

*Subcommittee on Water and Power
Senate Committee on Energy and Natural Resources
United States Senate*

*Hearing on Shale Gas Production and Water Resources
In the Eastern United States
October 20, 2011*

**Thomas W. Beauduy
Deputy Executive Director & Counsel
Susquehanna River Basin Commission
1721 N. Front Street
Harrisburg, PA 17102**

I. Introduction

Let me start off by thanking the Chair, Senator Shaheen, as well as Ranking Member Lee and all subcommittee members for the opportunity to appear before you today on behalf of the Susquehanna River Basin Commission (Commission) to address water resource issues associated with shale gas development in the eastern United States.

The Susquehanna River basin is in the heart of the Marcellus shale play, which underlies 72% of the land area of the basin. The basin itself is 27,512 square miles and extends from Cooperstown, New York, to the head of the Chesapeake Bay at Havre de Grace, Maryland. *Attachment 1* depicts the basin and the geographic extent of the Marcellus shale formation.

Geologically, the basin is home to a number of other tight shale formations that have, as of yet, an undetermined amount of recoverable natural gas. The level of recoverable gas beyond what is currently anticipated from the Marcellus, and the level of development activity and water use associated with it will become better known as information becomes available from exploratory work that is currently underway. These formations, in combination with the Marcellus, underlie 85% of the basin.

My comments today will reflect the management controls we have developed in response to shale gas development activity generally, and what we are currently seeing with regard to development of the Marcellus shale formation specifically.

II. Background: Water Allocation and Consumptive Use Management in the Basin

The Commission was created in 1971 as a result of the enactment of the Susquehanna River Basin Compact (Compact) by the states of Maryland, Pennsylvania and New York,

and by the United States.¹ Formed as a federal-interstate compact commission, the Commission is vested with broad statutory authority to manage the water resources of the basin, including the authority to allocate the waters of the basin.² It serves as a forum for the joint exercise of the sovereign authorities delegated to it by its member jurisdictions.³

The Commission has utilized its Compact authority⁴ to develop a regulatory program to manage the resource impacts of projects using the waters of the basin, to avoid conflicts, and to provide standards to promote the equal and uniform treatment of all water users without regard to political boundaries.⁵

Fundamentally, the regulatory program requires review and approval of any project proposing to withdraw 100,000 gallons per day (gpd) or more, based on a 30-day average, from groundwater or surface waters, or the consumptive use of 20,000 gpd or more, also based on a 30-day average.⁶ By definition, diversions of water out of the basin are considered to be a consumptive use and are subject to a similar 20,000 gpd threshold.⁷ Diversions into the basin, regardless of quantity, are likewise subject to review and approval.⁸ As expressly provided in the Compact, no allocation made pursuant to the authority of the Commission constitutes a prior appropriation of the waters of the basin or confers any superiority of right with respect to the use of those waters.⁹

With regard to groundwater withdrawals, the Commission requires project sponsors to conduct a 72-hour, constant-rate aquifer test pursuant to a pre-approved test plan with provisions for a groundwater availability analysis to determine the availability of water during a 1-in-10 year recurrence interval.¹⁰

For withdrawals generally, the Commission may limit, condition or deny a request to avoid significant adverse impacts, including cumulative adverse impacts, to the water resources of the basin. Limitations are imposed on approved amounts (both quantity and rate) needed to meet the reasonably foreseeable needs of the project without causing such impacts.¹¹ Adverse impacts include: excessive lowering of water levels; rendering competing supplies unreliable; causing permanent loss of aquifer storage capacity; degradation of water quality that may be injurious to any existing or potential water use;

¹ Susquehanna River Basin Compact, P.L. 91-575; 84 Stat. 1509 et seq. (1970).

² Susquehanna River Basin Compact, Article 3, *Powers and Duties of the Commission*.

