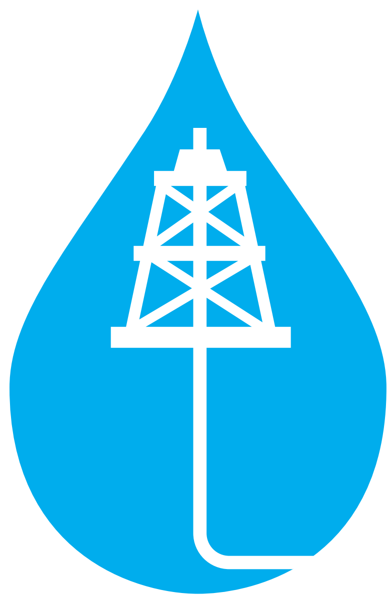
HYDRAULIC FRACTURING & WATER STRESS: Growing Competitive Pressures for Water



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Summary

This Ceres research paper analyzes water use in hydraulic fracturing operations across the United States and the extent to which this activity is taking place in water stressed regions.[1] It provides an overview of efforts underway, such as the use of recycled water and non-freshwater resources, to mitigate these impacts and suggests key questions that industry, water managers and investors should be asking. The research is based on well data available at FracFocus.org and water stress indicator maps developed by the World Resources Institute.

FracFocus data was collected for more than 25,000 tight oil (sometimes referred to as shale oil) and shale gas wells in operation from January 2011 through September 2012. The research shows that 65.8 billion gallons of water was used, representing the water use of 2.5 million Americans for a year. Nearly half (47 percent) of the wells were developed in water basins with high or extremely high water stress. In Colorado, 92 percent of the 3,862 wells were in extremely high water stress areas. In Texas, which accounts for nearly half of the total number of wells analyzed, 5,891 of its 11,634 wells (51 percent) were in high or extremely high water stress areas. Extremely high water stress means over 80 percent of available water is already being withdrawn for municipal, industrial and agricultural uses.

The research paper provides valuable insights about potential water use/water supply conflicts and risks, especially in basins with intense hydraulic fracturing activity and water supply constraints (due to water stress and/or drought). Given projected sharp increases in production in the coming years and the intense nature of local water demands, competition and conflicts over water should be a growing concern for companies, policymakers and investors. Prolonged drought conditions in many parts of Texas and Colorado last summer created increased competition and conflict between farmers, communities and energy developers, which is only likely to continue.[2] In areas such as Colorado and North Dakota, industry has been able to secure water supplies by paying a higher premium for water than other users or by getting temporary permits. Neither of these practices can be guaranteed to work in the future, however. Even in wetter regions of the northeast United States, dozens of water permits granted to operators had to be withdrawn last summer due to low levels in environmentally vulnerable headwater streams.[3]

The bottom line: shale energy development cannot grow without water, but in order to do so the industry's water needs and impacts need to be better understood, measured and managed. A key question investors should be asking is whether water management planning is getting sufficient attention from both industry and regulators.

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1 Where water stress refers to the proportion of the annual renewable supply of water in a region being withdrawn for human use.

2 Jack Healy, "For Farms in the West, Oil Wells Are Thirsty Rivals," *The New York Times*, September 5, 2012

3 Susquehanna River Basin Commission, Press Release, "64 Water Withdrawals for Natural Gas Drilling and Other Uses Suspended to Protect Streams," July 16, 2012

Research Background

FRACFOCUS

FracFocus.org was launched in 2011 to serve as a voluntary national hydraulic fracturing chemical registry and is managed by the Groundwater Protection Council and the Interstate Oil and Gas Compact Commission to provide the public with access to information about the chemicals used for hydraulic fracturing. The database provides the location of each well that was "fracked," the date it was fracked and the chemical additives and total volume of water injected down the well. However, information on the source and type of water used (e.g. freshwater, recycled, saline etc.) for each well is not disclosed and there are trade secret exemptions being claimed in supplying chemical information to the site. Since being launched, 10 states and two Canadian provinces have opted to use FracFocus for regulatory reporting.

