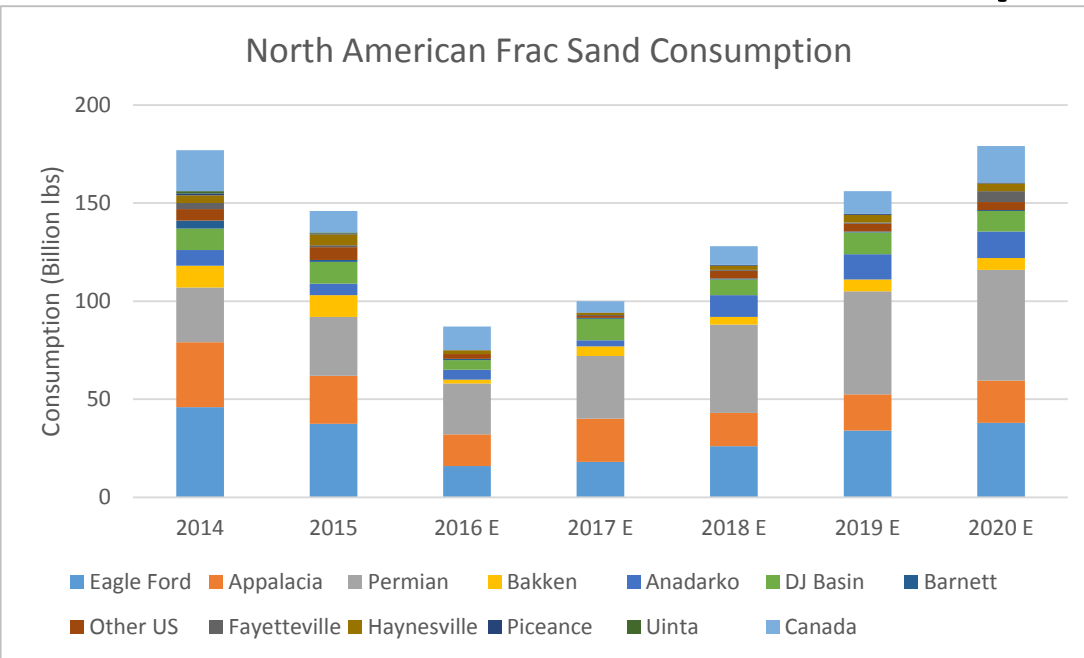


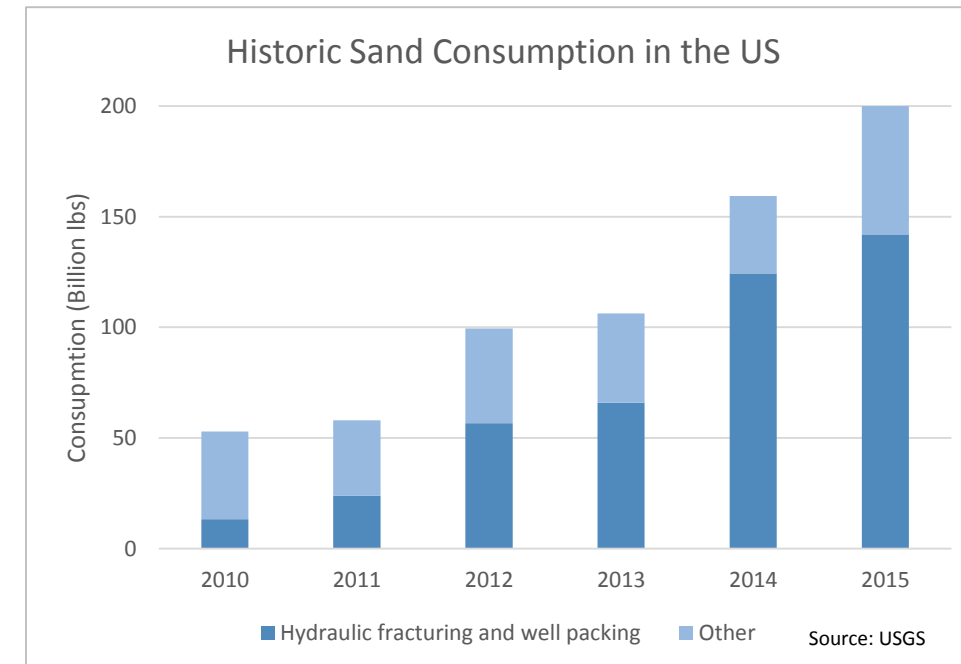
North American Frac Sand Consumption Will Grow with Drastic Shift in End Users



