



Water Withdrawals for Development of Marcellus Shale Gas in Pennsylvania

Introduction to Pennsylvania's Water Resources

Pennsylvania has considerable water resources both above and below ground. The state's surface water resources include more than 83,000 miles of streams and rivers, more than 4,000 lakes and reservoirs, hundreds of thousands of private ponds, and 120 miles of coastal waters, overall totaling nearly 2.5 trillion gallons of water (Figure 1). Below the surface, about thirty times more water (80 trillion gallons) is stored in groundwater aquifers after it percolates through layers of soil, sand, and rock. In an average year, Pennsylvania receives more than 40 inches of precipitation.

Water is a critical component of the process of removing natural gas from underground shale rock formations. Pennsylvania's precipitation totals and surface and groundwater volumes are significantly higher than those of some southwest-

ern and mountain states where other shale fields are already in full-fledged gas production. The abundance of water in Pennsylvania is a double-edged sword for drilling. Water is needed for drilling, but drillers need to avoid affecting the numerous water wells, streams, lakes, and other water bodies throughout the state with their operations.

Although water is plentiful in Pennsylvania, a variety of user groups place significant demands on our water resources (Figure 2). The total withdrawal of ground- and surface water in Pennsylvania approaches 10 billion gallons per day. In 2000 the state's largest users were thermoelectric power generators (70 percent); industrial and mining operations, including natural gas extraction (13.6 percent); domestic and commercial customers (16 percent); and agricultural users (0.4 percent).

Figure 1. Volume of water in Pennsylvania (2000).
Source: Abdalla, et al., *Access and Allocation of Water in Pennsylvania* (University Park: The Pennsylvania State University, 2008).

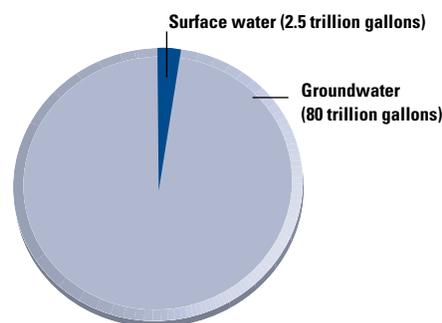
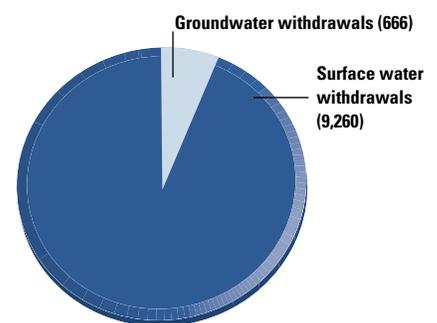


Figure 2. Total water withdrawals in Pennsylvania in million gallons per day (2000). Source: Abdalla, et al., *Access and Allocation of Water in Pennsylvania* (University Park: The Pennsylvania State University, 2008).



Consumptive uses remove water from a ground- or surface water source and do not directly return it to the same basin for future use. Two examples of consumptive use related to deep shale gas drilling include (1) loss of about 90% of water used for developing, or hydrofracturing (see below), the well (it remains deep underground), and (2) diversion of water from one river basin into another for drilling purposes.

It is important to put Marcellus shale drilling water withdrawals (Tables 1, 2) in context. The Susquehanna River Basin Commission (SRBC) estimates preliminarily that, at full development, basinwide water withdrawals (an average of 28 million gallons per day) by all gas extraction operators drilling in the Marcellus shale will equal the amount of water withdrawn currently in three days for power production in the basin. The SRBC considers all water used in hydrofracturing to be consumptively lost to the system. Any water ultimately returned to the surface is considered a waste product. Drilling water returned to the surface is the fracking fluid (also called drilling return water, drilling wastewater, flowback, or produced or stimulation fluid) (see “Water Quality Issues Related to Gas Drilling,” p. 7).

With the recent interest in extracting gas via deep well drilling and the large water use associated with this drilling and hydrofracturing (fracking), the portion of water withdrawals related to mining is likely to rise.

The information presented here is subject to rapid change due to the fast-paced, evolving nature of gas drilling in the Marcellus shale. Check the “Resources” section at the end of the publication for updates. Some areas of most rapid change and uncertainty include gas well permitting requirements, the sale of water for use in drilling, and the treatment and disposal of drilling wastewater.

Table 1. Usage of water in hydrofracturing in the Susquehanna River basin in Pennsylvania, June 1, 2008–May 21, 2010.

	<i>Average</i>	<i>Minimum</i>	<i>Maximum</i>
Water injected for hydrofracturing (million gallons)	3	0.1	8.3
Water brought onsite that is used (%)	84	30	100
Injected water that is recovered (%)	10	1	57

Source: Susquehanna River Basin Commission

Table 2. Water withdrawn for hydrofracturing in the Susquehanna River basin in Pennsylvania, June 1, 2008–May 21, 2010 (220 wells reporting).

	<i>Million gallons</i>	<i>Percent of total</i>
Public water supply	209.2	29
Surface water sites	506.8	71

Source: Susquehanna River Basin Commission

Pennsylvania: Site of the Country’s First Oil Well

The Appalachian Plateau and western Ridge and Valley provinces in Pennsylvania have seen previous oil and gas resource development. In 1859 Edwin Drake drilled the country’s first oil well in Titusville. Drake’s crew struck oil about 70 feet below ground. Modern-day drillers into the Marcellus shale face many new challenges as they often drill more than a mile into the earth.

