

## NEW REDUCE, REUSE, RECYCLE DRILLING WASTE TREATMENT TECHNOLOGIES AND PROGRAMS

Manny Gonzalez, U.S. Liquids of LA., L.P.; Wayne Crawley, U.S. Liquids of LA., L.P., and Dennis Patton, U.S. Liquids of LA., L.P.

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### Abstract

New waste treatment and disposal practices are being used in Texas and Louisiana to Reduce, Reuse and Recycle (R3) Oil and Gas Exploration & Production waste. Technologies and programs were developed to convert drilling muds and associated cuttings to beneficial and environmentally friendly road base material to help minimize or eliminate E&P operator liability.

A variety of techniques and methods are used to treat and dispose these wastes with the materials either land applied, injected or landfilled. At one landfill facility, the waste treatment process includes removing the water which decreases the soluble salt content and reducing the oil concentration by recovery or degradation.

With the R3 process, the landfill containing the clean treated waste solids can be mined converting it into a repository of aggregate or "reuse" material to be utilized in the manufacture of road base recyclable products.

Laboratory tests of the new road base recyclable product conducted in Texas prove that it meets or exceeds the engineering and environmental criteria required by the regulatory agencies and the road construction industry.

Rule changes by the Railroad Commission of Texas to reclassify treated cuttings as reuse material will allow the industry to convert drilling waste into a recyclable product.

Environmental recycling projects will not succeed without market sustainability. The R3 Process is based on an "Engineering First" principle. By following sound business management procedures, complying with stringent regulatory criteria, and maintaining client relations, then recycling oil field waste can be a beneficial path forward to the current waste management practices.

### Introduction

The purpose of this paper is to provide information on what is being done to convert Oil & Gas Exploration & Production (E&P) waste materials into legitimate road construction products and for the potential use for levee construction. This paper will focus on a project located approximately 30 miles NW of McAllen, Texas.

The oil and gas industry along the gulf coast whether on land or at offshore operations, one would say is "blowing and going." The industry continues to expand. Customer's expectations from service companies are high. Service

companies are doing all they can to keep up and exploration and production (E&P) waste continues to be high profile.

Operators that work through and within Louisiana, generate approximately 700,000 bbls of E&P waste monthly, not including produced water. The total waste volume generated in Texas is unknown because it does not have a tracking system as in Louisiana. What is known is that about 19,000 drilling permits were applied for in 2007 and about the same is expected in 2008. A tremendous volume of waste will be generated from those drilling operations.

In Louisiana, approximately 30-40% of the solids in this E&P volume are destined for potential reuse material, mostly for levee construction.

In Texas, the Railroad Commission of Texas (RRC), the agency that regulates the oil and gas industry in Texas, encourages the industry to minimize waste by following the Waste Management Hierarchy of Preference (*I*) as follows:

1. source reduction,
2. recycling,
3. treatment,
4. disposal

For example, during drilling operations, operators seek options to minimize waste generated at the source. One method is the use of mechanical means to separate the undesirable cuttings (waste) so that the drilling fluids may be reused. Once wastes are minimized at the source, the remaining solid wastes, meeting RRC criteria, are treated and disposed onsite (i.e. land application, burial, injected), or transported to a commercial facility for treatment and disposal. Surprising enough, recycling of these waste solids rarely occurs.

E&P waste recycling operations are not new. In fact, companies have been recycling waste since the 1950's. There are recyclers permitted by the Railroad Commission to process waste materials and have had varying degrees of success--mostly for the recovery of oil--because of the recent oil price increases. Oil, a non-renewable resource, is recovered for resale, however, little has been done for the reuse or recycling of the remaining treated solids destined for disposal. The treated waste solids are a non-renewable resource as well, and in prolific oil and gas areas, are generated in substantial volumes. At times, these treated waste solids have been used

for levee material, firewalls, pads and road base mostly within the generators' facility. For the most part these treated materials are not reused. Why? Consider the following:

- End users of the recyclable product may require larger volumes than the recycler has access to
- End users of the recyclable product may require stricter engineering product specifications than the recycler can provide or obtain
- Recyclers may lack the experience or the technology to manufacture a properly engineered recyclable product
- Transportation costs of recyclable product may be prohibitive
- Recycling industry has lacked standardized rules
- Recyclable product has lacked regulatory definition
- Generators have been reluctant to recycle E&P waste, as they do not want their name associated with the waste once it has been applied to the ground...

