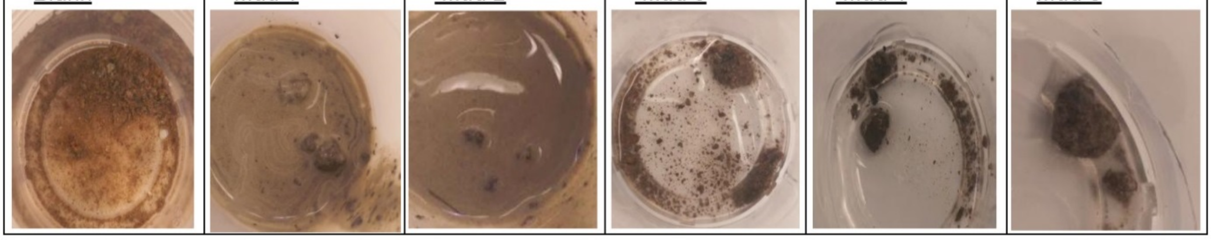
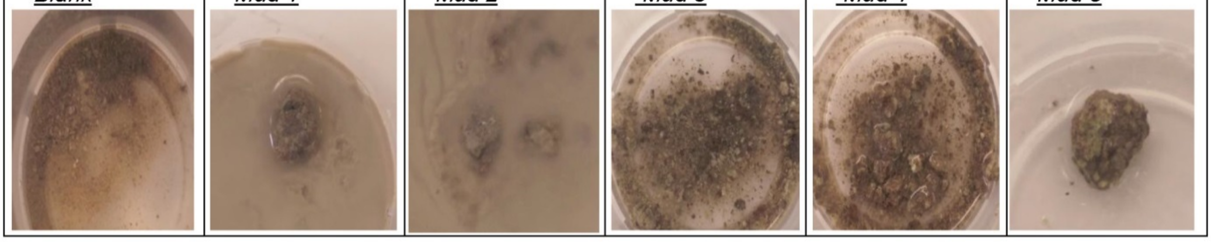
Harvey 1 (1210m-1215m) G32721)

Blank	Mud 1	Mud 2	Mud 3	Mud 4	Mud 5



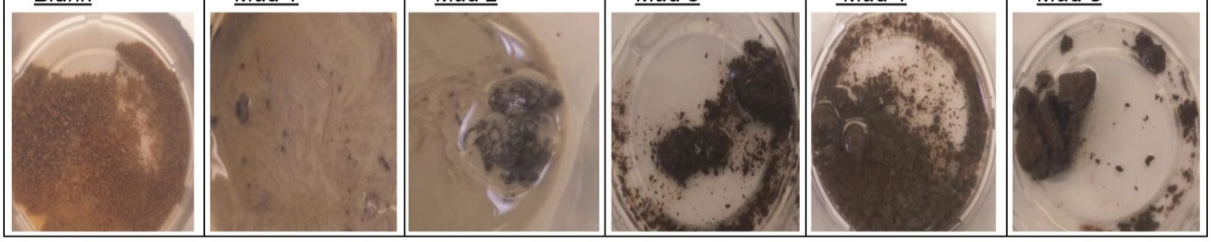
Harvey 1 (1225m-1230m) G32721)

Blank	Mud 1	Mud 2	Mud 3	Mud 4	Mud 5



Harvey 1 (1270.7m) G32721)

Blank	Mud 1	Mud 2	Mud 3	Mud 4	Mud 5



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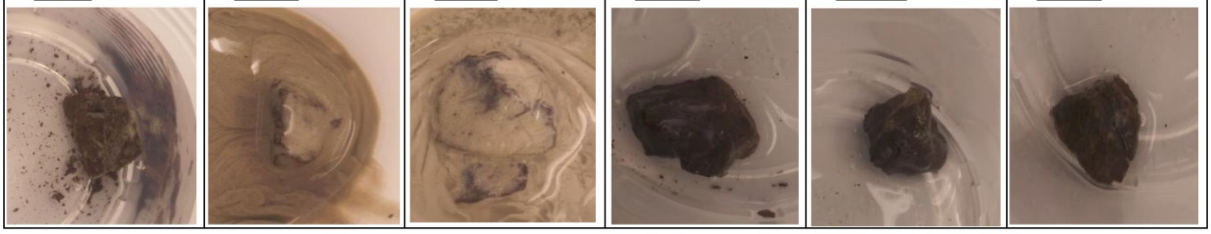
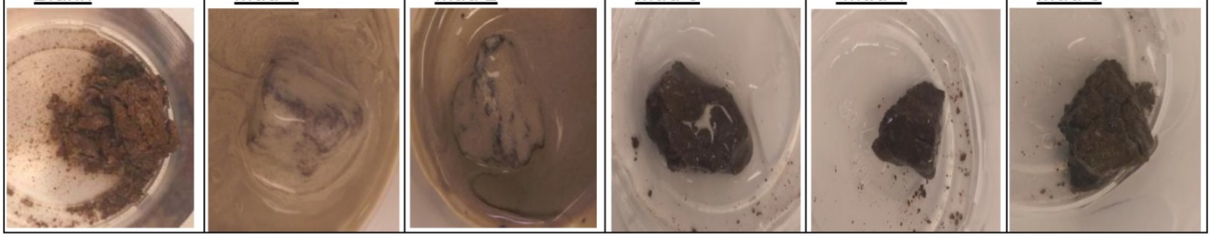
Harvey 1 (1277m) G32721)

Blank	Mud 1	Mud 2	Mud 3	Mud 4	Mud 5



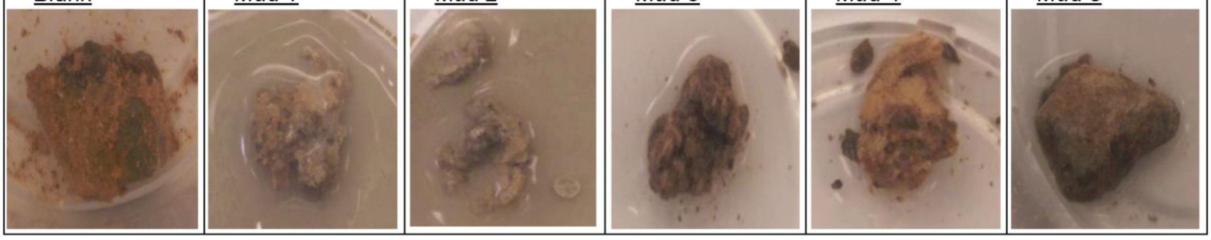
Harvey 1 (1333.3m) G32721)

Blank	Mud 1	Mud 2	Mud 3	Mud 4	Mud 5



Harvey 1 (1340m- 1345m) G32721)

Blank	Mud 1	Mud 2	Mud 3	Mud 4	Mud 5



Conclusions

Overall depending on application/Drill rig MUD 5 would be the optimal system to run on these types if dispersive clays especial the top section. However, if there is concern about blinding off screens using Mud 5, then either MUD 1 or MUD 2 would work well as an alternative system to stabilise the formation.

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