New Innovative Process Allows Drilling Without Pits in New Mexico

Dorsey Rogers, Cimarex
Gary Fout, M-I SWACO
William A. Piper, Piper Consulting

ABSTRACT

Several factors have led to the use of reserve pits in New Mexico. Primarily, poor solids control efficiency dictated a "dump and dilute" strategy where a large reserve of dilution fluid was required to maintain a low concentration of detrimental drilled solids. The "horseshoe" designed pit allowed a single pit to double as a collection point for drilled cuttings and associated fluid waste.

Recent improvements in solids control equipment coupled with new developments in chemical flocculants and coagulants have allowed high solids control efficiencies to be achieved without dilution. Further, the solid waste generated contains very little associated fluid.

This paper discusses the new, innovative process and the impact it has on waste generation and character, disposal options, cost, and liability issues.

EXHIBIT
tabbles
11

DISCUSSION

Solids Control and the Role of Earthen Pits

Earthen reserve pits have a number of functions in the drilling operation. Two are more prominent than the others and are relevant to the topic this paper. The first function of the reserve pit is to hold an abundance of "reserve" fluid for use as drilling fluid. The second function is to contain the waste generated by drilling a hole in the ground. This waste is generally called cuttings, but in this paper will be called discard or waste for reasons that will be described.

The role of the earthen reserve pit in the circulating system should be understood. In the circulating system, drilling fluid is pumped down the inside of the drill pipe and through nozzles in the bit where it sweeps cuttings chips or shavings away from the cutting face. These cuttings are carried in the fluid stream back to the surface on the outside of the drill pipe. The cuttings at this point are suspended particles in a fluid stream. At the surface, the returning fluid laden with drilled cuttings is directed to the shale shakers, which are the first components of a solids control system.

Shale shakers are equipped with vibrating screens that bounce the particles off the end of the shakers and allow fluid to flow through the small openings in the screen. The size of the particle removed depends on the opening size of the screen. The opening size that can be used on the shakers depends on the amount of fluid being pumped that must be processed. The "discard" is the portion of the particles along with associated drilling fluid that <u>does not</u> go through the screen openings. Not all of the particles are rejected from the fluid stream at the shale shakers.

The fluid stream that passes through the shale shakers (along with fine particles not removed) enters a series of steel tanks and may be processed by additional pieces of solids control devices. Each device has a similar characteristic to the shale shakers in that the device removes some portion of solid particles along with some associated drilling fluid and fails to remove some portion. Each solids control system is defined by its available pieces of equipment.

The efficiency of the solids control system is defined as the amount of particles removed divided by the amount of solid particles generated by the bit. A solids control system with low solids removal efficiency will leave large amounts of cuttings particles in the drilling fluid. These particles are detrimental to the drilling process in a number of areas. If the concentration of particles (called low gravity solids or LGS) exceeds 3% to 5%, then studies have shown a significant reduction in penetration rate. Also some of the fluid properties, like fluid loss or viscosity, are adversely affected by high concentrations of low gravity solids. The solids control system efficiency could be improved by supplying additional solids control equipment, but this is sometimes an expensive solution. With low efficiency systems, a strategy called "dump and dilute" has been adopted to meet the fluid needs without the expense associated with supplying additional solids control equipment.

The dump and dilute strategy can be described in the following terms. As the concentration of low gravity solids increases to some unacceptable level, dump some amount of drilling fluid containing the high concentration of LGS to the reserve pit. Replace the dumped volume with a like volume of fresh fluid without low gravity solids. This process is repeated over and over, as needed. If the cost of maintaining the drilling fluid properties is low, then this can be a low cost, effective strategy.

The total waste is the sum of the discard volume from all of the components of the solids control system and the total volume of dumped fluid. The affect of dumped fluid on waste volume can be seen in Figure 1. This table is a simple theoretical calculation where mud is dumped at 7% LGS. The table shows the effect of increasing solids control efficiency while drilling the same amount of hole volume. As the efficiency increases, the amount of discard increases linearly, but the amount of dumped volume decreases at a larger rate. The result is that the waste volume decreases with increasing solids control efficiency.

A second term is introduced in Figure 1. The term is the ratio of waste to hole volume. Since the hole volume drilled varies from well type to well type, a comparison between well types must be made on an equal basis. This is accomplished by creating the ratio of waste to hole volume (R). The ratio decreases with increasing efficiency. A ratio of 3 to 5 indicates very high efficiency. A ratio of 8 to 12 indicates low efficiency. A ratio higher than 12 indicates very low efficiencies and indicates poor solids control practices.