The issue -- Liability.

US Liquids of LA., L.P. (USLL) is an environmental waste management company that treats and disposes of exploration and production waste and owns and operates facilities in Louisiana and Texas with two of those facilities in South Texas. The Rincon (Starr County) and Zapata (Zapata County) facilities have managed waste for over 10 years. Treatment at these facilities includes the separation and recovery of oil for resale and removal of water for disposal. The solids undergo a land treatment process within the lined cells to degrade remaining hydrocarbons, assisted by disking and tilling. Once the solids are treated to a total petroleum hydrocarbon (TPH) compliance limit of 50,000 ppm or less, the solids are destined for disposal in onsite lined landfill cells. Over 400,000 cubic yards of E&P waste materials have been placed in the disposal cells throughout the life of these facilities.

The industry was surveyed, asking key players what they consider the most important issue regarding waste disposal. The answer was obvious. Liability. This paper describes the steps taken to develop its R3 Recycling Initiatives and more specifically what was done to convert E&P waste materials into a recyclable product so that the generators' liability will be minimized and possibly eliminated.

What was once waste in a landfill now has the potential of becoming a repository of aggregate to be mined and used as feedstock for the manufacture of a commercially viable recyclable road base material, simply referred to as the R3 Product.

## DEVELOPMENT OF THE R3 TREATMENT Reduce, Reuse and Recycle

The South Texas facilities receive large volumes of E&P waste, primarily oil based drilling muds and cuttings. To achieve R3, the waste must be **reduced** by properly segregating and separating the waste materials. The oil must be recovered and **reused** and the treated solid waste **recycled** into a product.

### Markets

No matter how environmentally conscientious or noble the intent of any recycling effort, success cannot be achieved without a viable and continuing market for the end product.

Prior to taking on an endeavor of this magnitude, a market study was conducted to understand and define the potential uses of the R3 Product. Market development began with an inventory of available waste materials, localized aggregate and of the requirements necessary to move the project forward.

Prospective customers were identified including the state of Texas, counties, cities, oil and gas operators and ranch owners. These potential end users stipulated the following criteria:

- location of product utilization must be relatively near the feedstock repository,
- sustainable quantity of the recyclable product must be available, and
- provide a cost competitive product to what currently exists in the marketplace

The market study also identified that the South Texas area was experiencing a shortage of economical aggregate, an escalation of rock and asphalt prices, and prohibitive transportation costs; while the area was planning infrastructure growth for the construction and improvements of several hundred miles of roads.

The state of Texas, specifically the Texas Department of Transportation (TxDOT), was easily determined to be the number one potential end user of the R3 Product. Historically, traditional road base products used in the South Texas TxDOT District are imported from areas as far as Central Texas and Southern Mexico making product transportation cost prohibitive. TxDOT became very interested in the R3 Product once it was learned that it would be manufactured within 25 miles of their District sub-office.

With an inventory of over 400,000 cubic yards of high quality, downhole bedrock aggregate at its South Texas facilities, the objectives were to:

- prove the ability to manufacture a product and meet both engineering and environmental specifications
- sustain long term operations
- maintain a low cost operation
- provide a competitive economical product to what currently exists in the marketplace

- commit to and comply with the health, safety and environmental regulatory requirements

## Regulations

The Railroad Commission of Texas regulates the treatment and disposal of oil and gas waste, as described and defined in Statewide Rule 8 and 30. It also regulates the recycling of the same waste via minor permits and/or the RRC Surface Waste Management Manual - Application Information for Permit to Treat Oil and Gas Waste for Use as Roadbase (2).

An extensive search was conducted at the state level for existing recycling rules. Even though the RRC maintains jurisdiction over E&P waste and had an existing regulatory framework, it was believed that the rules lacked definition, were not standardized and did not provide direction to one applying for a recycling permit. The rules certainly did not encourage the generator to recycle its waste. In November 2005 and with the support of the RRC, USLL sponsored commercial recycling rules and submitted a petition for rulemaking that was believed would provide consistency, uniformity of regulatory criteria and establish clear guidance for those in the E&P recycling business. The proposed rules were to be included in Chapter 4 entitled "Environmental Protection (3)." The rules were published in the Texas Register in June 2006 and included a 30-day comment period.

