AADE-16-FTCE- 05

Capturing the data needed to assess the economic benefit of solids control systems, a case study.

Ed Malachosky, Chevron Energy Technology Company, Andrew Reeder, Chevron Appalachia/Michigan Business Unit and Mike Joling, MiSWACO, a Schlumberger Company

Abstract

In general, the usual method to evaluate the performance of a drilling operation's solids control equipment is to monitor the accumulation of low gravity drilled solids (LGS) in the mud system. While this provides some evidence that the system is operating correctly, it fails to take into account any economic benefit of the system and how efficiently it is operated. A key aspect of the evaluation resides in how the equipment is operated. The same equipment operated in different manners will frequently produce significantly different results.

Focusing only on the LGS content of the drilling fluid leaves other key cost components out of the evaluation. These components include but are not limited to:

- The excess mud lost to cuttings.
- Preparing the cuttings for disposal.
- Transporting excess lost mud to the disposal site.
- Disposing of excess lost mud.

Of these items, the excess mud lost to cuttings is a key component of the economic equation.

Managing the process therefore requires capturing sufficient data to do an adequate analysis. Traditionally, this has been a significant challenge because capturing data costs money that most operators are unwilling to spend on this part of the drilling operation. This paper presents a case study comparing "managed" to "un-managed" solids control system operation, demonstrating the economic viability of the managed process.

Introduction

During the period of comparison, the usual configuration for solids control equipment on the rigs used by Chevron's Appalachia Michigan Business Unit (AMBU) to drill into the Marcellus shale consisted of 2 primary shakers, 2 drying shakers and a centrifuge operating in a "mud property" (viscosity, density, LGS content) maintenance mode. One slightly different arrangement is that the drilling contractor owns the drying shaker package. Therefore, its cost is included in the daily rig rate. The centrifuge was a third party add on.

These wells were typically drilled to ±800' on air. The intermediate hole section is drilled with light weight (<9 lb/gal) synthetic based drilling fluid (SBM) to about 2000'. The curve and lateral were drilled to TD with a heavier weight (~12.5 lb/gal) SBM.

The wells on a pad are drilled in batch mode with all of the intermediate sections being drilled consecutively. The light weight mud is then displaced with the higher weight mud after completion of the intermediate section of the last well. All remaining sections are then drilled with the heavier weight mud. The wells were drilled in a "closed loop" mode, meaning that all discharges were collected in tanks for disposal at an appropriate landfill.

For the start of the curve and lateral, the heavier weight drilling fluid properties were generally as follows:

- Mud Weight, lbs/gal 12.5
- Synthetic water ratio (SWR) 70:30
- Plastic Viscosity (PV) 20 - 30
- LGS, % by volume 5 - 6

With the solids control configuration described previously, it was not uncommon for the LGS content of the fluid to be higher than 15% by the end of the well. There were multiple reasons for this including:

- Primary shaker deck angles set too high causing excessive screen wear
- Screens with holes not being replaced frequently enough
- Miss matched screens
- Poor basket seal maintenance
- Completely filled sand traps early in each well
- Centrifuge run in the "on" or "off" mode with little regard for results
- Underflow from the drying shakers added back to the centrifuge suction tank (active system) for processing
- Moderate rates of penetration (ROP)
- Divided responsibility for equipment operation and maintenance (rig, mud company, solids control and waste management contractors)

These challenges resulted in increased costs due to:

- Excessive mud lost to surface processes
- Higher than expected drilling fluid maintenance cost
- The imposition of "reconditioning" charges for the returned "out of specification" fluid
- Excessive screen costs
- High cost for pit clean out on moves

In order to address these concerns, a program was undertaken to educate rig personnel about the issues and to immediately address some of them. Because of equipment ownership issues and staffing levels, these educational efforts were marginally successful.

As a step forward, one rig was equipped with a dual centrifuge system. A dedicated solids control person accompanied the system to help ensure the proper operation and maintenance of all of the equipment. The rest of this paper documents the differences observed between the two systems. The same rig models, from the same rig contractor, drilling similar wells through the curve and lateral sections of the hole are compared.

Discussion

As in any field study comparison, nothing is ever identical. Tables 1 and 2 contain a comparison of the factors for the two pads used in the comparison. The S pad used the rig that was augmented with the extra waste management equipment and dedicated solids control engineer. The extra piece of equipment was a barite recovery centrifuge.

At the time of the comparison (late 2014 and early 2015), a gallon of barite cost as much as a gallon of the synthetic base fluid used to prepare the drilling fluid, making barite recovery as economically important as base fluid recovery. In today's environment, the cost of the base fluid has diminished significantly but the cost of the barite has not. Consequently, minimizing the removal of barite from the system becomes economically viable, even in lighter weight mud systems. It also discourages the use of shaker screens with an API number greater than 200, as these higher number screens will remove some barite that is not recoverable.

The underflow of the barite recovery centrifuge was returned to the active system and the overflow sent to the high speed "polishing" centrifuge that also processed the drilling fluid recovered from the "drying shakers". This augmentation (including the additional engineer) added $1275 per day to the cost of the operation.

Table 1 shows several distinct differences in the operation:

1. The rotary steerable system (RSS) used on the B pad produced a significantly higher average rate of penetration.
2. The average low gravity solids (LGS) content of the S pad was significantly less than that of the B pad. (The B pad mud had to be sent offsite twice for reconditioning. The reconditioning charges are not included in the analysis.)
3. Given the items above, the mud treatment cost for the S pad was $3.90 per foot less than the B pad.

It should be noted that even though the S pad used a smaller centrifuge, it ultimately maintained a lower low gravity solids content of the fluid. This was a result of not only the higher processing rate but also the fact that the effluent (overflow) from the barite recovery centrifuge was being processed through the machine. More of the drilling fluid active system was therefore processed through the machine <u>without the removal of unacceptable amounts of barite</u> (as was the case on the B pad).