³ “The water resources of the basin are subject to the sovereign rights and responsibilities of the signatory parties, and it is the purpose of this compact to provide for a joint exercise of these powers of sovereignty in the common interest of the people of the region.” Susquehanna River Basin Compact, §1.3.2.

⁴ Susquehanna River Basin Compact, §1.3.5 and §3.10.

⁵ 18 CFR Parts 806-808.

⁶ 18 CFR §806.4(a)

⁷ *Id.*

⁸ *Id.*

⁹ Susquehanna River Basin Compact, §3.8.

¹⁰ 18 CFR §806.12. *See also* SRBC, *Aquifer Testing Guidance*, Policy No. 2007-01 (December 7, 2007).

¹¹ 18 CFR §806.23(b)(1).

adversely affecting fish, wildlife or other living resources or their habitat; and substantially impacting the low flow of perennial streams.¹²

In taking action on requests for withdrawals, both surface and groundwater, the Commission relies on guidelines it has developed to make determinations on appropriate passby flow and conservation release values to include as conditions to approvals.¹³ The guidelines are used to protect aquatic resources, competing users, instream flow uses downstream from the point of withdrawal, and prevent water quality degradation.¹⁴

Parenthetically, I should note that the Commission is now undertaking a re-evaluation of its existing guidelines related to flow protection following the completion of a recent basin study conducted by The Nature Conservancy that addressed how aquatic systems can be sustained by preservation of the long-term natural hydrologic variability of streams through ecosystem-based flow goals.¹⁵ We anticipate that the Commission will be releasing an updated policy within the next 3 to 6 months that reflects this new, contemporary science.

For each application seeking surface water withdrawal approval, the Commission undertakes a site-specific aquatic resource survey to establish baseline conditions and determine appropriate limitations, unless a similar study was conducted for the site within the past five years and can provide useful data. The Commission then utilizes these data to formulate conditions related to (1) limits on the quantity, timing or rate of withdrawal; (2) limitations on the level of drawdown in a stream, well, pond, lake or reservoir; and (3) streamflow protection measures.

Projects involving the consumptive use of water (i.e., where water withdrawn from the basin is used in such a manner that it is not returned to the basin undiminished in quantity) are required to mitigate the loss of water to the basin, particularly during low flow conditions¹⁶. Essentially, mitigation is required on a 1-to-1 basis by employing one of several options:

- Reducing withdrawals during prescribed low flow periods in an amount equal to the project's total consumptive use, and withdrawing from other secondary source(s) that have sufficient capacity to sustain withdrawals without impact to surface water flows for a period of at least 90 days.
- Releasing water during prescribed low flow periods from secondary source(s) for flow augmentation in an amount equal to the project's total consumptive use, provided the release can be sustained for at least 90 days without impact to surface water flows.

¹² 18 CFR §806.23(b)(2).

¹³ SRBC, *Guidelines for Using and Determining Passby Flows and Conservation Releases for Surface-Water and Ground-Water Withdrawal Approvals*, Policy No. 2003-001 (November 8, 2002).

¹⁴ *Id.*

¹⁵ Ecosystem Flow Recommendations for the Susquehanna River Basin (The Nature Conservancy, 2010),

¹⁶ 18 CFR §806.22

- Discontinuing the consumptive use during prescribed low flow periods.
- Using as the primary source for consumptive use water a storage impoundment that is subject to the maintenance of an acceptable conservation release requirement.
- Providing consumptive use mitigation fee payments to the Commission, which utilizes such funds for the acquisition and maintenance of water storage used to provide streamflow augmentation during low flow periods.¹⁷

The general regulatory framework noted above is applicable to natural gas development activity throughout the basin, except as modified by the regulatory enhancements described below.

III. Special Regulation of Marcellus Shale Development Activity

As exploratory well development of the Marcellus Shale formation got underway in the second half of 2008, the Commission experienced a dramatic increase in the number of applications seeking approval for water withdrawals and consumptive water use. It also saw the potential for this activity to create adverse, cumulative adverse or interstate effects to the water resources of the basin, regardless of whether individual projects met or fell below its regulatory thresholds.

