

The League of Women Voters of Pennsylvania



Marcellus Shale Natural Gas Extraction 2012 Study Guide Addenda

Water Management

League of Women Voters of Indiana County

Committee Members

Clarice Reber, Chair
Cindy Rogers
Mary Beth Sweeney
JoAnne Ferraro
Pepita Jimenez-Jacobs
Dream Van Cise-Watta
Vera Bonnet
Aida Shotts
Lori Rittle
Susan McClure
Sherene Hess, President LWVIC
palwvorg/indiana

This guide was researched and drafted by Indiana League members Cindy Rogers, JoAnne Ferraro and Clarice Reber with editing and review by Vera Bonnet (LWVIC), Mary Beth Sweeney, LWVPA Board of Directors/Natural Resource Specialist, and Roberta Winters, LWVPA Vice President/Issues and Action

**Marcellus Shale Natural Gas Extraction
2012
Study Guide Addenda
Water Management**

Water issues are an important consideration in natural gas extraction from shale. First, millions of gallons of water are required for the drilling and fracking process. Secondly, there is produced water filled with numerous contaminants, some of them toxic, that must be treated both initially and over the long haul. Finally, there are many points along the way from the extraction, production, and transmission processes during which water sources can be degraded. The following update, supplementing the 2009 Study Guide, provides information and resources in regard to recent developments in water quality and quantity management and the emergence of new technologies for drilling, treating, and disposing of wastewater. However, given that all aspects of natural gas operations are continually evolving, it is incumbent on those interested in these issues to follow closely new developments and monitor their consequences.

Water Sources

New Technology

Water for fracking has generally been potable – coming from rivers, streams, wells, and municipal water supplies. Given increasing concerns about the long-term supply of water, consideration is being given to alternative sources, particularly abandoned mine discharges (AMD). Seneca Resources Corporation estimates it is saving \$120,000 per well by using run-off water. In addition, by reducing truck traffic, using this “water” source saves wear and tear on roads (Rigzone staff, 2010).

More recently, a team of researchers from the University of Pittsburgh and Carnegie-Mellon University, funded by the National Energy Technology Laboratory (NETL), has been developing a novel approach for re-use of fracturing flowback water in the Marcellus Shale play. Begun in October 2009 and continuing into September 2013, the project examines the use of water from AMD as a possible supplement to flowback water. It also investigates methods of modifying mine water for use in Marcellus Shale drilling. Currently, the study is considering liabilities and regulations (NETL, 2012).

However, the use of AMD water is problematic. Not all coal mine run-off water is suitable for hydrofracking. AMD water is typically acidic and includes total dissolved solids, iron, aluminum, sulfates, manganese and barium. Sulfates can react with other chemicals underground and essentially clog a well. Since most mine water used by the gas industry is purified, the purification process must be cost-effective to become widely used. There are also legal barriers involving use and responsibility (Curtright & Giglio, 2012; Campbell, 2012). The Pennsylvania Department of Environmental Protection (DEP) issued a White Paper, *Utilization of AMD in Well Development for Natural Gas Extraction* (2011, November) delineating the issues of using AMD for fracking. Currently, research at Temple University is designed to develop a lipid-based technology that could mitigate AMD to make it useable for extracting natural gas from the Marcellus Shale formation (Temple University, 2011).

In attempting to gain an overview of the water issue, the Ground Water Protection Council and ALL Consulting (2009) examined ways to identify drilling and fracking water supplies that do not compromise the needs of the rest of the community. The resulting, comprehensive, 116-page shale

gas primer can be accessed at <http://www.all-llc.com/publicdownloads/ShaleGasPrimer2009.pdf>.

In summary, alternative water sources are emerging. However, the availability of AMD and the impact of the removal and reuse of this mine-related water continue to be debated.

Water during Drought Situations

According to the Penn State Extension publication, *Water Withdrawals for Development of Marcellus Shale Gas in Pennsylvania* (Abdalla & Drohan, 2010), the Clean Streams Law limits the amount of water that can be withdrawn from streams in order to maintain sufficient stream flows to protect aquatic life. In addition to these limitations, water withdrawals exceeding 10,000 gallons per day must be registered with DEP under authority of the Water Resources Planning Act. These regulations have, over the past several years, been used to shut down violators.

During specified drought conditions, water withdrawals can be further limited. Drillers are required to stop withdrawals from streams experiencing very low flow conditions known as Q7-10. Q7-10 refers to the lowest average consecutive 7-day flow that occurs with a frequency of one in ten years (PA Environment Digest in Gas Industry, 2010). For example, in July 2010, the Susquehanna River Basin Commission (SRBC), the interstate agency that issues permits for water withdrawals from specific streams in that watershed, reported 100 percent compliance with drought regulations. A July 16, 2012 SRBC press release for such a suspension of water withdrawals can be found at <http://www.srbc.net/newsroom/NewsRelease.aspx?NewsReleaseID=90>

Water Contamination

Routes of Contamination

The U.S. Environmental Protection Agency (EPA) has indicated that incidents of water contamination found to date are caused by inadequate stormwater management plans, surface spills and methane migration. Other research has focused on the possibility that fracking fluids may migrate upwards to near-surface water aquifers. Warner, et al (2012) sampled water from three northeastern Pennsylvania aquifers, Alluvium, Catskill and Lock Haven, and combined their data with previously published data from the same aquifers (a total of 426 water samples). They found no evidence of brine contamination from shale gas drilling and production. However, the research also found that “pathways, unrelated to recent drilling activities, exist in some locations between deep underlying formations and shallow drinking water aquifers.” Thus, contamination of shallow drinking water is at increased risk by fugitive gases, and polluted water could come to aquifers via natural pathways.

Myers (2012), using interpretive models, postulates that the time it takes brine from deep shale beds to move to the near-surface would require up to tens of thousands of years. However, fracking the shale could reduce the travel time to tens or hundreds of years. Fracture zones found in the Marcellus region could reduce travel time even further. Consequently, he recommends that “monitoring systems be employed to track the movement of contaminants and that gas wells have reasonable offset from faults.”