Sometimes the earthen reserve pit is incorporated into the solids control system. This technique is called "circulating the pit" and is commonly used in the Permian Basin and other areas. In this system, an initial load of "reserve" water is brought to the pit. Conventional mechanical solids control equipment is not used (is by-passed). Instead, returning fluid laden with drilled cuttings particles is discharged directly to the earthen reserve pit. The pit is designed to allow the low gravity solids to settle in the first part of the pit. Fluid continues to flow to the "deep" end, allowing solids to settle along the way. Fluid is recovered at the deep end and re-used in the drilling process. The waste volume created by this technique is very high. The ratio of waste to hole volume is frequently about 20.

In the Permian Basin a "horseshoe" pit has been developed and is in common use. Figure 2 shows a picture of a typical dual, lined horseshoe pit built above ground. The inside compartment of the pit generally holds fresh water for drilling surface hole and, later, brine for dilution of drilled solids in the active mud system. The outside portion of the pit is used in the "circulating the pit" technique. The solids side of the pit slopes gently away from the discharge point getting deeper with distance. At the far end of the pit there may be a shallow earthen wall that acts as a weir, over which fluid flows after a certain fluid depth has been reached. A floating suction is installed on the fluid side to complete the loop through the pit.

Eliminating the Pit

The reserve pit serves a useful function in the drilling operation. However, it is viewed by some as a liability with the potential for causing contamination. It also poses a potential for future clean-up. In the wrong site, with poor management, or if not closed properly it certainly could create unwanted liability.

For those wanting to eliminate the pit, certain technical and financial issues must be addressed. The solids control system must be highly efficient and capable of removing almost all of the drilled solids generated. With a highly efficient solids control system very little fluid would need to be dumped and discarded. The discard stream from the solids control system should be relatively dry, too. A system to handle and store the collected discard stream must be available. An alternate disposal plan, other than burial, must be developed; otherwise much of the logic for eliminating the pit is lost. And, finally, the net affect on drilling cost must be minor or the plan will not be implemented.

A system has been developed and used by Cimarex in New Mexico that can process water-based drilling fluid at the rig site with very high efficiencies and with relatively low fluid retention with the removed cuttings. The system consists of shale shakers sized to run fine screens at the required flow rate. Two shakers are generally required for the hole size and flow rate involved. Both can be fitted with 175 mesh to 200 mesh screens. There is also a mud cleaner to process the fluid. The mud cleaner consists of desilting hydrocyclones over a shale shaker.

The system is also equipped with a water-based mud de-watering system consisting of a chemically enhanced centrifuge package. The centrifuge is a high gravity separation device that can remove fine particles not removed by conventional shale shakers or hydrocyclones. Chemical flocculants or coagulants are injected into the suction line along with the drilling fluid to be processed. The chemicals cause the fine drilled solids particles to form "clumps" increasing their size. In addition to removing fine particles, the removed mass is relatively dry.

Figure 3 shows one view of the solids control equipment layout. The two shale shakers are on the left side of the picture. The hydrocyclones can be seen above the third shaker to the left of an operator. The enhanced centrifuge operation is on the right being tended by another operator.

As drilled solids are removed from the system, the waste is collected in a modified steel tank. In Figure 3 the steel tanks can be seen under the solids control equipment in the foreground. Dirt and gravel has been pushed in front of the tanks to prevent any liquid from escaping. Excess liquid can be recovered with a diaphragm pump.

As loader quantities are generated, a front-end loader removes the waste and begins stacking it on a specially prepared pad. The pad is constructed of compacted clay dirt (approximately six inches) over a plastic liner to prevent infiltration of any draining liquid. The perimeter of the pad is lined with ditches to prevent any run-off. The stacked cuttings are piled, mixed and turned to expose the small amount of liquid to the air for evaporation. Occasionally, a small amount of dirt or lime is added to aid in drying. The cuttings pile soon becomes dry enough to resemble a large mound of dirt. The cutting pile is shown being stacked on the pad in figure 4. The pad and ditch can be seen in the foreground with the rig and solids control system in the background.

The burial disposal option remains viable, but without a pit, a burial cell would have to be constructed. Burial is not desired in this case, though, since the object was to eliminate a pit. Another option is to remove the stacked cuttings to a commercial disposal site, which in New Mexico primarily means landfill burial or, occasionally, land farming. A third option would be to use a minimal treatment to convert the cuttings to usable fill material for future pad construction. The third option has not been tried yet and is still being considered.

Affect on Waste Generation

The increased attention to solids control has an impact on the quality and quantity of drilling waste produced. At the time of this paper three wells have been drilled using this new procedure. The approximate wellbore configuration of the wells is shown in figure 5. The hole volume representing the approximate amount of dirt removed from the wellbore is about 177 cubic meters. Waste generation will be a multiple of this volume.

