Drilling Waste Management Strategy for Field 'X'

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Abstract

Drilling waste management is a planing and implementation of a prudent drilling waste collection, treatment and final disposal. A well planned drilling waste management system not only ensure the health and safety of the surrounding environment, it also brings advantages to the drilling operation effectivity and economics. The drilling waste management technologies and practices can be grouped into three major categories : waste minimization, recylce/reuse and disposal. This essay will later discuss about planning a fit for purpose drilling waste management system for a new field by studying the waste generation from previous drilling activity, estimating waste generation of the planned wells, creating and evaluating drilling waste management scenarios and choosing the best scenario based on its environment safety, cost and doability through SWOT and analytic hierarchy process.

Keywords: drilling, waste, management, strateg

Introduction

Drilling activity is one of the main aspect in oil and gas operation. Drilling project main objective is to prove the possible reserve. Before drilling activity can be conduct, the amount of hydrocarbon reserved inside the reservoir is estimated through geologic and seismic calculation methods. The estimated amount of hydrocarbon reserve then is assumed as a possible reserve which can only be proven by drilling operation.

In drilling operation, drilling fluid is a vital aspect that holds important functions to keep the operation safe. Selection of drilling mud material and drilling mud system contributes to the success of the whole drilling operation. Regardless of the operation success to prove the possible oil reserve, a drilling operation will always generate waste. These drilling waste

includes whole spent drilling fluid, drill cuttings, excess cement, hole cleaning fluid and completion fluid. Drilling waste tend to contain toxic in a harmful amount for the surrounding environment which is caused by heavy metals, salts and hydrocarbon contained in it. These toxic substances can cause a chronic, acute and even causing a cancer to organism, organ or specific cells in organism. Worst than mentioned, drilling waste contamination could cause a long term effect on the surrounding environment if it is disposed without being treated first.

The harm that drilling waste could cause as mentioned above made it illegal to be dispose to the surrounding environment without being treated first. The disposal of the drilling waste is also regulated strictly by law from the local goverment in terms of the toxic content and ways to dispose it. Other than the harm it cause to the environment, a poorly planned drilling waste management system can increase the cost of waste handling and disposing which ultimately increase the whole operation cost and also increasing the potential of long term liabilty cost and fines from lawsuit regarding unsafe practice of hazardous waste disposal. For the reasons mentioned above, drilling waste management system becomes important to be planned carefully. A good drilling waste management system have a huge role in making the drilling operation efficient and economic. Drilling waste management is a planning and implementation of a prudent waste collection, treatment, and disposal plan. Drilling waste management begin from the process of selecting the type and material of a drilling fluid until the drilling operation finished. The type of drilling fluid used affect the volume and type of waste generated, type of treatment needed and specific tools needed. The process of mud filtration is also a part of drilling waste management methods where in the process, solids control equipment such as shale shaker, hydrocylcones, centrifuges, separator, cutting dryer etc is used. The last step of the drilling waste management system is the carefully planned disposal of the treated waste.

Problem Statement

In a drilling operation whether it ends up producing oil and gas or not, it will always generate a drilling waste. this drilling waste consist of solid waste and liquid waste. drill cutting is a solid waste while excess cement, whole spent drilling fluid, hole cleaning fluid, completion fluid and spacers are the liquid waste. Some of the components in the drilling waste are considered to be harmful and can cause a severe damage to the surrounding environment if not taken carefully and create liability issue to the responsible oil and gas company which can cost a lot of money. A poor management system of these drilling waste can cause a lot of problems from environmental to operation effectivity and economics. Considering the effect a poor drilling waste management system can cause to a drilling operation, a well planned drilling waste management strategy become essential and beneficial in a drilling operation. The drilling waste management strategy planning is carry out in order to decrease the risk of harming surrounding environment, increase drilling efficiency and reduce the cost of the operation. The strategy planning is done by studying a data from offset wells, estimating the waste generation of the new planned wells, creating possible scenarios or alternatives and analysing each scenario to find the most fit for purpose drilling waste management system.

