AWWA Webinar Program: What the Frack? The Real Deal with Fracking and the Water Industry –
Wednesday, November 14th, 2012

Agenda

I. Webinar Introduction  Adam Carpenter
II. Hydraulic Fracturing  John Satterfield
III. Fracking: Fears and Facts...  Van Brahana
IV. Bromide, TDS & Radionuclides...  Stanley States

Webinar Moderator

Adam Carpenter
Regulatory Analyst
American Water Works Association

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Panel of Experts

John Satterfield
Director of Environmental & Regulatory Affairs
Chesapeake Energy

Van Brahana
Professor of Hydrogeology
University of Arkansas

Stanley States
Director, Water Quality & Production
Pittsburgh Water & Sewer Authority

Ask the Experts

Enter your question into the question pane at the lower right hand side of the screen.

Please include your name and specify to whom you are addressing the question.
Hydraulic Fracturing

Objectives

• To define key aspects of hydraulic fracturing
  – The benefits of using HF for natural gas and oil production
  – History of the practice
  – Safe, engineered, regulated process
• To address industry concerns facing hydraulic fracturing
  – Groundwater protection
    • Casing program
  – Fluid migration
    • Frac design and physics
  – Surface water protection
    • Site construction
    • Spill control
  – Water disposal/recycle/reuse
  – Water use

Examples of Energy Impacts

Benefits

• Without the use of fracing, a major portion of domestic natural gas and oil could not be technically or economically produced.
• Increase in proved reserves:
  – In Natural Gas - from 164.42 trillion cubic feet (Tcf) in 1994 to 2,200 Tcf in 2012*
  – In oil – hydraulic fracturing has aided in the extraction of more than 7 billion barrels of oil**

*U.S. Energy Information Administration
History of Hydraulic Fracturing

- The first experimental hydraulic fracturing treatment was performed in Grant County, Kansas, in 1947.
- The first commercial application of hydraulic fracturing was performed on March 17, 1949 in Stephens Co., Oklahoma.

Photo Sources: JPT Online 'Official Publication of The Society of Petroleum Engineers'

Hydraulic Fracturing

- Fracing is the treatment applied to formation rock to improve the flow of trapped natural gas or oil from its initial location through the wellbore.
- Hydraulic fracturing occurs after the wellbore has been drilled, cased and cemented.
  - Drilling rig is removed from the site before fracturing begins
- Safe, engineered, regulated process

Hydraulic Fracturing Process

- Fluid mixed with sand/proppants and additives is pumped into the reservoir at high pressures
  - Fluids: Water, CO₂, Nitrogen, Foam, Propane
- Pressure is released and fractures are “propped” open to allow the natural gas and oil to flow towards and up the wellbore
- The hydraulic fracturing process is completed in a matter of days
Protecting Groundwater

- Several factors keep fluids out of drinking water aquifers
  - Wellbore construction: casing and cementing
  - Frac design and physics

Casing and Cementing Design

- Identifying where fresh water is located
  - Established by state water protection agencies
- Protective well design
  - Consist of multiple layers of steel casing
- Depths vary by play

Sealing Groundwater Aquifers from Operations

- Multi-Disciplined Approach to Mitigate
  - Drilling -- robust well design, cementing best practices
  - Geoscience -- gas & reservoir identification
  - Completion - analysis & feedback
  - Production – pressure monitoring program
- Casing & Cementing Best Practices
  - Casing design – new pipe, improved connections
  - Casing reciprocation and rotation while cementing
  - Centralization of all casing strings
  - Slurry design improvements – expansion, gas block
  - Wellbore & fluid conditioning – circulating
  - Engineered spacers efficient for mud removal
  - Rhot well in while waiting on completion

Fluid Migration

- Frac design and physics
  - Imbibition into face of fractures
  - Volume of water and horse-power necessary to force fluids to surface through multiple layers of both permeable and impermeable formations
  - Lack of energy once hydraulic fracturing job is over
  - Low pressure zone around wellbore
Site Erosion Control & Protection of Surface Water Resources

