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A supplement to

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Permian Basin: *The 2018 Playbook*

A supplement to *E&P and Oil and Gas Investor*

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Table of Contents

On the cover, hardy wildflowers blossom at a wellsite in Pecos County after a late March shower in the southern Delaware Basin. *(Photo by Mieko Mahi, courtesy of Hart Energy's* Oil and Gas Investor*)*

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The transaction comes days after Diamondback said it would add to its Northern Midland position with the purchase of Ajax Resources.
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PIONEER GEARS UP FOR MORE HIGH-INTENSITY PERMIAN COMPLETIONS

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4. Permian Sand Demand
5. Apache Prepares To Boost Production At Permian's Alpine High

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The Well Site Market Report

Hart Energy canvasses service providers, E&P companies and consultants for this benchmarking service that includes weekly updates and monthly overviews on the U.S. land oilfield services market, including the well stimulation, drilling, completions and well service/workover segments.

Emerging Plays: North Park Basin

The UG Center's Special Report on the North Park Basin provides an in-depth look at the petroleum-rich region spanning northwestern Colorado and southeastern Wyoming.

Drilling Highlights

This feature provides the latest results on wells in unconventional plays across the U.S.

Top IP Wells

UG Center features information on the wells with the top initial production rates in each unconventional play. Information includes flow rates, operators and location.

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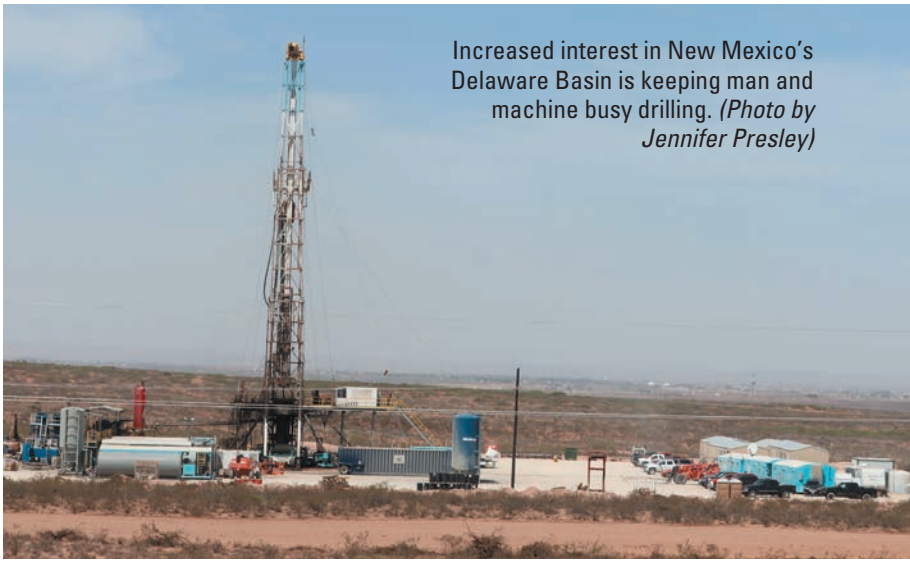


Increased interest in New Mexico's Delaware Basin is keeping man and machine busy drilling. *(Photo by Jennifer Presley)*

The Permian—**Wide Vistas** Ahead?

The industry is starting to feel the strain from the region's frantic rate of development.

By Rhonda Duey
Senior Editor, Exploration

Beneath the flat landscape of West Texas and eastern New Mexico lies one of the world's most prolific oil fields. While many locals joke that the region "isn't the end of the world, but you can see it from here," those in the oil and gas industry would beg to differ. Since the discovery of the Santa Rita #1 well in 1923, the Permian Basin has seen a boom-and-bust cycle spanning many decades. But there's no question it's in boom mode right now.

During a presentation given at the American Association of Petroleum Geologists annual meeting, Scott Sheffield addressed the "super basin" concept as it applies to the Permian Basin. Sheffield, currently chairman of the board of Pioneer Natural Resources, helped found that company 21 years ago. "We circled around the world thinking that the U.S. was dead, like a lot of CEOs," Sheffield said. "We came back to the Permian Basin about seven or eight years ago to find that that we had more than 10 billion barrels of resource potential."

Indeed. According to a recent IHS Markit report, production in the play is expected to continue to grow, and by 2023 this production could account for more than 60% of net global oil production.

Additionally, if it hits this production forecast, the play would exceed the production of every OPEC member except for Saudi Arabia, this in spite of well-publicized infrastructure bottlenecks.

The success stories continue to pile up. Devon Energy, for instance, recently spoke about its "monster wells" in the Delaware Basin at Hart Energy's DUG Permian conference in May. The company's second quarter earnings call indicated that 30-day IP rates in its Delaware Basin acreage averaged 3,000 boe/d, and John Raines, vice president of Devon's Delaware Basin business unit, told conference attendees, "I believe my team has brought on the third- and fourth-best Delaware wells Devon has ever put online." Added Dave Hager, president and CEO, in the company's first quarter earnings call, "This is not due to us opening the chokes up really wild to get a huge 24-hour IP. This is truly an exceptional area where we're seeing not only great wells with strong pressures. We can also anticipate the EURs in this area … to be two to three times what our normal type curve is out there. This is truly an outstanding area that we have discovered."

Endeavor Resources also has seen major success. Lance Robertson, COO and senior vice president of development, told the DUG crowd that it was faced with well productivity that was not competitive, but techniques such as optimizing landing points, zipper fracks and slick pipe drillout improved the average 30-day IP for a group of seven horizontal wells 43% in the first quarter of 2018. Robertson noted that these wells were among the fastest it had drilled because rock that is easily stimulated allows for faster ROPs. "We're happy with the results," he said. "[But] we recognize we still have more to do. We're just not finished yet."

Elevation Resources has recognized the importance of geology in the play. The company is seeing success in the Central Basin Platform in Andrews County, Texas. CEO Steve Pruett told DUG attendees that a combination of risk-taking by financial backers, creative ideas from the staff and a partnership with University Lands led to the discovery of a new play. But more work is needed.

"We need to transition from a science-based data collection effort to a manufacturing effort," he said.

Another success story is PT Petroleum LLC, which is having success in southwest Reagan County. Its Orange 6091C well produced more than 100,000 bbl of oil and 45 MMcf of gas during its first 140 days, CEO Cory Richards told conference attendees. "We believe that well will be transformational not only on the Trinity Project but for the entire southern Midland Basin," he said. "We believe it sets up a large-scale development opportunity."

Opportunities in the Permian Basin seem endless, but rapid development has strained local resources.

Constraints

Despite the oil and gas industry's ability to create boom towns where none previously existed, the fact is that the fervor showed by operators is outpacing the ability of the rest of the value chain to keep up. "We are a victim of our own success since we are developing bottlenecks in getting crude and natural gas out of the Permian Basin, and thus our differentials, in other words, what we get paid relative to the benchmarks, have widened," Pruett said.

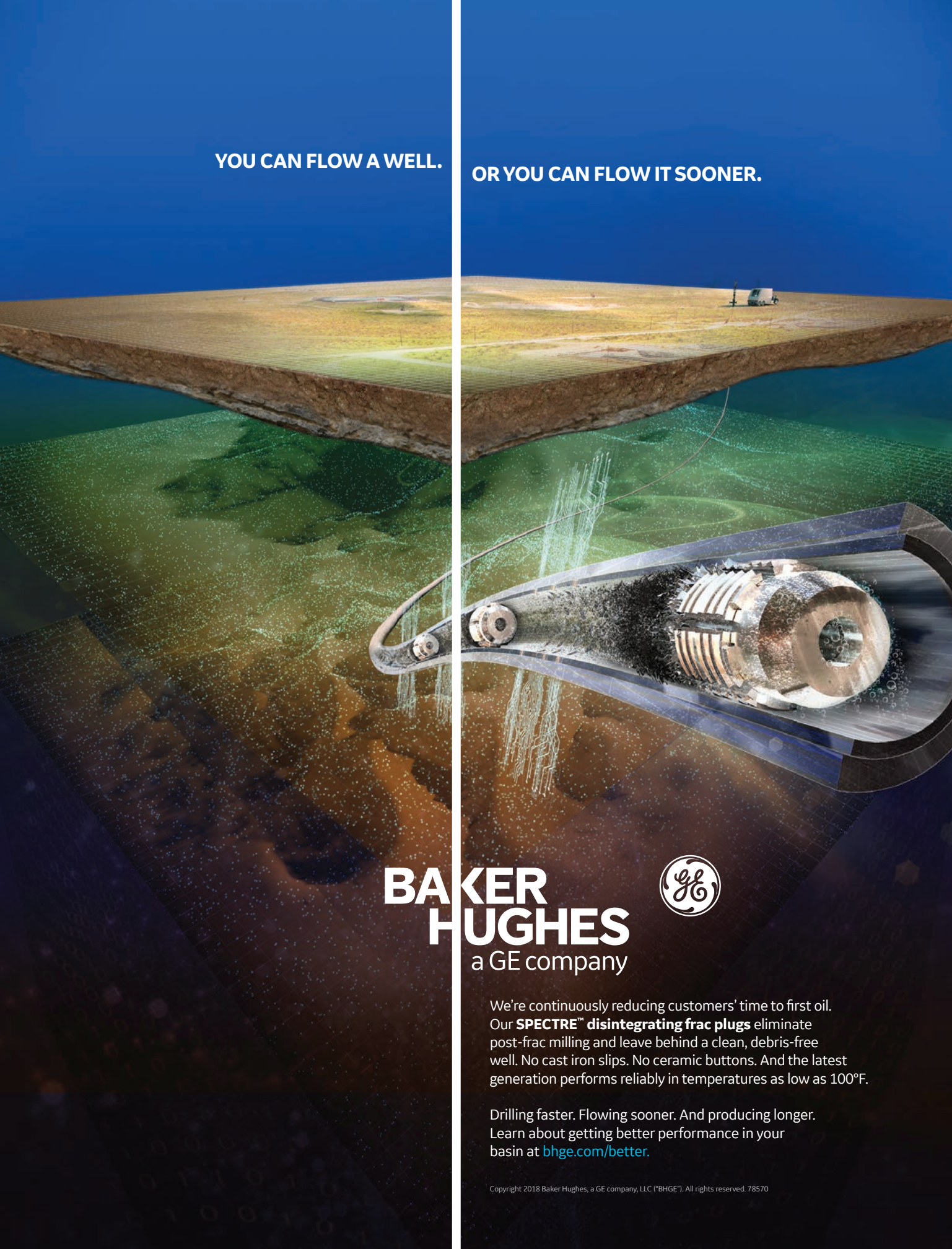
From takeaway capacity to labor, the region is struggling to capture the full value of its bountiful production. Pipeline capacity is a major concern. New pipeline projects are in the works, but for now it remains a challenging environment.

"There's no doubt that the oil and gas industry has hit its bottom and bounced back, with the Permian Basin leading the way," said Bernadette Johnson, vice president of market intelligence at DrillingInfo, in a recent release. "The Permian holds some of the best breakeven economics in the U.S., but not all leases and holdings are created equal. We also see takeaway capacity nearing its limits in the Permian, and constraints could have consequences for some. Some will thrive while others will barely survive."

According to a recent *Financial Times* article, Ryan Lance, CEO of ConocoPhillips, said his company was planning to redeploy assets out of the basin but that the move was only temporary. Lance noted that the current pipelines had filled up more quickly than expected.

"Production has come on quicker in the Permian Basin because the rigs were ramped up a lot faster than we would have thought maybe a year or a year and a half ago," he said.

Truck drivers, water, supplies and more are all in short supply in the Permian Basin due to the increased pace of development in the region. *(Photo by Jennifer Presley)*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In the IHS Markit report, Jim Burkhard, vice president for crude oil markets, said that the infrastructure challenges in the Permian Basin "illustrate a fundamental mismatch between upstream oil producers and midstream players. The former are focused on fast growth, while the latter require sustained high utilization of infrastructure over decades for projects to be viable."

One of the commodities hit hardest by the capacity challenge is natural gas. At Hart Energy's Midstream Texas conference in June, Bill Ordemann, executive vice president of Enterprise Products Partners LP, anticipated a serious problem moving gas if the infrastructure doesn't catch up quickly.

"The ball has got to get rolling on these gas pipelines because my biggest worry is that gas can strain some of the other production if we're not careful," he said.

Already this congestion is being felt on the NGL side, and meanwhile, despite being a world-class play, the Permian Basin has the lowest natural gas prices of any U.S. hub, Jake Fells, senior energy analyst at BTU Analytics, told Hart Energy. The 430-mile Gulf Coast Express, expected to come online in October 2019, will provide a much needed outlet. But it might not be enough.

"What's needed is infrastructure," Fells said. "The Gulf Coast Express is under construction, but even when that comes online we're going to need another pipeline right on its heels or else we're going to end up right back in the same situation in 2020."

Ironically, a report by McKinsey Energy Insights noted that the region could actually have too much pipeline capacity at some point. "While the fundamentals support additional pipelines (i.e. large quantities of new gas being produced), there is a real risk that the Permian will become over-piped in the medium to long term," the report noted. "As private equity looks to find the next major pipeline project, they will be increasingly drawn to projects linking the Permian to the demand centers in the U.S. Gulf Coast … Combining favorable fundamentals, minimal regulatory risk and private equity, there is a real risk that too much capacity will be developed in the long term."

Takeaway capacity is not the only issue impacting the region. Given the level of activity, labor shortages are bound to exist, particularly in this sparsely populated area.

In April the *Houston Chronicle* reported that data compiled by the Permian Basin Regional Planning Commission indicated a February 2018 unemployment rate of just 2.9%, well below state and national levels. While this sounds like good news, it also means that companies that rely on skilled labor might be coming up short. This is particularly true since many workers left the industry during the latest downturn.

One hard-hit area is truck drivers. An article on *EPmag.com* noted that Trip Rodgers, BP portfolio manager for BP Capital Fund Advisors, said that this labor shortage creates an additional bottleneck in addition to takeaway capacity since trucks are responsible for moving sand to wells and produced water away from them.

Additional issues include an aging workforce, a barrier of entry to younger workers due to commercial driver's license issues, drug testing and perceived health risks.

"People have extrapolated higher production growth," Rodgers said. "That's easy to do in an Excel spreadsheet. It's not as easy to do in the field."

Added Ryan Duman, principal analyst, U.S. Lower 48 Upstream Oil and Gas for Wood Mackenzie, "Managing costs going forward is going to be critical. As the rig count continues to accelerate, more operators are resorting to spot pricing or getting in on the lower end of deals. This pushes the cost up, and labor and trucking are two huge factors. The sheer number of trucks and drivers needed is unprecedented."

Then there is the issue of sand. Hydraulic fracturing requires vast amounts of sand, and while anyone who has visited the Permian Basin might wonder how there could possibly be a regional sand shortage, it's the quality that matters.

"The two major types of sand are the high-quality Northern White, which is more expensive, and the in-basin sand," Duman said. "The in-basin sand is cheaper because of the transportation issues, but it can be lower quality. But some operators are relaxing their standards." While a lower quality

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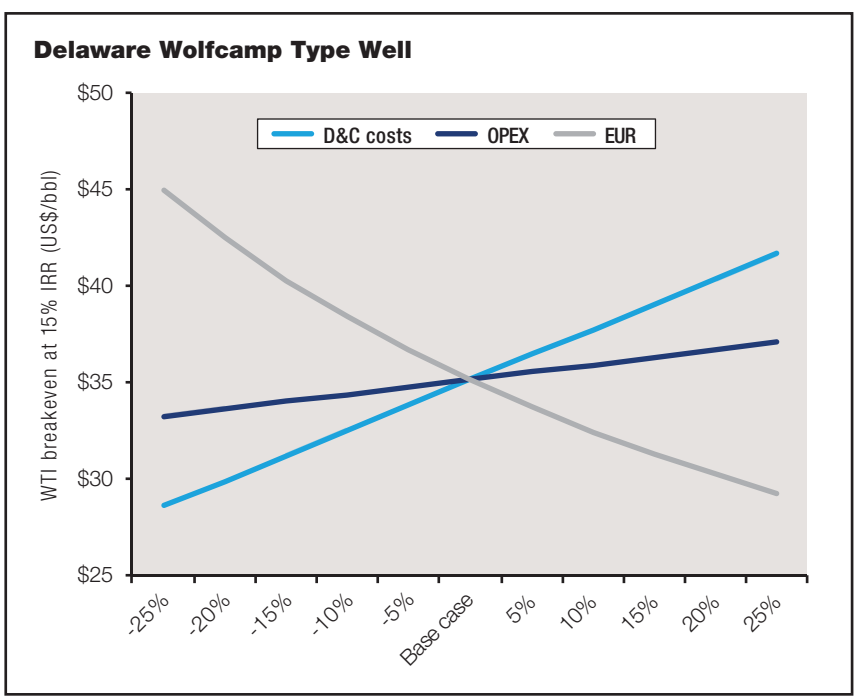
sand might result in a satisfactory frack job, he explained, over time the overburden pressure could disintegrate the sand.

But the basin's own proclivity for odd geology might be helping to solve this problem. A recent article in *Oil and Gas Investor* discussed the Kermit Sand Dune northwest of Odessa. The area has long been used for recreation, kind of the beach without the ocean, but it's now being eyed as a potential source of frack sand.



This chart shows breakevens for a Delaware Wolfcamp well with sensitivities around drilling and completion costs, opex and EUR. *(Source: Wood Mackenzie)*

"Multiple entrepreneurs were jockeying to be first to get a piece of the dune, which proved to hold finer grades of sand more suitable for downhole stimulation," the article noted, adding that since 2016 20 new mines are in place or planned.

They will be needed. Richard Spears, vice president of Spears & Associates Inc., told the magazine that the volume of drilling activity combined with lateral lengths and the amount of sand needed per linear foot of lateral has caused the demand for sand to skyrocket. "It's the fastest growing market in the entire oil field," he said.

Water is another issue plaguing the region. The continual ramp-up of activity means that operators are facing growing difficulties disposing of their frack water. A Wood Mackenzie report noted that the water-to-oil ratio in the Delaware Basin is as high as 10 to one. In the Wolfcamp play alone, producers use nearly 17 million gallons of water per well, a 50% increase over 2015. And water costs will continue to rise, amounting to 20% of drilling costs and affecting overall play economics.

Finally, there's the question of decline rates. While vertical wells in the region have been producing for years, noted another Wood Mackenzie study, the horizontal tight-oil wells are relatively young, and there's no guarantee of their longevity.

"Pure field data for horizontal tight-oil wells only goes back about eight years," the report noted. "Consequently, operators and investors have routinely used proxy values based on decades-old data from vertical wells and other shale plays to model tight-oil terminal decline rates."

The study noted that after five years of production the most active Wolfcamp plays have annual decline rates almost double the value that is typically used. This is likely to result in 800,000 bbl/d of production at risk by 2040.

Too much of a good thing? That remains to be seen. The Permian Basin has certainly proven its longevity over the decades. But perhaps a slower, steadier pace might be in the industry's best interest at some point. ■

Editor's Note: For a complete analysis of the Permian Basin see the Production Forecast by Stratas Advisors on page 70.

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Permian Players Picking Up **Production Pace**

These top 20 Permian operators are leading the way in one of North America's largest basins.

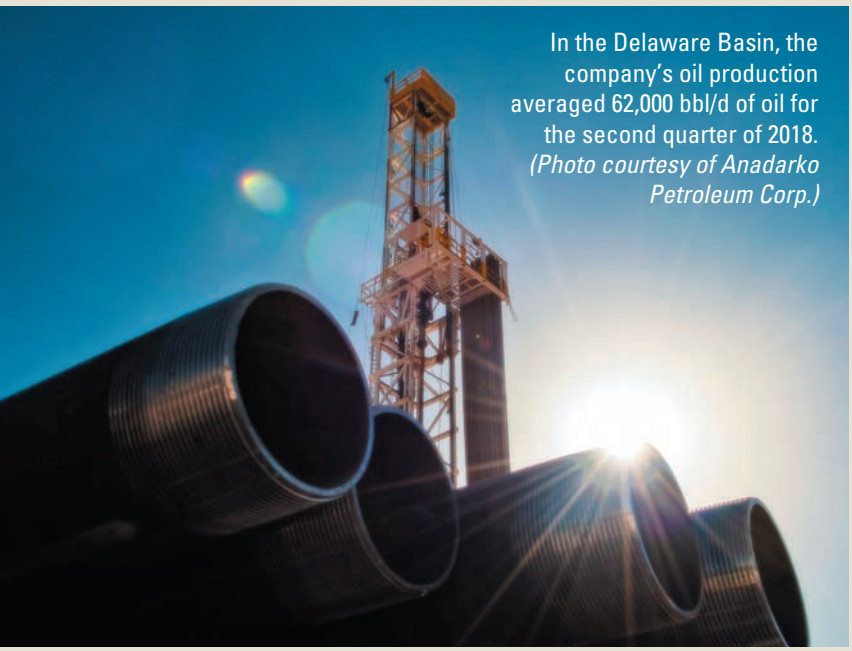
By Ariana Hurtado
Associate Managing Editor

The Permian Basin covers 75,000 sq miles over West Texas and southeast New Mexico and is the most prolific oil-producing basin in the country.

"During the last three years, companies operating in the Permian Basin have drilled much longer laterals and used substantially more complex well completion design in their newer wells with the aim of reaching higher initial production rates," according to a June 25 GlobalData news release. "Well lateral lengths in the Permian have increased on average by more than 1,500 ft since 2016 to approximately 7,500 ft by the end of 2017. An analysis of recent wells for 26 operators in the Permian Basin indicates a breakeven oil price range from $21 to $48 per barrel with lateral lengths ranging from 4,500 ft to 10,500 ft."

In the following section, Hart Energy profiles some of the most active operators in the Permian Basin.

Key Players



In the Delaware Basin, the company's oil production averaged 62,000 bbl/d of oil for the second quarter of 2018. *(Photo courtesy of Anadarko Petroleum Corp.)*

Anadarko Petroleum Corp.

Anadarko has been active in West Texas for more than 30 years and has estimated recoverable resources at more than 4 Bboe in the Delaware Basin, according to the company's website. Anadarko's Delaware Basin positions include nearly 600,000 gross acres and 8,500 ft of stacked oil potential, according to the company's Texas fact sheet.

"In 2017 and through the first half of 2018, Anadarko continued to advance several foundational components of the Delaware Basin value chain, securing locally sourced sand, increasing basin takeaway capacity and making significant progress on an extensive infrastructure backbone to facilitate future growth," the company said.

In the Delaware Basin, the company's oil production averaged 62,000 bbl/d of oil for the second

quarter of 2018, representing an 88% increase over the second quarter of 2017, according to Anadarko's second-quarter 2018 operations report.

