

# **COMPREHENSIVE DRILLING WASTE MANAGEMENT PROGRAM SIGNIFICANTLY INCREASES VALUE AND SETS STANDARD FOR COMPLIANCE IN BRUNEI OPERATIONS**

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## **ABSTRACT**

To improve solids control efficiency, gain control over drilling waste streams, and ensure compliance with ISO-14001 requirements, Brunei Shell Petroleum (BSP) implemented Total Fluids Management® engineering services in the Anduki, Seria, and Rasau Land campaign. As a result, BSP has reduced average total drilling fluids and waste management cost per meter drilled on land wells by 6.8%, including the additional cost of the Total Fluid Management service (personnel and additional equipment). Additionally an average decrease of 13% was seen in total waste management and drilling fluids costs. Key performance indicators include volumes of fluid disposed ( $m^3/m$ ), Total Fluids Management® services costs per meter drilled, HSE incidents, and third party costs.

Total Fluids Management service is designed to address every aspect of the drilling fluid system: mud and personnel, chemical treatments, solids control optimization, water recovery and treatment, and drilling waste handling and transportation. In support of the BSP operations, the team for Total Fluids Management services compiled and executed written procedures to identify waste streams and disposal options, including manifests to enable mass balance of waste volumes. These procedures were reviewed by the ISO audit team and accepted without changes.

The program for Total Fluids Management services features a centrally located waste water treatment plant and the process for drying drill cuttings prior to landfill disposal. Halliburton personnel manned and operated the waste water treatment plant. The drying facility was operated by a national third-party company, with volumes and logistics tracked and reported on the reporting data base for Total Fluids Management services. The land rig campaign generated 4,000  $m^3$  of liquid waste from water-based mud, brine, waste water, and pit cleaning sludge in a 12-month timeframe. From this waste stream, the waste water treatment plant produced 2,196  $m^3$  of treated water, of which 244  $m^3$  were reincorporated into the active system. The remainder of this waste was a dense mixture of solids and water, which after the removal of excess water through evaporation, had the necessary properties for disposal to landfill.

Based on twelve months of operations encompassing twenty-seven wells, BSP expects to save an average of US \$24,000 per rig per month through the continued use of Total Fluids Management services. This savings includes the additional cost of the Total Fluids Management services, including full time Waste Management Personnel on the rig, the operation of the Anduki Waste Water Treatment Plant, and the Environmental Compliance Reporting. This paper details the procedures and metrics used to establish, maintain, and continuously improve cost-efficient drilling waste management performance.

# TOTAL FLUIDS MANAGEMENT: KEY OBJECTIVES

Historically waste pits were used at land rig sites. At the end of each well the wet cuttings were dug out and trucked to landfill, where a significant cost was incurred as the cuttings were treated purely as a waste material. Once the water-based mud could no longer be directly reused, it was disposed of via a sewage works after pumping off from solids settling pits. This disposal also incurred significant cost and the polymers in the mud seriously disrupted the workings of the plant. This led to remedial work being carried out to maintain the sewage works and also meant that any prolonged shutdown of the plant could stop the drilling operation. A strategy was formed to turn the cuttings into a useful product no longer classified as waste and to find a better means of disposing of liquid mud and brine.

BSP established three goals to be achieved by the introduction of Total Fluids Management services in the Anduki, Seria, and Rasau Land campaign:

1. Reduce drilling fluid costs through improved solids control efficiency and performance.
2. Improve waste stream tracking related to drilling operations.
3. Assist BSP in becoming ISO 14001 compliant.

Total Fluids Management services were initially implemented on 12 wells over a six-month trial period. At the end of that interval, BSP had reduced overall total drilling fluids and waste management cost per meter drilled on land wells by more than 30% (Figure 1).

