

Flowback Treatment in the Marcellus Shale

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Abstract

Flowback treatment in Pennsylvania has evolved over the past several years for E&P companies in the Marcellus Shale. Flowback treatment has been a challenge for conventional treatment facilities due to the high level of chemical constituents within the waste stream. In order to effectively treat, manage, and reuse the flowback and production waters generated during the fracturing operations, the Pennsylvania Department of Environmental Protection has pushed for development of emerging technologies for flowback and produced water treatment. Fixed facility and mobile treatment operations have provided E&Ps with a solution to their flowback handling challenges in this sensitive, environmental compliance climate. The advent of these flowback treatment efforts have benefited the E&P companies by providing low cost reuse options for their flowback. Publically owned treatment facilities have benefited by removing the difficult to treat wastes and companies who can offer flowback treatment solutions have been able to thrive in a poor economic climate.

Introduction

This paper discusses past, current and future trends for the treatment of flowback and produced waters in the Marcellus Shale region of Pennsylvania.

Flowback Treatment in the Marcellus Shale

The Marcellus shale is the largest unconventional shale play in the United States. This shale play comprises predominantly the States of West Virginia, Pennsylvania, Ohio, and New York and covers over 60.8 million acres as shown on Figure No. 1.

Oil and gas are not new to Pennsylvania. The first oil well was drilled in Titusville, PA in 1859 by Edwin Drake. Since that time, oil and gas drilling continued with thousands of vertical gas wells drilled and placed into operation. As a result, the treatment of flowback/produced waters (waters) is not new to Pennsylvania especially in Western PA where methods were developed to address the waters. These methods included taking it to Centralized Waste Treatment (CWT) facilities which blended the waters with other industrial waste streams, in essence diluting the waters and ultimately discharging to Pennsylvania streams and rivers. Others transported their waters to Publicly Owned Treatment Works

(POTW) where the fluids were mixed with the raw wastewater and others were disposed of via deep well injection.

The development of horizontal drilling created an explosion of activity in the natural gas industry with 8,358 Marcellus Shale drilling permits being issued as of November 21, 2011. Of these permits, 1,606 were for vertical wells and 6,752 for horizontal wells. Due to the public outcry over this industry and perceived environmental risk, a greater number of treatment facilities/technologies have been developed to manage flowback/produced waters. In the Marcellus, it takes approximately 2.5 to 5.0 million gallons (60,000 to 119,000 barrels (bbls.) of water to frac a well. According to the Susquehanna River Basin Commission (SRBC), there are approximately 593 million gallons of water withdrawn daily from the basin. Of this, 30 million gallons or 5% is attributed to Marcellus activities as shown on Figure No. 2. Of this fresh water, approximately 8% to 15% (8000 to 10,000 bbls.) per well returns as flowback. This may not seem to be a large volume of flowback per well as compared in the Barnett Play where upwards of 50% of fresh water returns as flowback; but with the large number of wells being fraced daily in Pennsylvania, the flowback volume is tremendous.

In addition to the concern over the volume, there is also concern from the natural gas companies over the "cost" of acquiring fresh water to perform the frac as well as the associated logistics. The sources of this freshwater are public and private water utilities; surface water intakes from rivers and streams; groundwater wells and effluent from POTWs. The cost for surface water withdrawals and groundwater wells is not only monetary, but the amount of time and effort it takes to receive government agency approvals. For instance, those gas companies desiring to withdraw surface water from the Susquehanna River Basin must prepare and submit docket applications to the SRBC. These applications can take upwards of 3 months to prepare and once submitted to the Commission, can take upwards of 12 months for approval. For those desiring to use groundwater wells, it can take upwards of 24 months to receive approval from the SRBC. These approval timeframes do not work well with the fast pace of natural gas development. Once the fresh water is in hand, the logistics of getting the water to the actual frac location is of concern. Many gas well pads are not located within close proximity to cities or major transportation

networks, therefore it may take hours for a truck to get to the frac site. At the cost of approximately \$80 to \$95 per hour for trucking plus the fact that many Pennsylvania roads are inadequate for the weight and wear and tear of the trucks as well as the concerns over accidents and spills, the natural gas companies have explored alternatives to disposal of the flowback.

