Lessons Learned from the Barnett Shale Range Resources Litigation

Charles W. Kreitler
Senior Consultant
LBG-Guyton Associates
Austin, Texas

Texas Association of Professional Geologists (TAPG)
Hydraulic Fracturing and Environmental Implications
November 12, 2014
In 2010-2011, The U.S. Environmental Protection Agency initiated investigations and litigation at three locations where hydrofracking for the development of natural gas had supposedly caused groundwater contamination.

All three sites have received extensive notoriety in the press.

These locations were:
- Dimock, Pennsylvania (Cabot)
- Pavilion, Wyoming (Cantana)
- Parker County, Texas (Range Resources)
The Range Case

August 6, 2010 – Mr. Steve Lipsky, landowner, filed complaint with Texas Railroad Commission of natural gas in his domestic water well.
Location of Lipsky Water Well and “Surface” Range Gas Wells (2,000’ apart)
Lipsky Water Well
Lipsky Water Well Schematic

- Water line
- Vent Tube
- Garden Hose
- Grout (cement)
- 7" Hole 0' to 200'
- 4" Cag 0' to 180' solid
  180' to 200' slotted
- Discharge pipe

Submersible Pump 180 ft
Total Depth 200 ft
Chronology

• August 6, 2010 - Mr. Steve Lipsky, landowner, filed complaint with Texas Railroad Commission of natural gas in his domestic water well.

• August 6, 2010 – RRC District office staff inspects the water well, tests for chloride and notices gas smell.

• August 10, 2010 – RRC District Office staff inspects nearby Range Production Wells (Butler 1-H, Teal 1-H) in near-by Hood County.

• September 16, 2010 – RRC staff contact Range Production Co. and request additional gas samples from Butler #1-H production tubing and bradenhead for composition and isotope analysis. Also request pressure test of production casing.
• September 20, 2010 – Range collects gas samples.
• October 15, 2010 – Range pressure tests Butler 1-H well. Held 845 psi.
• October 26, 2010 – Joint sampling (EPA, Range).
• December 3, 2010 – Range sends letter to RRC outlining plans for additional assessment.
• December 7, 2010 – EPA issues Emergency Administrative Order. Cites, among other things, data showing that gas in water well is thermogenic.
EPA Emergency Order to Range Resources and Texas Railroad Commission

December 7, 2010

CERTIFIED MAIL - RETURN RECEIPT REQUESTED (7007 0710 0002 1385 1927)

Mr. Mike Middlebrook
Vice President of Operations
Range Resources Corporation and
Range Production Company
100 Throckmorton Street, Suite 1200
Fort Worth, TX 76102

Re: Findings and Emergency Order
Docket No. SDWA-06-2011-1208
Butler Unit, Lease No.: 253732, Well #1-H
Teal Unit, Lease No.: 253779, Well #1-H

Dear Mr. Middlebrook:

As a result of investigatory work performed, the U.S. Environmental Protection Agency (EPA) Region 6 has determined that an imminent and substantial endangerment to a public drinking water aquifer has occurred (or may occur) through methane contamination which is directly related to oil and gas production facilities under your operation. The Agency has data to indicate that two private drinking water wells, and potentially more, have been significantly impacted by the methane contamination which presents a potential threat of explosion due to high levels found dissolved in the drinking water and methane vapors present in the headspace of the drinking water wells, and therefore presents a potential imminent endangerment to the health of persons using these private drinking water wells.

Exhibit No. 5
Operator: Range Resources
Docket No. TB-0288629
Date: January 19, 2011
ENVIRONMENTAL PROTECTION AGENCY
REGION VI

IN THE MATTER OF:

RANGE RESOURCES CORPORATION
and
RANGE PRODUCTION COMPANY

Respondents.

(Texas RRC Operator I.D. No. 691703)

Proceedings Under Section 1431(a) of the
Federal Safe Drinking Water Act, 42 U.S.C.
§ 300(i)(a).

Docket Number: SDWA-06-2011-1208

EMERGENCY ADMINISTRATIVE ORDER

STATUTORY AUTHORITY

The following findings are made and Order issued under the authority vested in the
Administrator of the United States Environmental Protection Agency ("EPA") pursuant to the
authority of Section 1431 of the Safe Drinking Water Act ("SDWA" or "Act"), 42 U.S.C.
§ 300(i).

EPA may issue such Orders upon receipt of information that contaminants are present in
or are likely to enter an underground source of drinking water and may present an imminent and
substantial endangerment to the health of persons, and EPA has determined that appropriate State
and local authorities have not taken sufficient action to address the endangerment described
herein and do not intend to take such action at this time, as described in Section 1431(a) of the

• December, 2010 – January, 2011 – Extensive sampling testing and evaluation by Range “team”.
Technical data collected and evaluated.