The representative Total Fluids Management services analyzed the impact of Total Fluids Management services based on the following key performance indicators (KPI):

Type of Analysis	KPI
Volume (m <sup>3</sup> /m)	Fluid disposed per meter drilled Waste water disposed per meter drilled Mud consumption per meter drilled
Cost (USD\$)	TFM cost per meter drilled Planned versus actual drilling fluid cost Third party charges
Health, Safety, and Environment (HSE)	Number of recordable incidents Number of STOP cards produced Transportation (km)

To meet the project goals, the team immediately implemented several changes and improvements at the wellsite, as shown in the following examples. All rig centrifuges were replaced with new units that were maintained by skilled technicians. A fully functioning waste water treatment facility was installed to treat the waste stream from water-based fluids and return the treated water to the rig for reuse. Full-time, dedicated supervisors for Total Fluids Management services were placed on several rigs to track and

account for the waste streams and waste management, a step that strongly supported BSP's efforts to gain ISO 14001 certification.

## **Volume Analysis and Reduction in Disposal Volumes**

The representative for Total Fluids Management services reviewed the data collected by BSP each month on all wells, then correlated the information with data from each well to create a per well benchmark. The source for the BSP data was disposal manifests that broke out monthly volumes of fluid received for disposal. The representative observed variances between the actual volumes generated at the rig and the volumes recorded for disposal. Full-time supervision by personnel resulted in a significant reduction in disposal volume per meter drilled (Figure 2).

The waste water treatment plant was designed to treat water-based fluid waste streams generated by a land rig and return the treated water for reuse. The treatment process included advanced flocculation techniques. At the time this paper was prepared, the plant had received over 4,000 m<sup>3</sup> of drilling waste including drilling fluid, brine, waste water, and sludge from pit cleaning. From this 4,000 m<sup>3</sup> of waste fluid, the Anduki plant produced 2,196 m<sup>3</sup> of treated water. The rig was able to incorporate 244 m<sup>3</sup> of this volume into the active drilling fluid system. The dense mixture of solids and water remaining after the treatment and removal of excess water through evaporation had the necessary properties for disposal to landfill.

The volumes of water-based and synthetic-based drilling fluid consumed per meter drilled was also reduced by the application of Total Fluids Management processes. By installing new, well-maintained centrifuges at each rig and closely monitoring surface and downhole volumes as well as shaker performance, personnel were able to reduce the mud consumption from an average of approximately 3.0 m<sup>3</sup> per meter drilled during the first 10 wells to an average of approximately 0.25 m<sup>3</sup> per meter drilled on the 12 wells where Total Fluids Management services were implemented (Figure 3). These results also coincided with longer wells on average. Because every litre of water used on site needs to be trucked away, treated, and disposed of, a reduction in water usage is also a critical success factor.

## **Cost Analysis and Comparative TFM Costs**

The Total Fluids Management process addresses every aspect of the drilling fluid system: mud and personnel, chemical treatments, solids control optimization, water recovery and treatment, and drilling waste handling and transportation. For Total Fluids Management services to be cost effective, the savings achieved in waste handling and disposal and the prevention of non-compliance must be greater than the cost of maintaining Total Fluids Management services and necessary personnel on the project.

The cost of Total Fluids Management services to BSP was calculated on a per-meter-drilled basis (Figure 4), then analyzed in terms of savings in actual versus planned drilling fluids costs and a reduction in third party charges. After full Total Fluids Management services were established on the 12-well project, more than half the wells came in well under the planned drilling fluid cost, as compared to earlier wells where the actual cost exceeded planned cost the majority of the time (Figure 5). Third-party charges also dropped dramatically after the introduction of full supervision by Total Fluids Management services. The results achieved on the S-808 well demonstrate the type of savings effected by Total Fluids Management services:

Total Total Fluids Management Services Cost on Well (USD\$)	22,424
Less:	
Reduction in Third Party Charges	3,750
Savings between Planned and Actual Drilling Fluid Cost	52,002
<b>Total Savings Resulting from TFM Services (USD\$)</b>	<b>33,328</b>

## **Impact on Health, Safety, and the Environment**

A reduction in waste volumes translated into fewer kilometres driven by third-party disposal services. At the time this paper was prepared, BSP and the team for Total Fluids Management services agreed to a method for monitoring transportation kilometres as compared to target values. This documentation will help BSP reduce liability related to transportation.

