BIPARTISAN POLICY CENTER

Memorandum **July 2010**

To: **Task Force on Ensuring Stable Natural Gas Markets**

From: **BPC Staff – Lourdes Long**

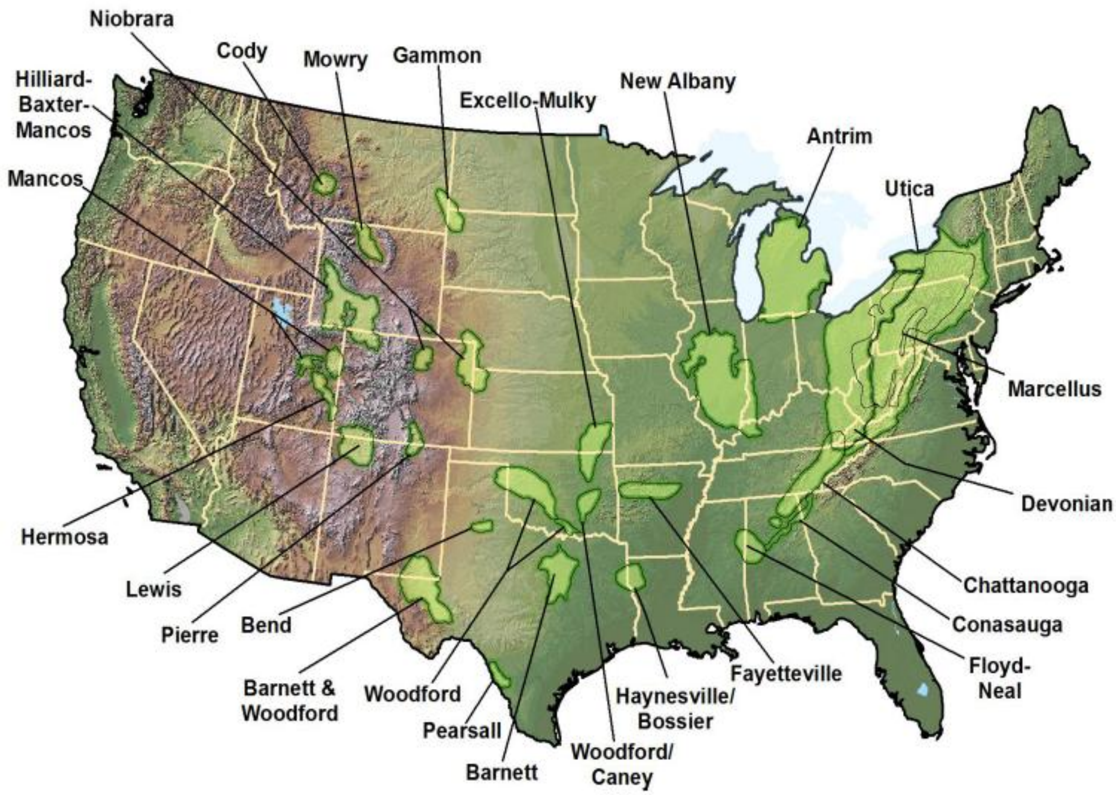
Subject: **Water Impacts Associated with Shale Gas Development**

During the May 2010 meeting of the Task Force on Ensuring Stable Natural Gas Markets, the task force examined the significant potential for shale gas development in the U.S. to dramatically increase the supply outlook for domestic natural gas resources. The Task Force acknowledged the unique water impacts of shale gas development and the importance of understanding the potential impact on production. Given the Task Force's scope, the key question raised was – How might water availability challenges constrain efforts to expand shale gas production? This memo summarizes the main water impacts associated with shale gas development in order to address this central question.

I. Introduction

Sharply higher estimates of the recoverable natural gas resource base in the United States depend on the ability to access new reserves through the process of hydraulic fracturing—artificially stimulating the shale deposits with an injected fluid to extract trapped natural gas. Shale gas represents a significant opportunity to expand domestic natural gas supply and extensive development activities associated with shale production have the potential to impact water availability and quality. Hydraulic fracturing is not a new process, but the technologies involved have evolved more quickly than gas developers, regulators, and the public's understanding of the potential environmental impacts. A number of environmental issues have been raised in connection with hydraulic fracturing, including concerns about the potential for groundwater contamination, regional water availability, land subsidence, and other above- and below-ground impacts. Environmental and public safety concerns are likely to become more salient as the practice of hydraulic fracturing is applied in new regions of the U.S. which have little prior experience with oil and gas development. The map below highlights the major shale gas basins the U.S. As is evident, there are significant shale gas resources in the Eastern states, areas that relatively unfamiliar with oil and gas production.

Figure 1. United States Shale Gas Basins[1]



Source: ALL Consulting, Modified from USGS & other sources

Several recent studies suggest that the environmental impacts of shale gas development are challenging but manageable.[2] This memo summarizes the key water issues related to shale gas development. The primary areas of concern are:

- Location of adequate water resources in regions of intense production
- Application of state and federal regulation of drilling and water management practices
- Contamination of freshwater aquifers, particularly with fracturing fluids
- Contamination of surface water, particularly from improper disposal of “flowback” fluids that return to the surface during fracturing operations
- Relative water impacts from shale gas production as compared to conventional gas production and of generating electricity from shale natural gas as compared to other sources of natural gas and other fuels.

[1] Ground Water Protection Council and ALL Consulting. Modern Shale Gas Development in the United States: A Primer. April 2009. Page 8.

[2] Massachusetts Institute of Technology. The Future of Natural Gas: An Interdisciplinary MIT Study. Interim Report. June 2010. Page xiii.