1. Mechanical Integrity testing of Butler 1-H and Teal 1-H gas wells.

2. Geologic setting

3. Hydrogeologic setting of
   a. Freshwater Trinity aquifer in Parker/Hood counties
   b. Underlying Pennsylvanian Strawn Formation
Technical data collected and evaluated, con’t.

4. 28 Water Wells Tested in 3,000’ radius
   a. Well Construction
   b. Dissolved Constituents
   c. Gas Constituents
      1) Methane, ethane, ...
      2) CO$_2$ and Nitrogen
      3) $\delta^{13}$C and $\delta$ D of CH$_4$
Technical data collected and evaluated, con’t.

5. Historical occurrence of natural gas in region.


7. Micro seismic analysis
The Team:

David Jackson, Jackson, Sjoberg, McCarthy and Wilson
Charles Kreitler, LBG-Guyton Associates
John McBeath, Platt and Sparks
Mark McCafferty, Weatherford Laboratories
Alan Kornacki, Weatherford Laboratories
Keith Wheeler, Pastor, Behling and Wheeler
Norman Warpinski, Pinnacle-Haliburton
Andrew Sims, Harris, Finley, and Bogle
The Big Questions

• Is there dissolved methane in the groundwater?
• Where did it come from and when did it occur?
• Was Range contributory?
• Butler and Teal wells were tested and found to be properly constructed (McBeathh testimony).
  Record review
  MIT testing
  Cement bond log
  Gas Chemistry

Schematic
Butler 1-H
GEOLOGIC MAP AND CROSS SECTION
PARKER COUNTY, TEXAS

Modified from Bulletin 5103, Texas Board of Water Engineers, “Ground-Water of Parker County”, Stramel, G. J., 1951

FREDRICKSBURG GROUP
Paluxy Formation
Glen Rose Formation
Twin Mountains Formation
Mineral Wells Formation
Garner Formation
Milsap Lake Formation

BEG Geologic Atlas of Texas, Dallas Sheet, revised 1987
# STRATIGRAPHIC CHART

**Teal & Butler Units Area**  
Hood & Parker Cos., TX

<table>
<thead>
<tr>
<th>SYSTEM</th>
<th>STAGE</th>
<th>GROUP or FORMATION</th>
<th>Time (my)</th>
<th>Thickness (ft)</th>
</tr>
</thead>
<tbody>
<tr>
<td>CRET.</td>
<td>LOWER</td>
<td></td>
<td>145</td>
<td>~400</td>
</tr>
<tr>
<td>PENNSYLVANIAN</td>
<td>MIDDLE</td>
<td></td>
<td>~310</td>
<td>~850</td>
</tr>
<tr>
<td>PENNSYLVANIAN</td>
<td>LOWER</td>
<td></td>
<td>(170 my)</td>
<td>~5200</td>
</tr>
<tr>
<td>PENNSYLVANIAN</td>
<td>LOWER</td>
<td></td>
<td>315 my</td>
<td>~5700</td>
</tr>
<tr>
<td>PENNSYLVANIAN</td>
<td>M-UPPER</td>
<td></td>
<td>325 my</td>
<td>~6000</td>
</tr>
<tr>
<td>PENNSYLVANIAN</td>
<td>LOWER</td>
<td></td>
<td>475 my</td>
<td></td>
</tr>
</tbody>
</table>

**Unconformity**  
145 my  
310 my  
(170 my)  
Lot of Erosion!
Angular Unconformity @ B/K
Truncation of Strawn Sandstones
Barnet Shale about 5700’ below land surface
320 micro seismic analysis from Parker County indicated that fractures from fracking are confined to Barnett Shale. (Warpinski testimony)
CRETACEOUS TYPE LOG BUTLER/TEAL AREA

Most easterly well with complete suite of open hole logs across the Cretaceous interval.

GOODLAND Lime & Clay

PALUXY Sandstone

GLEN ROSE Limestone

Shale & Sandstone

TWIN MOUNTAINS

PENNSYLVANIAN (Strawn)

GOODLAND at surface

Ground Level

Density/Neutron GR (w/PE) Dual Induction Guard Log

PE Curve

Sand 2.0 Lime 5.0
Geologic Cross Section showing Water Wells completed in Paluxy, Twin Mt, Strawn or Dual Completions
Hydrogeologic interaction between the Trinity and underlying Paleozoics
Historic Occurrences of Shallow Oil, Gas Coal (Parker, Wise and Hood Co.)
SHALLOW STRAVERN GAS FIELDS

Center Mills Gas Field
Occurrence of Natural Gas in Groundwater before Range Drilling

Hurst Water Well Flaring
2005
Occurrence of Natural Gas in Groundwater before Range Drilling

Lake Country Acres
Public Water Supply
Well Field
Reportedly this well pumped all summer, pumping 2" stream, to fill pond.