To determine if fracking fluid is moving upward via these natural pathways or newly created pathways resulting from fracking, the Department of Energy (DOE) has funded a preliminary research project in southwestern Pennsylvania to track fracking fluids by adding tracing elements to those fluids. Hopefully, it will allow scientists to determine if fracking fluids move upwards and/or

sideways from the drilled well. This is the first time experimental data will be gathered from a commercial well (Associated Press, 2012, July 11).

Public Information

Chemicals

Because of the proprietary formulas of many of the chemicals used in the drilling process, corporations have been reluctant to list the specific chemicals and quantities used in the fracking process. To help meet the public demand for more information, a collaborative project was conducted through the Ground Water Protection Council, the Interstate Oil and Gas Compact Commission, and the DOE. This resulted in a public-access web repository called FracFocus (FracFocus, n.d.). This non-governmental site is designed to supplement state regulatory websites and to provide factual information concerning hydraulic fracturing as it relates to groundwater. The site allows operators to list voluntarily the various chemical constituents used in fracturing fluids on their well sites. Although fracking companies have provided a list of commonly used chemicals, others - and their concentrations - are often exempt from disclosure because they are considered trade secrets or proprietary. State and federal laws also include other exemptions that permit drillers to avoid disclosing contents of fracking fluids after they return from deep underground. Details can be found at <http://truth-out.org/news/item/9004-silencing-communities-how-the-fracking-industry-keeps-its-secrets>

To provide more transparency, another website (<http://fracfocus.org>) went live on April 11, 2011. By April 2012, 15,000 disclosures by 231 companies were made in the USA, with over 1600 coming from Pennsylvania (FracFocus, n.d.). Users can search the site database for individual, hydraulically fractured wells by state, county, API number, lease number or well number. Additional data fields provide information on the type of well (oil or gas), the well's latitude and longitude location identifiers, and other information. The chemicals added to the hydraulic fracturing fluids utilized in the well, along with an explanation of their purpose and toxicity, are also listed. With the inclusion of a Public Education Area, this site is designed for ease of use, ease of understanding, clarity and accuracy of content.

Permit Applications

In an effort to raise public awareness and encourage civic participation, DEP has made it possible for landowners and municipalities to receive notice of a permit application at the same time that DEP receives the application. To locate permit applications, use the DEP website to access eNotice at <http://www.ahs2.dep.state.pa.us/eFactsWeb/default.aspx>. Users need to click on the eNotice link on the left side and create a log-in to use the site and receive notices.

Regulations

Water Use

Both the states and the federal government have the jurisdiction to regulate water. The New York State Department of Environmental Conservation (NYSDEC), the Pennsylvania Department of Environmental Protection (DEP), and the West Virginia Department of Environmental Protection (WVDEP) regulate water related to Marcellus Shale use. Beyond the state requirements, the SRBC and the Delaware River Basin Commission (DRBC) impose additional regulations on their watersheds. In recent months, there has been an attempt to change the 2005 Safe Drinking Water

Act. The “FRAC Act” (S. 587) would amend the present Safe Drinking Water Act by repealing its fracking exemption. Although it was reintroduced in U.S Congress in March 2011, the bill had not been reported out of committee as of June 2012. (Introduced bills and resolutions first go to committees that deliberate, investigate, and revise them before they go to general debate. The majority of bills and resolutions never make it out of committee.)

On the other hand, in March 2010 the EPA announced that it would study “potential human health and water quality threats” from fracking (Abdalla, Drohan, Swistock & Boser, 2011). According to the EPA (2012), “The scope of the research includes the full lifespan of water in hydraulic fracturing, from acquisition of the water, through the mixing of chemicals and actual fracturing, to the post-fracturing stage, including the management of flowback and produced water and its ultimate treatment and disposal. A first progress report is planned for late 2012. A final draft report is expected to be released for public comment and peer review in 2014.” The entire plan can be found at <http://www.epa.gov/hfstudy/>

Pennsylvania

The DEP is the main agency responsible for regulatory standards regarding water quality and effluent releases in the Commonwealth of Pennsylvania. All surface waters must meet protected water standards for aquatic life, water supply (potable, industrial, livestock, and wildlife), and recreation (boating, fishing, water contact sports, and aesthetics). Pennsylvania does not have regulatory passby flow requirements. These passby flows are a prescribed quantity of water that must pass a prescribed point downstream from a water supply intake at any time that water is being withdrawn. Pennsylvania's recommended standards are similar to those used by the SRBC. However, because they serve as guidelines, they lack the related enforcement and penalties inherent in rulings.

Instead of using passby flow measurements, DEP relies on management plans to determine water usage in a given stream. The PA Water Resources Planning Act (Act 220) requires registration and reporting of water withdrawals in excess of 10,000 gallons per day averaged over 30 days. Pennsylvania also requires that operators submit a Water Management Plan outlining the cradle-to-grave disposition of water use including the sourcing of water for drilling and fracturing activities. These uses are considered in conjunction with other water withdrawals on the same body of water. The Pennsylvania Fish and Boat Commission also requires a permit to withdraw water from impoundments inhabited by fish (Arthur, Uretsky & Wilson, 2010).

To reduce contamination, Pennsylvania's DEP finalized regulations covering improved well casing standards and allowable TDS in all oil and gas wastewater in 2010 and 2011. Regulations strengthening oil and gas well construction standards to prevent methane gas migration, among other purposes, became effective on February 5, 2011 (Pennsylvania Code, Title 25, Chapter 78, n.d.). The following best practices are included:

- Pressure barriers plan to minimize well control events;
- Provisions requiring operators to keep a list of emergency contact phone numbers at the well site;
- Provisions clarifying how and when blow-out prevention equipment is to be installed and operated;
- Provision requiring operators to condition the wellbore to ensure an adequate bond between

- the cement, the casing and the formation;
- Provisions requiring the use of centralizers to ensure that casings are properly positioned in the wellbore;
- Provision improving the quality of cement placed in the casing that protects fresh groundwater;
- Provisions specifying the actions of an operator in the event of a gas migration incident; and
- Revisions to the reporting requirements for chemicals used to hydraulically fracture a well.