Since disclosure to FracFocus is often still voluntary, the number of wells and volume of water injected/used is underreported. Bloomberg estimated that FracFocus captured data on about 60 percent of wells fracked through the end of 2011, but disclosure is likely now even higher.[4] The data in Ceres' analysis represents wells drilled from Jan. 1, 2011 through Sept. 30, 2012 and captures information on 25,450 wells. It includes both oil and gas and horizontal and vertical wells that have been hydraulically fractured. PacWest Consulting Partners helped organize and interpret the data.[5]

WRI AQUEDUCT WATER RISK ATLAS

The World Resources Institute's (WRI) recently launched Aqueduct Water Risk Atlas (Aqueduct) provides companies, investors and governments with a comprehensive, high-resolution picture of water-related risks worldwide. The Aqueduct includes 12 global water indicators grouped into three categories: physical water quantity risk; physical water quality risk; and regulatory and reputational risk.[6] Our analysis focused on the baseline water stress indicator, which is indicative of the level of competition in a given region and measures total annual water withdrawals (municipal, industrial and agricultural) expressed as a percentage of water available.[7]

LINKING THE DATA

By linking the two datasets together through matching latitude and longitude coordinates, Ceres was able to study well locations and water volumes being injected against geographic water quantity indicators provided by the WRI maps. This allows us to study the extent and distribution of well locations in regions with water-sourcing challenges. By aggregating the total volume of water used in any region, we gain valuable insights into the water demand for hydraulic fracturing against water supply constraints such as drought severity and water stress. These indicators speak to the growing competitive pressure for water.

4 Benjamin Haas, Jim Polson, Phil Kuntz and Ben Elgin, "Fracking Hazards Obscured in Failure to Disclose Wells," Bloomberg News, August 14, 2012

5 PacWest Consulting Partners provides a database of the FracFocus source data developed through custom-built software that parses, cleans, analyzes and interprets the data in conjunction with human analysts.

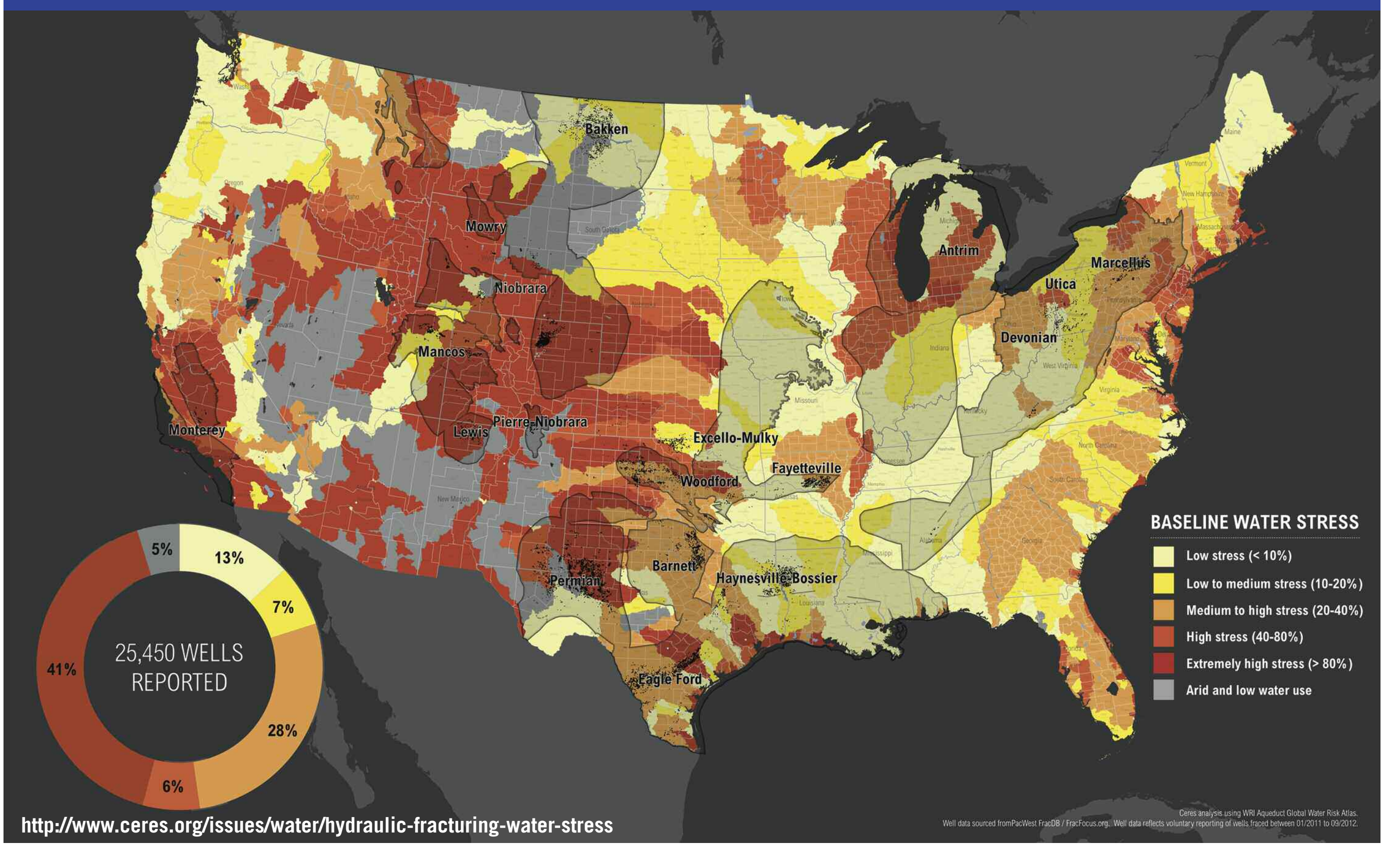
6 World Resources Institute, Release: "New Mapping Tool Provides Unprecedented Ability to Assess Water Risk," January 30, 2013;

