Evolving Water Management Practices in Shale Gas Development*

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Abstract

Environmental concerns resulting from the large-scale development of shale gas have changed the way industry obtains, transports, recovers, and ultimately disposes of water. In the early years of shale gas development, water for hydraulic fracturing was largely obtained from municipal taps, resulting in public concerns about impacts on local drinking water supplies, especially in semi-arid locations like Texas. Drillers have since discovered that much cheaper water of far lower quality will work for hydraulic fracturing in most shales and a combination of recovered flowback fluid and lower-quality water such as wastewater treatment effluent are now generally used. Transporting large volumes of water to well sites has also changed, where the current practice is to use a centralized impoundment to collect raw water and then send it to nearby well sites via a temporary, overland pipeline. This greatly reduces the number of tanker trucks driving on fragile dirt roads in sensitive stream headwater areas. Such improvements are largely the result of economics as well as regulations. However, some new problems have arisen. For example, disposal of high TDS flowback from the Marcellus Shale was initially done using a conventional wastewater treatment plant, which allowed the dissolved salts to pass through into freshwater streams, often resulting in fish kills. Regulatory changes and higher disposal costs have reduced this impact by encouraging drillers to recycle and dispose of their flowback water via Underground Injection Control (UIC) wells. This has resulted in a new problem of induced seismicity caused by large volumes of injected wastewater. Several new issues have become known from recent research. These include the potential for the drilling process itself to create groundwater surges in shallow aquifers, entraining pre-existing methane gas, minerals, and sediment. This can affect the taste and appearance of groundwater in nearby water wells, and may increase methane concentrations to explosive levels. Another concern is that toxic metals and radionuclides associated with black shale may oxidize at the surface and leach from any drill cuttings left behind. These issues will need to be addressed by industry practice, regulations, or both, but as evidenced by previous challenges, they can also be viewed as opportunities to improve economics and public opinion.

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Scott Goldsmith/National Geographic

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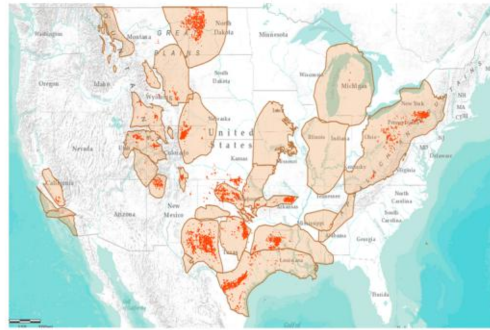
Evolving Water Management Practices in Shale Gas Development

- **Outline**
  - Introduction
  - Before the Well Pad
  - On the Well Pad
  - Leaving the Well Pad
  - Lingering Questions
  - Drivers of Change
  - References

marcellus-shale.us

Introduction

- Over 500,000 producing natural gas wells in U.S.[1]; over 42,000 unconventional well sites in U.S.[2]
- 2-13 million gallons of H_2O used per well[3]
- ~35% less waste H_2O produced per unit of gas than conventional wells[4]
- ~570% increase in waste H_2O generated since 2004[4]
- Sources, disposal, contamination
- Evolution from economic, regulatory, & community drivers
- *Flowback H_2O, produced H_2O, drilling fluids, wastewater*



FracTracker.org

1 U.S. Energy Information Administration, 2011; 2 FracFocus, 2013; 3 Seeking Alpha, 2013; 4 Lutz et al., 2013

Before the Well Pad…

Water Sources and Frac Fluids

- **Water Sources**
  - Tap water
    - *Scarcity, cost, pre-treatment, transportation*
  - Raw stream/river water
    - *Cheaper*
    - *Less transportation*
    - *Downstream effects*

Matthew Staver/New York Times

Akron Beacon Journal

Before the Well Pad…

Water Sources and Frac Fluids

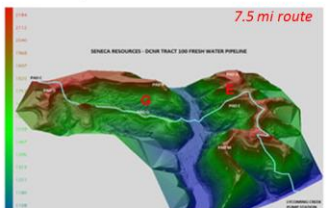
- **Water Sources, cont.**
  - Wastewater effluent (municipal, recycled)
    - *Minimize watershed strain & contaminants, cost*
  - Seawater or brine
    - *Up to 30% of frac H_2O used in some areas of Texas[1]*
    - *Offshore[2]*
  - Acid mine drainage[3, 4]
    - *PA DEP encouraging this*
    - *Reduce freshwater use*
    - *Disposal/treatment of AMD*

PetersCreek.org

Before the Well Pad...

Water Sources and Frac Fluids

- **Transportation and Storage**
  - Trucking
  - Direct Piping
    - *Local sources*
    - *Remote sources*
  - Impoundments, Centralized Impoundments[1]



Energy In Depth - Marcellus

marcellus-shale.us

1 Energy In Depth – Marcellus, 2011

NETL

Presenter’s notes: Remote sources pipelined in for large demand, also as private enterprise to sell to drillers

Before the Well Pad…

Water Sources and Frac Fluids

- **Alternative fluids**
  - Waterless frac fluids
    - *Propane gel (Can., TX)[1], liquid CO_2 (WY)[2]*
    - *Removes source & disposal as impacts on community*
- **Non-water ingredients**
  - Non-toxic frac fluids from food-grade ingredients
    - *Lowers contamination risk*
    - *Can reduce water usage – 45%[1]*