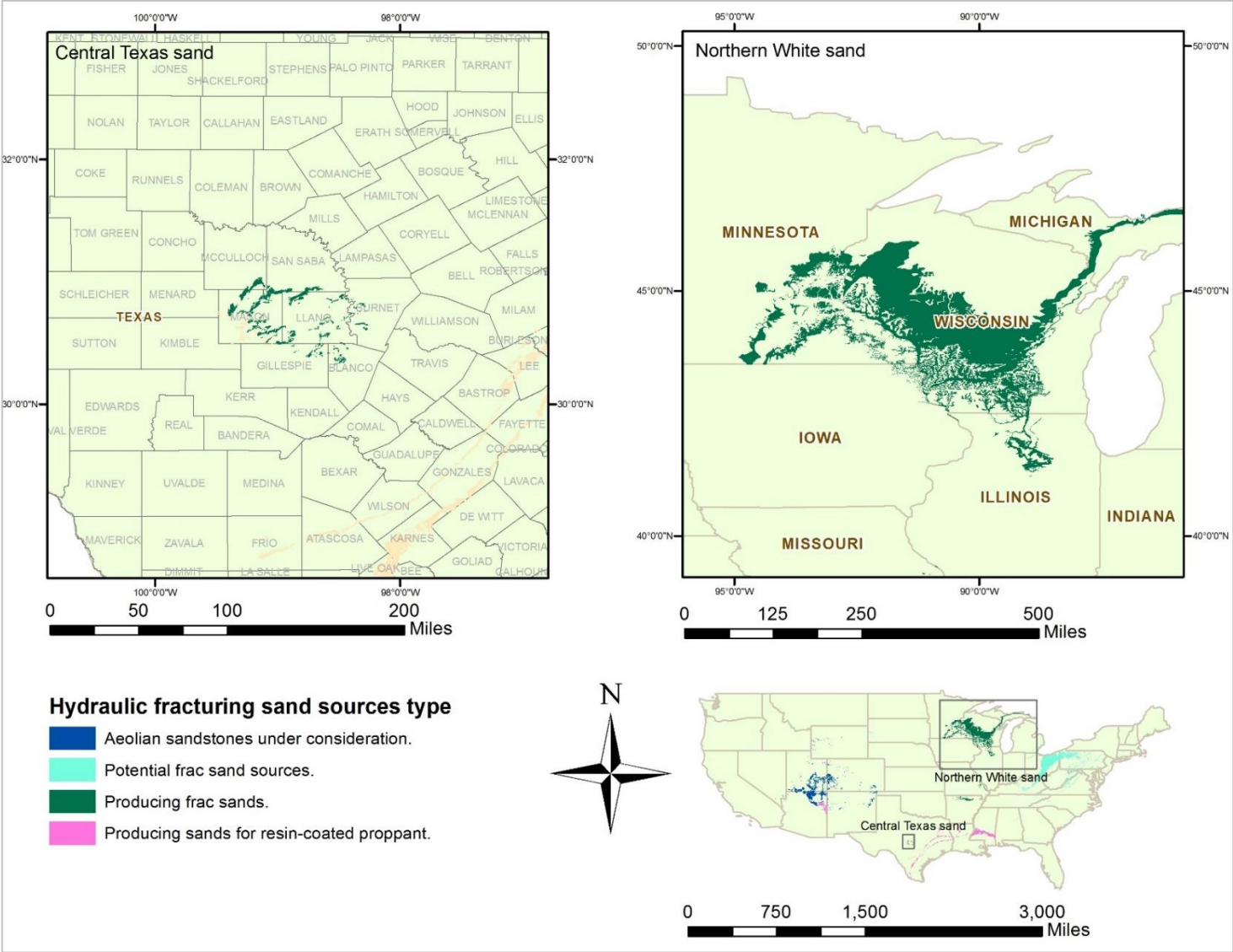
Source: IHS (5th Annual Frac Sand Supply & Logistics Conference, Sand Antonio TX, October 2016), USGS