One of the most significant excerpts from the proposed rule is the definition of recyclable product. The proposed rules intend to define "recyclable product" to mean a reusable material that has been created from the treatment and/or processing of oil and gas waste as authorized by a Commission permit and that meets the environmental and engineering standards established by the permit for the intended use as a legitimate commercial product. **"A recyclable product is not a waste, but may become a waste if it is abandoned or disposed of rather than recycled as authorized by the permit (3)".** The intent of the language is that once an E&P waste is recycled into a product, the generator's liability is greatly minimized and virtually eliminated as now the recycler is responsible for the product it manufactures. One year later in November 2006, the commercial recycling rules were approved and promulgated.

The decision was to move forward with a "Road Base" Pilot Project at the Rincon facility as the ground work was laid for a full scale recycling operation. To begin, a minor permit was applied for and received while concurrently applying for a full commercial recycling permit in addition to its existing commercial disposal permit. The key issues in the minor permit were to 1) protect the environment; and 2) manufacture a product that met engineering and environmental specifications.

In addition to the RRC regulations and requirements, TxDOT has an established program for accepting recyclable products for the use in road construction which contains engineering and environmental specifications that must be achieved.

The DMS-11000 (4) is the TxDOT process for

evaluating the environmental factors associated with nonhazardous recyclable materials (NRMs) not addressed in other TxDOT specifications.

TxDOT's approval criteria for the use of a NRM product is dependent on two factors:

- 1) Engineering – product must meet applicable department engineering specifications and other engineering evaluations deemed necessary by the TxDOT
- 2) Environmental – poses an acceptable level of potential environmental risk, following an evaluation of its environmental characteristics

### NRM Product Approval Process:

To be eligible for use on TxDOT projects, the NRM product must:

- meet all applicable department engineering specifications and other engineering evaluations deemed necessary;
- contain only NRMs that meet the standards listed under Item 6, "Control of Materials," Article 6.9, Recyclable Materials of the Standard Specifications for Construction and Maintenance of Highways, Streets, and Bridges;
- contain only NRMs that are managed and protected from loss, as would be raw materials, ingredients, or products;
- be used without the need for short-term or long-term management, such as special worker protection precautions, deed restrictions or notices (i.e., institutional control requirements associated with the reuse of contaminated media as discussed in 30 TAC 350.36), tracking, monitoring, special handling after the project life, or special engineering controls;
- not present an increased risk to human health, the environment, or waters in the state when applied to the land or used in products that are applied to the land.

The DMS-11000 provides for an eligibility process. In the process, bench scale recyclable products must be formulated, developed and manufactured and extensive tests performed on those products. The product selected was specified by TxDOT Item 345 (Asphalt Stabilized Base) and Special No. 3157 (Cold Processed – Recycled Paving Materials for Use as Aggregate Base Course).

### Recyclable Product Development

With the markets established, the regulations identified, and the product specified, the recyclable product development began. An engineering, environmental consulting and construction management company located in San Antonio, was selected to perform bench scale tests. Mix

design formulations were created by experienced, non-biased engineers, which included the comparison of various drilling waste/asphalt mixtures with traditional mix designs. The development goal was to meet engineering specifications, comply with environmental criteria and maximize the use of treated waste material in the final recyclable product.

As per the RRC minor permit, the first 1500 tons of recyclable product manufactured would be pledged to a trial run with samples collected from every 150 tons. The recyclable product criteria were as stated in Table 1.

TxDOT, Item 345 and Specification No. 3157 required:

- Minimum requirements for compressive strength shall be 35 psi for secondary roads and 50 psi for primary highways
- Minimum requirement for Hveem stability shall be a value of 35
- Asphalt content shall be determined according to product specific mix design requirements
- Gradation,

Sieve Size	Percent
1 3/4 inch	100
No. 4	60 maximum *
No. 40	50 maximum *

\* at the discretion of the Engineer

To meet the above criteria, the formulation included a course aggregate, a cement binder, an asphalt emulsion in addition to the E&P treated waste material or NRM. The aggregate is a native caliche located nearby the repository.