"The [second] quarter was highlighted by the successful startup of the Reeves ROTF [regional oil treating facility], the commissioning of its North Loving ROTF, as well as a record number of wells turned to sales," the report stated. "The company also advanced its first full pad development at the Silvertip-A location in Loving County, where it had completed 12 extended-reach lateral wells targeting multiple intervals in the Wolfcamp-A Formation. These wells are expected to begin producing in the second half of 2018 and will flow to the North Loving ROTF."

Apache Corp.

Apache has more than 2.8 million gross acres in the Permian Basin. Estimated proved reserves of 681 MMboe at year-end 2017 represented 58% of the company's worldwide reserves, according to the company's website. In 2017 Apache averaged 16 rigs and drilled or participated in 215 wells in the Permian; 158 were horizontal with a 97% success rate, the company said.

Second-quarter 2018 operational production highlights for the Permian included 89,928 bbl/d of oil, 134,621 bbl/d of total liquids and 403,267 Mcf/d of natural gas, according to the company's website. Additionally, the company also reported 201,832 boe/d in the second quarter.

"Apache plans to continue an elevated level of activity in the Permian region during 2018, while continuing to balance capital investments between its larger development project at Alpine High and focused exploration and development programs on other core assets in its Permian region," the company stated on its website.

This year the company expects to average about 14 drilling rigs in the Permian, which includes six to seven rigs at Alpine High focused on a combination of retention, development and delineation drilling. Approximately $1.6 billion (about two-thirds) of Apache's 2018 capital upstream budget will be allocated to the Permian region, according to the company.

Centennial Resource Development

Centennial Resource Development is an independent oil producer with about 80,100 net acres (90% operated) and 2,400 drilling locations (about 60% oil) in the Delaware Basin.

Average daily crude oil production increased 79% in the second quarter and 125% for the first half of 2018 compared to prior year periods, according to the company's second-quarter 2018 results press release.

The Red Rock A Unit T09H and U04H wells were drilled using a stacked, staggered pattern in the Third Bone Spring Sand and Upper Wolfcamp A intervals, respectively, with effective 10,900-ft laterals, according to the report. The T09H achieved a 30-day IP rate of 1,578 boe/d, with 1,143 bbl/d of oil, and the U04H reported a 30-day IP rate of 1,268 boe/d, with 940 bbl/d of oil.

In addition, the CWI Long A U31H, B U40H and C U49H wells were drilled in the Upper Wolfcamp A interval with about 9,850-ft laterals, the report stated. These wells achieved 30-day IP rates of 2,158 boe/d (78% oil), 2,899 boe/d (78% oil) and 2,278 boe/d (78% oil), respectively. The three-well pad delivered an average 30-day oil IP rate of 194 bbl/d per 1,000 ft of lateral per well.

The company's Miramar acreage, the Ninja 4-50 49 2H, 3H, 4H and 5H wells, were drilled on a four-well pad targeting the Lower Wolfcamp A, Upper Wolfcamp A, Wolfcamp C and Upper Wolfcamp A intervals, respectively. Drilled with an average extended lateral length of 9,800 ft, the wells delivered an average 30-day IP rate of 1,878 boe/d (58% oil) per well. During its 60-day IP period, the pad produced more than 225,000 bbl of oil, the report stated.

Moreover, targeting the Upper Wolfcamp A zone, the Balmorhea State G 8H, H 9H and I 10H wells were drilled with average 6,150-ft effective laterals. Each well began production at an average 30-day IP rate of 1,337 boe/d (77% oil) per well, or 166 bbl/d of oil per 1,000 ft of lateral, according to the report.

Chevron Corp.

Chevron is among the largest producers of oil and natural gas in the Permian Basin, and with about

Chevron builds well pads from which it can drill multiple wells. *(Photo courtesy of Chevron)*

2.2 million net acres, it is also one of the basin's largest net acreage holders. The company reported Permian production of 119,000 net bbl (Chevron share) of crude oil, 383 MMcf of natural gas and 45,000 bbl of NGL daily in 2017, according to Chevron's website.

As of July, the company was running 19 rigs in the Permian and had eight development areas underway across the Permian in the Delaware and Midland sub-basins, according to a Natural Gas Intelligence article.

Net production of 739,000 boe/d in the company's U.S. upstream operations in the second quarter of 2018 was up 38,000 bbl/d from a year earlier, according to Chevron's second-quarter 2018 results report. "Production increases from shale and tight properties in the Permian Basin in Texas and New Mexico were partially offset by the impact of asset sales of 54,000 barrels per day," the report stated.

In addition, Chevron's "cash flow continues to increase with the powerful combination of expanding upstream margins and volumes," Chairman and CEO Michael Wirth said in the company's first-quarter 2018 results press release. "Oil and gas production is increasing, most notably in our Gorgon and Wheatstone LNG projects in Australia, and our shale developments in the Permian Basin where production grew 65% from a year ago."

Cimarex Energy Co.

Cimarex Energy Co. is an independent oil and gas E&P company. The Permian Basin accounted for 48% of the company's year-end 2017 proved reserves and 55% of total production, and the Permian is expected to contribute about 55% to 60% of total 2018 production, according to Cimarex's website. In 2017 the company drilled and completed 55 net wells and reported production results of 218 MMcf/d of gas, 44,600 bbl/d of oil and 24,300 bbl/d of NGL.

Cimarex invested $375 million in exploration and development during the second quarter of 2018, 59% of which was devoted to the Permian Basin, according to the company's second-quarter 2018 results report.

Production from the Permian region averaged 121,744 boe/d and oil volumes averaged 48,797 bbl/d in the second quarter. Cimarex brought 49 gross (22 net) wells on production during the first half of 2018, and the company completed 32 gross (13 net) wells during the second quarter, according to the report. As of June 30, there were 45 gross (32 net) wells waiting on completion and Cimarex was operating 10 drilling rigs and five completion crews in the region.

Concho Resources

Concho Resources operations are focused in the Permian Basin of southeast New Mexico and West

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Concho Resources is the largest unconventional shale producer in the Permian Basin, with operations focused on acquiring, exploring, developing and producing oil and natural gas resources. *(Photo courtesy of Concho Resources)*

Texas and boasts it is a top 12 producer of oil in Texas. The company has approximately 260,000 gross acres in the Midland Basin, 380,000 gross acres in the Northern Delaware Basin, 130,000 gross acres in the New Mexico Shelf and 160,000 gross acres in the Southern Delaware Basin, according to the company's website.

In July Concho completed its acquisition of RSP Permian Inc.

Concho's Permian production for the second quarter of 2018 was 21 MMboe, an increase of about 24% from the second quarter of 2017, according to the company's second-quarter 2018 results report. Average crude oil production for the second quarter totaled 143,000 bbl/d, an increase of about 26% from the second quarter of 2017. Natural gas production for the second quarter totaled 515 MMcf/d, the report stated. During the second quarter, Concho averaged 21 rigs.

Following the closing of the RSP transaction, Concho is running 32 horizontal rigs, including 16 rigs in the Northern Delaware Basin, six rigs in the Southern Delaware Basin, nine rigs in the Midland Basin and one in the New Mexico Shelf, according to the report. Additionally, Concho was utilizing 10 completion crews as of Aug. 1.

Devon Energy Corp.

Devon Energy Corp. has operations in the Delaware Basin of West Texas and southeast New Mexico with 670,000 net acres. Devon's current focus is in the oil-rich Bone Spring, Leonard Shale, Wolfcamp and Delaware Sands formations.

In 2017 the company reported production of 56,000 boe/d (73% liquids) and 184 MMboe reserves in the Delaware Basin, according to Devon's website.

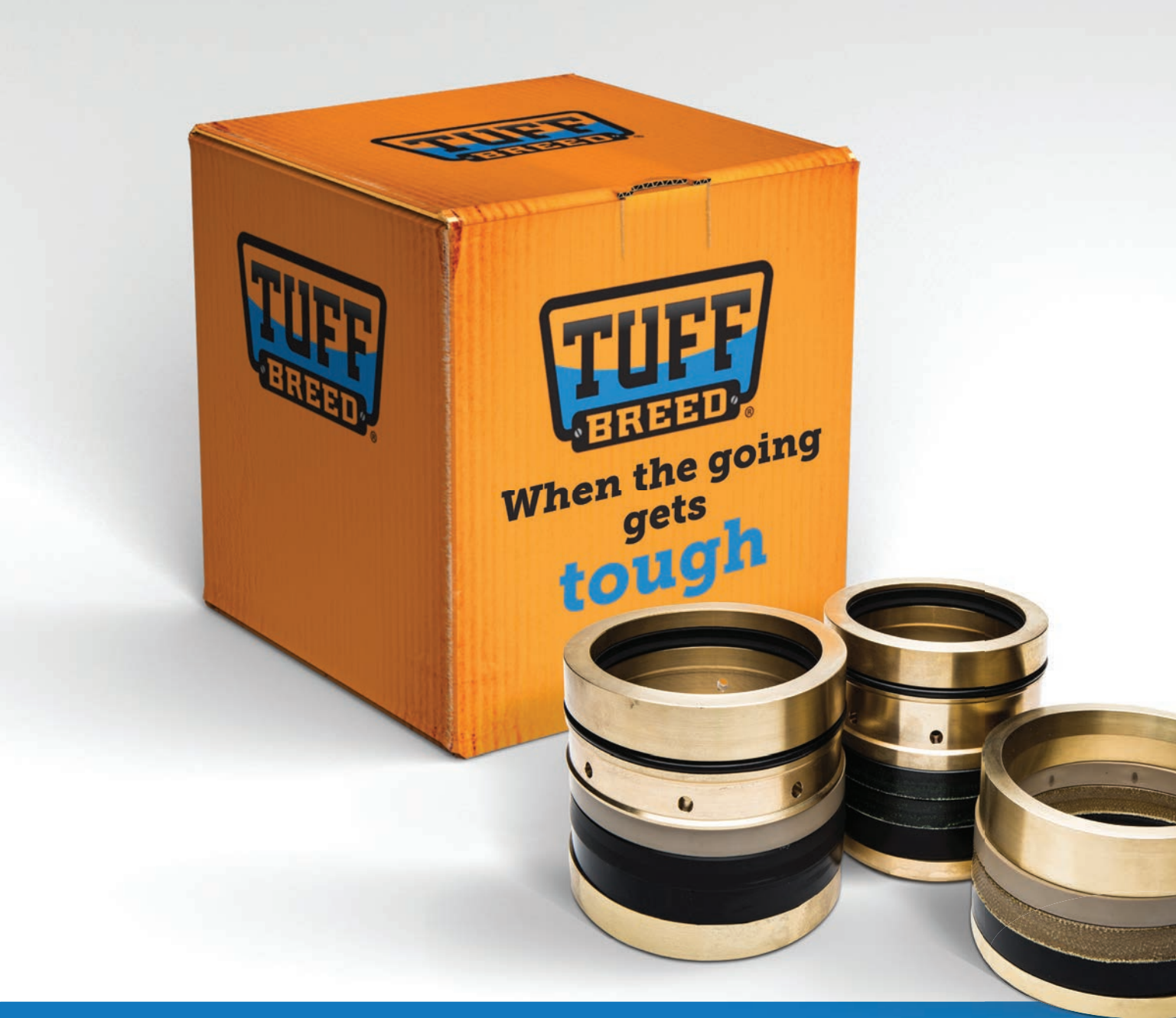
In the second quarter of 2018, "light oil production increased 54% year-over-year in the quarter, driving total volumes in the Delaware to 79,000 boe/d. Growth in the Delaware was driven by prolific well productivity, where the top 10 wells in the quarter averaged initial 30-day rates of about 3,000 boe/d," according to the company's second-quarter 2018 results report.

In the third quarter Devon entered into a definitive agreement to sell 9,600 net acres of noncore Delaware Basin acreage in Ward and Reeves counties to Carrizo Oil & Gas for $215 million, according to an August press release. Net production from these properties is approximately 2,500 boe/d (60% oil). The transaction is expected to close in the fourth quarter of 2018.

Diamondback Energy Inc.

Diamondback Energy Inc. solely operates in the Permian Basin with about 230,000 pro forma net acres (211,000 net surface acres) and about 4,700 gross locations, according to an August investor presentation.

For the second quarter of 2018, Diamondback reported production of 112,600 boe/d (73% oil) and operated 11 drilling rigs and five dedicated fracturing spreads, according to the company's second-quarter 2018 results report.



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A pumpjack and Diamondback rig are seen just west of the city of Midland. *(Photo courtesy of Diamondback Energy)*

For full-year 2018 the company expects to complete 170 to 190 gross horizontal wells with an average lateral length of about 9,300 ft, according to the investor presentation.

In August Diamondback announced two major Permian acquisitions. It will acquire Ajax Resources LLC for about $1.2 billion. The Ajax acquisition is expected to close at the end of October and will have an effective date of July 1, a press release stated. The Ajax acquisition will comprise 25,493 net leasehold acres in the Northern Midland Basin, including about 21,000 net acres in northwest Martin and northeast Andrews counties (about 89% HBP).

In addition, Diamondback plans to acquire Energen Corp. in an all-stock transaction valued at about $9.2 billion. The transaction is expected to be completed by year-end 2018, according to a company press release.

Encana Corp.

Encana Corp.'s Permian production was up 43% year-over-year with current production of more than 90,000 boe/d, according to the company's second-quarter 2018 results.

Encana brought three cubes onto production in the Midland and Martin counties in the second quarter. Four wells in the Jo Mill bench of Martin County are exceeding type curve with average 30-day IP rates of 1,100 bbl/d of oil, according to the report.

Four rigs operate on Encana's RAB Davidson pad cube development in Midland County, Texas. *(Photo courtesy of Encana)*

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"Encana's cube development approach combined with advanced completion practices significantly enhanced its Permian well performance and led to a 20% increase in the company's Permian type curves and 700 new premium return locations," the company said in a June 2017 press release. The 700 new premium return locations were five times the quantity the company drilled in 2017 and brought total premium return locations in the play to 3,450. "Encana expects it will develop less than 30% of its Permian premium inventory through 2021," the release stated.

Endeavor Energy Resources

Private E&P company Endeavor Energy Resources holds the second largest land position in the Midland Basin with more than 300,000 net acres. Its focus is on Martin, Midland, Glasscock, Upton and Reagan counties.

Production for the second quarter of 2018 was a company record 5.9 MMboe, according to the company.

Endeavor placed 41 gross wells on production and spudded 36 gross horizontal wells in the second quarter. The company also reported that average 30-day IP rates for the completed horizontal wells in this quarter were approximately 920 boe/d (88% oil).

EOG Resources

EOG Resources has a 416,000-net-acre position in the Delaware Basin.

"EOG has identified an additional 375 net undrilled premium locations in the Delaware Basin, raising the total to 4,815 locations and more than replacing the 250 locations drilled since the last premium inventory assessment in 2017," the company stated in its second-quarter 2018 results press release. "Cost reductions from infrastructure investments and the delineation of additional drilling targets supported the identification of the new premium locations."

During the second quarter of 2018, EOG continued development in the Delaware Basin with ongoing testing of additional targets and spacing. "Lateral lengths increased farther during the quarter, and the company increased its use of locally sourced sand beginning in June," the company stated in the report. Operations also commenced at additional locations on EOG's new crude oil gathering system commissioned earlier in 2018."

In the Delaware Basin Wolfcamp, EOG completed the Quanah Parker 8H-11H four-well package, and average 30-day IP rates per well of 2,565 boe/d, or 1,535 bbl/d of oil, 525 bbl/d of NGL and 3.0 MMcf/d of natural gas, according to the report. In the Delaware Basin Second Bone Spring, EOG completed the Bandit 29 State Com 501H-503H and 504Y four-well package with average 30-day IP rates per well of 2,410 boe/d, or 2,035 bbl/d of oil, 170 bbl/d of NGL and 1.3 MMcf/d of natural gas.

Looking ahead, "EOG said completions at its Delaware operations in the Permian will fall to 30% of total work in the second half of the year from 40% in the first half," according to an Aug. 3 Reuters report.

EP Energy

EP Energy's Permian focus is on the Wolfcamp Shale with about 178,000 net acres and 2,682 gross drilling locations as of year-end 2016. The company had $91 million in oil and gas expenditures and 0.6 average gross drilling rigs in the Permian in the first half of the year, according to the company's second-quarter 2018 results report.

During the second quarter in the Permian, EP Energy produced 26,500 boe/d, including 9,700 bbl/d of oil, averaged approximately one drilling rig, invested $48 million in capital and completed (fractured) 13 gross and nine net wells, according to the report.

In addition, the company constructed and operationalized its first produced water pond for recycling use in the Permian in the second quarter. "The facility became operational in April and is lowering operating costs by approximately $1.54/bbl of water," the report stated. "In addition, the facility lowers completion costs by providing a low-cost direct source of water for completion operations instead of trucking in freshwater, saving approximately $0.45/bbl of water."

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XTO Energy's operations at a Wolfcamp drillsite are producing high volumes of oil this year. *(Photo courtesy of Exxon Mobil)*

Exxon Mobil/XTO Energy

Exxon Mobil and its subsidiary XTO Energy are producing more than 165,000 net boe/d across their Permian Basin leasehold and more than 3.9 million acres in Texas, according to the company's website.

Exxon Mobil recently drilled its first 12,500-ft horizontal lateral length well in the Delaware Basin and has completed multiple 15,000-ft horizontal lateral length wells in the Midland Basin.

Assets acquired in 2017 included an estimated resource of 3.4 Bboe in the Delaware Basin and another 22,000 acres located in the Delaware and Midland basins, the website stated.

In a January 2018 press release, Exxon Mobil said it plans to triple total daily production to more than 600,000 boe by 2025 from its operations in the Permian Basin in West Texas and New Mexico. "Tight oil production from the Delaware and Midland basins will increase fivefold in the same period," the report stated. "Through capital-efficient production growth, the increased volumes will be driven by reduced drilling costs, technology improvements and expanded acreage."

Laredo Petroleum

Independent Laredo Petroleum operates primarily in the Permian Basin of West Texas. The company's Permian activities are centered on the east side of the basin in primarily Glasscock and Reagan counties. The company has more than 140,000 gross acres (mostly contiguous and 85% HBP).

In the second quarter, Laredo produced a company record of 67,206 boe/d, an increase of 15% from the second quarter of 2017, according to the company's second-quarter 2018 results report. The company completed 20 gross horizontal wells, exceeding the company's expectations of 17 gross completions, and it invested approximately $169 million in drilling and completions activities in the second quarter.

Laredo completed 40 gross horizontal wells in the first half of the year, and at press time it expected to complete 16 gross horizontal wells (16 net) in the third quarter of 2018 and approximately 70 net horizontal wells during 2018, according to the report.

Occidental Petroleum

Occidental Petroleum is one of the largest operators and oil producers in the Permian Basin with nearly 2.5 million net acres. The company's average total net Permian production in the second quarter of 2018 was 354,000 boe/d.

Permian Resources, the company's unconventional business unit, had 25 of the top 50 wells in the Permian Basin from July 2017 to July 2018, according to the company. Permian Resources production, primarily in the Delaware Basin in Texas and New Mexico, was 201,000 boe/d in the second quarter of 2018, up 14% from the previous quarter and up 46% from the second quarter of

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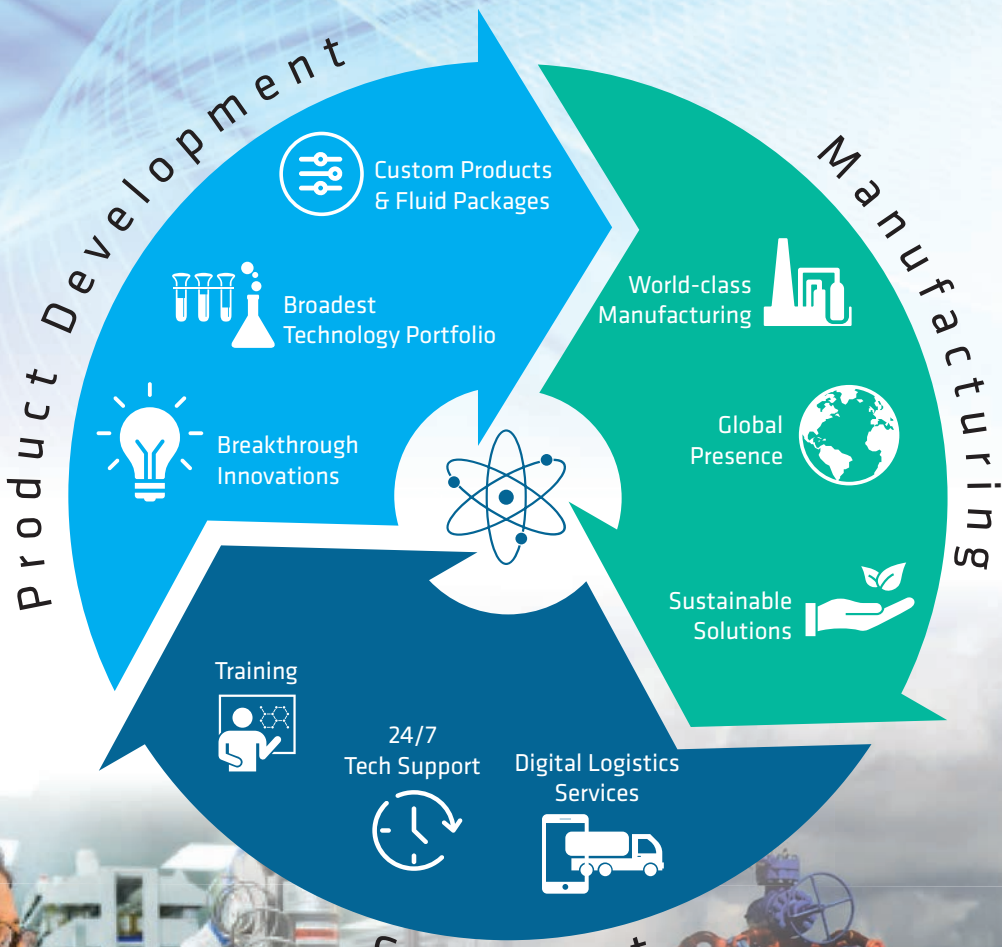

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Occidental staff ensure safety regulations are met at the company's Delaware Basin operations in the Permian Basin of West Texas. *(Photo courtesy of Occidental Petroleum)*

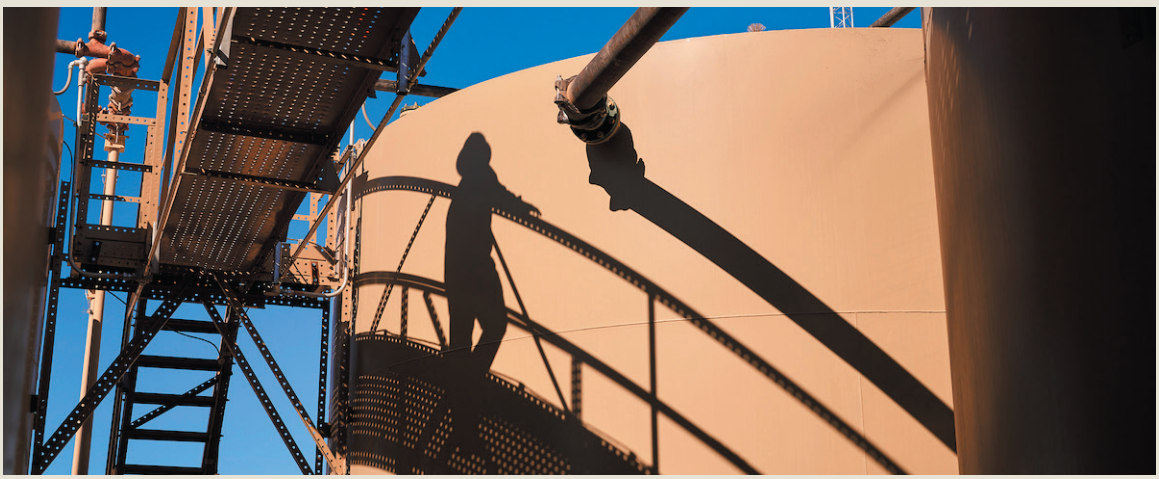
2017. The company's Aventine logistics and maintenance hub in New Mexico also began operations in 2018.