The personnel for Total Fluids Management services has demonstrated a commitment to safety throughout the project. Since commencing operations on the 15-well land project, the team has logged more than 13,000 man-hours with no recordable incidents. Representatives for Total Fluids Management services are also responsible for writing 372 STOP cards to help ensure continued safe operations on the project.

## **GAINING ISO 14001 CERTIFICATION**

Total Fluids Management services is a comprehensive quality management system that maps out the appropriate activities to complete seven key processes: developing solutions; preparing resources; mobilizing resources; delivering services; demobilizing resources; completing reports; and reviewing performance. Total Fluids Management services allow for adaptation to specific circumstances and help maintain a focus on continuous improvement. As demonstrated in the BSP project, the successful implementation of Total Fluids Management services had a positive impact on drilling fluid costs, waste stream reduction, waste management cost reduction, and a reduction in environmental liability for the operator.

Compliance with the ISO 14001 procedural standard relies on accurate identification and tracking of all waste volumes and the correct disposal of waste streams. The written procedures and fit-for-purpose forms that support the Total Fluids Management process are designed to meet or exceed the requirements of regulatory agencies and ISO standards (Figure 6). In support of the BSP operations, the team for Total Fluids Management services compiled and executed written procedures to identify waste streams and disposal options, including manifests to enable mass balance of waste volumes. These procedures were reviewed by the ISO audit team and accepted without changes.

## **IMPROVEMENTS AND ACHIEVEMENTS**

Simply drying the cuttings by frequent turning in tropical sunlight can reduce the liquid content of the cuttings to less than 20%. Below this level the cuttings can be used as capping material in the landfill and are received at no cost by the landfill operator. A low-cost drying operation thereby led to a

huge reduction in classified waste as well as an economic benefit. By means of a wastewater treatment plant utilising flocculation and centrifuging, liquid mud could be reduced to clean brine and a solids stream. The centrifuged solids are mixed in with the cuttings for drying. The clean brine can be injected into the produced water stream at the nearby crude oil terminal at no cost other than for the initial treatment in the wastewater treatment plant and transportation to the terminal. In addition, some of the regenerated brine can be used to build new mud so that some recycling can take place.

The team for Total Fluids Management services recommended and implemented a number of modifications to equipment and procedures. The examples shown below demonstrate the importance of educating each crew member and service company representative about his or her role in achieving better waste management performance. These examples also show how comprehensive the scope of Total Fluids Management services is on a given project, ranging from software development to reconfigured rig equipment. The following improvements were achieved:

- Incorporated a tracking database to assist with accurate accounting processes for fluid movement, costs, and other metrics that will help BSP with continued ISO 14001 compliance.
- Reduced the volume of waste water generated at the rig site through rig crew training.
- Worked with onsite drilling fluids representative to monitor and optimize dilution rates, shaker screen usage, and drilling fluid properties.
- Equalized the surface mud system so that surface volume was reduced by approximately 40%.
- Eliminated the need for solids control equipment wash water by installing hoses that wash the screens with drilling fluid rather than water.
- Enabled effective offline centrifuging and the reclamation of used mud volumes as well as centrifuging of the active system.
- Supervised and confirmed daily maintenance of all solids control equipment to ensure maximum performance.

## CONCLUSIONS

Based on twelve months of operations encompassing 27 wells on land and offshore, BSP expects to save an average of US \$24,000 per rig per month through the continued use of Total Fluids Management services. The key activities expected to generate this cost savings are as follows:

- Waste stream minimization
- Close supervision of the handling and disposal of drilling wastes
- Daily maintenance of solids control equipment by trained technicians
- Thorough training for rig crews and service personnel on waste stream reduction and management
- Evaluation and optimization of surface mud system
- Accurate performance measurements and focus on continuous improvement
- Compliance documentation