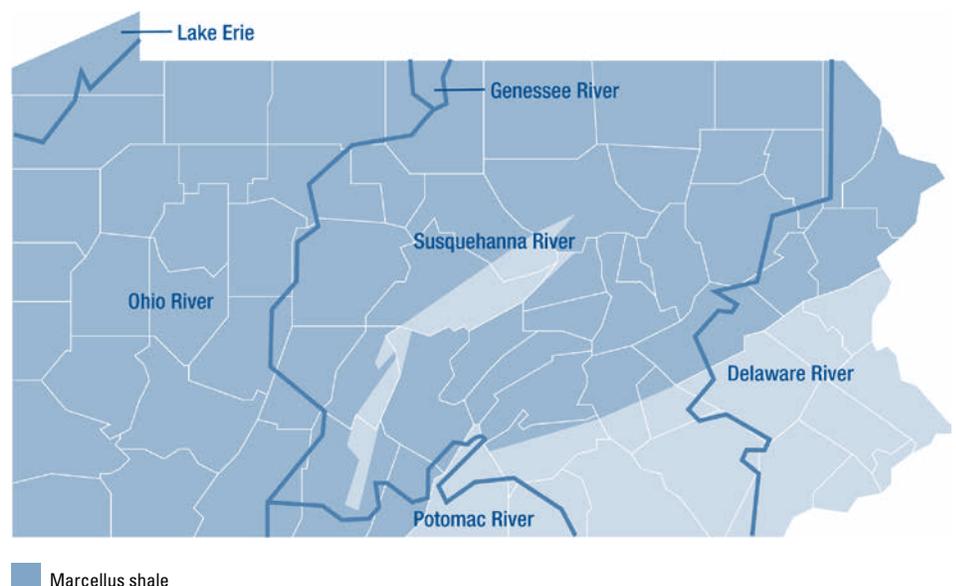
Introduction to the Marcellus Shale and Its Development for Natural Gas

The Marcellus shale lies 4,000–8,500 feet underground beneath southern New York, northern and western Pennsylvania, the eastern half of Ohio, and through West Virginia

(Figure 3). Expanding demand for energy in the developing world and for domestically produced energy in the United States, and new drilling technologies such as horizontal drilling and hydraulic fracturing, have whetted mineral exploration companies’ interest in tapping the deep gas reserves in the Marcellus shale. An additional key to the interest in Pennsylvania is the location of its gas reserves relative to the large gas markets in New York, New Jersey, Virginia, and New England.

After slowing dramatically in 2008 due to a sharp drop in energy prices and the worldwide economic slump, leasing and drilling activity again picked up speed in Pennsylvania in 2009 and 2010, based on gas

Figure 3. Distribution of Marcellus shale in Pennsylvania, with major river basins overlaid.



production information from early wells. How much money will eventually be put into wells in Pennsylvania, and how much gas will flow from them, remain to be seen.

Two issues holding up development of the Marcellus shale field are the limited number and locations of existing gas pipelines in the region and appropriate technology for treatment of wastewater from drilling operations (see "Water Quality Issues Related to Gas Drilling," p. 7).

The Susquehanna River Basin Commission preliminarily estimates that up to 5,000 wells may eventually be drilled into the Marcellus shale in this river basin alone (Pennsylvania and New York). The gas industry expects to drill as many as 1,750 Marcellus wells in 2010, compared to 763 in 2009.

There are varying estimates of the total and recoverable amounts of gas in the Marcellus shale. The U.S. Geological Survey estimated during the late 1970s a total of 295 trillion cubic feet (TCF), with 9 to 15 TCF recoverable. Estimates of total gas in the field made in 2008 range from 168 TCF to 4,300 TCF. Geologists estimate that resource companies may be able to recover 50 to 390 TCF of gas from the Marcellus shale.

The Marcellus shale is made up of sediments high in organic material. As this organic matter decayed, methane gas formed and dispersed throughout pores in the rock. About 300 million years ago, the pressure of the gas caused northeast-to-southwest fractures to form in the shale.

So a well drilled vertically into the Marcellus may cross one of these fractures, but new horizontal drilling technology can cross a number of fractures. After drilling several thousand feet into the earth, the new technology allows the bore hole to be turned 90 degrees over several hundred feet and to continue horizontal drilling for almost a mile (Figure 4). Cross-cutting multiple fractures is key to a highly productive well.

Water Is Essential to Marcellus Well Development

Water is a critical ingredient for extracting gas from the Marcellus shale. The drilling process itself can require up to 300,000 gallons per day per well. The shale around most new gas wells in Pennsylvania has to be hydraulically fractured to release the trapped gas so that it can be brought to the surface. Hydrofracturing uses high-pressure water, sand, and chemicals (see also "Water Quality Issues Related to Gas Drilling," p. 7) to break up the gas-holding rock and improve the flow of gas to the bore hole. According to the SRBC, hydrofracturing a deep vertical well may use 500,000 to more than 1,000,000 gallons of water. Hydrofracturing a horizontal Marcellus well may use 4 to 8 million gallons of water, typically within about 1 week. However, based on experiences in other major U.S. shale gas fields, some Marcellus wells may need to be hydrofractured several times over their productive life (typically five to twenty years or more).

Depending on the need for refracking, these types of water withdrawals might continue further into the future, past the industry's development stage and into the gas extraction stage. These large water withdrawals may come from streams, ponds, lakes, rivers, or ground-

water. They can have significant ecological effects if not done carefully. Large withdrawals could also affect nearby drinking water sources and other uses. Putting water to one use may mean that it is not available for another use, thereby increasing the potential for conflicts between water users and uses.

