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Gas Well Drilling and Your Private Water Supply

With discovery of new drilling technologies to reach previously untapped gas reserves, the number of gas wells is expected to rise dramatically over the next several decades.



A typical Marcellus gas well site (Tom Murphy, Lycoming County Extension).

Gas well drilling has occurred for decades in much of western and northern Pennsylvania with tens of thousands of active gas wells in the state and over 5,000 new wells drilled each year. Most of these wells tap gas reserves a few thousand feet below the earth's surface.

Gas Drilling Waste Fluids

Gas well drilling can occasionally impact groundwater resources that are the source of water for household water wells and springs. A single gas well can produce hundreds of thousands of gallons of waste fluids during drilling and during years of gas production. These waste fluids can be classified into several categories:

- **Top hole fluids** - the fresh water aquifers that are encountered usually within the first few hundred feet of the drilling process.

- **Bottom hole fluids** - very old salt water deposits encountered deep underground during drilling below the fresh water aquifers. These fluids are commonly referred to as “brines”.
- **Stimulation or flow back fluids** - fluids that are used to improve gas recovery from the rock and are returned to the ground surface during the “hydrofracturing” process. Along with large amounts of water, various other materials may be used or mixed with the water for the fracturing process, including sand, oils, gels, acids, alcohols and various man-made organic chemicals. A listing of additives used for hydrofracturing can be found on the Pennsylvania Department of Environmental Protection (PaDEP) website.
- **Production fluids** - produced along with the natural gas after the well is in production. Production fluids usually have a similar chemistry to bottom hole fluids.

The volume of fluids produced during gas well drilling and operation can vary considerably depending on the depth and location of the gas well. Drilling of deeper gas wells in the Marcellus formation relies more on hydrofracturing which requires several million gallons of freshwater. On average, about ten percent of the water used for hydrofracturing Marcellus wells returns to the ground surface as “flow back” waste fluid. Additional production fluid will continue to flow from the well, along with natural gas, during the production life of the well.

Groundwater Pollutants from Gas Wells

Pollution of private water supplies from gas well activity has occurred in Pennsylvania. This contamination may occur from absent or corroded gas well casings (on older or abandoned gas wells) or it may originate from flooded or leaking waste fluid holding pits or spills at the drilling site, or from other causes.

Gas well waste fluids usually contain levels of some pollutants that are far above levels considered safe for drinking water supplies. As a result, even small amounts of pollution from waste fluids can result in significant impacts to nearby drinking water supplies. Some pollutants like chloride or iron can cause aesthetic problems with drinking water, but other pollutants like benzene or barium can have significant health effects if above the safe drinking water standards. Categories of pollutants in gas drilling fluids include:

- Salts - most notably sodium and chloride. Gas well waste fluids can have over 100,000 mg/L of these compounds. Other pollutants that can occur as various salts include magnesium, calcium and potassium. These salts cause a high level of “total dissolved solids” or TDS.
- Metals - including iron, manganese, barium, arsenic and trace amounts of other heavy metals.
- Organics - these include both natural and man-made materials that are used during the drilling process, such as surfactants, detergents, oil, grease, benzene and toluene. Dozens of other man-made organics may be used in small concentrations during hydrofracturing.

Another problem that can occur from gas well drilling is methane gas migration from gas wells into nearby water wells. The methane gas will rapidly escape from the groundwater and may pose an explosion hazard in confined spaces. Methane gas testing in water is difficult but it usually creates obvious symptoms in the home including effervescence and spurting faucets due to gas build-up. To learn more about methane gas problems in private wells, consult the Penn State Extension publication entitled [Methane Gas and Its Removal from Wells in Pennsylvania](#) available from your local Extension office.

How Common are Problems?

Contamination of private wells and springs can occur from gas well drilling but it has not been common over the past few decades. Data from various regulatory agencies responsible for enforcement of gas well drilling regulations indicate that the majority of complaints received by homeowners suspecting problems from nearby gas well drilling are, instead, due to pre-existing problems or other nearby land use activities.

Penn State Extension, with funding from the Center for Rural Pennsylvania and the Pennsylvania Water Resources Research Center, conducted research on 250 water wells in proximity to Marcellus gas well drilling in an attempt to determine potential impacts on private water wells. This study was completed in late 2011 and a project report is posted on the [Center for Rural Pennsylvania](#) website.

