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# Collaborative Team Researches Best Management Practices For Drilling Wastes

By Richard C. Haut, John D. Rogers, Bruce W. McDole, David B. Burnett, Thomas E. Williams and Oluwaseun Olatubi

THE WOODLANDS, TX.–Exploration and production companies are well aware that minimizing or eliminating the waste they generate is crucial to reducing environmental liabilities and operational costs. Even so, the misconception that the oil and gas industry's environmental stewardship is inadequate has resulted in restrictions and outright prohibitions against drilling in many sensitive areas in the continental United States and around the world.

The principal aim of drilling waste management is to ensure that waste does not contaminate the environment at such a rate or in such a form or quantity as to overload natural assimilative processes. Sustainable development of petroleum resources requires careful monitoring and appropriate disposal of all waste streams generated over the life cycle of a development, from the initial planning of projects and operations through decommissioning and site restoration.

To help operators evaluate ways to consistently achieve their goals for sustainable development, a collaborative academic, industry, and government partnership formed in 2005 is aggressively researching best practices to manage drilling wastes through the Environmentally Friendly Drilling Systems Program (EFD). The program incorporates dual engineering and environmental research specifically aimed at reducing the environmental impact of oil and gas extraction activities.

Funded in part by the U.S. Department of Energy, the EFD was initiated by Texas A&M University, Anadarko Petroleum, Noble Technology Services (a subsidiary of Noble Corp.) and the Houston Advanced Research Center, and is managed by Texas A&M and the Houston Advanced Research Center. Direction for the EFD comes from a joint industry partnership among participating entities.

The JIP includes a growing number of exploration and production companies, academic and governmental ecologists, environmental scientists, and sociologists whose goal is to provide the social and ecological balance to the technical and economic needs for producing oil and gas in sensitive areas. Ultimately, EFD will incorporate a portfolio of known but unproven or novel technologies into a drilling process or system that enables drilling and production operations, which has as its target the least environmental impact possible during the life cycle of moderate (10,000-15,000 feet true vertical depth) and deep (15,000-20,000 feet true vertical depth) developments.

During the first phase, EFD participants identified low-impact technologies suitable for operations in two extreme environmental conditions: a desert-like ecology and a coastal margin ecosystem. A special-task working group focused on methods to integrate novel wastewater and solid waste treatment processes into a system that captures and treats all runoff and effluent fluids, drill cuttings, and other waste streams.

### Current Approaches

In 1995, the American Petroleum Institute estimated that 150 million barrels of drilling waste was generated from onshore wells in the United States alone. Drilling wastes are the second largest volume of waste, behind produced water, generated by the E&P industry.

Operators have employed a variety of methods to manage drilling wastes, depending on what state and federal regulations allowed and how costly those options were for the well in question. Often, because they want to be considered responsible guests by their host countries, oil and gas operators impose even more stringent environmental regulations on their operations than those imposed by the countries in which they are drilling.

Disposal methods include land spreading and land farming, dewatering and onsite burial, underground injection, incinerating and other thermal treatments, bioremediation and composting, and reuse and recycling. Onshore and offshore operators employ extensive fluid-recovery methods for both environmental and economic reasons. Some operators make use of computer models designed to help manage solids control, wastes, and liability issues that require attention during drilling projects.

Other waste materials also are considered in a drilling project plan, such as contaminated water, material and chemical packaging, air emissions such as carbon dioxide and oxides of nitrogen, scrap metals, fuel, lubricants and other oils, as well as the usual human and industrial wastes associated with E&P operations.

A number of companies have tested and adopted reliable approaches to managing drilling waste, as shown in these examples:

- Shell Exploration and Production Company developed a preferential hierarchy for managing waste: reduce, reuse, recycle, recover and dispose. As a result, Shell reduced mud use by 20 percent and mud component packaging by 90 percent through a combination of solids control efficiency, cuttings dryer technology, and bulk mixing equipment.
- Schlumberger introduced a total waste management program to mitigate rising quantities of landfill waste.
- Mobil deployed a semiclosed loop centrifuge flocculation dewatering process in its Hugoton Field operations that helped decrease overall waste-related costs while improving compliance and reducing potential liability. The resulting solids were safely buried on location.

### Best Practices

A comprehensive waste management program should address not only drilling fluids and cuttings, but also methods to reduce air emissions and control water runoff from the site so that natural waterways are not contaminated. Potential pollution from drilling rigs and other oil field related equipment is a concern.