7 For details on methodology see white paper by Francis Gassert, Matt Landis, Matt Luck, Paul Reig and Tien Shiao, Aqueduct Metadata Document, Aqueduct Global Maps 2.0, January 2013

Key Findings

In the below map and in Figures 1 and 2 (p. 6) one can see that almost half (47 percent) of shale gas and tight oil wells are being developed in regions with high to extremely high water stress. This means that over 80 percent of the annual available water is being withdrawn by municipal, industrial and agricultural users in these regions. Overall 75 percent of wells are located in regions with medium or higher baseline water stress levels. Although water use for hydraulic fracturing is often less than one or two percent of a state's overall use, it can be much higher at the local level, increasing competition for scarce supplies. **Please click on the map to access an online map that allows you to zoom in on specific regions and well sets.**

COMPETITION FOR WATER IN U.S. SHALE ENERGY DEVELOPMENT



Map of hydraulically fractured well locations as overlaid onto the WRI's Aqueduct water risk atlas using the baseline water risk indicator. Forty-seven percent of wells are found in regions with high or extremely high water risk indicating growing competitive pressure on water supplies for shale energy development. Well locations in the map above appear as black patches, in the online map where they are more easily viewed they appear as black circles. Shale basins are represented by shaded areas. Click on map to access online map.

FIGURE 1: NUMBER & PERCENTAGE OF HYDRAULICALLY FRACTURED WELLS BY WATER STRESS

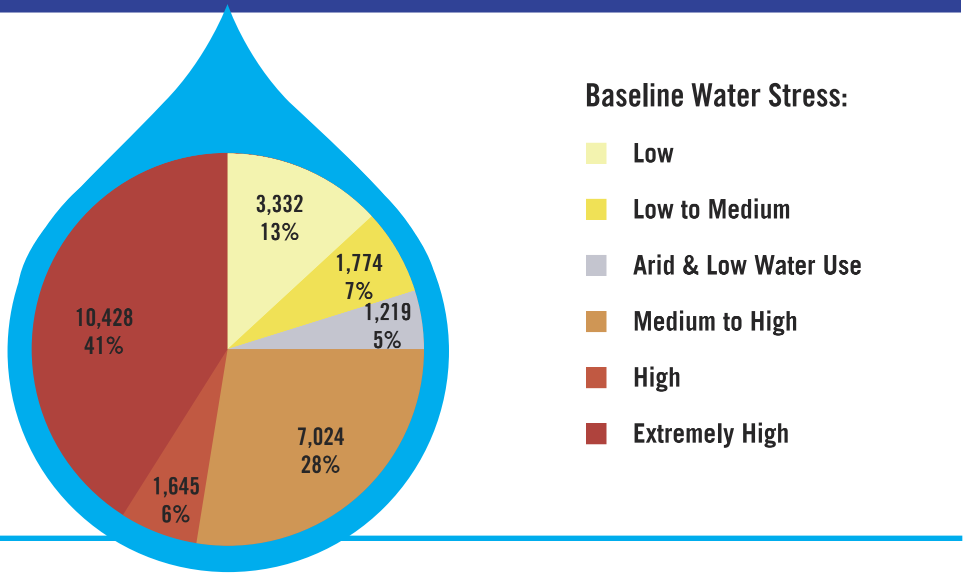
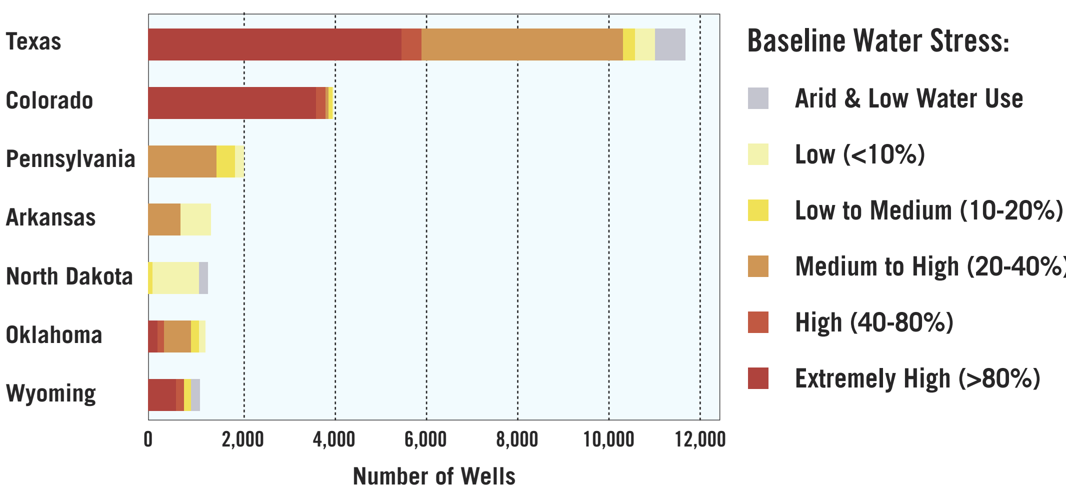