Because of the concern over these “Costs”, gas companies have embraced recycling/reuse and blending of the flowback for subsequent fracs. The Pennsylvania Department of Environmental Protection (PA DEP) is also a proponent of recycle/reuse and has cited the following as “the Many Benefits of Reuse of Frac Fluids”:

1. Reducing/eliminating disposal cost of frac water
2. Reducing/eliminating hauling cost of frac water
3. Reducing the need for finding large quantities of fresh water
4. Reducing truck traffic in the drilling area
5. Minimizing the environmental impact of drilling for natural gas

According to the SRBC, for the period of June 1, 2008 through May 21, 2010, there was 44.1 million gallons of flowback that was reused and 21 million gallons which was sent to disposal.

The recycling/reuse has taken many forms. Some of the gas companies have decided to forgo any treatment whatsoever and blend flowback directly with fresh water. Others have decided to use mobile filters to remove suspended solids. The filters used range from 5 to 20 micron bag type manufactured, as shown in Figure No. 3, by Rain for Rent for example. These are capable of filtering upwards of 14,400 bbls. per day. The bag filter results in a solid waste which needs to be disposed of at a landfill. Another type of filter is the Layne INTEGRA disc filter, as shown in Figure No. 4, which automatically backwashes into an on-site frac tank where it mixes with the flowback and as such does not directly create a solid waste. Other companies have decided to enhance their treatment by using a physical/chemical process consisting of chemicals, polymers, disinfectants and clarification in addition to offering filtration. This treatment removes suspended solids and also removes some heavy metals. This treatment is occurring by using both mobile and fixed technology. The mobile systems operate 12 to 24 hours per day, and operate at upwards of 10,000 bbls. per day and produce an effluent (processed water) which is used for subsequent fracs. The sludge that is produced is dewatered using a mobile plate frame and press. The dewatered cake is then transported to a landfill for final disposal. Such technology is provided by companies such as Rettew Flowback, Inc. as shown in Figure No. 5; Fountain Quail using their ROVER system as shown in Figure No. 6 and Aquatech’s MoTreat as shown in Figure No. 7. The advantage of mobile technology is that it reduces the need for

transporting flowback, reduces the need for on- site storage as it can be set up and operated at any location/well pad.

Facilities have been constructed at fixed locations. One such facility is the TerrAqua Resource Management (TARM) plant in Williamsport, PA which operates 24/7/365 with a permitted capacity of 400,000 gallons per day. The facility has a Part I and Part II Water Quality Management Permit and also operates under a Residual Waste Beneficial Reuse Permit. The flowback is received for treatment, treated via a physical/chemical process and the processed water is transported back to the well pad. This is an example of a zero liquid discharge facility. The flowback that is received for treatment is ultimately returned to the same customer as there are dedicated frac tanks used as storage for each customer. The Client’s flowback is not comingled. Trucks travel loaded at all times to and from the facility as the same truck that offloads is loaded with the client’s processed water. According to TARM officials, year to date they have treated over 100 Million gallons of flowback and are proposing three additional facilities in Lycoming, Bradford, and Tioga County in 2012. Another example of a fixed treatment facility is the Eureka Resources plant in Williamsport, PA. which operates a physical/chemical process in conjunction with three mechanical vapor recompression distillers to produce distilled water at a rate of 6,000 bbls. per day. This distilled water is then discharged into the Williamsport wastewater collection system.

In evaluating what type of technology to use, the costs of the actual treatment and the associated transportation costs are two critical components.

Table No. 1 below is a cost comparison of the various technologies.