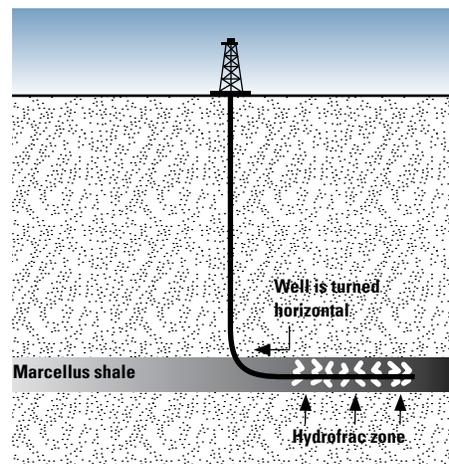
Pennsylvania's Oil and Gas Act protects both quantity and quality of existing water supplies. Under certain circumstances, an oil and gas company is presumed responsible for degradation of water quality in water supplies for six months following gas well drilling (see "Water Quality Issues Related to Gas Drilling," p. 7). However, this act does not presume responsibility by the oil or gas well company for water quantity problems in private water supplies near active oil and gas wells. Consequently, suspected impacts to water quantity would need to be investigated by the Pennsylvania Department of Environmental Protection (DEP) and/or proved by the water supply owner. A first step would be to contact DEP and ask them to investigate the water quantity problem. Predrilling flow data collected by a professional drinking water supply contractor or consultant would be important in helping prove that a water quantity problem was caused by oil or gas drilling.

Institutions Governing Interstate Waters in Pennsylvania

The Delaware and Susquehanna River basins cover the eastern two-thirds of the state (Figure 3). The western third is mainly in the Ohio River basin and, to a lesser extent, the Great Lakes watershed. In the 1960s and 1970s, Pennsylvania, its neighboring states, and the federal government created two federal-interstate compact commissions to manage water interests in the Delaware and Susquehanna river watersheds. The federal government is also a member of each of these river basin commissions.

Staff from the river basin commissions are working closely with Pennsylvania and New York state government agencies to coordinate actions and minimize duplication of

Figure 4. Drilling in the Marcellus shale takes advantage of new techniques that allow horizontal drilling for almost a mile from the vertical shaft.
Source: Geology.com.



effort. Companies must obtain the necessary state approvals as well as those of the applicable river basin commission. (In areas not covered by a river basin commission, applications for well drilling and water management plans go entirely through DEP.)

Susquehanna River Basin Commission

The Susquehanna River Basin Commission was established in late 1970 via legislation enacted by the states of New York, Pennsylvania, and Maryland and the federal government. The commission's 100-year compact seeks to protect and manage the water resources of the basin.

The Susquehanna River starts in Cooperstown, New York, and flows 444 miles to Havre de Grace, Maryland, where the water empties into the Chesapeake Bay. Almost three-quarters of the entire Susquehanna River watershed, comprising 27,510 square miles in three states, is underlain by Marcellus and other organic-rich shales.

Water withdrawals of any amount occurring in the Susquehanna River watershed to develop gas wells in the Marcellus or Utica shale formations also require approvals from the SRBC. In 2009 SRBC approved sixty surface water withdrawals for gas drilling in the Susquehanna basin (Table 3). They also issued 319 "Approvals by Rule" (see below for more information).

As of August 14, 2008, the Susquehanna River Basin Commission began requiring gas companies to seek prior approval before withdrawing or consumptively using

any amount of water to develop wells in the Marcellus or Utica shale formations in the Susquehanna watershed. Companies may not begin gas well construction, drilling, or hydrofracturing without commission approval. This requirement applies even if the anticipated water withdrawal or consumptive use would not have triggered commission review under its standard regulatory thresholds.

This requirement allows the commission to regulate the gas industry's individual and cumulative impacts on water resources. SRBC is concerned about the quantity and rate of water used, the source for withdrawals and consumptive uses, the potential to alter the physical, biological, chemical, or hydrological characteristics of the basin's water resources, and the potential to affect interstate water quality.

The commission streamlined the administrative procedure for reviewing these water uses. Effective January 2009, SRBC expanded approval by Rule procedures previously applied only to consumptively used water taken from public water supply systems. Gas companies can use the procedure to seek approval for consumptive water use, no matter where the water comes from. This encourages the reuse of municipal wastewater, mine pool water, and other lesser quality sources instead of freshwater. For more details on Approval by Rule, see [www.srb.net/programs/docs/ProjectReviewMarcellusShale\(NEW\)\(1_2010\).psd](http://www.srb.net/programs/docs/ProjectReviewMarcellusShale(NEW)(1_2010).psd).

On November 1, 2009, SRBC put into effect further regulatory updates. The main impact on gas drillers was that they can now use

water from any SRBC-approved source at any approved drill pad in the river basin. This streamlining effort should reduce truck traffic and administrative duties.

SRBC has stated that they intend to meet economic needs of the state and the industry while ensuring that adequate water resources are available for all users. The Approval by Rule process allows SRBC to efficiently handle the increase in regulatory review activity.

Reliance on public water supplies for hydrofracturing in the Susquehanna River basin in Pennsylvania declined from 45 percent in 2008 to 29 percent in 2009.