II. Ensuring Sufficient Water Resources for Robust Resource Development

The need to secure access to adequate water supplies may limit the speed with which shale gas is developed in some areas. The average well requires about 3 million gallons of water for both drilling and hydraulic fracturing.[3] Total water use could vary widely depending on the pace of shale development. If several hundred or as many as 1,000 wells are drilled annually, finding adequate water supplies may be challenging. The table below summarizes estimated total per-well water needs for four shale gas plays currently being developed. For comparison, an Olympic-size swimming pool holds over 660,000 gallons of water and the average annual per capita consumption of fresh water in the U.S. is 522,000 gallons.[4]

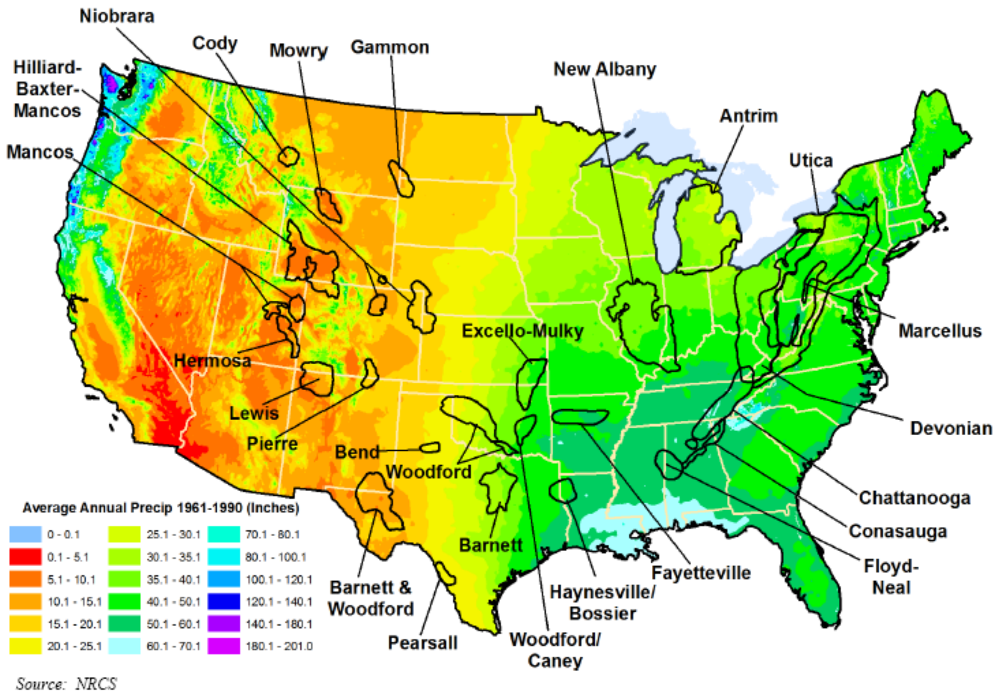
Table 1. Estimated Water Needs for Drilling and Fracturing Wells in Select Shale Gas Plays[5]

Shale Gas Play	Total Volumes of Water per well (gal)	Volume of Drilling Water per well (gal)	Volume of Fracturing Water per well (gal)
Barnett Shale	2,700,000	400,000	2,300,000
Fayetteville Shale	3,960,000	60,000*	2,900,000
Haynesville Shale	3,700,000	1,000,000	2,700,000
Marcellus Shale	3,880,000	80,000*	3,880,000
*Drilling performed with an air "mist" and/or water-based or oil-based muds for deep horizontal well completions. Note: These volumes are approximate and may vary substantially between wells. *Source: ALL Consulting from discussions with various operators, 2008.*			

The volume of water necessary to develop a shale gas well is large, but generally represents less than 1% of the total water resource consumed in the region where the shale gas basin is situated. (Calculations indicate that water use will range from less than 0.1% to 0.8% by basin.)[6] Shale gas production often takes place in regions with moderate to high levels of annual rainfall, as reflected in the map below.[7] The necessary water resources can come from a range of surface resources, including rivers and lakes, as well as ground water, private water sources, municipal water, and re-used produced water from previous drilling operations.[8]

[3] Ground Water Protection Council and ALL Consulting. Modern Shale Gas Development in the United States: A Primer. April 2009. Page 64.
[4] Congressional Research Service. Unconventional Gas Shales: Development, Technology, and Policy Issues. October 2009. Page 24.
[5] Ground Water Protection Council and ALL Consulting. Modern Shale Gas Development in the United States: A Primer. April 2009. Page 64.
[6] Ground Water Protection Council and ALL Consulting. Modern Shale Gas Development in the United States: A Primer. April 2009. Page 65. Note: See map above for definition of shale gas basins.
[7] Ibid.
[8] Ibid.

Figure 2. Annual Rainfall Map of the United States[9]



However, the incremental water demand from shale gas development may compete with demand from population growth, other industrial demand, and biological instream flow values, even in regions with moderate to high levels of precipitation. And, because the demand for water is greatest during fracturing operations, significant volumes of water must be withdrawn over a short period of time. If this peak water demand is during a period of low water resources, it could have a particularly significant impact on other recreational or commercial activities.

On some development sites, storage pits can be used to ensure sufficient water for drilling fluid. Storage pits are typically excavated containment ponds and may be lined, according to on-site conditions and regulatory requirements. This practice is more common in rural areas with sufficient space for storage pits that hold fresh water for drilling and hydraulic fracturing. Water can also be stored on-site in more urban settings using compact steel storage tanks.[10] In addition, in some instances produced water, or water that returns to the surface after a fracturing operation is complete, can be treated and reinjected during subsequent fracturing jobs. This strategy is discussed in more detail below.

[9] Ground Water Protection Council and ALL Consulting. Modern Shale Gas Development in the United States: A Primer. April 2009. Page 67.

[10] Ground Water Protection Council and ALL Consulting. Modern Shale Gas Development in the United States: A Primer. April 2009. Page 55.

III. State and Federal Regulation

As with most oil and gas production in the U.S., shale gas is primarily governed by state laws and regulations. At the federal level, the Clean Water Act (CWA) and the Safe Drinking Water Act (SDWA) also apply. Also, shale gas production is subject to all of the federal, state, and local laws, regulations, and permitting processes that apply to conventional oil and gas development.

At present, hydraulic fracturing is specifically exempted from regulation by EPA under the Safe Water Drinking Act (SDWA).[11] However, the SDWA allows states to obtain primacy for oil- and gas-related injection wells and at least 40 states have obtained primacy to date. In addition, a number of states—notably Colorado, Pennsylvania, and New York— have either passed or are developing their own regulatory requirements and procedures for projects that involve hydraulic fracturing.