More information on best practices in cement casing standards can be found at <http://www.pabulletin.com/secure/data/vol41/41-6/239.html>

In August 2010, DEP finalized new regulations under the Pennsylvania Clean Streams Law to protect Pennsylvania's water bodies and public drinking water by limiting the amount of total dissolved solids (TDS) that can be discharged into waterways by new and expanding facilities. Unless the water system has a more stringent standard than the National Pollutant Discharge Elimination System (NPDES) permit, the revised regulations include the following: (Abdalla, Drohan, Swistock & Boser, 2011; Pennsylvania Environmental Quality Board, 2011, Nov)

- No direct discharges of wastewater from natural gas production, drilling and exploration are allowed;
- Treated discharges may come only from centralized waste treatment facilities meeting the PA Code, titles 25, and 91, and federal regulations 40 CFR 437.34; and
- The discharges may not contain more than:
 - 500 Milligrams per Liter (mg/L) of TDS as a monthly average;
 - 250 mg/L of total chlorides as a monthly average;
 - 10 mg/L of total barium as a monthly average; and
 - 10 mg/L of total strontium as a monthly average.

To prompt additional consideration for updated regulations, the Marcellus Shale Advisory Commission (2011) issued its final report on July 22, 2011. It recommended: the imposition of a drilling impact fee; suggestions on forced pooling; increased penalties for violators of the Oil and Gas Act; setback requirements for streams, private wells and public water systems; establishment of best management practices and monitoring for well construction and operation; and public disclosure obligations. Governor Corbett announced that he had adopted most of the report's recommendations, with the exception of forced pooling. In addition, Act 13, amending Title 59 (Oil and Gas) of the Pennsylvania Consolidated Statutes, passed into law in February, 2012, has imposed an impact fee, increased set back requirements, and increased violation fines. Some provisions went into effect upon signing and others became effective on April 14, 2012 (Pennsylvania Public Utility Commission, 2012; DEP, 2012). A complete description of Act 13 will occur elsewhere in the Study Guide Addenda.

As of April 16, 2012, Act 13 mandates following practices for unconventional gas well operators (Pennsylvania DEP, 2012):

- Completion and submission of a chemical disclosure form to the DEP and publication of the form on FracFocus.org;
- Immediate verbal communication of any proprietary information to emergency responders

- to ensure appropriate health care;
- Setbacks of 1000 feet from a “water supply extraction point used by a water purveyor, unless written consent is obtained from the water purveyor.” Variances are obtainable if a plan is submitted “identifying additional measures, facilities or practices to be employed” and approved by the DEP;
- Setbacks of 300 feet from “any solid blue lined stream, spring, or body of water or wetland greater than one acre in size as identified on the most recent 7 ½ minute topographic quadrangle map of the US Geological Survey;”
- Setbacks of 100 feet between the edge of disturbance and any stream, spring, body of water or wetland greater than one acre in size.” Again, a waiver can be granted if a plan is submitted “identifying additional measures, facilities or practices to be employed” and approved by the DEP;
- Prohibition of a well within a floodplain if there is a “pit or impoundment containing drilling cuttings, flowback water, produced water, hazardous materials, chemicals or wastes located within the floodplain; or a tank containing hazardous materials, chemicals, condensate wastes, flowback or produced water within the floodway;” and
- Containment practices designed and constructed to prevent spills to the ground surface or off the well site during drilling and hydraulic fracturing and wherever drilling mud, hydraulic oil, diesel fuel, drilling mud additives, hydraulic fracturing additives, and/or hydraulic fracturing fluid are stored.

In addition, unless provisions of the act are legally challenged, the gas well operator is presumed to be responsible for pollution of any public or private drinking water supply within 2500 feet of the gas well **if** the event occurs within twelve months after completion of drilling or alteration of the gas well. Gas well operators are **not** presumed responsible for pollution of water supplies if they were denied access for water testing prior to drilling. However, they must provide written notice to landowners or water purveyors to this effect. If a well operator affects a public or private water supply by pollution or diminution, the affected water supply must be restored or replaced with an alternate source of water adequate in quality and quantity for the purposes served by the supply. Temporary water must be supplied until the water source is restored or replaced (Pennsylvania DEP, 2012). Again, complete requirements of Act 13 will be discussed elsewhere in the Study Guide Addenda.

New York Update

In response to public pressure, regulations in New York are being revised in advance of the implementation of widespread fracking. To help monitor use after February 15, 2012, any entity that withdraws surface water in quantities greater than 100,000 gallons per day must file an annual report with the NYSDEC (2012a). New York State also issues guidelines for determining passby flows during surface water withdrawals. To provide further safeguards, the NYSDEC released a draft on environmental impacts and recommendations on July 8, 2011 and updated it in September 2011. These recommendations included prohibition of hydraulic fracturing on: a) New York City or Syracuse watersheds, b) primary aquifers, c) certain state lands because drilling is “inconsistent with the purpose for which these lands have been acquired,” d) principal aquifers without site specific environmental review, e) land 2000 feet from a public water supply, f) floodplains, and g) land 500 feet from a private water well. After a public review and comment period that ended in December 2011, final results were released early in 2012 (NYSDEC, 2012b). A final report is expected at the end on 2012. The New York City Department of Environmental Protection has regulatory authority over the city’s drinking water supply that is also within the jurisdictional

authority of both the NYSDEC and the DRBC. The DRBC regulates the rate and volume of water within its basin.

Maryland Status

This state has not yet issued permits for hydraulic fracturing and is considering legislative and regulatory approaches to ensure fracking is done safely and responsibly. In June 2011, Maryland's Governor issued an executive order to conduct a full study of the impact of Marcellus Shale drilling with a report and recommendations on legislation to be issued by December 31, 2011, recommendations for best practices by August 1, 2012, and a final report with more comprehensive findings and recommendations by August 1, 2014 (Maryland Department of the Environment, n.d.).

West Virginia – Horizontal Well Act

In this state, the Horizontal Well Act became law in December 2011. The new law provides for: a) increased permit fees, b) increased well location restrictions, c) a road use agreement prior to issuing a permit, d) increased notice provisions and a new compensation statute for surface owners, e) increased enforcement authority for the WVDEP, f) increased civil penalties for violations, and g) codification of water use and wastewater handling regulations established earlier by the governor (Dickerson, 2011).