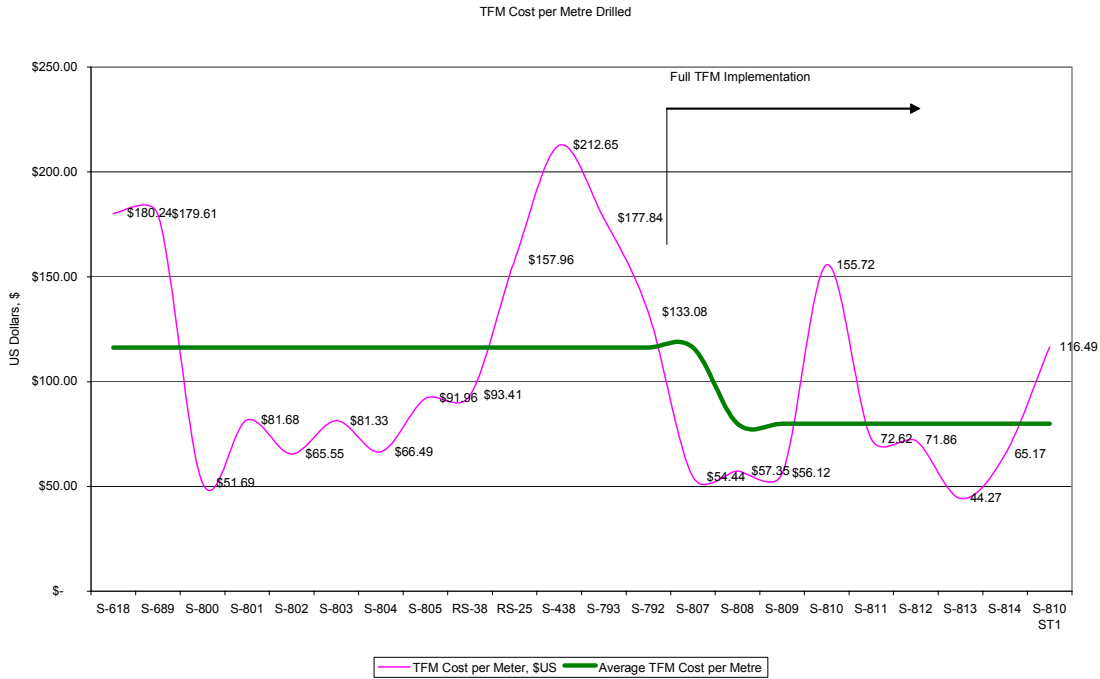


Figure 1: Average cost/m for Total Fluids Management services before and after implementation