Gravel Pack Completions (slotted or screened)

Shallow Structural Cross Section
Subject: CONTAMINANT DETECTION LETTER
Date of Sample: August 26, 1998
EP: 98-12333

CHEMICAL DETECTION HAS TRIGGERED AN ADDITIONAL SAMPLE
LAKE COUNTRY ACRES-HOOD CNTY WTR C - PWS ID=1110059
HOOD County, Texas

Dear Water System Official:

The results of a drinking water sample collected from your water system showed the detection(s) listed below. A "detection" simply means that the chemical(s) were present in the water sample. It does not mean that your system is in violation of drinking water standards and does not require any action on your part.

<table>
<thead>
<tr>
<th>Chemical</th>
<th>Level Detected (µg/l)</th>
<th>Entry Point #</th>
<th>MCL (µg/l)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Propane</td>
<td>65</td>
<td>001</td>
<td>None</td>
</tr>
<tr>
<td>Isobutane</td>
<td>21</td>
<td>001</td>
<td>None</td>
</tr>
<tr>
<td>Butane</td>
<td>16</td>
<td>001</td>
<td>None</td>
</tr>
</tbody>
</table>

Chemical Group: J3 (VOC)
Lake Country Estates Well Field

2000 report

<table>
<thead>
<tr>
<th>Tentative Compound ID</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>Propane</td>
<td>369.9</td>
</tr>
<tr>
<td>Isobutane</td>
<td>56.8</td>
</tr>
<tr>
<td>Butane</td>
<td>64.3</td>
</tr>
<tr>
<td>1-Methylbutane</td>
<td>33.2</td>
</tr>
<tr>
<td>Pentane</td>
<td>11.1</td>
</tr>
<tr>
<td>Methylpentane (2 isomers)</td>
<td>13.6</td>
</tr>
<tr>
<td>Hexane</td>
<td>2.1</td>
</tr>
<tr>
<td>Methylcyclopentane</td>
<td>1.8</td>
</tr>
<tr>
<td>Cyclohexane</td>
<td>4.8</td>
</tr>
<tr>
<td>2-Methylcyclohexane</td>
<td>1.5</td>
</tr>
</tbody>
</table>
At entry point 001 there are four active wells. Well G1110059A is indicated as being 360 ft. deep and has no known drill date. This well is well # 1. Well, G1110059C, is called well # 2 and has a drill date of 1/14/1986. Our files contain a drillers log for this well. Well # 3, G1110059D, was drilled in July 2000. Well # 4 was conditionally approved for construction by letter July 21, 2003. This well had high levels of natural gas and was abandoned and plugged. I have enclosed a copy of a letter which discusses the abandoning of well # 4 and the drilling of a replacement well, well # 5. These wells are not in the list of sources from the inspection done 10/17/03.
Sampling Locations
28 wells sampled
December, 2012
Dissolved Methane Concentrations in Water Wells within 3,000 ft of 1 year-old Range Wells
Random CH$_4$ Distribution, No Plume
“The water was fizzing from all the natural gas!”

Overpumping a water well causes cavitation and degassing.

- Land surface
- Static water level
- Cone of depression (local water level decline)
- Pumping level
- Aquifer

Depressurizing of aquifer from pumping causes:
1) Cavitation (fizzing water)
2) Gases to come out of solution

Low transmissive aquifer
Stable carbon and hydrogen isotopic composition ranges of methanes from different sources

δD of CH₄ (‰)

δ¹³C of CH₄ (‰)

(Reference: Coleman. 1993; Schoell. 1980)
Nitrogen and CO$_2$ Analyses (McCafferty Testimony)

Figure 6: This plot is similar to Figure 5, but is constrained to samples from Parker and Hood Counties. These data demonstrate that the natural gas in the Lipsky and Purdue water wells is the type of nitrogen-rich gas that occurs only in Pennsylvanian reservoirs in the Fort Worth Basin.
TDS in Water Wells within 3,000 ft of...
Chloride Concentrations in Water Wells within 3,000 ft of Range Wells
Na vs Cl
Twin Mountain Water Wells
(Silverado/Lake Country Drive Area)
Sampled December 2010