Delaware River Basin Commission

A longstanding interstate legal debate over water rights within the Delaware River basin and the diversion of water to New York City, which is not in the watershed, resulted in two U.S. Supreme Court decrees (1931 and 1954) to resolve the competing claims among the states. The realization that additional litigation might be needed to settle future interstate water disputes, along with basinwide concerns over water quality and flooding, provided the catalyst for the creation of the Delaware River Basin Commission (DRBC) in 1961. The DRBC brings together Pennsylvania, New York, New Jersey, Delaware, and the federal government to jointly manage the shared water resources of the basin without regard to political boundaries. Its members include the four basin state governors and the commander of the U.S. Army Corps of Engineers North Atlantic Division, who serves as the federal representative. The initial term of the federal-interstate compact creating the DRBC is 100 years.

The Delaware is the longest undammed river east of the Mississippi, extending 330 miles from the confluence of its east and west branches at Hancock, New York, to the mouth of the Delaware Bay, where it meets the Atlantic Ocean. More than 15 million people rely on the waters of the 13,539-square-mile Delaware River basin, and

Table 3. Surface water withdrawal and Approval by Rule actions taken by SRBC in 2009.

	<i>Surface water withdrawal applications</i>	<i>Approval by Rule (Notice of Intent applications)</i>
Total submitted in 2009	85	394
March approvals	19	—
June approvals	20	—
September approvals	12	—
December approvals	9	—
Total approved	60	319
Pending	25	0
Withdrawn	9	3

Source: Susquehanna River Basin Commission

three-quarters of the nontidal Delaware River (approximately 150 miles) is now included in the National Wild and Scenic Rivers System. The Marcellus shale formation underlies more than one-third of the basin.

The DRBC's executive director issued a determination in May 2009 that natural gas extraction projects located in shale formations within the drainage area of the basin's Special Protection Waters (SPW) may not begin without the sponsor first obtaining commission approval. This determination asserted commission review over all aspects of natural gas extraction projects in those areas regardless of the amount of water withdrawn or the capacity of domestic sewage treatment facilities accepting fracking wastewater. However, it expressly did not cover wells intended solely for exploratory purposes. The commission's SPW program is designed to prevent degradation in streams and rivers considered to have exceptionally high scenic, recreational, ecological, and/or water supply values through stricter control of wastewater discharges, nonpoint pollution control, and reporting requirements. Coverage of the DRBC's SPW antidegradation regulations includes the entire 197-mile nontidal Delaware River from Hancock, New York, south to Trenton, New Jersey, and the land draining to this stretch. In Pennsylvania, the SPW drainage area includes all or portions of Berks, Bucks, Carbon, Lackawanna, Lehigh, Luzerne, Monroe, Northampton, Pike, Schuylkill, and Wayne Counties.

In June 2010, the executive director modified the provisions of her original May 2009 determination to include natural gas exploratory wells. For more information, see www.nj.gov/drbc/naturalgas.htm.

As of August 2010, the DRBC had not approved any natural gas well drilling applications within the basin. The commission in July 2010 approved Stone Energy Corporation's proposed water withdrawal from the West Branch Lackawaxen River in Wayne County, Pennsylvania. Check the DRBC website for updates.

The commission is now developing new regulations concerning natural gas drilling in the basin. Draft natural gas regulations are expected to be published for public review in November or December 2010. The rulemaking process will include at least one public hearing and opportunity for public comment. Commission consideration of natural gas production project applications will be postponed until the new DRBC regulations are adopted. Stay tuned to the DRBC website for updates.

Other Pennsylvania Watersheds

There is no river basin commission regulating water quantity in the western third of Pennsylvania, but DEP is applying SRBC "passby" guidelines in that area to ensure a consistent regulatory environment across the state. These guidelines allow for water withdrawal from a stream during times of high or normal flow but require that the withdrawal stop or decrease during times of low stream flow, usually during the late summer or early fall.

Pennsylvania DEP is applying SRBC's passby flow guidelines to water management plans associated with applications for new gas well drilling permits targeting Marcellus shale across the state.

Some citizens and organizations in the Ohio River basin remain concerned about whether their water resources will be adequately protected given (1) DEP's limited ability to conduct routine inspections of drilling operations, and (2) the difficulty of proving adverse effects on water supplies from gas drilling activities. Some advocate for an Ohio River basin commission focused on water quantity, with powers similar to those of SRBC or DRBC (see sidebar).

A River Basin Commission Focused on Water Quantity for the Ohio River?

The Ohio River Basin Sanitary Commission (ORSANCO) regulates water quality in that basin, but not water withdrawals. Some citizens and organizations in western Pennsylvania and other parts of the Ohio River basin have asked what it would take to establish a water-quantity-focused river basin commission for the Ohio with powers similar to SRBC's and DRBC's.

A river basin commission is formed by an interstate compact adopted into law by each of the participating states and consented to by the U.S. Congress. It is a form of collaborative government. The new Great Lakes–St. Lawrence River Basin Water Resources Council is the most recently created interstate compact body. SRBC was created in 1970. DRBC was established in 1961, and the Interstate Commission on the Potomac River Basin in 1940. Creation of each commission required (1) adoption of concurrent state-level legislation in which each of the partners adopted the interstate compact, and (2) consent of Congress.

The Army Corps of Engineers in Pittsburgh is participating in the Ohio River Basin Comprehensive Reconnaissance Study to determine, among other things, the most efficient ways of reinvesting in existing reservoirs and flood protection projects in the basin. An official water-quantity-focused commission for the basin is one ultimate goal of the study. Some other participants in the comprehensive study include three other corps districts and the 15 basin states.