Why the concern? Save for the bottled water industry, which tends to focus on pristine watersheds for high quality water, the vast majority of projects regulated by the Commission have historically located themselves alongside the mainstem river, or major tributaries, or at least down in the valleys along streams with appreciable flow characteristics. Furthermore, the typical project could be analyzed for impact based on withdrawals from specific locations to feed adjacent operations with attendant calculations of return flow and consumptive loss.

But the natural gas development industry is different, fundamentally different. It takes water from multiple de-centralized locations, on an inconsistent basis, and uses it at any one of dozens of ever-changing locations, based on its operational needs. Perhaps most significantly, and what sets it apart, is the fact that it engages in water-demanding activity in remote, often environmentally sensitive headwater areas.

Quantities of water that one could otherwise consider inconsequential on a major tributary can represent an important component of the flow regime in headwater areas. When you overlay the extent of headwater streams in our basin with the extent of the Marcellus shale formation, as depicted graphically in *Attachment 2*, you can see that alignment.

¹⁷ *Id.*

As a result of that alignment, coupled with the operational nature of the industry, the Commission elected to modify its regulatory approach for this industry. It took administrative and regulatory actions in 2008, 2009 and 2010, all of which were intended to implement and refine a set of management controls it felt were necessary to avoid adverse impacts to the water resources of the basin, yet allow the industry to proceed with development activity.¹⁸ Those modifications include the following:

- The regulatory threshold for initiating Commission review and approval authority commences at gallon one, rather than the traditional regulatory thresholds noted above.¹⁹
- Although the threshold changed from 100,000 gallons to gallon one for water withdrawals, the Commission did not modify any of the current standards or requirements associated with the review and approval of water withdrawals. They continue to be subject to the same standards noted above that all withdrawals across the basin are subject to, and we believe are appropriate, to protect the basin's water resources and simultaneously allow for their utilization by this new industry.²⁰
- Consumptive use approvals to go through a new administrative Approval by Rule process specifically applicable to the natural gas development industry.²¹
- ABRs are issued on a drilling pad basis, regardless of the number of wells developed on the pad, and include appropriate monitoring, reporting and mitigation requirements.²²
- In addition to water withdrawal approvals, the industry may obtain source approvals under the ABR process, including approvals to including public water supplies and wastewater sources.²³ It is the policy of the Commission to incentivize the use of lesser quality waters, including effluent discharge and acid mine drainage, for hydrofracture stimulation in lieu of fresh water

¹⁸ First, the Commission's Executive Director issued a Notice of Determination for Natural Gas Well Development Projects, August 14, 2008 (as revised October 8, 2008), pursuant to 18 CFR §806.5(a), that all natural gas well development projects in the Susquehanna River Basin targeting the Marcellus or Utica shale formations, and involving the withdrawal or consumptive use of water, are subject to review and approval regardless of whether they otherwise meet existing regulatory thresholds, effectively establishing a "gallon one" regulatory threshold. Final rulemaking changes were published at 73 FR 78618 (December 28, 2008, which became effective January 15, 2009; at 74 FR 49812 (September 29, 2009), which became effective November 1, 2009; and at 74 FR 190 (October 1, 2010), which became effective November 1, 2010.

¹⁹ 18 CFR §806.4(a)(8).

²⁰ 18 CFR §806.4(a)(2).

²¹ 18 CFR §806.22(f).

²² *Id.*

²³ 18 CFR §806.22(f)(12)(ii).

sources. This incentive also extends to the reuse or recycling of flowback and production fluids for that purpose.

