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Rig Waste Reduction Pilot Project

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Abstract

Shell Exploration and Production Company (SEPCo) initiated the Rig Waste Reduction Pilot Project in 2001 to further its goals toward Sustainable Development. SEPCo ran the pilot project on two contract drilling rigs and a drilling and production platform. After characterizing and measuring the waste streams, 26 potential waste reduction strategies were considered for implementation. A preferential hierarchy for consideration was used: *reduce, reuse, recycle, recover, and dispose.* SEPCo found that its drilling discharges and non-hazardous oilfield waste (NOW) comprised the lion's share of the total waste and therefore represented the greatest opportunity for reduction. SEPCo used a combination of solids control efficiency, cuttings dryer technology, and new bulk mixing technology to reduce mud use by up to 20% and mud component packaging by up to 90%. Solid waste (consumables and trash) also comprised a large volume of waste. SEPCo implemented a sorting, compaction, and recycling process for this waste stream to reduce landfill disposal. This paper describes the process used by SEPCo to develop the pilot project, the strategies implemented, and the effectiveness of those strategies.

Introduction

The SEPCo Rig Waste Reduction Team was commissioned in the first quarter 2001 to evaluate SEPCo's waste generated from offshore drilling operations and to recommend and implement reduction strategies as a pilot project that might be employed throughout SEPCo's drilling operations if proven viable.

Project Objective.

The objective of the project was to perform a pilot study of two SEPCo drilling rigs (one floater and one platform) to characterize, quantify, sort, and apply waste reduction strategies (prevention, minimization, reuse, recycling) to all wastes generated consistent with SEPCo's Sustainable Development (SD) principles. SD can be defined as "Meeting the needs of the present generation without compromising the ability of future generations to meet their needs". At the heart of SD is the simple idea of ensuring a better quality of life for everyone, now and for future generations to come. Pressing societal concerns – such as poverty and wealth, exponential population growth, biodiversity loss, deteriorating air and water quality and climate change – are seen as threats to the continued quality of life. If society is to advance and develop without jeopardizing the prospects for future generations, then we must take into account the environmental and social consequences of our activities as well as the economic benefits.

SEPCo's approach to SD is to:

- Integrate economic, environmental and societal considerations,
- Balance short term priorties and long term needs, and
- Engage with stakeholders.

Project Drivers.

The Team identified five project drivers which helped determine the Team's direction and project deliverables:

1. Earn the license to operate in sensitive areas
2. Meet EPA discharge effluent limitation guidelines for synthetic based mud and provide for environmental protection
3. Reduce cost over time
4. Meet SD continuous improvement goals
5. Reduce the risk of future liabilities associated with waste disposal

Approach

The Team applied a problem-solving model to generate rig waste reduction strategies. The strategies were then piloted on two drilling rigs – the Noble Paul Romano and the Noble Jim Thompson – and a deepwater tension leg platform – Ursa. The steps followed were:

1. Characterize waste types/streams
2. Measure waste types/streams (i.e., by weight/volume, by POB, by foot drilled, etc.)
3. Develop and implement sorting procedures
4. Identify potential waste reduction strategies (consider heirarchy of *reduce, reuse, recycle, recover, dispose*)
5. Define pilot waste reduction strategies
6. Implement pilot reduction strategies
7. Measure effectiveness of reduction strategies

8. Document final recommendations in a Waste Management Plan

Characterize Waste Types/Streams.
The waste types/streams for SEPCO Drilling Operations have been tracked on a per rig basis since 1999. The major waste categories tracked are:

- Discharges to the water
- Non-hazardous Oilfield Waste (NOW)
- Industrial waste
- Trash
- Naturally Occurring Radioactive Material (NORM)
- Hazardous waste

The Team conducted a field assessment of the waste generated on the rigs/platform. Based on the field assessment, the waste streams were characterized into waste types for the purpose of identifying waste reduction strategies. The assessment also identified treatment/disposal method and whether the waste stream was sorted, compacted, or recycled. The waste characterization is provided in **Table 1.**

Measure Waste Types/Streams.
SEPCo has measured its waste streams in two different ways. The first way is through the tracking of non-hazardous oilfield waste (NOW) manifests and disposal facility invoices. This provides a very accurate accounting of the types of NOW and the quantities. Hazardous and NORM waste is measured by this same process but is a smaller waste stream compared to NOW. The second way of measuring is performed on the rigs whereby each rig maintains an accounting of the number of trash bags or bins offloaded and transported to the terminals.

As seen in Table below, NOW comprises the lion's share of the total SEPCo waste and therefore represents the greatest opportunity for reduction. [Not shown in these figures are the rig wastes which were discharged in accordance with the NPDES permit (e.g., water-based mud and cuttings, and completion fluids).] **Figure 1** shows the breakdown of NOW waste for 1999 and 2000. **Figure 2** shows these volumes normalized by 1000 feet drilled.

Waste Type	Quantity (Tons)
NOW	94,782
Trash	Tracked by rig
Industrial	280
NORM	90
Hazardous	1.2

SEPCo 2000 Waste Volumes

Drilling Operations tracked environmental data for the rigs, including wastes which are discharged in accordance with the NPDES Permit and those which are shipped to the terminals for disposal onshore. These data are compared for two rigs in **Table 2**. **Figure 3** shows a subset of these data normalized by 1000 feet drilled.

Develop and Implement Sorting Procedures.
The Team found that sorting was performed on the rigs to some degree by use of different waste containers and voluntary compliance by rig personnel. However, there was a weak infrastructure and few vendors available to remote terminal locations for plastics, glass, paper, and other recyclable materials. As a result, some of the sorted materials that came from the rigs were recombined at the terminals, and recycling efforts were not completed.

The reduction strategies address sorting procedures at the rig and improvements at the terminals to increase the materials being recycled and to ensure that sorted commodities reached the recycling facility. It is recognized that added effort is required at the rig locations for sorting waste streams and to ensure sorted streams are not re-combined at the shore base.

Identify Pilot Waste Reduction Stategies.
The Team reviewed the waste streams from the field assessment for potential reduction opportunities considering the heirarchy of *1) reduce, 2) reuse, 3) recycle, 4) recover, and 5) dispose.* Several potential reduction strategies were discussed during the field assessments with the rig personnel and URSA production personnel. The Team identified several strategies through these discussions that would be considered traditional waste reduction strategies (e.g., sorting and recycling) which in some cases was already being implemented to some degree. In other cases, the Team identified significant opportunities for reduction through process changes and new technologies.