As per the DMS-11000, a recyclable product can be compared to “traditional material being replaced.” The R3 Product was compared in side-by-side engineering and environmental comparisons to materials such as:

- “MC-30 mixture”, a product prepared to TxDOT 3157 (i.e., oil field materials, native caliche, CKD and an emulsified asphalt). MC-30, a “Cut Back” emulsified asphalt, commonly used by TxDOT, which contains a medium weight petroleum hydrocarbon and used as a “Cut Back Solvent.”
- “Type-D mixture”, hot mix asphalt prepared to TxDOT Type D specifications.
- “SS-1h mixture”, a product prepared to TxDOT 3157 (i.e., oil field materials, native caliche, CKD and an asphalt emulsion binder). SS-1h is a water based asphalt emulsion containing no VOC or solvents.

After extensive testing, the laboratory results proved that the bench scale recyclable products met or exceeded the minimum engineering and environmental requirements identified by all regulatory agencies.

## Recyclable Product Application

Encouraged by the successful bench scale testing, a recyclable product launch program was established. With the permits in place and customers established, the program began by sourcing experienced personnel in the management and operations of mixing plants and recycling projects, securing full scale equipment such as a crusher, screens, pugmill, feed bins, radial conveyors, weighting systems, silos, etc.

The setting for the R3 project (the “project”) was at the Rincon facility in Starr County. Over its history, this facility has disposed over 200,000 cubic yards of E&P waste materials into its landfill cells. The proposal was to incorporate the treated, nonhazardous oil field materials into specified grades of commercially viable asphalt paving products based on TxDOT Item 345 Modified Cold Mix/Cold Laid Asphalt Stabilized Base Course and Special Specification 3157. The TxDOT DMS-11000 Guidelines were utilized to demonstrate that the subject products will meet these criteria and be protective of the environment, public health and the waters of the State of Texas.

Work and QA/QC Plans were drafted as part of the DMS-11000 submittal and internal operation documentation. The QA/QC Plan was designed to document that the R3 Product passes TxDOT defined “acceptable level of potential environmental risk”, and conforms to the DMS-11000 Eligibility Criteria. The QA/QC Plan was also designed as a risk management tool and as an in-house check list that provides defensible documentation of the product’s environmental and engineering characteristics. The objective of this plan is for all R3 Product to be warranted to comply with project specific and overall TxDOT and RRC requirements.

The NRMs to be excavated from the repositories for use in the R3 Product have data on file indicating that they are nonhazardous in accordance with the RRC analytical requirements of the minor permit and the Stationary Treatment Facility (STF-009) permit. The NRM sampling and testing protocol for the Pilot Project followed the RRC guidelines. Beyond the Pilot Project, the sampling and testing protocols were amended as prescribed by TxDOT DMS-11000.

The emphasis was that no R3 Product may be used on-site, or transported off-site, until engineering test data and environmental analytical reports have been received, reviewed and signed off by trained senior staff at the site of production and that any R3 Product transported offsite would be documented on a Bill of Lading.

The Pilot Project began in the Fall of 2006 and manufactured a production volume of 3500 tons of recyclable product. A RRC pre-requisite “trial run” was conducted and yielded the results stated in Tables 2 and 3.

TxDOT however, as part of the DMS-11000, requested additional testing to research and document the potential affects of Total Metals and Total Petroleum Hydrocarbons (TPH) in the NRM’s and compare these constituents to the levels in the Texas Commission on Environmental Quality (TCEQ) Texas Risk Reduction Program. The results proved that the R3 Recyclable Product

is protective of human health and the environment. This was based on information submitted to TxDOT regarding the analysis of a wide range of potential chemicals of concern, which showed the concentrations were below Tier 1 residential Protective Concentration Levels (PCL) or were representative of background concentrations, and the Tier 2 analysis of TPH.

The R3 Product has been utilized on facility roads, county roads and in the Fall of 2007, TxDOT provided written authorization for the use of the R3 Product. This product continues to be used on TxDOT projects such as shoulders, Farm to Market roads, patch work, etc.

Other potential materials will be explored that can be used as aggregates such as reclaimed asphalt pavement, cutlets, ceramic, and crushed concrete, to name a few. The project has become a full fledged commercial recycling facility and is fully permitted to manufacture recyclable products, primarily for roadbase.