Additionally, Occidental is a Permian leader in CO_2 EOR technology, injecting more than 950 Bcf annually into basin reservoirs. Since acquiring the Seminole-San Andres CO_2 EOR unit in 2017, the company has lowered the unit's operating expenses by $7/boe. Occidental is advancing CO_2 EOR as a form of carbon capture, utilization and storage. In 2018 Occidental and White Energy said they were evaluating a project to build a carbon capture facility at White Energy's Texas ethanol facilities and transport the CO_2 to the Permian Basin for use in Occidental's EOR operations.

Parsley Energy Inc.

Independent Parsley Energy's focus is in the Permian Basin in West Texas with a reported total net production that averaged 107,800 boe/d in the second quarter, according to the company's second-quarter 2018 results report.

During the second quarter, the company spud 43 wells and placed 45 gross operated horizontal wells on production. "Completion activity was weighted toward the Midland Basin, where the company placed on production 37 gross operated horizontal wells, with the Delaware Basin comprising the remaining eight gross operated horizontal wells," the report stated. "Parsley expects that development activ-



This Parsley Energy production facility operates in the Delaware Basin. *(Photo courtesy of Darren Carroll Photography)*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ity will remain weighted to the Midland Basin for the remainder of the year."

Parsley turned 14 wells to production in Glasscock County during the second quarter. These wells included two wells on the Brunson lease, which targeted the Wolfcamp A and Wolfcamp B zones in a stacked configuration. The company reported early results from these two wells of peak 30-day production rates averaging 1,277 boe/d (84% oil), representing the company's strongest stacked Wolfcamp results in Glasscock County to date, according to the report.

Parsley is increasing its full-year 2018 net oil production guidance to 68,000 to 70,500 bbl/d of oil.

Pioneer Natural Resources

According to Pioneer Natural Resources' second-quarter 2018 results news release, the company is the largest acreage holder in the Midland Basin with approximately 550,000 gross acres in the northern portion of the play and approximately 200,000 gross acres in the southern Wolfcamp joint venture area.

Cementing operations take place on a Permian rig. *(Photo courtesy of Pioneer Natural Resources)*

Also in the second quarter, the company produced 280,000 boe/d and placed 67 horizontal wells on production in the Permian Basin. The company also said its Permian Basin oil production increased to 175,000 bbl/d of oil.

Pioneer forecasted its Permian Basin production to average between 278,000 boe/d and 288,000 boe/d in the third quarter.

The company's full-year 2018 plans include "operating 20 horizontal rigs in the Permian Basin; planning to add four rigs to support the 2019 plan, two in August and two during the fourth quarter of 2018; expecting to place 250 to 275 wells on production during 2018; [and] drilling wells in the Permian Basin that deliver strong cash operating margins and high rates of return," according to the release.

Shell

Shell has shared its Permian acreage with Anadarko Petroleum Corp. in a joint venture (JV) since 2012.

The JV's Permian operations are in Loving, Ward, Winkler and Reeves counties, covering about 280,000 to 300,000 net acres, and Shell produces about 39,000 total gross barrels of oil.

In the Delaware Basin, Shell's primary focus is on the Wolfcamp, Bone Springs and Avalon formations. The company has 400 Shell-operated wells and 500 nonoperated wells.

The company also has several central processing facilities in the Permian and operates eight saltwater disposal facilities.

"Shell is running six rigs as it familiarizes itself with the Permian and develops methods and systems to extract oil efficiently. Shell's goal is to produce oil profitably there by next year and ramp up output in the 2020s," according to a March 2018 *Houston Chronicle* article.

Looking ahead, "Shell hopes to boost its North American shale output by 140,000 barrels of oil equivalent per day in the next three years, a goal that relies largely on the Permian," according to a Reuters report released in March 2017.


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SM Energy

SM Energy has 82,460 net acres, seven rigs and three fracturing crews in the Midland Basin, according to a company investor presentation released in August.

SM Energy has 82,460 net acres in the Midland Basin. *(Photo courtesy of SM Energy)*

The company completed 38 net wells in the second quarter and is focusing on co-development of intervals. It drilled 29 gross (28 net) wells in the second quarter. The company reported 50 gross (48 net) drilled but uncompleted wells as of June 30.

SM Energy expected to reduce its rigs to six and have about 37 net completions in the third quarter, according to the presentation.

WPX Energy

WPX Energy has about 131,000 net acres in the Delaware Basin with about 6,600-plus gross locations (52% oil, 18% NGL and 30% gas), according to its second-quarter 2018 investor presentation.

WPX's Delaware production averaged 74,400 boe/d and had 20 wells with first sales in the basin during the second quarter. Most of the activity occurred in the Wolfcamp A interval.

"Average lateral lengths of 7,500 ft in the Delaware during 2018 are on track to be approximately 20% longer than in 2017," according to the company's second-quarter 2018 results report. WPX has "roughly doubled its average lateral lengths in the Delaware since entering the basin in 2015 via its acquisition of RKI E&P."

WPX participated in seven gross (1 net) non-operated well(s) in the Delaware Basin in the second quarter. ■

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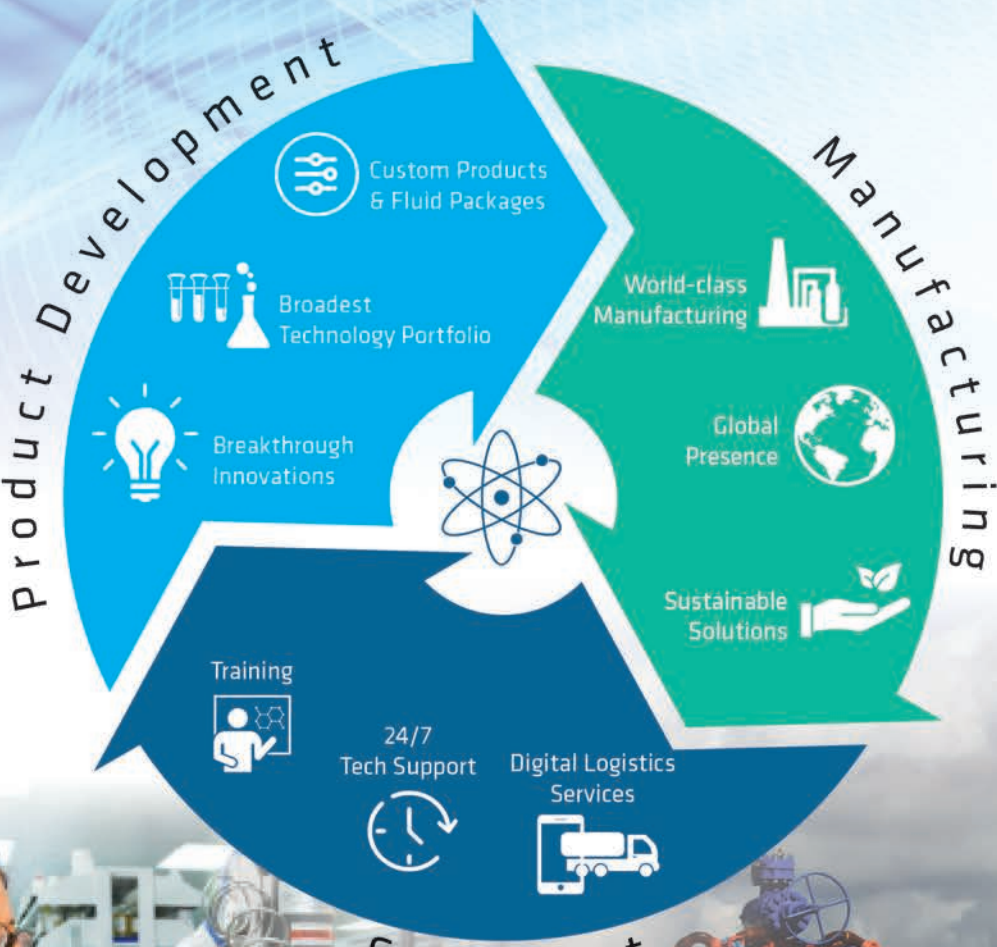

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By Blake Wright
Contributing Editor

The Permian Basin of West Texas and Southern New Mexico remains one of the most prolific oil theaters in the U.S., pumping nearly 3.3 MMbbl/d of crude in August according to the U.S. Energy Information Administration. That's pretty impressive for a century-old oil field. However, it is not all roses and rainbows in the region currently. Takeaway constraints due to pipeline bottlenecks and general lack of infrastructure have prompted some producers to ease off the accelerator and rein in drilling programs while export projects in the region play catch-up. The squeeze on natural gas movement from the area has resulted in an estimated $1 million per day of gas being burned off via flaring, but state restrictions won't allow that to last forever. With no place to flow residual gas, oil production is being curtailed. Some operators have already begun looking beyond the Permian and moving rigs out of the area to locations that are not facing the same challenges.

Even as infrastructure woes weigh heavy on the minds of producers there is still a bounty to be had in the Permian, and many continue the search for the perfect balance of low cost, high yield dynamics to ensure the oil isn't the only thing that flows black; their bottom lines must follow suit. Technological advancements have always played their part in both boosting production—via artificial lift, pressure pumping agents and perforation controls—and lower cost, through streamlining existing concepts, cheaper chemistries or logistical gains, among other things.

The current hiccup has not deterred tech companies and tech-driven operators from experimentation with and implementation of the latest bit of industrial science. From automation and artificial intelligence to the latest piece of kit to help conquer a two-mile lateral and coax oil and gas out of the tightest formations, the Permian Basin remains both a laboratory and proving ground for technologies of all kinds.

Contractor targets completions triad

Schlumberger has set its sights on a trio of technologies to assist in everything from customizing the right chemical cocktail to increase reservoir performance to additive management addressing cost, shelf life and more. The Schlumberger ShalePrime rock-fluid diagnostic service uses customer-supplied shale core or cuttings to create a consistent pack of material to imbibe water and water treated with a small amount of surfactant.

"The rate at which the water is taken up by the test pack tells you everything you need to know, if you are measuring carefully and have a good mathematical model for the process," explained Bruce MacKay, Schlumberger OneStim chief technologist. "The contact angle tells you about how the water—after we inject it into the formation—is going to be retained in very small cracks and features out in the distal portion of the fracture network, where the reservoir and the proppant pack are in ultimate contact."

ShalePrime service follows a scientific process and engineered workflow to study rock-fluid interactions using a small amount of formation material. *(Photo courtesy of Schlumberger)*

The industry understands well how water, oil and gas will flow through a sand pack. The choke point is really out where the rock governs production, according to MacKay.

"Most operators will agree that they are limited by the performance of the reservoir and not necessarily the conductivity of the proppant pack, so having a test that is particular to that regime is really important. These small features are where the capillary pressure are highest, and if pressure within them is not managed you end up with a fairly high threshold pressure to initiate flow from the reservoir through the proppant pack and into the well," MacKay said. "This test allows us to do exact, meaningful laboratory measurements that compare the various available surfactants—measurements that commute consistently to a threshold pressure for the initial of flow in that well. If we trot out all of the surfactants that are available, the measurement gives us a way of baselining their performance against one another, and even deciding whether or not surfactants are going to make a difference at all. My experience with this over many dozens of wells and tests, especially in the Permian Basin, is that the rock wants what it wants. Sometimes it wants a little bit of surfactant. Sometimes it wants a lot."

The service company remains engaged with its family of diverters, including the Broadband Sequence fracturing service with diverter technology that can direct the flow of fluid from perforations that are accepting fluids to those that are not, perhaps due to stress fields. Although diversion is common in the industry, the missing piece has been how to make accurate, prescriptive statements about how to engineer diverter pill size in real time, and about how to determine whether or not there has been success in redirecting the flow of fluid.

"Pressure changes are nice, but unless you are running something like distributed temperature sensing, which is more complicated and costly, you don't really get a notion where the fluid is going," MacKay said. "By incorporating some techniques from seismic processing, we have learned how to interpret some parts of the wave form of the water hammer that occurs naturally when we stop the pumps in hydraulic fracturing. If we're running pumps at 80 or 100 bbl/min and then we shut down, this induces a water hammer in the well. It acts like a sound wave. It is a pressure wave that starts at the front of the well and goes all the way down to where the bridge plug is. It reflects off of that plug and comes all the way back. In so doing, it is attenuated a little as it passes features in the well that were taking fluid. We can identify the difference between zones that are taking fluid and those that are not, if we have access to the signal processing math."

Dry friction reducers are another technology that has been floating around the patch for a while, but an ultimate answer has remained elusive. There are some noted benefits in the wellsite delivery equation regarding the use of dry friction reducers—spills on soil, handling of liquids on location, reblending requirement after delivery, and not having to depend on liquid transport, instead going to sacks on a flatbed or bulk transport of dry polymer.

"Going to dry friction reducer is something we have been interested in for a long time," MacKay continued. "There were offerings on the market, and it took a long time to find one that we liked enough in terms of the rapidity of its activity—how fast does it work after you get it into water? A lot of the product offerings we examined initially four or five years ago took about two to three minutes to get to their ultimate yield as friction reducer molecules in solution. That wasn't satisfactory. That really means you have to construct an additional hydration unit for the polymer that adds two to three minutes of residence time at surface, or you have to accept pumping a lot harder and burning a lot more diesel fuel to get the same velocity at the perforation if it is going to happen in the well. It's a question of how fast we can condition the fluid to make it completely performative and function as a slick fluid and immediately minimize pipe friction, so we can increase the injection velocity to do effective slickwater fracturing."

Schlumberger confirms it has identified a couple of products that hold promise in terms of rapid hydration, shelf life, ease-of-use, and tolerance of irregular salinity in mix water. The company is in the middle of field deployment with them right now. Schlumberger is working with 10 to 13 operators, depending on the month, using these products in the Permian Basin in particular.

"We are pleased with the progress today," MacKay added. "The additional surface and operational efficiencies are helping us to bring operators' assets to market more quickly and efficiently."

Let's get small

Back in 2008, Approach Resources was drilling deep gas wells in the Midland Basin of West Texas. The company drilled over 600 verticals there, and through those gained its first exposure to the Wolfcamp shale. In 2009, Approach began drilling Wolfcamp horizontals and since that time has drilled and completed around 200 horizontals in the region. In 2014, the company boasted a $400 million budget. When the downturn hit in 2015, Approach basically shuttered its operations. In June 2016, the company restarted its program, but at a much more deliberate, slower pace.

Last year, Approach drilled a trio of "science" wells to test the use of nanoparticles downhole. Nanoparticles are meant to drive deeper into the cracks and fissures caused by hydraulic fracturing and yield improved production results.

"We picked A, B and C bench wells to pump particles on," explained Ross Craft, chairman and CEO of Approach Resources. "Then we modified each well just a touch, and what was interesting about the first-year results from the three science wells as compared to our oil portion of our 700 Mboe type curves, [was that] we saw a 22% improvement in first-year cumulative oil production from these wells. One well in particular that we pumped metal-oxide particles throughout the stimulation treatment, as well as reduced our stage spacing by an additional 25 feet, down to 156-foot spacing—that well's first-year cumulative oil production exceeded our first-year oil type curve forecast by 93%, which was quite impressive."

Approach then shifted to using silica nanoparticles made by Nissan Chemical. The switch from metal oxide particles was due to size constraints. Silica particles are considerably smaller than metal oxide particles, 10 nanometers compared to 130 nanometers and 100,000 times smaller than conventional proppant, thus allowing deeper penetration in the hydrocarbon rich nano and micro fracture network within the shale reservoir.

"The nanoparticles utilizing Brownian motion and diffusion continue to travel further into nano- and micro-sized fracture network once the stimulation treatment is stopped. These nanoparticles through disjoining pressure continue to seek equilibrium, move between the rock surface and the much larger hydrocarbon molecule contained in the fracture, freeing the trapped hydrocarbon molecule by reducing the capillary pressure effect being exerted on the hydrocarbon molecule. Nano technology is all about particle size. The speed of the particle is inversely proportional to its mass; small equals faster. Hydrocarbon production in a shale reservoir is all about increasing the effective stimulated rock volume," Craft said. "We are seeing improvements in oil production and early production data suggest shallower production declines utilizing nanoparticles in our stimulation fluids.

(continued on page 38)

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Permian Study Attempts to Determine More about Fractures

Yes, the rock has cracked. But is all of that time and effort actually producing results?

By Rhonda Duey
Senior Editor, Exploration

Back when a hydraulic fracturing job required one or two stages, a little allowance was granted for the petroleum engineers. This is no longer the case.

In shale plays that require many stages, it's very helpful to know exactly where those fractures are going. Often it helps to intersect natural fractures, and other times it's best to avoid them. But operators haven't always understood the mechanics necessary to develop these challenging plays.

A recent U.S. Department of Energy (DOE) project is attempting to solve this issue by coring into fractured reservoirs to determine fracture patterns as well as environmental impacts, fracture efficiencies, and safe and reliable operations. The study, conducted with the Gas Technology Institute, Laredo Petroleum and other partners, is intended to provide information about how fractures spread underground during shale operations.

According to the DOE website, current fracturing operations are "inefficient in several aspects." The idea is that having a better understanding of how fractures actually propagate underground could reduce the number of wells being drilled as well as the amount of water, sand and energy required, resulting in a smaller environmental footprint, according to the website.

The bulk of the study was based on 11 10,000-ft laterals in the upper and middle portions of the Wolfcamp Formation in the Permian Basin. About 600 ft of core was acquired from these fractures.

"The process allowed researchers to obtain phenomenal-quality core samples," the study noted. "Based on a first look at the core, the research team predicts that the fundamental understanding of hydraulic fracture propagation, modeling and effectiveness is about to undergo a game-changing alteration."

These observations will include the concepts of fracture connectivity and conductivity, according to the study, and also will better indicate drainage patterns across multiple formations.

Data acquired included

- Well logs;
- Sidewall cores;
- Diagnostic fracture injection tests;
- Crosswell seismic surveys;
- Water and air samples;
- Production and pressure monitoring;
- Radioactive and chemical tracers;
- Colored proppant;
- Microseismic monitoring; and
- Fiber-coil production logs.

As of early this year, field data analysis was continuing.

Chevron uses hydraulic fracturing to free oil and gas trapped in tight rock. *(Photo courtesy of Chevron)*

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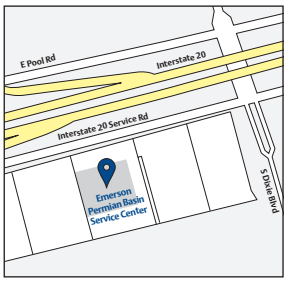

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Now, is it cheap? No. It is expensive, but because we are utilizing the physics of nanoparticles we're able to reduce and in some cases eliminate other chemicals that we historically would have run in our stimulation fluids, resulting in a pseudo net neutral cost. I am really impressed with the technology. We will continue to refine the use of nanoparticles in our stimulation treatments."

Approach started using smaller sand particles in its mix of stimulation sand back in 2012 and experienced positive gains, but it was still facing fluid production drop-off once the wells were online for a while. The company suspected that the micro-fractures created by the frack job were getting water or fluid blocked by capillary pressure effects as a result of probable fine migration and normal pressure depletion within the fracture network. Water and oil molecules are big as compared to the smaller, more nimble gas molecule. While gas can get through the micro- and nano-fractures with little effort, fluids often times cannot.

"The silica particles are very small; one grain of frack sand is roughly one millimeter in size, it would take roughly 90,000 silica nanoparticles to equal one sand grain," Craft said. "There are numerous types of nanoparticles and sizes and each type of particle has unique physical properties. Larger metal oxide particles tend to reduce fine migration within the fracture network due to their surface area. The smaller lab-created silica nanoparticles tend to be superior for accelerating the mobility of fluids within the formation. Some particles are showing promise in heavy oil EOR projects. Currently we have about a year and a half of production data on wells utilizing metal oxide particles, and roughly six months of data on wells utilizing silicon dioxide particles. The data we have collected is encouraging. We're not the only E&P company experimenting with nanoparticles."

The center of the universe

Weatherford President and CEO Mark McCollum told attendees at the Weatherford Technology Event last April that, in many industry circles, the Permian Basin is referred to as "the center of the universe." It is not a difficult analogy to connect with. From investment levels, project opportunities and shear manpower, the venerable West Texas oil basin has likely never been as scrutinized by as many industry players as it has over the past half-decade. Weatherford, knowing that robust potential and favorable economics could equal long-term demand for services, invested in a supercenter facility that will consolidate its expertise in Odessa, Texas. The facility combines the contractor's technology and solutions across many of its product lines to increase efficiency and enhance service quality for its customers. It's an important step given the unique demands the basin requires.

"Our customers have encountered multiple challenges when drilling wells in the Permian Basin, which in turn creates the demand for unique solutions," said Michael Guajardo, area sales manager, Permian Basin/San Antonio for Weatherford. "When drilling, many customers have experienced a water flow zone and a depleted zone in the same borehole, which results in opposite issues. Wells like this complicate the drilling process and challenge us to engineer various solutions, such as our managed pressure drilling, drilling with casing and solid-expandable liners. In production, our customers face issues with decline rates and flow assurance. These production issues are more aggressive in the Permian Basin than other plays."

To assist operators with some of the more common challenges in the Permian, Weatherford has introduced an array of new offerings into the basin covering everything from rotary steerables, minimal frack plugs as well as production data-gathering technologies.