Technology	TREATMENT COSTS	
	Cost (\$) per bbl.	
Filtration	0.50-1.35	
Chemical/Physical	4.0-10.00	
Evaporation	9.00-15.00	
Injection Well	2.50	

Table No. 2 below is a comparison of fixed vs. mobile treatment

	<u>Fixed</u>	<u>Mobile Filtration</u>	<u>Mobile Chemical</u>
Volume bbls	30,000	30,000	30,000
Trucking (one way)	\$114,000 (2 hours)	\$28,200 (1 hour)	\$28,200 (1 hour)
Treatment/Operational Cost	<u>\$189,000</u>	<u>\$39,000</u>	<u>\$158,100</u>
Total Cost	\$303,000	\$67,200	\$186,300
Cost Savings		\$235,800	\$116,700

As previously stated, there were a number of POTWs and industrial wastewater facilities accepting flowback. As a result of concerns with increasing levels of total dissolved solids in Western PA Rivers and Streams, such as the Monongahela River, the PADEP enacted new regulations (Chapter 95) effective in January 1, 2011. These regulations established stringent effluent/discharge concentrations of 500mg/l limit for Total Dissolved Solids(TDS); 250 mg/l limit for chlorides and limits of 10mg/l for barium and strontium. These limits forced a number of POTWs and CWTs to cease accepting flowback as the facilities were not capable of meeting the new limits without significant capital expenditures and increased operation and maintenance costs. For those companies using these existing facilities, it created a disposal crisis and forced a number of the gas companies to transport their flowback to Ohio and West Virginia for deep well injection where there are a number of Class II D UIC facilities. There are currently seven US EPA approved Class II D disposal well facilities in PA, however only one of these is a commercial enterprise. Pennsylvania's geology does not generally lend itself well to injection wells.

With the current price of natural gas at record lows and with the evolving Utica play, predominantly in Ohio providing gas and liquids, the natural gas companies currently operating in PA have either shifted some of their resources to Ohio or have slowed their drilling schedule in PA. This will lead to a longer period of time before all the wells are fraced and there will be a continued use of current technologies. However at some point in the future, the quantity of produced water, which has higher levels of TDS compared to flowback, will surpass the volume required for fracing operations. This will cause an over- abundance which will require new technologies to manage the amount of water. Technologies envisioned to reduce the volume are mobile evaporators such as Fountain Quail's NOMAD unit, as shown in Figure No. 8, which has a 2000 bbls. per day distillate capacity based on a feed capacity of 2500 bbls. per day. Other technology is Aquatech's MoVap, as shown in Figure No. 9, which is a mobile evaporator which has an inlet capacity of 30-50 gallons per minute (gpm) and a distillate water flow of 20-25 gpm. Aquatech also provides a pre-engineered 200 gpm Modular ZLD system as shown in Figure No. 10, which provides a zero liquid discharge solution and it produces salt as a byproduct.

No doubt, over time, other technologies will be developed to meet the ever demanding need to decrease the volume of produced water at reasonable costs.

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Marcellus Shale: Geographic Footprint