1 StateImpact Texas and Texas Tribune, 2013; 2 Co.Exist, 2013

NETL

Presenter's notes:
-CO_2 won't dissolve salts and return them to the surface, can displace gas/oil and enhance production, CO_2 sequestration, currently being used in Wyoming
-2000 fracs with propane by 1 company (GasFrac). Propane doesn't impede hydrocarbons' flowing the way water can => increased production
-Non-water ingredients reducing water usage: marathon is using guar to thicken their fluids, which reduces the amount of water needed

On the Well Pad…

Drilling, Testing, and Storage

- **Drilling on mud vs air**
  - Mud: less groundwater disturbance
- **Groundwater testing**
  - Baseline and post-completion[1,2]
    - *PA, CO requirement*
    - *Liability*

1 CBS News, 2012; 2 Colorado Springs Gazette, 2013

Presenter’s notes: Before and after gh2o testing now required in PA and CO, cabot says they’re doing it everywhere for liability reasons/preexisting methane.

On the Well Pad…

Drilling, Testing, and Storage

- **Tanks vs Impoundments**
  - Overflow/flooding
  - Leakage
  - Trend in produced water toward tank storage[1]
  - ND, CSSD: no wastewater impoundments[2]

Eric Schlegel/Texas Tribune

Gary C. Caskey/UPI

1 Scranton Times-Tribune, 2013; 2 Canon-McMillan Patch, 2013

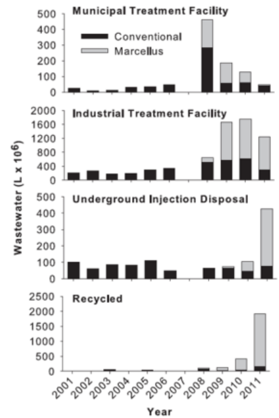
NETL

Presenter's notes: Most drillers do not use impoundments for long-term storage of produced water anymore, just temporary storage of flowback, according to Scranton Times-Tribune. Tanks are generally used for storage of produced water over the lifetime of the well.

Leaving the Well Pad…

Fate of Wastewater

- **Municipal treatment facilities**
  - Not designed to handle high TDS
    - *Bromide reactions (trihalomethane)*[1,2]
    - *PA request/voluntary cessation*[1]
- **Recycling**
  - Cost/availability of water
    - *$200K-$400K saved per well*[3,4]
  - Up to 72% total recycled, 90% flowback recycled[5]
- **Underground Injection**
  - Wastewater, Non-recyclable wastewater



Lutz et al., 2013

1 Lehigh Valley Morning Call, 2012; 2 Pittsburgh Post-Gazette , 2012; 3 Range Resources, 2010; 4 Bloomburg, 2013; 5 Maloney & Yoxtheimer, 2012;

NETL

Presenter's notes: Bromide reacts with chlorine during water treatment process to create carcinogen trihalomethane
PA DEP request was in spring 2011

Leaving the Well Pad…

Fate of Wastewater

- **Alternative disposal methods**
  - Spray on roads
    - *Dust suppression*
    - *Deicing*
  - Spray on land[1]
    - *Not common*
    - *Damages plant life*
- **Transportation**
  - Trucking
  - Wastewater pipelines[2]
    - *Just approved in TX, pipe to disposal wells*

BCEO.org

SFGIowa.com

1 Adams, 2011; 2 StateImpact Texas, 2013b

Lingering Questions

- **Recycling not ubiquitous**
  - Some plays still 0%[1] (Texas)
- **Waterless Frac Fluids**
  - Leaks/spills still problematic
- **Underground Injection**
  - Earthquake hazard[2,3]
  - Leaking through abandoned wells[4]
- **Dust Suppression/Deicing**
  - Stormwater runoff
- **Spraying on Land**
  - Effects on vegetation[5]
- **All water management techniques**
  - Spills!

1 Texas Tribune, 2013; 2 Keranen et al., 2013; 3 Pittsburgh Post-Gazette, 2013; 4 New York Times, 2013; 5 Adams, 2011

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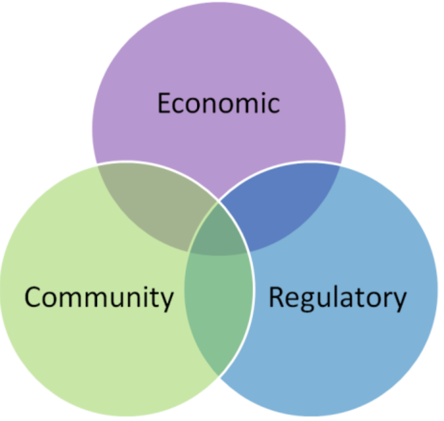
Presenter's notes: Photos of spill in Windsor, CO before it was controlled, and a vacuum pumping up runoff from a surface spill in Dimock, PA. Recycling lower in Texas than PA bc of abundance of UIC (injection disposal) wells, also working on legislation to take away wastewater designation for recycled water so its handling and storage isn't as limited

Drivers of Change

- **Economic**
  - Reduce costs
  - Positive public image
- **Regulatory**
  - Environmental protection
  - Resident protection
- **Community**
  - Property protection
  - Resource protection
  - Environmental protection
- **Joint efforts**
  - Center for Sustainable Shale Development



- **Overlap yields Environmental Benefit**

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