"Our Magnus rotary steerable system (RSS) is a new drilling technology that enables reaching total depth [TD] in extended-reach laterals where conventional systems have exceeded the technical limit," Guajardo said. "After a hole is drilled conventionally, our Magnus RSS can continue drilling the lateral to TD while optimizing weight transfer and eliminating sliding. A new completions technology, the Minima composite frack plug, is one of the shortest plugs in the industry. The plug provides superior performance and mills up in as little as five minutes. In the field of production, we offer the Surface Pumping Unit Reliability (SPUR) Mobile App, which enables service crews to log and create

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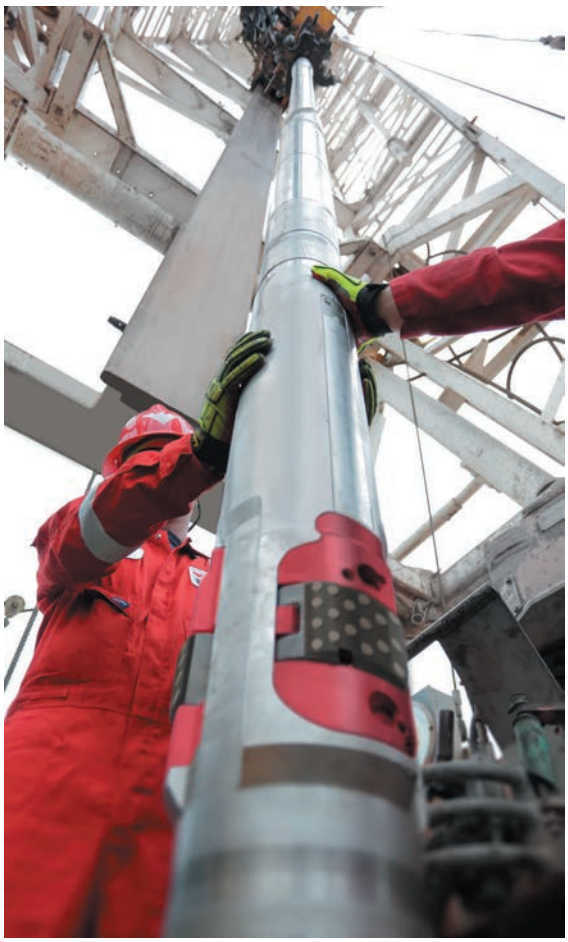

The Magnus RSS improves directional control when drilling in tight target windows. *(Photo courtesy of Weatherford)*

service reports from their handheld tablet devices. These crews can also retrieve information from field instrumentation and access work instructions and job safety analyses at the field level. All this job and equipment information is then loaded into our PUMT Portal so that customers can generate specific reports and trends."

The contractor also is now using artificial intelligence in the region to assist with personnel safety as well as production optimization. The company is installing facial recognition technology in its work vehicles to help reduce the amount of time their drivers' eyes leave the road in the truck-heavy region.

On the production side, Weatherford's ForeSite production optimization platform is a digital breakthrough that optimizes production in this basin, according to the company. The platform analyzes historical data to predict failures, which can revolutionize the way operators plan their intervention campaigns.

"We are constantly updating models in the platform with real-time data from the basin," Guajardo added. "As a result, the platform provides actionable intelligence for Permian-specific challenges so that our customers can optimize output from these assets."

Water works

Not unlike oil infrastructure, the expansion of water systems in the Permian remains an ongoing and dynamic project, especially for water management companies like Select Energy Services. With 575 miles of flat hose and over 350 pumps in the region, Select's footprint in the Permian is expanding in step with the company's suite of offerings, many of which are tied into the provider's AquaView monitoring network.

"In the Permian Basin we do a great deal of produced water transfer," said Nate Banda, vice president, technology for Select Energy Services. "Produced water is recovered everywhere, but not at the scale of the Permian and certainly not across such distances. The largest driver for our automated pumps was the need to mitigate the risk of transferring produced water across longer distances. Our automated pumps have been very popular in the Permian and they are largely deployed there. It is our area of highest demand for produced water transfer."

The pump's onboard sensor system allows detection of burst lines, closed valves and any overpressure or underpressure situation. Discharge and recirculation valving can trigger throttling down and closing of valves in the event of a line break or other damage. The pumps log a history of pressure readings and use trending to predict possible pressure issues. "This concept has played very well in the Permian," Banda noted. "We now have automation actively working to prevent a spill."

Beyond pumps, Select also deploys an automated manifold for fracturing used almost exclusively in the Permian Basin. Pumps move the water into the manifold, which uses level sensors

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and automated valves to automatically distribute water evenly across the frack tanks on site. It does this in concert with the pumps' own logic controllers. Regardless of manifold demands, the pumps will not violate a preprogrammed hierarchy of safety protocols.

"So we are supplying the water and the pumpers are pulling it," Banda explained. "Keeping those things exactly synced up is virtually impossible. When you have a row of frack tanks, the issue is demand variability, and, at times, supply variability. Pressure pumpers never want those frack tanks to become too full or too empty. The whole system needs to be dynamic to feedback. As frack intensity in the Permian increases, we depend on a system like this that is highly mobile and self-adjusts to the conditions at each location."

Another pair of sought-after Select assets in the Permian is Select's Automated Proportioning Systems (APS) and their quick chemical dosing trailers. The APS allows customers to dynamically maintain a mix of freshwater and produced water. Both solutions are ideal because there are produced water constituents that could become problematic during fracturing without some level of treatment or dilution.

"Every situation is going to be different and the water chemistry is going to vary across the region as will the operator's standards," Banda said.

Select's APS system is mounted on a standard trailer with two incoming lines and one discharge line. Each of the incoming lines has an electrochemical sensor, a flow meter, a flow switch and a pressure sensor. The water in those lines is constantly being tested using that sensors linked to an onboard controller that controls a pair of electronically actuated valves to achieve a consistent chemical makeup. The discharge leg also supports a static mixer and a low pressure mixing area to ensure a thoroughly homogenized flow before it leaves the skid.

"This requirement makes that section fairly long—about 28 feet," Banda noted. "It is amazing how little the water flows mix in a short distance without a concerted effort to make them mix. The system allows you to set a conductivity target and maintain it without any specialized labor. You might not always be able to dilute your way out of a problem with water chemistry, but if you can this is a quick and affordable solution."

Select's dosing trailers have been in service for nearly a year. They are self-contained, automated dosing units that release a specific concentration of chemicals that is dynamic to flow. Each unit boasts a 10-in. dosing spool that circulates the water. The unit is built with high-alloy stainless steel so powerful oxidizers, water-based chemicals, oil-based chemicals, etc. can all be used. The trailer has capacity for up to four separate totes and includes a self-powered onboard command center for local control and monitoring. The dosing itself is automated.

"We are impartial to what chemical the operator wants to use," Banda said. "The common one being used now is peracetic acid (PAA). So we can use that, we can also use hydrogen peroxide, bleach, scale inhibitors, etc."

The use of recycled water is a bit trickier in the Permian Midland Basin due to the fact that much of the region's producing wells don't flow back much water. Back in 2015, when Approach Resources shut down its drilling program due to low commodities prices, it shifted its focus to finalizing its fully integrated 329,000 bbl water recycling facility, which has helped the company reduce well costs and lease operating expense (LOE).

"I cannot over-emphasize using produced water to frack with; it saves money and makes better wells," said Approach's Craft. "When we started working on the technology of cleaning and recycling the water there were not many workable blueprints available. During the design stage we were told by most of the water companies—there weren't many back then—that it was cost prohibitive and probably not achievable to clean the water to our high KPI requirements. We told them 'We'll see.' So we designed a process and a system to where not only could we clean it, but we could take it down our initial KPI requirements. In the wells that we utilize recycled water on, they are better wells than the ones where you don't run recycled water. The reason for that is the minerals in the shale. The shale is made up of mixed layers and what we saw utilizing low chloride water was concerning;

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as soon as we would start the flowback process the flowback water would now have 60,000 to 76,000 parts per million of chlorides and other dissolved minerals. Think about it; we would inject 350,000 to 400,000 barrels of water containing 2,000 to 3,000 parts per million chlorides and the return water was 60,000 to 76,000 parts per million chlorides. To dissolve that amount of minerals within the formation, then our fracture system that we spent good money to create has become unstable, releasing formation fines into propped fractures and plugging what little permeability you developed in the unpropped fractures. Using compatible produced water is the key to making better wells and it cut our well cost by approximately $1 million to $1.5 million per well."

Approach's plant is located right in the middle of its contiguous lease hold. Every horizontal location has six pipelines buried in a corridor—one oil gathering line, one low-pressure gas gathering line, one high-pressure gas lift and miscible flood gas supply line, and three water lines (one for produced water coming back to the facility, one for low chloride water going to sites for future makeup water and one for recycled water going to the new well sites).

"We can deliver water to a frack site at rates up to 90 barrels per minute though over pipeline network. We bring all water into this facility," Craft said. "We clean it, capture any free hydrocarbons, then move it to our aboveground 329,000 barrel storage tanks. From there we can blend the water to bench specific specifications, filter the water through a five-micron filter system, treat for new bacteria using chlorine dioxide or another sterilization process. Once this is complete we can send it to the frack sites. If we are not stimulating new wells we can send it to our company-owned SWD [saltwater disposal] facilities located throughout our acreage. It has really been the foundation of our low-cost structure, both drilling and completions and LOE."

In 2015, Approach received the Bruno Hansen award in the Permian for its water recycling system. Now, many producers either have their own system or can contract with one of the many water recycling companies. The facility and the pipelines are 100% owned by Approach.

"I wish I had more produced water—we don't," Craft said. "The water in the Wolfcamp Formation in our area of the basin for the most part is non-moveable, so you only get what you put in. Typically, a well will be fracked with 50% recycled water or higher, if we have it. I wish I could do 100%, but I just don't have it."

Bits, plugs and more

Permian drilling offers challenges that can prove most extreme in the cases of deep wells with long lateral sections. Severe conditions often are quick to expose the weakest link in the chain—that usually falls on PDC bits. Baker Hughes, a GE company (BHGE) recognized that problem as one both time consuming and costly to its customers. Lessons learned forged the idea for the Dynamus extended-life drillbit, which combines a series of innovations into a fast, rugged and reliable package that offers

The water recycling system is an integral part of Approach Resources' plan for sustainable, environmentally sound asset development. *(Photo courtesy of Approach Resources)*

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enhanced stabilization, greater durability and improve azimuthal control to track straight to stay on target in lateral and tangent sections.

"As the number of reservoir targets that require a horizontal or deviated wellbore to maximize reserve recovery continue to expand, it is even more important than ever for the drillbit to stay in zone," said Afton Noel, PDC product manager, drillbits for BHGE. "A new gauge pad feature enables the Dynamus drillbit to spend less time sliding in tangents and laterals. This results in performance gains and better hole quality. The Dynamus extended-life bit also features a high-torque shank to withstand the demands of high-torque motors. An optimized blade layout, coupled with new cutter geometry, minimizes load fluctuations, which leads to a more durable cutting structure that doesn't compromise performance."

The Dynamus extended-life drillbit enables the user to reduce trips while protecting sensitive bottomhole assembly components and hole quality by mitigating lateral vibrations. *(Image courtesy of Baker Hughes, a GE company)*

BHGE configured an anti-walk gauge for conventional motors to improve tracking and reduce slide time, resulting in an increase in the overall section ROP. This benefits operators by reducing drilling time, optimizing wellbore quality, and allowing for greater flexibility in bottomhole assembly design. Slides can account for up to 45% of the drilling time, but only 10% to 15% of the distance drilled, according to BHGE. The bit's anti-walk gauge pad includes a stripe to limit the depth of cut against the borehole wall for reliable tracking, and it features a relief on the gauge pad to allow for planned build-up rates when required. As of mid-August, BHGE completed multiple anti-walk gauge tests in different areas in North America. One of the runs in the Permian resulted in the new Dynamus anti-walk bit increasing the ROP by 40%, which reduced the time to drill a lateral by three days compared to the competition's average drill times.

"The Dynamus platform is built on a combination of revelations in drilling technology: StayTrue, StayCool 2.0 and the newest addition, AntiWalk i technology," Noel said.

"Dynamus AntiWalk i bit technology came as a direct result of listening to customers talk about leaving performance on the table due to difficulties with tracking and excessive slides while drilling horizontals. This revelation was developed specifically to address these inefficiencies and provide a one-of-a-kind solution to track straight and stay on target."

Beyond bits, BHGE also is looking at new facets of completion technologies and has most recently introduced a new formula for its SPECTRE disintegrating frack plug, aimed at delivering predictable, reliable performance at lower temperatures like those in the Permian Basin. The company's disintegrating materials technology has been evolving for almost a decade. The new formula expands the SPECTRE plug's function—including maintaining pressure integrity and disintegrating at predictable rates—to temperatures as low as 100 F.

"No other 'disintegrating' plug on the market can reliably perform in these conditions," said Gabe Casanova, product line manager, wireline conveyed completions for BHGE. "In addition, most so-called disintegrating plugs contain cast iron or ceramic components, so they don't truly disintegrate."

BHGE views the primary benefit of the reformulated SPECTRE plug as its dissolvability. It does not have to be milled out, which saves time and thus money. The SPECTRE plug has been applied in just about every major basin in North America and, with the new BHGE-developed low-temperature version, it is now being run in the Permian. Coiled tubing units can be hard to come by and costly, making the benefits of the SPECTRE plug

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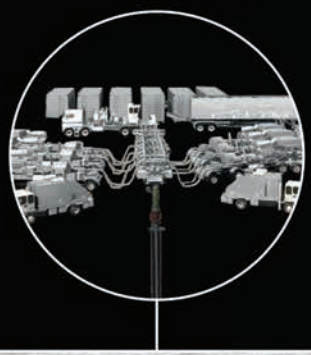

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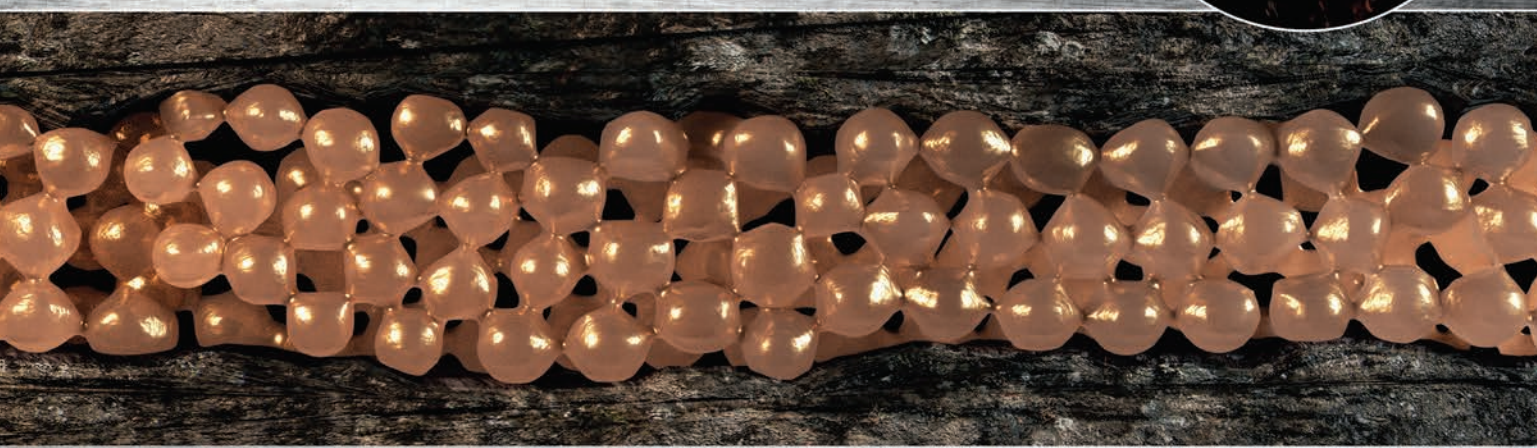

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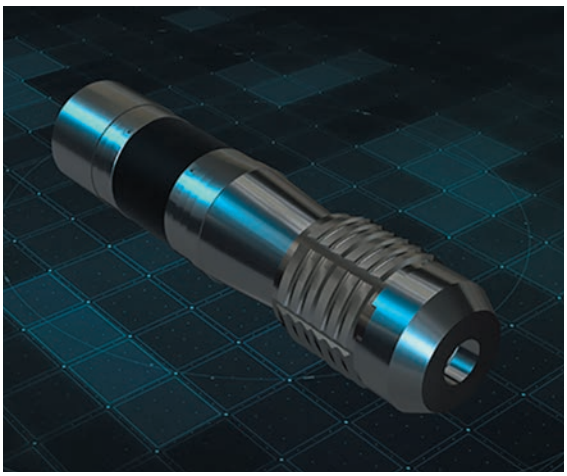

The SPECTRE frack plug offers the same flexible stage placement as traditional composite plugs, but the entire plug fully disintegrates downhole in the presence of wellbore fluids, requires no post-frack intervention and leaves no debris. *(Image courtesy of Baker Hughes, a GE company)*

even more valuable, according to the company. Customers don't need coil, and unlike other disintegrating plugs with cast iron or ceramic components, they don't need to spend any extra time or money circulating heavy plug debris out of the well. The SPECTRE plug leaves behind no debris.

"One of our customers recently told us that by running full wellbores of SPECTRE plugs and reducing coiled tubing cost they can save several hundred thousand dollars per well," Casanova said. "But the savings go beyond just coiled tubing. The low-temperature SPECTRE plugs also help to reduce the time between completion and production, bringing wells online faster than ever before."

Slugging it out in the name of longevity

When Canadian independent producer TriAxon Oil Corp., a deep Bakken player, developed a system capable of smoothing out inconsistent flows from the wellbore, it soon became the talk of the town. In 2015, it began providing the service to neighboring operators looking to mitigate slug flow and keep their artificial lift pumps working for longer. The system generated enough operator interest that it made sense to spin out the technology into a new service company called Production Plus Energy Services.

"The turning point came when we started to make the correlation between pump failures and downtime," explained Jeff Saponja, CEO of HEAL Systems, a joint venture (JV) between Production Plus Energy Services and Schlumberger. "Anytime we had a power failure in the field or the downhole artificial lift pumps had to go down temporarily, when we started one back up again, we would often soon after have pump failures. We started to explore why and study the flow behavior of the gas and oil and water and all the different mixtures of fluids coming out of the wellbore. We discovered that the flow coming out of the horizontal part of the wellbore was inconsistent, very sluggy. What this means for example is there would be 10 minutes of straight gas coming out of the wellbore followed by 10 minutes of liquids, then 10 minutes of nothing. The flow behaves like a geyser, and pumps don't like these inconsistent flows. We hypothesized that maybe the key to artificially lifting these wells efficiently is smoothing out these inconsistent flows before they reach the artificial lift pump. This is fundamentally where the HEAL System was born. We are a slug flow mitigation company."

The HEAL System is best described as an efficiency driver for artificial lift systems. Artificial lift systems were designed for vertical wells and were not designed to handle slug flows. The HEAL System handles the slug flows and is a downhole solution that seamlessly integrates an artificial lift system in the curved or bend section of a horizontal well. With no moving parts, it is designed to perform for the life of the well. It is made up of the HEAL seal at the lower part of the bend section, an engineered variable-internal-diameter tubing interval through the bend section called a sized regulating string, and a vortex or cyclonic separator positioned at the top of the bend section. This positions a traditional artificial lift system in the vertical part of the wellbore, where it can operate most efficiently. The seal forces production from the horizontal section through a smaller diameter flow path in the build section. Production therefore flows up the sized regulating string, and due to the smaller and variable internal diameter is conditioned into a desired multiphase state that lowers fluid density to lift the liquids from the horizontal to the vertical and simultaneously regulates the flow to mitigate slugs. The conditioned flow is then delivered to the vortex separator, which discharges

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the flow to the tubing annulus for separation of gas and solids from the liquids. Gas rises up through the annulus, and liquids are delivered to the pump. In addition, pump-damaging solids are separated out and settled into a sump.

In 2016, Encana brought the HEAL System to the Permian, Great Western Oil and Gas brought it to the Niobrara, and the technology soon caught the attention of Schlumberger. In June of 2017, Schlumberger and Production Plus Energy Services formed their JV to further develop the HEAL System technology and business. The JV offers operators global accessibility, enhanced quality control and assurance, and greater credibility for the beneficial capabilities of the HEAL System.

"We knew there was huge potential for the technology," Saponja said. "Through our collaboration with Schlumberger and its global manufacturing footprint, we've been able to further the development of this technology. By focusing on service quality for fit-for-purpose tools, we are able to fine-tune system performance, and reduce costs and operational risks.

"We have put this technology into every major unconventional oil basin in the U.S and Canada," he continued. "The growth rate continues to be increasing at a rate of 100% more wells than the previous year. We have now coupled this technology with every type of artificial lift system and have been able to demonstrate that smooth flow conditions offer lower operating expense and lower bottomhole pressures for maximizing production."

In the Permian, the challenge the HEAL System is addressing revolves around preventing solids damage to the pumps. The mountains of sand that are forced downhole during hydraulic fracturing are necessary to achieve formation production, but some of that sand flows back and can damage the pumps. As it happens, mitigating slug flows also help mitigate sand and solids returns. To date, the service provider has almost 100 HEAL systems installed in the Permian.

"Schlumberger has been instrumental by helping us extensively redesign the HEAL system with drivers to address those Permian challenges in the engineering and design of the system, but also primarily to lower its cost by nearly half," Saponja said. "The joint venture has allowed us to have access to Schlumberger's resources to enhance the HEAL system from client feedback."

The redesigned HEAL system made its debut in late August. The new version targets risk reductions associated with installation and retrieving, and added utility. With several of these new systems installed in the Permian, the new design is helping producers lower their operating expenses and increase their cash flows, ultimately making their artificial lift strategies simpler and more concise.