Considering that the S pad wells' production section averaged about 9050 feet and that they took roughly 9 days to drill, the $3.90 per foot mud treatment cost reduction results in about $35,295 in savings. The incremental cost of the engineer and centrifuge was $11,475.

An additional benefit proved to be significantly reduced trucking costs for mud and mud additives. That added an additional $25K savings per well. A significant portion of this saving was the result of not having to truck liquid mud from the location to the mud plant for reconditioning and back again. That occurred on the B pad when the LGS of the drilling fluid exceeded 14% in one instance and again when it reached 17.5% in another (Figure 1).

Data Collection

In addition to the usual mud data collected for a synthetic based, non-aqueous drilling fluid, specific attention was given to collecting data that would quantitatively estimate the amount of drilling fluid discharged with the cuttings from the shakers and centrifuges. This was accomplished by utilizing a standard 50 cc retort to measure the amount of synthetic base fluid (SBF), water and solids contained in the cuttings discharged. From these measurements, the base fluid retention on cuttings (ROC) and whole mud discharged with the cuttings can be calculated. The procedure for the test can be found in API RP 13B-2.

The data for the ROC calculation is not normally captured during drilling as it is very labour intensive to collect. A single retort run can take 2 to 3 hours to complete and monitoring 3 discharge points twice a day consumes a considerable amount of time. However, it is necessary if one is to track where the mud losses are occurring and ultimately understanding why they are occurring.

Tables 3 and 4 contain the data captured to ensure that the ROC and the corresponding mud loss ratio (MLR) can be calculated. The data contained in the tables have been condensed by only showing the retort input data for the section labelled rig shaker. The retort data collected for the sections labelled “drying shaker” and “centrifuge 1” are hidden in the chart. Unused rows reserved for additional discharge equipment have also been removed to allow for easier reproduction of the tables.

In Table 3, note the similarity of the ROC values for both the rig and drying shakers. This was caused by the same size or, occasionally, higher API number screens being used on the drying shakers and is an indicator that the process was not fully understood and that the equipment was not working to its full potential (i.e. the process was unmanaged).

Table 4 contains data from the same well showing a more effective process. Note the much larger difference between the values recorded for the rig and drying shakers. This indicates that the operation is recovering additional drilling fluid, as well as additional drilled solids. Because of the detrimental effects these additionally recovered drilled solids have on cost, the fluid recovered from the drying shakers should be diluted and processed through a high speed centrifuge.

The Table 4 data were collected after some adjustments to the process were made. These adjustments were to lower the shaker deck angle and to allow a wetter discharge to the drying shakers. Note that the drying shaker ROC values are generally lower than those in Table 3, indicating a much more efficient system.

The concept of the modifications was to control the low gravity solids build up in the fluid by running the rig shakers “wet” and to recover some of that fluid with the drying shakers. Since the centrifuge was typically being run full time to control the LGS, this would theoretically reduce the mud lost to cuttings by reducing the centrifuge run time, thereby reducing mud lost to the fine centrifuge solid discharge. Unfortunately, the underflow from the drying shakers was being added back to the active system before being processed through the centrifuge. The net result was an unacceptable increase in the LGS content of the drilling fluid.

A drilling fluid volume tracking sheet was also used. Table 5 is an example of that data collection sheet and is the result of a series of iterations generated by the drilling engineers in AMBU. Note that the values obtained from the ROC measurements and dilution calculations can be compared to the losses determined by volumetric techniques.

Mud Loss Ratio (MLR)

The reasons for installing additional solids control equipment acting in a waste management role include:

- Recovering excess drilling fluid discharged with the cuttings
- Reducing “lost mud” costs
- Reducing cuttings treatment costs incurred in preparation for transportation
- Reducing transportation loads (trips)
- Minimizing the disposal cost of the discarded cuttings

One way to monitor the performance of the solids control and waste management equipment is to measure the amount of drilling fluid adhering to the discharged cuttings. A reduction in the amount of fluid adhering to the cuttings indicates an improvement in performance (reduction in mud lost). The use of a ratio also facilitates comparisons between wells of differing length and diameter.

The mud loss ratio is defined as the volume of drilling fluid lost per volume of hole drilled. It is occasionally referred to as the mud to cuttings ratio (MCR). It can be measured by different means. One way is to monitor pit volume and whole mud or mud component additions. Another is to measure the amount of drilling fluid discharged by the solids control equipment.

The latter method uses a standard 50 cc retort to separate and measure the solids, water and base fluid, from which the ROC and MLR can be calculated. As described earlier, this is the method used in this work to assess the equipment performance. That measurement was then compared to the volumetric method. Both methods have limitations that are well known in the industry. The most significant of these, loss of circulation, is extremely rare in this area of the Marcellus.

Figures 2 and 3 demonstrate the importance of the MLR on the treatment cost for the wells. Note that on almost every well, the cost per foot of hole drilled varies directly with the MLR and significantly over shadows the impact of the low gravity solids content of the fluid on these two pads.

The ROC of the drying shakers and centrifuges was monitored on both pads. However, the S pad had the advantage of having a dedicated solids control engineer to assist with the monitoring and measuring of the ROC. This resulted in significantly more reliable and regular data acquisition. From the data contained in Table 2, it appears that the introduction of the extra equipment to the S pad drilling did not reduce the total mud loss values as documented by fluid volume measurements.

It should be noted that the last well on the S pad had an exceptionally high MLR of 1.81. This is significantly higher than the highest MLR (1.59) for the wells on the B pad. It also had the highest mud cost per foot and the slowest ROP. Since this was the last well on the S pad, it could be a result of the pit clean out technique used or some other operational practice “peculiar” to that period of the pad completion. If only the centrifuge and shaker losses are considered, the MLR drops to 1.51 for the well, indicating that roughly 200 bbls of mud was discharged by a process not accounted for.

