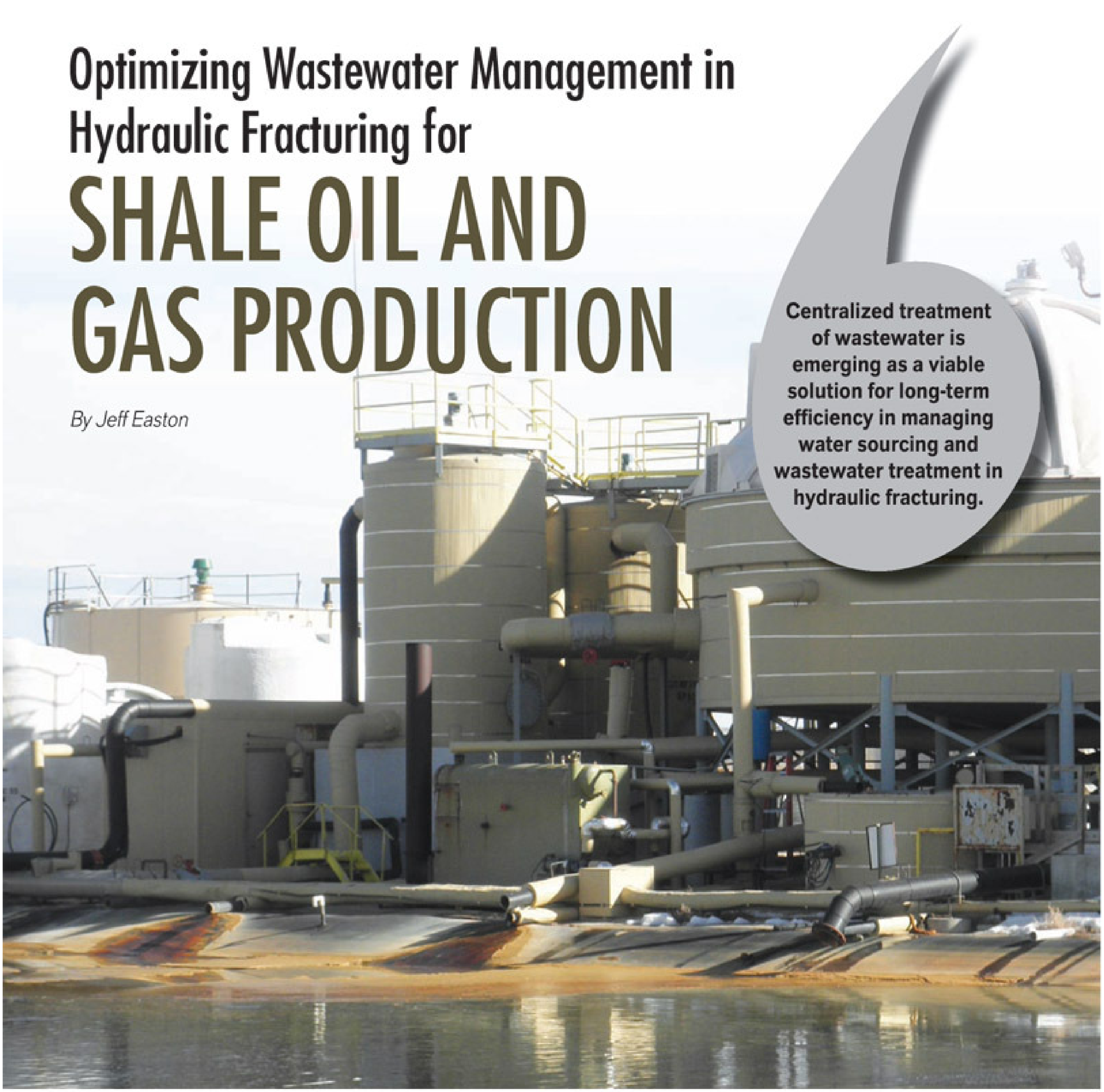
Optimizing Wastewater Management in Hydraulic Fracturing for SHALE OIL AND GAS PRODUCTION

By Jeff Easton

Centralized treatment of wastewater is emerging as a viable solution for long-term efficiency in managing water sourcing and wastewater treatment in hydraulic fracturing.



