Frac Sand Update

J.P. Morgan
Transportation and Logistics

Taylor Robinson
President, PLG Consulting
January 11, 2018
PLG Team

- Real-world, industry veterans
- Delivering value to over 200 clients since 2001
- Over 50 logistics, supply chain & engineering experts with operational leadership experience

Core Expertise

- Bulk commodity logistics
- Surface transportation – all modes
- Energy & chemical markets
- Private equity and corporate development

Services

- Frac sand supply chain design & operational improvement
- Diagnostic assessments & optimization
- Logistics infrastructure design
- Investment strategy, target identification, due diligence, post-transactional support
- Site selection
- Independent logistics technology assessment & implementation
- Hazmat training, auditing & risk assessment

Partial Client List
“Stable” Price / Rig Count Environment

WTI Oil price has been rangebound $40 to $60 for ~18 months

Onshore rig count has stabilized around 900 rigs over ~past four months
- ~60% of rigs are in TX, OK, NM

Implications for frac sand:
- Demand growth not driven by rigs, but other factors in place
- Tight frac sand capacity through early 2018
- Producers’ conservative, tight cashflow will remain – little room for sand price inflation
- Permian and SCOOP/STACK are the hot oil growth plays

Source: Infillthinking.com
Source: Energentgroup.com Nov 17, 2017
Increasing lateral lengths

- Nearly all producers continue to extend lateral length with similar or higher sand intensity
- Experimental wells extending well beyond 10,000 feet

More sand / lateral foot

- 2,000 lbs per foot becoming commonplace
- Experimental wells up to 5,000 lbs/foot
- Higher density drives more 100 mesh

Leads to more sand per well

- Sand volume is still different by play
- All plays continue to rise
- Note that last quarter always has some delayed reporting issues, so some lag in the Q2 volume

Source: Pioneer Natural Resources Investor Presentation – November 2017
Majority of industry still growing sand volumes and increasing efficiency

- Industry “darlings” are implementing latest version of higher intensity campaigns
- “Followers” are working hard on their generation of well completions, many with more sand intensive well designs
- A handful of producers talked about cutting back on sand volume during Q3 calls

100 mesh availability - a competitive advantage

- 100 mesh volume likely will overtake 40/70 in 2018 for volume
- 40/70 still key in many well completion designs
- 100 mesh growth trend enables regional sand growth
- Will regional sand production growth cause another increase in the percentage of 100 mesh downhole?

Devon Proppant per Well in Mid-Con

Source: Energentgroup.com

US Frac Sand Pumped Per Drilling Rig Year

Source: Infillthinking.com

By Grade

Source: U.S. Silica, August 2017
Frac Sand Supply Chain Overview

The Northern White supply chain is long and complex – Logistics makes up about 3/4 of the total delivered cost

<table>
<thead>
<tr>
<th>Stage</th>
<th>Costs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mining</td>
<td>Operating Costs = $10 - $30 / ton</td>
</tr>
<tr>
<td>Processing</td>
<td></td>
</tr>
<tr>
<td>Rail Load-out</td>
<td>Freight + Railcar Leases + Fuel Surcharges + Logistics = $30 - $60 / ton</td>
</tr>
<tr>
<td>Long Haul Rail</td>
<td>Transload Facility Fees = $7 - $20 / ton</td>
</tr>
<tr>
<td>Transloading and Storage</td>
<td></td>
</tr>
<tr>
<td>Trucking to Well</td>
<td>“Last Mile” Trucking Costs = $15 - $50 / ton</td>
</tr>
</tbody>
</table>

Northern White

| X | X | X | X | X | X |

Regional Sand

| X | X | ? | X |

Source: Headwaters MB research, PLG Consulting

Regional Sand is a game changer
Shale Operations Are Logistics-Intensive – Challenges Pushing Downstream

Each well drilled requires:

**Materials**
- **Proppants**
- **OCTG (Pipe)**
- **Chemicals**

**Railcars to Transloading**
- Avg - 55
- Largest - 240
- 5~8
- Avg – 65
- Up to 250 Railcars

**Trucks to Well Site**
- Avg – 220
- Largest - 960
- 20~32
- Avg – 260
- Up to 1,000 Truckloads

**Clean Water**
- From local reservoir / well
- ~300,000 barrels water / job **

**Waste Water**
- Initially 2 barrels of produced water per barrel of Crude increasing to 5 barrels on average
- Avg – 65
- Up to 250 Railcars

**Oil / Gas / NGLs**
- Pipeline, Truck, Rail
- Note: A majority of crude is still moved by truck for some distance at some plays
- Avg – 220
- Largest - 960
- 20~32
- Avg – 260
- Up to 1,000 Truckloads

* Example is for rail-delivered supply chain  ** Horizontal/Directional well average in last 6 months (Energent Group)
Emergence of Regional Sand

Regional sand growing share since 2014 downturn

Regional sand share expected to grow significantly in 2018 as Permian dune mines start

Source: EIA, US Geological Survey, Headwaters MB Research

Revised产沙量市场占比

2014 2016E

16% 34%

Regional Sands Northern White

Source: U.S. Silica December 2016
“Back of the envelope” math for Permian dune sand

Conservatively a $50 per ton logistics reduction (eliminating rail & transload)

Average well uses 5,500 tons of sand

$275,000 savings per well
Will Permian Dune Sand Be “Good Enough” For a Majority of Users and Applications?

<table>
<thead>
<tr>
<th>Permian Dune Sand</th>
<th>Texas Regional “Brown” or “Hickory” Sands</th>
<th>Northern White Sand</th>
</tr>
</thead>
<tbody>
<tr>
<td>Black Mountain</td>
<td>Unimin</td>
<td>Unimin</td>
</tr>
<tr>
<td>40/70</td>
<td>40/70</td>
<td>40/70</td>
</tr>
<tr>
<td>Winkler, TX</td>
<td>Brady, TX</td>
<td>Brady, TX</td>
</tr>
<tr>
<td></td>
<td>Texas Gold</td>
<td>Texas Gold</td>
</tr>
<tr>
<td></td>
<td>40/70</td>
<td>40/70</td>
</tr>
<tr>
<td></td>
<td>Premium Hickory</td>
<td>Premium Hickory</td>
</tr>
<tr>
<td></td>
<td>Unifrac</td>
<td>Unifrac</td>
</tr>
<tr>
<td></td>
<td>40/70</td>
<td>40/70</td>
</tr>
<tr>
<td></td>
<td>White</td>
<td>White</td>
</tr>
<tr>
<td></td>
<td>40/70</td>
<td>40/70</td>
</tr>
<tr>
<td></td>
<td>White</td>
<td>White</td>
</tr>
</tbody>
</table>

| K Value           | 7,000                                      | 8,000               |
| Sphericity        | 0.7                                        | 0.7                 |
| Roundness         | > 0.6                                      | > 0.6               |
| Turbidity         | < 100                                      | < 100               |
| Acid Solubility   | < 3.0%                                     | < 3.0%              |

Only limited volumes have been pumped since Hi-Crush started in July – initial production results only

Projected mix (on average) ~75% / 25% between 100 mesh (70/140) and 40/70

Unanswered questions:

- Will dune sand 40/70 be acceptable? Esp. for deep, high pressure Delaware wells….
- Will industry gravitate towards “West TX 100 mesh” (50/140) and not use the fine 40/70?
- Will E&Ps continue to “import” 40/70 from upper Midwest?
- Or will E&Ps shift towards an even higher share of 100 mesh due to cost advantage and success in high intensity applications?

**Burning industry question – What will be the dune sand share in the Permian a year from now?**

Source: Company websites, Headwaters MB research
Regional Sand Growth – Not Just the Permian…

Permian

SCOOP / STACK

Eagle Ford

Haynesville
Frac Sand Supply Chain Evolution

Shifting Supply Chain Responsibilities

E&Ps are taking a more active role in sourcing and managing the frac sand supply chain as frac sand cost becomes a larger share of the total well cost.