Ohio Status

The Ohio Department of Natural Resources (ODNR), Division of Mineral Resources Management has primary regulatory authority over oil and gas drilling activity. The impact of drilling on water resources and air is regulated by the Ohio Environmental Protection Agency. Restrictions on drilling in Ohio are related to wastewater disposal. Wastewater with lower contamination levels may be sent to authorize sewage treatment plants, while higher contamination levels require the transport of wastewater to deep injection wells. Prompted by a series of earthquakes around an injection well near Youngstown in 2011, the ODNR has issued a series of new regulations which include: Prohibition on locating new Class II disposal wells in geologic faulted areas; comprehensive geophysical logs on newly drilled Class II disposal wells; plugging wells penetrating into the Precambrian basement rock; and prohibiting injection into the Precambrian basement rock (Risk & Brown, 2011; ODNR, 2012).

Virginia Update

Marcellus Shale drilling was not permitted in this Commonwealth as of 2011. However, elected officials continue to evaluate the feasibility of future fracking. The first permit for hydrofracturing shale in Virginia was proposed near Harrisonburg, Rockingham County in 2010 (Shenandoah Valley Network, n.d.). This exploratory well application was received from the Texas company Carrizo Marcellus, LLC. Because this county is studying the potential impacts of exploratory drilling, the company has set aside its application indefinitely (Virginia Department of Mines Minerals and Energy, n.d.).

Other States

For a more complete comparison of state regulations, see *A Review of Shale Gas Regulations by State*. This study was prepared in July 2012 by Resources for the Future (RFF) through its Center for Energy Economics and Politics under the direction of Alan Krupnick (www.rff.org/shalegasrisks).

Wastewater Treatment

Quantity of Produced Water

According to the original study of The League of Women Voters of Pennsylvania (LWVPA) *Natural Gas Extraction from Marcellus Shale*, experiences in other states indicated that 30% to 70% of the wastewater returned to the surface. Currently, in Pennsylvania, approximately 10% to 30% resurfaces within 30 days after drilling. Using the lower, ten percent figure to calculate total volume, each well produces about 300,000 to 800,000 gallons of wastewater (Abdalla et al, 2012). The remaining water remains deep underground with most of it being absorbed by the shale formation that is isolated from the water table. Abdalla, Drohan, Blunk and Edson (2011) reported that 235 million gallons of wastewater were produced in the second half of 2010 using data reported to the DEP by the gas industry. The DEP in 2009 projected the demand for treating wastewater from oil and gas production would be as high as 19 million gallons a day in 2011 (DEP, 2009). Discrepancies in the figures exist because of the difficulty in accurately assessing the amount of wastewater. Pennsylvania has only recently developed a system for tracking wastewater in the Commonwealth (Abdalla, et al, 2012). Nevertheless, natural gas wells that are fracked produce large volumes of contaminated water that are a continued challenge to manage. This produced water must be hauled away and treated, recycled, or placed in deep injection wells. Techniques to recover and reuse frac water provide a way to limit environmental degradation in numerous ways. Reuse reduces the use of fresh water from our rivers and streams. Additionally, truck traffic, noise, and dust pollution are also minimized. Because there are only a few injection wells to store such wastes in Pennsylvania, the costs of transporting wastewater to distant, out-of-state injection wells are significant.

Reuse of Water

Over time, the reuse of wastewater from fracking has continued to evolve. In 2008, on-site recycling of frac water was thought to be very expensive and impractical to implement. However, since that time, the situation has changed dramatically. A majority of companies are now working to reuse 100 percent of their flowback water. Industry representatives claim that the amount of chemical additives in the fracking fluid, including biocides, corrosion inhibitors, acids and friction reducers, has also been reduced from several years ago. This is, in part, due to the high cost of chemicals.

Research and Development Projects

In August 2009, the U.S. DOE funded nine projects to study alternative sources to the fresh water currently used in fracking (NETL, 2009). According to the DOE, "the nine projects, which have a total value of \$10.2 million (\$7 million DOE; \$3.2 million cost share), are developing environmental tools and technologies to improve management of water resources, water usage, and water treatment required for shale gas development across the United States. Several additional demonstrations focusing on other water treatment technologies will be conducted during the remainder of fiscal year 2011" (NETL, 2011, April 13).

One of these nine projects was Altela. This research project was funded by the NETL through the Office of Fossil Energy's Oil and Natural Gas Program in fiscal year 2009. Altela Inc. is a privately held water desalination company in Albuquerque, NM. Its AltelaRain® 4000 water desalination system was tested at BLX, Inc.'s Sleppy well-site in Indiana County, PA, as part of a NETL-sponsored demonstration. During nine continuous months of operation, the unit treated 77 percent of the water on site, producing distilled water. The average cost per barrel of treated water over the

demonstration period was approximately 20 percent lower than the previous total conventional disposal costs at the site. The system also significantly reduced the need for trucking wastewater from the site. Based on field data generated from the demonstration, Altela increased the efficiency of its technology by more than 30 percent. All of the clean water produced at the site was suitable for reuse by well operators for additional well stimulations and was also suitable to be discharged into surface waterways. This technique reduces both the economic and environmental impacts of clean water usage. As a result of the initial project, Altela designed larger towers for the system that is being installed in Williamsport, PA. There they will be able to treat approximately 100,000 gallons per day of produced and flowback water from hydraulic fracturing (Environmental Protection Magazine, 2011, Altela, 2011).

A partnership between Casella Waste Systems, Inc. based in Rutland, VT, and Altela, Inc., was announced in October 2011 to work on the environmental problems created by wastewater in the Marcellus Shale basin. Until recently, the wastewater was often discharged into area rivers, with little or no treatment for hard-to-remove salt contaminants. Casella-Altela Regional Environmental Services, LLC, or “CARES,” will recycle brackish oilfield and natural gas wastewater to produce water as “clean as rainwater.” The first installation, to be located in McKean County, PA, will be powered by methane from a landfill with the water being transported to the site by rail (American Recycler.com, 2011).

NETL is currently managing a number of Research and Development (R&D) efforts that have a direct bearing on natural gas production from shales. Four areas will be examined: water treatment and management; resource characterization; energy and petroleum (E&P) technology; and environmental issues. Some of these projects are part of NETL’s traditional R&D program, and some were created under the Energy Policy Act of 2005 Section 999 R&D Program. About half a dozen of the projects deal specifically with Marcellus Shale, but all of them address some problematic aspect of drilling in the shale play. One initiative comes from the Barnett Shale area of Texas where drilling companies formed a consortium to study how to coordinate drilling needs with available water supplies (NETL, n.d. a).