- Diversion ditches
- Berms
- Drainage ditches and ditch checks
- Sediment traps and basins
- Culvert pipes and outlet protection
- Sediment barriers such as silt fences and windrows of brush
- Stockpiling of topsoil
- Temporary and permanent revegetation
- Regular inspection and maintenance of controls

Typical Padsite Construction Elements for Spill Control

Water Sourcing

- Water sources vary among rivers, creeks, lakes, discharge water, groundwater and the reuse of produced water
- While working with local officials, water is purchased and properly permitted
- Water is typically transported via temporary pipelines or trucked to drilling locations

UIC Class II Wells

- Disposal of mostly salt water (brine), which is brought to the surface in producing oil and gas.
- Enhanced Oil Recovery
- Injection of fluids over long periods into porous formations
- Regulatory Structure
  - Protection of drinking water
  - Casing program
  - Mechanical integrity
  - Inspected and reviewed
Historically – Only freshwater
Regulatory hurdles
Chesapeake has explored the limits on conventional additive chemistry
Industry development of higher TDS tolerant additives
Currently filter (20 Micron) & blend into next job
Reduces truck traffic / road wear
Reduces freshwater demand
Less expensive than conventional disposal or reclamation
Cost - $1.50-$2.00 / bbl

Water Used to Produce Energy
Myth: Natural gas and oil industry is the largest water user
Fact: Deep shale natural gas is the least water-intensive energy to produce

Water Use
Total water use (surface water and groundwater) in North Central Texas (20-county area) by sector

Power Generation Water Use Efficiency
Parasitic Effect of Carbon Capture

Source: USDOE 2006 (other than CHK data)
*Average consumption for fuels; Chesapeake data
MWh = megawatt-hour

Water Used for Transportation Fuels

<table>
<thead>
<tr>
<th>Fuel Type</th>
<th>Consumption, Gallons of Fuel/100 Miles Driven</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ethanol from Ethanol Distilleries</td>
<td>2.300</td>
</tr>
<tr>
<td>Blended from Ethanol Distilleries</td>
<td>2.000</td>
</tr>
<tr>
<td>Hythane from Distillation</td>
<td>1.500</td>
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<tr>
<td>Syr Diesel from Refinery</td>
<td>2.000</td>
</tr>
<tr>
<td>Coal Bed Liquefaction</td>
<td>3.750</td>
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<tr>
<td>Syr Diesel from Refinery</td>
<td>3.500</td>
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<td>Oil Shale Gasolene</td>
<td>3.000</td>
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<td>Ethanol from Ethanol Distilleries</td>
<td>2.500</td>
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<td>Electric Vehicles (Electric Fuel)</td>
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<td>Ethanol from Ethanol Distilleries</td>
<td>1.900</td>
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<td>Ethanol from Ethanol Distilleries</td>
<td>1.600</td>
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<td>Ethanol from Ethanol Distilleries</td>
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<tr>
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<td>1.300</td>
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<tr>
<td>Ethanol from Ethanol Distilleries</td>
<td>1.200</td>
</tr>
<tr>
<td>Gasoline with 25% Ethanol Blend</td>
<td>1.000</td>
</tr>
</tbody>
</table>

Compressed Natural Gas (CNG)

- The production during the life of 1 Marcellus well is equivalent to 46,888,700 gallons of gasoline
  - 562,664,300 Heavy Duty CNG miles
- The production during the life of 1 Marcellus Pad (typically 6 wells) is equivalent to 281,332,150 gallons of gasoline
  - 3.38 billion Heavy Duty CNG miles

Additional Resources
- [www.AskChesapeake.com](http://www.AskChesapeake.com)
- [www.NaturalGasWaterUsage.com](http://www.NaturalGasWaterUsage.com)
- [www.FracFocus.org](http://www.FracFocus.org)
- [www.EnergyinDepth.com](http://www.EnergyinDepth.com)
- [www.ANGA.com](http://www.ANGA.com)

Ask the Experts

Enter your question into the question pane at the lower right hand side of the screen.