Pennsylvania Department of Environmental Protection and Other Relevant State Government Agencies

More than 350,000 oil and gas wells have been drilled in Pennsylvania since Drake's well in 1859. Most of these are very shallow in comparison to the wells now being drilled into the Marcellus shale. Pennsylvania regulates water management related to oil and gas exploration and drilling under the state's oil and gas laws, the Clean Streams Law, the Dam Safety and Encroachments Act, and the Water Resources Planning Act. DEP reviews and issues drilling permits (Figure 5), inspects drilling operations, and responds to complaints about water quality problems.

Water withdrawals generally exceeding 10,000 gallons per day for any average thirty-day period require registration with Pennsylvania DEP under authority of Act 220 of 2002, the Water Resources Planning Act, and implementing regulations at 25 Pa. Code Chapter 110.

Regardless of the basin in which water sources are located, DEP requires an approved water management plan in connection with the gas well permit to cover the water sources used for fracturing each Marcellus shale gas well in the Commonwealth. A water manage-

ment plan includes information about the sources of water to be used in the fracking process, expected impacts of withdrawals on water resources, and proof of approval by the appropriate river basin commission, among other items. (See the "Resources" section at the end of this publication for a link to the latest information from DEP.) This should help protect water resources, especially in areas not covered by a river basin commission.

DEP and the river basin commissions are concerned about large-scale water use for gas drilling largely from small, remote, forested streams, often home to wild trout and other sensitive species, that are very susceptible to damage from withdrawals. However, the location of water use is critical. Marcellus shale wells tend to be in upland areas with streams and smaller tributaries, not near major rivers, as power plants are. Withdrawals from small forested streams must be closely regulated to minimize the potential ecological consequences.

Water-use plans can be structured to allow operators to continuously withdraw water from a stream in a small quantity that has minimal impact on stream flows, such as a quantity that individually or cumulatively does not exceed about 10 percent of very low, drought flows (called an uninter-

rupted withdrawal). Alternatively, operators can withdraw larger amounts during times of high flow, usually in the spring, and store that water for use throughout the year. The SRBC has granted some "passby flow determinations with interrupted withdrawal" that allow water withdrawal from smaller streams with the condition that withdrawal stop or decrease to a previously designated level when flows reach a preset minimum.

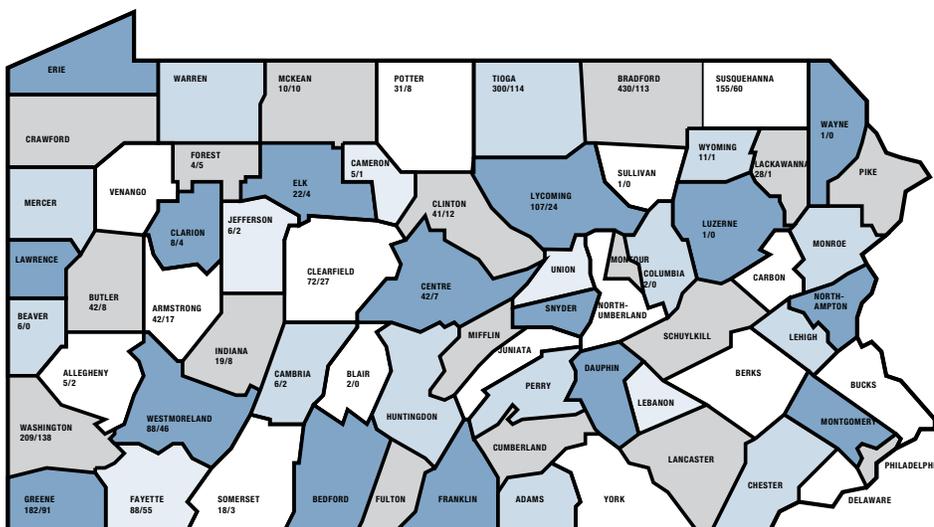
Gas companies can also seek to withdraw groundwater, but the rules for figuring the allowable withdrawal amount are complex. The companies point out that having the water source at the drilling pad decreases the amount of truck traffic to the site, thereby lowering their costs and the future costs of road repairs and lessening the impact on neighbors' quality of life.

The Pennsylvania Department of Conservation and Natural Resources (DCNR) says that companies are very unlikely to be given access to small forested streams in any state parks, and that they should not assume that DCNR will give them access on state forestland. DCNR is expected to give preference for water access to companies with which they are leasing. The Pennsylvania Game Commission is expected to take a similar stance regarding access to water on state game lands.

As for future trends in water use for gas drilling in the state, DEP and SRBC hope to see more reuse of water for fracking, and more use of other waters, such as treated wastewater and acidic mine drainage, in the hydrofracturing process. They expect that future water withdrawals will focus on removing water from streams during springtime high flows and storing that water in centralized impoundments for use in many gas wells in an area. Companies must comply with the provisions of the Dam Safety and Encroachments Act for impoundments.

Municipalities and counties must be notified of water management plans for gas wells in their area. State and river basin commis-

Figure 5. DEP Marcellus shale permits issued and wells drilled in 2009.



sion regulations consider impacts to existing water users at the time of review of proposed new uses.

Pennsylvania's Clean Streams Law limits the amount of water that can be withdrawn from streams to maintain sufficient stream flows for aquatic life. Failure to obtain necessary approvals or follow regulations on water withdrawals for drilling can shut down gas well drilling operations.

In September 2008 DEP had just 35 employees to inspect almost 75,000 oil and gas wells. The growth of interest in the Marcellus shale field made clear that this was insufficient, and DEP announced plans in early 2010 to add 68 new inspectors to oversee these wells. The hirings will be paid for through increases in fees for well permitting. This latest group is in addition to 37 new employees added in 2009, who are more focused on administrative work related to oil and gas drilling.