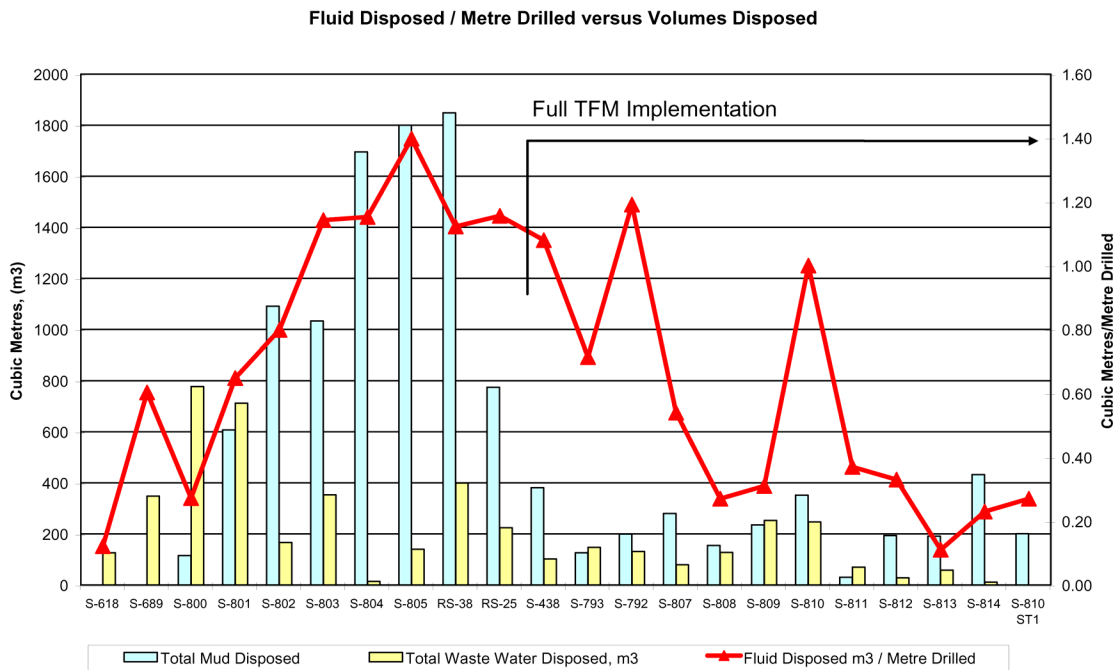


Figure 2: Volume disposal per meter drilled before and after Total Fluids Management services

