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Coal Mine Drainage for Marcellus Shale Natural Gas Extraction

Proceedings and Recommendations from a Roundtable on Feasibility and Challenges

Aimee E. Curtright • Kate Giglio

Sponsored by the Marcellus Shale Coalition
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Summary

In recent years, natural gas production in the United States has increased as a result of extraction from shale gas formations, such as the Marcellus Shale. The process of hydraulic fracturing used to tap this resource requires the injection of substantial amounts of water, on the order of 3–5 million gallons, along with chemicals and sand, into a typical horizontal well.1

Pennsylvania and the surrounding region have substantial amounts of coal mine water (CMW) in abandoned, closed but actively managed, and active coal mines. Some mines release this polluted, often acidic water into nearby rivers and streams, resulting in coal mine drainage (CMD).2 In light of the ongoing environmental problems posed by CMD, some have suggested that it could be used as a water source for hydraulic fracturing operations.

These proceedings provide an overview of the topics and discussions at a roundtable conference exploring the use of CMD for hydraulic fracturing in the Marcellus Shale formation. The objective of the roundtable was to assess the technical, economic, legal, and regulatory feasibility of using CMD, and CMW more broadly, in hydraulic fracturing operations. An additional objective was to identify research priorities and to facilitate efforts to address remaining implementation issues.

The event, “Feasibility and Challenges of Using Acid Mine Drainage for Marcellus Shale Natural Gas Extraction,” was held in RAND’s Pittsburgh office on December 14, 2011. With funding from the Marcellus Shale Coalition (MSC), RAND hosted and moderated the roundtable and retained full editorial control of the writing and production of these proceedings. The roundtable brought together leading researchers, hydraulic fracturing operators, legal experts, representatives from the Pennsylvania Department of Environmental Protection and corresponding agencies in neighboring states (Maryland, Ohio, and West Virginia), and other stakeholders. This document summarizes the presentations of the panelists and the audience’s responses and highlights the primary takeaway messages from the day, including a number of research gaps. Resolving these gaps may help policymakers and other stakeholders make better-informed decisions regarding the opportunities and challenges of using CMD for hydraulic fracturing.

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1 Estimates start at 2–3 million gallons of water per horizontal well and go as high as 10 million gallons, i.e., between 7.6 million and 38 million liters per well (Kargbo, Wilhelm, and Campbell, 2010; Mooney, 2011; MSC, undated).

2 Also known as coal mine discharge.
Overview of the Roundtable

The roundtable conference opened with introductory remarks by RAND’s Pittsburgh office director Susan Everingham and MSC president Kathryn Klaber. The event included four sessions that were moderated by RAND staff.

The first session featured an overview of the availability of CMW in Pennsylvania’s Marcellus Shale gas region. Professor Anthony Iannacchione of the University of Pittsburgh shared estimates of the quantity of CMW available for use by operators. He also described the large variation in the chemical composition of CMW, which may affect its suitability for hydraulic fracturing. The remainder of the session focused primarily on the use of CMD, the CMW that is actively draining from mine pools. Charles Cravotta of the U.S. Geological Survey underscored the importance of assessing the suitability of CMD for fracturing operations on a case-by-case basis, referencing his work characterizing CMD in the region.

The second session delved deeper into the technical challenges and uncertainties of using CMD. Professor Radisav Vidic of the University of Pittsburgh discussed the ranges of chemical composition, such as acidity and solute concentrations, that might be acceptable for hydraulic fracturing, stressing that current guidelines are not based on rigorous research. He suggested that a wide range of concentrations of many chemicals may be acceptable for use in hydraulic fracturing operations. This is because chemical treatments and a combination of CMD and fresh or flowback water can be used to adjust the chemical properties of the water used for hydraulic fracturing. Doug Kepler of Seneca Resources Corporation gave an overview of technical challenges from the perspective of industry.

The third session addressed the potential costs of using CMD. David Yoxtheimer of Penn State University discussed his cost estimate for CMD acquisition, transport, treatment, and storage. He and his Penn State colleagues found that transporting water to a well site can account for a significant fraction of the total expense of obtaining water, especially if trucks must travel long distances because of a lack of appropriate local CMD. Furthermore, the approach to treatment will be driven by both the chemistry of a specific CMD source and final operator specifications, with a potential significant impact on cost. Eric Cavazza of the Pennsylvania Department of Environmental Protection presented estimates of the cost of using CMD based on the operating and maintenance costs of existing CMD treatment facilities, which were significantly lower than the cost of building and operating new treatment facilities.