EnCana Corporation tested a natural gas-fired drilling rig that reduced emissions by 90 percent compared to conventional diesel rigs, and also is evaluating the possibility of providing electrical service to power drilling rigs with direct electrical power, reducing emissions to negligible amounts.

Table 1 provides an overview of trends in several key areas of waste management, including both conventional and nontraditional methods.

**TABLE 1**

| Waste Type | Treatment/Disposal Method |
|---|---|
| Solids and cuttings | Land spreading and land farming<br>Dewatering and burial on site<br>Cuttings injection in dedicated injection wells, in annuli, or in suitable formation in development well<br>Incinerating and thermal desorption<br>Bioremediation<br>Vermi-composting with worms |
| Contaminated water (containing drilling fluid sediments, runoff from rig washing and operations, etc.) | Berming and banked containment areas to prevent contact with stormwater<br>Treatment and reuse<br>Priority disposal (i.e., first waste type to be injected or remediated) |
| Air emissions | Diesel exhaust gas after-treatment technologies<br>Fuel quality changes<br>Selective catalytic reduction systems to reduce oxides of nitrogen |

The vermi-compost technique listed in Table 1, when combined with environmentally friendly design of the drilling fluid, is the preferred treatment technique compared with thermal treatment of the cuttings. The worms remediate the cuttings, converting them into a compost material that is useful as a soil enhancer. This technique not only cleans the cuttings, but also converts them into a valuable resource.

The selection of best practices includes project economic considerations. For example, additional best practices could have been included in the operations at a site visited by EFD team members, but the cost of the additional practices prevented their implementation.

**Rig Site Optimization**

A 2006 visit to a high-pressure/high-temperature Louisiana well site located a half mile from the bank of the Mississippi River helped EFD team members identify and describe a number of best practices for minimizing the waste stream, recovering materials for reuse, and safely disposing of final waste products. In particular, the trip focused on the layout and operation of the reserve pit system, the water-based mud recirculation/reuse system, and the oil-based mud/cuttings processing system.

An aerial photograph of the rig site shows its proximity to the Mississippi River. The layout and operating practices show special sensitivity to the impact of drilling operations on this particular land and water environment. Entrance to the rig site is from the left. Crew quarters are set up away from the pad to minimize the potential for involvement in a rig incident. The well site leader's trailer is behind the rig mast. Drill pipe and casing lie to the left of the rig. Mud pits are in the foreground.

A typical HPHT well bore similar to the one visited is illustrated in Figure 1, including a planned annular injection disposal zone. The stormwater runoff calculations shown in Table 2 are based on rig site dimensions, and the configuration and capacities of the reserve pits. Table 2 gives the potential volumes of rainwater that may be expected to accumulate in open reserve pits and become waste water as a result of contamination.

For solids control, the rig was equipped with three linear motion shakers, a 3/12 desander and a 16/5 desilter fluid conditioner. A high-speed/high-volume centrifuge mounted on a stand was installed downstream from the rig equipment. The centrifuge helps to maintain proper mud weight and viscosity while drilling the unweighted water-based sections, and reduces the volume of liquid mud that needs to be disposed.

The centrifuge processes underflows from the 16/5 fluid conditioner and whole mud from the active system. The resulting dried solids are processed into the dry cuttings pit, where they are combined with the dried solids from the desilter. The clean fluid from the centrifuge is discharged into the active mud system. A portable slurry pump is used to circulate the pits and transfer fluids from pit to pit.

**Reserve Pit Layout**

All waste drilling fluid and cuttings are segregated by the amount of fluid content. The wet discards from the linear motion shakers are deposited into pit 1 (Figure 2). The dry discards from the centrifuge and desilter are deposited in pit 2. Recovered mud that cannot be immediately transferred to the active mud system is stored in pit 3 (1,923-barrel capacity).

Pit 1 (3,967-barrel capacity) is excavated to pit 5 as it fills. Pit 5 has a wet storage capacity of 14,426 barrels. Pit 2 (1,923-barrel capacity) is excavated to pit 4 (28,851-barrel dry storage capacity).

During the casing/cementing process in the initial hole section, pit 1 is emptied and the material is transferred to pit 5 to avoid cement contamination of potentially recoverable mud. The hole volume of recovered mud will be placed in pits 1 and 3 for reuse after the cementing process is completed.