The results of an ongoing EPA study of hydraulic fracturing may lead to additional federal involvement in regulating shale gas development. In 2004, EPA first conducted a study to assess the potential for contamination of underground sources of drinking water from the injection of hydraulic fracturing fluids in coal-bed methane wells. Based on the information collected and reviewed at the time, EPA concluded that there was little or no threat to underground sources of drinking water from hydraulic fracturing in this context and that additional studies were not justified (the EPA did note, however, that it retained the right to conduct additional studies in the future). However, this finding—which was specific to a particular geological context—did not resolve important regulatory questions, either with respect to hydraulic fracturing itself or with respect to the appropriate role of federal versus state regulation. In March 2010, the EPA announced that it will conduct a comprehensive, peer-reviewed research study to investigate the potential adverse impact that hydraulic fracturing may have on water quality and public health. The interim findings are expected in late 2012.

IV. Freshwater Contamination

The primary contamination concern from hydraulic fracturing operations is that fluids used in the hydraulic fracturing process may infiltrate freshwater aquifers. The oil and gas industry states that there has been no groundwater contamination to date, though more than one million fracture operations have taken place.[12] However, there have been a handful of reports of well contamination.[13] The following section summarizes the potential for freshwater contamination from drilling and fracturing operations and provides an overview of these processes.

[11] Section 322(1)(B)(ii) of the Energy Policy Act of 2005 excluded "the underground injection of fluids or propping agents (other than diesel fuels) pursuant to hydraulic fracturing operations related to oil, gas, or geothermal production activities" from the definition of "underground injection" in the Safe Water Drinking Act.

[12] ICF International. Joel Bluestein. February 19, 2010. *Natural Gas, Shale Gas and Environment.* Presentation for the Hewlett Foundation.

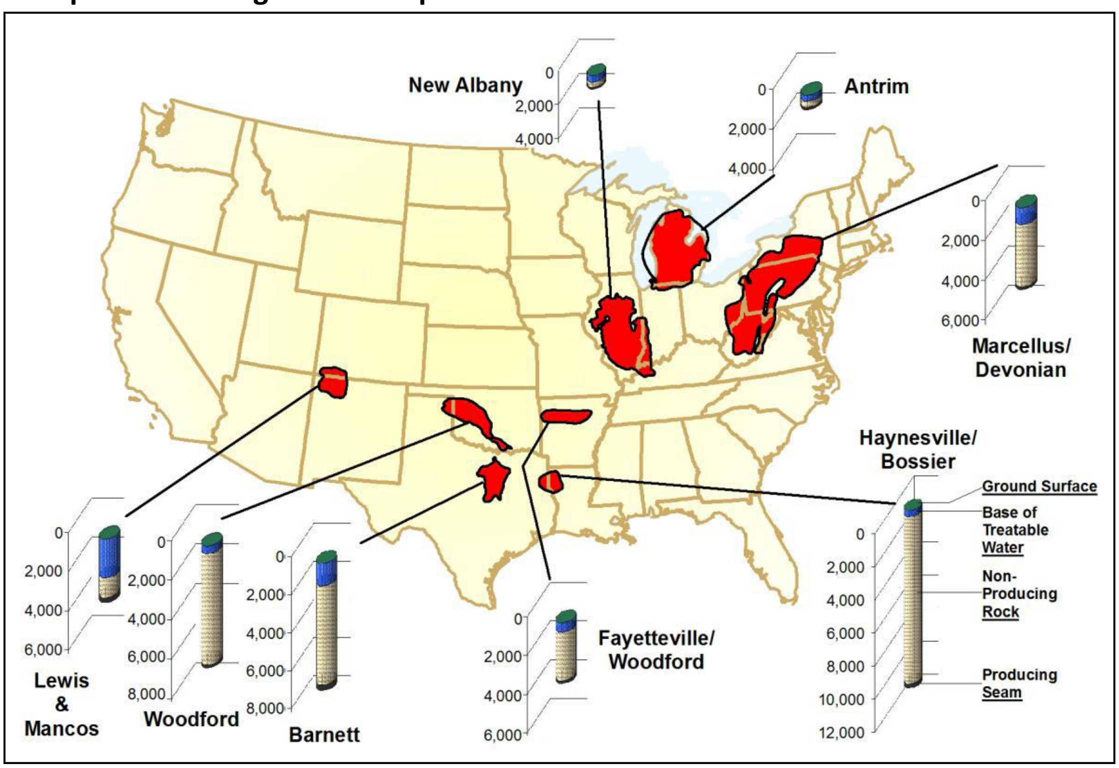
[13] Ibid.

Shale gas formations are far deeper than most freshwater aquifers. The average shale gas well is more than 7,700 feet below surface level (almost 1.5 miles), far below typical groundwater resources.[14] These distinct formations are often separated by intervening and highly stable geologic layers. The table below and the subsequent chart summarize the relative depths of major U.S. shale formations and the associated aquifers. It is important to note that while the depth to shale or depth to aquifer varies across shale formations, in each case the shale is far deeper than the freshwater aquifer.

Table 2. Vertical Separation of Shale Formations from Freshwater Aquifers[15]

Basin	Depth to Shale (ft)	Depth to Aquifer (ft)	Distance Between Aquifer and Average Shale Depth (ft)
Barnett	6,500-8,500	1,200	6,300
Fayetteville	1,000-7,000	500	3,500
Marcellus	4,000-8,500	850	5,400
Woodford	6,000-11,000	400	8,100
Haynesville	10,500-13,500	400	800

Figure 3. Comparison of Target Shale Depth and Base of Treatable Groundwater[16]



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[14] Ibid.

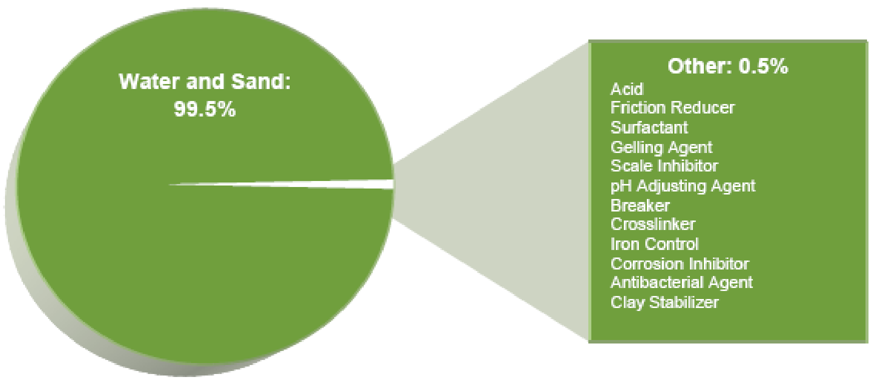
[15] Adapted from Massachusetts Institute of Technology. The Future of Natural Gas: An Interdisciplinary MIT Study. Interim Report. June 2010. Page 15.