Strategy profiles were developed for each of the potential reduction strategies. The profiles considered the following information to help evaluate the strategies:

- State of Technology (in use, developing, mature, etc.)
- Performance (% reduction, efficiency, environmental benefits, S/D):
- Cost of Technology (day rates, purchase, cost/unit reduced)
- Suppliers (name, address, phone)

The criteria for evaluation of the reduction strategies was, first, to use the hierarchy of *reduce, reuse, recycle, recover, dispose* to prioritize the strategies that should be implemented. Second, the Team used its knowledge of waste practices and drilling operations to look at the reasonableness of the strategies and the probability of success. Third, the Team tried to think "out of the box" to look at emerging technologies that might provide good returns in the future as the technology develops.

The costs and benefits of each reduction strategy were projected in the strategy profiles. In some cases, the benefits clearly outweigh the costs and implementation was an easy decision. In other cases, this distinction was not as clearly evident and some judgement was needed to move forward. The Team felt that a 6-12 month pilot would not result in significant expenditures for any of the strategies being recommended. One of the objectives of the pilot study was to determine the actual costs and benefits of these strategies, which can be projected on a company-wide basis.

The pilot waste reduction strategies identified for implementation or for further study are provided in **Table 3.**

Implement Pilot Reduction Stategies and Measure Effectiveness.

This paper focuses on three strategic areas of waste reduction:

1. Reduction of rig discharges and NOW wastes
2. Reduction of drilling bulk packaging
3. Recycling of residual drilling solid waste

1. Reduction of Rig Discharges and NOW wastes by Improving SCE, Reducing ROC, and Use of BMP's.

Rig discharge of mud is inversely proportional to solids control efficiency (SCE): the higher the SCE, the lower the mud dilution rate and concomitantly the lower the rig discharge. With improved SCE two goals are met at the same time: (1) both discharges and mud waste are reduced, and (2) drilling fluid logistics and economics are improved, as less material is necessary for mud maintenance.

The initiative to improve solids control efficiency on SEPCo rigs coincided with the effort to achieve compliance with the new NPDES General Permit for the Western Gulf of Mexico on discharge of non-aqueous fluid (NAF) cuttings, which went into effect in February 2002. This permit enforces strict stock base fluid and discharge limitations on the discharge of NAF cuttings and associated fluids (see **Tables 4 and 5**). Particularly, operators using NAF fluids as the base for Synthetic Based Muds (SBM) are required to minimize average synthetic retention on cuttings (ROC) values of discharged cuttings to a maximum of 6.9% (meaning a maximum of 6.9 grams of NAF per 100 grams of wet cuttings) for olefin-based NAF and a maximum of 9.4% for ester-based NAF. Such ROC values can be achieved with good solids control in combination with cuttings drying technology.

The NPDES Permit includes a provision that allows the use of Best Management Practices (BMPs) (see **Figure 4**). If compliance with the ROC limits can be demonstrated for the first third ($1/3^{rd}$) of the interval drilled with NAF fluid, then ROC monitoring and reporting may cease if a certified BMP plan is implemented at the rig site. The BMP plan, of which the elements are summarized in **Table 6**, ensures that drilling operations proceed with an optimum in solids control efficiency, spill prevention, pro-active equipment maintenance, proper rig crew training, etc. An important advantage of the use of BMP's over routine ROC monitoring is that the BMP plan actively involves the entire rig crew in the solids control optimization process, rather than placing the responsibility for monitoring in the hands of only a select few specialized compliance experts. Engaging the entire rig crew makes for a safer and more complete environmental solution.

To improve SCE and achieve NPDES permit compliance, a fleet-wide solids control performance improvement plan was implemented, which consisted of the following phases:

a) Rig Auditing / Best Practices Screening.

Solids control experts visited all rigs and audited solids control equipment, fluid/solids routing, historical solids control efficiencies, economics, etc. Moreover, the applied solids control practices were documented. Based on the observations, rig-specific reports detailing the requirements to achieve NPDES permit compliance and the measures to achieve SCE improvement (including changes/additions to hardware and fluids/solids routing, improved solids control practices etc.) were developed for each rig individually.

b) Training.

Special rig-specific, one-day training sessions were held with all rig crews. Included in these sessions were stakeholders encompassing the entire range of rig authority (from the drilling manager down to the mud engineers and rig crew) from all companies involved (i.e., operator, mud company, solids control equipment and services providers, consultants, etc.).

Training materials included a set of solids control best practices guidelines, which was made available in concise form using easily accessible key-cards. The sessions also served to familiarize the rig crews with the new NPDES Permit on NAF cuttings discharge. Roles and responsibilities as well as expectations with regard to solids control optimization and NAF cuttings discharges were clearly communicated.

c) Rig modification.

Based on the rig-specific plans, rig equipment was modified and/or expanded. Specific examples of problems that were corrected included:

- Most of the high-speed centrifuges in use were found to provide insufficient fines screen-out capability for maintaining rig circulation rates, thereby reducing solids control efficiency. They were promptly replaced with higher-capacity machines.
- Routing of return mud to scalpers and shakers proved to be non-optimum, leading to a highly uneven loading of shale shakers. Moreover, routing of processed mud down the solids control array was often incorrect, leading to the by-passing of drilled solids. This non-optimum routing was corrected, yielding a much improved solids screen-out process and reduced dilution rates.
- Starting in 1998, rigs were outfitted with cuttings conveying systems and dryers for ROC reduction. Special provisions were made to make sure that rigs could go to zero discharge (e.g. using storage of drill waste in cuttings boxes) in case cuttings drying equipment had to be taken offline without upsetting drilling operations.
- When left unprocessed, cuttings dryer effluent can significantly raise the level of low-gravity solids (LGS) in the drilling mud upon re-introduction. It was determined that the effluent of the cuttings dryer was best combined with the effluent of a low-speed centrifuge working in barite recovery mode, to be processed subsequently by a high-speed centrifuge working in fines separation mode. The equipment arrangement, adopted with only slight modifications by all rigs, is shown in **Figure 5**.