During the open hole displacement to oil-based mud, pits 1

**EFD team members used an environmentally friendly rig site located a half mile from the Mississippi River in Louisiana to analyze reserve pit location, drilling fluid circulation, and cuttings processing.**

**TABLE 2**

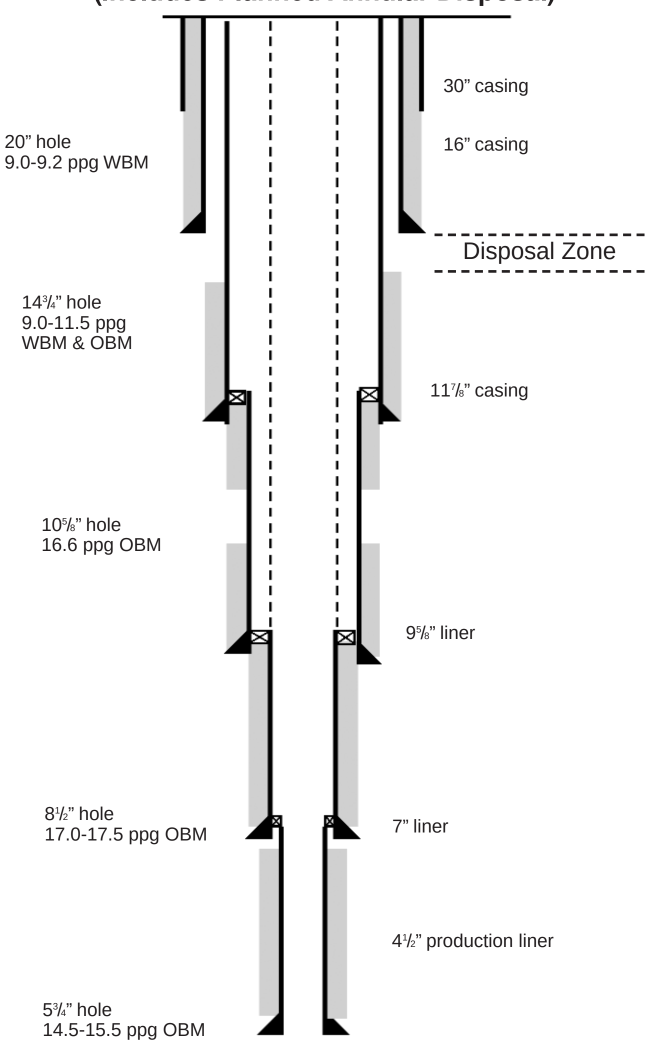
| Stormwater Accumulation (inches) | Rig Location | Pit Location | Total Volume |
|---|---|---|---|
| 2.6” rainfall | 1,719 bbl/inch volume<br>4,469 bbl rain<br>3,352 bbl/inch at 75% | 633 bbl/inch volume<br>1,650 total bbl at 100% | 5,002 bbl rainwater |
| 9.2” rainfall | 1,719 bbl/inch volume<br>15,878 bbl rain<br>11,840 bbl/inch at 75% | 789 bbl/inch volume<br>7,258 total bbl at 100% | 19,098 bbl rainwater |

and 2 are emptied, and the material is transferred to pits 5 and 4, respectively, to avoid contaminating water-based mud and cuttings. Preventing contamination facilitates a greater range of disposal options. The hole volume and active system of good mud are recovered between pits 1 and 3, then stored in pit 5 for reuse in the waste injection process.

In the weighted section, use of the 3/12 desander is discontinued. The 16/5 desilter continues to operate along with supplemental barite recovery, oil recovery, and solids discharge through the use of the barite-recovery and high-speed centrifuges.

**FIGURE 1**

**Typical HTHP Well Bore (Includes Planned Annular Disposal)**




During casing/cementing operations in this section, pit 1 may be emptied and the material transferred to pit 2 to avoid contaminating potentially recoverable mud. The hole volume of good mud will be recovered between pits 1, 2 and 3 for reuse after the cementing process is completed. At this point, the supplemental solids control equipment is rigged down and moved out. While the crane is on location, the slurry and annular injection equipment will be moved in and rigged up.

The first-phase annular injection of drilling fluid and cuttings commences as soon as the annulus is available for injection. The fluid and cuttings with the highest contaminant values are injected first. The larger pits used to store waste drilling fluid and cuttings are emptied and closed as soon as possible to reduce contact with stormwater. The second-phase annular injection commences after drilling and completion operations are finalized.

Pit closure activities include removing all contact soils commingled with drilling fluid and cuttings. The contact soils are injected into the annulus. The heavy sand and shale, which cannot be effectively entrained in the slurry, are transported to an off-site commercial disposal facility. The pits are backfilled, compacted and recontoured to pre-project elevation.