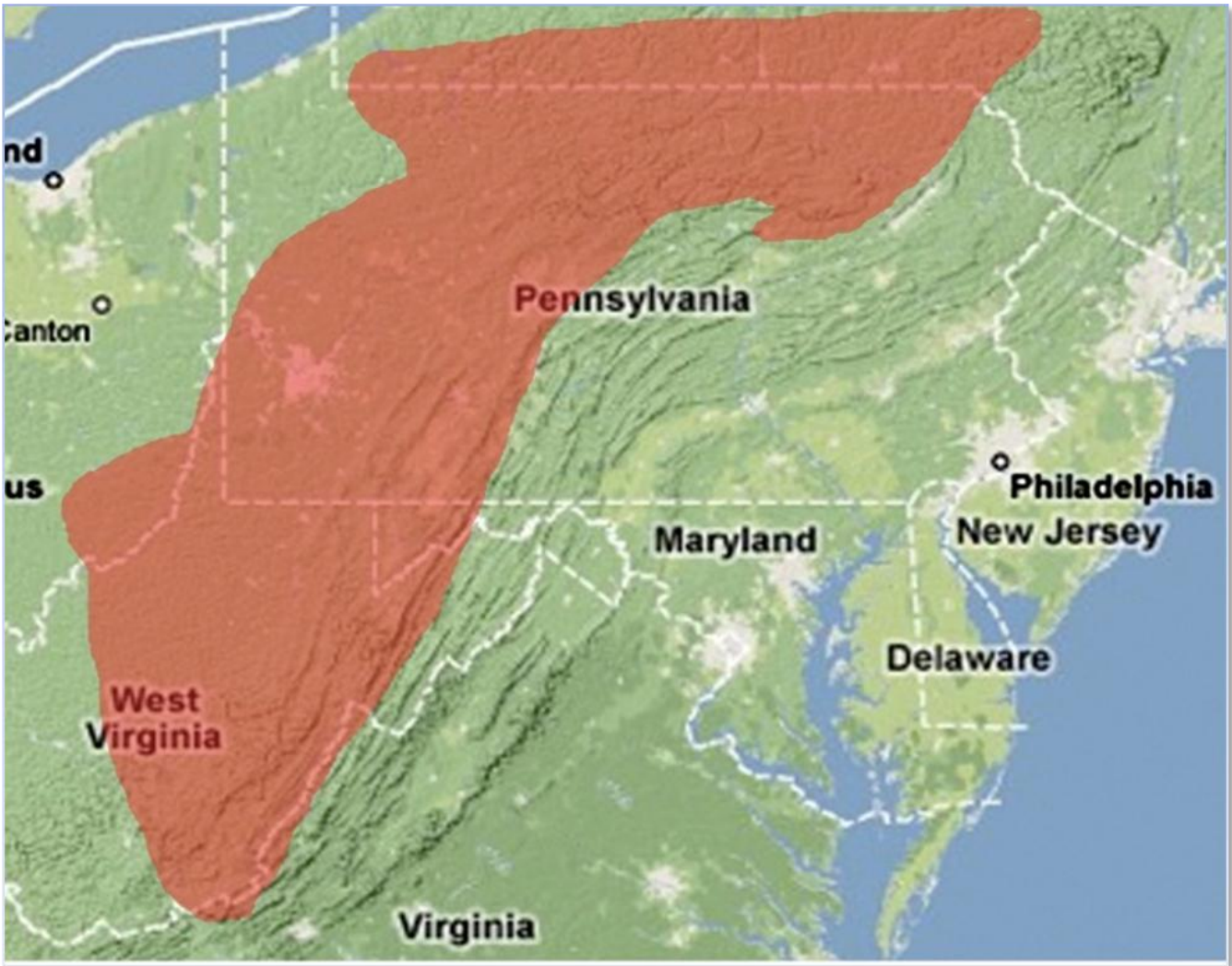


Figure No. 1

Where Pennsylvania is now:
Water Usage/Management

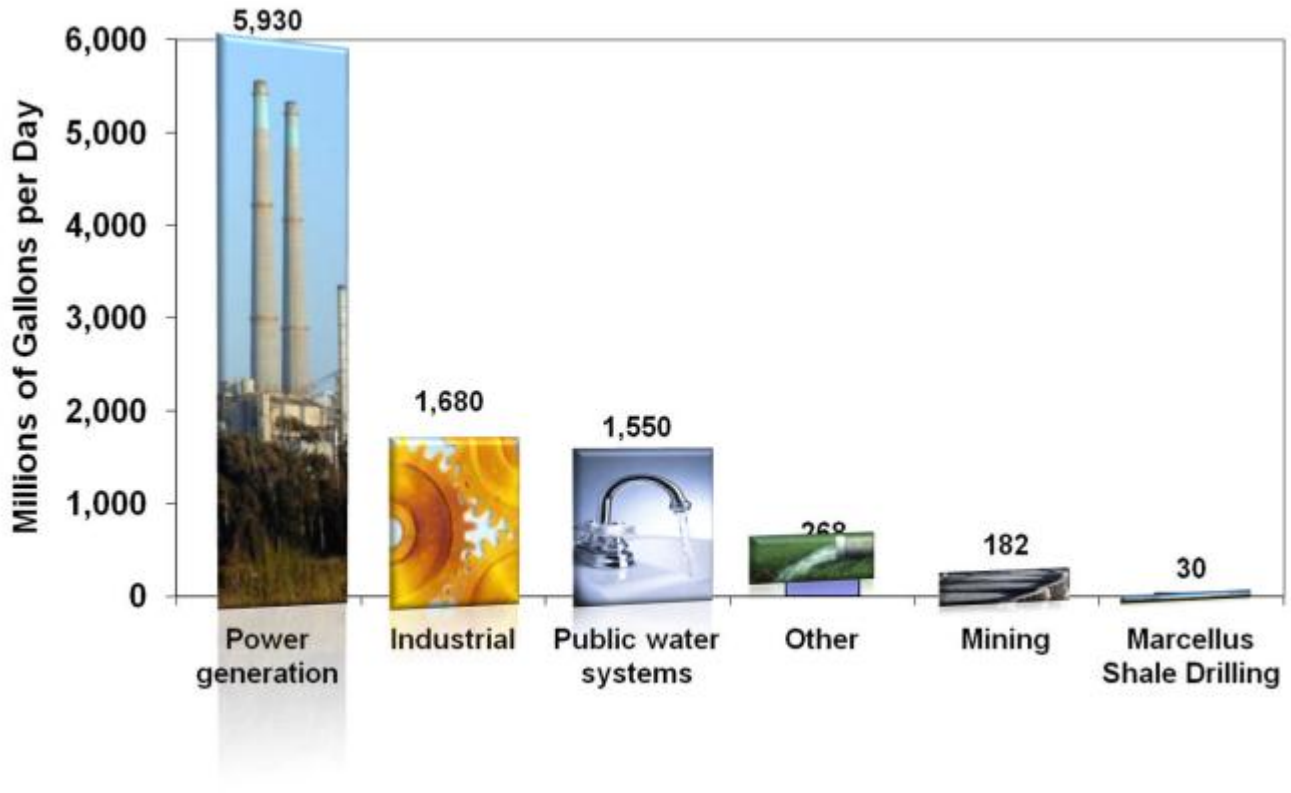


Figure No. 2

Rain for Rent Bag Filter



Figure No. 3