In addition, SCE best practices taught in the training sessions were implemented in the field. The impact of these practices was measured using a performance measurement program (see (e) below).

d) Compliance Services & BMP Implementation.
Compliance with stock base fluid and discharge limitations was aggressively pursued in collaboration with the incumbent mud supplier. Special compliance engineers provided by the mud supplier were trained and certified on all permit requirements. The prime responsibility of these engineers is to perform all monitoring, maintenance and reporting associated with achieving compliance with the discharge limitations. Moreover, they are key focal points in the execution of the rig-specific BMP plans that were implemented on all drilling units.

e) Performance Measurement & Results.
Two performance measures were used as a gauge on SCE: (1) daily measurement of the API System Performance (SP) as a measure of overall efficiency of the solids control array and reporting of this measure on the daily mud report; (2) measurement of solids control efficiency trends and its impact on waste generation and mud economics in quarterly business performance reviews with the incumbent mud supplier. The calculation of the SP is outlined in **Table 7**. Comparisons were made of SP numbers before and after implementation of the solids control improvement plans. An example is shown in **Table 7**.

In general, an improvement in SP of 8 – 20% (see e.g. **Table 7**) was observed as a result of the various improvement initiatives. Such an improvement translates into several hundreds to thousands of barrels of mud per well that is not used for dilution purposes and subsequently discharged in the case of water based mud. Moreover, accordingly there are significant savings in mud costs. In fact, it was calculated that the tangible and intangible savings generated on a single Mars platform well paid for the entire performance improvement program.

2. Reduction of Drilling Bulk packaging with Bulk Handling & Mixing Technology.
A prime source of rig waste is packaging materials (e.g., pallets, sacks, shrink wrap, plastic pales & buckets, etc.) used for mud components, many of which offer limited opportunity for re-use or re-cycling. Bulk handling and mixing technology may eliminate this source of rig waste completely. To demonstrate the viability of this approach to waste elimination, a “zero-waste” trial was organized on an offshore SEPCo rig for drilling several synthetic-based mud sections using a bulk handling & mixing system. The elements of this trial are summarized in the following.

a) Dry product packaging and transportation.
Powdered dry chemical products for synthetic-based mud were supplied to the rig in bulk bags (see **Figure 6**). These bags are durable and re-usable, constructed from PVC, with reinforced lifting straps for safety. After use, they are returned to the supplier, refilled and returned to the rig for service. Such bulk bags were sent out to the primary manufacturers and suppliers of mud chemicals used by the preferred mud company for the zero-waste trial. This ensured that waste was eliminated at the very start of the supply chain. No re-packaging of additives (leading to waste from temporary packaging materials) occurred. Most companies supplying dry mud materials, located in various parts of the world, had little difficulty adapting to filling bulk bags instead of paper sacks. The filled bulk bags were transported to the rigs by boat and stored appropriately at the rig until they were used. After use, the bags, which take up very little space when emptied, were crane-lifted off the rig for shipment back to shore.

b) Dry product dispensing.
Using technology adapted from other industries, the bulk bags were placed on an unloader (see **Figure 6b**), which allowed for product to be dispensed dust-free into the main mixing vessel of a special bulk mixing system for processing. No product was allowed to escape into the atmosphere or wasted by spilling. An added bonus was that the bulk mixing system proved capable of handling materials that became water-wet in transit. Note that materials from paper sacks that have become water-damaged are oftentimes rendered unusable. Moreover, once the shrink-wrap is cut and a pallet of materials opened, additives packaged in paper sacks are difficult to preserve and many times cannot be returned for credit. Worker contact with dry materials was avoided by dispensing into a closed area. After products were dispensed from the bulk bags, an auger transferred the dry product to the bulk mixer, which was located below decks. The empty bags were removed from the unloader and collected for return to shore for refilling.

c) Polymer / liquid product packaging & transportation.
Polymers are susceptible to deterioration from moisture and/or oxidation. To allow for efficient product transportation, and to provide extended shelf-life, specially designed polymer tanks were used which kept the dry polymer materials under slight pressure of nitrogen gas. Shelf-life tests showed that polymer products can be preserved perfectly for months without any deterioration in such tanks. Polymer pictured in **Figure** 7 was stored for six months in pressurized polymer tanks, was completely dry, and still flowed freely. This allowed for inventory control on polymers without wasting product.

At the rig, the polymer tanks allowed dispensing of product into the bulk mixing system through quick-connect hoses and dust-free piping. No product escaped into the atmosphere and none was spilled to create a slippery deck hazard. The tanks permitted the use of small amounts of the product without contaminating the remaining contents of the tank. Liquid additives were stored and handled using tote tanks. Using the polymer tanks eliminates several hundred plastic buckets normally used as packaging to avoid deterioration from moisture and/or oxidation.

d) Bulk mixing.
In the bulk mixing system used during the trial, base fluids were combined with dry chemicals at the rig in a closed, dust-free mixing vessel (tank, see **Figure 8**). Using mixing technology adapted from other industries, a high-volume, high-shear mixer was used to produce rapid and efficient preparation of drilling fluids on the rig. For mixing polymers, the system additionally uses a high-volume, high-shear in-line pump in tandem with the main mixer vessel. The mixer is very versatile and can accept materials from bulk bags, the rig’s bulk barite supply (via a pneumatic line), polymer tanks or liquid additive tote tanks. The mixer also has an auxiliary

hopper to accommodate product that is used in small quantities or is unavailable in bulk form. After mixing, the finished drilling fluid was sent through various output lines either to the active mud pit, to the cementing unit, directly to the suction line downhole, or into auxiliary mud pits.

A main advantage of the bulk mixing system is the efficiency of mixing of chemicals, allowing chemicals to be used optimally without waste, and the ability for mud properties to be managed more effectively. Note that conventional dry chemicals mixing by hopper can result in inefficient mixing and subsequent high loss of additives on solids control equipment.

Bulk mixing furthermore enables significant timesavings. Using conventional hopper systems, barite is typically mixed at the rate of 200 to 300 sacks per hour. Actual performance by the mixing system over a period of several months has shown that barite can be mixed at the rate of 50 sacks per minute = 3000 sacks per hour (i.e., a ten-fold mixing rate increase). Similar improvements have been observed for mixing bulk gel / bentonite. Furthermore, one rig hand cutting sacks can normally achieve a rate of 40 to 50 sacks per hour. By comparison, a single bulk mixer operator using bulk bags can mix 2000 lbs. of material in 5 to 10 minutes (i.e., 5 times faster). Such improved efficiencies translate into considerable timesavings.