"We've been expanding the system's capabilities and have been working with Schlumberger to track flowback and natural flow through the HEAL system," said Saponja. "Smooth flows and managed pressures for the life of the well are our goal and our mission. The technology will be installed at the beginning and will be there right through to the end." ■

The HEAL system—which separates the horizontal from the vertical well sections and regulates the flow between them—has no moving parts and can be connected to any variant of lift system. *(Photo courtesy of Schlumberger)*

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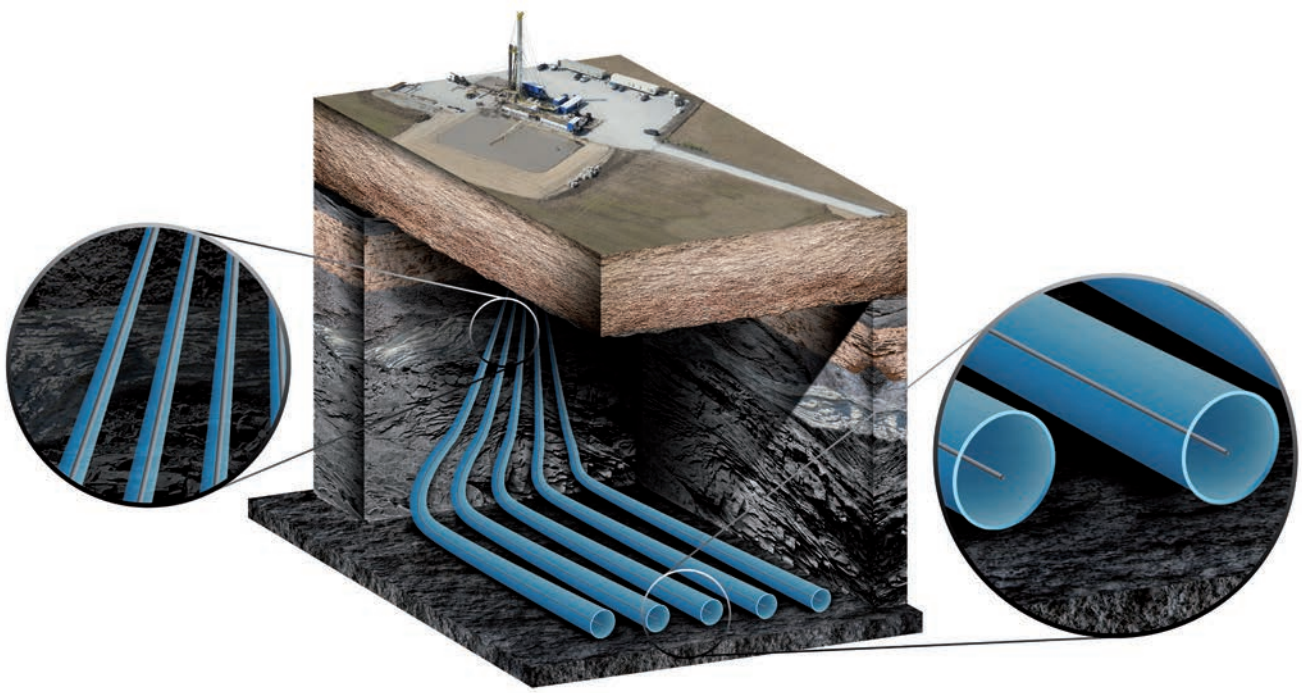

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The Permian takeaway situation will get worse before it gets better and, possibly, reappear in 2020 or shortly thereafter, securities analysts expect.

By Nissa Darbonne
Editor-at-Large, *Oil and Gas Investor*

In August, the Permian's oil pipelines were essentially full. In June, they were at 95% of capacity. Analysts expect it to get worse before it gets better, with options on non-basis-hedged, Permian-weighted producers' shares seeing maximum pain around year-end.

Why was anyone surprised? "Yeah," said Subash Chandra, managing director and senior equity analyst for Guggenheim Securities LLC. The equity market was focused on the upcoming gas takeaway bottleneck out of the Permian, which, according to several analysts' estimates, is happening right about now as well.

And publicly held producers' combined guidance in fourth-quarter 2017 on their increased Permian oil output for 2018—if combined with

Increased production is keeping pipeline installation crews busy in the Permian Basin. *(Photo by Tom Fox, courtesy of Hart Energy's* Oil and Gas Investor*)*

increased output by private operators—wasn't being given as much investment-market attention.

"I think some operators also thought that way," Chandra said. "They didn't think the overall group would be able to generate such high amounts of oil growth out of the basin in 2018. The mindset, if you recall, was the U.S. supply-growth numbers are too strong. They're artificial. They're going to get revised down. It can't be 'happening.'

"And, then, it became one of no revisions [after all]. In fact, the possibility of upward revisions to U.S. oil-supply growth is very strong. 'There is no end in sight.' That happened fairly quickly," Chandra said.

So operator A didn't think operators B-Z would actually show up? And B didn't think C-Z would show up? "Yes, and the privates, the PE-backed, the integrateds, right? So I think, by the first quarter, it became clear U.S. oil supply growth was not going to be de-rated in any way."

Production phenom

In the first half of 2017, Michael Hanson posed a question: "What if everyone does what they say they will do?" At the time, Permian output was 2.2 MMbbl/d. Hanson, a founding member of investment banker Parkman Whaling LLC, went to work on the math. The results: Mid-2018 Permian production would be at least 3.2 MMbbl/d.

In late June, Permian production was 3.2 MMbbl/d. At the same time, Permian takeaway and in-basin refining capacity was about 3.2 MMbbl/d.

Jean Ann Salisbury, senior analyst for Bernstein Research, and colleagues Bob Brackett and Dave Vernon gathered some slides in late May to explain the phenomenon to investors and hedgers. Salisbury said, "We had expected this [would appear] in the second half of 2018—that you would outpace pipeline capacity—but it happened a bit earlier than we thought for a couple of reasons."

One of her charts showed the number of new Permian wells. "But, more importantly," in the other chart, "you can see that the average well in the Permian just keeps getting better," Salisbury said.

Recent results include two Devon Energy Corp. wells in its Boundary Raider development in the Delaware Basin. These IPed earlier this year with a combined 24,000 boe/d, 80% oil. John Raines, Devon vice president, Delaware Basin business unit, said at Hart Energy's DUG Permian conference in May that the company may have two more company-record Delaware wells.

As for EOG Resources Inc., J.P. Morgan Securities LLC analysts wrote in a note that the producer's Convoy-pad results in New Mexico "rival" Devon's Boundary Raiders, which, they added, "are clearly the best wells in the history of the Delaware Basin." EOG's six Convoy wells averaged some 5,600 boe/d, 76% oil, for a combined 33,000 boe/d from completions in May.

In summarizing the Permian's oil potential, Bill Marko, managing director for Jefferies LLC, pointed to a 20,000-acre development in the northern Delaware, for example. "This is why the Permian really matters," he told members of the M&A group ADAM-Houston this summer.

"On current spacing, the recovery factor is 3.2%," he said. "If you talk about really tight well spacing and being able to produce all nine benches, you've got a 17.6% recovery factor [with original oil in place of 29.3 billion—yes, billion—barrels]. ... This is why everyone is so excited about the Permian."

Flashpoints

Bernstein's Salisbury, in her client call, said that, while the market may have been expecting 3.2 MMbbl/d from the basin in the latter part of this year, there isn't significant takeaway scheduled to come online until 2019. "E&P didn't really underwrite new pipelines for all of 2017," she said.

KeyBanc Capital Markets Inc. analyst David Deckelbaum noted that this has happened before in this new century of Permian production: "Throughout early 2015, the Midland differential was over $10/bbl as production exceeded takeaway capacity and began to narrow down in [the second half of 2015] as capacity expansions kicked in."

In early June, Brent was +$10/bbl to West Texas Intermediate (WTI) Cushing, and WTI Midland was -$12/bbl to WTI Cushing. "Midland is a whopping $22/bbl off Brent," Tudor, Pickering, Holt & Co. (TPH) analysts summarized.

How bad is it? Greg Haas, director of integrated oil and gas for research firm Stratas Advisors, told

clients, "It's so bad that the sour and sweet WTI grades at Midland are nearly priced at parity."

And there's more: "It's so bad that light WTI Midland costs significantly less than heavy sour crude delivered from Mexico—$62.90/bbl—at the U.S. Gulf Coast. It's so bad that Midland light sweet crude is underperforming the light syncrude—$63.79/bbl—manufactured up in Canada.

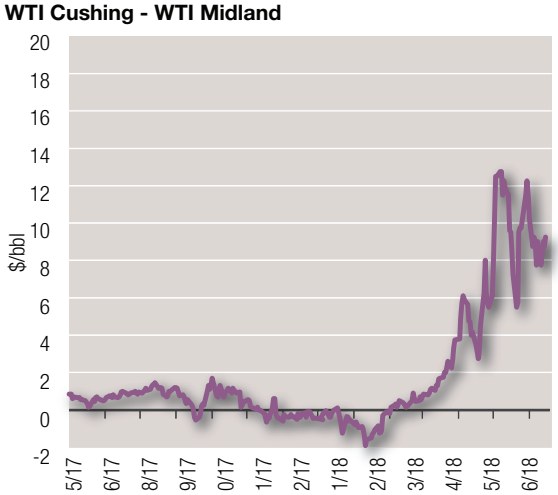
"The only good news for WTI Midland is that at least it is outperforming the price of heavy Canadian Select crude—WCS, $42.04/bbl—for now, but, a few days ago, we saw intraday prices for WTI Midland and WCS at parity."

The WTI Midland (Argus) versus WTI futures on Nymex in late June had Midland at more than -$6 into August 2019 and as much as -$14.48 this October. WTI Cushing itself was $69, propped by an OPEC decision to not increase output beyond its existing quota. Brent was $75.

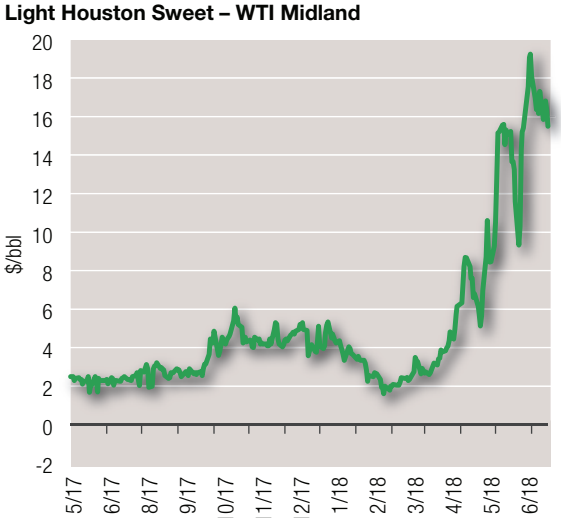
Several analysts estimate that most Permian producers' flashpoints are at below $50/bbl. R.T. Dukes, research director of U.S. Lower 48 upstream for Wood Mackenzie, tweeted, "If my Monday morning eyes are seeing it right, Midland WTI futures no longer fall below $50 per barrel. That's an important threshold for planning and sentiment in the Permian Basin."

Mid-Cushing and Mid-LLS Differentials

WTI Cushing - WTI Midland



Light Houston Sweet – WTI Midland



WTI Midland fetched a premium to Cushing at the beginning of 2018 and a roughly $2/bbl discount to the Gulf Coast. Entering the summer, it was discounted between $8/bbl and $16/bbl. *(Source: Platts, Bloomberg, Barclays Research)*

DUCing

What will this second half and into 2019 look like? KeyBanc's Deckelbaum titled and subtitled his summary with lyrics from a 1970s ballad that isn't identified here because it might evoke a most unwelcomed earworm. He dropped the "max pain" bomb—besides having already prompted mind pain—in describing where this is headed.

In max pain, the greatest number of options, in dollar value, will expire worthless. On a SUDS (subjective units of distress) scale, that would be a 10—unbearably bad. The Mid-Cush differential had been just -$0.40/bbl in January.

Deckelbaum had expected in June that every cubic inch of big-pipe takeaway would be in use by now. Further phenomena may include converting water hauling trucks into oil hauling trucks, putting further pain on operators that don't have their water on pipe, Deckelbaum added.

Those in-basin water hauling trucks might not be in as much demand, though. The Barclays Capital Inc. team expects Permian DUC (drilled, but uncompleted, well) builds and/or operators spending in other basins until the additional pipes arrive.

The U.S. EIA estimates some 3,200 DUCs in the basin—roughly twice as many as a year ago. Deckelbaum estimates the top oil-play beneficiaries of redirected spend will be the Eagle Ford and Bakken as that oil has sufficient direct routes to Gulf Coast pricing.

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There is also rail, but Ethan Bellamy, senior research analyst for R.W. Baird & Co. Inc., said, after Plains All American Pipeline LP's analyst day in early June, that truck and rail options are limited. "Plains estimates 150,000 bbl/d of total truck and rail capacity, which won't add materially to Midland and Delaware takeaway capacity."

TPH analysts took a look at the truck option in early May. Training to receive the proper license is up to 10 weeks, so labor availability is possible—"at a cost." But mandatory trucker electronic logging went into effect in December and enforcement began in April.

"Lastly," TPH reported, "the average [truck] tanker holds some 9,000 gallons—or some 215 barrels. That means 100,000 bbl/d by road takes 1,000-plus trucks—factoring in travel time to and from the Gulf Coast along with driver-resting rules."

Defer?

Guggenheim's Chandra said that adding basis hedges for the balance of this year and into 2019 isn't really possible now for producers. "I think the market conditions have gotten away from them. In other words, if they attempted to basis hedge now, it would be pretty expensive. I think the opportunity is gone."

Instead, exposed Permian producers' other opportunity is "slowing your program down. Just tell people that, 'We can defer this program and we can restart this program without a whole lot of friction or time lapse. If we do that, we spare ourselves one year of trauma and volatility. We come out on the other side and we can recapture and sell our oil for a lot more without locking ourselves into anything.'"

He added, "Which could be what Halcón [Resources Corp.] is trying to message today."

Delaware Basin pure-play Halcón announced in mid-June that it was dropping one of its four rigs. It expects to have firm transport of 25,000 bbl/d to the Gulf Coast by the second half of 2019. In April, it sold in-the-money basis hedges for some $30 million.

That and some ongoing Mid-Cush hedges mean its discount to WTI is $3.90/bbl on 8,000 bbl/d in this half and a $0.03/bbl premium on 12,000 bbl/d in the first half of 2019.

TPH analysts called the Halcón ("hawk" en espanol) news "El Canario in the Coal Mine," adding, "... This falls in line with our thinking from last week that privates and smaller operators in the basin are most likely to feel the pressure from a pricing standpoint."

In client calls in early June, the analysts found both long-only and hedge fund clients "are now generally convinced that [Permian] activity cuts are a matter of 'when,' not 'if.'" They're staying on the sidelines, meanwhile."

The team expected more news like Halcón's "as we believe Midland differentials have the potential to get worse before they get better in the fourth quarter of 2019 and first quarter of 2020, when Midland-Gulf Coast lines come online."

J.P. Morgan's oil and gas analysts estimated that operators without firm transportation (FT) "may have to at least consider the idea of deferring completions if the basis in fact blows out past a $15 to $20/bbl differential for a considerable period of time or if physical constraints become reality."

Chandra said, "The initial concern is folks don't want to lower their production numbers for '18 or '19. But, if they can just explain that one year of deferral doesn't cost you much in terms of valuation—in fact, what you lose on time, you more than gain on pricing—it's not a terrible message. I think if you put in the right slides and show the math, folks will get it."

Less is more? "Yeah, at least for a short period of time. If you truly believe this is a short-term issue and the pipes are coming, which they are, the question becomes how much of a delay there could be in those pipes coming on. But the pipes are coming on.

"If you believe it is going to get worse before it gets better, but the whole span of this event is a year, then defer. And, if what you get on the other side of that is $4 or $5 per barrel or better, I think the market would be like 'Cool' versus saying, 'Hey, we're going to basis-hedge our way through this and lock ourselves into these hedges—and these hedges are increasingly expensive, so we're locking ourselves into worse pricing. But we're doing it because we just don't want to show less volume.'

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"For optics, you're paying a price. It's better to make an economic decision. Now, if they look at it internally and find that 'If deferring production, we lose efficiencies in X, Y and Z' and, if the efficiencies lost are overwhelming, then I would understand. They need to convey that.

"But, if it's just to preserve optics, which is consensus production—'We've got to get to X. We don't want to disappoint on that number even if it means we're selling oil for a lot lower prices or tying this company up for longer than we need to into a crappy market'—that makes no sense."

"The initial concern is folks don't want to lower their production numbers for '18 or '19. But, if they can just explain that one year of deferral doesn't cost you much in terms of valuation—in fact, what you lose on time, you more than gain on pricing—it's not a terrible message."

—Subash Chandra, Guggenheim Securities LLC

Exiting 2017, the Permian rig count was 398, three times the 132 of April 2016, according to Baker Hughes, a GE company. On June 22, it was 473.

Capital One Securities Inc. analysts estimated a drop in the count might look like this: The rigs go to the Eagle Ford and other basins with stronger netbacks. Some wells are DUCed. Some oil capacity may be put in trucks and on rail. A worst case is the count drops 25% or some 120 rigs, "however," they added, "that's a bit draconian."

Baird analysts wrote after pipeline operator Plains' analyst day, "Plains anticipates shut-in and/or foregone production growth in the Permian Basin to persist through 2020."

As for operators slowing down, Imperial Capital LLC senior analyst Irene Haas reported, "So far, public companies we speak with have no plan to change their development plans for 2018. ... Private companies could be more susceptible to pulling back due to a lack of scale and internal expertise in the marketing and hedging arenas."

The hedged

Devon has Midland swaps on 23,000 bbl/d at -$1.02 to Cushing this year and on 28,000 bbl/d at -$0.46 in 2019. J.P. Morgan analyst Arun Jayaram reported that "Devon does not anticipate slowing down its activity in the Delaware Basin as basis swaps and firm transport protects some 90% of its oil volumes from a margin perspective."

Guggenheim's Chandra told *Oil and Gas Investor* that, within his coverage universe, the leading basis-hedged Permian producers are, in this order, Concho Resources Inc., SM Energy Co., Jagged Peak Energy Inc., Energen Corp., Matador Resources Co., Carrizo Oil & Gas Inc., QEP Resources Inc. and Encana Corp. At average is Centennial Resource Development Inc.

"So Centennial is at half the basis hedges of a Concho, SM and Jagged Peak. There is a pretty wide disparity."

That's for 2018. "The problem is, by the time you get to 2019, everyone is overwhelmingly underhedged on basis."

Energen's April-December 2018 Mid-Cush hedges on 9.2 MMbbl—about 58% of midpoint-guidance production in that timeframe—are at an average of -$1.37/bbl. Julie Ryland, Energen vice president, investor relations, told *Oil and Gas Investor,* "Assuming the differential for this time period is actually -$10/bbl, the hedges would represent pre-tax savings on these volumes of approximately $80 million."

Energen also has -$1.11 Mid-Cush hedges on 6.8 MMbbl in 2019 and, Ryland said, "The company continues to look for opportunities to add to its 2019 hedge position."

SM has roughly -$1 basis swaps on about 70% of its Permian production through year-end. Next year, swaps are on about 50% of production at up to -$4.49. It reported in late June that it didn't expect to change its $1.27-billion 2018 capex plan.

Jay Ottoson, president and CEO, told shareholders, "For context, if actual market differentials are -$15/bbl through the second half of 2018 and 2019, our expected realized differential on total Midland oil production, net of hedges, would be approximately -$5/bbl for the second half of 2018 and -$8.50/bbl in 2019.

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Among small and mid-caps TPH covers, the team cited WPX Energy Inc., PDC Energy Inc., Parsley Energy Inc., Encana and Diamondback Energy Inc. as "best positioned in our coverage to weather the storm in 2019."

KeyBanc's Deckelbaum liked Parsley, Oasis Petroleum Inc. and Pioneer Natural Resources Co. Yet, he warned: "While we believe Permian challenges may be temporary, being selective has never been more critical."

Getting Brent

Bernstein's Brackett named Pioneer as "furthest ahead of the bunch. For quarter-after-quarter now, we have heard Pioneer talk about how many cargos they exported. It seemed kind of cutesy and less relevant four or five quarters ago.

"Now it's clearly a source of competitive advantage where they're delivering 160,000 bbl/d of the Permian straight to the Gulf Coast, exporting about half of it and getting Gulf Coast refinery prices for the other half."

According to Pioneer, its exported portion is expected to grow in this half from 110,000 bbl/d to 150,000 bbl/d.

Capital One Securities Inc. E&P analysts wrote, "Pioneer looks to have the most advantaged marketing position out of any Permian producer, as far as we can tell." Having firm transport to the Gulf Coast, "the vast majority of [its] barrels are getting premium pricing to WTI rather than a noticeable discount."

Its firm transport to the Gulf is on more than 90% of its expected production through 2021. "We are not aware of any other Permian producer that can make such an emphatically positive claim," they added.

KeyBanc's Deckelbaum added that Parsley is getting a third of its production to the Gulf and PDC "has tied most of its Delaware crude volumes to the Gulf Coast as well."

Seaport Global Securities LLC (SGS) analysts found that PDC's "takeaway position is more favorable than widely understood." Its contracts have 85% of its Delaware output going to the Gulf Coast this and next year.

" ... We believe many may have underappreciated how insulated the company will be as Mid-Cush diffs take their toll on the Permian-levered group."

The SGS team noted that Diamondback bought some firm transport in mid-June to switch from none of its oil on contract to 66% in this half, 70% in 2019 and 100% in 2020. "In order to make this happen, Diamondback gets dinged with a hefty transport/marketing fee over the next two years," they added.

Under the contracts, Diamondback's average discount to the Gulf Coast price is between $14 and $17/bbl. In 2019, it's between $10 and $12; in 2020, $5. The SGS analysts estimate a net effect on Diamondback's EBITDA of some 8% less for this half and some 4% less in 2019, but some 4% greater in 2020.

Implications for M&A

Jefferies' Marko told *Oil and Gas Investor* the basis situation in the basin may chill M&A activity there. "I think it will mean lower valuations because people are going to grind those [differentials] in. Certainly, the buyers are going to grind those in. And I think it will make the sellers reluctant to sell because they don't want to be schmucks who sell now and, in a year, it gets cleaned up and they've lost $15 a barrel.

"Any time there is uncertainty and risk, it chills things a bit. I think it's just another bit of a headwind into the amount of deals we see."

Bernstein's Brackett told clients in May, "If valuations were to be punished enough, look at it as a tool for industry consolidation. We've talked about that previously—that there is a scale that matters in the Permian: the ability to run enough rigs, ability to be able to call Halliburton [Co.] and secure a frack fleet, the ability to be an anchor on a pipeline takeaway project.

"So," Brackett continued, "this congestion in the Permian might have the unintended consequence of consolidating the basin and actually making it stronger on the way out. In that case, we would be interested in any stocks that are overly punished for what ultimately should be a multiquarter misstep as opposed to a long-term net-asset-value story."