Regulations to Protect Water Supplies

Gas well drilling is regulated by the Oil and Gas Act (amended as Act 13 of 2012). This Act regulates the permitting, construction and abandonment of gas wells drilled throughout the state. A summary of the various relevant components of the Oil and Gas Act is provided here.

Types of Gas Wells

Conventional gas wells are drilled vertically into reservoirs of relatively permeable rock, from which hydrocarbons can be economically produced without large-scale fracturing operations. The natural gas in these reservoirs is derived from a deeper source rock where the gas originally formed but then migrated upward toward areas of lower pressure until becoming trapped in the reservoir rock. In Pennsylvania, these are also known as “traditional” or “shallow” wells.

Unconventional gas, by the broadest definition, is natural gas that is held tightly within the rock and requires horizontal drilling and fracturing to extract the gas. The natural gas found in the Marcellus and Utica shale layers requires unconventional methods of extraction such as high-volume, horizontal hydraulic fracturing, because of the way the natural gas is trapped in the formation.

Permits

Before drilling a gas well in Pennsylvania, the operator must submit an extensive permit application for approval from the PaDEP. Among other things, the permit application must include a map showing the location of the gas well, proximity of the gas well to coal seams, and distances to nearby surface water and water supplies. The map must also include the projected horizontal boreholes, gas tract lines and acreage in the tract to be drilled.

A bond ranging from \$2,500 to \$600,000 must be posted with the permit to ensure compliance with environmental regulations related to the well drilling. The permit also requires notification of surface land owners, coal mineral right owners, coal mine operators, gas storage field operators and municipalities at the well location, and within various distances from the well, along with all drinking water supply owners. Notification of these stakeholders is done by certified mail. As a result, homeowners with private water wells or springs located within 1,000 feet of a proposed conventional gas well site and 3,000 feet of a proposed unconventional gas well site should receive notification by certified mail during the permit process.

Setback Distances

Conventional gas wells must be at least 200 feet from any drinking water supplies and unconventional gas wells must be at least 500 feet from drinking water supplies. This setback may be increased or waived by the water supply owner in a lease agreement. All gas well sites must be at least 100 feet and unconventional vertical well bores must be at least 300 feet from any stream, spring or body of water identified on the most current 7.5 minute USGS topographic map. A 100 foot site and 300 foot vertical wellbore setback is also required for unconventional gas wells from any wetland greater than one acre in size. Some setbacks may also be relaxed if additional protections are put in place.



Gas well drilling companies contract with independent state-accredited water testing labs to conduct pre-drilling water testing.

Protection of Drinking Water Quality

Section 3218 of the Oil and Gas Act specifically includes language to protect nearby drinking water supplies. This includes a requirement that gas well drilling operators restore or replace any water supply determined by the PaDEP to be contaminated as a result of nearby gas well drilling. The gas well operator is presumed to be responsible for contamination of any drinking water supply within 1,000 feet of a conventional gas well if it occurs within six months after completion or within 2,500 feet of an unconventional gas well if it occurs within twelve months after completion. The operator can use any one of five defenses to prove they are not responsible for water contamination including:

- The pollution existed prior to the drilling
- The landowner or water purveyor refused to allow the operator access to conduct a pre-drilling water test
- The water supply is not within the regulated distance to the well
- The pollution occurred beyond the time limit after completion of drilling
- The pollution occurred as the result of some cause other than the gas drilling

To preserve their defense, most gas well operators will collect pre-drilling water quality information from all drinking water supplies within the notification distances of their drilling operation (some drilling companies are testing water supplies beyond these distances). Although there is no list of required water quality parameters, most pre-drilling survey water samples and samples collected by PaDEP during investigations are analyzed for many of the parameters listed on pages one and two. Gas well companies and PaDEP may choose additional water tests depending on the circumstances.

As part of any pre-drilling survey water sample, the gas well company is required to hire an independent state-accredited water testing laboratory to conduct the water testing. A [list of state-accredited labs](#) from the PaDEP Bureau of Labs is linked on the Penn State Water Resources Extension website.

