Shale Energy Produced Fluids Management and UIC Well Disposal Trends

Dave Yoxtheimer, PG
Hydrogeologist
Penn State Marcellus Center for Outreach and Research

GWPC Annual Forum
Seattle, WA
October 8, 2014
U.S. Natural Gas Production

Source: EIA (2014)
U.S. Oil Production

U.S. crude oil production
million barrels per day

History 2012 Projections

U.S. maximum production level of 9.6 million barrels per day in 1970

Tight oil
Lower 48 offshore
Alaska
Other lower 48 onshore

Source: EIA (2014)
• Typically use about 1 million gallons (24 MBBLs) per 1,000 feet of lateral

• Return of flowback ranges from approximately 5-50%

• Produced fluids range from 5-10 BBLs for every 1 MMCF of gas or 1 BBL of oil produced

• Water sources in Appalachian Basin are primarily surface water (80%) whereas ground water is the primary source in Western US plays
Hydraulic fracturing often involves the injection of more than a million gallons of water, chemicals, and sand at high pressure down the well. The depth and length of the well varies depending on the characteristics of the hydrocarbon-bearing formation. The pressurized fluid mixture causes the formation to crack, allowing natural gas or oil to flow up the well.

**Water Use in Hydraulic Fracturing Operations**

- **Water Acquisition**: Large volumes of water are transported for the fracturing process.
- **Chemical Mixing**: Equipment mixes water, chemicals, and sand at the well site.
- **Well Injection**: The hydraulic fracturing fluid is pumped into the well at high injection rates.
- **Flowback and Produced Water**: Recovered water (called flowback and produced water) is stored on-site in open pits or storage tanks.
- **Wastewater Treatment and Waste Disposal**: The wastewater is then transported for treatment and/or disposal.

Source: EPA Hydraulic Fracturing Study Workplan
Produced fluid management options

- Direct reuse (blending)
- On-site treatment w/reuse
- Off-site treatment w/reuse
- UIC well disposal

Treatment technologies include

- Filter socks
- Chemical precipitation
- Electrocoagulation
- Evaporation (MVR)
- Filtration
- Costs of <$2 to $10+/BBL

Most major shale plays recycle 10-50% of produced fluids and use disposal wells for the balance in PA during 2013 ~87% of shale gas flowback and produced water was recycled and ~13% disposed (mainly via injection wells) at cost of $15-20/BBL
• ~151,000 Class II UIC wells in US
• 80% are Class II-R wells for enhanced recovery
• 20% are Class II-D wells for disposal
• Inject about 2 billion gpd into Class II wells
Summary of PA Shale Production in 1H 2014
- 5388 producing wells
- 1.94 TCF of gas produced
- 15.6 MMBBLs of brine produced
- 8 BBLs brine produced per MMCF gas

http://marcellus.psu.edu
2014 PA Unconventional Energy Wastewater Figures

15.6 million barrels (MMBBLs) of flowback and produced water generated in PA in 1H 2014

- 5 MM BBLs of flowback (fluids returning after fracturing and before production)
- 10.6 MM BBLs of produced water (fluids generated during production)
- Generate ~8 BBLs of fluids for every 1 million cubic feet of gas produced
- 89% recycling rate for hydraulic fracturing
  - 78% of fluids stay in the field for recycling
  - 22% of fluids recycled via centralized treatment facilities
- 10% disposal rate via UIC wells
Brine Disposal In Pennsylvania

-8 operating Class IID UIC wells in PA w/ 3 permits pending with only 2 commercial wells

-150,660 BPM of total capacity with 60,000 BPM commercial

-75,000 BPM of additional capacity with issued permits

-Most wells targeting deeper sandstones (Oriskany, Medina, Whirlpool Fms), carbonates or shallower sandstones often via depleted gas wells

-Total 1H 2014 unconventional brine injection in PA UIC wells was 74,046 BBLs (408 BPD)

-PA shale brine disposal locations
  -94% injected into 42 OH wells
  -5% injected into 2 PA wells
  -1% injected into 3 WV wells

Source: Skoff and Billman (2013)
UIC Wellfield Capacity Example

Bear Lake Properties

- Depleted Medina gas well field
- Over 11,000 acres
- 2 Commercial UIC Well permits
- 30,000 bbl/mo/well
- Approx. 20 wells could potentially be converted to injection
- Est. 300 million BBLs capacity within the potential injection field
- Could represent decades of disposal capacity for PA

Source: Skoff and Billman (2013)
Summary of OH Shale Production in 1H 2014

- 503 producing wells
- 4.42 MMBBLs oil
- 156 BCF of gas produced
- 2.52 MMBBLs of brine produced
- 13.8 BBLs of brine/MMCF of gas
Class II-D UIC Wells in Ohio

- 240 permitted with 200 operational Class IID wells in OH
- Injected ~16.3 MMBBLs in 2013,
- Project ~20 MMBBLs in 2014
- 51% of injected fluids from out of district
- Average injection rate of ~415 BPD/well
- Estimated <25% recycling rate of flowback and produced fluids
Bakken and Three Forks Production

Source: Bakken and Three Forks Assessment, USGS (2013)
Disposal Wells in ND

Approximately 470 brine disposal wells in ND

In 2013 468,000 BPD of brine was injected into the Dakota Formation.

Average well capacity of ~1,000 BPD
Eagle Ford Shale

- Typical well use about 6 million gallons
- Flowback and produced fluid reuse at about 30%
- Seeing increase in reuse with severe drought
- Approximately 7,500 Class IID disposal wells in TX
- Ellenberger Formation is common injection zone with very high capacity
Niobrara Production in CO

- Approximately 350 Class IID wells in CO
- 51 percent of produced fluids are disposed via UIC wells
Current disposal gap of 3 MMBBLs of UIC disposal capacity increasing to 15 MMBBLs over next 30 years. Assuming 500 BPD/well capacity need about 20 wells now and 80 wells in the future.
Conclusions

• Every 1 MMCF shale gas or BBL of shale oil generates approximately 5-10 BBLs of produced fluids
  – Ratio tends to decrease as production numbers increase

• Range of recycling varies from approximately 10-90% in different shale plays

• Availability of UIC wells and associated disposal costs seems to dictate rate of recycling (more wells=more disposal)

• Future projections of US shale energy related brine disposal could vary by 8-fold depending on recycling rates (ranging from 20 MMBBLs-160 MMBBLs)

• Some regions experiencing large scale shale energy development may require significant numbers of new UIC wells (ie Marcellus) to keep pace with disposal trends
Questions??

Thank you!!

David Yoxtheimer, P.G.
Extension Associate
PSU MCOR
320 EES Building
University Park, PA 16802
814-865-1587 (office)
day122@psu.edu
www.marcellus.psu.edu