Additional uses for the mixing equipment included the preparation of cement spacers. Because the unit was self-cleaning, there was no need for hazardous confined space cleanout. Another useful application, capitalizing on the improved mixing speed, is mixing on the critical path of pills in case lost circulation occurs. In a trial event, sudden loss of circulation occurred, prompting the mixing system to mix 150 bbls of 60 pounds/barrel of fibrous lost circulation material in only 50 minutes. By comparison, preparation of the same pill by the conventional hopper method would have taken four hours, with associated loss of rig time, additional mud losses downhole, etc.

e) Metering & monitoring.

Digital readout scales precisely measured the amount of polymer being dispensed. The digital readout showed the mud weight in the rig's active system, volume of mud in the mixing unit, and mud weight of the mud being mixed in the mixer. Precise control of the mixer's operation was obtained by push buttons at the unit's console. Mixer, pump, and blower functions with automated valves are controlled with a lighted console. An emergency shutoff button is included.

f) Trial results.

Summarizing, the bulk handling and mixing system employed offered the following benefits for drilling fluids production and handling:

- More efficient packaging and transportation of drilling fluids products
- Dust-free dispensing of dry products at the rig
- Combining of dry products with liquids in a mixing system that features speed and efficiency, minimizes waste, and provides maximum monitoring and control
- Significant reduction of wasted chemicals and reduction of trash to be disposed of
- Improved worker health and safety
- Improved drilling fluid properties

During the 3-month trial the following efficiencies were gained:

1. Barite saved. Considerable amounts of barite (estimates are up to 15% of the total bulk barite supply) are usually lost at the rig through the vent pipe. In the mixing system, the bulk barite storage was connected directly by a pneumatic transfer line to the mixing unit's input. This way, 100% of required barite was dispensed at the rig's maximum transfer rate (50 sacks per minute) into the mixer with no loss by venting. It was estimated that 1520 sacks of barite were saved and therefore not discharged during the trial by using the bulk mixing arrangement. This translates to 6080 sacks of barite per rig-year.
2. Paper sacks eliminated. A total of 124 bulk bags (at 1500 lbs each, i.e. 186,100 lbs of material) were handled and mixed during the trial. It would have taken 4865 sacks of mud additives, with associated waste, to mix an equivalent amount of material. This translates to 19,460 sacks (130 cubic yards waste) per rig-year.
3. Pallets & shrink wrap eliminated. A total of 152 wooden pallets and shrink wraps was eliminated during the trial by using re-usable bulk bags. In all, it was estimated that 60 cubic yards of waste was prevented from disposal at a landfill site by elimination of sacks, pallets and shrink wraps. This translates to 608 pallets and shrink wraps (106 cubic yards waste) per rig-year.
4. Transport efficiencies. Steel pallet boxes are used to transport sacks and other materials on the boats to the rigs. The pallet boxes weigh more than a ton each, and when empty, must be transported by boat back to shore. It costs the operator just as much to transport the boxes when empty as when they are filled. Bulk bags, when emptied, can be compacted for return to shore to be refilled. They take up little space on the boat for the return trip to shore. During the trial, the use and transport of some 70 pallet boxes was eliminated.
5. Improved Health and Safety. Worker health and safety issues abound with the currently used hopper system of mixing on the rigs. Because sacks of powdered mud chemicals must be cut and dispensed by hand into the hopper, workers are exposed to respiratory, lifting, and handling risks. The bulk handling and mixing system, with its dust-free operation, virtually eliminated worker exposure, thereby improving overall health and safety.
6. Time-savings. It was estimated that a total of 195 man-hours was saved by using the bulk handling and mixing system compared to conventional mixing systems. Unquantified rig time was saved through more efficient bulk handling and mixing.

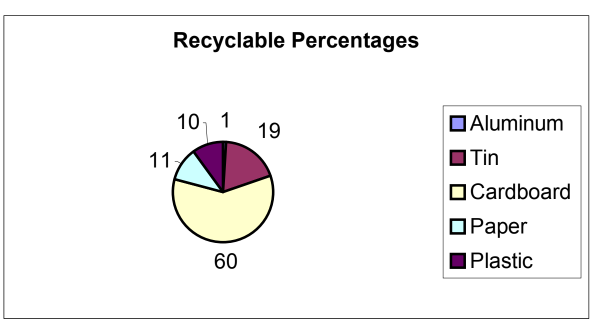
3. Recycling of Drilling Solid Waste.

a) Sorting and Recycling Process.
The waste types that are suitable for recycling are solid waste (trash) and industrial non-hazardous waste. Refer to **Table 1** for the waste streams included in these two waste types. Before recycling can be achieved, the waste streams must be sorted into commodity categories on the rig before shipment to the recycling center. Once waste streams are combined, recycling is virtually impossible.

Solid waste (trash) is sorted on the rig into commodity categories (aluminum, tin, cardboard, paper, and plastic). [At this time, lumber and wood materials are not being recycled. A survey is underway to determine the feasibility of reuse for pallets and wood crating materials.] Multiple bin trash compactors are designed to handle each of these categories (**see Figure 9**). Green colored bags are used for the recyclables to differentiate from non-recyclables. A tagging system is used to identify the rig and the commodity. Storage bins are placed at the dock facility in Fourchon to store the compacted bags until pick up. A pickup service transports the bags to the recycling center in New Iberia where mentally and physically challenged adults weigh the bags, inspect the commodities and remove any impurities. A tracking system is used to report the amount (in pounds) of recyclables sent to the dock by each rig.

Non-hazardous industrial waste is sorted on the rig into categories (steel drums, rags/pads/filters, and scrap metal). Steel drums are shipped to a recycling facility for recleaning and reuse. Rags/pads/filters are placed in metal drums for shipment to the recycling facility. The recycling facility separates the waste into three components: oil, scrap metal, and a flammable material. The oil and scrap metal are sold to a vendor for re-use. The flammable material is burned in a process that generates electric power, which is sold. Scrap metal collected on the rigs is stored in bins for shipment to a scrap metal broker.

b) Reductions Achieved.
During 2002, the Paul Romano Rig recycled 44,930 pounds (22.5 tons) of commodities, and the Jim Thompson rig recycled 25, 942 pounds (13 tons). [Ursa is in the beginning stages of implementation.] The percentage of each category is seen in the following chart:



During 2002, 256 empty steel drums and 238 drums of rags/pads/filters were recycled from the three facilities. The volume of rags/pads/filters translates to 60 cubic yards of waste that was recycled and not disposed of in landfills. The vast majority of these recyclables were generated on the Ursa platform. This is because these waste streams are primarily related to production activities and not drilling.