Direct reuse of frac water with minimal pre-treatment is an effective method for disposing of frac water. However, long-term shale gas development requires a salable product in addition to water recovery and the generation of clean water. Begun in the fall of 2009, a research project was undertaken by GE Global Research with funding from NETL, to examine ways to pre-treat frac water for thermal recovery of clean water and a salable salt product. Preliminary investigation showed that naturally occurring radioactive material (NORM) is rather prevalent in frac water, particularly in the Marcellus Shale. Thus, NORM removal from flowback water is an important step in recovering a salable salt product from NORM-containing frac water. Two processes to remove barium and radium from produced water were investigated. Researchers recommended that the “lime-soda process” be further developed in the lab in preparation for pilot testing. The second process, “the MnO₂ adsorption process,” has potential for being a lower cost alternative, but it still requires further laboratory development (NETL, n.d. b; Silva, Matis, Kostedt, & Watkins, 2012).

Although Silva, et al (2012) have found NORM to be prevalent in frac water, the Pennsylvania DEP announced that test results of water taken downstream from wastewater treatment plants accepting Marcellus flowback and production water showed levels of radioactivity “at or below the normal naturally occurring background levels of radioactivity.” This statement was a result of water samples that were taken during November and December 2010 in seven of the Commonwealth’s

rivers (DEP, 2011, March 7). However, in April 2011, the DEP requested that public water treatment plants NOT accept flowback and production water for treatment. In May, the EPA told the DEP to make this order mandatory (Rassenfoss, 2011).

On December 20, 2011, the Research Partnership to Secure Energy for America (RPSEA), released a request for proposals (RFP) seeking research projects to explore ways to extract more energy from natural gas resources while reducing environmental risk. Nine projects were awarded a total of \$8.4 million. Participating industries and universities supplemented this NETL funding was by \$5.7 million through cost sharing (RPSEA, 2012).

In other initiatives, Rex Energy Corporation of State College claims that all the water that the company recovers from drilling in the Marcellus Shale is being recycled. Range Resources Corporation emphasized the importance of recycling and reusing water recovered from its natural gas drilling operations in Washington County and claims to be recycling 100 percent of the flowback water. This accounts for 15 percent to 30 percent of all water used during Marcellus Shale well drilling (Konche Water Treatment Co., LTD, n.d.). Although significant, recycling recoverable water alone is not the total answer to potential water pollution in the Marcellus Shale region.

Other Potential Wastewater Solutions

Private companies are developing new and innovative solutions to treat wastewater. Aquatic Synthesis Unlimited, LLC in partnership with Terra Services, LLC is processing drilling wastewater in Indiana County using chlorine dioxide to remove bacteria, hydrogen and iron sulfides. This process results in the precipitation of iron, strontium, barium, radium, and lead (personal communication, 2012). Water can then be cleaned at their facility for reuse in drilling for \$4/barrel (42 gallons). This is the cost to not only to treat the water but also to return the treated water to the truck in less than an hour. The charge is \$6/barrel if the water is not taken back! The company claims that less than 60 pounds of chlorine dioxide takes the place of 12,000 pounds of formaldehyde to disinfect a well. However, this process is not intended to remove salts.

Another new fracking technique claims to be entirely waterless. GASFRAC Energy Services employs high-pressure propane, another hydrocarbon, as a gel in place of the water to frac wells. The propane mixes with the oil or natural gas coming back to the surface, and this mixture can be used as a fuel avoiding any of the contamination that leaches out of the rock as is the case when water is used. Various companies, including Chevron and Shell, are testing this process. (Biello, 2012). Although propane fracking eliminates the need for the high volumes of water and the subsequent wastewater issues, there are concerns to be resolved with this technique as well. Propane is highly explosive. Safety at the drill pad will be an issue with need to prevent leaks and subsequent pooling of propane due to the fact that propane is heavier than air. The risk of accidents by trucks carrying propane to the drill site is a source of real concern. Compressors will also be needed to recombine propane for reuse on most drill sites. This further will increase noise and air pollution (Catskill Mountain Keeper, n.d.). Goodwin (2012) reported that Mukul Sharma and Tex Moncrief of the Cockrell School of Engineering at University of Texas at Austin point out that companies are reluctant to use this technique due to the cost and safety issues handling this volatile gas.

Another technique being researched by the Massachusetts Institute of Technology uses a "directional solvent." This process involves liquids that molecularly bind to water but not to the

other contaminants in the water. The water is then be recovered from the solvent by cooling it so that the water flows back to the surface (Biello, 2012).

Consol Energy, in an effort to clean up water used in natural gas extraction in the Marcellus Shale, has recently invested in Epiphany Solar Water Systems. This New Castle, Pennsylvania, start-up company uses solar power to purify water. The investment of Consol is funding Epiphany's technology through a pilot system designed to purify wastewater and to separate out the contaminating salt and metals. The contaminants will be recovered and repurposed. For example, the removed salts will be used on roads or for water softening. Epiphany has completed two to three months of testing at a well in Greene County with the results being released in September (Bloom, 2012).

Other Options – Injection Wells

All fluids related to oil and gas drilling can be disposed of in deep injection wells. Impermeable rock layers surround these facilities that also referred to as brine disposal wells or class II underground injection wells. Although regulated by the EPA since 1985, there is no requirement for disclosing the composition of injected wastewater from oil and gas operations. Much of the wastewater produced in Pennsylvania has been trucked to injection wells located in the neighboring states of New York, West Virginia, and Ohio. Demands for such wells are increasing. In fact, a report by *StateImpact*, a reporting project of local public media and NPR, states, "In Ohio, 16 new wells are under construction to take waste "brine" from oil and gas wells. Seven have been granted permits but have not yet been drilled, according to figures provided by the Ohio Department of Natural Resources. An additional 20 applications for new brine wells are under review" (Phillips, 2012, May 24).

