About Scott

• Headquartered in Longview, Texas
• 20 years experience managing solid drilling waste
• Scott treats and recycles waste into drill pads, service roads and other infrastructure
• Partners with research universities on testing, solutions
Overview of Issues with Solid Drilling Waste and Location Construction

• How can solid-drilling waste management costs be reduced?
• How can consistent solid-drilling waste management results be obtained?
• How can environmental footprints be reduced?
• How can location construction costs be reduced?
• How can consistent results be obtained from location construction?
• How can rig costs per hole be reduced?
• How do we know on each job that the waste management results have been achieved?
The Problem: What is solid drilling waste?

• According to the American Petroleum Institute, for every foot drilled in the U.S., 1.21 barrels of drilling waste are generated.

• Approximately 50 percent of this is solid drilling waste.
The Problem: What is solid drilling waste?

- Solid drilling waste is comprised of drilling mud and cuttings that cannot be pumped which include contaminants such as:
  - Salts
  - Hydrocarbons
  - Metals
  - pH
Solid Drilling Waste: Environmental Concerns

Salts (Chlorides)
Sodium Chloride (NaCl) – From Formations
Calcium Chloride (CaCl₂) – From Mud Additives
Potassium Chloride (KCl) – From Mud Additives

- Completely soluble and very mobile throughout the environment
- Can be toxic to aquatic life and impact vegetation and wildlife
- There is no known natural process by which chlorides are broken down, metabolized, taken up, or removed from the environment
- EPA Secondary Drinking Water Standard of 250 mg/L or less
Solid Drilling Waste: Environmental Concerns

Heavy Metals

- Arsenic
  - Discoloration of the skin and the appearance of small corns or warts
  - May increase risk of getting cancer
  - May cause death after high exposure rates
  - National Primary Drinking Water Standard of 0.01 mg/L

- Barium
  - Increase in blood pressure.
  - National Primary Drinking Water Standard is 2.0 mg/L

- Cadmium
  - Risk of Kidney Damage
  - National Primary Drinking Water Standard is 0.005 mg/L

- Chromium
  - Multiple Forms: Chromium-3 and Chromium-6
  - Chromium-3 has relatively low toxicity
  - Chromium-6 is more toxic and poses potential health risks, such as Allergic Dermatitis
  - Can easily transform from one form to the other
  - National Primary Drinking Water Standard of 0.1 mg/L Total Chromium
Solid Drilling Waste:
Environmental Concerns

Heavy Metals

• Lead
  - Infants and children: Delayed physical or mental development, deficits in attention span and learning abilities
  - Adults: Kidney problems or high blood pressure

• Mercury
  - Kidney Damage
  - National Primary Drinking Water Standard is 0.002 mg/L

• Selenium
  - Hair or fingernail loss, numbness in fingers or toes, or problems with circulation
  - National Primary Drinking Water Standard is 0.05 mg/L
Heavy Metals

• Silver
  - Soluble Silver may cause liver and kidney damage, irritation of the eyes, skin, respiratory, and intestinal tract, and changes in blood cells
  - Metallic silver appears to pose minimal risk to health
  - National Secondary Drinking Water Standard of 0.1 mg/L

• Zinc
  - Drinking water which contains high concentrations of zinc may cause stomach cramps, nausea, and vomiting
  - Long term exposure may cause anemia, damage the pancreas, and decrease levels of high-density lipoprotein (HDL) cholesterol
  - May cause copper deficiency in humans
  - National Secondary Drinking Water Standard of 5 mg/L
Solid Drilling Waste: Environmental Concerns

Hydrocarbons
- Large family of several hundred chemical compounds
- Primarily made up of Hydrogen and Carbon atoms
- Generally measured as Total Petroleum Hydrocarbons (TPH)
- Health risks vary by compound and can affect the blood, immune system, lungs, skin, eyes, liver, and kidneys
- Environmental effects vary greatly depending on compound

Volatile Organic Compounds (VOCs)
- Emitted as gases from certain solids or liquids
- Include a variety of chemicals, some of which may have short- and long-term adverse health effects
- Eye, nose, and throat irritation; headaches, loss of coordination, nausea; damage to liver, kidney, and central nervous system
The Problem: What is solid drilling waste?