Addition of Saline Formation Water to Groundwater

Na/Cl = 0.6

Background Twin Mountains Water
Discharge of Saline Water and Hydrocarbons from Underlying Saline Formations into Fresh Water Aquifers?
Distribution of 1000 mg/l (brackish or greater) ground water at depths <500Ft

Figure 1. Map of the United States showing areas of ground water containing more than 1,000 mg/L total dissolved solids at depths less than 500 ft below land surface (data from Feth and others, 1965).
Sedimentary Basins of Texas

Permian

Gulf Coast
Pressure Depth Plot for Frio Formation, Texas Gulf Coast showing Geopressuring

Upward Potential for Flow from Geopressured Sediments to Hydrostatic Sediments
Cross Section of Texas Gulf Coast
Showing Flow Lines from Geopressured Sections
to Hydropressured Sections
Saline Groundwater Flow in Coleman Junction/ Wolfcamp Fm, Palo Duro Basin (Permian Basin)
Discharge of Saline Water and Hydrocarbons from Underlying Saline Formations into Fresh Water Aquifers?
Conclusions before Texas Railroad Commission

1. Source of Natural Gas
   a. Thermogenic gas was present in the Trinity aquifer water wells
   b. Not Range Barnett hydrofracking operations (Wells were properly drilled, cased and operated)
   c. Upward leakage from underlying gas-bearing Strawn Formation, and not the deeper Barnett Shale.
Conclusions, con’t.

2. Evidence

1) Geologic setting
   a) Unconformity (where is the base of Trinity and the top of the Strawn?)
   b) Some water wells may be dual completions Strawn and Cretaceous
   c) Occurrence of shallow Strawn gas fields

2) Pervasive occurrence of natural gas in groundwater

3) Predrilling/prefracking occurrence of natural gas in groundwater
4) Elevated Groundwater inorganic chemistry (Cl and TDS)
5) Gas chemistry.
a. Presence of thermogenic gas is not confirmatory to a specific formation
b. Methane in groundwater not normally tested
c. Other gases (CO₂ and N₂)
c. Noble gases (will discuss in a second)
Conclusions, con’t.

3. Interaction between “freshwater” aquifers and underlying saline formations in sedimentary basins.
Outcome of RRC Hearing

- Based on these data, the Commission found that Range Resources’ natural gas wells did not cause or contribute to contamination of any Parker County domestic water wells (March 22, 2011).
Since then

- EPA Emergency order (political)
- RRC presentation in Washington (political)
- RRC follow up (technical)
- Noble gases (technical)
EAP withdraws emergency order
March 30, 2012
U.S. House of Representatives Committee on Science, Space, and Technology
Examining the Science of EPA Overreach: A Case Study in Texas

Texas Railroad Commissioner David J. Porter
February 5, 2014
Railroad Commission of Texas

Water Well Complaint Investigation Report

Silverado on the Brazos Neighborhood

Parker County, Texas

May 23, 2014
Between August 5, 2013 and September 6, 2013, the Railroad Commission of Texas (RRC) District 7B Office was contacted by seven property owners concerning the occurrence and apparent increase in methane in their water wells and an eighth property owner regarding the occurrence and apparent increase of chloride in two water wells. The District Office performed initial inspections in August and September 2013. Complaint status reports were issued January 24, 2014.

A ninth complaint was filed on January 28, 2014, due to the complainant’s concern about methane in a water well based on proximity to other complaints. An initial inspection was performed February 4, 2014.
- Surface casings of nearby Barnett Shale wells are sufficiently deep to isolate useable quality groundwater. Records show that surface casing cement was circulated to ground surface at each well.
- Bradenhead pressures were either absent or sufficiently low when monitored so as not to be considered a threat to surface casing integrity based on the RRC’s Bradenhead Pressure Management Guidance procedure.
- Records submitted to the RRC, including cement bond logs, show that tops of production casing cement occur in excess of 600 feet above the productive zones in each well.
- Mechanical Integrity Tests (MITs) performed by Range Resources on the Teal 1-H and Butler 1-H wells revealed no leaks in the production casing of each well, according to expert testimony provided at the January 19-20, 2011, hearing.
- Plugging records for the Carrizo Mund-Lipscomb 1-H well show that cement plugs were placed across the fresh water interval.
- Hydraulic fracturing was performed in the Barnett shale which occurs at approximately 5,700 feet below ground surface.