In Pennsylvania, three of the Commonwealth's deep injection wells are "commercial," according to *State Impact* (Phillips, 2011). These facilities can take wastewater from any energy company. Other such sites, operated by oil and gas companies, are permitted to only dispose of their own "frac" water. These wells can vary in size from those taking as little as 4200 barrels per month to those take about 30,000 barrels each month. Range Resources had the largest injection well in the state in Erie County. Although it is now plugged, it was permitted to pump 45,000 barrels per month underground. Other operators include Columbia Gas, Cottonwood, and CNX Gas with wells in Beaver and Somerset counties. EXCO Resources operated two facilities in Clearfield County. However, EPA fined this company and closed one of the wells for failure to report a leak from April to August 2011. (Phillips, 2012, April 12). There are two new wells slated to begin operation by Bear Lake Properties in Warren County. As of May 2012, Pennsylvania had only five operating deep injection wells with all being located in the western part of the state. Two new permits for the anticipated wells in Warren County have been approved by the EPA but have been appealed by local residents. Two other permit applications are pending. However, given public sentiment and questions regarding environmental impacts, State Representative Bud George, from Clearfield County, has proposed a two-year moratorium on any new injection wells in Pennsylvania (Phillips, 2012 May 24).

Why in there controversy about deep injection wells? During recent months, these types of deep injection wells have been linked to earthquakes in Arkansas, Ohio and Texas (Phillips, 2011, Frohlich, 2012). Many postulate that such tremors may be the result of the high pressure associated with the deep injection wells (Hunter, 2012). Frohlich (2012), reporting in the *Proceedings of the National Academy of Sciences*, analyzed seismic information from a dense array of monitors around

Dallas from Nov. 2009 to September 2011. Of 67 earthquakes that he could measure, 24 could be precisely located. All of those 24 earthquakes were within 2 miles of a high quantity injection well. Although most of the earthquakes were small, magnitude 2 or lower, these results suggest that “injection-triggered earthquakes are more common than is generally recognized (Abstract).” Because there were many injection wells where no earthquakes occurred, Frohlich hypothesizes that injection only triggers earthquakes if the well fluids reduce friction on a nearby fault that is experiencing tectonic stress. *ProPublica* (Lustgarten, 2012) reviewed well records, case histories and government summaries of more than 220,000 well inspections. This research found that from 2007 to 2010 structural failures were common finding more than 17,000 violations nationally from These violations included leaking from well walls and operating in violation of safety regulations. Such failures increase the risk of fluid leakage and water contamination.

After examining the overall picture of wastewater disposal, Abdalla, Drohan, Blunk & Edson (2011) noted, “Industry watchers expect the future breakdown of Marcellus wastewater treatment to look something like this (all percentages are approximate): brine disposal plants-35 percent; deep injection wells-10 percent; reuse/recycle-30 percent; advanced treatment (e.g., evaporators, crystallizers, membranes)-20 percent; publicly owned sewage treatment plants-10 percent” (p. 7).

Land Management – Clarification

Since the publication of the 2009 LWVPA Marcellus Shale Study Guides, two clarifications in the area of Land Management need to be made. They are:

- If surface rights are owned by a landowner who has an existing gas lease, no changes can be made to the lease even if an existing well is being drilled to a deeper level. If a new lease is being considered, the owner should get legal advice for the new lease.
- Natural gas companies do NOT have the power to drill horizontally under your property if you have not entered into an Oil and Gas Lease (Penn State Extension, n.d., Clark Law Firm, n.d.).

References Study Guide Addenda Water Management

The web addresses for the references below have all been checked by the committee. However, we recognize that some of the documents may not be maintained at the addresses given. If the links do not work for you, we recommend entering the title of document into your web browser.

Abdalla, C.W., & Drohan, J.R. (2010). Marcellus shale fact sheet: Water withdrawals for development of Marcellus shale gas in Pennsylvania. The Marcellus Education Team, Penn State Cooperative Extension. Retrieved from <http://pubs.cas.psu.edu/FreePubs/pdfs/ua460.pdf>

Abdalla, C., Drohan, J., Blunk, S., & Edson, J. (2011). Marcellus shale wastewater issues in Pennsylvania—Current and emerging treatment and disposal technologies. Penn State Extension. Retrieved from [http://cce.cornell.edu/EnergyClimateChange/NaturalGasDev/Documents/PDFs/marcellus_wastewater_fact_sheet\[1\].pdf](http://cce.cornell.edu/EnergyClimateChange/NaturalGasDev/Documents/PDFs/marcellus_wastewater_fact_sheet[1].pdf)

Abdalla, C., Drohan, J., Rahm, B., Jacquet, J. Becker, J., Collins, A., Klaiber, A., Poe, G., Grantham, D. (2012). Water's journey through the shale gas drilling and production processes in the Mid-Atlantic region. Penn State Extension. Retrieved from <http://pubs.cas.psu.edu/FreePubs/PDFs/ee0023.pdf>

Abdalla, C., Drohan, J., Swistock, B. & Boser, S. (2011, March). Marcellus shale gas well drilling: Regulations to protect water supplies in Pennsylvania. Pennsylvania State University Extension. Retrieved from http://www.cce.cornell.edu/EnergyClimateChange/NaturalGasDev/Documents/PDFs/marcellus_regulations_fact_sheet%5B1%5D.pdf

Altela (2011, October 25). New recycling solution introduced to treat Marcellus shale flowback frac water. Retrieved from <http://www.netl.doe.gov/publications/press/2011/Altela%20Casella%20JV%20Press%20Release,%2024%20Oct%202011.pdf>

American Recycler.com (2011, December). Casella waste and Altela join to treat frac water. Retrieved from <http://www.americanrecycler.com/1211/1287casella.shtml>

Arthur, J.D., Uretsky, M., Wilson, P. (2010). Water resources and use for hydraulic fracturing in the Marcellus shale region. All Consulting. Prepared in conjunction with co-researchers including the New York State Energy Research and Development Authority, Susquehanna River Basin Commission, and the Delaware River Basin Commission under U.S. Department of Energy Research Project DE-FE0000797. Presented at the International Petroleum and Biofuels Environmental Conference, San Antonio, Texas, Aug. 30-Sept. 2, 2010. Retrieved from http://www.netl.doe.gov/technologies/oil-gas/publications/ENVreports/FE0000797_WaterResourceIssues.pdf