[16] Ground Water Protection Council and ALL Consulting. Modern Shale Gas Development in the United States: A Primer. April 2009. Page 54.

Fracturing Fluids

The current hydraulic fracturing process injects millions of gallons of water-based fracturing fluids into each well. Fracturing fluids are used to create and open the fracture and to ensure the "propping agent" or proppant, which holds the fracture open, travels the length of the fracture.[17] These fluids are mostly water (typically more than 99%) but also contain very low concentrations of between 3 and 12 additive chemicals.[18] The chemical additives used depend on the site-specific characteristics of the shale and water resources, and the specific proportions of each chemical additive are often kept proprietary. The figure below identifies some of the engineering benefits of these chemical additives.

Figure 4. Fracturing Fluid Composition[19]



The actual hydraulic fracturing process could be responsible for introducing contaminants into aquifers. Because hydraulic fracturing, as the name implies, creates new fractures in the shale formation, there is some potential that the fractures propagated may breach an overlying aquifer.[20] The likelihood of this intrusion depends on the depth separating the shale formation and the overlying aquifer. As noted above in Table 2, the separation between shale formation and overlying aquifer is usually several thousand feet.

Reports of contamination allege that chemicals used in the fracturing process have leaked into the groundwater supply. However, the connection between instances of water pollution and the hydraulic

[17] Congressional Research Service. Unconventional Gas Shales: Development, Technology, and Policy Issues. October 2009. Page 24.

[18] Ground Water Protection Council and ALL Consulting. Modern Shale Gas Development in the United States: A Primer. April 2009. Page 61.

[19] ICF International. Joel Bluestein. February 19, 2010. *Natural Gas, Shale Gas and Environment.* Presentation for the Hewlett Foundation.

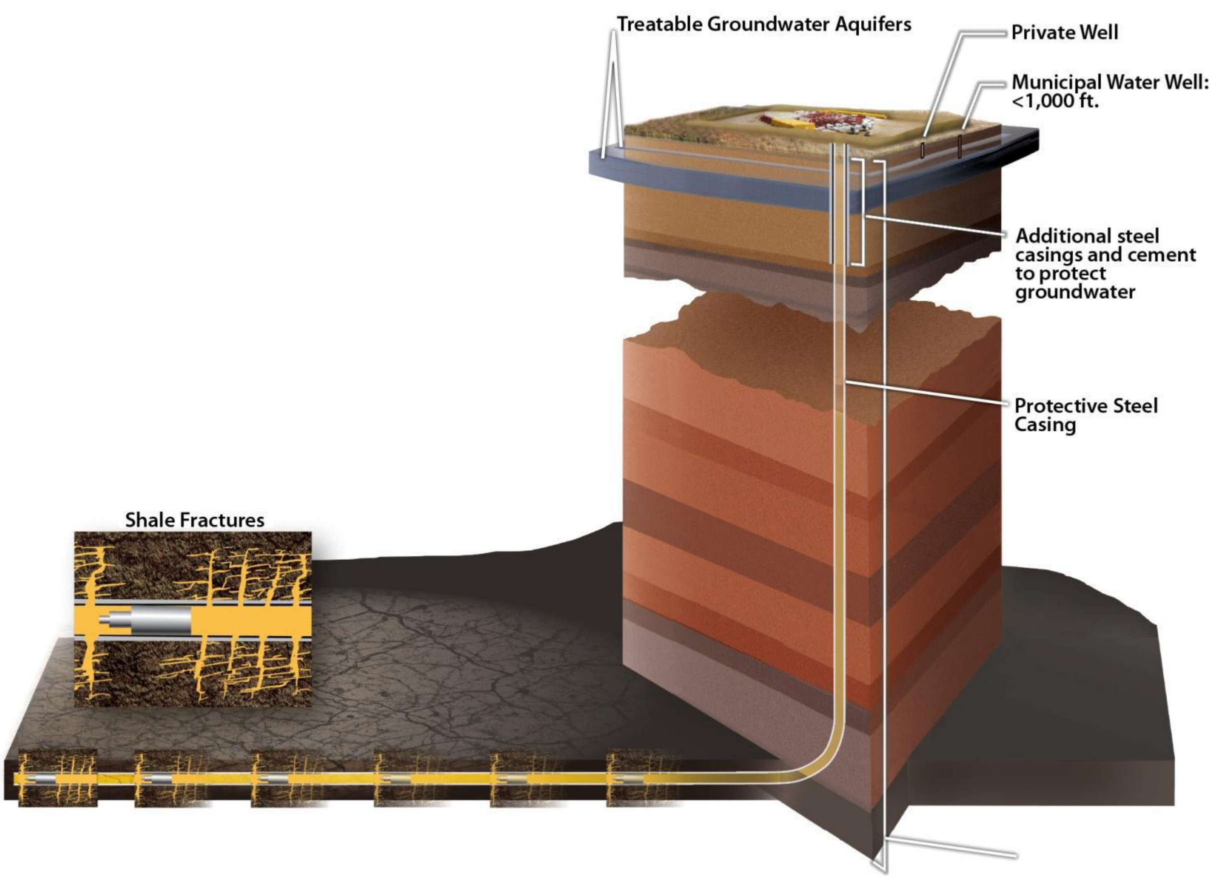
[20] Congressional Research Service. Unconventional Gas Shales: Development, Technology, and Policy Issues. October 2009. Page 26.

fracturing process or the fracturing liquids is not obvious. The casing near the surface may be more at fault than the fracturing operations.[21]