Conversely, the discrepancy could be the result of the fluid movement on the B pad resulting in a lower MLR on the last well. This might occur if the pits were cleaned during the period of time that the fluid was sent back for processing.

Nevertheless, the measurements did identify that there was a gap between what the ROC measurements on the equipment (shakers and centrifuge) were indicating that the MLR should be and what was actually being measured by conventional strapping and volume accounting techniques. On the average, this gap translates into roughly $16.5K for a well on the S pad or roughly $131K for the pad. Consequently, identifying the reason for the gap becomes financially significant.

After investigating the operational practices on the rigs, it was found that one major factor for the gap was the amount of mud lost to cement spacer displacements. In some cases, the discarded contaminated drilling fluid volume was relatively small, while in other cases it was significant. This seemed to depend on a number of factors, including the pump rates, the spacer design and how diligently the mud engineer monitored the displacement.

In another case, it was found that the rig’s sand trap was being dumped once or twice daily, resulting in 10 to 20 barrels of mud and solids being discharged directly to the catch tank without passing over the drying shakers. This resulted in the loss of an additional ~150 barrels of drilling fluid per well and drove the total MLR for that rig to larger numbers.

It’s obvious from these examples that factors other than the equipment’s performance contribute to excessively high mud loss ratios and can overcome and mask other improvements. Unless the appropriate measurements are made, one might be tempted to blame “poor equipment” for the problem instead of poor operational practices.

One of these other factors was the conscious decision to trade mud lost to cuttings through the centrifuge for the increase in the LGS content of the drilling fluid on the B pad. When the trucking and reconditioning fees are added back into the equation, the indication is that this may have been the wrong decision.

While it is discouraging to find that the MLR for the S pad was not reduced by the introduction of the additional equipment and engineering service, the findings from the investigations conducted into the process have resulted in MLR reductions for subsequent pads. (These wells are producing equipment mud loss ratios of 1:1 and total MLR values of about 1.25.) In addition, the added services more than paid for themselves in reduced mud treatment and trucking costs.

Rate of Penetration (ROP) Considerations

Because attempts have historically been made to correlate ROP to plastic viscosity and LGS content of the drilling fluid, the data collected in this comparison were used to explore that relationship. Figures 4 and 5 are trends of the average rate of penetration achieved for each well on both pads compared to the plastic viscosity (PV), low gravity solids content and mud treatment cost. Although the range is not very broad, the PV does track with the LGS content for both pads reasonably well. No positive correlation between mud cost and ROP could be made for either pad.

Since two different directional systems were used on the rigs, no attempt was made to compare the ROP between the pads. In general, for the B pad and the Rotary Steerable System (RSS), the LGS and PV increased as the ROP increased, probably signifying that the solids removal efficiency was decreasing as the ROP increased. This is in concert with the conscious decision to limit centrifuge processing for the mud loss reasons identified in the previous sections.

It is interesting to note that the wells with the highest ROPs on this pad were achieved with the highest <u>and</u> second to lowest average low gravity solids content. The well with the lowest LGS content had the lowest ROP. This provides evidence that other factors affect ROP. These factors, like weight on bit and its impact on flounder point were not evaluated in this comparison.

For the S pad, ROP declined over the length of the drilling program. This is most likely the result of geosteering considerations rather than any impact from the drilling fluid. It may also be a result of the fact that the rig experienced generator issues that frequently limited the total amount of power available for drilling. The mud cost increased slightly from the first to the last well drilled.

Conclusions

Although the comparison between the two pads is not exact, the following points were extracted from this work:

1. Monitoring the ROC and the corresponding predicted MLR and comparing that to the MLR acquired from volumetric methods is crucial to obtain a complete understanding of the economic impact of the entire process.

2. Monitoring the retention of synthetic base fluid on cuttings (ROC) discharged from the solids control system aided in the identification of sources of spurious drilling fluid losses.

3. Mud treatment costs were significantly reduced through the introduction of the barite recovery centrifuge.

4. The barite recovery centrifuge did maintain the LGS content at a more acceptable level and did not increase the MLR.

5. The reduction in mud treatment and trucking costs more than offset the increased cost of the additional equipment and personnel.

Acknowledgements

The authors wish to extend their utmost appreciation to the organizations and individuals, who contributed to this publication, including:

- Chevron, AMBU and Schlumberger for permission to publish this paper.

- The Schlumberger drilling fluid and solids control engineers that collected the data.

- The rig crews that have worked to implement the lessons learned from these wells.

- The internal Chevron reviewers who helped make the paper more coherent and concise, particularly Neil Trotter and Jon Getliff.

Tables

Table 1 - Study Parameter Comparison

Pad	B	S
Number of wells	8	8
Horizontal hole size, in.	8.5	7.875
Total footage drilled on weighted mud	71,412	72,455
Directional system	RSS	Mud Motor
Bits	Various – Smith MDi516	Smith SDi513
Polishing Centrifuge	CD 500	518
Centrifuge RPM	2300 – 2500 (~1520 g)	2800 – 2900 (~1615 g)
Centrifuge Feed Rate, gpm	~40	~60
Centrifuge Retention Time, seconds	~39	~16
Rig shaker screen sizing, API Screen Number	170, 200, 230	170, 200
Drying shaker screen sizing, API Screen Number	170, 200	140
Drying Shaker type	Hyperpool	Hyperpool
Average ROP, ft/hr	97.5	60.76
Average LGS, Vol %	10.65	6.04
Average mud weight	12.49	12.42
Average PV, cps	26	26
Average YP, lbs/100 ft^2	19	11
Average mud treatment cost, $/ft	21.80	17.90
Average cost per barrel of hole drilled, $/bbl	310.53	297.09

Table 2 – Mud Loss Ratio Comparison

Pad	B	S
Total volume of hole drilled, bbl	5012	4364
Total mud losses, bbl	6690	6175
Total MLR (bbl/bbl)	1.33	1.41
MLR, attributed to shakers & centrifuge	1.21	1.25