A variety of E&P sourcing models exist:

- **Traditional** - Utilize pressure pumper to source and deliver frac sand to their well site operations
- **Growing** – Self sourcing sand at mine or transload facilities and manages logistics providers with internal team
- **Exceptional** - Vertically-integrated supply chain with capability to source all pieces of the supply chain internally and externally

New Entrants / Offerings

Frac sand providers continue to grow in-basin sand sales volume

- Have built rail logistics capabilities over past several years
- Continue to build out their own transload facilities

Sand companies are increasing last-mile capabilities with numerous options including:

- U.S. Silica – pushing use of SandBox containers
- Hi Crush selling delivered sand to wellsite with PropX boxes (PropStream)
  - PropX also leases equipment and customer manages sand sourcing and trucking
- Arrows Up containers (owned by OmniTrax)
  - Delivered to wellsite option – can use any sand
- Other large sand companies managing last mile logistics for E&P via pneumatic trucks; sometimes utilizing portable silos

New sand mining companies in regional sand

Transloaders and other 3rd party logistics providers offering last-mile services
High Intensity Drilling Expanding

- Latest generation of high intensity can add 25-40% recovery per well

... Driving More Development with Finer Sand

- 100-mesh sold out/in short supply for foreseeable future
- Crush resistance not seen as important with finer sand

Increased Shale Oil Production Flattens/Shrink Oil Prices

- Sands nearby active basins will become the lowest delivered cost, displacing some current mines and transloading
- Trucking volume growth will drive innovation in storage solutions at well site

... Which Limits 2018+ Sand Volume Growth

Shale oil is a victim of its own success for a second time

... Enabling Regional Sand Market to Grow

- Increasing the Role of Trucking in the Supply Chain

... Growing Focus on Last Mile Logistics

BUT

Experience / Expertise / Excellence
Impacts to Frac Sand Last-Mile

- Sand Intensity Per Well
- Regional Sand Growth
- E&P Direct Sourcing Growth
- New Entrants Offering LM Solutions
- OSHA Silica Dust Mandate 6/18
- New Equipment Innovation
- Low Price Oil/Gas Environment
- Trucking Industry Challenges (Drivers, ELD)
New FMCSA Standards for Truck Driver Hours of Service Compliance

- Implementation mandated by December 18, 2017
- Requires use of an Electronic Logging Device (ELD) use by all commercial drivers who are required to prepare hours-of-service (HOS) records of duty status (RODS)
  - Exceptions are given to drivers in certain short-haul situations and also for drivers of vehicles manufactured before 2008
- Sets ELD performance and design standards
- Requires ELDs to be certified and registered with FMCSA
- Establishes what supporting documents drivers and carriers are required to keep

To-date implementations are already resulting in driver turnover, availability issues and increased driver compensation

Industry expects trend to continue at an accelerated rate
New OSHA Standards for Silica Sand Exposure

- Published on March 26, 2016
- Established a reduced Permissible Exposure Limit (PEL) for crystalline silica
  - 50 µg/m³ (micrograms per cubic meter of air)
- Requires employers to monitor crystalline silica exposure if workplace levels exceed 25 µg/m³ for at least 30 days in a year
  - Employers must provide medical monitoring to employees in those workplaces
- Employers involved in hydraulic fracturing must comply by **June 23, 2018**

OSHA = Occupational Safety and Health Administration - OSHA standards details are included in Appendix

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Industry is quickly implementing use of boxes and silos to comply with PEL standards

Sand King-type equipment is also being modified with additional dust-suppression features

Source: blowing.sucks
Permian Dune Sand Concerns & Challenges – Traffic Congestion, Driver Shortages

If Permian sand volume reaches 45M Tons/Year in 2018…

- 1,800,000 truckloads/yr sand (if all are pneumatic trucks)
- Requires over 1,500 truck fleet

National truck driver shortage expected to reach 50,000 at end of 2017

- West Texas is a low population area with few potential drivers

Source: Texas DOT

Note that not all dune sand mines are shown on the map

Source: Infillthinking.com, Baker Hughes, PLG analysis

Potential Impact/Concerns

Access:
- Limited routes in some areas
- Truck congestion at major intersections, in towns, and near high intensity well locations

Supply:
- Are there enough truck/trailers of the right configuration?
- Are there enough drivers?