The situation may redirect some spending. Capital One Securities analysts reported in early June, after visiting with E&Ps in Houston, that Permian takeaway and WTI Midland differentials "are currently, by far, the biggest themes/concerns in the E&P space." They estimate a "likelihood for companies to expand

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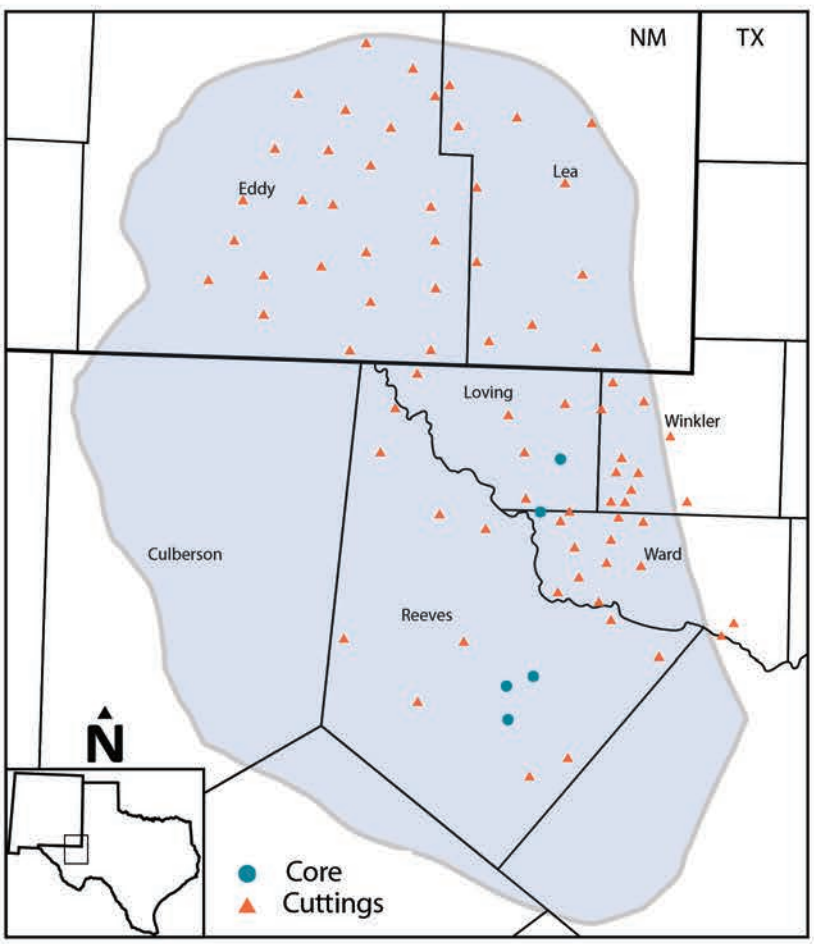

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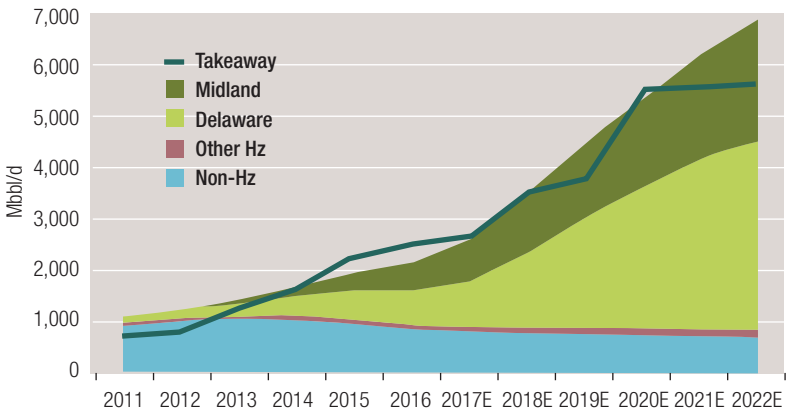
activity and/or acreage positions outside the Permian, given takeaway constraints."

SGS reported it was seeing interest in Eagle Ford- and Bakken-weighted stocks. An operator in the former, Lonestar Resources US Inc.'s "exposure to premium Gulf Coast pricing looks extremely hard to resist, given the near-term [Gulf] LLS-Midland spread." At the time, the second-half 2018 spread was more than $18.

Permian Production Versus Takeaway
Permian Basin Oil Production



Bernstein analysts expect the upcoming new round of big-pipe additions will get the Permian only into mid-2020, when there will be another shortfall at the current rate of production growth. *(Source: EIA, HPDI, Bernstein estimates)*

In the Bakken, SGS cited Whiting Petroleum Corp. "A Bakken-levered E&P provides safe haven from Permian differentials and exposure to one of the highest rate of change plays in the Lower 48."

Where's the pipe?

This pipe-short situation in the basin has appeared before. In this century, until 2013, Permian production was less than 1 MMbbl/d, according to the University of Texas of the Permian Basin (UTPB). About half of that is used in-basin, equity analysts estimate. In the 1970s, at its peak, the basin produced about 2 MMbbl/d, according to UTPB.

2013 began with a Mid-Cush differential of -$14. In August of 2014, it was -$21.

Without takeaway or other above-surface constraint, KeyBanc's Deckelbaum expects Permian production of 4.9 MMbbl/d by 2022.

Hanson at Parkman Whaling forecasted in the first half of 2017 that it will get there sooner, when answering the "What if everyone does what they say they will do" question. By January 2021, Permian production will be between 4.5 and 5.3 MMbbl/d, according to his calculation.

In Hanson's analysis, what was needed—capital, equipment, materials, people, low or no cost inflation, an improved commodity price, takeaway—to reach the 3.2 MMbbl/d that he forecasted would be seen this summer was tremendous, suggesting the mark wouldn't be reached.

But it was reached.

Announced new takeaway underway, according to Imperial's Haas, would bring capacity by year-end 2019 to more than 5 MMbbl/d, "which should be more than enough to accommodate the expected production—and growth—in 2019 and 2020, in our opinion," she reported.

The leading projects are Cactus II (585,000 bbl/d) to Corpus Christi/Ingleside with a third-quarter 2019 completion; EPIC (590,000 bbl/d with 440,000 of those from the Permian) to Corpus Christi, second-half 2019; Gray Oak (up to 700,000 bbl/d) to Corpus Christi and Sweeny/Freeport, year-end 2019; and an Enterprise NGL-to-oil conversion (200,000 bbl/d) to the Gulf Coast, 2019.

Exxon Mobil Corp. and Plains surprised the market in mid-June with news of a letter of intent to partner in a 1-MMbbl/d pipe to the Houston Ship Channel and Beaumont. TPH analysts reported that, with this news, the conversation about Permian oil bottlenecks is "quickly shifting ... to a 2020-plus overbuild scenario."

SunTrust Robinson Humphrey midstream analyst Tristan Richardson estimated that, "although the announcement is purely an LOI at this point" a timeline of a year-end 2018 investment decision would have the pipe in service in mid-2020 at the earliest.

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"While we believe Permian challenges may be temporary, being selective has never been more critical."

—David Deckelbaum, KeyBanc Capital Markets Inc.

"Given this is a producer-backed project—for all practical purposes, even if this producer is massive and is also a refiner—we expect the project timeline will be more dictated by Exxon Mobil's development plans than the overall needs of the basin and, as such, may not be some 'race to market' type of endeavor."

Meanwhile, why is Cushing pricing for WTI still relevant when more and more WTI is going to the Gulf Coast? Reuters took up the topic in April. Carlin Conner, SemGroup Corp. CEO, said, "I believe Cushing's next chapter is that it's going to become an offsite Gulf Coast storage center."

Cushing's reign as the Nymex trading price for WTI was borne from the 1980s launch of Nymex WTI futures trading during the U.S. crude export ban that ended in late 2015.

TPH analysts reported in early June that, with further Permian takeaway projects directed to the Gulf Coast, "we believe Permian operators will cease flowing barrels to Cushing in favor of better priced, export-linked markets."

Imperial's Haas wrote after the Exxon Mobil-Plains news, "Permian outbound congestion is real, but we believe the market has overreacted." She anticipates WTI relief will come in early 2019.

"Texas is a mature petroleum province crisscrossed by a dense network of pipelines, some of which can be repurposed, reactivated and upgraded within short time periods."

That natgas

Adding to the Mid-Cush equation is associated-gas production. Permian producers are expected to capture associated-gas production, and that takeaway capacity is also full.

TPH analysts estimated that the "gas wall likely hits at a similar time to crude—late 2018 into early 2019—and could prove an equal barrier to growth as increased flaring may draw additional regulatory and environmental scrutiny."

KeyBanc's Deckelbaum is less concerned. "We view natural gas as less of an issue as the region does not have basin-wide regulation on absolute flaring volumes. Rather, restrictions are granted at the lease level during what is the most sensitive production timeframe—initial production."

Meanwhile, Baird analysts drew a different conclusion: "The fate of Permian oil this summer looks set to come down to the [Texas Railroad Commission (RRC)]. Natural gas export capacity is maxed out.

"To keep the oil flowing, producers will need to flare, find excess capacity elsewhere or shut in production. Producers can receive a 45-day permit from the [RRC] to flare gas for a maximum of 180 days, primarily for casinghead gas. ... Rare exceptions for long-term flaring may be made in cases where the well or compressor is in need of repair."

SunTrust upstream analyst Neal Dingmann wrote that the RRC "plays ball, but the New Mexico Oil Conservation Division may not." Many Permian producers have gas takeaway contracts, but "several companies have nothing firm."

He expects Texas "will allow mostly all needed Permian natural gas flaring," but New Mexico won't. "This would be pressure on the northern Delaware Basin operators."

Imperial's Haas reported, "Natural gas transport capacity is tight, but most of the public companies under our coverage have secured outbound transportation arrangements and will have flow assurance, in our opinion.

"However, companies will still take varying degrees of revenue hit, as it is difficult to hedge for Permian-gas basis differentials. We believe that smaller, private E&Ps might become 'swing producers,' opting to slow down with unfavorable differentials and help ease the congestion, and more related consolidations could be on the horizon."

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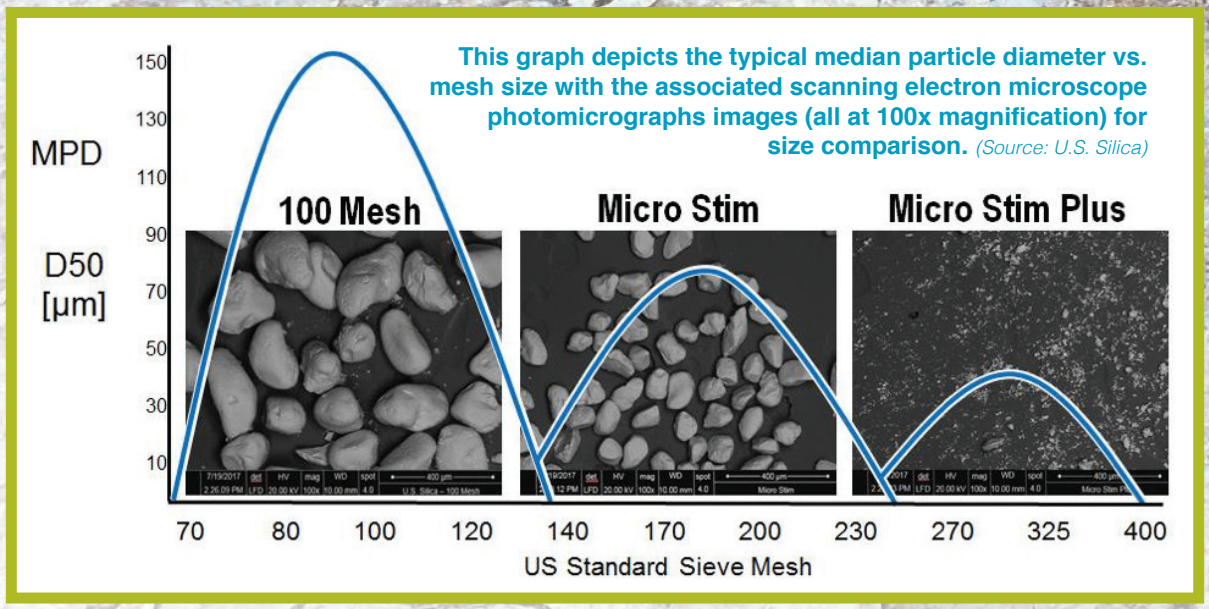

This graph depicts the typical median particle diameter vs. mesh size with the associated scanning electron microscope photomicrographs images (all at 100x magnification) for size comparison. *(Source: U.S. Silica)*

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DUC and Abnormal DUC Counts **Rise** in Permian

Infrastructure bottlenecks are impacting completion times.

By Velda Addison
Senior Editor, Digital News Group, Hart Energy

The Permian Basin's inventory of drilled but uncompleted (DUC) wells continues to swell amid increased drilling activity as operators work their way through cycle times.

But infrastructure bottlenecks in one of the world's most active basins are playing a role in the rising number of "abnormal" DUCs, or wells that remain uncompleted longer than the typical four to seven months it usually takes an operator to complete a well, according to Artem Abramov, vice president of shale analysis for Rystad Energy. The time frame depends on the operator's strategy and maturity of development, he added.

The growing counts come as some E&Ps gear up to increase spending and activity, eyeing improved market conditions. More efficient drilling rigs, pad drilling and fine-tuned completion recipes among other techniques and technology have sent production from the biggest U.S. shale play soaring.

Takeaway capacity has been unable to keep pace.

"Since first-quarter 2018 we started observing somewhat abnormal DUC buildup in the Permian Basin," Abramov told Hart Energy. "Some of these delayed completions (especially for small private operators and new entrants) are clearly related to severe pipeline bottlenecks. Essentially, smaller companies rarely have any firm commitment in pipelines and are fully exposed to Midland spot pricing, which degraded severely."

Data from Rystad Energy ShaleWellCube show the number of abnormal DUCs has risen from 99, or 7% of the Permian's total DUC count, in January 2017 to 235 in January 2018. The latter represents about 9% of the basin's total DUC count. The figure inched down in March to 228.

"It is no longer economically rational to complete some of these wells especially in the non-core parts of the basin as initial well economics assessment was made under more favorable price strips," he said. "Meanwhile, pressure pumping capacity is no longer a bottleneck. In fact, service providers deployed too many new frack spreads over 1H18, whereas demand for pumping service flattened out somewhat."

Rising

Statistics from the U.S. Energy Information Administration's (EIA) drilling productivity report released Aug. 14 show the number of total DUCs in the Permian Basin jumped to 3,470 in July, compared to 2,621 in January 2018 and 1,423 in January 2017.

The number of wells drilled during that time also increased, moving from 363 in January 2017 to 510 a year later and to 601 in July.

But as the EIA explained, "there will always be some DUCs" given the time needed to plan and schedule completion jobs.

"When drilling activity grows it's just normal for the DUC inventories to grow proportionately," Abramov said, noting the bulk of the rising DUC count is associated with growing activity in the basin.

Bringing down the DUC count is on some operators' minds. The topic surfaced briefly on Pioneer Natural Resources Co.'s second-quarter 2018 earnings call Aug. 8. The company announced it plans

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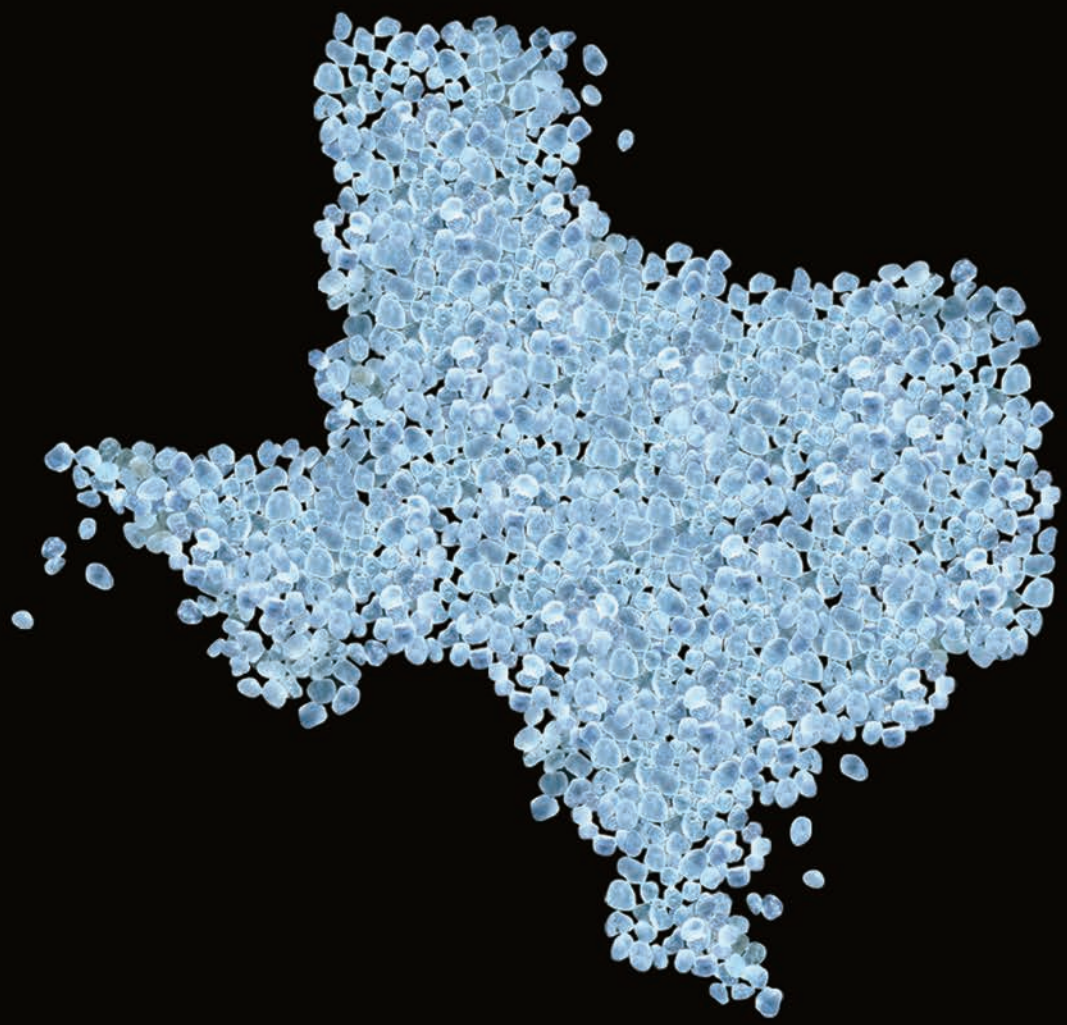

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to run four more rigs in the basin as it gears up for more high-intensity completions for some of its wells. John Freeman, an analyst from Raymond James & Associates, asked about the cadence of DUCs being worked down in 2019.

> "Since first-quarter 2018 we started observing somewhat abnormal DUC buildup in the Permian Basin. Some of these delayed completions (especially for small private operators and new entrants) are clearly related to severe pipeline bottlenecks."
>
> *— Artem Abramov, Rystad Energy*

"Our typical spud-to-POP timing is going to be, say, 150 to 170 days on a three-well pad. You can see that we're talking five months," Pioneer CEO Timothy Dove said. "So we really won't even be completing wells until probably January from the additional rigs. ... It'll affect the cadence of 2019 POPs basically or DUCs. We'll start to reduce that count of DUCs starting early next year."

Others like Noble Energy are also adjusting completion activity as they work to secure long-term out-of-basin takeaway capacity to the Gulf Coast with export opportunities.

"Our decision to moderate some of our completion activity in the near term aligns with the timing of additional takeaway capacity later next year," Gary Willingham, executive vice president of operations for Noble, said on the company's latest earnings call. "This deferral of activity also provides the opportunity to transition our development utilizing the row concept, slightly earlier than we originally planned. Our row-style development mitigates the potential for interference that has been faced by multiple operators across multiple basins."

Coping

Companies with less exposure to pipeline bottlenecks are typically the largest operators that have a greater share of firm transportation commitments, according to Abramov.

To cope with infrastructure constraints, most operators have focused on securing growth through such commitments with gatherers and pipeline owners. For those unable to secure all volumes, long-haul trucking combined with crude-by-rail are seen as temporary relief—something some gatherers have already built toward Wichita Falls and the Gulf Coast, Abramov said.

"So Permian Basin oil production is not stuck at all," he said. "It will continue growing, but the pace of growth will likely slow down a bit. ... The main relief will come in second-half 2019 when 2 million barrels per day of pipeline capacity is expected to be added."

In the meantime, Rystad hasn't noticed any Permian players lowering production guidance due to pipeline constraints. And, shutting in wells is a last resort, he added.

However, a "few operators indeed decided to prioritize development of other plays this year (mainly applies to those who have competitive acreage quality in other basins), but overall industry sentiment remains as follows: 'If I have acreage in the core are of the Permian, upside potential is yet to be seen amid significant multistack potential yet to be unlocked, so I will continue focusing on the Permian.'"

The main implication of the massive DUC buildup is the ability to ramp up production quickly when significant takeaway capacity expansion happens in second-half 2019, Abramov said. "This will require some additions on pressure pumping side, but service companies and proppant suppliers have one year to prepare for this properly on both labor and equipment side."

As for whether delayed completions could lead to well productivity issues later Abramov doesn't believe that will be a problem. Citing the downturn of 2015-2016 as an example, Abramov explained how some major operators in the Bakken, Denver-Julesburg Basin and Eagle Ford delayed a significant number of completions. "Most of these wells were completed in second-half 2016 to 2017 with modern completion techniques performing as well as new drilled wells when controlling for acreage quality," he said. ■

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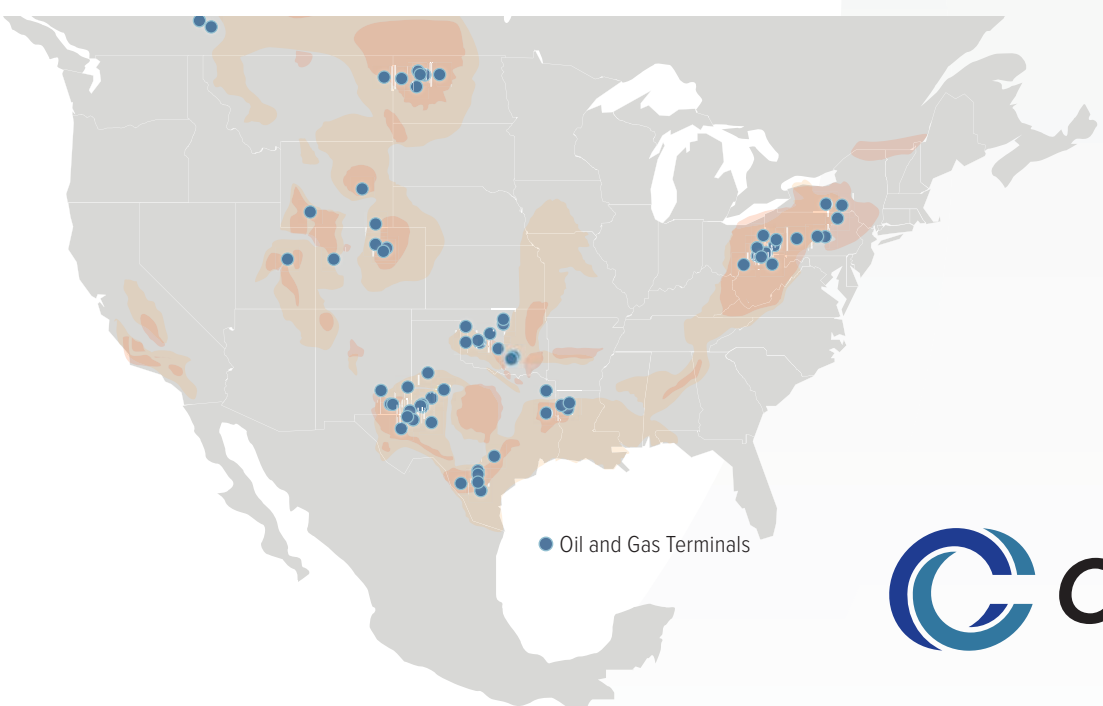

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The **Permian** Shuffle

Operators continue moves to cut operating costs and increase efficiencies.