Please include your name and specify to whom you are addressing the question.
Fracking: Fears and Facts—Charting a Path to an Optimum Solution

Dr. Van Brahana
Professor, Department of Geology
University of Arkansas

Overview

- A complex issue, with deeply held feelings, adversarial positions, and conflicting “science”;
- This presentation will help you sort out the facts from the emotions to evaluate the overall benefits and drawbacks of hydraulic fracturing.

Learning Objectives

- As a result of this presentation, you will be able to assess 3 major questions about hydraulic fracturing;
  1. you will learn about induced seismicity;
  2. you will see impacts from traffic; and
  3. you will gain facts about contamination.
- The understanding gained should allow you to more effectively and accurately respond to stakeholder’s concerns.

Agenda

1. Examine the risks, both real and perceived;
2. List limitations to our understanding;
3. Evaluate data from two “case-study” areas, the Marcellus and the Fayetteville;
4. Propose approaches to optimize both resource exploitation and environmental preservation.
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What Are the Risks?

- Earthquakes
- Increased traffic
- Blowouts during fracking process
- Increased sedimentation
- Degraded environment
- Degraded water quality

Earthquake Risk—Fear or Fact?

- Injection of fracking solutions into the gas-bearing shale formations causes earthquakes.
- Deep-well injection of the spent fracking fluids produces small-magnitude earthquakes.

Magnitude 7.4 Chi-Chi Earthquake 9/21/99 in Taiwan,

Theory

photo: Karl Mueller, Colorado Univ
Overpressuring Shifts Mohr Circle Into Failure

Mohr envelope

Second Mohr Circle (Effective Stresses)

First Mohr Circle (Total Stresses)

Normal Stress, $\sigma$ (10^6 N/m^2)

Outcrop of Fayetteville Shale

Fracking in the Fayetteville Shale

Source: Scott Ausbrooks
Risk 1—Earthquakes

• Perceived risk—injection of fracking solutions into the gas-bearing shale formations causes earthquakes.

   No scientific evidence supports this

• Actual risk—deep-well injection of the spent fracking fluids does produce small-magnitude earthquakes.

   Theory and seismic data support this; earthquakes produced are in the 2-4 M range.

What Are the Risks?

• Earthquakes
  • Increased traffic

• Blowouts during fracking process
• Increased sedimentation
• Degraded environment
• Degraded water quality
Traffic Risk—Fear or Fact?

- Fracking is a major industrial process, and the complete process is conducted in typically rural areas, using heavy equipment.
- Fracking is an in situ process, so the equipment must be transported to the site.
- Increased traffic occurs because of the need for large volumes of water used in the fracking process. In terms of tanker trucks, this typically can be from many tens to several hundred tanker trucks per frack job.
**Risk 2—Increased Traffic**

- **Fact** - Fracking is a major industrial process, and the complete process is conducted in typically rural areas, using heavy equipment.
  
  *Observed-evidence supports this*

- **Fact** - Fracking is an *in situ* process, so the equipment must be transported to the site.
  
  *Observed-evidence supports this*

- **Fact** - Increased traffic occurs because of the need for large volumes of water used in the fracking process. In terms of tanker trucks, this typically can be from many tens to several hundred tanker trucks per frack job.
  
  *Observed-evidence supports this*

**Risk 2—Increased Traffic (2)**

- **Fact** - It should be noted that the traffic to and from the well pad decreases significantly after the major construction phase, so that only operation, monitoring, maintenance, and security traffic occurs later in the history of each site. These latter activities do not require heavy equipment.
  
  *Observed-evidence supports this*

- **Fact** - It should also be noted that although major traffic occurs for a limited time at a single site, typically there are numerous sites within the area of a “play”, and although the traffic increase of a single site has a relatively short duration, traffic in the entire play occurs over an extended period.
  