In 2009 DEP raised the fees for well permitting, adding a sliding scale based on well depth and type, with horizontal Marcellus wells being more expensive than traditional vertical wells. DEP cites the extra oversight necessary on these wells—for water use, hydrofracturing, and wastewater treatment and disposal—as the reason for the increase.

The regulations governing water withdrawals for gas drilling may continue to change rapidly as the industry expands and moves into full production. Check the Internet for the latest regulations (see the "Resources" section at the end of this publication).

The Sale of Water for Use in Gas Drilling

It is important to note that the water management agencies discussed here approve water withdrawal projects, but landowners control access to water. Some landowners are charging drilling companies a fee for access to the water on their property.

Within the Susquehanna River basin interested parties can purchase water, up to the total permit-

ted amount, from other users who have surplus water for use by the natural gas industry under their approvals. These sources may be used as long as they are registered under the applicable Approval by Rule for each drilling pad at which such sources would be used.

A number of gas companies also have purchased water from municipal water systems and other permitted users. Permit holders should consider future drinking water needs and other water-related economic development opportunities before agreeing to a sale. Transportation of water from the source to the drilling location can put tremendous stress on rural roads, so some local governments require gas companies to post a bond for road repair and maintenance.

Water can be withdrawn from private ponds and lakes if companies have permission to access the water body, for which some landowners are charging an access fee. Withdrawals of water from ponds or lakes more than one acre in size may require additional approvals, such as a drawdown permit from the Pennsylvania Fish and Boat Commission. Water withdrawals from ponds or lakes that do not receive stream water would generally be much easier to approve than withdrawals from stream-fed ponds and lakes. SRBC approval is likewise required for all surface-water withdrawals used in conjunction with Marcellus shale development.

In Pennsylvania water can be sold in certain situations. Water that is on or under the land, such as accumulated snowmelt, stormwater runoff, or water from a spring-fed pond, can be sold as long as it has no impact on water on or under another property. Landowners do not have the right to sell water from a watercourse that passes through their land parcel. Landowners can, however, charge an access fee. Some landowners have addressed access to water on the property in the addendum to a gas well drilling lease, and some landowners have sought compensation for access to water resources on their property. Although landowners may be con-

sidered to have certain ownership rights in subsurface waters on their property, they can incur liability if their sale of water adversely affects a well or spring on another property. Generally, it will be difficult for landowners to sell water.

The legality of selling water in Pennsylvania has been decided by case law rather than regulations. The sale of water for use in gas drilling and payments to private landowners for access to water are evolving issues surrounded by a good deal of confusion. Check the "Resources" section at the end of this publication for updates.

Water Quality Issues Related to Gas Drilling

Sand and chemicals are added to water used for hydrofracturing to facilitate gas extraction. Water returned from the well during hydrofracturing, called fracking fluid, contains high total dissolved solids (TDS) and other contaminants, such as radioactive radon released from the underground rock formation. The chemicals used in hydrofracturing may include oils, gels, acids, alcohols, and various human-made organic chemicals. Therefore, this fracking fluid is a water quality concern, and separate regulations and issues surround it.

In 2005 the U.S. Congress exempted fracking from coverage under the Safe Drinking Water Act. Therefore, the regulation of fracking and fracking fluids falls to the states. There is an ongoing discussion among some federal policy makers and stakeholders about the appropriate roles of the federal and state governments in regulating the environmental impacts of fracking and related issues. Several changes to federal laws were proposed in spring 2009. The U.S. Environmental Protection Agency (EPA) announced in March 2010 that it will study "potential human health and water quality threats" from fracking. The study should be finished by 2012.

DEP Is Updating Regulations

TDS concentrations nearly double the state and federal recommended levels were measured in 2008 and 2009 in the Monongahela River in southwest Pennsylvania. In 2009 DEP proposed regulations to limit the amount of TDS drilling operators could discharge in wastewater to waterways. The final rule, completed August 2010, requires that gas drilling wastewater not exceed 500 milligrams TDS per liter or 250 milligrams chlorides per liter. It applies to new and expanding wastewater treatment facilities.

DEP and SRBC are encouraging the reuse and recycling (Tables 4, 5) of drilling wastewater to reduce withdrawals of fresh water while also reducing discharges to surface water, and the industry reported in 2009 that they are increasingly using these techniques.

DEP is also updating water quality regulations to protect aquatic life throughout the state. In May 2010 the agency proposed an ambient water quality criterion for chloride of 250 mg/l. This regulation should be finalized after a public comment period and review by several additional state boards.

DEP has also proposed tougher standards for well construction to protect drinking water sources. The proposal would also require drilling companies to restore or replace water sources contaminated by drilling. As of October 2010, the pro-

Table 4. Average total volume of fluid used per well in the Susquehanna River basin in Pennsylvania, June 1, 2008–May 21, 2010 (220 wells reporting).

Fresh water	2.8 million gallons
Flowback reuse	0.5 million gallons

Source: Susquehanna River Basin Commission

Table 5. Use of flowback water in hydrofracturing in the Susquehanna River basin in Pennsylvania, June 1, 2008–May 21, 2010 (220 wells reporting).

Wells using flowback water in fracking	59%
Companies using flowback water in fracking	56%
Flowback water brought onsite that is used	88%
Total flowback reused	44.1 million gallons
Total flowback disposed	21.0 million gallons

Source: Susquehanna River Basin Commission

posed regulations were still subject to review by two committees and the attorney general.