Theory

Drilling activity generate several main types of waste such as whole spent drilling fluid, drill cuttings, cement, spacer and completion fluid. The drilling waste is differentiate into three phase, solid dry waste, solid wet waste and liquid waste. these waste are differentiate based on the specific gravity of each components. The solid dry waste have a specific gravity between 1.7 to 2.4, the solid wet waste have a specific gravity above 2.4 and the liquid waste have a specific gravity below 1.7. These drilling waste is differentiate based on phase because the treatment and disposal cost of the each phase is different. Drilling Waste management is a planning and implementation of a prudent waste minimization, reuse/recyclye, treatment and disposal plan. Drilling waste management must be a standard in every drilling operation because of many factors such as government rules and regulations, public outcries about unsafe waste disposal practices, which resulted in environmental pollution and public health risks, increasing costs of handling and disposal and the enormous costs associated with liability for wastes and remediation of prior disposal sites. Drilling waste management practice can be grouped into three major categories: waste minimization, recycle/reuse, and treatment and disposal which sets out a hierarchy.The Drilling waste management hierarchy sets out a prefer sequence of options. The first and most preferred option is minimization, minimization is activity that reduce or eliminate either the generation of waste at the source or the release of a contaminant from a process. The second preferred option is recycling. Recycling is the reclamation of the useful constituents of a waste for reuse, or a reuse of a waste as a substitute for a feedstock in an industial process. The last two and least preferred options are treatment and disposal. One effective way used in drilling waste management is solid control equipement. Solid control is one of the most important aspects in minimizing waste generation from a drilling well. Before the introduction of mechanical solids-removal equipment, dilution was used to control solids content in the

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drilling fluid. The typical dilution procedure calls for dumping a portion of the active drilling-fluid volume to a waste pit and then diluting the solids concentration in the remaining fluid by adding the appropriate base fluid, such as water, oil or synthetic oil. This “zero efficiency” approach result in a huge amount of waste fluid which is capable of leaching into the environment and harmed the organism in it. Nowadays, solid control is done with a mechanical solids-removal equipment. This method is highly efficient compared to the dilution process. Although by using mechanical solids-removal equipment does not completely erase the needs of dilution, it greatly minimize it. Using solid control equipment has been a standard practice for the drilling industry for more than 60 years and is considered as critically important to waste management as well as to overall drilling efficiency.

There are many advantages to efficient solids control, such as :

- Increased penetration rates
- Lower mud cost and base fluid requirements
- Reduced torque and drag
- Less differential sticking
- Lower pump wear and maintenance cost
- Lower disposal cost

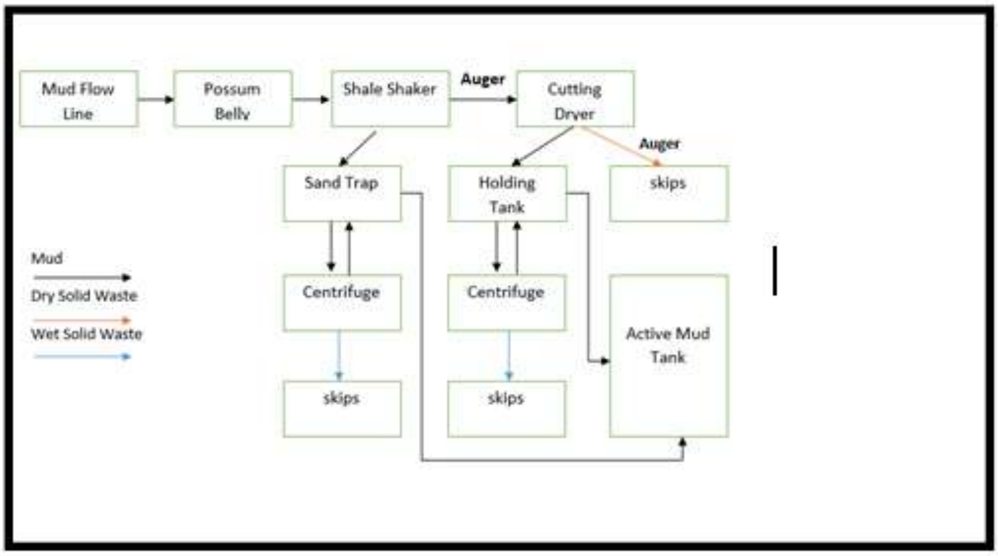
Although solids control equipments and method have change over the periode of time due to technologies developement, the fundamental behind the process have not change:

- Solids concentration matters—increasing solids content is detrimental to fluid performance.
- Economics matter—mechanical removal of solids costs less than dilution.
- Volume matters—the volume of waste generated is indicative of performance.
- Size matters—fine solids are the most detrimental and difficult to remove.
- Shaker-screen selection matters—shaker screens make the only separation based on size.
- Footprint matters—the space available for equipment on rigs always is limited.