Integra Disk Filtration System

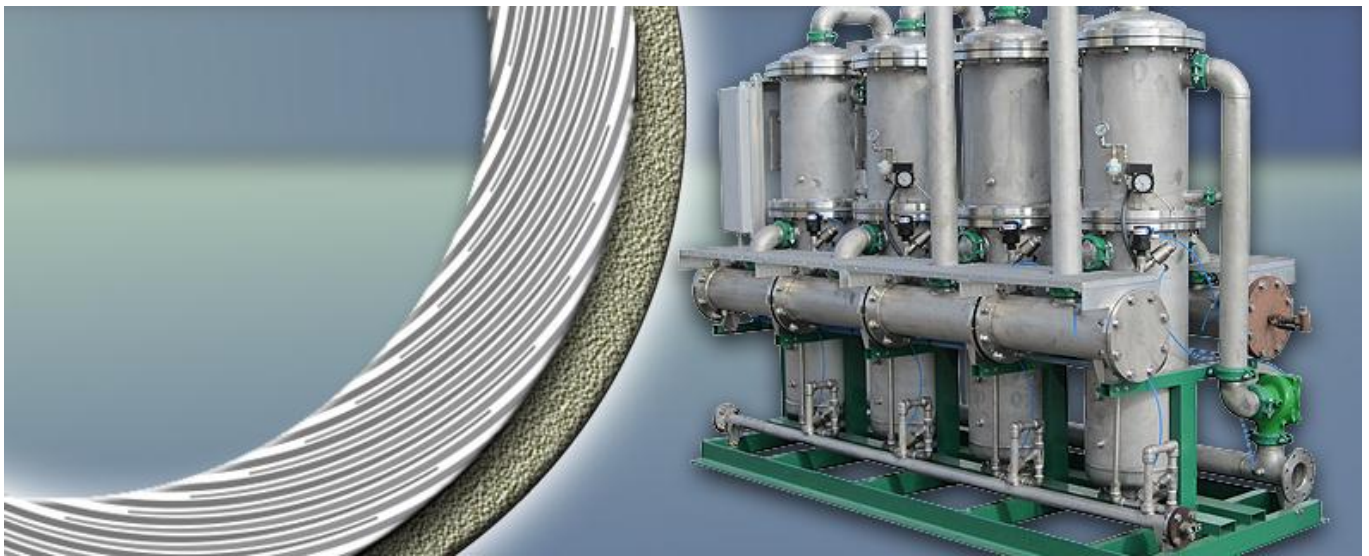


Figure No. 4

RFI Mobile Treatment System



Figure No. 5

Fountain Quail Rover System



Figure No. 6

Aquatech Mobile Treatment System



Figure No. 7