An employee or subcontractor from the accredited laboratory will visit homes within the notification distances of the proposed gas well site to collect the water samples. This ensures that the samples are collected correctly using proper methods and materials. To ensure data quality, documentation must be completed for each sample showing proper collection, preservation, handling procedures and chain of custody (people who handled the sample). Here are some important things to remember if you are visited by someone wanting to test your water as part of a pre-drilling survey:

- Do not deny access to the water testing laboratory personnel. It is important to note that gas well operators are NOT presumed responsible for pollution of water supplies that they were denied access to prior to the drilling.
- Get the name and company affiliation of any person asking to sample your water supply and ask for proof of identification.
- Provide information about your water supply including approximate depth, yield, age, and treatment devices. This will help the water testing professional determine proper sampling locations. It will also help the drilling company choose proper drilling techniques to avoid causing problems to your water supply.
- Ask what water quality tests will be performed by the laboratory on your water sample. This list may help you decide if you want to have your own, more extensive test done at your own cost (consult the Penn State Extension publication entitled [Testing Drinking Water Supplies Near Gas Drilling Activity](#) available from your local Extension office.
- The owner of the water supply has a right to receive a copy of any pre-drilling water test results collected by a lab representing the energy company. You can request a copy of these water test reports from the water laboratory or the energy company. If they are unwilling

to provide a copy, contact one of the Pennsylvania DEP, Office of Oil and Gas Management locations below and they will obtain a copy for you.

Pennsylvania DEP, Office of Oil and Gas Management

- Central Office - 717-772-2199
- Southwest Office- 412-442-4024
- Northcentral Office - 570-321-6550
- Northwest Office - 814-332-6860

Protection of Water Flows from Wells and Springs

Gas well drilling can occasionally change the flow of water from a water well or spring, although these changes are often temporary. Unlike water quality impacts, gas well operators are **not** presumed responsible for water quantity impacts to nearby water supplies. (Consult the Penn State Extension publication entitled [Testing Drinking Water Supplies Near Gas Drilling Activity](#) available from your local Extension office.

Land Disturbance

Gas well construction involves extensive disturbance including roads, drilling pads and pipelines. Drilling pads alone may be four to six acres in size for unconventional gas wells. Various regulations are in place to protect surface water and groundwater from erosion and sedimentation due to these disturbances. Erosion and sediment plans or permits may be required that include the use of filter fence, sediment traps, vegetation, hay bales, culverts and rock road entrances. These plans also include a requirement to restore vegetation to the drill site within nine months after well completion. Enforcement of erosion and sediment problems related to gas drilling is overseen by PaDEP, Office of Oil and Gas Management.

Groundwater Protection During Drilling

Protections were included in the Oil and Gas Act (Act 13 of 2012) to ensure that groundwater aquifers are not contaminated by drilling fluids, brines and wastes. A thick, steel casing is cemented into place from the ground surface to below the deepest freshwater aquifer (typically several hundred feet below the ground surface). This freshwater protection string segregates the fresh groundwater from the drilling process and prevents waste fluids from entering freshwater aquifers. More detailed requirements on casing and cementing of Marcellus gas wells went into effect in February 2011 in order to provide greater protection for groundwater aquifers.

Disposal of Drilling Fluids

Disposal of the various waste fluids generated during and after the drilling process is also regulated to protect surface and groundwater resources. All waste fluids are collected in metal tanks or lined pits. Fluids that are not immediately reused or recycled are piped or trucked to various treatment facilities. Recent changes to regulations require newer treatment plants to provide advanced treatment of waste fluids before they can be discharged into streams. Other less common methods of waste fluid disposal include injection wells (regulated by the U.S. Environmental Protection Agency) or application to roads (regulated by PaDEP). Regulations now require the gas well drilling operators to identify where waste fluids from well sites are taken for treatment, reuse, or disposal. For more details about wastewater treatment methods, see the Penn State Extension fact sheet entitled [Marcellus Shale Wastewater Issues - Current and Emerging Technologies](#).