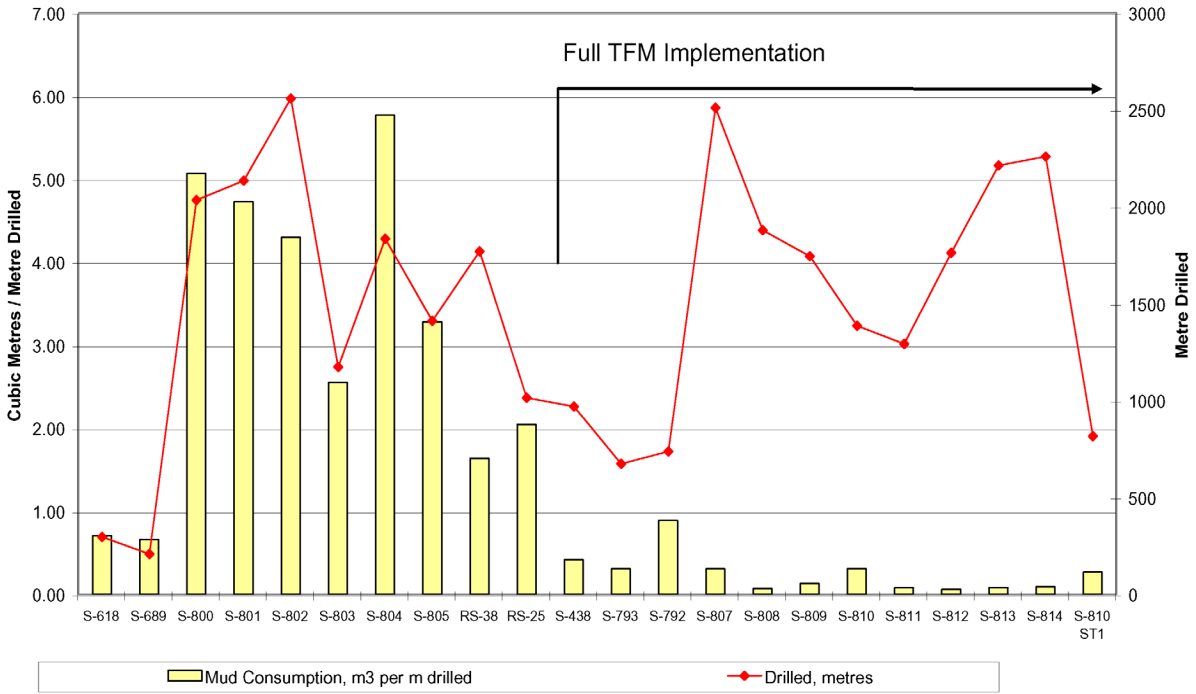


Figure 3: Drilling fluid consumption per meter drilled