- The industry is authorized to utilize any of its approved water sources at any ABR site so as to provide operational flexibility.²⁴
- The industry is incentivized to share source approvals between companies by providing for a simple registration process to facilitate that sharing and limit the number of withdrawal locations in a given watershed or area.²⁵

As a final point on the scope of its regulatory program, and beyond the water quality considerations taken into account in issuing withdrawal approvals, it should be noted that the Commission relies on its member jurisdictions to generally manage the water quality aspects of this activity. This is consistent with its Compact mandate to properly utilize the functions, powers and duties of the agencies of its signatory members.²⁶

Given that its member states all have comprehensive well permitting, construction and hydrofracture stimulation standards, erosion and sedimentation control, and disposal and treatment standards, the Commission does not regulate these aspects of natural gas well development activity. Instead, and so as to not duplicate those efforts, it requires the industry to comply with the applicable requirements of state and federal law.²⁷

IV. The Marcellus Water Use Profile

The development of the Marcellus shale in the basin unquestionably represents both a tremendous opportunity and a series of water resource-related challenges. On the economic side, there are numerous studies and projections that attempt to quantify the significant economic value of Marcellus development activity. On the water resource side, the bigger challenges focus on cumulative impact, from both a water quality and water quantity perspective.

From a management perspective, there is value in viewing these challenges in the broader context of energy water use demands and impacts basin-wide. The amount of water withdrawn and consumed by the energy sector, principally for power production, dominates all other industry sectors save for that attributable to public water supply in the basin.²⁸ Of the 563 mgd of total approved consumptive use in the basin as of 2005, 149 mgd, or 26%, was for power generation.²⁹ Deducting from that total the amount authorized as an out-of-basin diversion to the City of Baltimore, Maryland for public water supply (250 mgd), power generation jumped to 47%, or nearly half, of the total

²⁴ 18 CFR §806.22(f)(11).

²⁵ 18 CFR §806.22(f)(12)(i).

²⁶ Susquehanna River Basin Compact, §3.2.

²⁷ 18 CFR §806.22(f)(8).

²⁸ See SRBC Consumptive Use Mitigation Plan (March, 2008). Data contained in the plan are as of 2005.

²⁹ *Id.* at pg. A-6. When (unregulated) consumptive use associated with grandfathered power generation facilities are added in, the number increases from 149 mgd to 180.5 mgd.

approved consumptive use occurring in the basin as of the date of that report.³⁰ Since then, the quantity of approved consumptive use for that industry has increased from 149 mgd to 192 mgd.

With regard to the energy profile, the current basin power production capacity is 15,300 megawatts, of which 37.5% is nuclear, 31% is coal, 15.5% is natural gas, 12% is hydroelectric and the remaining 4% is other (wood, ethanol, solid waste, etc.).³¹ Combined, these projects are approved to withdraw 3.44 billion gallons per day (gpd), which does not include an additional 814 mgd that is currently grandfathered.³²

So how does Marcellus shale development activity compare in a relative sense? First, it should be noted that the full extent of potential activity has yet to be empirically documented. Estimates have varied widely, and the Commission will continue to monitor them and rely on the most contemporary estimates, particularly to enable a more objective analysis of potential cumulative impact.

Preliminarily, in 2008, it looked at the production build-out of the Barnett shale in Texas, and other shale plays across the United States such as the Haynesville and Fayetteville, in order to develop some estimation of that potential.³³ It originally estimated the consumptive use potential at full build-out level to be 28 mgd, on an annualized basis, and then revised that number to 30 mgd.

This estimate still holds based on what has transpired to date, but will no doubt be modified over time as more objective criteria become available, particularly in-basin development data over a sustained period of time.

Interestingly, and for comparative purposes, it should be noted that air quality control upgrades (scrubbers) at typical power plants in the basin each consume 4 to 5 mgd, and single plant generation upgrades can require 30 mgd or more.³⁴ Nonetheless, and even though it represents a little more than half of the amount currently used consumptively by the recreation sector (golf courses, water parks, ski resorts, etc.)³⁵ on a seasonal basis, it does represent a 19% increase in the amount attributable to the energy sector.

For planning purposes, the Commission recently undertook an analysis of energy sector trends and has estimated a potential 2025 demand of 230 mgd of increased consumptive use for power production.³⁶ This does not include the Marcellus projection noted above since it is not power production-related, but it does add to the overall energy water use demand.