Water Withdrawals

A major concern with newer and deeper gas well drilling technologies has been the withdrawal of large volumes (millions of gallons) of water used mostly in the hydrofracturing process. These large water withdrawals may come from many sources (streams, ponds, lakes, etc.) and can have significant effects if not done carefully. Water withdrawals require the submission of Water Management Plans and authorization by PaDEP under authority of the Water Resources Planning Act. Withdrawals occurring in the Susquehanna or Delaware River watersheds may also require permits from the Susquehanna River Basin Commission or the Delaware River Basin Commission. The Clean Streams Law also limits the amount of water that can be withdrawn from streams to maintain sufficient stream flows to protect aquatic life. These regulations have all been used to shut down gas well drilling operations that failed to acquire the proper permits or exceeded allowable withdrawals from streams.

Concerns over water use during gas well drilling prompted changes in 2008. Water Management Plans now must be submitted and include information on the sources and locations of water to be used in the drilling process, the impacts of drilling on water resources and proof that the water withdrawals have been approved by the appropriate river basin commission.

Well Plugging

Once a well is no longer in production (a period of a few years to several decades for most wells), it must be decommissioned and plugged. In some cases, the production well casing (below the freshwater protection string) may be removed and re-used at other sites. The freshwater protection casing is left in place and the hole is filled to the ground surface with non-porous material.

Prior to current regulations, gas wells were often left in place even after they were taken out of production. Thousands of these wells are located throughout much of western and north-central Pennsylvania. These abandoned gas wells, often referred to as “orphan wells” should be properly decommissioned to prevent future groundwater contamination. The state has a fund to properly decommission orphan gas wells. Contact one of the regional PaDEP, Office of Oil and Gas Management locations listed on page three to report an orphan gas or oil well in your area.

Homeowner Strategies to Protect Water Supplies

Maintain Your Water Supply

Most homeowner complaints related to gas well drilling and drinking water supplies are determined to be problems that existed before gas drilling or were caused by other activities. Periodic maintenance and testing of private water supplies can help to identify and avoid these problems. Penn State Extension has many resources and publications dedicated to proper management of private water systems available at the [Penn State Extension Water Quality](#) website.

Be an Active Participant

Introduce yourself to the drilling company and to PaDEP. Ask questions, and make sure that the drilling company and PaDEP know that you have an active interest in water quality issues related to the proposed drilling.

Learn When and Where Drilling Will Occur

Some homeowners will learn of nearby gas well drilling plans through lease agreements or through required notification by certified mail if their water supply is within 1,000 feet of a proposed conventional well or 3000 feet of a proposed unconventional well. Additionally, anyone can be kept abreast of gas well drilling plans through several online features available through the PaDEP including:

- [PA DEP Marcellus website](#): includes spreadsheets, graphs and maps of Marcellus drilling activity. Enter Marcellus as a keyword.
- [eNotice](#): once registered on this web site you can choose to receive notice of gas well permits in your area.
- [eMap](#): a web-based geographic information system that allows mapping of proposed gas well locations by permit number.
- [eFacts](#): after drilling begins, monitor inspection reports, violations, etc. on this web site.

For more information on testing your private water supply before gas well drilling activities, consult the Penn State Extension publication entitled [Testing Drinking Water Supplies Near Gas Drilling Activity](#), available from your local Extension office.

Include Water Resource Protection in Your Lease

Many of the aforementioned ideas for protecting a water supply can be stipulated in a gas leasing agreement (if a lease is offered by the gas company). The lease agreement provides an opportunity for the homeowner to set rules for the gas company to follow in order to access private property. Some items to consider for the lease agreement include:

- Setback distances - don't allow drilling or seismic testing within several hundred feet of any water sources (wells, springs, ponds, streams, etc.).
- Water testing - request pre- and post-drilling testing of all drinking water supplies. Stipulate a complete list of test parameters. If you are concerned about other sources of water on your property (springs, streams, ponds, etc.), request that these water sources also be tested.
- Water flow - request measurement of water flow from wells and springs prior to gas well drilling by a water well contractor certified by the National Ground Water Association.
- Water sources - stipulate which sources of water on your property can and cannot be used during the drilling and hydrofracturing processes.
- Waste handling - stipulate proper off-site disposal of all drilling waste materials.

More Information

For additional information on all aspects of managing a private water system or help in reading your water test results, contact your local Penn State Extension office or consult the [Penn State Extension Water Quality](#) website.

For more information on all aspects of gas and oil well drilling in Pennsylvania, consult the [PaDEP](#) website and choose keyword: “Oil and Gas”.

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