Centralized Wastewater Treatment Facilities Handle Both the Flowback Wastewater and Produced Wastewater from Oil and Gas Hydraulic Fracturing Wells within a Region, at a Radius of 40 to 50 Miles. Pipelines Connect all Wellheads Directly with the Central Treatment Plant.

The number of hydraulic fracturing (fracing) shale oil and gas wells in the United States and worldwide continues to increase. Within the Bakken Shale formation alone, in North Dakota and Montana, upwards of 15,000 hydraulic fracturing wellheads are in operation, with another 20,000 wells planned for opening.

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The U.S. has vast reserves of oil and natural gas that are commercially reachable as a result of advances in horizontal drilling and hydraulic fracturing technologies, which have enabled the improved access to oil and gas in shale formations, such as the Bakken. But as more hydraulic fracturing wells come into operation, so does the stress on surface water and ground water supplies from the withdrawal of large volumes of H_2O used in the process - needing up to one million gallons (almost 24,000 barrels) of fresh water per wellhead to complete the fracing process alone.

Equally important is the growing volume of wastewater generated from fracing wells, requiring disposal or recycling. Up to 60 percent of the water injected into a wellhead (potentially 600,000 gallons) during the fracing process will discharge back out of the well shortly thereafter, as flowback wastewater. Thereafter, and for the life of the wellhead, it will discharge up to 100,000 gallons per day of produced wastewater.

This wastewater needs to be captured, and disposed of or recycled. Because water is the base fluid and biggest component used in hydraulic fracturing, its importance remains a critical factor in the operation and economics of shale oil and gas production. But significant and growing water management challenges are impacting hydraulic fracturing. Fresh water and wastewater operating procedures which have been in place since the late 1990s are experiencing increasingly stiffer governmental regulations on water availability and disposal limitations. These factors are prompting oil and gas executives to reassess their current water utilization activities regarding fracing, and adopt a more unified, and longer-range perspective on their water life-cycle management.

One solution that promises a truly comprehensive approach to integrating all aspects of fresh water and wastewater management in shale oil and gas production, while optimizing the utilization of water resources throughout the entire lifecycle of well production, is a centralized approach to the treatment and reuse of wastewater. Centralization not only provides treatment and reuse of flowback wastewater from a large number of wellheads when the wells are fraced, but also provides treatment and reuse of produced wastewaters for the long-term, full lifecycle of the wells - which represent the vast majority of wastewater flowing from wellheads. Further, a centralized system can more easily access and utilize alternative water sources, such as from municipal wastewater facilities, which otherwise would be highly unlikely to be accessed.

Inherently, wellheads providing shale oil and gas production are long-term processes, typically exceeding 20-year terms, but conventional solutions in play for handling fresh water resources and wastewater are geared towards the short-term. Impounding wastewater for evaporation in surface ponds, trucking water over long distances to deep-well injection sites, and treating flowback wastewater for reuse at the wellhead are all short-term wastewater handling options which do not address critical long-term issues impacting of the industry - such as diminished water sources, increasing regulations limiting wastewater disposal, and growing safety and environmental concerns from government and the public.

The centralized wastewater management concept is gaining momentum. In North America, well over a dozen centralized wastewater treatment facilities servicing shale oil and gas drilling are now either up and producing, or in development.

Diminishing Options for Water Sourcing

Fresh water supplies for use in hydraulic fracturing are becoming more expensive and more unobtainable. Relatively recently, the Army Corps of Engineers mandated against the long-standing policy of acquisition of water

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from the Missouri River watershed for use in shale oil and gas fracturing. This diverted fracing operators to purchase pond and well water at higher rates from local landowners. Now these landowners are running out of water. 2013 water usage in Bakken formation fracing wells is expected to reach 6 billion gallons. Today, water sourcing is the main fracing challenge in the Bakken.

In Texas, where hydraulic fracturing wells work the Eagle Ford, Barnett Shale or Permian Basin formations and deal with the constant threat of drought, fracing operators compete with farmers and ranchers for their share of fresh water. As with North Dakota, water sourcing is the main fracing challenge in Texas. In both of these areas, an indefinite supply of water for expansion of hydraulic fracturing operations does not exist.