Conclusions
SEPCo's Rig Waste Reduction Pilot Project is in the process of being implemented on two drilling rigs and one drilling/production platform. Results of the pilot project to date show that significant discharge/waste reductions are achieveable through processes and technologies that:

- Optimize drilling fluids solids control efficiency and drill cuttings managagement (source reduction),
- Provide for bulk handling and mixing of mud components (source reduction), and
- Optimize recycling of residual solid wastes (reuse and recycling).

These strategic areas capitilalized on the top priorities of the waste reduction hierarchy of *1) reduce, 2) reuse, 3) recycle, 4) recover, and 5) dispose.* Other targeted reduction strategies are in the process of being implemented and will provide added waste reduction benefits.

The waste reductions achieved by the pilot project are summarized as follows:

- SCE SP and ROC improvement of 8-20% which translates into hundreds to thousands of barrels of mud per well which is not discharged or treated as NOW
- Source reduction of packaging materials through bulk handling and mixing (per rig-year basis)
  - 6080 sacks barite
  - 130 cubic yards of paper sacks
  - 106 cubic yards of wood pallets and shrink wrap
  - Several hundred plastic buckets used for polymers with water based mud
- Boat transportation efficiencies, worker health and safety improvement, and rig time savings through bulk handling and mixing
- 22.5 tons of recycled solid waste per rig, reuse of 256 steel drums, and 60 cubic yards of recycled rag/pads/filters.

Based on these pilot project results, SEPCo will consider which reduction strategies to implement company wide in 2003.

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Table 1 – Rig Waste Characterization

Waste Types – URSA/H&P and Romano Rigs	Units	Treatment/ Disposal Method	Sorted/ Compacted/ Recycled?
N.O.W. - Muds and Cuttings			
WBM bulk mud	Bbls	Discharged	
WBM cuttings	Kg-wet	Discharged	
OBM mud	Bbls	Returned to Vendor	
OBM cuttings	Kg-wet	Onshore disposal at Newpark	
SBM mud	Bbls	Returned to Vendor	Reused
SBM cuttings	Kg-wet	MRU treatment and discharged	
Barite	Cu. Ft.	Returned to Vendor	Reused
Washwater	Bbls	Discharged	
Cement	Cu. Ft.	Slurried and discharged	
N.O.W. – Completion Fluids			
Completion fluids	Bbls	Discharged or onshore disposal at Newpark if contaminated	
Completion fluids (priority pollutants)	Bbls	Returned to Vendor	Reused
Sand	Bbls	Onshore disposal at Newpark	
Filter media (D.E.)	Cu. Ft.	Discharged	
Interface fluids	Bbls	Treated and discharged	
Trash (solid waste)			
Sacks	Cu. Yd.	Onshore trash disposal at landfill	
Pallets			Recycled
Shrink wrap	Cu. Yd.	Onshore trash disposal at landfill	Compacted
Aluminum cans	Lbs.		Recycled in Galley
Drums (plastic & steel)	Cu. Yd.	Triple rinsed for onshore disposal	
Pales (plastic)	Cu. Yd.	Onshore trash disposal at landfill	
Galley food waste	Cu. M.	Ground and discharged	
Galley non-food waste	Cu. Yd.	Onshore trash disposal at landfill	Compacted
Paint cans and brushes	Cu. Yd.	Onshore trash disposal at landfill	
Cooking oil	Drums		Recycled
Lumber	Cu. Yd.	Onshore trash disposal at landfill	
Spools		Onshore trash disposal at landfill	
Black Water	Gal.	Sanitized and discharged	
Grey Water	Gal.	Discharged	
Misc. deck waste	Cu. Yd.	Onshore trash disposal at landfill	Compacted
Industrial Waste (non-haz)			
Rags/pads/filters	Drums	Omega Waste Management	Recycled
Scrap metal	Lbs.	Southern Scrap	Recycled
Lube Oil	Gal.	Injected into lube oil header (Ursa)	Recycled
Antifreeze	Gal.	International Petroleum Corp.	Recycled
NORM			
Tubulars			
Hazardous Waste			
Batteries		Onshore disposal at landfill	Some Recycled
Solvents and paint waste	Lbs.	Onshore disposal	

Table 2 – 2000 Environmental Data

Disposition	Rig Waste Types	URSA	Romano
Discharged at rig	Total SBM Lost from System (BBL)	4329	32416
	Total SBM Less Down-hole losses (BBL)	1734	13599
	SBM Losses on Cuttings (BBL)	1419	9126
	Cuttings (BBL)	3999	9182
Disposed onshore	Hazardous Waste (Lbs)	0	550
	Solid Waste (Trash) (Cubic Meters)	1084	361
	NOW Waste (BBL)	2983	2132

Table 3 – Pilot Waste Reduction Strategies

Strategy No.	Waste Streams Reduced	Strategy Description	Pilot Recommendation
1	WBM bulk mud	Develop Solids Control Workshop and Training for rig personnel to identify optimal SRE performance, diagnose problems, and make improvements. Consider ongoing rig support.	Proceed
2	WBM bulk mud	Develop options for mud vendor reuse of bulk mud	Study Further
3	OBM cuttings	Document best practices for annular re-injection	Proceed
4	OBM cuttings	Evaluate APV cuttings processing and drying	Proceed
5	SBM bulk mud	See Strategy No. 1	Proceed
6	SBM cuttings	Install Mud Recovery Units on all rigs drilling with SBM and implement SBM Best Management Practice (BMP)	Proceed
7	Barite/Cement	Develop plan to transport unused barite and cement to other rigs at completion of well/job	Proceed
8	Barite/Cement/wash water	Evaluate Enviro Center at C-Port to recycle barite and synthetic material from boat tanks	Proceed
9	Completion Fluids	Implement Supply Boat Discharge procedure while en-route to minimize tank wash water and waste in port	Proceed
10	Trash – paper, plastic, aluminum, iron, lumber	Implement a sorting procedure to facilitate reuse and recycling of waste types.	Proceed
11	Pales, Shrink wrap, sacks, pallets, mud	Install Bulk Mixer unit on rig to mix bulk mud additives on site (Jim Thompson)	Proceed
12	55 gal drums –steel and plastic	Reuse or recycle steel and plastic drums.	Proceed
13	Lumber	Develop options and procedures for donation to Habitat for Humanity and other groups.	Proceed
14	Lumber	Procure equipment (flowlines, etc.) with reusable crates	Study Further
15	Spools	Develop options and procedures for donation	Proceed
16	Rags/pads/filters	Continue to implement and document recylcing procedures	Proceed
17	Paper and plastic cups in galley	Switch to reusable plastic cups within galley	Proceed
18	Antifreeze	Implement Product Substitution to a less toxic material	Study Further
19	Batteries	Implement recycling program for all types of batteries	Proceed
20	Flares	Implement procedures to shoot flares onsite with notification to Mariners	Proceed
21	5 gal. Plastic pales	Implement procedures for reuse or recycling of plastic pales	Proceed
22	Galley Waste	Implement procurement process to bulk package or minimize packaging of food to reduce galley waste	Study further
23	All waste streams	Implement rig waste survey with digital photos of waste types and reduction opportunities	Proceed
24	Cuttings (onshore)	Land farm cuttings	Proceed
25	All waste streams	Participate in R/D Shell Group GameChanger Waste Reduction Project	Proceed
26	NOW Wastes	Dispose of drill cuttings and NOW waste in offshore salt dome	Study Further