For land locations with pits drilling waste is usually estimated by two techniques: pit volume estimation and the water delivery technique. In the case of this project in New Mexico, previous wells were drilled with pits. Subsequently, several of these pits have undergone remediation. The contents of the pits were removed and taken for commercial disposal. This means that the transportation volumes can be added to obtain the waste volume.

Records indicate that an average of 5,000 cubic yards (24,044 barrels or 3,823 cubic meters) of waste material was removed from each pit. Since the hole volume for each well was 177 cubic meters, this represents a ratio of 21.6 times the hole volume. This figure compares reasonably well with other information collected during other jobs where pits are used. Figure 6 shows waste generation figures from jobs in other areas. The data was collected from two different well types using pits in West Texas. The first well type (designated "A") is a relatively deep well. The second well type (designated "B") is a moderate depth well. The ratios on these well vary from a low of 20:1. The higher numbers of 30 and above may be due to completion activities using the same pit with drilling activities adding waste volume to the pit.

With the new process the waste volume can be estimated by estimating the volume of the cuttings pile created. No significant amount of fluid, other than contaminated mud/cement returns, has been removed for disposal. Figure 7 shows one pile quantity estimation diagram for the new system. The volume of cuttings estimated in the pile is 819 cubic meters. This represents a ratio of 4.6 times the gauge hole volume. This is dramatically lower than the 21.6 ratio to hole volume for cuttings and fluid left in the pit for disposal under the previous operating mode.

Affect on Drilling Cost

Any time a change is made to the drilling process, there is a ripple affect which changes many other aspects of the operation. The same principle applies to solids control and waste management modifications. Not only are equipment costs added, but other drilling process costs are affected too. In order to determine the net impact on overall drilling cost, all of the associated changes must be addressed.

When using an earthen reserve pit, the pit is constructed and possibly lined. Water deliveries to the location will be high, since the amount of fluid used will be high. If mud is needed, mud costs may be high (relative to mud costs with reduced fluid usage). Solids control equipment is not used extensively, so rental equipment costs are minimal or non-existent. After drilling, fluid is removed from the pit and disposed. Solids may be removed or buried in place. The pit is closed and surface remediation is addressed.

When the pit is eliminated, the costs associated with the pit are eliminated, but other costs must be considered. Equipment rental costs are increased, including surface handling of the removed discard. Mud costs and water usage costs are decreased, since fluid usage volume is reduced. A staging pad must be constructed to store and dry the discard prior to ultimate disposal. In addition, maintaining low levels of low gravity solids can decrease drilling time and reduce non-productive time (NPT) associated with stuck pipe and loss of circulation. This last affect is the most difficult to quantify.

Figure 8 shows the cost of operations associated with having an earthen pit. All of these costs may be changed by eliminating the pit, thus they must be considered as part of the overall cost associated with that decision. Figure 9 shows the cost associated with operations where the pit is not used.

The results of this analysis indicate that eliminating the pit in New Mexico is cost effective and does not add significant cost to the overall operation. When solids can not be buried on-site and must be hauled to commercial disposal, eliminating the pit actually saves money.

FIGURES

Efficiency	Hole Volume (bbls)	Discard Volume (bbls)	Dumped Volume (bbls)	Waste Volume (bbls)	Ratio - Waste:HV
10%	2,000	400	25,352	25,752	12.9
30%	2,000	1,200	19,718	20,918	10.5
50%	2,000	2,000	14,085	16,085	8.0
70%	2,000	2,800	8,451	11,251	5.6
90%	2,000	3,600	2,817	6,417	3.2