FIGURE 2: NUMBER OF HYDRAULICALLY FRACTURED WELLS BY STATE & WATER STRESS



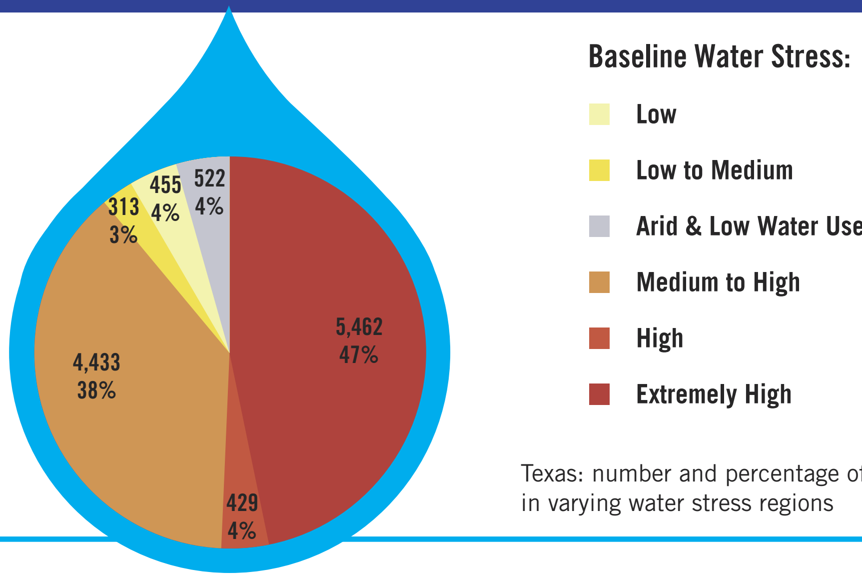
Numbers of wells in top seven shale energy producing states by water stress.

Figures 3 through 6 (pp. 7-8) graphically extrapolate from the maps the number of wells and the volume of water injected for hydraulic fracturing in the major energy development states. Wells in Texas make up just under half of the total wells reportedly drilled and water volumes injected. Just under half of the wells developed in Texas are in regions with high to extremely high water stress. In Colorado, 97 percent of wells are being developed in regions of high or extremely high water stress.

According to the data, from Jan. 2011 to Sept. 2012, 65.8 billions of gallons of water were used in hydraulic fracturing operations both for oil and gas development and in vertical and horizontal wells across the U.S. This amount represents roughly the water use of 2.5 million Americans for a year.[8]