The relevance to the road construction industry is that now there is a localized viable industrial material that meets the immediate needs of the infrastructure growth and provides another viable option for potential users.

In addition, the recyclable material is affordable. By being manufactured locally, transportation costs are greatly reduced and by having available aggregate at hand makes the recyclable product cost effective. With affordable road base materials, more roads can be constructed and subsequently, much better for the community.

## Conclusion

It is firmly believed that exploration and production waste streams must be handled as a waste first and its solids be treated to an acceptable compliance limit before using it as a feedstock for any recycling application. Also, the regulatory landscape must acknowledge that when a waste is properly recycled into a commercially viable product that the generators' liability is absolved and that genuine recyclable products manufactured from a non-hazardous wastes be afforded the same consideration as any other manufactured product and not judged on what the material once was.

The new RRC commercial recycling rules are taking E&P generators and the waste industry closer to achieving

those goals. Other state agencies, like the TxDOT have recycling initiatives and are championing efforts as well.

E&P generators and the waste industry closer to achieving those goals. Other state agencies, like the TxDOT have recycling initiatives and are championing efforts as well.

When manufacturing a recyclable product, the environmental and engineering analysis must prove that the product is cost effective, meets or exceeds the engineering requirements of the traditional materials being replaced and is environmentally acceptable. Only by developing partnerships and complying with the permits and requirements of the predominant state agencies; the Railroad Commission of Texas, the Texas Commission on Environmental Quality and the Texas Department of Transportation, can success be achieved.

Environmental recycling projects will not succeed without market sustainability. The market demands a quality product. No market, no product. The R3 Process is based on an "Engineering First" principle. By following sound business management procedures, maintaining client relations, working with suppliers and buyers as a team, then recycling oil field waste can be a beneficial path forward to the current waste management practices.

The purpose of the R3 Technology was to develop processes to manufacture engineered and environmentally sound recyclable product from treated exploration and production waste and encourage recycling for use as road base materials and other purposes like levees. It is believed that the R3 Process meets those goals.

## References

1. Oil and Gas Division, Railroad Commission of Texas, Waste Minimization in the Oilfield, Publication Revised (July 2001)
2. RRC Surface Waste Management Manual - Application Information for Permit to Treat Oil and Gas Waste for Use as Roadbase
3. 16 TAC, Chapter 4. Environmental Protection, Subchapter B.
4. Texas Department of Transportation, Environmental Manual, DMS-11000 Evaluating and Using Nonhazardous Recyclable Materials Guidelines, (August 2004)

## Tables

**Table 1 - Railroad Commission of Texas - Recyclable Product Criteria**

PARAMETER	LIMITATION
Compressive Strength by Method Tex-126-E	35 psi minimum
Hveem Stability by Method Tex-208-F	35
SPLP by EPA Method 1312	
Metals	
Arsenic	<0.50 mg/l
Barium	<100.00
Cadmium	<1.00
Chromium	<5.00
Lead	<5.00
Mercury	<0.20
Selenium	<1.00
Silver	<5.00
Benzene	<0.50
1:4 Solid: Solution 7 Day Leachate Test (LA 29-B Method)	
Chlorides	<700.0
TPH	<100.0
pH	6 – 12.49