Overview of the Casing Process

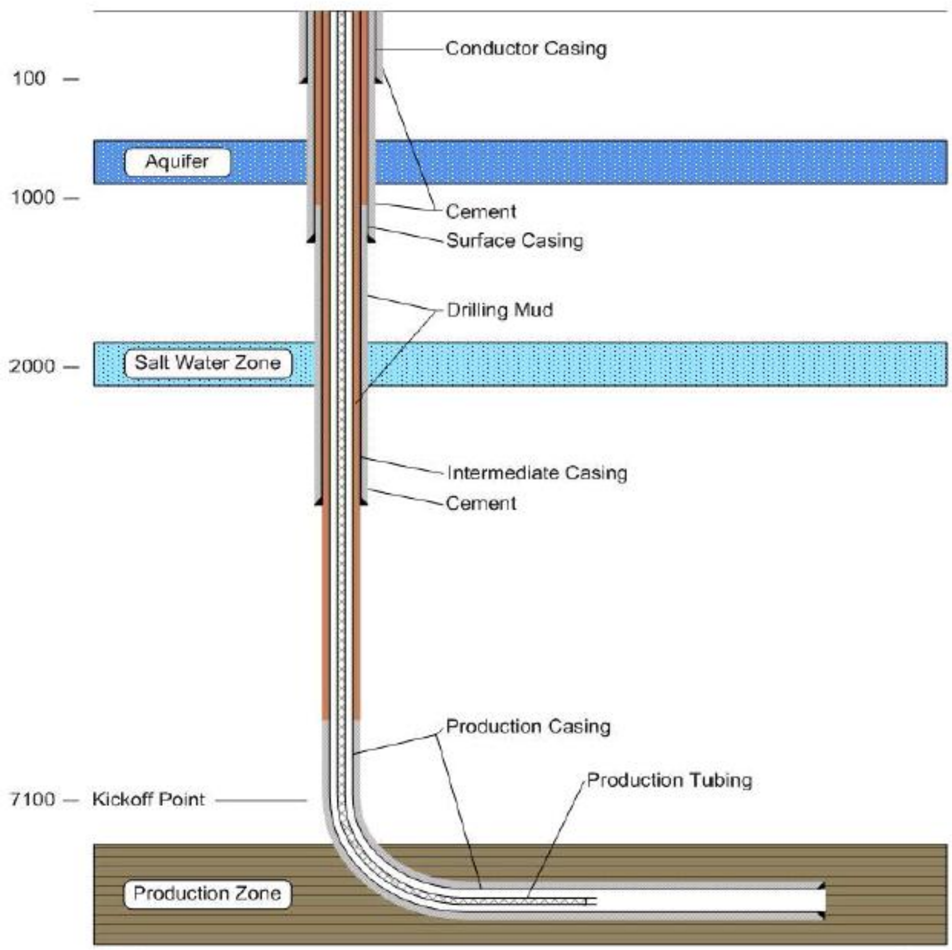
As shown in the figures below, shale gas wells are constructed with multiple layers of steel and cement casing to isolate the producing zone from more shallow formations, including fresh water aquifers.[22] Once the casing and cementing is completed, there may be five or more barriers between the inside of the production tubing and a water formation.

Figure 5. Shale Gas Well with Hydraulic Fracturing[23]



[21] ICF International. Joel Bluestein. February 19, 2010. *Natural Gas, Shale Gas and Environment.* Presentation for the Hewlett Foundation.
[22] Ground Water Protection Council and ALL Consulting. Modern Shale Gas Development in the United States: A Primer. April 2009. Page 52.
[23] Chesapeake Energy. Hydraulic Fracturing: Fact Sheet. March 2010. http://www.chk.com/Media/CorpMediaKits/Hydraulic_Fracturing_Fact_Sheet.pdf.

Figure 6. Casing Zones and Cement Programs[24]



Initially, the conductor and surface casing string are set in the borehole and cemented into place.[25] The conductor casing prevents the surface soils from caving in and the surface casing isolates freshwater-bearing zones from drilling mud and contaminated fluids. Air-rotary drilling, a technique that uses air as the drilling fluid, is often used to drill these initial portions of the well to protect fresh water zones from potential contamination from drilling mud. Before intermediate casings are installed, each casing is cemented to establish a seal between the casing and formation and between the two strings of casing. Regulatory agencies often establish a minimum time to allow the cement to set before additional drilling continues. Intermediate casings may be necessary to isolate the producing wellbore from non-freshwater-bearing zones, including over-pressured zones or a deep saltwater zone. The area below an intermediate casing is often filled with drilling mud rather than cement until just above the kickoff point for the horizontal leg. The casing system and production tubing ensures that the gas flows up into the well rather than into lower pressure zones outside the

[24] Ground Water Protection Council and ALL Consulting. Modern Shale Gas Development in the United States: A Primer. April 2009. Page 52.
[25] Ibid.

casing. In fact, engineers seek to prevent water intrusion into wells, as poorly sealed casings are more likely to contribute to leakage and diminished output.

V. Surface Water Contamination

Shale gas production creates the risk of surface water contamination due to the chance of spills, poorly constructed water wells, and management of fluid "flowback" or produced water from drilling operations. Groundwater can be contaminated by drilling or fracking fluids that spill on the ground and infiltrate the shallow groundwater below. Superficial aquifers, including those in production areas in northern Pennsylvania and southern New York, are particularly at risk.[26]

Poorly constructed water wells can also increase the risk of surface water contamination, particularly domestic water wells that are not subject to the same level of oversight as municipal wells or drilling wells. Improperly constructed or cased water wells could allow contaminated surface water to enter the well water. This risk may be compounded by surface contamination from drilling or fracking fluids. However, it is important to note that water wells can be contaminated by a number of different sources, including leaking septic systems or improperly disposed batteries or used oil.[27] It may be difficult to determine whether surface water contamination is related to shale gas drilling.