- The base of the aquifer and the Barnett shale are separated by approximately 5,300 feet of geological strata. Seismic reflection data submitted by Range Resources to the RRC do not show the presence of faults above the Barnett Shale beneath the neighborhood.
Conclusions

Based on the information described above, Commission staff has determined that the evidence is insufficient to conclude that Barnett Shale production activities have caused or contributed to methane contamination in the aquifer beneath the neighborhood.

Railroad Commission re-affirms their March 2011 ruling

Parker County wells
Parker County Wells
(Darraha and others, 2014)

significantly greater than other natural groundwaters in the area. The similarity between the C2H6+/CH4, 4He/40Ar*, and 4He/20Ne composition of the five impacted wells, including the two that changed between the first and second samplings (Fig. S8), and Strawn-produced gases, suggests an intermediate depth Strawn gas (scenario 4) as the most likely cause for the fugitive gas contamination observed in Texas.
CH$_4$ in Groundwater
Other Locations and Other Times

• Other locations
  – Texas
  – West Virginia
  – New York
  – Pennsylvania
Methogenic vs Thermogenic

CH₄ in Central Texas Aquifers
(Grossman and others, 1995)

Thermogenic
Cretaceous

"Biogenic"
Eocene

Carbon isotopic composition versus dissolved methane concentration for central and east-central Texas groundwaters.
In cooperation with the West Virginia Department of Health and Human Resources, Bureau for Public Health, Office of Environmental Health Services, Environmental Engineering Division, and the West Virginia Department of Environmental Protection, Division of Water and Waste Management

Methane in West Virginia Ground Water

(1997-2005)
The 1999–2011 analysis of dissolved methane in groundwater in New York is meant to document the natural occurrence of methane in the States aquifers. The data...
Historic Accounts of Natural Gas Springs in New York

Otisco Lake—Easternmost Finger Lake, Onondaga County, N.Y.

From the Skaneateles Historical Society’s Girl Scout Scrapbook, Skaneateles, N.Y., December, 1942.

“Troop 57 Does Out-Door Cooking in a New Way”

“We’ve heard of a lot of ways to do outdoor cooking but Troop 57 of Skaneateles certainly pulled a new one out of the bag recently. The girls hiked along Otisco Lake through Puddin’ Mill Gorge where they cooked their lunch with natural gas which came up through the creek bed.”

(USGS 2012)
PHILADELPHIA (July 25, 2012) – The U.S. Environmental Protection Agency announced today that it has completed its sampling of private drinking water wells in Dimock, Pa. Data previously supplied to the agency by residents, the Pennsylvania Department of Environmental Protection and Cabot Oil and Gas Exploration had indicated the potential for elevated levels of water contaminants in wells, and following requests by residents EPA took steps to sample water in the area to ensure there were not elevated levels of contaminants. Based on the outcome of that sampling, EPA has determined that there are not levels of contaminants present that would require additional action by the Agency.
Methane in Susquehanna County groundwater

From May 2008 through 2009, in accordance with current Pennsylvania DEP guidelines, Cabot Oil & Gas Corp. collected water samples from all existing water wells within 1,000 ft of proposed gas well drilling sites.
Methane in Pennsylvania water wells unrelated to Marcellus shale fracturing


• Results from more than 1,700 water wells sampled and tested prior to proposed gas drilling in Susquehanna County, Pa., show methane to be ubiquitous in shallow groundwater, with a clear correlation of methane concentrations with surface topography.
Specifically, water wells located in lowland valley areas exhibit significantly higher dissolved methane levels than water wells in upland areas, with no relation to proximity of existing gas wells. The correlation of methane concentrations with elevation indicates that, on a regional level, elevated methane concentrations in groundwater are a function of geologic features, rather than shale gas development.

Technical literature and historical publications confirm the presence of methane gas in natural seeps and water wells in this region for many decades, long before shale gas drilling operations were initiated in 2006.
“In addition, the Pennsylvania Geological Survey's 1922 publication "The Oil and Gas Fields of Pennsylvania" describes several instances of known shallow hydrocarbon production less than 2,100 ft beneath the surface in the Catskill formation in Wyoming County, directly to the south of Susquehanna County. Numerous other instances of methane gas encountered at depths ranging from 80 to 800 ft below grade in the Catskill or Lock Haven, dating to recent years, are indicated on Table 1 and Fig. 3.”
Pavilion, Wyoming

- EPA developed draft report implying fracking had caused the presence of frack fluids in monitoring wells. (2010)
- Not a CH₄ issue, but a frack fluid issue
- EPA withdrew
- State of Wyoming presently evaluating
What more can I say?

Any Questions?

Charles Kreitler
Senior Consultant
LBG-Guyton Associates
Austin Texas
512-327-9640
ckreitler@lbg-Guyton.com