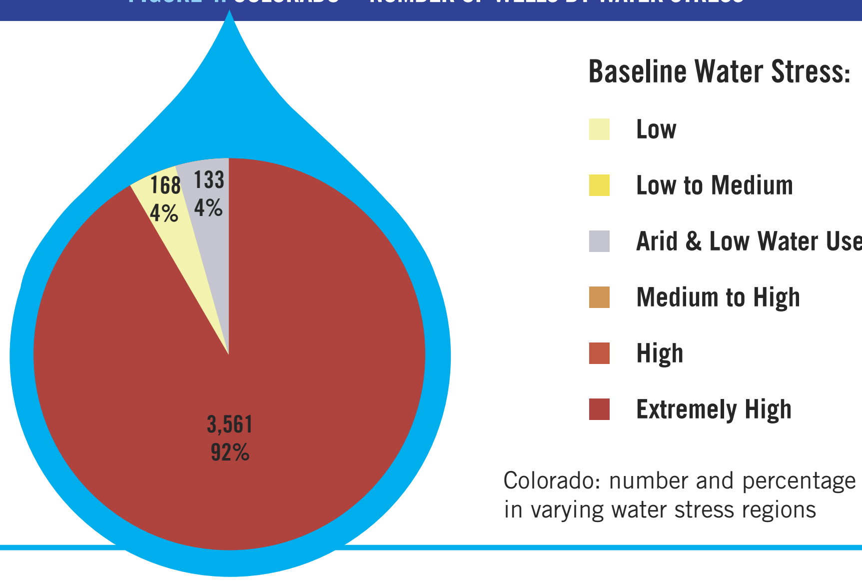
8 The EPA estimated that 70bn gallons represented the water use of one city with 2.5m inhabitants in its Draft Plan to Study the Potential Impacts of Hydraulic Fracturing on Drinking Water Resources, February 2011

FIGURE 3: TEXAS—NUMBER OF WELLS BY WATER STRESS



Texas: number and percentage of wells in varying water stress regions

FIGURE 4: COLORADO—NUMBER OF WELLS BY WATER STRESS



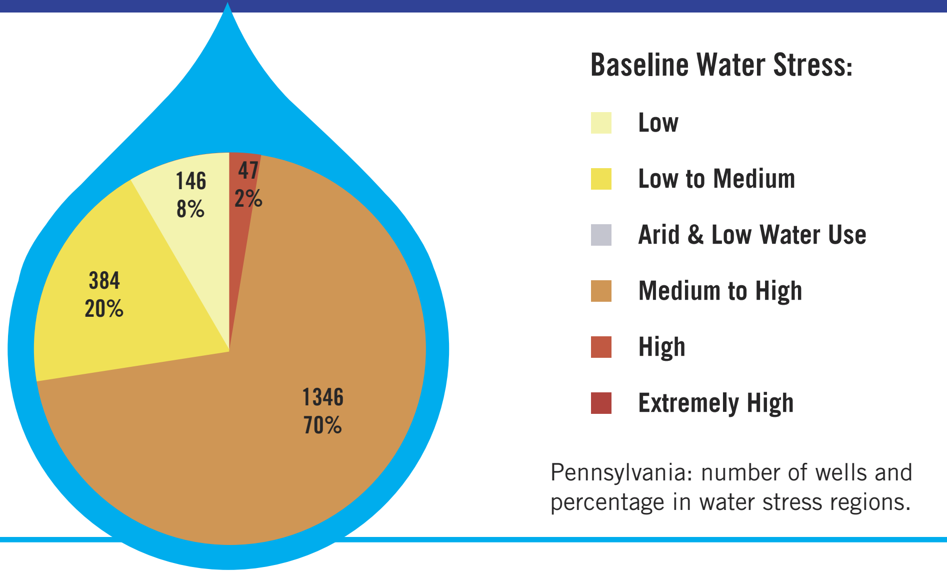
Colorado: number and percentage of wells in varying water stress regions

Texas, Pennsylvania and Arkansas were the three states with the highest water use for shale energy. Water use data for oil and gas development in Texas in another study was estimated to be about 26 billion gallons of water for 2011.[9] Our data reflects similar water use but from a longer period of time, thus supporting that FracFocus data under reports water use. Similarly the Colorado Oil and Gas Conservation Commission estimated water use in 2011 for hydraulic fracturing to be just under five billion gallons.[10] Our numbers for Colorado water use are similar, but again are from a longer period of time.

9 Scott Tinker, "Oil & Gas Water Use in Texas: Update to the 2011 Mining Water Use Report," Bureau of Economic Geology, September 2012