Price:
- Inflation on trucking services expected

Legend
- Permian Shale Layers
- Active Permian Rig
- Sand Transload
- Existing Sand Mine
- Potential Sand Mine
- Frac Sand Truck Movement

Note that not all dune sand mines are shown on the map.
**Permian Dune Sand Concerns & Challenges – Sand Mining Challenges**

**Water availability for mines**

- Dune sand mines are mostly located in “very high risk” areas for water availability.
- Most dune sand mines are being designed with 85-90% water recycling capability, but a 3M ton per year plant that still requires ~400M gallons of fresh water annually.

**Dune Sagebrush Lizard (DSL)**

- Five (5) companies have been awarded a Certificate of Inclusion into the Texas Conservation Plan (“TCP”) for the DSL.

**Available Workforce**

- 1,500 mine workers likely needed in Kermit/Monahans area based on 14 mines coming online.
- Kermit county population 6,300 with an unemployment rate of 5.4%.
- Besides hiring challenges, retention will be a challenge.
<table>
<thead>
<tr>
<th>CHARACTERISTIC</th>
<th>ARROWS UP</th>
<th>SANDBOX</th>
<th>PROPX</th>
</tr>
</thead>
<tbody>
<tr>
<td>Box Weight (tons)</td>
<td>1.8</td>
<td>4.4</td>
<td>4.1 (two boxes moving on one truck)</td>
</tr>
<tr>
<td>Advertised Box Capacity (tons)</td>
<td>25.0</td>
<td>22.5</td>
<td>25.0 (two boxes moving on one truck)</td>
</tr>
<tr>
<td>“Real Life” Lading Weight per Load (tons) (*)</td>
<td>21.0 – 21.5 (up to 23.5)</td>
<td>up to 21.0</td>
<td>22.0 – 25.0</td>
</tr>
<tr>
<td>Truck Trailer Type</td>
<td>Flatbed / Drop Deck</td>
<td>Proprietary Drop Deck</td>
<td>Flatbed</td>
</tr>
<tr>
<td>Loaded Boxes per Trailer</td>
<td>1</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Conveyor at Wellsite</td>
<td>None</td>
<td>Proprietary “Cradle” (up to 4 boxes at a time)</td>
<td>Proprietary Conveyor System (“PropBeast”)</td>
</tr>
<tr>
<td>Risers at Wellsite</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Max Discharge Rate into Blender (tons/minute)</td>
<td>16.5</td>
<td>12.5</td>
<td>16.7</td>
</tr>
<tr>
<td>Ownership by Sand Co.</td>
<td>None</td>
<td>U.S. Silica – 100%</td>
<td>Hi Crush (“investor”)</td>
</tr>
<tr>
<td>Proprietary Use by Sand Co.</td>
<td>No</td>
<td>No (~)</td>
<td>No</td>
</tr>
<tr>
<td>Box Tracking</td>
<td>RFID/GPS-based with software</td>
<td>Q2 2018 – QR code-based tracking with software</td>
<td>QR code-based tracking with software</td>
</tr>
</tbody>
</table>

**Truckers have reported lading weights as low as 18 tons due to leaking boxes**

(*) Dependent on overweight permits, tractor weight
## Last Mile Equipment Solutions - Portable Silo Solution Characteristics/Specifications