TABLE 2 - Summary of USLL R3 Product Engineering Test Results

<b>(composite of sub lots 1-4 Lot# 1-121906-1)</b>					
<b>TxDOT Test Method</b>	<b>TxDOT Product Specifications</b>			<b>Engineering Test Results</b>	<b>Pass / Fail</b>
	<b>Pharr District Flex Base</b>	<b>TxDOT Item 3157</b>	<b>TxDOT Item 345 Grade 1</b>		
Sieve Analyses	0%	100%	100%	0%	Pass
TXE-110-E	Retained 2"	Passing 1-3/4"	Passing 1-1/2"	Retained 2"	
	0-20%	Maximum 60% Passing No. 4	90-100%	100%	Pass
	Retained 1/2"		Passing 1"	Passing 1-3/4"	
	40-75%	Maximum 50% Passing No. 40	45-70%	95%	Pass
	Retained No. 4		Passing 3/8"	Passing 1"	
	70-90%		30-50%	20%	Pass
	Retained No. 40		Passing No. 4	Retained 1/2"	
			15-30%	71%	(*)
			Passing No. 40	Passing 3/8"	
				55%	Pass
				Retained No. 4	
				45%	Pass
				Passing No. 4	
				77%	Pass
				Retained No. 40	
				23%	Pass
				Passing No. 4	
*Indicates a 1% deviation from Item 345 Grade 1 Specifications. Within specification deviation limits of 2.5%					
Compressive Strength TXE-126-E	Not Specified (N/S)	Minimum 35	Minimum 50	54 psi	Pass
Molded Density (wt./ft <sup>3</sup> x27 ft <sup>3</sup> /yd <sup>3</sup> = tons per yd <sup>3</sup> )	N/S	N/S	N/S	136 lbs/ft <sup>3</sup> = 1.83 tons per yd <sup>3</sup>	Pass*
*Indicates comparison to Hot Mix Asphalt for construction purposes. Per Asphalt Institute Publication MS-22 "Construction of Hot Mix Asphalt Pavements" the acceptable range to this type of asphalt is 130-150 lbs/ft <sup>3</sup>					
Triaxial Strength (psi)					
	@ 0 psi N/S	N/S	N/S	41 psi	Pass
TEX-113-E	@ 15psi min. 150	N/S	N/S	152 psi	Pass
HVEEM Stability TEX-208-Modified Average Stability	N/S	Minimum 35	N/S	56	Pass

**TABLE 3 - Summary of USLL R3 Product Environmental Analytical Results**

<b>(composite of sub lots 1-4 Lot# 1-121906-1)</b>									
<b>Material Analyzed</b>	<b>Constituent Analyzed</b>	<b>Analytical Method</b>	<b>RRC Limitation (MCL)</b>	<b>Analytical Results (results in mg/L)</b>					
			<b>(results in mg/L)</b>						
Cement Kiln Dust	RCRA Metals	TCLP	Arsenic <5.0	<0.1				Pass	
			Barium <100.0	0.734				Pass	
			Cadmium <1.0	<0.05				Pass	
			Chromium <5.0	0.164				Pass	
			Lead <5.0	<0.01				Pass	
			Mercury <0.2	<0.01				Pass	
			Selenium <1.0	<0.05				Pass	
			Silver <5.0	<0.002				Pass	
Recycled Product	RCRA Metals	SPLP		<b>Lot-1/200T</b>	<b>Lot-1/100T</b>	<b>Lot-1/209T</b>	<b>Lot-1/67T</b>		
			Arsenic <5.0	<0.01	<0.01	<0.01	<0.01	Pass	
			Barium <100.0	0.074	0.072	0.086	0.134	Pass	
			Cadmium <1.0	<0.005	<0.005	<0.005	<0.005	Pass	
			Chromium <5.0	<0.01	<0.01	<0.01	<0.01	Pass	
			Lead <5.0	<0.01	<0.01	<0.01	<0.01	Pass	
			Mercury <0.2	<0.0002	<0.0002	<0.0002	<0.0002	Pass	
			Selenium <1.0	<0.01	<0.01	<0.01	<0.01	Pass	
Recycled Product	VOC Benzene	7 Day Leachate	Benzene <0.50	<b>Lot-1/200T</b> <0.005	<b>Lot-1/100T</b> <0.005	<b>Lot-1/209T</b> <0.005	<b>Lot-1/67T</b> <0.005	Pass	
			Chlorides <700.0	<b>Lot-1/200T</b> 592	<b>Lot-1/100T</b> 553	<b>Lot-1/209T</b> 494	<b>Lot-1/67T</b> 444	Pass	
			Total Petroleum Hydrocarbon <100.0	<b>Lot-1/200T</b> <5	<b>Lot-1/100T</b> <5	<b>Lot-1/209T</b> <5	<b>Lot-1/67T</b> <5	Pass	
			Corrosivity pH	USEPA 9045C (standard units) 6-12.49	<b>Lot-1/200T</b> 10.8	<b>Lot-1/100T</b> 10.8	<b>Lot-1/209T</b> 10.1	<b>Lot-1/67T</b> 10.4	Pass