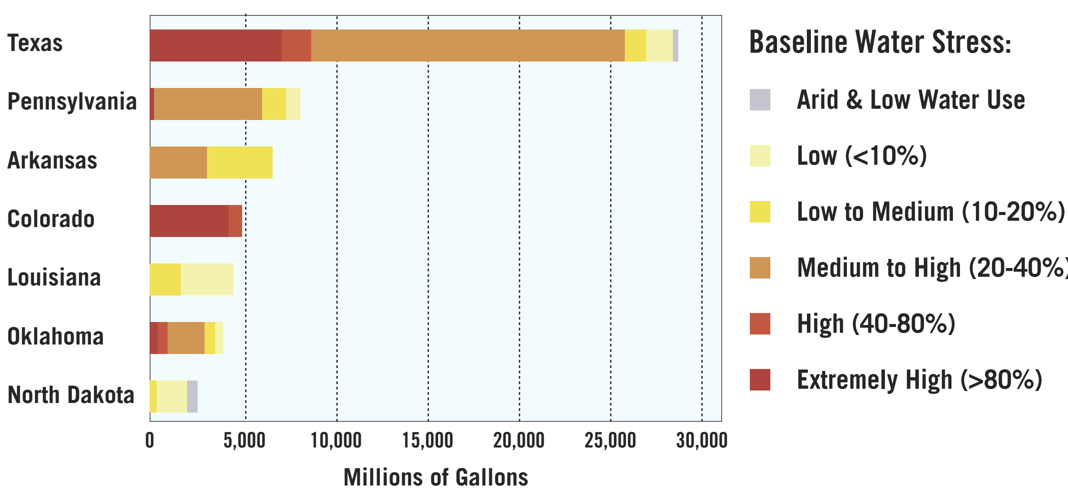
10 Estimates of 2011 Colorado water use for hydraulic fracturing were 14,900 acre feet with one acre foot being equivalent to ~326,000 gallons. From "Water Sources and Demand for Hydraulic Fracturing of Oil and Gas Wells in Colorado from 2010 through 2015," jointly prepared by the Colorado Division of Water Resources, the Colorado Water Conservation Board and the Colorado Oil and Gas Conservation Commission; http://cogcc.state.co.us/Library/Oil_and_Gas_Water_Sources_Fact_Sheet.pdf

FIGURE 5: PENNSYLVANIA—NUMBER OF WELLS BY BASELINE WATER STRESS



Pennsylvania: number of wells and percentage in water stress regions.

FIGURE 6: VOLUME OF WATER INJECTED FOR HYDRAULIC FRACTURING BY STATE & WATER STRESS REGIONS



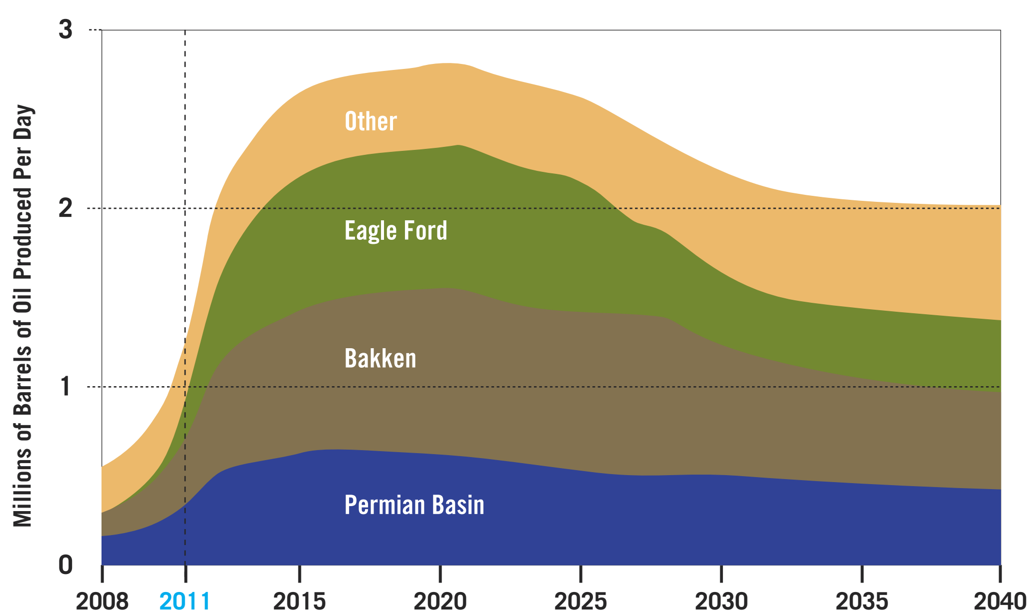
Water use by state and base line water stress level. Only states with one billion or more gallons of cumulative water use included.

Looking Toward Future Water Requirements

There needs to be across the board disclosure of the sources of water used for hydraulic fracturing, the amount withdrawn from each source, the amount used for each fracture and the amount of flowback water (initial flows) and produced water (later flows) returned to the surface.

Shale energy extraction is a thirsty business. The U.S. Energy Information Administration (EIA) predicts that shale gas production will rise from 23 percent of U.S. natural gas production in 2010 to 49 percent in 2035 and that tight oil (also known as shale oil) production will rise from just over 1.2 million barrels per day in 2011 to 2.8 million by 2020.[11] Given these trends, investors should to be asking if water management planning is getting sufficient attention from both industry and regulators. Shale development needs water to grow, but in order to do so, the industry's water requirements need to be better understood, measured and managed. The adage, "what gets measured, gets managed," holds true. There needs to be across the board disclosure of the sources of water used for hydraulic fracturing, the amount withdrawn from each source, the amount used for each fracture and the amount of flowback water (initial flows) and produced water (later flows) returned to the surface.