Table 3 - Retort Data Collection

	Oil Density, g/ml	**0.77**		**Input**		
	Cuttings Density, g/ml	**2.60**		**Output**		
			% Discharge from Drier	**90**		
			% Discharge f/ Centrifuge 1	**10**		
			% Discharge f/ Centrifuge 2	**0**		
	Well name:		% Discharge f/ Centrifuge 3	**0**		
	Date					
	Time of sample	1800	1800	1800	1800	1300
	Start Depth,ft	5520	6215	6467	6563	6694
	End Depth, ft	6215	6467	6563	6694	6880
	Hole size (inches)	12.25	12.25	12.25	12.25	12.25
	Mud Weight, lb/gal	12.50	12.50	12.40	12.50	12.50
	Vol.% NABF (from mud report)	54.00	54.00	54.50	55.00	57.00
Rig Shaker	Retort weight (empty), g	863.00	861.00	861.00	861.00	862.00
	Retort weight + cuttings before test,	923.00	923.00	927.00	925.00	924.00
	Retort weight+ cuttings after test,	913.00	914.00	918.00	917.00	913.00
	Graduated cylinder weight (empty), g	46.00	46.00	46.00	46.00	45.00
	Graduated cylinder weight + condensate, g	56.00	56.00	57.00	56.00	55.00
	Volume of water, ml	1.80	0.90	0.70	0.40	0.50
	Mass of condensate, g	10.00	10.00	11.00	10.00	10.00
	Mass of oil, g	8.20	9.10	10.30	9.60	9.50
	Mass of cuttings sample before test, g	60.00	62.00	66.00	64.00	62.00
	Mass of cuttings sample after test, g	50.00	53.00	57.00	56.00	51.00
	ROC cuttings (% by weight), Wet	**13.67**	**14.68**	**15.61**	**15.00**	**15.32**
	Mass Balance - (0.97 to 1.03)	1.00	1.02	1.03	1.03	0.98
Drying Shaker	Volume of water, ml	1.30	1.30	0.50	0.20	0.40
	Mass of condensate, g	10.00	10.00	10.00	10.00	10.00
	Mass of oil, g	8.70	8.70	9.50	9.80	9.60
	Mass of cuttings sample before test, g	66.00	62.00	66.00	68.00	64.00
	Mass of cuttings sample after test, g	56.00	51.00	57.00	59.00	55.00
	ROC cuttings (% by weight), Wet	**13.18**	**14.03**	**14.39**	**14.41**	**15.00**
	Mass Balance - (0.97 to 1.03)	1.00	0.98	1.02	1.01	1.02
Centrifuge 1	Volume of water, ml	0.50	0.40	0.20	0.10	0.20
	Mass of condensate, g	10.00	11.00	11.00	11.00	10.00
	Mass of oil, g	9.50	10.60	10.80	10.90	9.80
	Mass of cuttings sample before test, g	68.00	71.00	73.00	76.00	72.00
	Mass of cuttings sample after test, g	58.00	61.00	62.00	64.00	61.00
	ROC cuttings (% by weight), Wet	**13.97**	**14.93**	**14.79**	**14.34**	**13.61**
	Mass Balance - (0.97 to 1.03)	1.00	1.01	1.00	0.99	0.99
	Hole Volume, bbls	101.31	36.74	13.99	19.10	27.11
	Drier ROC cuttings (% by weight) Wet	13.18	14.03	14.39	14.41	15.00
	Centrifuge 1 ROC cuttings (% by weight) Wet	13.97	14.93	14.79	14.34	13.61
	Daily Average ROC cuttings (%) Discharge	**13.26**	**14.12**	**14.43**	**14.40**	**14.86**
	Well Average ROC cuttings (%) Discharge	13.26	13.49	13.58	13.67	13.83
	NABF lost per Interval Drilled, bbls	86.15	35.36	13.82	18.76	27.40
	Mud Lost off Drier per Interval Drilled, bbls	**141.88**	**58.13**	**22.69**	**30.73**	**44.01**
	Mud Lost off Centrifuge 1 per Interval Drilled, bbls	**17.66**	**7.35**	**2.67**	**3.38**	**4.05**
	Total Mud and Cuttings Discharged, bbls	260.85	102.21	39.36	53.21	75.18