• The various types of solid drilling waste are classified according to the mud that was used to drill the well. There are three basic types of solid drilling waste:
  • Water-Based Mud and Cuttings
    – Fresh-water mud and cuttings (FWMC)
    – Salt-water mud and cuttings (SWMC)
  • Oil-Based Drilled Cuttings (OBC)
  • Synthetic Oil-Based Cuttings
### Characteristics of Different Types of Solid Drilling Waste from Various Fields*

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>FWMC**</th>
<th>FWMC***</th>
<th>SWMC</th>
<th>OBC</th>
</tr>
</thead>
<tbody>
<tr>
<td>pH (S.U.)</td>
<td>8.9</td>
<td>10</td>
<td>7.2</td>
<td>10.5</td>
</tr>
<tr>
<td>EC (mmhos/cm)</td>
<td>4.26</td>
<td>18</td>
<td>120,000</td>
<td>8.23</td>
</tr>
<tr>
<td>ESP (%)</td>
<td>1.3</td>
<td>61</td>
<td>Not Analyzed</td>
<td>2.23</td>
</tr>
<tr>
<td>TPH (mg/kg)</td>
<td>1570</td>
<td>114</td>
<td>61,000</td>
<td>156,000</td>
</tr>
<tr>
<td>Arsenic (mg/kg)</td>
<td>13.1</td>
<td>92.8</td>
<td>31</td>
<td>74</td>
</tr>
<tr>
<td>Barium (mg/kg)</td>
<td>5970</td>
<td>148</td>
<td>143</td>
<td>215</td>
</tr>
<tr>
<td>Cadmium (mg/kg)</td>
<td>0.343</td>
<td>0.511</td>
<td>0.342</td>
<td>1.22</td>
</tr>
<tr>
<td>Chromium (mg/kg)</td>
<td>30.9</td>
<td>72.6</td>
<td>27.6</td>
<td>15.5</td>
</tr>
<tr>
<td>Lead (mg/kg)</td>
<td>70.2</td>
<td>390</td>
<td>120</td>
<td>248</td>
</tr>
<tr>
<td>Mercury (mg/kg)</td>
<td>0.140</td>
<td>0.970</td>
<td>0.566</td>
<td>0.628</td>
</tr>
<tr>
<td>Selenium (mg/kg)</td>
<td>0.552</td>
<td>0.876</td>
<td>0.419</td>
<td>2.13</td>
</tr>
</tbody>
</table>

* This data is not intended to be considered an average of the specified analytes from the mud types.
** This FWMC was used on the top section of the hole through the fresh-water zone.
*** This FWMC was used during the entire hole depth.
How is solid drilling waste regulated?

• The U.S. enacted The Resource Conservation and Recovery Act (RCRA) in 1976
• RCRA was created to provide guidance for managing both hazardous and non-hazardous solid waste
• Most E&P wastes were exempted from being hazardous under RCRA
How is solid drilling waste regulated?

- The oil and gas industry must dispose of solid drilling waste in accordance with various laws and regulations of federal, state and local governments.
- Extreme variability in state laws.
- Need for producers to have consistent approach.
Example:
Comparison of Landspreading in Louisiana and Texas