Figure 1. Theoretical waste volume with respect to solids control efficiency

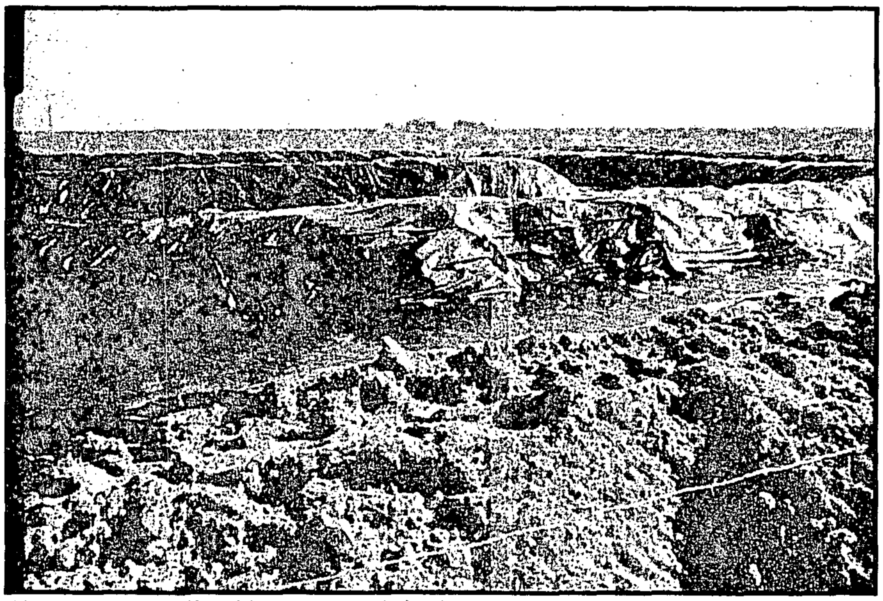

Figure 2. Dual lined horseshoe pit in the Permian Basin

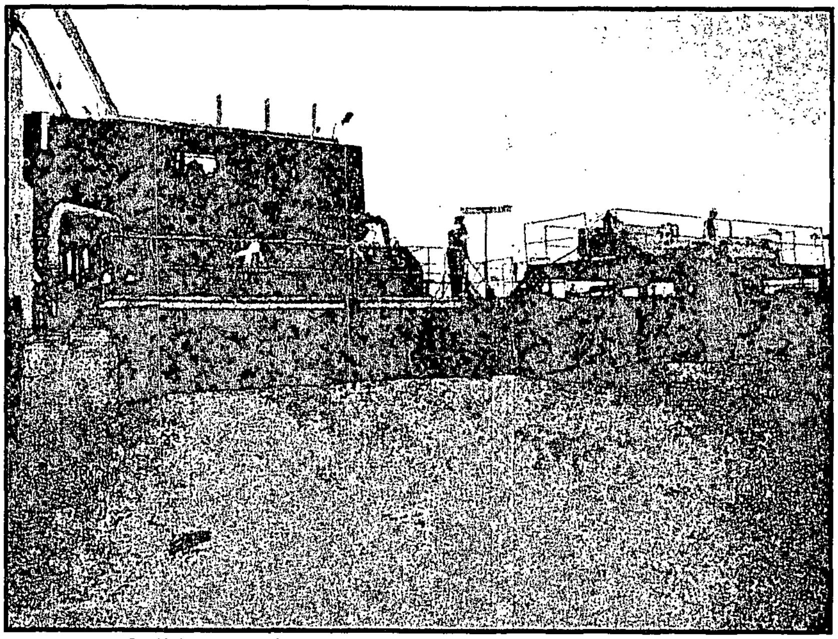

Figure 3. Solids control system being used to eliminate the pit

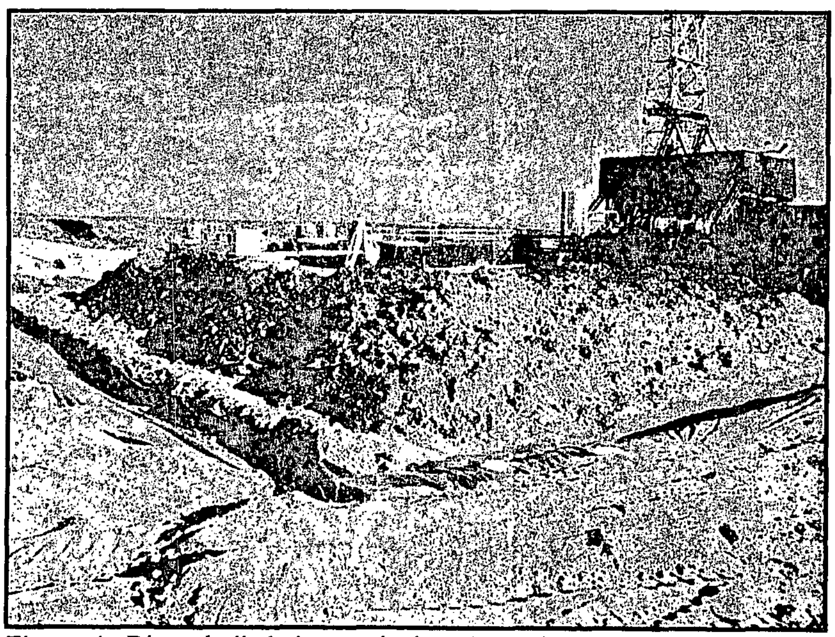

Figure 4. Discard pile being stacked on the drying pad

Hole Volume Calculation				Cimarex - New Mexico Wells		
Hole Size	**Depth**	**Length**		**Cu. Ft.**	**Bbls**	**Cu. M.**
17.500	300	300		501	89	14.2
12.250	1,900	1,600		1,310	233	37.1
8.750	12,500	10,600		4,426	788	125.3
		12,500		6,237	1,111	176.6