Mechanical solids-removal equipment also known as solids control equipment consist of many devices that works in a sequence. In order to understand solids control program, it is necessary to understand each of the devices used in solids control.

The drill cuttings generated from the drilling process is transported to the surface by the drilling fluid, in order to maintain balance in the active mud system these drill cuttings must be seperated from the circulating mud. The separation process is done by means of mechanical process that involves many solid control equipments such as the shale shakers, centrifuges and cutting dryer. The flow of the drill cuttings will be explained through a schematic diagram in figure 1 below in order to better understand the drilling waste management system.

Figure 1. Drilling Waste System Schematics



Drill cuttings which is transported by the drilling fluid reach the surface into the mud flow line which then goes to the possum belly – a tank to contain mud and drill cuttings- from the possum belly the mud and drill cuttings enter the shale shaker – a vibrating screens device which seperate a coarse cuttings from the mud- the shale shaker can only seperate a relatively large size cutting, this large size cuttings which still contain some part of mud on it will then enter the cutting dryer to reduce the oil on cutting. The oil with low residue of fine solids which is successfully seperated by the cutting dryer will be contain in a holding tank and sent to the centrifuge in order to seperate the fine solids. After the seperation process the oil will be send back to the holding tank and ultimately to the active mud tank to be reuse while the fine solid will be disposed to the skips. The finer cutting that escapes the shale shakers will be send to another centrifuge to seperate the fine solid from the usable oil. The process is similar with the other centrifuge, the fine solids will be disposed into the skips while the usable oil will be send back to the active mud tank. The methodology used to plan a suitable drilling waste management strategy is to study drilling waste data from previous drilled well, estimating the drilling waste generation for the new wells with washout factor & mud and expansion factor methods and fluid waste calculation methods, creating possible drilling waste management scenarios and evaluating each scenarios by SWOT analysis and Analytic Hierarchy Process methods.

The formula of washout factor and mud & expansion factor method is as follows :
W = (HV x (1+WF)) x MEF..............................(1)
Information :
W = Total Waste, bbl
HV = Hole Volume, bbl
WF = Washout Factor, %
MEF = Mud & Expansion Factor

Or,

W= gauge x WF x & MEF x h..........................(2)
Information :
W = Total Waste, bbl
Gauge = $\frac{Bit\ Size^2}{1029.4}$, bbl / ft
WF = Washout Factor, %

MEF = Mud & Expansion Factor

The formulas of fluid waste calculation is as follows :

Extra Discard = Spacers Vol. x 25%..(3)

Clean Out = $3\ x\ [\left(\frac{ID\ Csg^2 - OD\ Tbg^2}{1029.4}\right) xh]$ + Pills vol..(4)

Total Waste = Extra Discard + Clean out + Spacers vol..(5)

Information :

Cont. Fluid vol. = Contaminated Fluid Volume, bbl
Spacer vol. = Volume of Spacers, bbl
HC = Hole Cleaning Fluid Volume, bbl
ID csg = Casing Inside Diameter, inch
OD t bg = Tubing Outside Diameter, inch
h = Depth, ft
Pills vol. = Volume of Train Pills, bbl
Spacers vol. = Volume of Spacers, bbl
Total Waste = Total Liquid Waste, bbl