Table 4 - Retort Data Collection after Primary Shaker Adjustment

	Oil Density, g/ml	**0.77**		**Input**		
	Cuttings Density, g/ml	**2.60**		**Output**		
			% Discharge from Drier		**90**	
			% Discharge f/ Centrifuge 1		**10**	
			% Discharge f/ Centrifuge 2		**0**	
	Well name:		% Discharge f/ Centrifuge 3		**0**	
	Date					
	Time of sample	1400	1300	1100	1700	1800
	Start Depth,ft	7630	8544	8820	9043	9716
	End Depth, ft	8234	8820	9043	9305	10000
	Hole size (inches)	12.25	8.50	8.50	8.50	8.50
	Mud Weight, lb/gal	12.80	12.80	12.80	12.80	12.70
	Vol.% NABF (from mud report)	50.00	49.00	51.50	51.00	52.50
Rig Shaker	Retort weight (empty), g	862.00	863.00	862.00	863.00	863.00
	Retort weight + cuttings before test,	915.00	918.00	915.00	921.00	919.00
	Retort weight+ cuttings after test,	895.00	898.00	893.00	901.00	896.00
	Graduated cylinder weight (empty), g	46.00	47.00	46.00	46.00	46.00
	Graduated cylinder weight + condensate, g	67.00	68.00	67.00	66.00	69.00
	Volume of water, ml	8.10	7.50	7.00	6.50	6.80
	Mass of condensate, g	21.00	21.00	21.00	20.00	23.00
	Mass of oil, g	12.90	13.50	14.00	13.50	16.20
	Mass of cuttings sample before test, g	53.00	55.00	53.00	58.00	56.00
	Mass of cuttings sample after test, g	33.00	35.00	31.00	38.00	33.00
	ROC cuttings (% by weight), Wet	**24.34**	**24.55**	**26.42**	**23.28**	**28.93**
	Mass Balance - (0.97 to 1.03)	1.02	1.02	0.98	1.00	1.00
Drying Shaker	Volume of water, ml	2.80	3.00	3.00	2.80	4.80
	Mass of condensate, g	6.00	8.00	8.00	9.00	12.00
	Mass of oil, g	3.20	5.00	5.00	6.20	7.20
	Mass of cuttings sample before test, g	46.00	48.00	45.00	51.00	54.00
	Mass of cuttings sample after test, g	39.00	40.00	36.00	40.00	43.00
	ROC cuttings (% by weight), Wet	**6.96**	**10.42**	**11.11**	**12.16**	**13.33**
	Mass Balance - (0.97 to 1.03)	0.98	1.00	0.98	0.96	1.02
Centrifuge 1	Volume of water, ml	0.40	0.35	0.25	1.00	1.40
	Mass of condensate, g	11.00	11.00	8.00	12.00	13.00
	Mass of oil, g	10.60	10.65	7.75	11.00	11.60
	Mass of cuttings sample before test, g	80.00	78.00	56.00	66.00	66.00
	Mass of cuttings sample after test, g	71.00	68.00	47.00	53.00	52.00
	ROC cuttings (% by weight), Wet	**13.25**	**13.65**	**13.84**	**16.67**	**17.58**
	Mass Balance - (0.97 to 1.03)	1.03	1.01	0.98	0.98	0.98
	Hole Volume, bbls	88.05	19.37	15.65	18.39	19.93
	Drier ROC cuttings (% by weight) Wet	6.96	10.42	11.11	12.16	13.33
	Centrifuge 1 ROC cuttings (% by weight) Wet	13.25	13.65	13.84	16.67	17.58
	Daily Average ROC cuttings (%) Discharge	**7.59**	**10.74**	**11.38**	**12.61**	**13.76**
	Well Average ROC cuttings (%) Discharge	7.59	8.15	8.57	9.09	10.29
	NABF lost per Interval Drilled, bbls	33.85	12.54	10.75	15.75	19.52
	Mud Lost off Drier per Interval Drilled, bbls	**51.18**	**21.54**	**17.85**	**25.15**	**30.61**
	Mud Lost off Centrifuge 1 per Interval Drilled, bbl	**16.53**	**4.05**	**3.03**	**5.74**	**6.57**
	Total Mud and Cuttings Discharged, bbls	155.75	44.96	36.53	49.27	57.11

Table 5 – Mud Loss Data

	Date:						
Drilling Info:	Hole Size	12.25	8.5	8.5	8.5	8.5	8.5
	BHA	Intermediate	Prod Vert.	Prod Vert.	Prod Vert.	Prod Vert.	Lateral
	Start Depth	2220	2220	2917	4640	5270	7025
	End Depth	2220	2917	4640	5270	7025	8684
	Additional Footage (Sidetrack, etc.)						
	Time On Bottom Drilling (hrs.)	0	8	22	14	23	3
	Daily Mud Cost						
	Daily Solids Control Cost						
	% LGS	8.3%	8.6%	8.4%	7.1%	8.1%	7.3%
	Primary Shaker Screen Mesh	170	170	170	170	170	170
	Drying Shaker Screen Mesh	140	140	140	140	140	140
	Total Length Drilled	0	697	1723	630	1755	1659
	Volume of Hole Drilled (BBL)	0	49	121	44	123	116
	Mud Cost/ft.	$ -	$ -	$ -	$ -	$ -	$ -
	Solids Control Cost/ft	$ -	$ -	$ -	$ -	$ -	$ -
	Average ROP	0	87	78	45	76	553
Volume Build:	Base Fluid						
	Water						
	Chemicals						
	Total	0	0	0	0	0	0
Dilution Volume:	Base Fluid		30	86.05	33.69	100	48.17
	Water		10	29	11	33	16
	Chemicals		10.29	62.57	26.77	57.18	39.95
	Total	0	50.29	177.62	71.46	190.18	104.12
	Total Volume Built	0	50.29	177.62	71.46	190.18	104.12
Losses:	Shaker		0	49.98	23.61	123	116
	Centrifuge		0	62.94	15.74	23.45	24.92
	Formation						
	Evaporation						
	Other						
	Total Losses	0	0	112.92	39.35	146.45	140.92
	Loss Ratio at Shakers	0.00	0.00	0.41	0.53	1.00	1.00
	Loss Ratio at Centrifuge	0.00	0.00	0.52	0.36	0.19	0.21
	Lost Ratio all Other Sources	0.00	0.00	0.00	0.00	0.00	0.00
	Total Loss Ratio	0.00	0.00	0.93	0.89	1.19	1.21
Transfers:	Chevron SBM Preloaded (+)						
	Chevron SBM Transferred To Well (+)		0				
	Chevron SBM Transferred Away (-)						
	Mud Company SBM Preloaded (+)						
	Mud Company SBM Transferred To Well (+)		1900	268			
	Mud Company SBM Transferred Away (-)	-1760					
	Total Daily Mud Transferred	-1760	1900	268	0	0	0
Measured Volumes:	SBM Pit Volume	0	665	683	675	712	643
	SBM Reserve Volume	0	1105	1310	1310	1205	1120
	Other SBM Surface Volume		0				
	SBM Left in Casing for Cement Displacement	140					
Error:	Measured Volume of SBM	140	1770	1993	1985	1917	1763
	Calculated Volume of SBM	139.55	2089.84	2422.54	2454.65	2498.38	2461.58
	Difference in Calculated and Actual Volume	0.45	-319.84	-429.54	-469.65	-581.38	-698.58
Calculations:	Daily Chevron SBM Build/Transferred	0	50.29	177.62	71.46	190.18	104.12
	Total Chevron SBM Balance	0	50.29	114.99	147.1	190.83	154.03
	Chevron Daily SBM Loss	0	0	112.92	39.35	146.45	140.92
	Total Chevron SBM Loss	129.55	129.55	242.47	281.82	428.27	569.19
	Mud Company Daily SBM Loss	0	0	0	0	0	0
	Total Mud Company SBM Loss	190.45	190.45	190.45	190.45	190.45	190.45
	Total SBM Loss	320	320	432.92	472.27	618.72	759.64
	~ Hole Volume	193	49	170	214	337	454