Even in Pennsylvania, and throughout the Marcellus and Utica Shale formations, where water availability is more accessible, with the increase in numbers of well sites water sourcing is becoming more tightly controlled. According to the Susquehanna River Basin Commission (SRBC), hydraulic fracturing a horizontal Marcellus well may use 4 to 8 million gallons of water, typically within about a one week period. However, the Commission states, some Marcellus wells may need to be fractured several times over their productive life (typically five to twenty years, or more). These large water withdrawals may come from streams, rivers, privately-owned lakes and ponds, or groundwater, and could affect availability of nearby drinking water sources and other uses, increasing the potential for conflicts between water users.

Wastewater Disposal Limitations

States and some local governments have primary responsibility for adopting and implementing programs to ensure proper management of hydraulic fracturing wastewater. Many fracturing wells operating in the Bakken formation in North Dakota and Montana, and those functioning in the Eagle Ford, Barnett Shale and Permian Basin formations in Texas use surface ponds to store hydraulic fracturing fluids (flowback and produced wastewater) for evaporation, or until arrangements are made for disposal. Almost 50 percent of the wastewater generated from hydraulic fracturing in these states is diverted and stored in surface ponds. Pennsylvania, however, within the past 24 months, has completely eliminated the use of surface ponds for wastewater storage.

But the future use of surface ponds is surely to become more regulated. EPA is currently evaluating industry practices and state requirements and is considering the need for technical guidance on the design, operation, maintenance, and closure of surface ponds under the Resource Conservation and Recovery Act (RCRA) in order to minimize potential environmental impacts.

In many regions of the U.S., including Texas, North Dakota and Montana, deep-well underground injection is a popular method for the disposal of fracing fluids and other substances from shale oil and gas extraction operations. Pennsylvania, some time ago, has outlawed the use of deep-well injection within the state. Fracing companies operating in Pennsylvania, desiring to deep-well inject their wastewater, must have it trucked to Ohio for deposition. This opens another set of potential issues relating to transporting large volumes of wastewater. Municipalities are concerned about the safety of high numbers of trucks traveling on rural roads and through small towns, and the safety impact this may be having on residents. Another is the impact of fleets of heavy trucks traveling on these roads. To help offset this issue, some local governments in Pennsylvania require fracing companies to post bonds to cover road repair and maintenance. Issues with trucking wastewater from fracing wells to deep-well injection sites are not isolated to Pennsylvania.

The costs for hauling away wastewater for deep-well injection ranges between $3 and $7 per barrel. For a newly fraced well, the cost could reach $100,000 for transporting over 14,000 barrels of flowback - water levels produced from each basin, and indeed, each wellhead can vary. Plus, an additional potential 3,400 barrels each day of transported produced wastewater, at $20,000 per day. To haul water off-site for disposal over the 20 year life of a hydraulic fracturing well-project, it was estimated to cost $160 million (includes trucking costs, water disposal costs and labor).

Surface ponds and deep-well injection have served the wastewater needs of shale oil and gas production for well over a decade. From a short-term view, these methods have provided a cost-effective solution. But as well operators are progressively beset with the need to better manage their water resources, it is necessary to be truly cost-effective from a longer-term perspective, one that more appropriately approximates the longer-term investment into their wells, and more closely aligns with tightening restrictions being imposed upon their industry.

Wellhead Wastewater Treatment

Wastewater associated with shale oil and gas extraction can contain high levels of total dissolved solids (TDS), fracturing fluid additives, total suspended solids (TSS), hardness compounds, metals, oil and gas, bacteria and bacteria disinfection agents, and naturally occurring radioactive materials. These contaminants are partially a combination of chemicals and agents inserted deep into the well (9,000 feet and deeper) which facilitate fracing by modifying the water chemistry to increase viscosity, carry more sand and improve conductivity.

Effectively, the fracing process is pushing the water down into the rock formation, trying to wedge the rock cracks open. The sand fills in between the cracks that the hydraulic fluid has propped open. Once the fracing is done, much of the water comes back up the well as flowback wastewater. Along with it comes the bacteria and characteristics of the geologic formation, including minerals, radioactive materials and oil and gas.