For shale gas production, the primary risk of surface water contamination is due to challenges in disposing recovered water and fluids from fracking operations. After a fracturing operation has occurred, a mixture of fluids returns to the surface over the course of several hours, weeks, or even months. The majority of fluids injected into the well, 60% to 80%, return to the surface as "flowback."[28] Flowback generally contains proppant (water, sand, and fracking fluids), water present in the natural formation, chemical residue, and trace amounts of naturally occurring radioactive materials (NORM).[29] The natural formation water often contains very high concentrations of brine and the concentration of total dissolved solids (TDS) can range from 10,000 parts per million (ppm) to 100,000 ppm.[30]

One fracturing operation may return as much as 50,000 barrels of flowback. By comparison, the U.S. onshore gas industry disposes around 18 billion barrels of produced water annually. However, the challenge for shale gas production is the concentration of demand in time and space - one well may

[26] Congressional Research Service. Unconventional Gas Shales: Development, Technology, and Policy Issues. October 2009. Page 26.

[27] Ibid.

[28] Fluids that do not return to the surface most commonly remain in natural macro-porosity in the shale formation of micro-pore space that the gas resource once occupied. In some instances, fractures in the reservoir rock heal after fracturing and trap some of the fracturing fluids. (Source: Ground Water Protection Council and ALL Consulting. Modern Shale Gas Development in the United States: A Primer. April 2009. Page 66.)

[29] Congressional Research Service. Unconventional Gas Shales: Development, Technology, and Policy Issues. October 2009. Page 26.

[30] Ground Water Protection Council and ALL Consulting. Modern Shale Gas Development in the United States: A Primer. April 2009. Page 66. And Hightower, Mike. Sandia National Laboratory. Energy and Water: Shale Gas Issues and Challenges. May 2010.

require several fracturing operations and thousands of wells may be drilled in a given region.[31] The lack of infrastructure to manage flowback may limit the speed of shale gas development in some areas.[32]

Managing Produced Water

The gas producer may store the flowback and brine solutions in on-site, open-air retention ponds before reuse or disposal. The well operator must separate, treat, and dispose the natural brine co-produced with gas and must reclaim the temporary storage pits when on-site operations end.[33]

The most commonly applied water management techniques are deep injection, treatment and discharge, and recycling. In many oil and gas production operations, recovered water is disposed of through injection into deep wells, using salt water disposal wells to pump the produced water deep underground into existing rock formations.[34] This technique may be the best strategy for produced water from shale gas, but is not feasible in all regions and is particularly difficult in areas without existing oil and gas production infrastructure.[35] The oil and gas industry uses deep well injection in some western states and in Ohio, but has not yet applied this strategy in the eastern states, including the Marcellus Shale formation.[36]

Water treatment can take place on-site or at municipal or commercial treatment facilities. Produced water may be transported by tanker truck to distant injection sites or to wastewater treatment facilities, but there are a number of associated environmental and cost issues. Specifically, trucking represents an added cost and increases the chance of a leak or spill that may contaminate surface or groundwater.[37] The volumes of wastewater produced by shale gas production in a relatively short timeframe may overwhelm wastewater treatment facilities.[38] And there is some uncertainty that publicly owned treatment works (POTW) can accommodate the contaminants present in flowback – particularly the chemicals in the fracturing fluid and the produced brine.

Increasingly, water is retreated for reuse in subsequent fracturing operations rather than fully treated for discharge. Recycling can contribute to overall reduction in water demand for shale production,

[31] Massachusetts Institute of Technology. The Future of Natural Gas: An Interdisciplinary MIT Study. Interim Report. June 2010. Page 16.
[32] Hightower, Mike. Sandia National Laboratory. Energy and Water: Shale Gas Issues and Challenges. May 2010.
[33] Congressional Research Service. Unconventional Gas Shales: Development, Technology, and Policy Issues. October 2009. Page 35.
[34] Ground Water Protection Council and ALL Consulting. Modern Shale Gas Development in the United States: A Primer. April 2009. Page 68.
[35] Hightower, Mike. Sandia National Laboratory. Energy and Water: Shale Gas Issues and Challenges. May 2010.
[36] Congressional Research Service. Unconventional Gas Shales: Development, Technology, and Policy Issues. October 2009. Page 34.
[37] Ibid.
[38] Note that this occurred in Pennsylvania's Monongahela River during the fall of 2008. Congressional Research Service. Unconventional Gas Shales: Development, Technology, and Policy Issues. October 2009. Page 34.

but additional technological development is necessary to make this a widespread practice.[39] As summarized in the table below, water management strategies differ across the various shale gas basins.

Table 3. Current Produced Water Management by Shale Gas Basin[40]

Shale Gas Basin	Water Management Technology	Availability	Comments
Barnett Shale	Class II injection wells[41]	Commercial and non-commercial	Disposal into the Barnett and underlying Ellenberger Group
	Recycling	On-site treatment and recycling	For reuse in subsequent fracturing jobs
Fayetteville Shale	Class II injection wells	Non-commercial	Water is transported to two injection wells owned and operated by a single producing company
	Recycling	On-site recycling	For reuse in subsequent fracturing jobs
Haynesville Shale	Class II injection wells	Commercial and non-commercial	
Marcellus Shale	Class II injection wells		Limited use of Class II injection wells
	Treatment and discharge	Municipal waste water treatment facilities, commercial facilities reportedly contemplated	Primarily in Pennsylvania
	Recycling	On-site recycling	For reuse in subsequent fracturing jobs
Woodford Shale	Class II injection wells	Commercial	Disposal into multiple confining formations
	Land Application		Permit required through the Oklahoma Corporation Commission
	Recycling	Non-commercial	Water recycling and storage facilities at central location
Antrim Shale	Class II injection wells	Commercial and non-	

[39] Ground Water Protection Council and ALL Consulting. Modern Shale Gas Development in the United States: A Primer. April 2009. Page 70.
[40] Ground Water Protection Council and ALL Consulting. Modern Shale Gas Development in the United States: A Primer. April 2009. Page 69.
[41] Class II wells are used to inject fluids produced by oil and natural gas development. Class II wells are used for enhanced recovery, disposal, and hydrocarbon storage. There are approximately 150,000 Class II wells in operation in the U.S. and most are located in Texas, California, Oklahoma, and Kansas. The most commonly injected fluid is brine, which is brought to the surface when oil and gas are extracted. More than 2 billion gallons of brine is injected daily into Class II wells. (Source: U.S. Environmental Protection Agency. Underground Injection Control Program. Oil and Gas Related Injection Wells (Class II). http://www.epa.gov/safewater/uic/wells_class2.html.)

		commercial	
New Albany Shale	Class II injection wells	Commercial and non-commercial	

VI. Relative Water Impacts Across Production and Power Generation Technologies

At the first meeting of the Task Force on Ensuring Stable Natural Gas Markets, there was some discussion of the relative water impacts of shale gas development as compared to production of other fuels, including conventional gas. There was also discussion of the relative water demand associated with generating electricity from various fuels. This final section summarizes these relative impacts.