Result and Discussion

In planning a drilling waste management system for a new field, a study from an existing wells or usually called offset wells can help better understanding of the waste generation volume, equipment used, favourable scenarios, disposal option used and testing the accuracies of drilling waste volume estimation. The offset well drilling waste data used to help plan a driling waste management system for Field X is from four ABC's well (ABC-16, ABC-17, ABC-18, ABC-19). These four ABC wells drilling waste data were used because it is by far the most well recorded drilling waste volume generation data. The well depths of this four well is accumulated per sections to simplified later calculation. The footage of section 17-1/2" is 499 ft, the footage of section 12-1/4" is 3922 ft, the footage of section 8-1/2" is 7737 ft and the footage of section 6-1/8" is 5640 ft. The drilling waste of these four wells is differentiate into two categories based on it's phase, solid waste and liquid waste because the disposal cost is different. The solid waste includes wet and dry cuttings while the liquid waste includes spacers, excess cement, hole cleaning, completion fluid and workover fluid. The solid waste of these four wells is recorded a total of 883.98 tonnes and the total liquid waste is recorded at 2539.42 m^3. Two methods of calculation are used to estimate the solid drilling waste generation, the estimate waste generation method and the washout factor and mud & expansion factor method. The accuracies of both method is tested by comparing the estimation of drilling waste generation to the actual drilling waste data. The estimate waste generation methods estimate a total of 951 tonnes of solid drilling waste while the washout and mud & expansion factor method estimate a total of 881.67 tonnes of solid drilling waste. The actual solid drilling waste data record a total of 883.98 tonnes. In comparisson, the washout factor and mud & expansion factor shows a more accurate estimation with a difference of 0 % while the estimate waste generation method gives a 7 % difference from the actual data. The estimate waste generation method is not choosen because it is less accurate and the assumption used in calculation such as the fraction of dry solid and solid control efficiency have more uncertainties. The washout factor and mud & expansion factor is choosen but the 0 % difference is considered to be too optimistic for a plan, the washout factor is later changed from 3.23 % to 15 % in order to have a safe number incase the actual waste turn to be bigger than predicted. The liquid waste is calculated by fluid waste method with a result of a total 954.62 m^3. The result of this estimation method is far off compared to the actual data of liquid waste which is 2539 m^3 . the difference between the actual and estimation is as huge as 166%. The difference is studied and found out that the source of the huge gap is the workover fluid recorded in the actual data. The fluid waste method is then considered accurate to be used in estimating liquid drilling waste volume because workover fluid is not considered a drilling waste.The scenarios of the drilling waste management system for field X will used a device called a cutting dryer, in order to find out how much effect a cutting dryer cause in the operation cost and effectivity a field experiment is conducted to test the efficiency of the device. From the experiment it is known that a cutting dryer can reduced a solid drilling waste mass for up to 24% of its original mass while also reducing the oil on cutting percentage. The mass reduction will affect the disposal cost and impact the overall operation cost.

After the studies of offset wells and cutting dryer efficiency a drilling waste management can be planned for the new field. Field X is planned to have 6 wells, with 4 new wells and 2 re-drill wells. The sections and depths of the new wells will be 1500 ft for 17-1/2”, 6000 ft for 12-1/4”, 3500 ft for 8-1/2” and 2500 ft for 6-1/8” section. While the sections and depths for the re-drill well will be 4500 for 12-1/4”, 6500 ft for 8-1/2” and 2500 ft for the 6-1/8” sections. The footage of the 6 wells are accumulated into one data to simplified later calculation of drilling waste generation. . The footage of section 17-1/2” is 6000 ft, the footage of section 12-1/4” is 24000 ft, the footage of section 8-1/2” is 27000 ft and the footage of section 6-1/8” is 15000 ft. Each of the new wells is planned to be drilled in 40 days while each of the re-drill well is planned to be drilled in 35 days which in total the 6 wells will be drilled in 230 days. There will be two drilling waste management system scenarios for field X, scenario A is disposing the waste directly to the 3rd party waste facility while scenario B is treating the solid drilling waste with cutting dryer before disposing it to the 3rd party waste facility. The use of cutting dryer will only affect the solid drilling waste generation and not the liquid drilling waste generation. The methods use to calculate the solid drilling waste generation is the washout factor and mud & expansion factor while the fluid waste method is used to calculate the liquid drilling waste generation. The total solid drilling waste of scenario A is estimated to be 5608.78 tonnes while the total solid drilling waste of scenario B is estimated to be 4207.64 tonnes (as shown in figure 2). The difference in solid waste mass between the two scenarios is up to 25 % and is caused by the use of cutting dryer (as shown in figure 1). While the total liquid drilling waste of the two scenarios are 1,507,584 liter which is completely the same because cutting dryer have nothing to do with the liquid drilling waste. This great difference in solid drilling waste mass will affect the cost of each scenarios. The cost for each scenarios is calculated in order to help decide which scenario is the best from the economics point of view. The total cost for scenario A is a staggering 4,324,482 US$(as shown in figure 3), the solid waste disposal cost contribute 1.5 million US$. While the major contributor of the operation cost is the mud build cost which reached almost 2 million US$. The mud build is needed because by not using a cutting dryer, a large amount of drilling mud get discarded along with the wet solid drilling waste. this discarded mud cause the mud system to be underbalance and need to be replace with the equal amount of discarded mud and the cost for replacing SBM mud is relatively expensive. The total cost of scenario B is 2,741,795 US$ (as shown in figure 3), the major contributor to the cost is the solid waste disposal cost which is 1,165,516 US$ or almost 400 thousand US$ less than solid waste disposal cost of scenario A. The cutting dryer reduced the mass of the solid waste which later on lower the cost of disposal, and the mud build cost is also negligible by using a cutting dryer because the usable mud is gathered back from the wet cutting into the active mud system. By not spending on mud build alone save the operation cost up to 1.9 million US$. From an economics point of view scenario B (with cutting Dryer) is highly favourable because it saved 37 % of the cost from scenario A (as shown in figure 4).