Table 4— Stock Limitations for NAF

Pollutant Parameter	Limit	Method
Mercury	1 mg/kg	Maximum in stock barite measured by GC/MS
Cadmium	3 mg/kg	Maximum in stock barite measured by GC/MS
PAH	0.001% (10 ppm)	PAH (as phenanthrene) content by EPA Method 1654A
Sediment Toxicity[1]	1.0	Modified ASTM E 1367-92 with *Leptocheirus Plumulosus* using C_{16}-C_{18} IOs as the reference base fluid
Biodegradation[2]	1.0	Modified ISO 11734 (Closed Bottle Test) using C_{16}-C_{18} as the reference base fluid

[1] The sediment toxicity rate ratio (10-day LC_{50} of C_{16}-C_{18} IOs / 10-day LC_{50} of stock base fluid being tested) must be equal to or less than 1.0.

[2] The biodegradation rate ratio (percent degradation of C_{16}-C_{18} IOs / percent degradation of stock base fluid being tested at 275 days) must be equal to or less than 1.0.

Table 5— Discharge Limitations for NAF

Pollutant Parameter	Limit	Method
Diesel Oil	No Discharge	Static Sheen
SPP Toxicity	LC50 of 3% (30,000 ppm)	SPP Aquatic Toxicity Test with *Mysidopsis bahia*
Formation Oil	No Discharge	RPE (screening method) and GC/MS (compliance assurance method)
Base Fluid Retention on Cuttings (ROC)[1]	6.9%	Retort Test Method in App. 7 of 40 CFR 435 for base fluids that meet the fluid performance of C_{16}-C_{18} IOs
	9.4%	Retort Test Method in App. 7 of 40 CFR 435 for base fluids that meet the fluid performance of vegetable esters
Sediment Toxicity[2]	1.0	Modified ASTM E 1367-92 with *Leptocheirus Plumulosus* using C_{16}-C_{18} IOs as the reference base fluid

[1] The ROC (measured as wet weight percent) must be measured from all discharge points at least once per day or every 500 feet drilled up to a maximum of three times per day and averaged over all well sections drilled with SBM. Compliant ROC values must be demonstrated only for the first third (1/3rd) of the interval drilled with SBM if a Best Management Practice (BMP) including the record keeping requirements is in place on the rig.

[2] The sediment toxicity rate ratio (4-day LC_{50} of C_{16}-C_{18} IOs / 4-day LC_{50} of drilling mud being tested) must be equal to or less than 1.0.

Table 6— BMP Plan Elements

Statements & Descriptions	Operational Best Practices, Inspections, Maintenance & Repair	Other Elements
Policy Statement	General Housekeeping	Supporting Documentation
Certification Statement	Mud Pits	Recordkeeping
Facility Description	Fluid Transfers	Discharge Monitoring
Wells & Discharge covered by BMP Plan	Solids Control Equipment	Contingencies & Miscellaneous
BMP Committee	De Minimis Discharges	MSDS information
BMP Development & Implementation	Small Volume Discharges	NPDES Checklist
BMP Plan Re-evaluation	BMP Forms, Inspection & Maintenance Records, Training Records associated with the above	

Table 7— API SP Calculation, Example and Field Data

Calculation:

$$\text{Actual Dilution (bbl)} = \text{Measured or Estimated Dilution (bbl)}$$

$$\text{Mud Built} = \frac{\text{Base Fluid Added (bbl)}}{\text{Mud Base Fraction}} = \frac{\text{Actual Dilution}}{(1 - \text{Drilled Solids Fraction})}$$

$$\text{Total Dilution} = \text{Dilution with } 0\% \text{ Solids Removal} = \frac{\text{bbls of New Drilled Solids}}{\text{Drilled Solids Fraction}}$$

$$\text{API System Performance} = \left(1 - \frac{\text{Mud Built}}{\text{Total Dilution}}\right) \text{x}\, 100\%$$

Example:

100 bbls of new hole drilled, 800 bbls of mud dilution, 5% drilled solids fraction (LGS)

Actual Dilution = 800 bbls; Mud Built = 800 / (1-0.05) = 842 bbls

Total Dilution = 100 / 0.05 = 2000 bbls; API SP = 1 – (842/2000) = 0.58 or 58%

Drilling Rig	API SP before solids control training	API SP after solids control training	Improvement in API SP
TLP	84% (based on 12 hole section drilled)	92% (based on 6 hole sections drilled)	8%
Floater 1	69% (based on 5 hole sections drilled)	89% (based on 22 hole sections drilled)	20%
Floater 2	72% (based on 10 hole sections drilled)	85% (based on 26 hole sections drilled)	13%

Figure 1 – Non-hazardous Waste (NOW) for 1999 and 2000

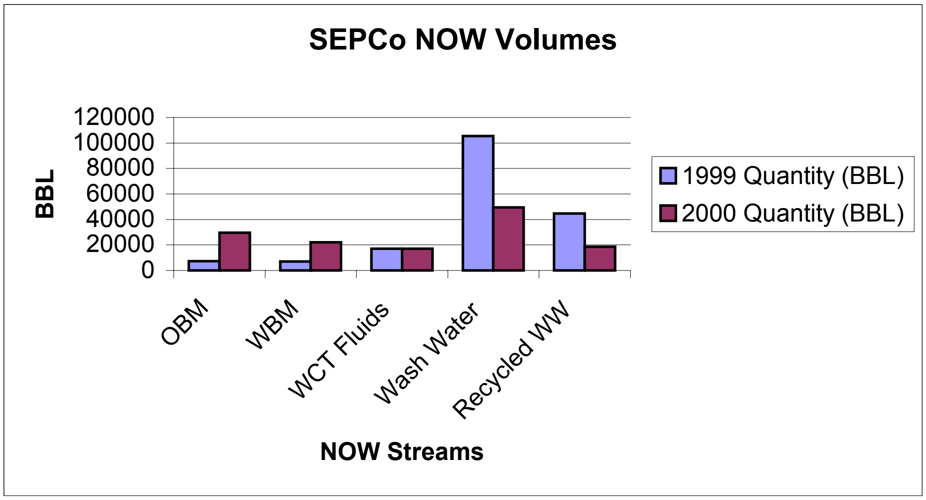


Figure 2 – Non-hazardous Waste (NOW) for 1999 and 2000 (Normalized)