Fountain Quail NOMAD Evaporator System

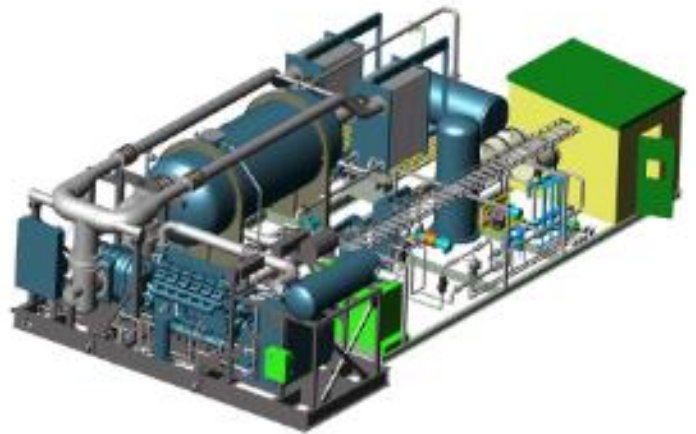


Figure No. 8

Aquatech Mobile Evaporator



Figure No. 9

Aquatech Modular ZLD System

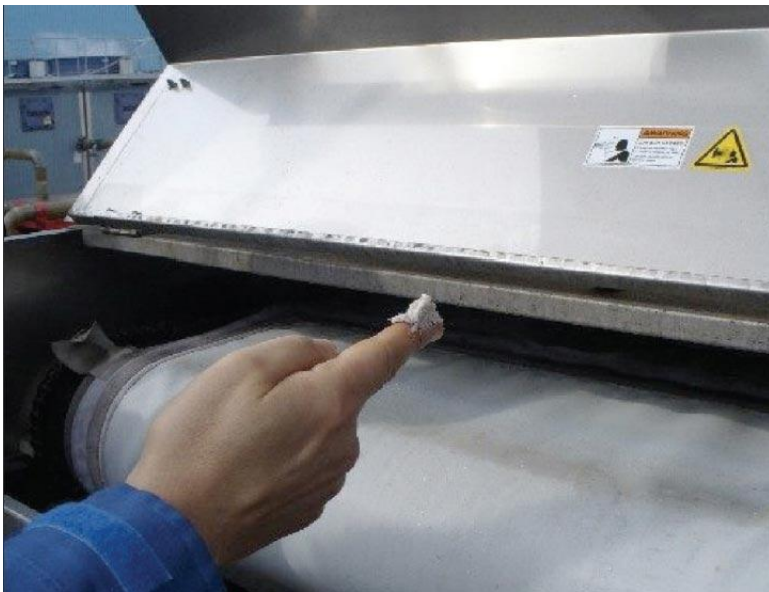


Figure No. 10