  *Observed-evidence supports this*

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**What the Risks Are**

- Earthquakes
- Increased traffic
- Blowouts during fracking process
- Increased sedimentation
- Degraded environment
- Degraded water quality

**Water-Quality Risk—Fear or Fact?**

- Injection of fracking solutions will create gas and brine contamination pathways into the shallow aquifers that serve as drinking-water supplies.
- Fracking fluids contain “poisons”.
- Unmapped faults and unplugged, abandoned wells are present, and these are leakage pathways.
- Failure of cement/casing couple will allow blowouts, which contaminate streams and shallow aquifers.
Subsurface Zones and Fracking in the Subsurface—Fayetteville Shale

Source: Sandia Technologies, LLC

Shallow Groundwater Monitoring Fayetteville Shale

- Nottemeier (2012) sampled more than 100 wells from the Fayetteville Shale in north-central Arkansas, and found no evidence of groundwater contamination from fracking;
- Kresse et al. (2012) sampled more than 120 shallow wells in the major area of development of the Fayetteville Shale play and found no evidence of groundwater contamination from fracking.

Shallow Groundwater Monitoring Marcellus Shale

- Researchers from Duke University took hundreds of samples from groundwater aquifers in six counties overlying the Marcellus Shale in northeastern Pennsylvania and found elevated brine, biogenic gas (NOT thermogenic), but no evidence of fracking fluids.
- The study says it is unlikely that the elevated salinity is connected to hydraulic fracturing, or "fracking", but they are concerned that the presence of the brine suggests "natural pathways" leading up to aquifers from far below the surface, [unmapped faults] and that these pathways might allow gases from shale-gas wells to put drinking-water supplies at risk. (Osborn et al., 2011; Warner et al., 2012)

Composition of Fracking Fluids

Suspect Appearances—The 2005 Bush-Cheney energy policy bill excluded fracking and the chemicals used in the process from the Safe Drinking Water Act.
Unmapped Faults & Unplugged Abandoned Wells

- In the tectonically deformed region of the Marcellus Shale (described earlier), unmapped faults might allow “gases from shale-gas wells to migrate and put shallow wells at risk.” (Warner et al., 2012)

- Bertetti and Green (2012) indicated that “abandoned wells pose the greatest potential threat in deep-well disposal of waste fluids” … in the area of the Eagle Ford Shale play in south Texas.

- “Migration via an existing borehole (i.e., an abandoned, open well) is possible, particularly if an abandoned well is not identified, is reasonably close to the disposal well, and the contaminant is injected into the same horizon as the screened section of the abandoned well.” (Bertetti and Green, 2012)

Blowouts

“ALLENTOWN - A blowout at a natural gas well in rural northern Pennsylvania spilled thousands of gallons of chemical-laced water Wednesday, contaminating a stream and forcing the evacuation of seven families who live nearby as crews struggled to stop the gusher.”

No injuries; no explosion; no fire; no natural gas emissions; no fish kill in Towanda Creek, which is stocked with trout.

The point to be made is that the company experienced failure in the cementing job, but had followed regulations, thereby preventing any contaminated water to reach the stream.

Risk 3—Water-Quality Degradation

- Perceived risk—Injection of fracking solutions will create gas & brine contamination pathways into the shallow aquifers that serve as drinking water supplies. 
  
  No scientific evidence supports this at this time, although it is a possibility

- Perceived risk—Fracking fluids contain "poisons". 
  
  Fracking fluids and formation brines contain undesirable constituents, but these are not toxic or “poisonous”

Risk 3—Water-Quality Degradation (2)

- Actual Risk—Unmapped faults and unplugged, abandoned wells are present, and these are leakage pathways.
  
  These appear to represent a real risk of unknown probability. Characterization, monitoring, and mitigation strategies should be in place, and rules rigidly enforced.

- Actual Risk—Failure of cement/casing couple will allow contamination of shallow aquifers & streams.
  
  These appear to represent a real risk of unknown probability. Characterization, monitoring, observation and mitigation strategies should be in place, and rules rigidly enforced.
**Summary**

1. With fracking, there are risks that are both real and imagined. We need to share our understanding with all stakeholders, and be open and respectful.