Environmental Impacts of Gas Production – Comparing Production of Shale Gas to Other Fuels

As discussed previously, shale gas production requires a significant amount of water to drill, complete, and fracture a shale gas well. However, production of shale gas is far less water-intensive than extraction of other fuels, including coal gasification or coal liquefaction. The table below summarizes the water use per unit energy for other conventional fuels for power generation.

Table 4. Water Use per Unit Energy[42]

Water Use per Unit Energy (gallons/MMbtu)	
Shale Gas Extraction	1-2
Coal Gasification	50-100
Coal Liquefaction	20-50
Insitu Oil Shale	2-10

Relative to natural gas production from other gas resources, shale gas production, and hydraulic fracturing in particular, presents unique challenges to water resources. Shale gas production differs from conventional natural gas development in the use of horizontal drilling and hydraulic fracturing. The table below summarizes the similarities and differences between the environmental impacts of conventional production and shale gas production. The primary differences are the overall volume of water required and the additional risk of contamination from fracturing fluids.

[42] Hightower, Mike. Sandia National Laboratory. Energy and Water: Shale Gas Issues and Challenges. May 2010.

Table 5. Environmental Impacts of Gas Production[43]

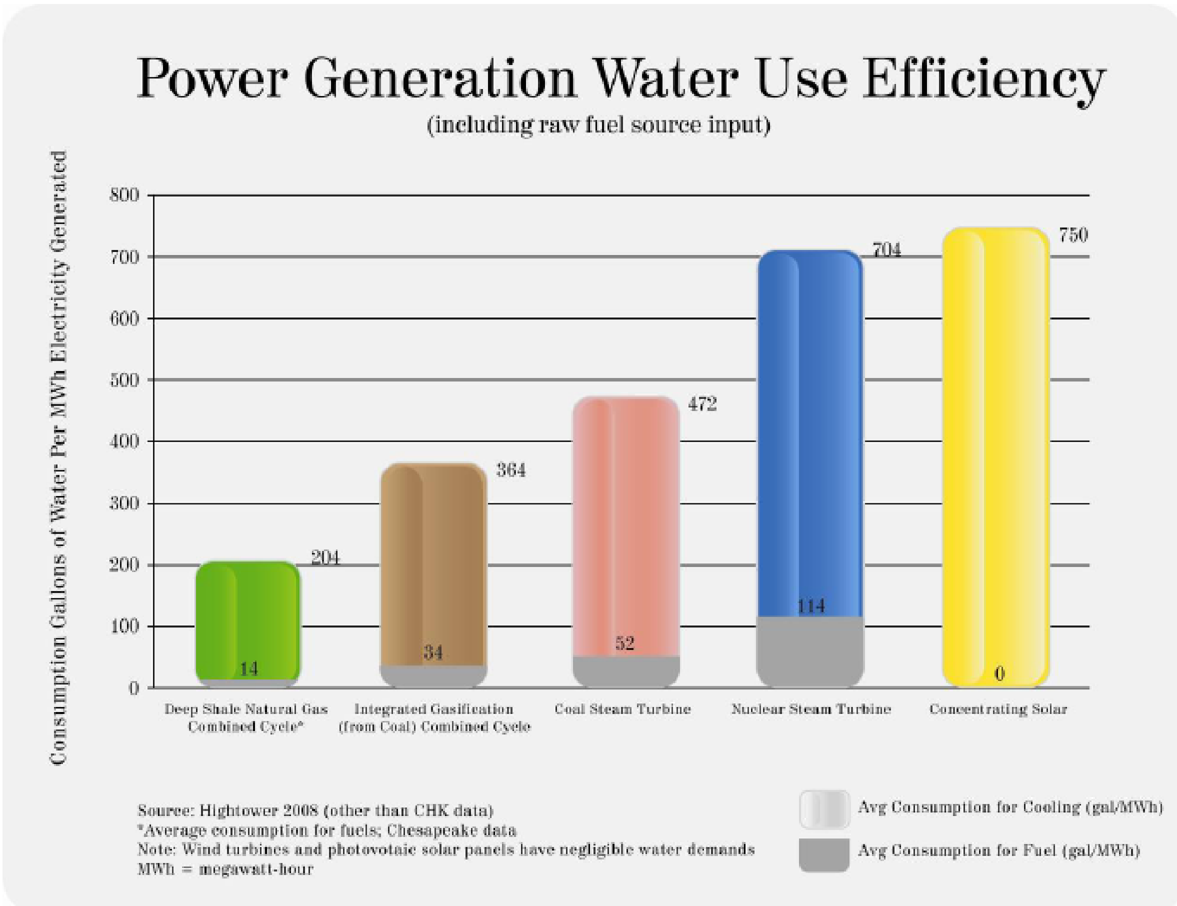
Operation/source	Shale gas-specific
Land use impacts	Different locations
Drill rig emissions (diesel engines)	No
Fracturing emissions (diesel engines)	Yes
Well completion (raw gas)	No
Fracturing clean-out (raw gas)	Yes
Water consumption	Greater for shale
Fluid disposal	Greater for shale
Groundwater impacts	No
Gathering and pipeline compression	No

Comparing Power Generation Technologies

Generating electricity with shale gas uses less water per megawatt hour than other common generation resources, including coal, nuclear, and concentrating solar.[44] Power generated by wind turbines and photovoltaic solar panels do not have significant water demands. As compared to conventional natural gas, the figures that follow demonstrate that natural gas combined cycle firing shale gas consumes less water than conventional natural gas or other generation technologies.