By Stephen G. Beck
Senior Director, Upstream, Stratas Advisors

For several years now, the Permian Basin has dominated the oil and gas spotlight with promises of a larger-than-life hydrocarbon bonanza based on a seemingly never-ending stack of pay zones. References to as many as 50 hydrocarbon zones and in-place resources of tens of billions of barrels lit up presentation materials and water-cooler chatter alike.

As resource estimates went skyward, capital inflows followed suit. It wasn't long before Permian activity surged and production growth bubbled higher and higher in spite of challenges in various market sectors. Critics, some of whom hailed from the oil and gas community itself, raised doubts about the basin's ability to deliver. But shalers, especially those in the Permian, forged ahead with sheer determination. With the benefit of hindsight, Stratas can take stock of today's Permian opportunity.

The phrase "this is different" seldom rings true. However, this is indeed true when speaking of the Permian. For starters, the Permian is truly immense in terms of areal extent. Add to that promising developments in producing from stacked, multilaterals. Finally, tack on transitioned business models, and there are year-on-year production increases in the basin of about 1 MMbbl/d for December 2018.

Looking at the Permian Liquids Production Estimate chart (Figure 1), no doubts remain regarding the Wolfcamp Delaware's role as a key driver of growth in the Permian. At year-end, Wolfcamp Delaware production will be almost double compared to last year's figure. Key drivers behind the rapid growth are much higher rig counts and enhanced completion designs. Stratas is modeling a 31% year-on-year average increase in Wolfcamp Delaware drilling rigs for 2018. As for completions, watch lateral lengths, proppant loadings and proppant volumes.

Permian Basin represents almost half of spuds.

The Permian continues its march of market dominance. The basin is now home to almost half of U.S. spuds. Using StratasScope, Stratas Advisors' data and data-visualization toolkit, we reviewed the number and aging of DUCs (drilled but uncompleted wells). By our estimates, the Permian is sitting with a little more than 1,000 active DUCs. Obviously, most of these will be worked off in the normal course of operations. Some, however, will become "fallen angels." Fallen angels are wells that held DUC status more than two years ago and are now considered abandoned. In our recent tally of fallen angels, we counted roughly 300 wells.

Permian = quality wells

Great wells are easy to spot in the Permian. The following series of charts capture producing wells in the Permian according to productive categories. Colors range from red to blue, generating a heat map, where red indicates star performing wells, or MVPs (most valuable performers), or wells with peak production rates of 800-plus boe/d. On the other end of the spectrum are the Benchwarmers in cold blue, those wells with peak rates of less than 100 boe/d.

In the Delaware Basin, a pronounced sweet spot is well defined and big. When looking at these maps, it is important to remember that the

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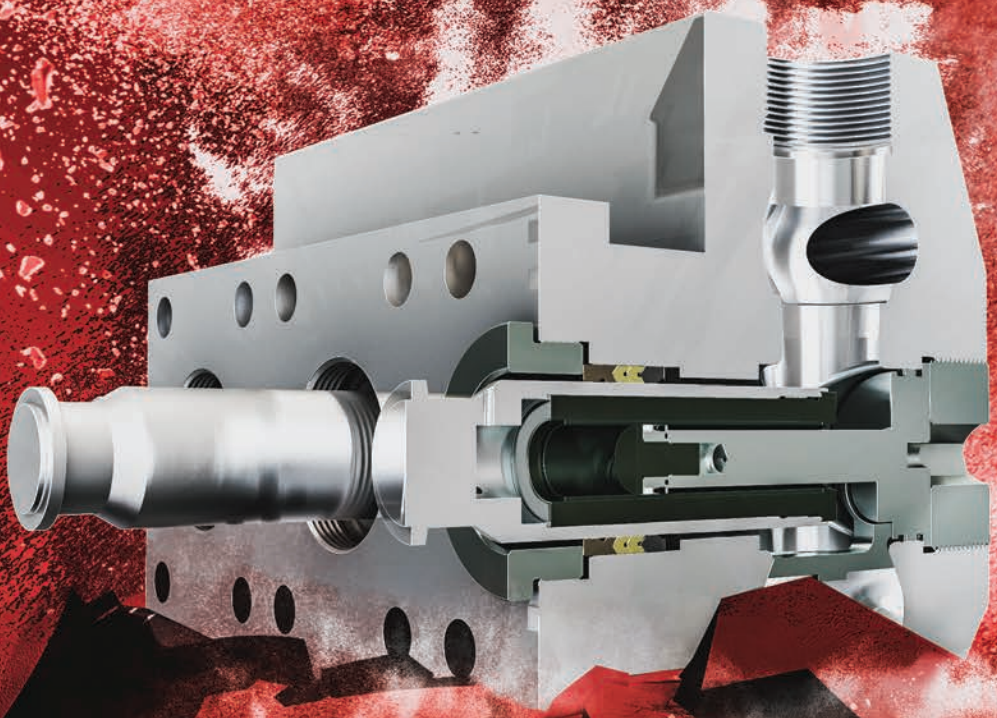

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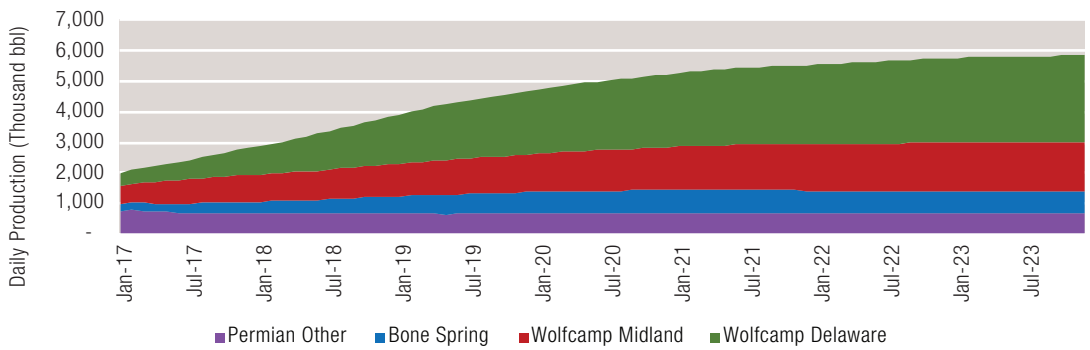
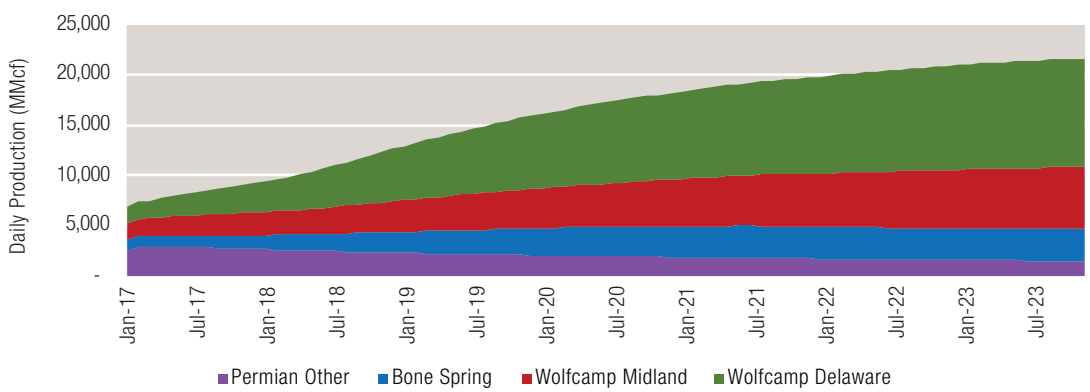
FIGURE 1. Permian Liquids Production Estimate



(All data and images courtesy of Stratas Advisors)

FIGURE 2. Permian Shale and Tight Gas Production Estimate



images are comprised of multiple plays. In this case, the Delaware sub-basin heated (red) area is comprised of both Bone Spring and Wolfcamp Delaware wells.

To the east in the Midland sub-basin, the Wolfcamp Midland (which includes horizontal Spraberry) provides a clear image of where the good wells are located. Not evident from the image is the fact that many Benchwarmers are also found interbedded with these star performers. Consequently, deeper analysis of the Midland sub-basin is needed to gain a better perspective on opportunities and risks.

Looking at just the Bone Spring wells, there is an arc of high-quality wells located almost exclusively in New Mexico. While the map paints a positive image in general, the lack of consistency throughout is a drawback to the Bone Spring and key to our assessment on the limited areal extent of the play.

Filtering down for the Wolfcamp Delaware, a large core area emerges in Ward, Winkler, Reeves and Loving counties. This large areal extent of consistent and highly prospective locations is key to the high values found in the play.

The play continues to capture a modicum of attention and capital. Importantly, a number of companies made recent announcements of expanding success in the second and third Bone Spring. This is to be expected as the Bone Spring has a smaller, but still impressive inventory of high-quality locations. Stratas estimates

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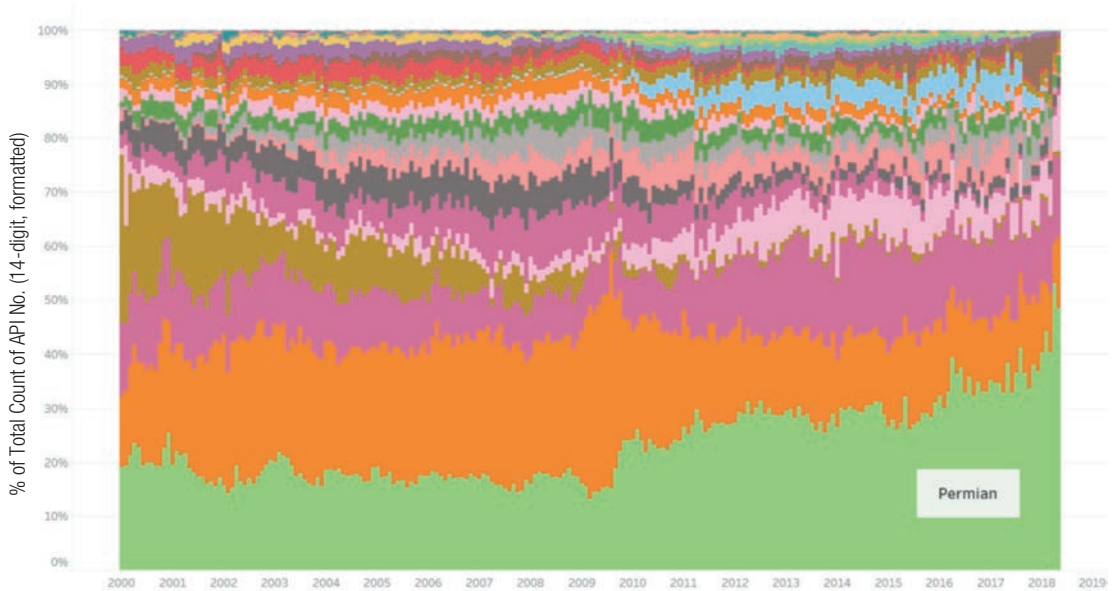
FIGURE 3. US Spud Trends



Stratas expects Permian spud activity to closely track recent levels in 2019.

the Bone Spring will exhaust its inventory of top-class locations in the early 2020s. The Bone Spring remains limited by its relatively small areal extent.

Breakeven prices for the Wolfcamp are some of the best around. Hence, we refer to this play as the MVP of the Permian. That said, the Wolfcamp Midland is no slouch. In recent years, the play has posted some of the best improvements seen. Hence, the Wolfcamp Midland is our MIP, or most improved play.

For those wondering about Alpine High, the play is included with our Wolfcamp Delaware wells. Notably, Alpine High production, while growing rapidly, is a relatively small part of the Wolfcamp Delaware. It is important to remember that Alpine High is only a couple of years old. The play is in the early stages of its life cycle. That said, the play has an ardent champion in Apache Corp. Apache is driving fast and has already invested about a billion dollars on infrastructure alone.

Elsewhere, Wolfcamp Delaware operators are building out infrastructure at a rapid pace. Anadarko Petroleum recently announced the startup of its Reeves County Oil Treatment Facility (ROTF) and the imminent startup of a second facility nearby in Loving County. Other operators have installed water recycling facilities. In aggregate, these investments open the door for more efficient and cost effective logistics in the basin. Collectively, the ongoing buildout of infrastructure is key to long-term growth potential. At press time, long-term production rates are tracking toward 6 MMbbl/d due in large part to these and other infrastructure investments.

In the Midland, year-on-year production growth is estimated to grow by almost 20%, with year-end production settling at a little more than 1 MMbbl/d. As we mentioned previously, we considered the Wolfcamp Midland the most improved play based on breakeven economic terms. Unfortunately, headwinds in the Midland appear to be intensifying due to some extent on bottom-hole conditions. A natural solution to this is to drill longer laterals. Several operators announced intentions to do just that.

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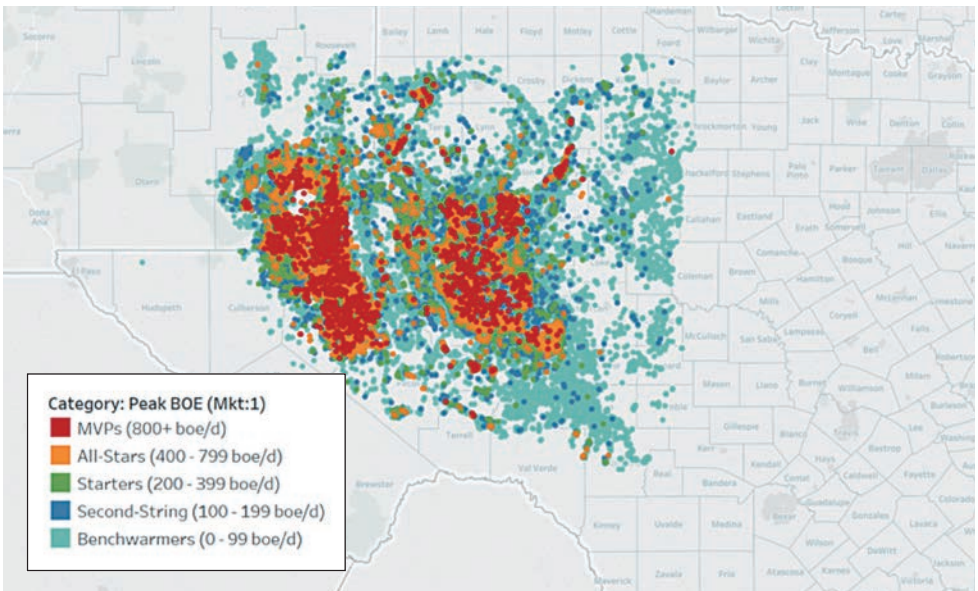
FIGURE 4. Permian Basin Categories



Sticking with what works

In 2019, leading operators will continue to push on levers that served them well in recent years. Efforts will focus on maintaining firm control on completed well costs, leveraging infrastructure to control both procurement and field operating costs, and bolstering capabilities to increase probabilities for success in turning on lesser resources more economically. To accomplish this, operators have begun outlining plans to increasingly focus on development mode activities. One key benefit of operating in development mode is increasing the number of wells and zones per pad.

However, we expect only modest gains from increases in wells per pad. When it comes to drilling, the low-hanging fruit was harvested years ago. Skidding and walking rigs took over the landscape and changed the drilling operations forever. Mobilization times cratered, nonproductive drill times were reduced, and automation slashed costs while enhancing performance and safety. Today, pilots testing remote drilling using remote sensors are breaking new ground. If successful, the fundamental relationship between equipment and crew will surely change. In the present, not much is left to pick from the rig tree—maybe some bi-fuel savings, but not much else.

In recent years, more time and attention have been devoted to planning of wells and drilling. Greater emphasis on drilling high-quality wells seems to be the norm. Operators value the benefits of working on a high-quality well, wells with fewer extreme doglegs. Hence, drillers are motivated to drill both fast and straight. With drilling operations appearing in good order and with estimates attributing about 35% of total capex to drilling, the operators began shifting their attention to completions.

Completions and related activities

Shining the light on procurement, much has happened to drive down costs in recent years. Expect to see limited improvements from here. Sand is increasingly sourced nearby, ensuring operators the lowest cost on the single largest cost in a well. With the transition to local sand now well underway, most operators have established multiple direct channel sources and have begun reducing long-haul sources in


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FIGURE 5. Bone Spring Categories

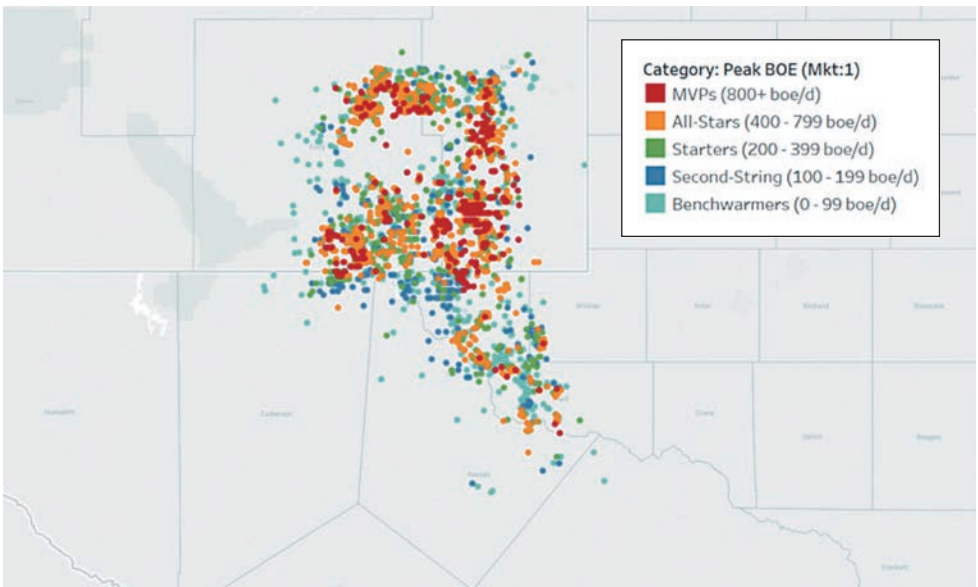
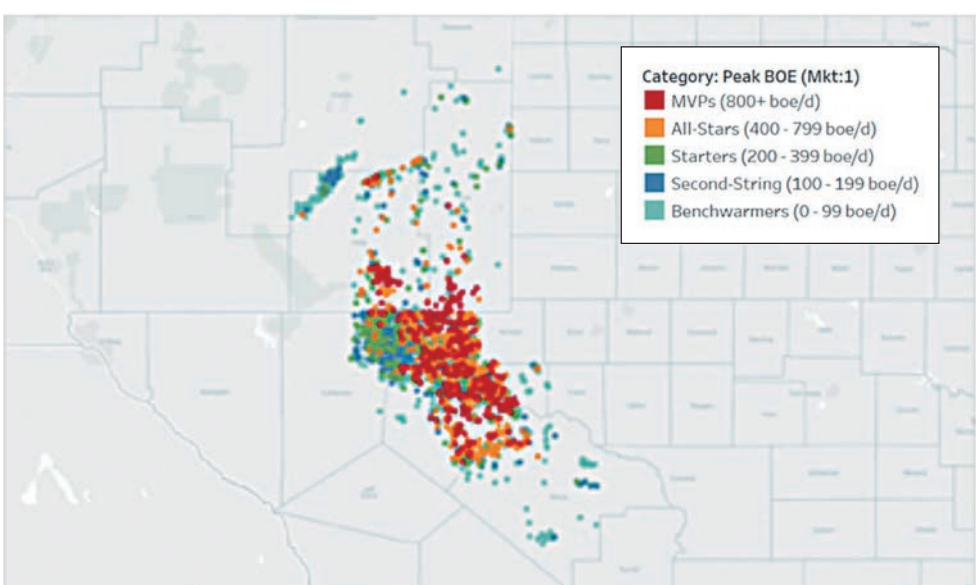


FIGURE 6. Wolfcamp Delaware Categories



earnest. Some larger operators pushed beyond sand in direct sourcing and now source their own chemicals and other consumables too. Stratas believes that only the most sophisticated operators can execute this level of procurement effectively due to the need for specialists needed and the substantial risks with less than optimal procurement results.

Turning to completions, most gains have been captured. The shift from single well pads and single well completions to multiwell pads coupled with zipper frack completions generated the greatest

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opportunity to realize efficiency improvements. During the past 18 months, companies increasingly shifted to two-well pads and zipper fracks in efforts to drive down completion expenses. The benefits of a zipper frack are derived from the ability to cycle completion equipment and resources between pairs of wells during fracking.

One more thing on completions and rigs. The move to zipper fracks has tilted the balance between rigs and spreads in several basins, including the Permian. In response, some operators are adding rigs, while others are releasing completion crews. Regardless of which direction a company takes, the fact remains that demand for completion spreads has eased on a normalized basis. A clear positive development in all this is the alignment of interests between completion crews and operating companies. There are examples of contractual structures that encourage cost reductions for the operator while providing uplift opportunities to the fracking company. Mechanisms like this spell a win-win for oil and gas development.

Returning to the infrastructure discussion introduced in the Wolfcamp Delaware section, the investments highlighted include buildouts of water infrastructure and infrastructure for gathering, processing and distribution of products, and the construction of local sand mines. These actions were taken to address operational constraints, rising costs and pressure to live within cash flow.

The aforementioned infrastructure solutions were a direct response to all three concerns listed. With respect to operational constraints, the water and processing facilities go a long way in preparing a company to supply, treat and dispose of water at lower cost and without the need for as many trucks. With respect to oil and gas processing and treating facilities, regional treatment of products opens access to pipelines. Treated crude products meet pipeline specs, thus reducing the need to transport product by truck.

By now, it is probably clear that trucks and trucking are a major bottleneck in the Permian. With respect to field ops, water is huge. During drilling and completions, water is needed for mud, completion fluids and general purposes. Trucks are a primary mover of water in oil fields. Historically, trucks hauled freshwater in and hauled flowback and produced water out. Enter centralized water treatment and infrastructure. These facilities and pipelines enable water to be handled and treated in ways that dramatically reduce road loads. Other options also presented themselves. For example, operators increasingly experimented with brine and recycled water with good results. Consequently, numerous operators have plans to increase their use of recycled water, and this trend will likely continue.

Truck transportation serves many other roles around oil fields. Completions equipment, rigs and materials all make their way to pads via trucks. The number of trucks is huge. Consider a standard drilling rig: a double or triple with walking systems, high volume mud pumps, AC power with all the bells and whistles configured in modular form. Moving that rig from pad to pad will likely require 22 tractor-trailer loads. That doesn't sound bad until you consider that the Permian has averaged about 450 rigs week-in and week-out this year.

So, time for a little napkin math: 22 tractor-trailer loads times 450 rigs equals 9,900 truckloads. Assuming a rig drills 18 wells per year on pads comprised of three wells each leads to six moves per rig through the year. Multiplying 9,900 truckloads by six moves equals 59,400 truckloads, and this is just for rigs. Completion spreads and materials shipments exert even greater demand than rigs. Hence, operators who are able to find alternatives to trucks and trucking stand to benefit.