- The U.S. is the world's largest sand producer, contributing almost 56% of the global sand production, 8 times the second largest producer, Italy.
- **Total sand production in the U.S. has quadrupled** since 2014.
- Oil and gas industry share grew from just 25% in 2014 to **more than 70%** in 2015; similar trend is expected in the future.
- Other major consumers are the glass and ceramics industry and the construction industry.
- The delivered price of sand has two main components: (1) mining and processing, and (2) transportation.

- Frac sand consumption declined the last two years **but will resume growth in 2017**, reaching the 2014 level near 2020.
- Due to a stark difference in the 2020 end destination compared to 2014, **even similar production levels will need new transportation infrastructure.**
- **Permian basin's share of total frac sand consumption will double** in 2020 from its 2014 level.
- Lack of transportation infrastructure will be a key bottleneck in fulfilling the region's hydraulic fracturing sand demand.



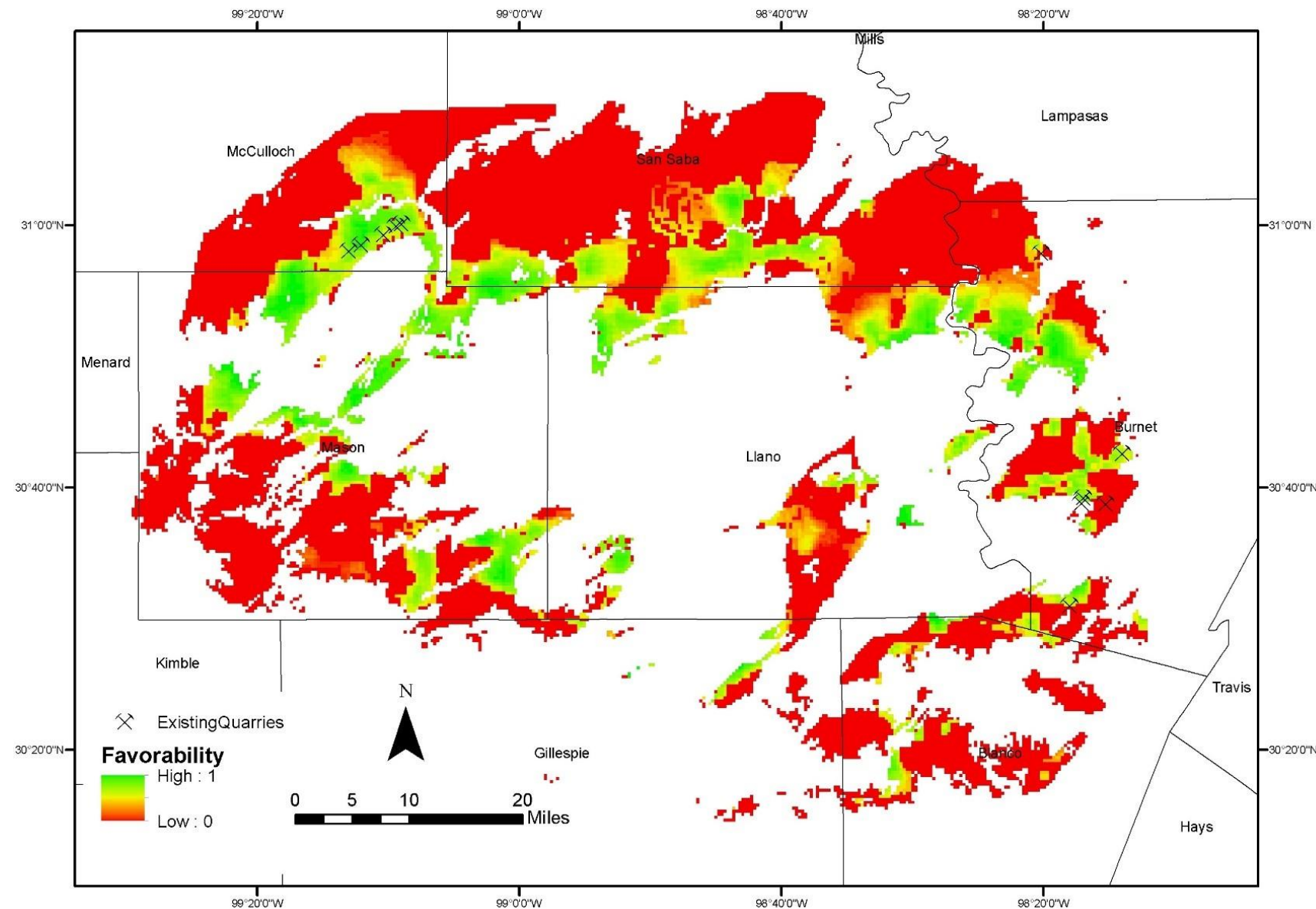
A Comparison of Brown Sand and Northern White Sand