³⁰ *Id.*

³¹ SRBC, *Water Resource Challenges from Energy Production*, June, 2008.

³² *Id.* Groundwater withdrawals for this industry only total 14.2 mgd, and are generally limited in uses to non-thermal related aspects.

³³ Galusky, Jr., L. Peter, Ph.D., P.E., "Fort Worth Basin/Barnett Shale Natural Gas Play: An Assessment of Present and Projected Fresh Water Use", prepared for Gas Technology Institute, April, 2007.

³⁴ SRBC, *Water Resource Challenges from Energy Production*, June, 2008.

³⁵ SRBC Consumptive Use Mitigation Plan at pg A-6.

³⁶ *Id.* at pg. A-14. (Original published amount of 134 mgd updated to 230 mgd by SRBC, 2010).

A second comparison to note is the water withdrawal demand for the Marcellus as it relates to the power production sector. Given the assumption that every gallon withdrawn by the natural gas industry is consumptively lost to the system, the estimate of 30 mgd is equally applicable to both withdrawals and consumptive use.

Completion of natural gas wells involves a one-time use of water for hydrofracture stimulation of the well (which may be repeated over the life of the well to re-stimulate production). On the other hand, power generation, especially base load operations, require water on a constant basis (generally 24/7 year round). Currently, 3.44 billion gallons per day is authorized for withdrawal from the basin for power generation.

Using the estimate of 30 mgd, Marcellus shale development activity would require slightly less than 11 billion gallons per year. Comparing that to the amounts approved for power production withdrawals, the annual volume for Marcellus development would be slightly more than what is authorized for withdrawal in a single 3-day period for power production. Accordingly, the concern with regard to water demand associated with development of the Marcellus shale is not focused on the total quantity, but more on the location and timing of withdrawals and their impact on smaller order streams.³⁷

So what does the current data reported to the Commission tell us about the nature and amount of actual water use by this industry? *Attachment 3* provides summarized information concerning withdrawals and consumptive use for the first three years of development activity in the basin. *Attachment 4* provides profile information on a per well basis for the last four reported calendar quarters. Of note are the following:

- Thus far, over the past three years, the industry has withdrawal 3.6 billion gallons of water from the basin.
- Based on average daily withdrawal rates per quarter, average daily withdrawals over the most recent four quarters equals 7.1 mgd.
- Consumptive use, including water obtained from withdrawals and all other approved sources, totals 4.5 billion gallons for the past three years.
- Based on average daily consumptive use rates per quarter, the average daily consumptive use over the past four quarters equals 8.5 mgd, with the most recent quarter representing approximately 10 mgd.
- The pattern for consumptive water use continues to trend upward, for water withdrawals it is more variable.
- Over the most recent four calendar quarters, the average total water volume for hydrofracture stimulation, per well, is 4.24 mgd.

³⁷ Power production facilities, on the other hand, are generally located along the mainstem river or major tributaries.

- During that same period, the average recovery of flowback, as a percentage of total injected water, ranges from 5% to 12%. More recently, and possibly attributed to formation characteristics in the area of the play where most activity is occurring, the reported numbers have been consistently close to 5%.
- During that same period, the average amount of flowback reused per well fracturing event is approximately .5 mgd, or 12% of the total volume.

These data are derived from quarterly monitoring reports over the past three years and the 654 event-specific post-hydrofracture reports filed over the past four quarters by the industry.

V. Water Quality Monitoring

As noted above, the Commission is relying on its member jurisdictions to provide water quality regulatory oversight of the natural gas development industry. Consistent with its history, the Commission provides water quality monitoring and assessment support to its members. As natural gas development activity unfolded across the basin, the Commission saw the need for additional monitoring in the more remote areas where this activity was occurring.