Some drilling operators elect to re-use a portion of the wastewater to replace and/or supplement fresh water in formulating fracturing fluid for a future well or re-fracturing the same well. Reuse of shale oil and gas wastewater is, in part, dependent on the levels of pollutants in the wastewater and the proximity of other fracturing sites that might reuse the wastewater. This practice has the potential to reduce discharges to surface ponds, minimize underground injection of wastewater, and conserve and reuse water resources.

Mobile solutions to treat wastewater at the wellhead enable recycling and reuse of flowback without the need for storing wastewater in surface ponds on-site, or for trucking flowback wastewater for disposal at off-site deep-well injection locations. The recycled wastewater is treated specifically for a different well site frac. The treatment is customized for the geology of that specified well site.

The drawback of wellhead mobile solutions is that they do not provide continuous processing to handle produced wastewaters, which would need to be processed for potentially 20 years following fracing. Since produced wastewater represents 95 percent, or more, of the wastewater generated during the lifecycle of a well, mobile processing systems do not provide a solution adequate to solving the long-term problems of diminished water sourcing and tightening wastewater disposal limitations.

Centralized Water Management

Centralized treatment of wastewater is emerging as a viable solution for long-term efficiency in managing water sourcing and wastewater treatment in hydraulic fracturing. Centralized treatment facilities handle both the flowback wastewater and produced wastewater from oil and gas wells within a region, at a radius of 40 to 50 miles. Pipelines connect all wellheads directly with the central treatment plant.

Wastewater received by the plant is identified as originating from a specific well. The targeted usage requirements for that wastewater are specified. Then the wastewater is processed to meet that usage. Once processed, the wastewater is then piped directly to the targeted well site.

Central wastewater treatment facilities are in a better position to provide a broader scope of treatment options than what would be available otherwise, such as with mobile wellhead treatment plants. They can provide a just-in-time processing capability, whether it is for a slickwater application in a well, or suitable for discharge to a watercourse. These processes can include:

- Primary three-phase separation to remove dissolved natural gas, floating gel, oil, sand and suspended solids, followed by storage for equalization of chemical composition and flow.
- Secondary separation utilizing dissolved air or gas flotation for removal of a wide variety of contaminants including polymers, oils and suspended solids. Bactericide is added to control bacterial growth.
- Removal of metals by precipitation, and removal of salts by reverse osmosis.
- Sludge management for dewatering collected solids.

Such centralized plants can be integrated with alternative sources of water to supplement fresh water needs for fracing, such as from abandoned mines, storm water control basins, municipal treatment plant effluent, and power plant cooling water. These initiatives are in alignment with mandates from Pennsylvania's SRBC and its Department of Environmental Protection, which emphasize future trends in water use for oil and gas drilling should represent more reuse of water for fracing, and more use of other waters, such as treated wastewater and acidic mine drainage, in the hydraulic fracturing process.

The development of an integrated infrastructure for water management in shale oil and gas production has lagged behind improvements in drilling technology, which have been successful in spearheading this industry into recent national prominence.

In the face of increasingly constricting traditional water sourcing options and tightening wastewater treatment regulations, the need for an industry initiative to develop this infrastructure network to deal with these water related issues is of critical importance if oil and gas producers are to effectively manage their frac well operations and maximize profits.

Centralized water management allows wastewater processing to be implemented on an economy of scale that has not before been realized in the shale oil and gas production industry. Reduced capital costs for treatment and distribution systems, lower operating costs, and a more favorable position to garner public and governmental acceptance are the key benefits of this centralized approach to water management.

About the Author

Jeff Easton is a principal process engineer at WesTech Engineering, where he has worked for the last 25 years. He has a Bachelor of Engineering degree from the University of Utah and is a registered professional engineer. Jeff's field of expertise is liquid-solids separation including a broad background in physical-chemical and biological processes. He has contributed to several journals and books on the subject of sedimentation, filtration and biological treatments. Jeff is the father of four and lives with his lovely wife Liz in the foothills outside of Salt Lake City, Utah where he enjoys tinkering in his workshop.

WesTech Engineering Inc. engineers and manufactures water and wastewater treatment process equipment for power generation, mineral, and industrial applications worldwide. With broad experience in providing process equipment for diverse liquid-solids separation settings, WesTech's process approach provides solutions for any water treatment challenge. WesTech is ISO 9001:2008 certified.

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