The final pit closure steps are replacing stockpiled topsoil and revegetating.

## Bioremediation

Biotreatment methods represent some of the most promising, cost effective and safe technologies for treating waste and remediating impacted areas. They continue to gain wide acceptance in the industry. There are numerous reports concerning the successes and challenges of the various biotreatment methods for treating wastes and remediating soils and aquifers contaminated with crude oil, gasoline and various oil-based wastes.

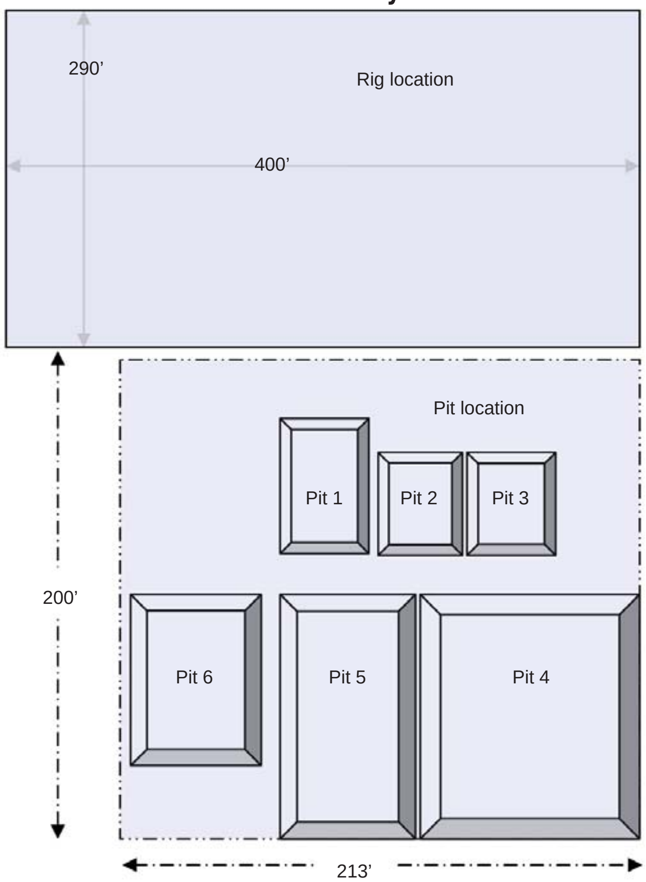
Successful biotreatment operations that restore contaminated soils and aquifers to conditions near their pre-contamination states also have been documented. Studies have been carried out that manipulated various parameters in these methods that are essential to effective biodegradation of wastes, and significant insights have been acquired to optimize biotreatment methods.

One challenge posed by the wholesale adoption of biotreatment methods is optimizing conditions to achieve regulatory waste limits within a reasonable period and at reasonable cost. Another challenge is the “whole” treatment of the waste of all contaminants, or rather the “custom” treatment of the waste to levels within all permissible regulatory limits rather than employing different treatment methods for the same waste.

Pilot studies are needed to determine appropriate treatment methods on case-by-case bases. This would provide adequate information on treatment options and modifications required to achieve optimal results.

**FIGURE 2**

**Reserve Pit Layout**




Finally, a holistic approach needs to be adopted to properly manage exploration and production wastes. This should be an integrated approach that looks at the constituents of the drilling process with the aim of making them environmentally friendly and easily biodegradable. The approach should look at minimizing waste from the source, and optimizing use and reuse of materials, and should view treatment options as processes to generate safe, reusable products. Such an integrated and scientific approach would advance environmentally friendly drilling for the industry.

### Bioremediation Pilot Project

A project has been established to investigate the possibility of developing a bioremediation treatment processor that can be located at a drill site (Figure 3). The intent of the project is to devise a small-footprint, low-impact environmental treatment process that can be adapted to real-life drilling operations based on sound engineering and biological principles, and is capable of converting drilling wastes to usable products. The goals associated with the project include the following:

- Determine an optimized treatment process that can be adapted to build mobile, small-footprint treatment processes;
- Determine waste(s) that can be effectively treated using this method;
- Determine conditions such as climate, environmental areas and drilling sites where treatment processes can be used, and their limitations; and
- Determine the efficiency of the process, cost and environmental implications, product uses, and the environmental laws and regulations associated with processes.

The work will investigate the safe conversion of drilling wastes to an environmentally friendly end product. Rather than burying wastes in reserve pits, landfills and wells, the goal is to reduce the ecological footprint.