Figures

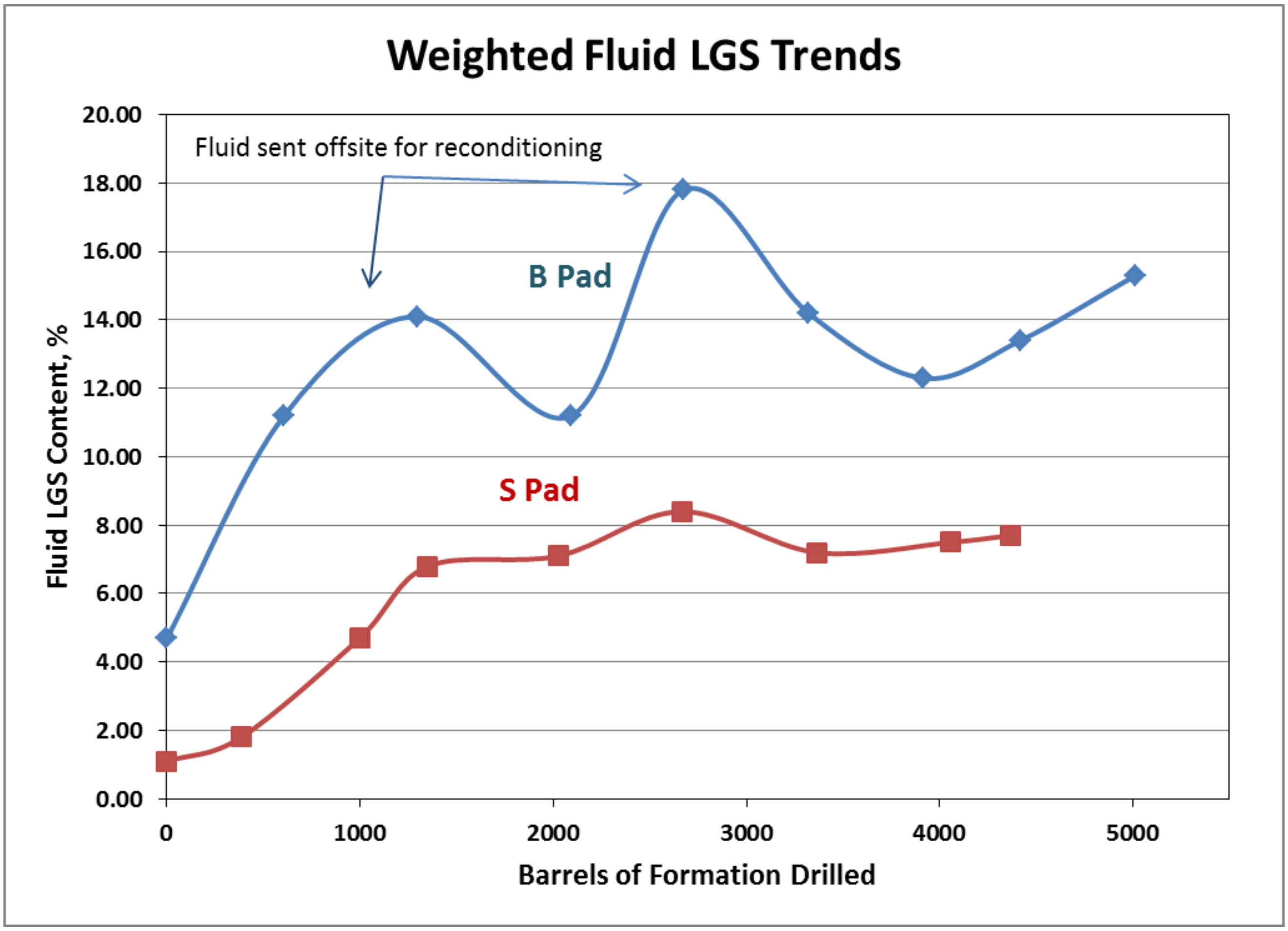

Figure 1 - Low Gravity Solids Comparison

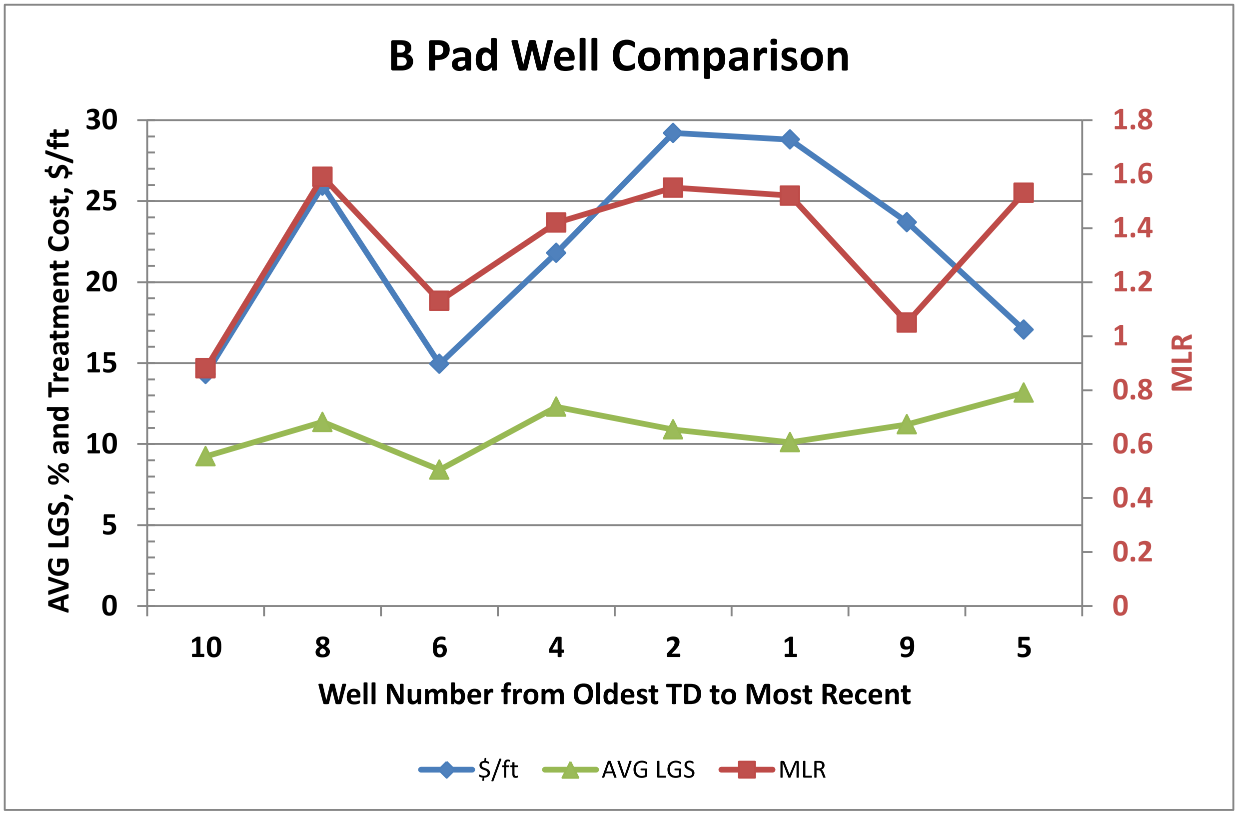