### Louisiana

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Limitation</th>
</tr>
</thead>
<tbody>
<tr>
<td>pH</td>
<td>6-9</td>
</tr>
<tr>
<td>Arsenic</td>
<td>≤10 mg/kg</td>
</tr>
<tr>
<td>Barium&lt;sup&gt;A&lt;/sup&gt;</td>
<td>≤40,000 mg/kg</td>
</tr>
<tr>
<td>Cadmium</td>
<td>≤10 mg/kg</td>
</tr>
<tr>
<td>Chromium</td>
<td>≤500 mg/kg</td>
</tr>
<tr>
<td>Lead</td>
<td>≤500 mg/kg</td>
</tr>
<tr>
<td>Mercury</td>
<td>≤10 mg/kg</td>
</tr>
<tr>
<td>Selenium</td>
<td>≤10 mg/kg</td>
</tr>
<tr>
<td>Silver</td>
<td>≤200 mg/kg</td>
</tr>
<tr>
<td>Zinc</td>
<td>≤500 mg/kg</td>
</tr>
<tr>
<td>Oil and Grease</td>
<td>&lt;10,000 mg/kg</td>
</tr>
<tr>
<td>Electrical Conductivity&lt;sup&gt;A&lt;/sup&gt;</td>
<td>&lt;4 mmhos/cm</td>
</tr>
<tr>
<td>SAR&lt;sup&gt;A&lt;/sup&gt;</td>
<td>&lt;12</td>
</tr>
<tr>
<td>ESP&lt;sup&gt;A&lt;/sup&gt;</td>
<td>&lt;15%</td>
</tr>
</tbody>
</table>

<sup>A</sup> Upland Values

### Texas<sup>B</sup>

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Limitation</th>
</tr>
</thead>
<tbody>
<tr>
<td>pH</td>
<td>N/A</td>
</tr>
<tr>
<td>Arsenic</td>
<td>N/A</td>
</tr>
<tr>
<td>Barium</td>
<td>N/A</td>
</tr>
<tr>
<td>Cadmium</td>
<td>N/A</td>
</tr>
<tr>
<td>Chromium</td>
<td>N/A</td>
</tr>
<tr>
<td>Lead</td>
<td>N/A</td>
</tr>
<tr>
<td>Mercury</td>
<td>N/A</td>
</tr>
<tr>
<td>Selenium</td>
<td>N/A</td>
</tr>
<tr>
<td>Silver</td>
<td>N/A</td>
</tr>
<tr>
<td>Zinc</td>
<td>N/A</td>
</tr>
<tr>
<td>TPH</td>
<td>&lt;10,000 mg/kg</td>
</tr>
<tr>
<td>Electrical Conductivity</td>
<td>N/A</td>
</tr>
<tr>
<td>Chlorides</td>
<td>&lt;3,000 mg/l</td>
</tr>
</tbody>
</table>

<sup>B</sup> These values only apply to fresh-water mud and cuttings with less than 3,000 mg/l chlorides and landspread on the same lease and with landowner permission.
U.S. EPA Waste Hierarchy

• Most states with closure criteria primacy over E&P waste have adopted the Federal waste hierarchy
How is the waste managed?

Traditional Approaches

• Exploration & production operators:
  – Bury waste after partial treatment
  – Landspreading
  – Transport to commercial, centralized waste management facilities (most used in Pennsylvania)
  – Inject it into the annulus
Traditional Approaches: Burial

- **Pros**
  - Simplicity
  - Low cost
  - Limited surface area requirements
  - Most likely onsite, or nearby in pits

- **Cons**
  - Potential for waste to migrate and contaminate groundwater, resulting in liability
  - **Not a choice for wastes with high concentrations of oil, salt, metals and industrial chemicals without further treatment**
Traditional Approaches: Landspread

- Pros
  - Simplicity
  - Low cost
  - Potential to improve soil conditions
  - Naturally occurring microbes assimilate waste constituents in place

- Cons
  - Salts and metals cannot biodegrade
  - Potentially large land requirements
  - Soil may be damaged, depending on amount of high-molecular weight compounds
  - Extreme variability in contaminant levels in material
Traditional Approaches: Example of Variability

<table>
<thead>
<tr>
<th>Load</th>
<th>Pile A (mg/kg)</th>
<th>Pile B (mg/kg)</th>
<th>Pile C (mg/kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>12,400</td>
<td>17,700</td>
<td>20,800</td>
</tr>
<tr>
<td>2</td>
<td>13,600</td>
<td>14,000</td>
<td>22,700</td>
</tr>
<tr>
<td>3</td>
<td>14,500</td>
<td>20,700</td>
<td>18,600</td>
</tr>
<tr>
<td>4</td>
<td>8,620</td>
<td>20,900</td>
<td>16,600</td>
</tr>
<tr>
<td>5</td>
<td>15,900</td>
<td>39,600</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>10,700</td>
<td></td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>9,870</td>
<td></td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>13,800</td>
<td></td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>9,980</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Traditional Approaches: Haul to a Commercial Facility