Figure 5. Wellbore configuration showing hole volume calculation

Well	Hole Volume (bbls)	Fluid to Location (bbls)	Fluid from Location (bbls)	Waste Generation Ratio - R	Ratio of Waste Left in Pit to HV
A1	1,100	33,850	15,260	31.8	16.9
A2	1,100	50,110	9,835	46.6	36.6
A3	1,100	22,980	8,480	21.9	13.2
A4	1,100	24,220	13,550	23.0	9.7
A5	1,100	38,090	6,830	35.6	28.4
B1	700	12,930	4,390	19.5	12.2
B2	700	13,180	3,140	19.8	14.3

Figure 6. Waste generation as a ratio to hole volume

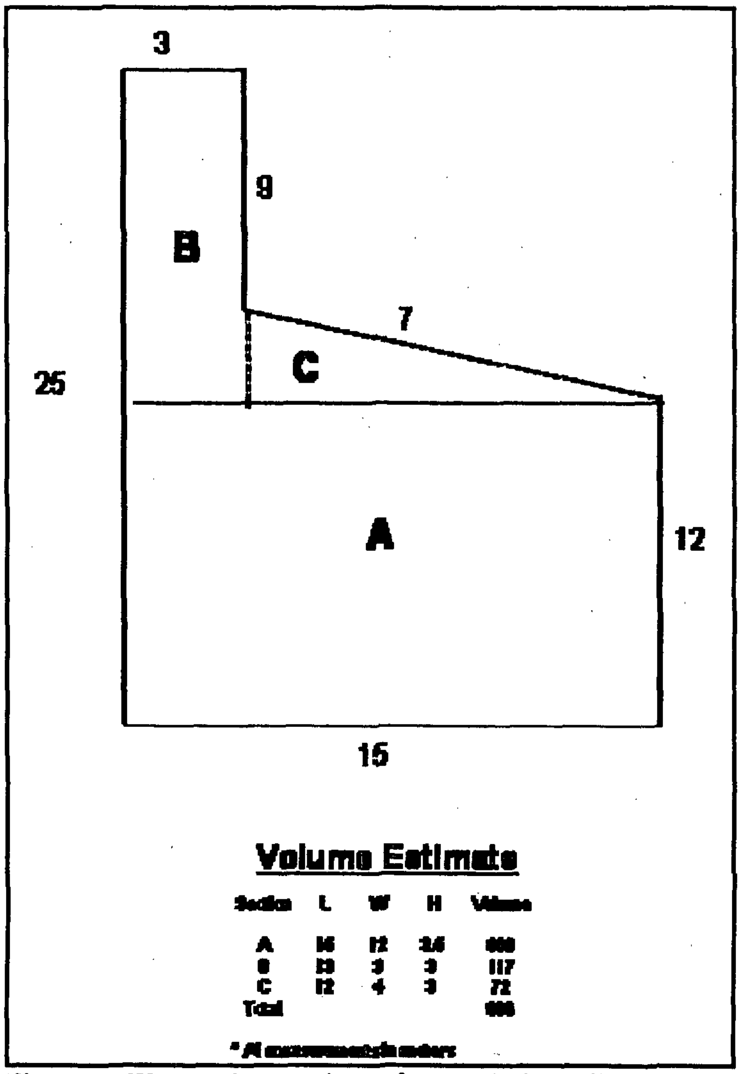

Figure 7. Waste volume estimate for one cuttings pile

Cost comparison items	Low	High
Reserve pit construction, liner	$31,000	$54,000
Water delivery, transport and cost	$13,500	$18,000
Water haul off, disposal	$42,000	$47,000
Mud costs	$74,000	$74,000
Pit closure activities	$50,000	$104,000
Extra rig time, NPT		$150,000
Total Cost	$210,500	$447,000

Figure 8. Cost of portions of operation affected by using a pit

Cost comparison items	Low	High
Pad construction, liner	$5,000	$12,000
Water delivery, cost	$5,000	$5,000
Trucking recycled fluid	$4,000	$4,000
Solids control equipment rental	$100,000	$127,000
Surface handling equipment rental	$18,000	$26,000
Mud costs	$40,000	$40,000
Re-use solids costs	$14,000	
Haul and dispose solids		$50,000
Pad closure, restoration	$3,000	$3,000
Total Cost	$189,000	$267,000

Figure 9. Cost of portions of operation affected by eliminating the pit