In January 2010, the Commission began deployment of a Remote Water Quality Monitoring Network (Network) designed to monitor water quality conditions to maintain and protect surface waters in selected remote portions of the Susquehanna River basin. The monitoring network uses state-of-the-art monitoring and communication technology to collect and transmit real time water quality data, including the following parameters: temperature, pH, conductance, dissolved oxygen, turbidity, and relative water depth. The data is made available continuously on the Commission's website, www.srbc.net, and is accessible to resource agencies and the general public. Additional details concerning the network are provided in *Attachment 5*.

At present, the network consists of fifty (50) monitoring stations in the Pennsylvania and New York portions of the Susquehanna basin. These stations were installed over a period of a year and a half, with the last station installed in August 2011.

While we have been monitoring the data being reported by the Network on an ongoing basis, the Commission has just now started to analyze the data in earnest, especially given the need to acquire an adequate amount of data to work towards establishing baseline conditions. Thirty-seven (37) stations had sufficient data records to begin more rigorous analyses. Upon completion of the very initial stage of the analyses, the dataset is proving to be very complex given the range of possible influences within each of the monitored watersheds and the lack of historical data.

In addition, the range of hydrologic conditions experienced in the Susquehanna River basin over the last year and a half, during the period of record for the first set of stations,

shows the importance of characterizing water quality conditions over the longer term prior to making any cause/effect determinations. Although generalized summary statistics for the entire Network's dataset could be considered within normal ranges, a select subset of stations have not exhibited what might be considered predictable water quality conditions based on their physical setting (geology, land use, topography, soils, etc.). Also, a subset of stations experience occasional "spikes" in certain parameters not readily explained by typical natural conditions. At present, seven (7) stations fall into this category and will require more extensive data collection and analyses. However, in all cases, it is important to note that natural gas development is not the exclusive activity within the monitored watersheds, and that irregular water quality conditions do not necessarily equate to impacts from human activities.

Beyond the continuous water quality data, we have also been monitoring for a more extensive suite of parameters more indicative of natural gas activity (i.e., chloride, barium, bromide, radionuclides) through the collection of "grab" samples throughout the year. Staff also just completed the first round of biological and habitat data collection at each of the stations, and will be including those data in future analyses as well. Upon completion of these comprehensive analyses, we will be in a better position to characterize conditions in each of the monitored watersheds. We anticipate publication of our first analytical report in January, 2012, and we would be happy to provide it to the Subcommittee.

V. Conclusion

As noted above, development of the Marcellus shale formation represents both an opportunity and challenge for the Susquehanna River Basin. The Commission's water withdrawal regulations are designed to allow proper development, utilization and protection of the basin's water resources. Instream uses, competing uses, localized cumulative impact analyses and water quality considerations are comprehensively addressed.

The Commission believes the regulatory adjustments it has made in response to the industry have been appropriate and it continues to refine its management controls as it gains more experience. Additionally, its ongoing work in the area of ecological flows will also help to assure that we are applying the best science in making management decisions, whether for this industry or any other.

With regard to water quality issues, the Commission will continue to look to its member jurisdictions to take the primary regulatory role, we will continue to provide monitoring support, and we will continue to participate in the necessary planning and assessment initiatives attendant with this activity.

The cumulative impact of consumptive use by this new activity, while significant, appears to be manageable with the mitigation standards currently in place. This demand, coupled with that anticipated for public water supply and other industry sectors, represents a challenge for the Commission, the water users who have an obligation to

mitigate, and for the basin generally. As part of its consumptive use strategy for the basin generally, the Commission will continue to evaluate and refine its mitigation standard and pursue additional opportunities for low-flow augmentation.³⁸

Combined, these efforts will help to insure the proper and sustainable utilization of the water resources of the basin for this new energy resource development opportunity.

On behalf of the Commission, I will be happy to respond to any questions, comments or informational requests of the Subcommittee. Thank you for this opportunity to testify.

Attachments 1-5

³⁸ SRBC Consumptive Use Mitigation Plan, at pg. 23.