The final roundtable session examined the impact of existing legislation on the use of CMD in hydraulic fracturing operations, especially in the case of abandoned mine drainage (i.e., CMD from mines that are no longer owned by private entities). Pam Milavec of the Pennsylvania Department of Environmental Protection opened the session by introducing a draft white paper that is intended to simplify the process of reviewing and approving proposals to use CMD (see Pennsylvania Department of Environmental Protection, 2011b). She explained that the Commonwealth of Pennsylvania intends to establish a multi-program workgroup that will evaluate and make recommendations concerning proposals for the use of CMD. Joseph K. Reinhart and Kevin J. Garber of the law firm Babst Calland lauded the department’s recognition of the regulatory and legal barriers facing operators that want to use CMD. They discussed how Pennsylvania’s Clean Streams Law often serves to discourage the use of abandoned mine drainage by placing open-ended liability on the user of CMD water. Peter J. Fontaine of the law firm Cozen O’Connor recommended a number of changes in the liability rules, including amending the 1995 Environmental Remediation Standards Act to include covenants...
not to sue for natural gas operators and others that implement approved, comprehensive, long-term CMD abatement projects in conjunction with natural gas extraction.

Opportunities, Challenges, Potential Research, and Policy Questions

The presentations and discussions covered a range of opportunities and challenges associated with using CMD to support hydraulic fracturing operations throughout the Marcellus Shale region. Several presentations highlighted current research needs and noted some policy questions that decisionmakers will need to address. Chapter Six includes a more in-depth discussion of the following key points.

The use of CMD for hydraulic fracturing activities is technically viable. The panelists and participants were in agreement that the Commonwealth of Pennsylvania has very large amounts of CMW—much more than could be used in the coming decade for hydraulic fracturing. Even considering only CMD, there is a large quantity of water in the region. Operators would most likely not encounter economically significant problems in hydraulic fracturing with much of the CMD available: Many sources would require modest or, in some cases, no pretreatment. Attendees did stress that chemical properties may vary greatly between sites and even sometimes at the same site over time. CMD water from some mines is acidic; from others, it is alkaline. These differences may affect the suitability of the CMD for hydraulic fracturing. However, many CMD sites are close to drilling areas, and piping CMD to fracturing operations is a technically viable option.

Further research could clarify the viability of using CMD for hydraulic fracturing operations at specific sites. The technical and economic viability of hydraulic fracturing with CMD will depend on site-specific characteristics, such as the properties of the particular mine water and CMD-source proximity to natural gas extraction sites. Along these lines, several data and information gaps were identified in the first two sessions of the roundtable and are summarized in Table S.1. There is an additional need to identify the benefits and costs of the near- and midterm use of CMD for hydraulic fracturing relative to long-term CMD remediation and, if appropriate, to craft appropriate mechanisms to obtain a more permanent remediation benefit.

The economics of using CMD could be attractive in some instances but will be highly dependent on site-specific conditions. Estimates of the economic viability of using CMD vary depending on (1) assumptions regarding transport distance and method, (2) the extent of pretreatment required, (3) the cost of the treatment required, and (4) storage requirements, both in terms of total volumes and regulatory containment specifications. None of the analyses presented during the roundtable were completely comprehensive in terms of costs; for example, many parameters were estimated with limited data and assumptions that could not be made a priori. It is clear, however, that the costs of using CMD will be very site-specific. In some cases, using CMD may be less expensive than using fresh water; in other cases, it will be more costly. This is due to transport and storage costs and (often more importantly) to the fact that the extent of treatment required will depend both on the starting quality of the CMD source and the specifications of the final type of water desired by the operator at the extraction site.

The current legal and regulatory framework may discourage the use of CMD for hydraulic fracturing but could be reinterpreted or modified. The Pennsylvania Department of Environmental Protection hopes to clarify and streamline the process of applying to use CMD in
hydraulic fracturing. However, current laws and regulations appear to make operators that make use of CMD liable for environmental damage caused by legacy mine drainage. Both the Environmental Good Samaritan Act and the Environmental Remediation Standards Act (also known as Act 2) set precedents for the possible reinterpretation of the law and can be further explored as CMD use is considered as a part of legacy mine cleanup initiatives. However, legal and regulatory changes must be approached carefully to maximize the specific long-term environmental benefits of using CMD and to simultaneously avoid modifying existing regulations in a manner that is not broadly beneficial or that is even harmful to the environment in some other way.