– Pros
  • When a regulatory agency does not allow onsite disposal
  • When onsite techniques are problematic (e.g. in marshy, high water table environments)
  • For relatively small volumes of waste

– Cons
  • Less universal regulations
  • Large processing facilities could have impact on nearby populations or surrounding environment (including increased risks associated with airborne particulate emissions)
  • Drilling can be interrupted
  • Some states have few or no disposal sites (cost-prohibitive)
Traditional Approaches: Annular Injection

- Pros
  - Returns material to subsurface strata below underground source drinking water.
  - May be conducted during drilling – after annulus is available and reduces required storage capacity.
  - Provides adequate documentation of mechanical integrity, analytical data and process.
  - Does not require additional land.

- Cons
  - **Potential for groundwater contamination (no proof of disposal zone).**
  - Increased mechanical risk factors (during drilling).
  - **50/50 Failure (broach/bridge) Potential**
Cutting-Edge Solutions: Solidification/Stabilization

• Evidence-supported field technology used to treat contaminated sediment, sludge and soils

• Involves mixing contaminated solid waste materials with treatment reagents to cause physical or chemical changes that will reduce environmental impact
  
  • **Solidification**: encapsulates contaminants
  • **Stabilization**: adsorbs contaminants
The Benefits

Why solidification and stabilization technology?

• To meet and often exceed the requirements of state and federal E&P waste management laws
• Limits offsite movement of drilling waste - reduces environmental impact, including possibility of accidental spills and other liabilities
• Peace of mind in efficient control of the waste produced from unconventional drilling – it’s never mixed or commingled with another company’s waste
The Benefits

Why solidification and stabilization technology?

• Provides a mechanism for the recycling of solid drilling waste in the construction of roads, drilling pads, and other such structures, thereby reducing costs associated with construction materials

• Saves the industry money in areas with high disposal and construction costs (which are on the rise)

• Construction practices are verified on each job to specifications.
The Benefits

Why solidification and stabilization technology?

• Evidence-supported results
• Follows the waste hierarchy
Scott’s Process

1. Scott services and state closure criteria are discussed with the customer
2. Sample and test each well’s solid waste to determine the salts, metals, hydrocarbons, and geotechnical properties
3. Conduct bench-scale studies
4. Engineer the job
5. Provide a quote
6. Schedule the job following quote approval
7. Job execution and quality control
8. Post-job sampling and confirmatory testing
9. Report confirmatory testing to the customer and regulatory agencies
Recycling Services Offered by Scott

- **The Firmus® Process**
  - The recycling of solid drilling waste using stabilization and solidification technology to create new load-bearing structures on different areas than the waste was generated for lease roads, drilling pads, compressor stations, etc. The process is most effective when a customer has high disposal costs and high construction costs.

- **The Firmus® On-Site Process**
  - The recycling of solid drilling waste using stabilization and solidification technology to create load-bearing structures on the same location it was generated to be used for future drilling and/or to set frac tanks or other completion or workover equipment. The process is most cost effective when a customer has high disposal costs but few new drilling locations.
The Results

• S/S Process Option: Treat and Reuse for a Pad

Before: Reserve pit with oil-based cuttings

During construction: Mixing processed material and compacting
The Results

- S/S Process Option: Treat and Reuse for a Pad and Road

After: Solidified/Stabilized and recycled into a pad

After: Solidified/Stabilized and recycled into a road
In Conclusion

• We offer specialized, cost-effective solutions that reduce the oil and gas industry’s environmental footprint

• By applying these solutions to solid drilling waste management practices, we can optimize a company’s sustainability practices and its economic stability

• Technological, engineered approaches make sense
Thank you

Questions?

For more information:

www.scottenv.com

info@scottenv.com