A later studies of each scenarios strategies using SWOT analysis and analyitic hierarchy process is conduct for each scenarios. A lot of factors is considered in choosing the scenario such as health and safety of the environment, doability, compliance and economics. The SWOT analysis is conduct first to list all important factors present in each scenarios, it helps to sort the kind of advantages and disadvantages one scenarios have over the other. It also helps to decide which factors should be the priority of the operation which aid in later analytic hierarchy process. The SWOT analysis study shows that scenario B have less environmental issue risk due to less oil on cutting and less waste generation and also a much cheaper option than scenario A while from a doability point of view, scenario B is much more complicated and need extra working space. In the analytic hierarchy process, three criteria are choosen to consider which alternatives is the most fit for purpose. Those criteria are environment safety, cost and doability. Super Decision software is used to carry out the analytic hierarchy process. By setting criteria priorities and criteria categories, alternatives are weigh and compare with each other in order to find the best one. The analytic hierarchy process shows that scenario B have a priority value of 0.624 while scenario A have a lower priority value of 0.376 (as shown in figure 5). These numbers suggest that scenario B is more favourable to be choosen based on the environment safety, cost and doability factors.

Conclusion

From the analysis and evaluation of each drilling waste management scenarios, it can be concluded:

1. Record keeping is essential for a future planning of drilling waste management system
2. By using cutting dryer the total solid waste is reduced by 24% from its initial mass
3. Mud build cost is the biggest contributor in increasing the overall operation expenses
4. Waste disposal cost to the 3rd party is costly, hence reduction of waste mass or volume significantly cut the cost spend
5. The total solid drilling waste generated in scenario A is estimated to be 5608.78 tones
6. The total solid drilling waste generated in scenario B is estimated to be 4207.64tones
7. The total liquid drilling waste generated in scenario A and B are estimated to be 1,507,584 liter
8. The total drilling waste management cost of scenario A is 4,324,482 US$
9. The total drilling waste management cost of scenario B is 2,741,795 US$
10. Scenario B (cutting dryer + 3rd party disposal waste facility) is the most fit for purpose scenario
    - Less environmental issues
    - Cost effective

List of Symbols

%	= Percent
“	= Inch
Bbl	= Barrel
Ft	= Feet
H	= Depth, ft

HC	= Hole Cleaning Fluid Volume, bbl
HV	= Hole Volume, bbl
ID csg	= Casing Inside Diameter inch
m^3	= Meter Cubic
MEF	= Mud & Expansion Factor
OD tb g	= Tubing Outside Diameter, inch
Pills vol	= Volume of Train Pills,
Spacers vol	= Volume of Spacers, bbl
Total Waste	= Total Liquid Waste, bbl
W	= Total Waste, bbl
WF	= Washout Factor, %
US$	= United State Dollar