Figure 2 – B Pad Well Comparisons

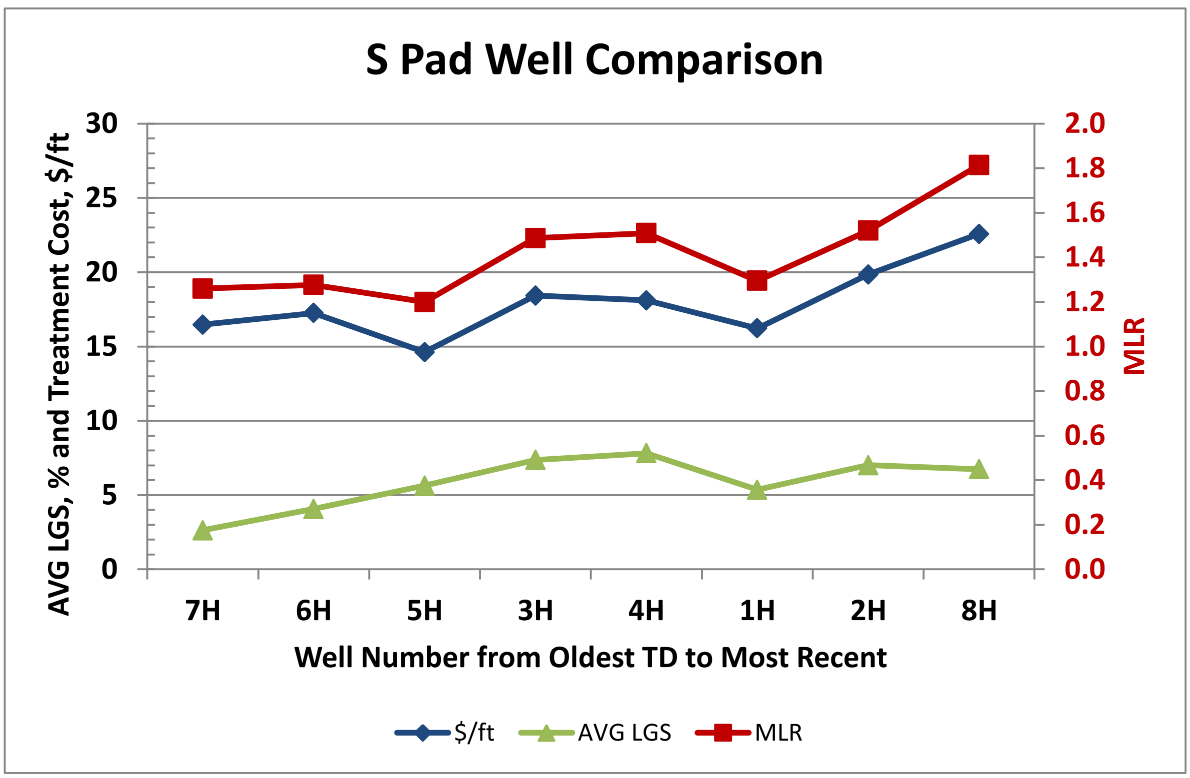

Figure 3 – S Pad Well Comparisons