2. Our understanding of the groundwater systems is limited, especially for subsurface conditions that are impossible to view directly. Those risks that occur at land surface appear to be well understood; those risks that deal with the subsurface should have a level of safety built in to protect the environment.

3. Based on natural variations in the tectonic setting and hydrogeologic framework of different areas, water-quality conditions should be fully characterized, monitored, observed, and if necessary, mitigated. We should implement and rigorously enforce regulations.

4. To optimize both resource exploitation (which will occur because the energy from this resource is fairly clean and fairly inexpensive) and environmental preservation (which is necessary because of our need to protect our water supplies in the shale-gas areas), we need to work together for long-term solutions built on the best understanding available. We need to overcome fear, share information openly, develop mutual respect, include all stakeholders, and technically strive to educate all.

**Ask the Experts**

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**Bromide in the Allegheny River: A Link with Marcellus Shale Operations**

Stanley States, Ph.D.
Director of Water Quality and Treatment
Pittsburgh Water and Sewer Authority

**Pittsburgh Water and Sewer Authority**

- Stanley States
- Gina Cyprych
- Mark Stoner
- Faith Wydra
- Jay Kuchta

**University of Pittsburgh School of Engineering**

- Leonard Casson
- Jason Monnell
Rationale
This presentation will help the viewer recognize drinking water quality problems that may be associated with fracking.
This may help drinking water personnel deal with similar issues at their treatment plants.

Learning Objectives
As a result of this presentation, viewers will become familiar with specific source water and finished water parameters that may change as a result of fracking.
Viewers should also become aware of specific sources of contaminants in the raw water.

Disinfection Byproduct Formation

Natural Organic Matter (NOM) + Chlorine + Bromide → Trihalomethanes:

Chloroform (CHCl₃)
Dichlorodichloromethane (CH₂Cl₂Br)
Dibromochloromethane (CHBr₂Cl)
Bromoform (CHBr₃)

Total THMs and % Bromoform Contribution for PWSA Distribution Sites (Sept 2010)

<table>
<thead>
<tr>
<th>SAMPLE LOCATION (Date)</th>
<th>TTHM (ppb)</th>
<th>% CONTRIBUTION OF BROMOFORM</th>
</tr>
</thead>
<tbody>
<tr>
<td>Brashear Tank Influent (10 Sept)</td>
<td>132</td>
<td>59</td>
</tr>
<tr>
<td>4063 Perryville Ave (16 Sept)</td>
<td>226</td>
<td>60</td>
</tr>
<tr>
<td>2000 Mt. Troy Rd. (16 Sept)</td>
<td>191</td>
<td>46</td>
</tr>
<tr>
<td>4620 Evergreen Rd. (17 Sept)</td>
<td>270</td>
<td>60</td>
</tr>
<tr>
<td>928 Clairmont Ave. (21 Sept)</td>
<td>225</td>
<td>48</td>
</tr>
<tr>
<td>Chestnut St. (21 Sept)</td>
<td>205</td>
<td>50</td>
</tr>
<tr>
<td>139 Homestead St. (21 Sept)</td>
<td>143</td>
<td>43</td>
</tr>
</tbody>
</table>
Questions

1. What effect does excess bromide in the river have on THM formation in drinking water?
   - Total THM concentration
   - % brominated species
2. How effective are drinking water plants in removing bromide from source water?
3. How much bromide is in the Allegheny River; how much does it vary; and what is the source of excess bromide?
   - Coal- Fired power Plants
   - Steel Mills
   - POTWs treating Marcellus Shale flowback water
   - Industrial ww plants treating Marcellus Shale flowback water
   - Abandoned mine drainage