It's now time to bring it all together under a single umbrella. Drilling and completion of wells are now mostly optimized, procurement of materials has been in-sourced and localized where feasible, and infrastructure is being leveraged to reduce exposure to volatile costs. That covers the key cost concerns.

With all the emphasis for companies to reside within cash flow in recent years, and with excess costs already driven out, companies are left with few options for working with sub-optimal assets. Therefore, we see the transition to longer and longer lateral lengths. Over the span of many years, we have observed a consistent response by operators when faced with lower performing rock: Drill a bigger well. This is tried and true. Based on reviews

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of wells ranked and grouped according to Quintile Ranks (QR) covering many years, wells in the bottom ranks (QR4 and QR5) tend to have longer lateral lengths. The move to longer laterals closes the chapter on first-generation solutions.

Multizone completions

Operators have been producing from multiple zones for years. A shining example is the Bakken/Three Forks. Moreover, tapping into even greater number of zones has been a goal of many operators. One science project that seems intent on pushing the boundaries is Encana Corp.'s Cube design, which just happens to be in the Permian. For years, we refused to give credit for large numbers of hydrocarbon zones due to commerciality concerns. Being conservative in this area was the prudent thing to do.

Hence, it is no small measure for us to make such a change. Until now, Stratas gave credit to no more than four productive zones in any square mile area. While changes will be made on play-by-play and case-by-case basis, Stratas now feels comfortable allotting up to six zones per section in the Permian. This change fundamentally raises our economic assessment of the Permian.

In the coming months, Stratas will kick off an unconventional resource study and estimates of the Permian will figure prominently. As we mentioned at the outset of the article, the Permian is different. In the Permian, everything is bigger—bigger crowds, bigger capital, bigger rig counts, bigger well packages. In many respects, the Permian and its constituent members appear stronger than ever. There really is no substitute to being tested. ■

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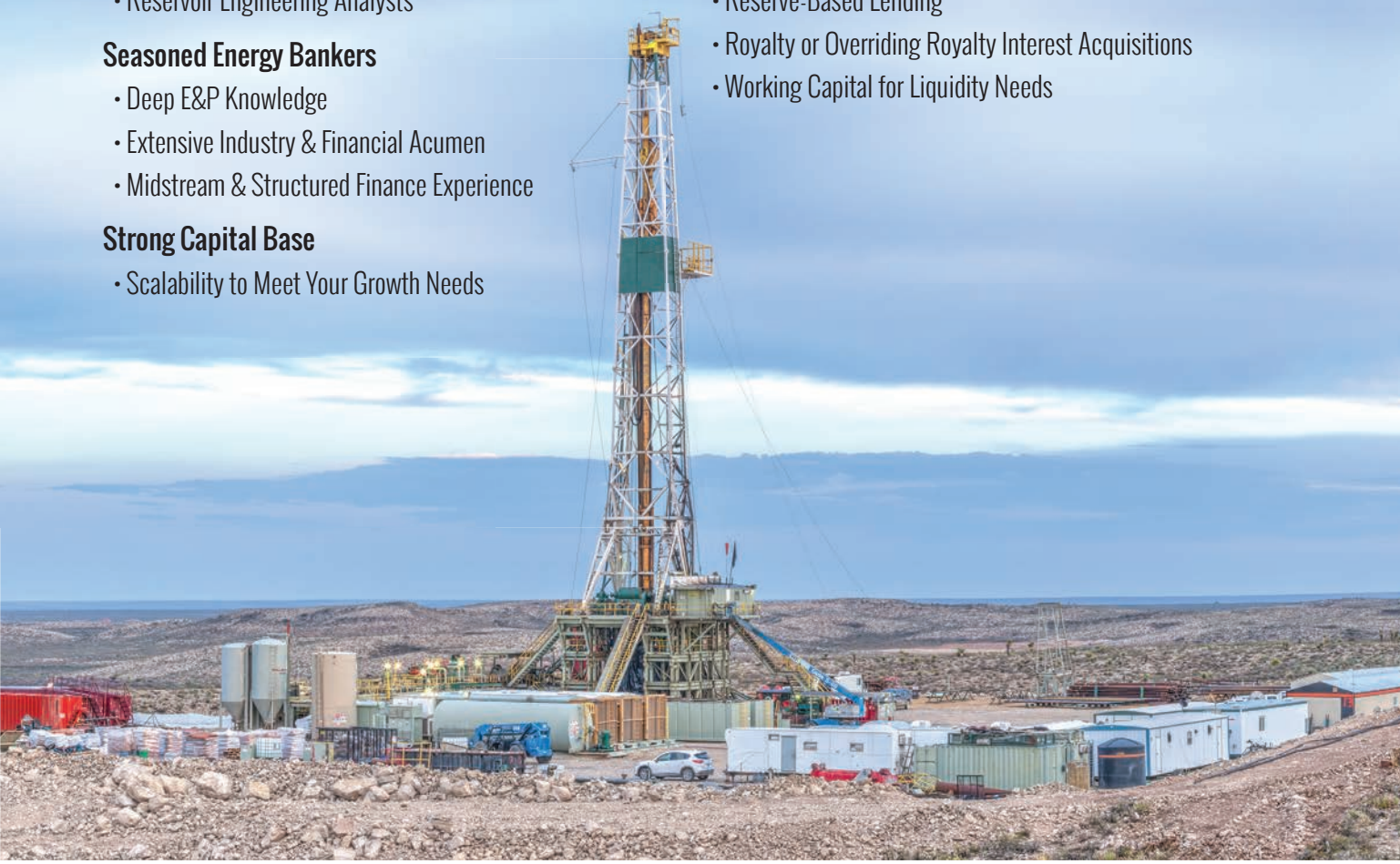

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Apache Prepares to **Boost Production** at Permian's Alpine High

Recent report indicates a steep production increase is on course for third- and fourth-quarter 2018.

By Velda Addison
Senior Editor, Digital News Group, Hart Energy

With completion design changes in hand, spacing and pattern tests underway and costs down, Apache Corp. said production growth is entering the acceleration phase at its Permian Basin Alpine High development.

The Houston-based company reported production at Alpine High jumped 23% to average 32,000 boe/d in second-quarter 2018, compared to a year earlier. By the end of July, production had already climbed by 70% to 54,000 boe/d as optimization continues.

"For 2018 our Alpine High production is on track to achieve 45,000 boe/d, which is the midpoint of our previous guidance," Apache CEO John Christmann said on a conference call Aug. 2. "The benefits of pad drilling coupled with continual progress on well costs and well productivity are driving a positive bias to our production outlook for next year. As a result, we anticipate that 2019 production from Alpine High will trend toward the high end of 85,000 to 100,000 boe/d guidance range that was established in February."

The emerging oil and gas play sits in the Delaware Basin, mostly in Reeves County, Texas. The company announced the discovery in September 2016, estimating 75 Tcf of rich gas and 3 Bbbl of oil in place in the Barnett and Woodford formations plus potential in the shallower Pennsylvania, Bone Springs and Wolfcamp formations. Apache puts its drilling inventory for the play at more than 5,000 wells, but Christmann called the inventory count "conservative" based on results of landing zone and spacing tests.

The 2018 Alpine High program includes pad and pattern development tests, geographic delineation and acreage retention drilling, Christmann said, noting the move to large pad drilling. A steep production increase is on course for third- and fourth-quarter 2018 following a completion ramp-up that Apache said is in progress. Plans are for the company to place about 90 wells on production this year as well as conduct tests on the southern flank to delineate the play.

So far, optimization efforts appear to be paying off based on recent Alpine High well results shared in the company's operations supplement.

Blackfoot, a 12-well pad that is testing 660-ft spacing and three Woodford landing zones on a half section, flow tested at 99 MMcf/d of gas and 200 bbl/d of oil, and is improving, said Tim Sullivan, executive vice president of operations support for Apache.

Christmann pointed out that the production had increased further by the morning of Aug. 2, producing 102 MMcf/d. "That shows you the

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trajectory that it is on. ... It is performing very strongly," he said.

Positive results were also shared for other wells, including the six-well Dogwood pad in the play's dry gas area where 660-ft spacing in the Woodford and Barnett formations were tested.

> "The benefits of pad drilling coupled with continual progress on well costs and well productivity are driving a positive bias to our production outlook for next year."
>
> — *John Christmann, Apache*

"The Dogwood wells went online around the beginning of the year and continue to deliver at a stabilized gross rate of nearly 50 million cubic feet per day. This pad has been producing for more than 180 days with a cumulative production of 11 Bcf, and we see no signs of interference," Sullivan said. "We believe that this performance on 660-foot spacing in the dry gas window has positive implications for future additional inventory in the source interval where we have assumed 800- to 1,000-foot spacing in our current location count."

The next phase of optimization at Alpine High includes testing spatial positioning within and between target intervals as well as refining landing zone targeting, drilling longer laterals where possible and increasing the use of larger stimulations, Christmann said.

The plans are part of the reason why Apache is upping capital guidance in the play.

During the second quarter, the overall oil and gas capital investment for Apache—which also has assets in the North Sea, Egypt and elsewhere in the Permian Basin—was $833 million, including $116 million for Alpine High midstream, the company said in its second-quarter 2018 earnings release. The company shelled out about $1.7 billion in total capital investment for the first six months of the year and expects to spend about $3.4 billion total for the year. That's up from prior guidance of $3 billion, Apache said.

"This spend level anticipates a full year of Alpine High midstream investment, which may change with a potential transaction," the company said. "The incremental capital is necessary to align and optimize drilling and completion activity in the Midland Basin and to fund investment in longer laterals, larger completions and facility expansions at Alpine High. These activity modifications incorporate learnings from the company's recent strategic tests and are expected to result in increased productivity and improved returns."

Given today's strip prices, Apache said the cash flow from operations will fully fund the capital increase.

Supply cuts courtesy of an OPEC-led initiative have helped buoy oil prices. Since the downturn, which forced oil companies to become more efficient, oil prices have steadily increased, rising to around $70/bbl from lows below $30 in 2016.

On Aug. 1, Apache reported $1.9 billion in oil and gas revenue for the second quarter, up from $1.38 billion a year earlier.

Earnings were $195 million for the second quarter, compared to $572 million a year ago. Apache said the latest earnings results "include a number of items outside of core earnings that are typically excluded by the investment community in their published earnings estimates."

On the call, executives said the company is hitting goals when it comes to bringing down drilling and completion costs, which fell by 25% despite downward pressure on service costs. Apache targeted well costs below $1,380 per treated lateral foot, but costs are now averaging less than $1,260 per treated lateral foot, according to Sullivan.

Most of the savings were attributed to operational efficiencies.

"On the completion side we've really been able to reduce pump time substantially," Sullivan said. "We're drilling out our plugs even quicker, and we've even made progress just on frack crew moves. This has given us a 20% reduction in our cycle time, which for a 1½-mile lateral is about a $400,000 saving."

Apache also raised its U.S. production guidance to 260,000 boe/d. It was previously between 250,000 and 258,000 boe/d. ■


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Additional Information on the Permian Basin

For more details on the Permian, consult the selected sources below.

By Alexa West
Assistant Editor

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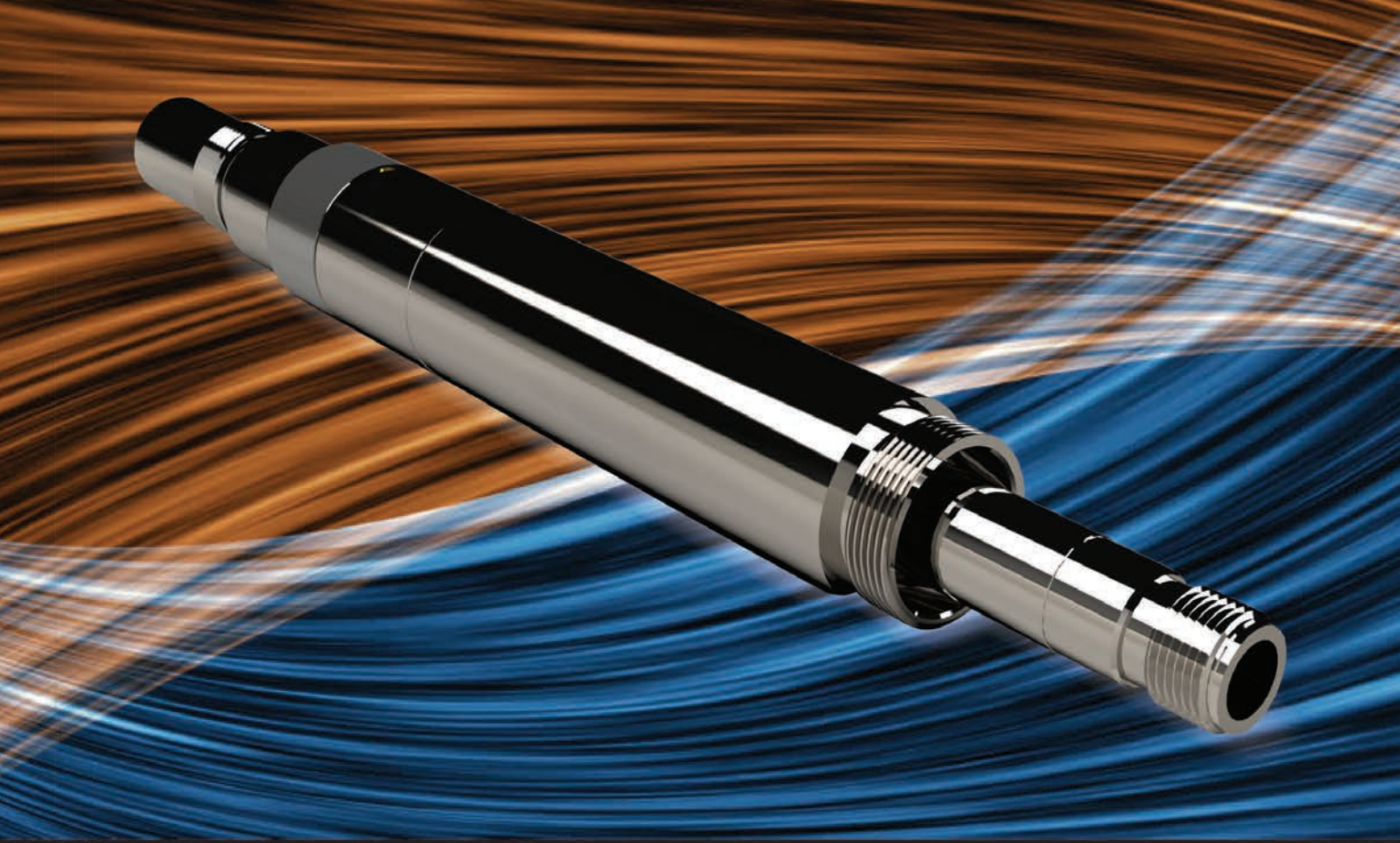

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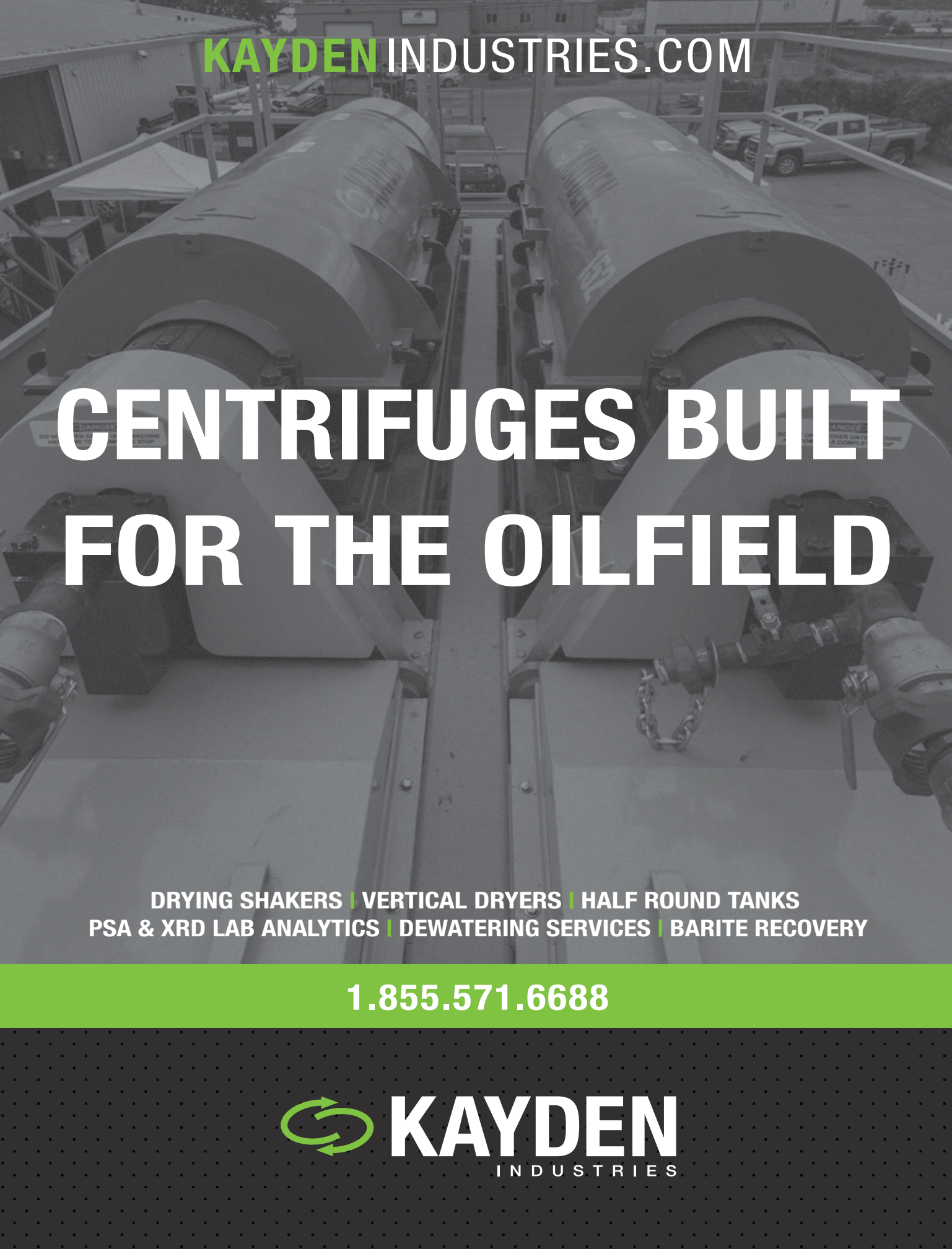

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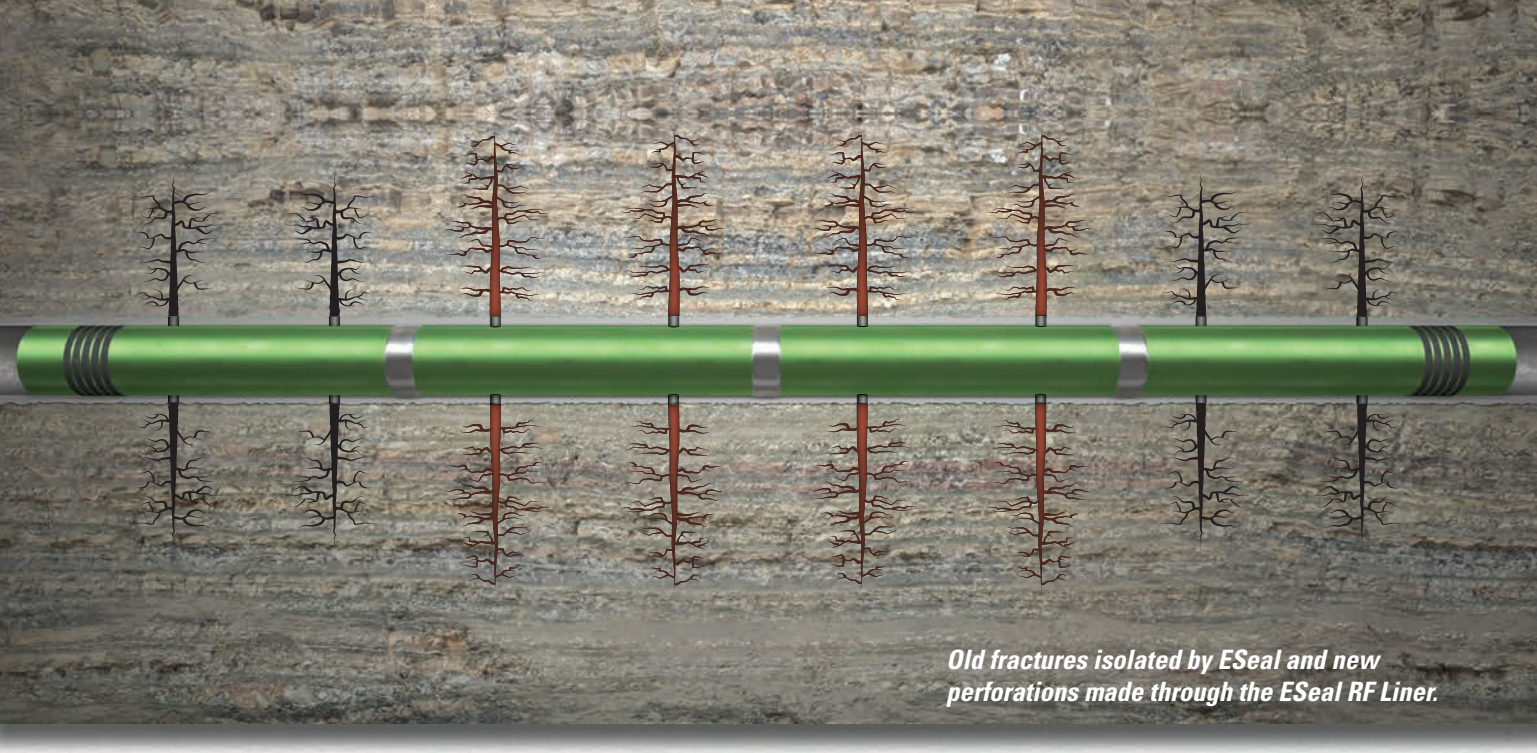

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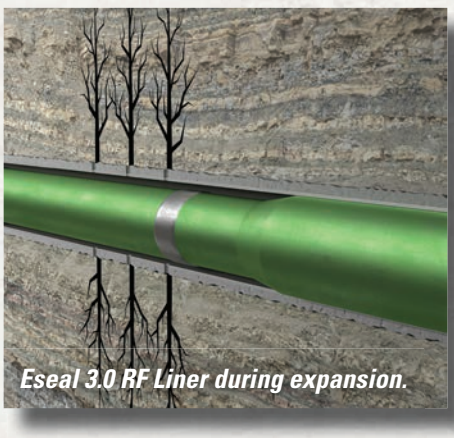

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