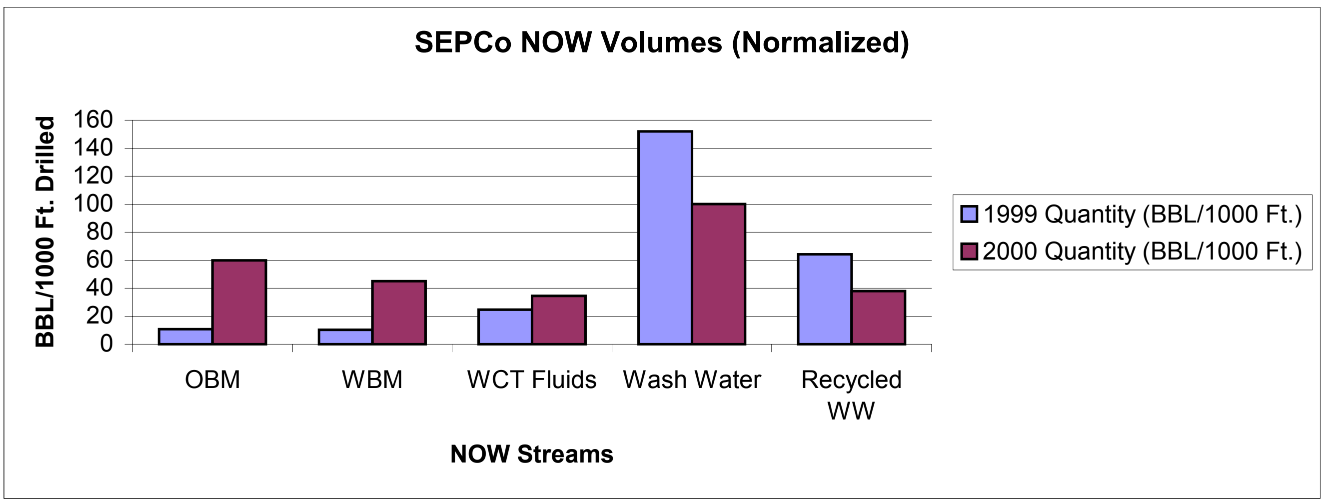
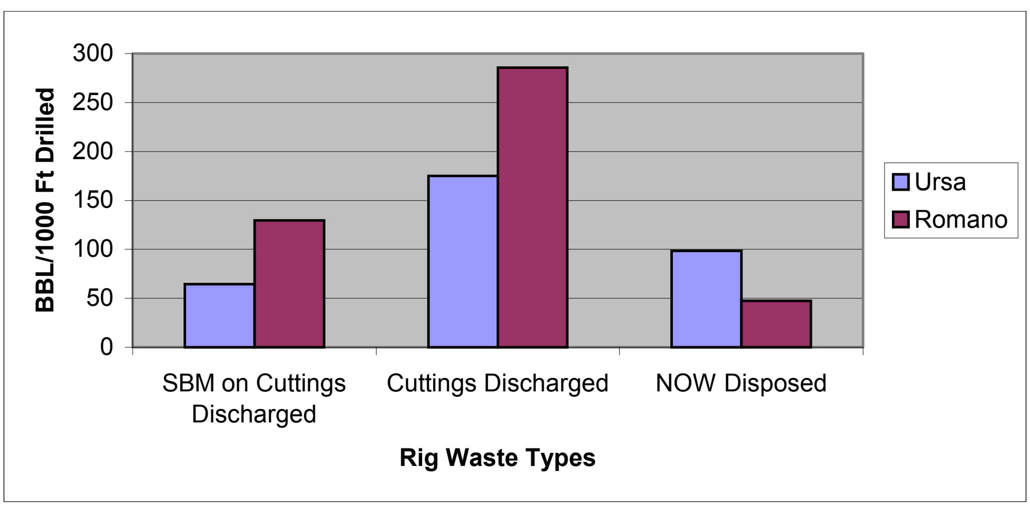


Figure 3 – 2000 Rig Waste Volumes (Normalized)