Effect of Excess Source Water Bromide on THM formation

<table>
<thead>
<tr>
<th>Bromide Supplement (ppb)</th>
<th>Total THMs (ppb)</th>
<th>% Concentration of Bromoform</th>
<th>% Concentration of Brominated Species</th>
</tr>
</thead>
<tbody>
<tr>
<td>0*</td>
<td>102</td>
<td>1</td>
<td>22</td>
</tr>
<tr>
<td>20</td>
<td>88</td>
<td>1</td>
<td>31</td>
</tr>
<tr>
<td>60</td>
<td>121</td>
<td>1</td>
<td>44</td>
</tr>
<tr>
<td>100</td>
<td>113</td>
<td>3</td>
<td>58</td>
</tr>
<tr>
<td>150</td>
<td>129</td>
<td>5</td>
<td>69</td>
</tr>
<tr>
<td>200</td>
<td>133</td>
<td>10</td>
<td>77</td>
</tr>
<tr>
<td>300</td>
<td>125</td>
<td>27</td>
<td>89</td>
</tr>
</tbody>
</table>

*Baseline bromide concentration= 39ppb

Effectiveness of Conventional Drinking Water Treatment in Removal of Bromide from Source Water
Removal of Bromide by PWSA Drinking Water Treatment Plant

<table>
<thead>
<tr>
<th>SAMPLE SITE</th>
<th>2010 Date &amp; Time</th>
<th>Bromide Concentration (ppb)</th>
<th>2011 Date &amp; Time</th>
<th>Bromide Concentration (ppb)</th>
</tr>
</thead>
<tbody>
<tr>
<td>River Intake</td>
<td>25 Oct - 07:30</td>
<td>188</td>
<td>21 Mar - 07:20</td>
<td>44</td>
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<tr>
<td>Flume</td>
<td>25 Oct - 12:00</td>
<td>158</td>
<td>21 Mar - 12:10</td>
<td>40</td>
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<tr>
<td>Settled Water</td>
<td>26 Oct - 12:10</td>
<td>173</td>
<td>22 Mar - 13:00</td>
<td>45</td>
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<tr>
<td>Pre-filtered Water</td>
<td>26 Oct - 15:15</td>
<td>192</td>
<td>22 Mar - 16:00</td>
<td>&lt;25</td>
</tr>
<tr>
<td>Post-filtered Water</td>
<td>26 Oct - 16:05</td>
<td>134</td>
<td>22 Mar - 16:05</td>
<td>&lt;25</td>
</tr>
<tr>
<td>Finished Water</td>
<td>27 Oct - 08:00</td>
<td>&lt;50</td>
<td>23 Mar - 08:00</td>
<td>&lt;25</td>
</tr>
</tbody>
</table>

- How Much Bromide is in the Allegheny River?
- How Much Does the Concentration Vary (with Time and Location)?
- What is the Source of Excess Bromide in the River?
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**UPPER ALLEGHENY RIVER**

Bromide Concentration (ppb)

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
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</thead>
<tbody>
<tr>
<td>Warren Bridge</td>
<td>32 (19th)</td>
<td>32 (19th)</td>
<td>31 (19th)</td>
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<td>Evening Bridge</td>
<td>41 (19th)</td>
<td>41 (19th)</td>
<td>41 (19th)</td>
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<tr>
<td>Special Bridge</td>
<td>81 (18th)</td>
<td>81 (18th)</td>
<td>81 (18th)</td>
<td>81 (18th)</td>
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<tr>
<td>Industrial Waste Plant A</td>
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<td>1.6 X 1.3 X</td>
<td>1.6 X 1.3 X</td>
<td>1.6 X 1.3 X</td>
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<tr>
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<td>1.4 X 1.4 X</td>
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<td>1.4 X 1.4 X</td>
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<tr>
<td>Schenley (LDB)</td>
<td>170 (24th)</td>
<td>114 (15th)</td>
<td>64 (12th)</td>
<td>146 (16th)</td>
</tr>
<tr>
<td>Sample Site</td>
<td>Jan 2012</td>
<td>Apr 2012</td>
<td>May 2012</td>
<td>Jul 2012</td>
</tr>
<tr>
<td>Clarion River</td>
<td>101 (13th)</td>
<td>90 (13th)</td>
<td>117 (19th)</td>
<td>90 (13th)</td>
</tr>
<tr>
<td>Armstrong Railroad Bridge</td>
<td>46 (31st)</td>
<td>36 (3rd)</td>
<td>90 (13th)</td>
<td>117 (19th)</td>
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<tr>
<td>Lock and Dam #8 (RDB)</td>
<td>43 (31st)</td>
<td>43 (3rd)</td>
<td>89 (13th)</td>
<td>144 (19th)</td>
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<tr>
<td>Kittanning Bridge</td>
<td>41 (3rd)</td>
<td>70 (13th)</td>
<td>125 (19th)</td>
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<tr>
<td>Ford City Bridge</td>
<td>47 (27th)</td>
<td>54 (11th)</td>
<td>84 (18th)</td>
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<td>Crooked Creek</td>
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<td>1.1 X 1.1 X</td>
<td>1.1 X 1.1 X</td>
</tr>
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**UPPER ALLEGHENY RIVER**