The focus also entails designing methods aimed at making drill cuttings more amenable to bioremediation, coupled with methods to drastically reduce the volume of the final biodegradable waste material. This would be accomplished by maximizing the amount of reusable product extracted from the waste so that the ultimate treatable waste volume is more manageable.

The hypothesis is that biotreatment methods will emerge as the preferred processes for treating exploration and production wastes in the near future, especially in view of increasingly strict environmental regulations and heightened community interest in safeguarding the environment.

Biotreatment methods could represent viable long-term treatment options that would satisfy both host communities and oil industry operators’ criteria. The science behind biotreatment methods is easily communicated to stakeholders, thereby allaying the fears and distrust that accompany other treatment methods.

Proactive and widespread application of biotreatment methods can transform public perceptions about the oil and gas industry, and can help remove the barriers to exploring for hydrocarbons in environmentally sensitive areas. ❐

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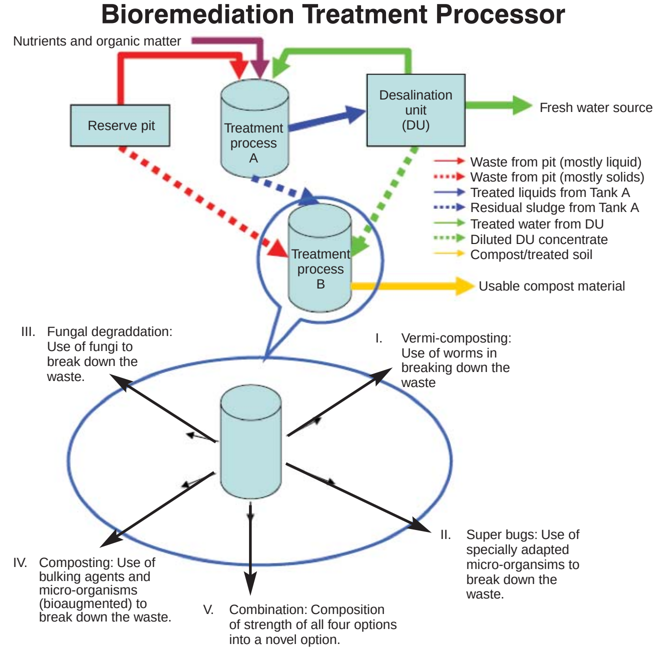
**FIGURE 3**

**Conceptual Design of Bioremediation Treatment Processor**



**RICHARD C. HAUT** *is a senior research scientist at the Houston Advanced Research Center. Prior to joining HARC in June 2002, Haut had more than 25 years of energy industry technical and management experience, having been responsible for analyzing offerings for key technologies or niche capabilities, and developing synergistic, strategic relationships. He holds a master's and a Ph.D. in engineering.*

**JOHN D. ROGERS** *is a senior research scientist at HARC, emphasizing sustainable energy issues and energy life cycle analysis. His background includes working as a roughneck, production/operations engineer, environmental supervisor, senior research associate in enhanced oil recovery, and project manager and research team leader in the Department of Energy's E&P gas technology program. Rogers holds a M.S. in petroleum engineering from Texas Tech University, and a B.S. and Ph.D. in chemical engineering from New Mexico State University.*

**BRUCE W. McDOLE** *is the senior construction and environmental specialist for BP America Production Company. He has extensive experience in well site construction, restoration, remediation, and related waste management practices in environmentally sensitive areas. He holds a patent on compost bioremediation of oil-based drilling mud and cuttings. McDole is a member of the Global Petroleum Research Institute's Environmentally Friendly Drilling Working Group. He holds a B.S. in petroleum engineering technology from Francis T. Nicholls State University.*

**DAVID B. BURNETT** *is the director of technology for the Global Petroleum Research Institute and is a member of the faculty of the Texas A&M University Petroleum Engineering Department. He has extensive experience in technology related to oil field production, produced water management, and low-impact drilling. Burnett leads the Environmentally Friendly Drilling Program in addition to a team of scientists and engineers recovering fresh water from oil field brines and brackish groundwater. Burnett has a B.S. and a M.S. in chemistry from Sam Houston University and an M.B.A. from Pepperdine University.*

**THOMAS E. WILLIAMS** *retired as vice president of research and business development for Noble Technology Services Division, and serves on the EFG Steering Committee. He also serves on a variety of boards, including Far East Energy Corp., Research Partnership to Secure Energy for America, DeepStar CAP, and the Consumer Energy Alliance.*

**OLUWASEUN OLATUBI** *is a Ph.D. candidate at Texas A&M University.*