Associated Press (2012, July 11). Researchers monitor gas well as they try to answer: Can drilling pollute drinking water? *The Washington Post*. Retrieved from http://www.washingtonpost.com/national/energy-environment/researchers-monitoring-fracking-fluid-to-say-whether-gas-drilling-can-pollute-drinking-water/2012/07/11/gJQAK6KMdW_story.html

Biello, D. (2012, May 25). How can we cope with the dirty water from fracking? *Scientific American*. Retrieved from <http://www.scientificamerican.com/article.cfm?id=how-can-we-cope-with-the-dirty-water-from-fracking-for-natural-gas-and-oil&page=2>

[Bloom, E. \(2012, June 26\). Consol invests in Epiphany solar power water treatment. *Pittsburgh Post Gazette Pipeline*. Retrieved from http://shale.sites.post-gazette.com/index.php/news/archives/24655-consol-invests-in-solar-power-water-treatment](http://shale.sites.post-gazette.com/index.php/news/archives/24655-consol-invests-in-solar-power-water-treatment)

[Campbell, C. \(2012, April 25\). Mine water eyed for fracking use. Observer Publishing Co. Retrieved from http://www.energycapitalonline.com/news/article.php?aid=89](http://www.energycapitalonline.com/news/article.php?aid=89)

Catskill Mountain Keeper (n.d.). Fracking with Propane. Retrieved from <http://www.catskillmountainkeeper.org/our-programs/fracking/whats-wrong-with-fracking-2/fracking-with-liquid-propane-gas/>

[Clark Law Firm \(n.d.\). Rule of capture: The rule of capture, or law of capture, does apply to the Marcellus shale formation in Pennsylvania. Retrieved from http://www.pagasleaseattorney.com/rule-of-capture.html](http://www.pagasleaseattorney.com/rule-of-capture.html)

Curtright, A.E. & Giglio, K. (2012). *Coal mine drainage for Marcellus shale natural gas extraction: Proceedings and recommendations from a roundtable on feasibility and challenges*. Rand Corporation, Santa Monica, CA. Retrieved from http://www.rand.org/content/dam/rand/pubs/conf_proceedings/2012/RAND_CF300.pdf

Dickerson, C. (2011, December 14). Lawmakers pass Marcellus shale bill. *The Record*. Retrieved from <http://www.wvrecord.com/news/240331-lawmakers-pass-marcellus-shale-bill>

Environmental Protection Agency (2012, July 4). EPA's Study of hydraulic fracking and its potential impact on drinking water resources. Retrieved from <http://www.epa.gov/hfstudy/>

Environmental Protection Magazine (2011, April 16). Treatment system cleans Marcellus shale wastewater, Retrieved from <http://eponline.com/articles/2011/04/16/treatment-system-cleans-marcellus-shale-wastewater.aspx>

Frac Focus: Chemical disclosure registry (n.d.) Retrieved from <http://fracfocus.org;>

Goodman, M. (2012, January 12). Waterless fracking method targets natural gas industry's gaze. CBS DFW. Retrieved from <http://dfw.cbslocal.com/2012/01/12/waterless-fracking-method-target-for-natural-gas-industrys-gaze/>

Ground Water Protection Council and ALL Consulting. (2009, April). *Modern shale gas development in the United States: A primer*. Prepared for U.S. Department of Energy, Office of Fossil Energy and National Energy Technology Laboratory. Retrieved from http://www.netl.doe.gov/technologies/oil-gas/publications/EPreports/Shale_Gas_Primer_2009.pdf

Hunter, P. (2012, June 25). National research council finds little correlation between fracking and earthquakes. ENR.com. Retrieved from http://enr.construction.com/infrastructure/power_industrial/2012/0625-little-correlation-between-fracking-and-earthquakes.asp

Konche Water Treatment Co., LTD (n.d.). Major companies drilling for natural gas in Western Pennsylvania's Marcellus shale rock formation are or soon will be recycling all the waste water recovered from their operations, executives said Monday. Retrieved from http://www.konchewater.com/News/Media_Report/Waste_water/139.html

Lustgarten, A. (2012, June 21). 680,000 wells hold waste across US—with unknown risks. Open Channel on msnbc.com. Retrieved from <http://openchannel.msnbc.msn.com/news/2012/06/21/12339805-680000-wells-hold-waste-across-us-with-unknown-risks?lite>

Marcellus Shale Advisory Commission (2011). Final Report. Retrieved at http://www.portal.state.pa.us/portal/server.pt/community/marcellus_shale_advisory_commission/20074/

Maryland Department of the Environment (n.d.). Facts about... The Marcellus shale safe drilling initiative. Retrieved from http://www.mde.state.md.us/programs/Land/mining/Non%20Coal%20Mining/Documents/Shale_EO_factsheet_061011.pdf

Myers, T. (2012). Potential contaminant pathways from hydraulically fractured shale to aquifers [Abstract]. *Ground Water*. doi: 10.1111/j.1745-6584.2012.00933.x (Retrieved from <http://onlinelibrary.wiley.com/doi/10.1111/j.1745-6584.2012.00933.x/abstract>)

National Energy Technology Laboratory (2009, August 19). DOE projects to advance environmental science and technology. The energy lab. Retrieved from http://www.netl.doe.gov/publications/press/2009/09058-DOE_Selects_Natural_Gas_Projects.html

National Energy Technology Laboratory (2012, May 15). Oil and natural gas projects: Sustainable management of flowback water during hydraulic fracturing of Marcellus shale for natural gas production. The energy lab. Retrieved from http://www.netl.doe.gov/technologies/oil-gas/Petroleum/projects/Environmental/Produced_Water/00975_MarcellusFlowback.html

National Energy Technology Laboratory (n.d. a). Highlights. The energy lab. Retrieved from <http://www.netl.doe.gov/>

National Energy Technology Laboratory (n.d. b). NORM mitigation and clean water recovery from Marcellus frac water. The energy lab. Retrieved from <http://www.netl.doe.gov/technologies/oil-gas/EPAAct2005/Projects/UNC/1012207-ge-global-abstract.html>

New York Department of Environmental Conservation (2012a). Annual water withdrawal reporting: Entities capable of withdrawing more than 100,000 gallons per day must report well use data to DEC. Retrieved from <http://www.dec.ny.gov/lands/55509.html>

New York Department of Environmental Conservation (2012b). Marcellus Shale: The Environmental Review Process for natural gas exploration in the Marcellus shale. Retrieved from <http://www.dec.ny.gov/energy/46288.html>