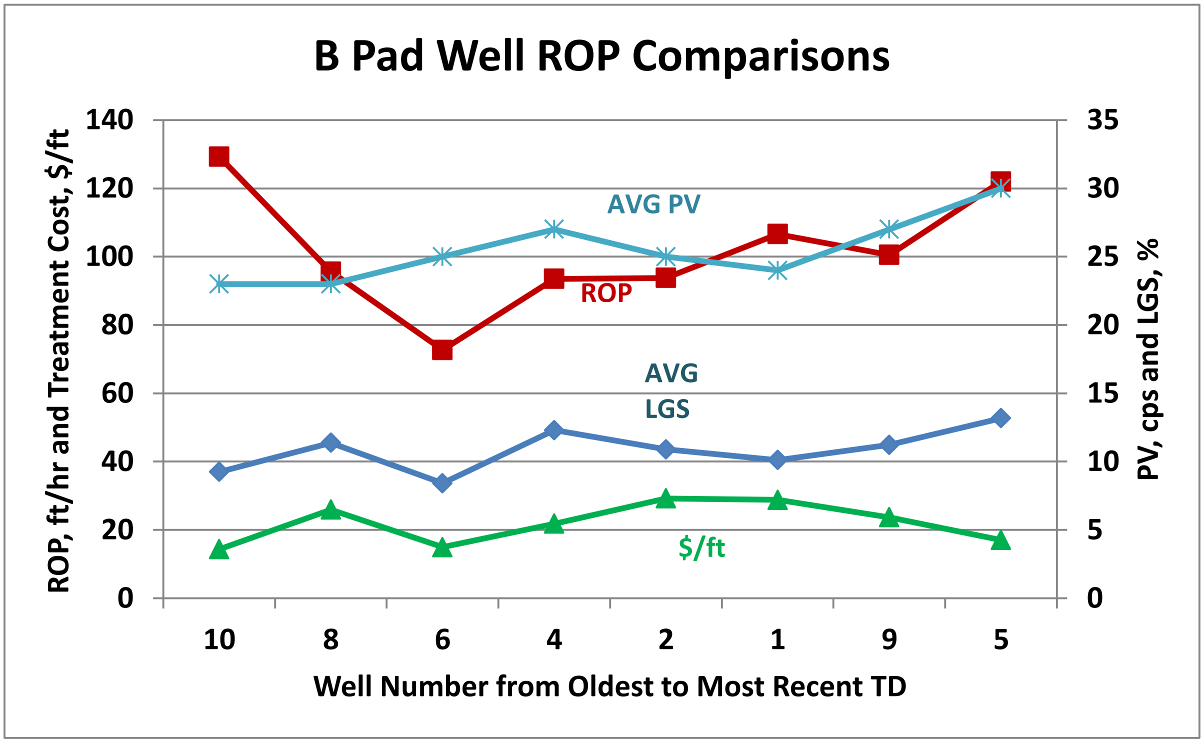

Figure 4 – B Pad ROP Comparisons

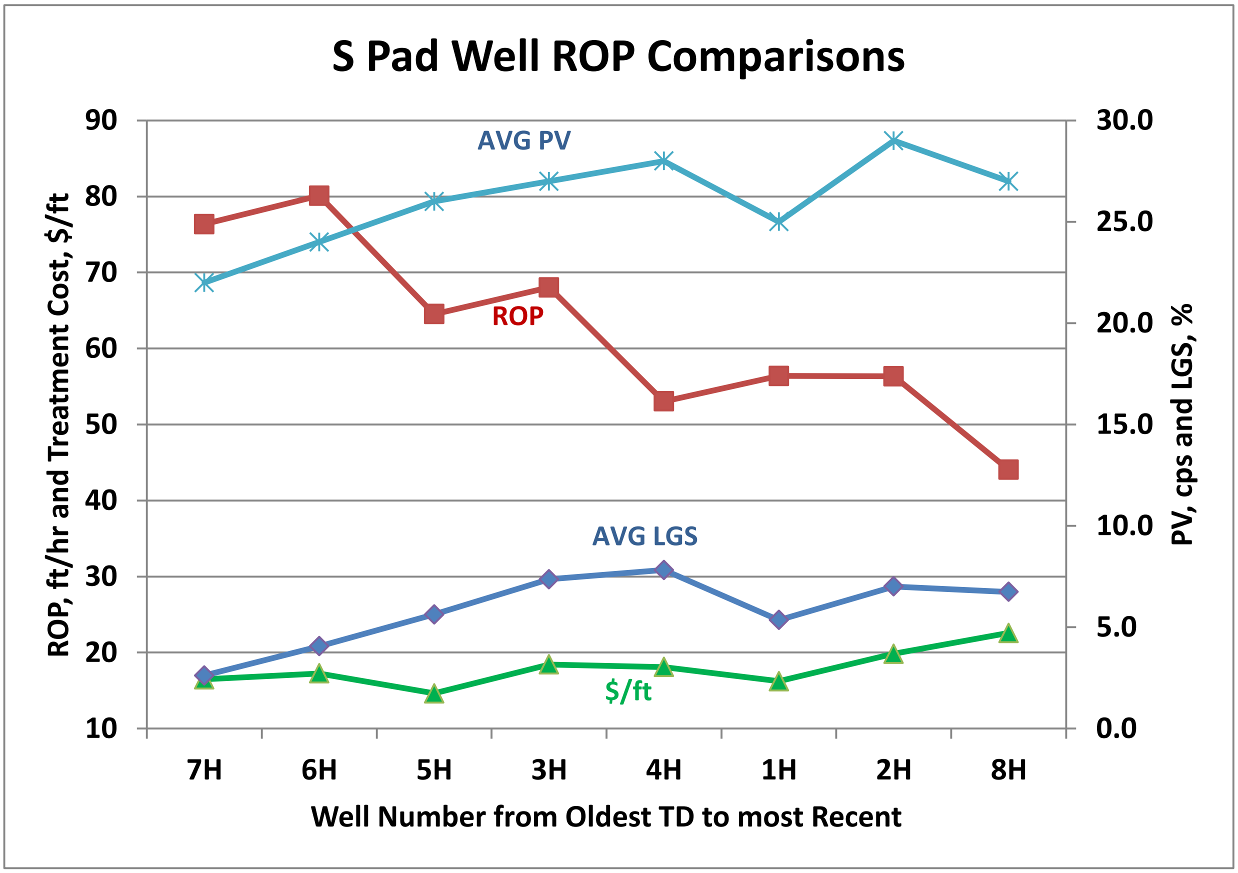

Figure 5 – S Pad ROP Comparisons