SRBC requires well operators to certify that all disposal methods meet DEP standards. SRBC and DEP require disclosure of the chemicals used in well development, although the exact ratios are proprietary. Some water experts are quite concerned about the storage, treatment, and return of these waste fluids to the environment. This set of issues is a major challenge to development of gas from the Marcellus shale in Pennsylvania. If not thoroughly addressed, ecological, social, and economic costs will be incurred as a result of gas extraction from the Marcellus shale.

Recent Incidents Prompt Concern

A number of recent incidents and violations by Marcellus drilling operators has prompted growing concern among many about the industry's potential toll on the state's environmental resources.

In Dimock, Susquehanna County, Cabot Oil & Gas Corporation's failure to properly seal off the drinking water aquifer during a Marcellus drilling operation is blamed for the explosion of a residential water well due to high levels of methane in 2009. Since then, several other area water wells have been found to have potentially explosive levels of methane. Cabot supplied an alternative drinking water source for each of the affected houses. DEP fined the company \$250,000 for these violations.

In 2009 DEP fined Cabot more than \$50,000 for three drill pad spills totaling about 8,000 gallons of a liquid gel that is used as a lubricant during hydrofracturing. The spill caused a fish kill. DEP also ordered Cabot to cease all hydrofracturing in Susquehanna County until it met DEP's requirements for explanations for these incidents and outlined and implemented new and improved safety procedures.

In March 2010 an impoundment holding gas drilling wastewater ignited in Washington County.

In June 2010 a Marcellus well in Clearfield County blew out, shoot-

ing pressurized gas and frack fluids 75 feet into the air. About 35,000 gallons of brine and frack fluids spilled. DEP is investigating the cause of the blowout.

Less than a week later, a fire at a West Virginia drill pad injured seven workers. While drilling a Marcellus well, the workers hit a pocket of methane in a different inactive mine.

In response to all of these incidents, some Pennsylvania legislators are urging a statewide moratorium on Marcellus drilling until environmental concerns are addressed and safeguards are implemented. Various groups are pushing for tighter federal and/or state standards for well drilling and maintenance.

Water Quantity Affects Quality

It is important to remember that there is a connection between water quantity and water quality. Taking water from a small stream concentrates any contaminants in the stream water. If small streams are used for release of fracking fluid, the lower dilution rate can damage fragile ecosystems and harm aquatic life.

Owners of private drinking water supplies in areas with active Marcellus shale drilling should be alert for a sudden change in water quantity and/or quality. Under certain circumstances, the oil and gas company is presumed responsible for degradation of water quality in water wells or springs for six months following gas well drilling. Concerned private water supply owners should contact the local DEP office if they suspect that a water quality problem was induced by a new oil or gas well. Refer to the Penn State Extension publication *Gas Well Drilling and Your Private Water Supply* for more information related to Marcellus shale well drilling and water quality issues (see the "Resources" section at the end of this publication).

Compliance with the regulations governing gas well drilling and private water supplies is variable, especially when water supply owners are unaware of their rights. Keeping good records of well wa-

ter quality will help establish a baseline in case of a problem. The public policies described here with respect to interactions between oil and gas and private water supply quality may be reevaluated as drilling continues. Given the uncharted, fast-paced nature of developments, citizens may be wise to be alert for possible environmental impacts from drilling operations in their area.

“An ounce of prevention is worth a pound of cure.”

—Ben Franklin

Conclusion

Water is a critical ingredient for extracting gas from the Marcellus shale. Without adequate water, the shale around the well bore hole cannot be hydrofractured to allow the efficient and economical flow of gas into the well. This is another of water’s invaluable and innumerable uses.

Regulators estimate that the total annual water withdrawal by drillers into the Marcellus shale (roughly ten billion gallons per year)

will equal about the same amount of water as thermoelectric power plants in the Susquehanna basin use in three days (Figure 6). In this light, the amounts seem manageable. But given that these gas wells often occur in remote areas where the closest water source may be an ecologically sensitive, small forested stream, Pennsylvania’s overall environmental and economic health demands that these withdrawals receive the kind of scrutiny that they are getting. The unknown extent to which well refracking may be needed could increase water demands for extracting gas from the Marcellus shale, thereby increasing the potential for water-use conflicts.

It is important to realize that water quantity and water quality are intimately linked. If the amount of water in a stream is reduced, any pollutants in the remaining water become more concentrated. Currently, the treatment and disposal of drilling wastewater is an obstacle to the full-fledged development of gas from the Marcellus shale in Pennsylvania. This is an area of intense research.