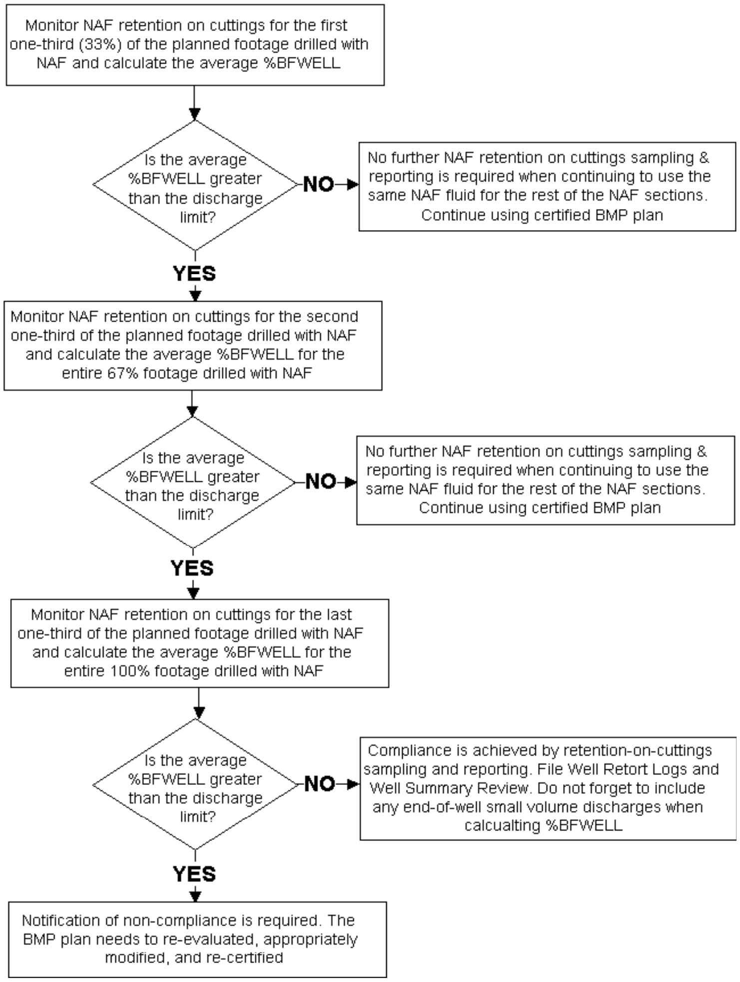


Figure 4 — Flowchart overview showing the requirement to monitor NAF retention on cuttings (%BFWELL) and the decision to start using BMP's.

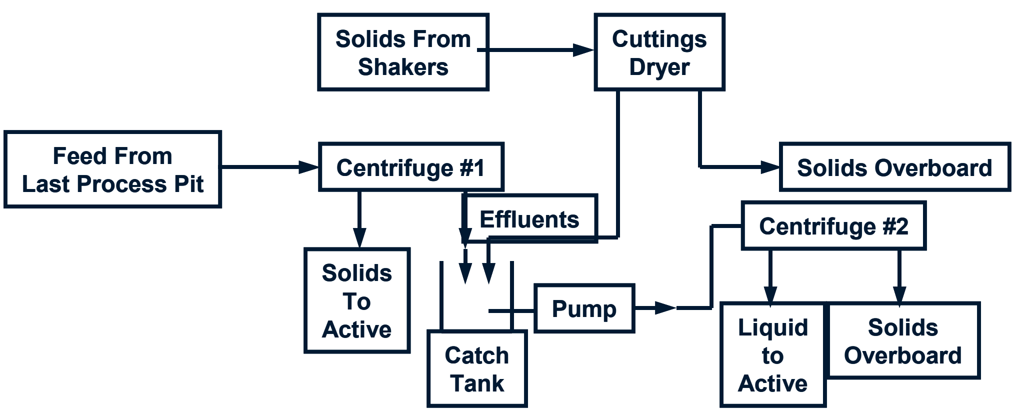


Figure 5 — Optimum set-up for processing solids using a barite-recovery centrifuge (Centrifuge #1), high-speed fines removal centrifuge (Centrifuge #2) and cuttings dryer.

(a)

(b)

(c)

Figure 6 ─ (a) Bulk bag close-up; (b) bulk bag hoisted to the unloader from a lower deck; (c) emptied bulk bag ready for shipment to shore

(a)

(b)

Figure 7 ─ (a) Nitrogen-purged tank used for polymer storage & transport; (b) Free flow of polymer out of tank after 6 months of storage

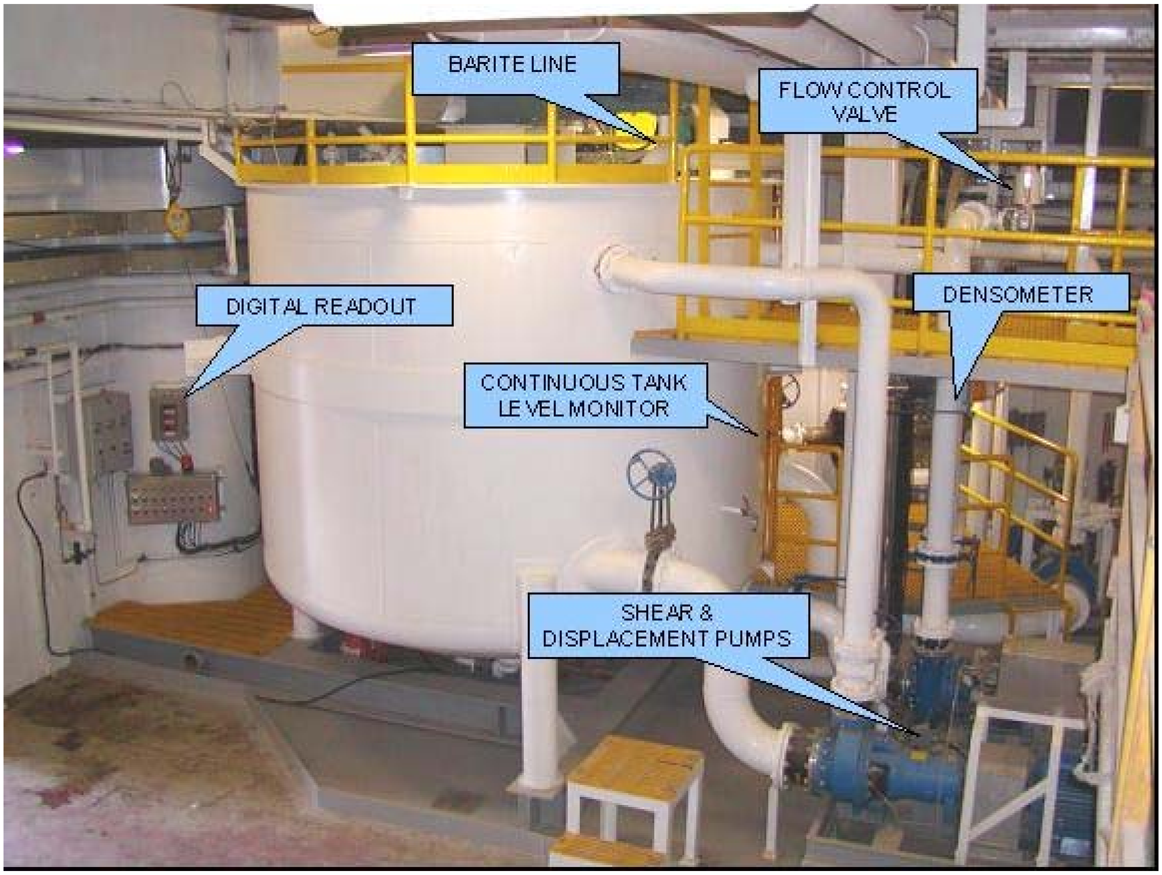


Figure 8 ─ Photograph of bulk mixing system, showing main tank, instrumentation, main pumps & valves

Figure 9 ─ Photograph of multiple bin trash compactor