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Attachment

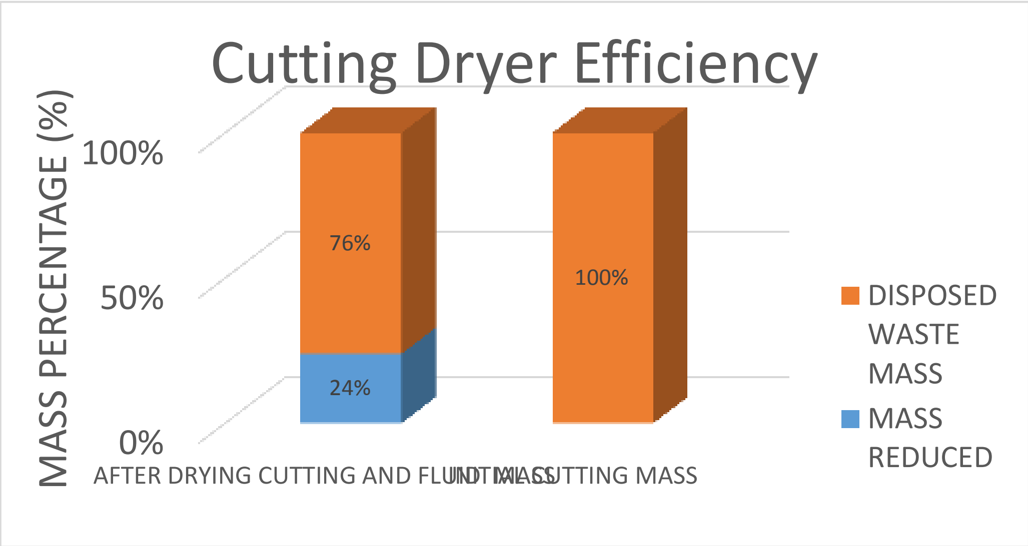

Figure 1. Cutting Dryer Efficiency

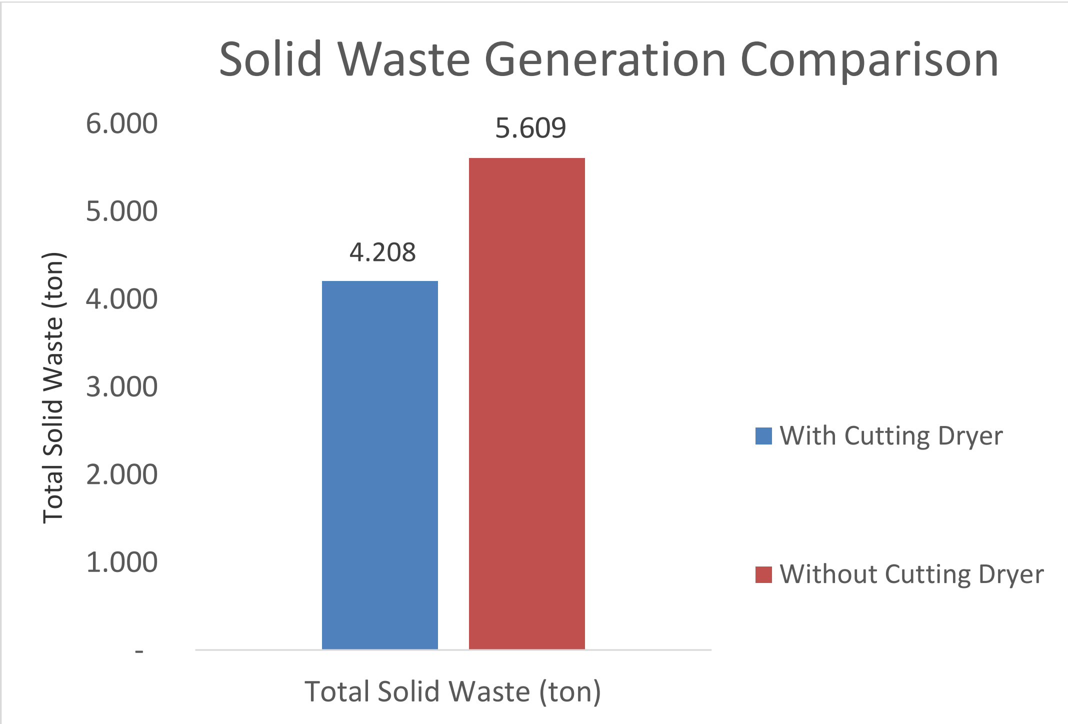

Figure 2. Waste

Generation Summary per scenarios