FIGURE 8: TOTAL & PROJECTED U.S. TIGHT OIL PRODUCTION BY GEOLOGIC FORMATION FROM 2008-2040



Source: EIA Annual Energy Outlook 2013

11 US Energy Information Administration, EIA Annual Energy Outlook 2013

Development of shale energy resources requires a large amount of water, with estimates ranging between two to 10 million gallons per well. The amount of water consumed per well depends on the geology of the shale, the number of fracturing stages and the amount of water that flows back to the surface (estimated between 20-80 percent). Although total water use for hydraulic fracturing is often less than 2 percent of a state's overall water use, requirements at the local level can be much higher.[12] The map of Tarrant County, Texas below highlights the potentially intense localized nature of shale energy development. The estimated water used for hydraulic fracturing in Tarrant County alone in 2011 was 2.8 billion gallons of water, which is equivalent to about 10 percent of the water used in all of Texas for hydraulic fracturing. Several other Texan counties such as Wise and Johnson are experiencing high water demands from hydraulic fracturing representing 19 and 29 percent of their overall county water use respectively.[13] Investors should ensure that companies have a local stakeholder engagement process in place on water issues.

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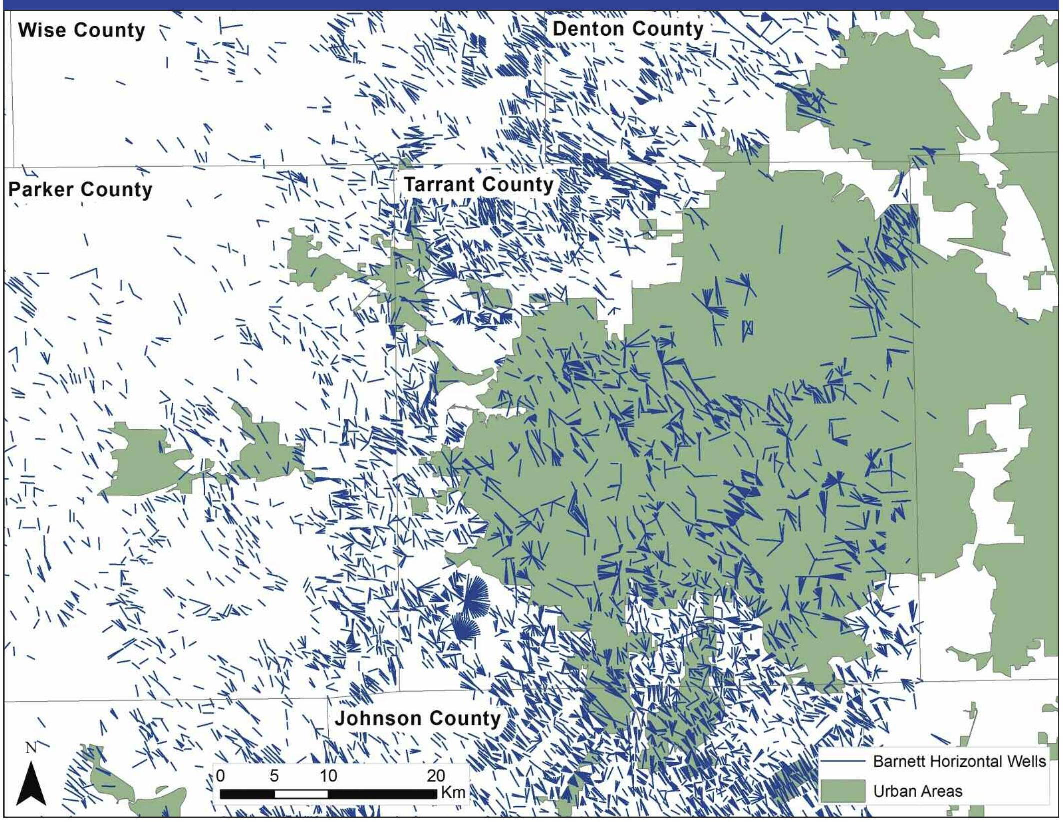
FIGURE 9: HORIZONTAL WELLS IN THE BARNETT SHALE, TARRANT COUNTY, TEXAS



Map view of horizontal wells in the Barnett Shale centered on Tarrant County.