Ohio Department of Natural Resources (2012, March 9). Ohio's new rules for brine disposal among nation's toughest. News release. Retrieved from <http://live.psu.edu/story/58300>

PA Environment Digest in Gas Industry (2010, July 8). Drought conditions begin to curtail some Marcellus shale drilling operations. *NorthcentralPA.com*. Retrieved from http://www.northcentralpa.com/feeditem/2010-07-08_drought-conditions-begin-curtail-some-marcellus-shale-drilling-operations

Penn State Extension (n.d.). Frequently asked questions: A list of the most commonly asked natural gas questions and their answers. Retrieved from <http://extension.psu.edu/naturalgas/frequently-asked-questions>

Pennsylvania Code (n.d.). Title 25, Chapter 78. Environmental Protection, Retrieved from

<http://www.pacode.com/secure/data/025/025toc.html>

Pennsylvania Department of Environmental Protection, (2009, April 11). Permitting strategy for high total dissolved solids (TDS) wastewater discharges. Retrieved from www.portal.state.pa.us/.../high_tds_wastewater_strategy_041109_pdf
www.portal.state.pa.us/.../high_tds_wastewater_strategy_041109_pdf

Pennsylvania Department of Environmental Protection (2011, March 7). DEP announces testing for radioactivity of river water downstream of Marcellus water treatment plants shows water is safe. News release. Retrieved from <http://www.portal.state.pa.us/portal/server.pt/community/newsroom/14287?id=%2016532%20&typeid=1>

Pennsylvania Department of Environmental Protection (2011, November). White Paper: Utilization of AMD in well development for natural gas extraction. Retrieved from http://www.dep.state.pa.us/dep/subject/advoun/MINREC/MRAB_2012/apr/White_Paper_Use_of_AMD_for_natural_gas_extraction.pdf

Pennsylvania Department of Environmental Protection (2012). ACT 13 frequently asked questions. Retrieved from http://www.portal.state.pa.us/portal/server.pt/community/act_13/20789/act_13_faq/1127392

Pennsylvania Environmental Quality Board (EQB) (2011, February 5). Title 25—Environmental Protection {25 PA.CODE CH78}, Oil and Gas Wells {41 pa.B. 805}. *The Pennsylvania Bulletin*. Retrieved from <http://www.pabulletin.com/secure/data/vol41/41-6/239.html>

Pennsylvania Public Utility Commission (2012). Act 13 of 2012. Retrieved from http://www.puc.state.pa.us/naturalgas/naturalgas_marcellus_Shale.aspx

Pennsylvania State University (2012, March 8). Initiative to provide training in shale-development best practices. Penn State Live. Retrieved from <http://live.psu.edu/story/58300>

Phillips, S. (2011, September 22). Burning question: Where are Pa.'s deep injection wells? *StateImpact*. Retrieved from <http://stateimpact.npr.org/pennsylvania/2011/09/22/burning-question-where-are-pas-deep-injection-wells/>

Phillips, S. (2012, May 24). Deep injection well construction booms despite push to recycle. *StateImpact*. Retrieved from <http://stateimpact.npr.org/pennsylvania/2012/05/24/drilling-waste-disposal-well-construction-booms-despite-push-to-recycle/>

Rassenfoss, S. (2011, July). From flowback to fracturing: Water recycling grows in the Marcellus shale. *JPT Online* (Official Publication of the Society of Petroleum Engineers). Retrieved from: <http://www.spe.org/jpt/print/archives/2011/07/12Marcellus.pdf>

[Research Partnership to Secure Energy for America \(2012, June 20\). Request for Proposal; RFP2011UN001, Unconventional onshore program. Retrieved from](http://www.businesswire.com/news/home/20120620006290/en/RPSEA-Selects-Projects-Award-8.4-Million-Small)
<http://www.businesswire.com/news/home/20120620006290/en/RPSEA-Selects-Projects-Award-8.4-Million-Small>

Rigzone Staff (2010, September 17). Seneca uses Abandoned Mine water for Marcellus fracking. Rigzone. Retrieved from http://www.rigzone.com/news/article.asp?hpf=1&a_id=98973

Risk, J.A., & Brown, A.D. (2011, November 30). States' regulations on Marcellus shale gas extraction continue to take shape. DLA Piper Publications. Retrieved from <http://www.dlapiper.com/states-regulations->

[on-marcellus-shale-gas-extraction-continue-to-take-shape/](#)

Shenandoah Valley Network (n.d.). Marcellus shale gas drilling in the Shenandoah Valley. Retrieved from <http://svnva.org/index.cfm/1,244,0,0,html/Marcellus-in-the-Shenandoah-Valley>

Silva, J.M., Matis, H., Kostedt IV, W.L. & Watkins, V. (2012, January 26). Produced water pre-treatment for water recovery and salt production: 08122-36. final. Research Partnership to secure energy for America. Retrieved from <http://www.rpsea.org/0812236/>

Temple University (2011, November 18). Acid mine drainage technology could aid Marcellus shale drilling. Newswise. Retrieved from <http://newswise.com/articles/acid-mine-drainage-technology-could-aid-marcellus-shale-drilling2>

U.S. Department of Energy (2011, April 13). Water treatment system cleans Marcellus shale wastewater. Fossil Energy Techline. Retrieved from http://fossil.energy.gov/news/techlines/2011/11020-Water_Treatment_System_Cleans_Marc.html

Virginia Department of Mines Minerals and Energy (n.d.). Hydraulic fracturing in Virginia and the Marcellus shale formation. Retrieved from <http://www.dmme.virginia.gov/DGO/documents/HydraulicFracturing.shtml>

Warner, N.R., Jackson, R.B., Darrah, S.G, Osborn, S.G, Down, A., Zhao, K., White, A., Vengosh, A. (2012, July 9). Geochemical evidence for possible natural migration of Marcellus formation brine to shallow aquifers in Pennsylvania. Proceedings of the National Academy of Sciences of the United States of America. doi: 10.1073/pnas.1121181109 (Retrieved from <http://www.pnas.org/content/early/2012/07/03/1121181109.full.pdf+html?sid=e34c0ba6-9713-4512-9e74-f9600fde450e>)