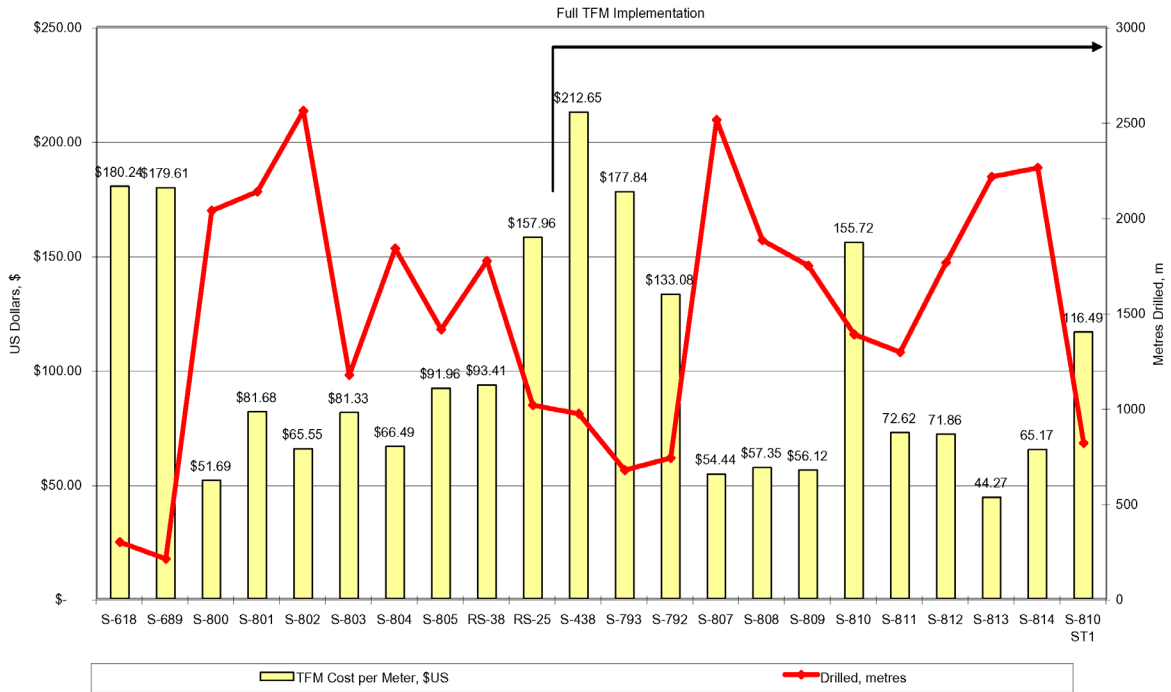
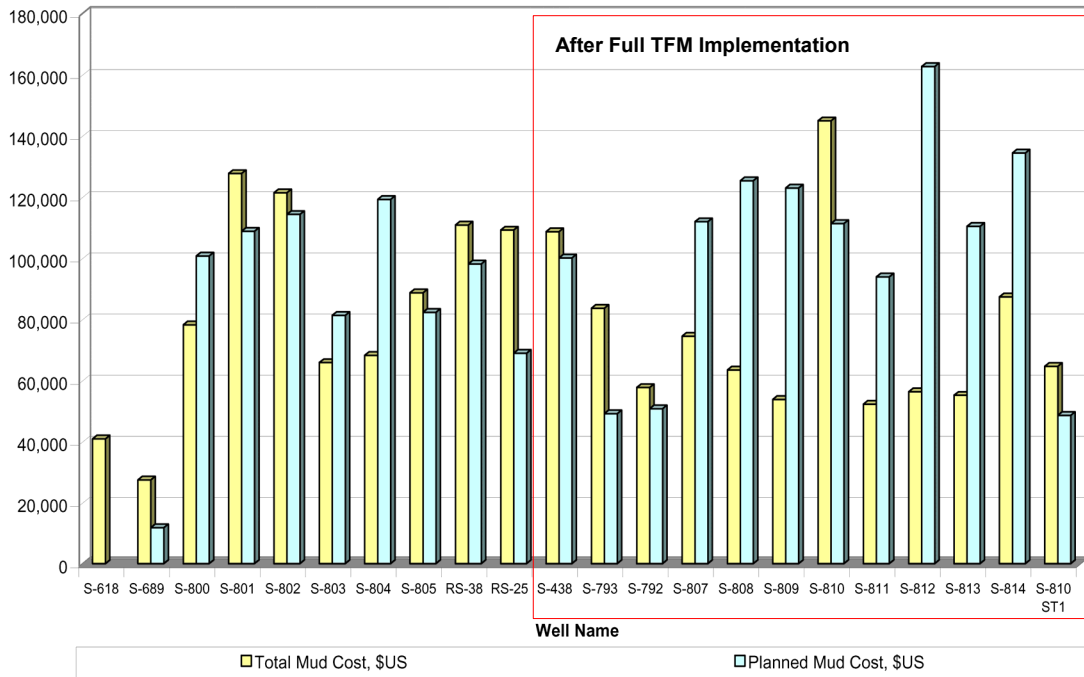