Bromide Concentration (ppb)

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AWWA Webinar Program: What the Frack? The Real Deal with Fracking and the Water Industry – Wednesday, November 14th, 2012
AWWA Webinar Program: What the Frack? The Real Deal with Fracking and the Water Industry –
Wednesday, November 14th, 2012

**LOWER ALLEGHENY RIVER**
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PWSA Bromide Samples, July 2011

Bromide Mass (lbs/d) Input to the Allegheny River System

Radiological Survey (2011) (PWSA River Intake and Finished Drinking Water)

Radiological Survey (March 2011) ( Allegheny River)
Conclusions

- Increased bromide in source water causes elevated TTHM concentrations and increased % contribution of brominated THMs in drinking water
- Conventional drinking water treatment does not remove bromide from raw water
- Radionuclides are not elevated in the Allegheny River System
- Bromide concentrations throughout the Allegheny River System vary from <25 - 3900 ppb
- Bromide concentrations in the Allegheny River at PWSA intake vary from <25 - 299 ppb
- Bromide increases as water flows downstream

Bromide concentrations are significantly affected by river volume
- Bromide problems for PWSA are more acute during low river flow conditions
- TDS is not a good indicator for bromide concentrations in the Allegheny River System
- Bromide concentrations increase downstream of industrial wastewater treatment sites
- Bromide concentrations do not increase downstream of most POTWs treating Marcellus Shale wastewater, steel plants, and coal mine drainage sites
- Bromide concentrations increase seasonally downstream of some coal fired power plants. However, the increase is less than observed at industrial wastewater plants

Ask the Experts

Enter your question into the question pane at the lower right hand side of the screen.

Please include your name and specify to whom you are addressing the question.
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Presenter Biography Information

Adam Carpenter works in AWWA’s DC Government Affairs Office, and serves as an expert on a diverse set of drinking water issues including climate change, hydraulic fracturing, consumer confidence reports, carbon capture and storage, the energy-water nexus, and other water and environmental issues. Along with his colleagues, he works to further AWWA’s mission of supporting clean, affordable drinking water through sound application of science into policy, source water protection, sensible regulation, public awareness, and building stakeholder consensus.

John Satterfield is the Director of Environmental and Regulatory Affairs for Chesapeake Energy. He is responsible for interacting with federal regulatory agencies and stakeholder groups, assisting in the implementation of environmental policies and strategies and managing environmental research projects. He has worked for Chesapeake for more than 6 years.

Van Brahana currently is a Professor of Hydrogeology at the University of Arkansas, Fayetteville. He is an Emeritus Research Hydrologist with the U.S. Geological Survey, where he worked for 28 years prior to his current position. His focus has been ground water in karst in the midcontinent.

Stanley States is the Director of Water Quality and Production for the Pittsburgh Water and Sewer Authority. He has been with this utility for the past 36 years. Stanley has an MS in Forensic Chemistry and a Ph.D. in Environmental Biology.

Thank You for Joining AWWA’s Webinar

- As part of your registration, you are entitled to an additional 30-day archive access of today’s program.

- Until next time, keep the water safe and secure.