Development of the Marcellus shale for gas extraction may present

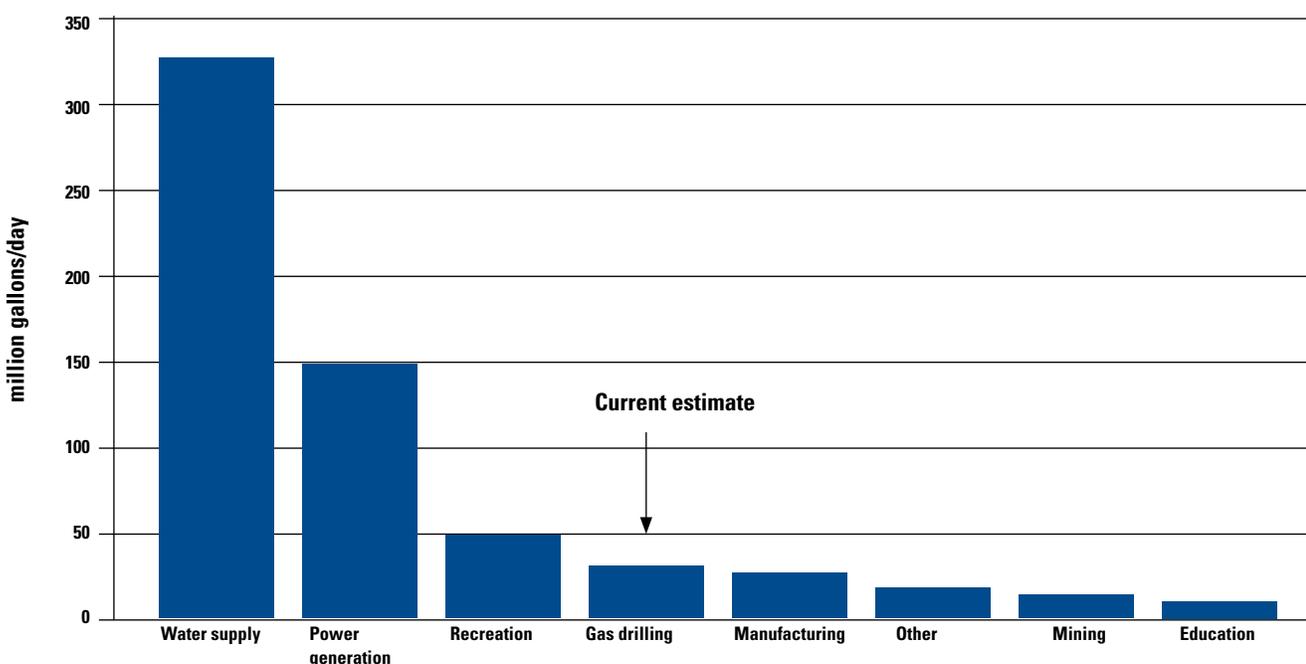
a major economic expansion opportunity for Pennsylvania, but we need to learn from the legacy of coal mining in the state and ensure that environmental protections are in place up front, before drilling happens. “An ounce of prevention is worth a pound of cure,” as famous Pennsylvania resident Ben Franklin once said. The state’s water supplies are critical inputs for the activities of households, municipalities, and industries, and support water-based tourism and recreation. They are vital to Pennsylvania’s economy and residents’ quality of life, and they need up-to-date protections.

As of June 2010, it appears that the Marcellus gas industry in Pennsylvania is here to stay and will only grow. The blowout of the Deepwater Horizon oil rig in the Gulf of Mexico in April 2010, and the resulting moratorium on new offshore drilling, further increased the industry’s interest in the Marcellus gas field.

But clearly the regulatory climate is changing in response to on-the-ground issues.

Existing permit requirements may be further modified. SRBC on June 25, 2010, published proposed

Figure 6. Maximum approved daily consumptive water use by various industries.



Source: Susquehanna River Basin Commission.

revisions to Marcellus regulations in the Federal Register. The final rulemaking is expected to be effective November 1, 2010. See SRBC's website for updates.

DRBC expects to publish draft natural gas regulations before the end of 2010, with a public rulemaking process to follow. Stay tuned for updates (see the "Resources" section at the end of this publication) to state regulations regarding water quantity and quality issues surrounding Marcellus shale natural gas development.

Some water experts and interest groups have called for updates, including

- designation of required water quality testing parameters for fracking fluid;
- an increase in the water protection bond required from drilling companies; and
- an increase in the minimum distance of wells from streams or ponds.

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Resources

Delaware River Basin Commission
www.state.nj.us/drbc

Interstate Council on Water Policy
www.icwp.org/cms

Penn State Extension Natural Gas Impacts
extension.psu.edu/natural-resources/natural-gas

Penn State Dickinson School of Law, Agricultural Law Resources and Reference Center, Natural Gas Exploration
law.psu.edu/academics/research_centers/agricultural_law_center/resource_areas/natural_gas_exploration

Penn State Earth and Environmental Systems Institute, Earth Talks, Marcellus Shale Play: Boon or Burden? (spring 2009)

www.eesi.psu.edu/news_events/EarthTalks/2009Spring/Earth-talksSpring09.shtml

Pennsylvania Department of Environmental Protection

www.dep.state.pa.us/dep/deputate/minres/oilgas/new_forms/marcellus/marcellus.htm

Pennsylvania Independent Oil & Gas Association

www.iogapa.org

Soeder, D. J., and W. M. Kappel. 2009. "Water Resources and Natural Gas Production from the Marcellus Shale." U.S. Geological Survey Fact Sheet 2009-3032. pubs.usgs.gov/fs/2009/3032/

Susquehanna River Basin Commission

www.srbc.net

Water Resources Education Network, Pennsylvania League of Women Voters

wren.palwv.org

The U.S. EPA recently set up a tip line for citizens to report nonemergency "dumping and other illegal or suspicious hauling and/or disposal activity" related to oil and natural gas development. Citizens can call 1-877-919-4EPA (toll free) or e-mail to eyesondrilling@epa.gov. Citizens may remain anonymous.

In case of an emergency, such as a spill or a release of hazardous material, including oil, to the environment, citizens should call the National Response Center at 1-800-424-8802.

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Put Our Experience to Work for Your Community

The Penn State Extension Marcellus Education Team strives to bring you accurate, up-to-date information on natural gas exploration and drilling in Pennsylvania. Learn about your rights and choices as a landowner, a businessperson, a local official, or a concerned citizen. Discover the resources available to you.

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