- TX, WI, MN, IA and IL are the largest producers.
- Great Lakes region sand, commonly known as “Northern white”, has superior properties over TX “brown”, **but producers have actively secured and use TX brown.**
- Northern white sand travels **almost 10 times the distance** as compared to brown sand to reach hydraulic fracturing sites in TX.
- Average cost of mining Northern white is \$20-30 per ton; transportation cost **can exceed \$100 per ton** depending on the distance and mode.
- Transporting TX sand to the in-state hydraulic fracturing sites **costs less than \$50 per ton and as low as \$20 per ton** in some cases.

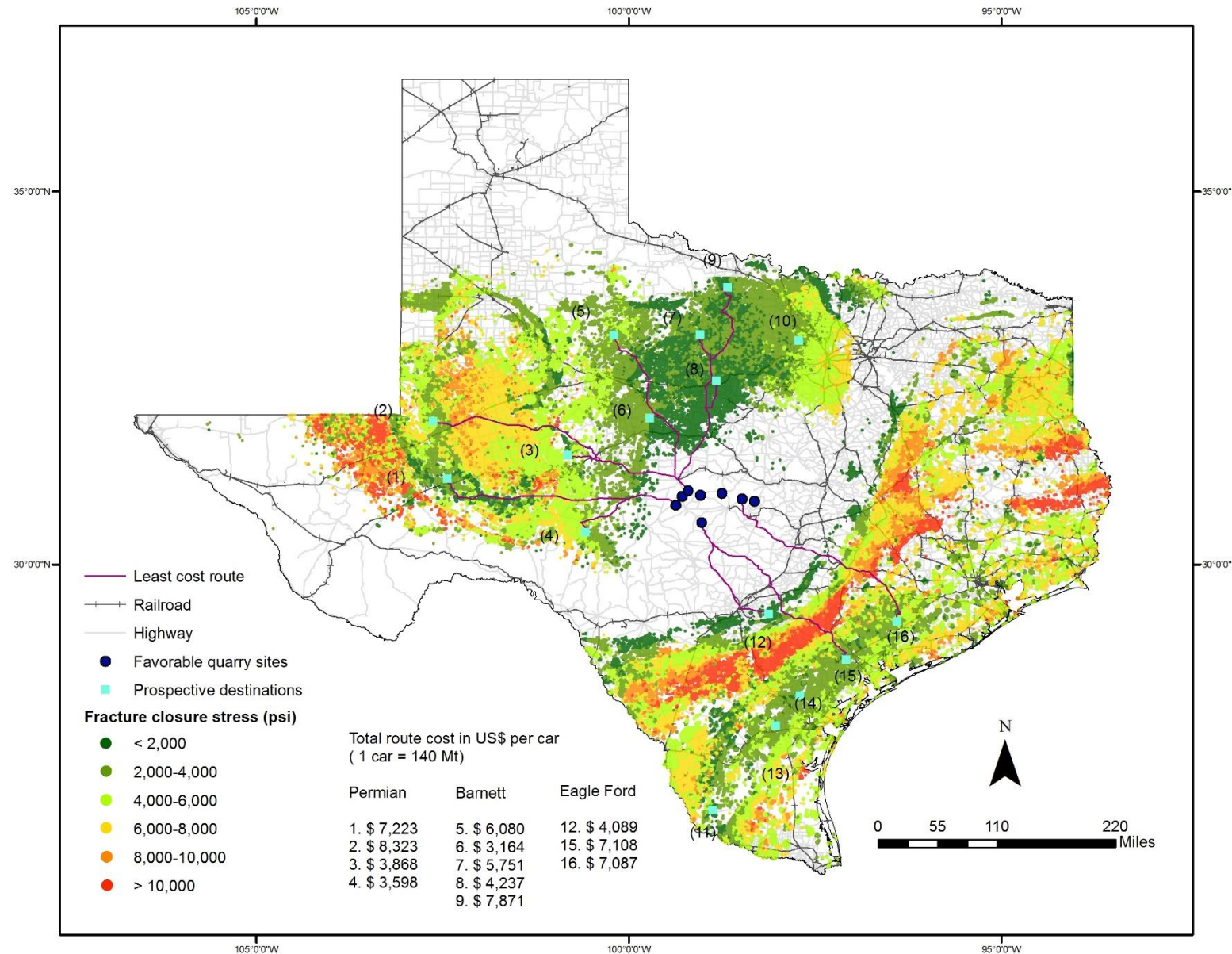
Typical Properties	ISO 103503-2
Turbidity (NTU)	≤250
Krumbein shape factors	
Roundness	≥0.6
Sphericity	≥0.6
Clusters (%)	≤1.0
Solubility in 12/3 HCl/HF for 0.5hr @ 150° F (weight loss %)	≤3.0

Frac Sand Resources in Central Texas Exceed 5 Billion Metric Tons



- Stratigraphic information from over 2,000 wells in Central Texas indicate **over 24 billion metric tons of sand resource untapped by any existing mining lease.**
- 20 billion metric tons has favorable properties like near surface access, close proximity to railways and highways, and safe distance from cities and water bodies.
- **Even a 25% yield for frac sand is equivalent to 5 billion metric tons of sand.**
- New prospective sites are in many cases located close to the existing quarries, areas with existing infrastructure to support new mines.
- Mason, McCulloch, Llano, and Burnet counties have the largest sand resource.

A Comparison of Brown Sand and Northern White Sand



- Brown sand has lower compressive strength, 4,000-8,000 psi, as compared to Northern white @ greater than 8,000 psi.
- Sites with low fracture closure stress are most suitable for TX brown.
- Wells in the Fort Worth basin may be most amenable followed by selective sites in the Permian and the Eagle Ford basin.
- Transportation analysis for 16 sites indicates highway (truck transport) is most preferred.
- Railways, being the cheaper mode of transport, can be used only in a few locations because of lack of infrastructure.
- Growing demand in the Permian basin will exert stress on the transportation industry, pushing the prices upwards.
- New trans-loading infrastructure and rail lines in the Permian basin will be crucial for hydraulic fracturing coming into the Permian basin from either Texas or other parts of the country.

A collaboration of BEG's Economic Minerals Program



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