Figure 4: Total Fluids Management services cost per meter drilled



**Figure 5:** Planned versus actual drilling fluid costs before and after Total Fluids Management services

HALLIBURTON Baroid		BAROID SURFACE SOLUTIONS TOTAL FLUIDS MANAGEMENT - DAILY REPORT Brunei Shell Petroleum			BSP	
OPERATOR	Brunei Shell Petroleum	CONTRACTOR	KCA Deugang	DATE	09/09/2009	
OPERATOR REP(S)	Sandy Buchanan	CONTRACTOR REP(S)	MangUalphones	REPORT NUMBER	0	
ADDRESS	Seria #B 3034	COUNTY	Kuala Belait	ROTARY TABLE (m)	7	
WELL NAME	SHRON-N 5-226	RIG	T-11	FIELD	Seria	
CURRENT ACTIVITY	Drilling	PROJECT PLATFORM	Phase II	BLOCK	09	
WELL INFORMATION		HSE			WELL PERFORMANCE	
BK Diameter (in)	8 1/2	Actual	Target	Actual	Target	
Start Depth (m)	2247	LTI (TFM)	0	0	0.00%	
End Depth (m)	2279	Spills (TFM)	0	0	0.00%	
Daily Metres Drilled (m)	32	Man Hours (TFM)	338	533		
Average ROP (m/hr)	0	STOP Cards (HSE)	20	24	TFM Cost (m)	38.45
TOTAL FLUIDS MANAGEMENT VOLUMES			TOTAL FLUIDS MANAGEMENT COST (\$)			
DAILY CUM.			OPERATION (\$) DAILY CUM.			
DRILLED CUTTINGS (m <sup>3</sup> )	Generated	1.17	104.58	Baroid Surface Solutions (B.S.S.) Supervisor	880.00	5,280.00
	Shipped to H.T.E.	0.00	232.00	Solids Control Equipment	255.00	2,040.00
	Shipped to Dua Dua	0.00	152.00	Solids Control Personnel	0.00	0.00
	A.W.W.T.P. to H.T.E.	0.00	92.00	Shaker Screens	0.00	1,595.00
WASTE WATER (m <sup>3</sup> )	OTHER	0.00	0.00	Arabic Waste Water Treatment Plant (A.W.W.T.P.)	450.00	3,800.00
	Disposed from Cellar	0.00	8.00	J.K.R. (Public Water Works)	0.00	0.00
TREATED WATER (m <sup>3</sup> )	Disposed from Pit/Tank Cleaning	0.00	4.00	Seria Crude Oil Terminal (S.C.O.T.)	0.00	0.00
	Added to Drilling Fluid / Brine	0.00	0.00	Cumulative Operation Cost	1,365.00	12,515.00
	Returned from AWWTP (storage)	0.00	0.00	TREATMENT (\$)	DAILY CUM.	
WBM	A.W.W.T.P. to S.C.O.T.	0.00	0.00	A.W.W.T.P. Treatment Chemicals	158.76	1,802.77
	A.W.W.T.P. to S.C.O.T.	0.00	188.00	Cuttings Treatment cost	190.00	5,828.00
A.W.W.T.P.			Cumulative Treatment Cost			
DAILY CUM.			TRANSPORTATION (\$)			
A.W.W.T.P.	14.00	316.00	A.W.W.T.P.	0.00	0.00	
Seria Mud Plant (SMP)	0.00	112.00	SMP	0.00	0.00	
S.C.O.T.	0.00	0.00	S.C.O.T.	0.00	0.00	
J.K.R.	0.00	0.00	J.K.R.	0.00	0.00	
Pits & Spacers			Cuttings to			
A.W.W.T.P.	0.00	0.00	A.W.W.T.P.	0.00	0.00	
Seria Mud Plant (SMP)	0.00	0.00	SMP	0.00	0.00	
S.C.O.T.	0.00	0.00	S.C.O.T.	0.00	0.00	
J.K.R.	0.00	0.00	J.K.R.	0.00	0.00	
Waste Water			All Fluids to & from (WBM, Brine & Waste Water)			
DAILY CUM.	0.00	48.00	Other	0.00	0.00	
Location	Sewage	J.K.R.	6.00	0.00	0.00	
Actual m <sup>3</sup>	0.00	48.00	Actual m <sup>3</sup>	6.00	0.00	
DRILLING FLUID RECOVERED (Drig Ops)			CUMULATIVE BSS COST			
DAILY CUM.	0.00	0.00	DAILY CUM.	34.071	48,790	
Recovered from Cellar	0.00	0.00	CUM. DRILLING FLUID COST	53.572	97,894	
Recovered from Cuttings Skip	0.00	5.00	CUMULATIVE TFM COST (\$)	87,443	143,674	
Other Fluid Recovered	0.00	0.00	CUMULATIVE TFM COST			
Fluid Distributed From Seria Mud Plant	To Rig for Re-Use	0.00	188.00			
To AWWTP for Dewatering	0.00	56.00				
To AWWTP for Centrifuging	0.00	0.00				
SERIA MUD PLANT CAPACITY						
FLUID TYPE	MPa/in	Volume	Pr. Cap. (m <sup>3</sup> )	52MT	51Utilized	
KCL/POLYMER	11.80	4	45.6	00/01/00	29/05/04	
KCL/POLYMER	11.80	4	45.6	25/05/04	-	
KCL/POLYMER	11.80	5	43.6	00/01/00	29/05/04	
-	-	0	94.1	-	-	
-	-	0	119	-	-	
-	-	0	94.1	-	-	
SMP UTILISATION	13	444	39			
SOLIDS CONTROL INFORMATION						
SHAKER DATA		CENTRIFUGE DATA				
Equipment Type/Model	Brand	Brand	Equipment Type/Model	Brand		
Screen Size	140	140	Rot. Speed (rpm)	2500		
Weight in (kg/m <sup>3</sup> )	11.4	11.4	Rot. Drive speed (rpm)	2420		
Weight out (kg/m <sup>3</sup> )	11.2	11.2	Feed Rate (t/hr)	200		
Discard Weight (kg/m <sup>3</sup> )	18	18	Weight in (kg/m <sup>3</sup> )	11.4		
Flow Rate (l/hr)	4	4	Weight out (kg/m <sup>3</sup> )	11.1		
Hours Run (hrs)			Hours Run (hrs)	20		
TRANSPORTATION KILOMETRES						
Transport	Destination	ACTUAL	TARGET			
Cuttings to	To A.W.W.T.P. Truck @ Site	842.00	830.00			
	Dua Dua	548.00	550.00			
Fluid to	A.W.W.T.P. to H.T.E.	472.00	500.00	Comments: No precipitation.		
	To Arabic W.W.T.P.	730.40	500.00	MAY and NOV new BHA. Cuttings to cell from 2247m. Depth at report time 2287m. Sent 6m <sup>3</sup> sewage to JKR.		
	Seria Mud Plant	30.00	485.00			
	S.C.O.T.	133.20	254.00			
J.K.R.	294.00	100.00				
OTHER	OTHER	0.00	300.00			
TOTAL TRANSPORTATION KILOMETRES		2194.40	3350.00			
TFM Engineer:	Sandy Chiew	Office:	F18 Lorong 4, Seria	Telephone :	8733223048	

Figure 6: Example Total Fluids Management Services Daily Report