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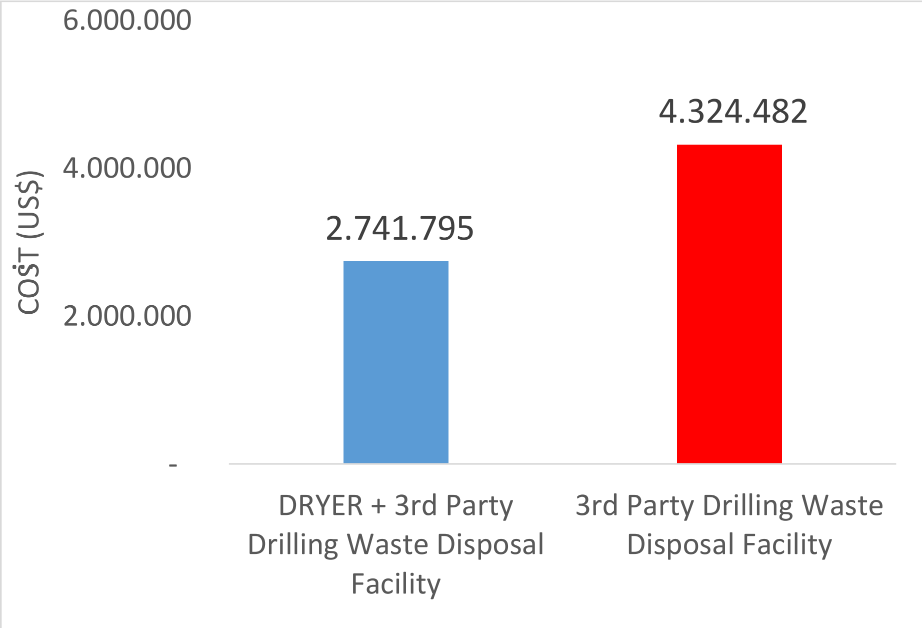

Figure 3. DrillingWaste Management Scenarios Cost Comparison

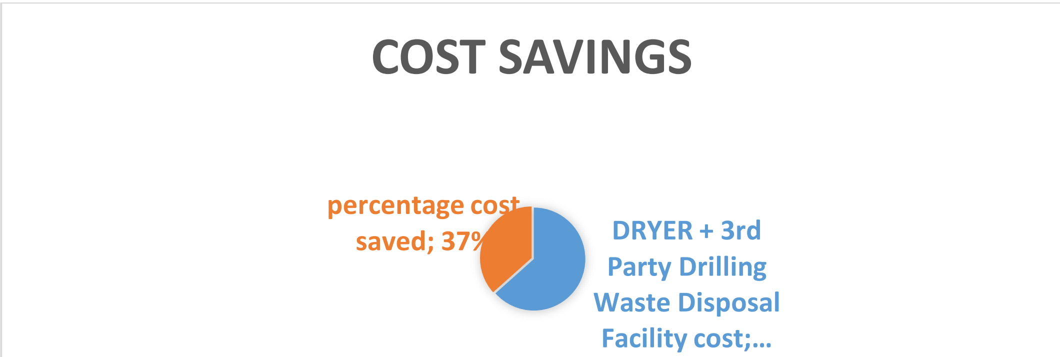

Figure 4. Cost Saving

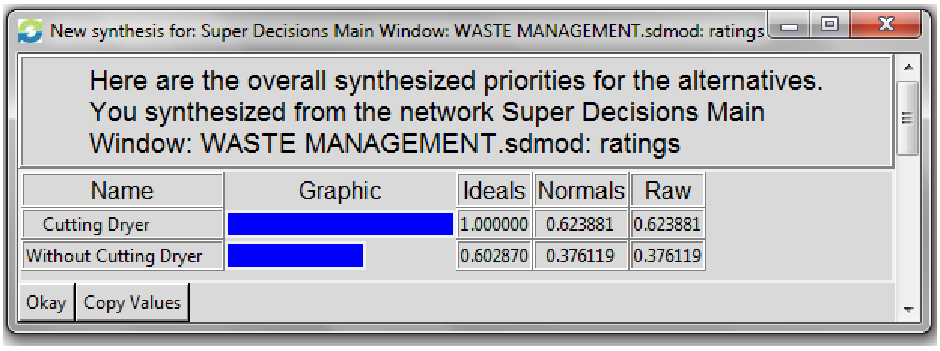

Figure 5.Analytic Hierarchy Process Results