Source: Oil & Gas Water Use in Texas: Update to the 2011 Mining Water Use Report, Prepared for Texas Oil & Gas Association, By the Bureau of Economic Geology, Scott W. Tinker, Director, Jackson School of Geosciences, The University of Texas, Austin, September 2012

12 Oil & Gas Water Use in Texas: Update to the 2011 Mining Water Use Report, Prepared for Texas Oil & Gas Association, by the Bureau of Economic Geology, Scott W. Tinker, Director, Jackson School of Geosciences, The University of Texas, Austin, September 2012

13 Jean-Philippe Nicot and Bridget Scanlon, "Water Use for Shale-Gas Production in Texas," U.S., Environmental Science and Technology, 46,3580-3586, 2012

Efforts To Mitigate Water Stress

Many important efforts and innovations are taking place to limit the use of freshwater. The use of recycled water and alternative sources such as wastewater, saline water, seawater or acid-mine drainage is growing. In some regions such as the Marcellus in Pennsylvania, recycling rates are estimated to reach 40 percent.[14] Although the Northeast is one of the "wetter'" regions, high water recycling rates are due to lack of wastewater disposal infrastructure. Recycling rates in many other regions remain in the single digits.[15] However in some parts of Texas the use of saline water is increasing. For example, saline water use in the Eagle Ford in Texas is about 20 percent.[16] Overall water recycling and the use of non-freshwater sources must increase considerably to make a significant impact.

The U.S. Environmental Protection Agency in its review of drinking water impacts from hydraulic fracturing is studying the problem of water sourcing and looks to release those results in 2014. However, some are choosing to act now. Efforts are underway by both industry and regulators to use non-freshwater sources such as saline groundwater, seawater or to use more recycled water.[17] The Texas Railroad Commission recently changed permitting requirements making it easier to recycle.[18] Other lawmakers in Texas are pursuing measures such as legislation that would introduce mandatory across-the-board water recycling requirements.[19] The recently launched Center for Sustainable Shale Development in Pennsylvania is calling for 90 percent recycle rates.[20] These steps are encouraging, but it is important to realize that recycling can only go so far in solving water sourcing problems since much of the water injected remains in the formation. Nevertheless companies should be disclosing their aggregated use of recycled and non-freshwater sources as well as a breakdown of these numbers by region of production. Quantifiable water recycling and non-freshwater use targets should be in place and on-going dialogue should be encouraged between industry and investors to better understand the roadmap, challenges and barriers (be it technical or regulatory) to reaching these targets.

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14 Brian Lutz. Aurana Lewis and Martin Doyle, "Generation, transport, and disposal of wastewater associated with Marcellus Shale gas development," Water Resources Research, Feb. 8 2013

15 Note 11

16 Note 11

17 American Water Intelligence, "Finding a brackish alternative to fresh frac water," Vol 2. Issue 3, March 2011

18 The Railroad Commission of Texas, Press Release, "TRC Adopts New Hydraulic Fracturing Wastewater Rules," March 26, 2013

19 Karen Boman, "Legislation Targets Mandates for Water Recycling in Oil, Gas Industry," Rig Zone, April 15, 2013

20 Center for Sustainable Shale Development, Performance Standards (March 2013); http://037186e.netsolhost.com/site/wp-content/uploads/2013/03/CSSD-Performance-Standards-3-27-GPX.pdf

Conclusion

Advances in hydraulic fracturing and horizontal drilling and resulting extraction of energy in shale gas and tight oil formations has truly been a disruptive technology. First, this technology has enabled producers to achieve exponentially more hydrocarbons per well versus old technologies and techniques. Second, the resulting rapid development of shale energy needs to be put in context of already at-risk water resources. Growing economic and energy production pressures are putting added pressures on water supplies, especially in regions such as Texas and Colorado, which are already under severe strain due to recent droughts. Climate change will only exacerbate water supply and demand imbalances. Shale energy development highlights the fact that our water resources were already vulnerable before additional demands were introduced. Regulators, water managers and ultimately all significant economic players who rely on abundant supplies of water must double-down their efforts to better manage this limited and most precious resource.

ABOUT THIS RESEARCH

This white paper is part of a larger, more comprehensive study Ceres is undertaking to analyze the water risks across the entire hydraulic fracturing lifecycle—from water sourcing to final treatment and disposal of wastewater—across different regional basins in North America. Further analysis of well locations and water data compared to other WRI water indicators, such as seasonal variability of water supplies, ground water stress and drought severity, will also be included. The research is aimed principally at investors who have financial stakes in well operators and support services in these regions.

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