<table>
<thead>
<tr>
<th>CHARACTERISTIC</th>
<th>PROPELL (Sandstorm)</th>
<th>SOLARIS</th>
<th>FB INDUSTRIES (Titan)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Silo Size (tons)</td>
<td>275</td>
<td>205</td>
<td>190, 280</td>
</tr>
<tr>
<td>Silo Configuration(s)</td>
<td>3-pack, 6-pack, custom</td>
<td>6-pack</td>
<td>6-pack</td>
</tr>
<tr>
<td>Truck Type</td>
<td>Pneumatic, Bottom Dump</td>
<td>Pneumatic (Bottom Dump under development)</td>
<td>Pneumatic, Bottom Dump (December 2017)</td>
</tr>
<tr>
<td>Conveyor Interface</td>
<td>Proprietary Conveyor System (&quot;VectorBelt&quot;)</td>
<td>Proprietary Conveyor System</td>
<td>Proprietary Conveyor System (&quot;Cobra&quot;)</td>
</tr>
<tr>
<td>Max Discharge Rate into Blender (tons/minute)</td>
<td>10.0</td>
<td>11.5</td>
<td>16.5</td>
</tr>
<tr>
<td>Sand Co. Relationship</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>Local Sand Management Software</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
</tbody>
</table>
### Last Mile Equipment Solutions – Best-In-Class Solution Comparisons

<table>
<thead>
<tr>
<th>Boxes</th>
<th>Silos</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ability to utilize low cost, flat bed truck -Can truck be further light-weighted?</td>
<td>Ability to utilize bottom dump trucks -Drive through unloading will eliminate backing in trucks at well site (big inefficiency)</td>
</tr>
<tr>
<td>Maximized loaded sand volume of 25k tons+ -Volume based on permitting allowances</td>
<td>Maximized loaded sand volume of 27k tons+ -Need ultra-light trailer and permitting allowances (where possible)</td>
</tr>
<tr>
<td>Minimal demurrage due to five min unload time</td>
<td>Minimal demurrage due to five to ten minute unload time</td>
</tr>
<tr>
<td>Capable software integration enabling real- time monitoring</td>
<td>Capable software integration enabling real- time monitoring</td>
</tr>
<tr>
<td>Ability to meet OSHA June 2018 requirements</td>
<td>Dust suppression on conveyor and into silo with the ability to meet OSHA June 2018 requirements</td>
</tr>
</tbody>
</table>

Trucking will become the biggest bottleneck and inflationary portion of the frac sand supply chain. Therefore, equipment/process improvements will focus to:

- Minimize truck cycle time
- Maximize volume per truck
- Minimize trucking rate
- Minimize demurrage
Will new entrants to last-mile services be successful in gaining market share?

Can/will box solutions gain share with high-intensity frackers?

Will bottom-dump solutions (including retro-fitted pneumatic trailers) become mainstream for silo solutions?

Are there further payload increases available through light-weighting tractors / trailers?

What will be the actual driver capacity lost from the implementation of the ELD mandate?

What will be the impact of the Permian dune sand traffic congestion in 2018+ after mines come online in first half of year? What will be done to improve the situation? Impact on road conditions and “who pays”? 
Summary

Frac sand industry has evolved rapidly this decade
- It has been a rollercoaster ride!
- Latest downturn was driven by oil price/rig activity crash
- Past year shows the challenges to ramp up – 100% volume growth in 2017 vs. 2016

Regional (actually “local”) sand is revolutionary
- More capacity needed and will eliminate costly logistics
- Challenges and barriers abound that could slow/limit growth
- Permian is the obvious hotbed, but other plays will also grow local sand use

Focus on last-mile will intensify in the coming year
- Regulatory issues are imminent and impactful
- Truck drivers will be the most precious resource in the supply chain
- Equipment innovation will continue with a focus on driving reduced cycle times
- Permian trucker shortage and congestion could become severe in second half of 2018

Frac sand is a competitive advantage (or disadvantage) for the O&G producers – and will continue to grow in importance in the future
Thank You!

For follow up questions and information, please contact:

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And thanks to our friends for their help:

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Headwaters MB