Table S.1
Potential Research Areas Identified During the Roundtable

<table>
<thead>
<tr>
<th>Research Need</th>
<th>Research Priorities</th>
<th>Responsible Stakeholders</th>
</tr>
</thead>
<tbody>
<tr>
<td>Synthesis, organization, and compilation of existing data on sources of CMW</td>
<td>Distinctions between CMW pools should be clearly made in terms of quantities, quality,</td>
<td>Pennsylvania Department of Environmental Protection</td>
</tr>
<tr>
<td>in a publicly available database</td>
<td>and location, including</td>
<td>U.S. Department of the Interior/U.S. Geological Survey</td>
</tr>
<tr>
<td></td>
<td>Chemical composition, pH, and variability</td>
<td>Regional research universities</td>
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<td></td>
<td>Coal mine water (CMW) generally or coal mine discharge (CMD) specifically</td>
<td>Watershed authorities</td>
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<tr>
<td></td>
<td>Among sources of CMD—abandoned or actively managed</td>
<td>Nongovernmental organizations</td>
</tr>
<tr>
<td></td>
<td>Among abandoned mines—treated or untreated</td>
<td>Industry</td>
</tr>
<tr>
<td>More complete, updated characterization of CMD sources to augment existing</td>
<td>Three specific data needs:</td>
<td>Pennsylvania Department of Environmental Protection</td>
</tr>
<tr>
<td>data in database</td>
<td>Quantity (volumes or flow rate)</td>
<td>U.S. Department of the Interior/U.S. Geological Survey</td>
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<tr>
<td></td>
<td>Quality (chemical composition and variability)</td>
<td>Regional research universities</td>
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<td></td>
<td>Location of CMD sites, including relative to natural gas extraction activities</td>
<td>Industry</td>
</tr>
<tr>
<td>Development of experience-based guidelines for CMD quantity and quality needs</td>
<td>The guidelines should address the following questions:</td>
<td>Marcellus Shale Coalition</td>
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<tr>
<td></td>
<td>Which dissolved constituents are truly of concern, and what (ranges of) levels are</td>
<td>Individual operator companies</td>
</tr>
<tr>
<td></td>
<td>acceptable?</td>
<td>Research universities</td>
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<td></td>
<td>How much variability is tolerable within and between natural gas extraction sites?</td>
<td></td>
</tr>
<tr>
<td>Development and analysis of appropriate technical concepts and</td>
<td>The policy research might include</td>
<td>Pennsylvania Department of Environmental Protection</td>
</tr>
<tr>
<td>implementation mechanisms to encourage the long-term remediation of CMD</td>
<td>Cost-benefit analysis of the different technical concepts for long-term CMD</td>
<td>Watershed authorities</td>
</tr>
<tr>
<td>in conjunction with its near- and midterm use for hydraulic fracturing</td>
<td>remediation</td>
<td>and nongovernmental organizations</td>
</tr>
<tr>
<td></td>
<td>Identification of appropriate funding sources and financial incentives for both</td>
<td>Industry and Marcellus Shale Coalition</td>
</tr>
<tr>
<td></td>
<td>near- and midterm goals</td>
<td></td>
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<td></td>
<td>Development of policy mechanisms and identification of appropriate entities for</td>
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<td>coordinating stakeholders, developing infrastructure, and operating permanent</td>
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<td></td>
<td>facilities for CMD water remediation</td>
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</tbody>
</table>

3 The Pennsylvania Department of Environmental Protection released a draft white paper on this topic in November 2011. As of late March 2012, the department was in the process of reviewing the feedback provided during the open comment period.
The broader context of watershed quality and sustainability in the region needs to be addressed. Several participants noted that the use of CMD for hydraulic fracturing will not be a panacea for the abandoned mine drainage problem. Regulations allowing operators to use CMD without assuming past liability will not necessarily provide incentives for its use, and long-term remediation requires not a temporary diversion of the CMD water but the establishment of a permanent water remediation infrastructure. These realities should inform realistic goals for the use of CMD for hydraulic fracturing. The policy goals should, in turn, drive the regulatory framework. Nevertheless, a concept that reduces freshwater use in hydraulic fracturing and simultaneously removes contaminated CMD from the watershed represents a potential area of common ground for a diverse group of stakeholders.