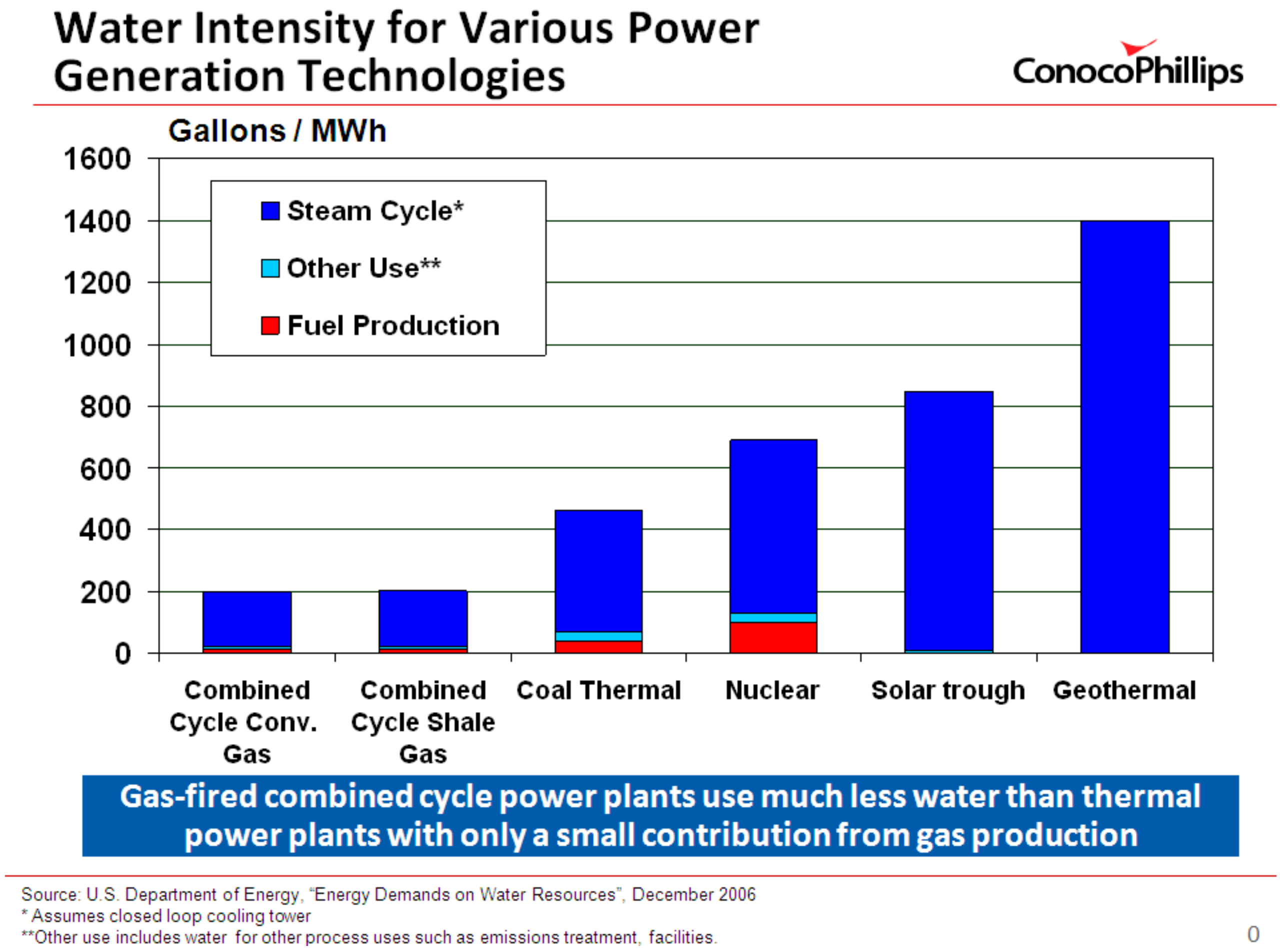
[43] ICF International. Joel Bluestein. February 19, 2010. *Natural Gas, Shale Gas and Environment.* Presentation for the Hewlett Foundation.
[44] Natural Gas: A Bridge Fuel to a Low Carbon Future? February 19, 2010. Presentation for the Hewlett Foundation.

Figure 7. Power Generation Water Use Efficiency[45]



[45] Natural Gas: A Bridge Fuel to a Low Carbon Future? February 19, 2010. Presentation for the Hewlett Foundation.

Figure 8. Water Intensity for Various Power Generation Technologies[46]



It's also important to note that newer power plants generally have lower water demand than older plants, as they can be far more efficient, require less cooling, and consume less fuel. Therefore, modern gas-fired power plants provide a number of environmental benefits compared to other forms of generation. Not only do modern gas-fired plants produce fewer air pollutants, they use far less water than other technologies. Modern plants don't employ a once-through cooling technique which can harm marine life. Some plants are air-cooled rather than water cooled and some units use recycled waste water.

[46] ConocoPhillips. Provided by a participant of the Task Force on Ensuring Stable Natural Gas Markets.

VII. Conclusion

Realizing the potential of the significant domestic shale gas resource requires expanded drilling using new applications of technology, namely hydraulic fracturing, in regions relatively unfamiliar with oil and gas development. There are a number of environmental challenges associated with shale gas production beyond water concerns, including air quality, surface disturbance, and wildlife and community impacts. However, water issues have the greatest potential to impact the cost and speed with which shale can be produced.

In the near-term, ensuring sufficient water supplies for expanded fracturing and drilling operations may present the biggest challenge to a steady expansion of production from U.S. shale gas resources. This is of particular concern in regions with relatively little oil and gas production and with little experience with the associated water and environmental challenges.

Based on the current state of knowledge, the potential for water contamination from fracturing and drilling operations is manageable, but may require efforts to adhere to best practices and to improve regional infrastructure for water management. For example, in June 2010, the American Petroleum Institute issued a guidance document titled *Water Management Associated with Hydraulic Fracturing* that identifies the current industry best practices for water and other fluids management for hydraulic fracturing.[47] These best practices include proactive communication with local water planning agencies, basin-wide hydraulic fracturing planning, and coordination with state and local regulators to better understand the water quality characteristics of local groundwater and surface water bodies. Attention to water management challenges, particularly in shale gas basins that have not traditionally been the site of oil and gas production, can help ensure that water issues do not overly constrain shale gas development.

[47] American Petroleum Institute. *Water Management Associated with Hydraulic Fracturing.* API Guidance Document HF2. First Edition, June 2010.