

# ENVIRONMENTAL REGULATORY DRIVERS FOR COAL BED METHANE RESEARCH AND DEVELOPMENT

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## ABSTRACT

In 1999, the National Petroleum Council (NPC)\* stated that the resource base for meeting growing natural gas demands in the United States is adequate. A significant and increasing portion of natural gas production (8% by 2015) is expected to come from coal bed methane (CBM). The NPC cautions that for this to occur, certain factors, including compliance with environmental requirements, must be addressed. Numerous federal, state, and local programs address a variety of environmental issues, including water quality and quantity, air quality, wildlife, noise, and visibility. This paper examines existing and potential environmental regulatory requirements that could affect the timely development and production of CBM resources in the United States. Such an examination can help technology developers and policy makers target areas for research and development (R&D), demonstration, and implementation to help facilitate cost-effective CBM development and production to meet the nation's natural gas demands. It can also help identify R&D areas that will give rule-making bodies the information they need to incorporate more science into the regulatory development process.

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\* National Petroleum Council, *Meeting the Challenges of the Nation's Growing Natural Gas Demand, Volume I*, December 1999.

# INTRODUCTION

The U.S. Department of Energy (DOE) projects that domestic energy consumption will increase at an average annual rate of 1.4% per year between 2000 and 2020, or from roughly 99 quadrillion British thermal units (quads) to 131 quads (1). Environmental issues associated with coal mining and burning, uncertainties about the supply of oil imports, and lack of public confidence in nuclear power all point to an enhanced role for natural gas in meeting this demand. DOE projects that U.S. natural gas consumption will increase at an average annual rate of 2% between 2000 and 2020, or from 22.8 trillion cubic feet (TCF) in 2000 to 33.8 TCF in 2020. The National Petroleum Council (NPC) has stated that the resource base for meeting growing natural gas demand in the United States is adequate, but that certain factors, including compliance with environmental requirements, must be addressed for these resources to be realized. The U.S. Department of the Interior (DOI) reports that coal bed methane (CBM) accounts for about 9% of the total natural gas reserves in the United States and that the Rocky Mountain States contain an estimated 30 to 48 TCF of undiscovered CBM (2). The DOI also reports that CBM can be developed more quickly and economically than other deep reservoir onshore gas or deepwater offshore gas. However, as with natural gas in general, environmental requirements must be reviewed for CBM to meet its projected demand share. These requirements, and the underlying environmental issues they are designed to mitigate, can help guide research and development (R&D) into areas that will help ensure that natural gas — and CBM in particular — can be developed in a cost-effective, efficient, timely, and environmentally protective manner.

CBM development poses several environmental concerns. Although the mechanics and ultimate significance of these concerns are not fully understood, regulators are starting to develop standards and rules to address them. Some of these requirements may be costly to implement, may slow the resource development process, or may not produce the intended results. R&D targeted toward mitigating environmental concerns and any negative regulatory impacts can help limit costs, delays, and unintended negative consequences.

This paper reviews environmental concerns associated with CBM development, notes uncertainties associated with these concerns, and describes regulatory requirements designed to mitigate these concerns. It identifies R&D study areas in which findings could help mitigate negative cost, schedule, and other compliance impacts. Research organizations and decision makers can use this information to target R&D efforts and budgets. Results of this R&D can also assist regulators in developing rules on the basis of sound science. Thus, the regulatory process can help guide R&D, and R&D can help improve the regulatory process, so that over time, these R&D-regulatory interactions will continuously increase the likelihood that CBM can meet energy demand targets in an environmentally protective and cost-effective way.

# ENVIRONMENTAL CONCERNS WITH CBM DEVELOPMENT

Environmental concerns associated with CBM development include water quality and quantity, air quality, and noise.<sup>2</sup> These and other potential environmental impacts associated with CBM development are discussed below.

## Water Quality and Quantity

CBM-produced water is pumped in large volumes from the coal seams to the surface to release the gas trapped in the coal seams. It is discharged to the land surface, to surface water, stored in evaporation ponds, used for stock or wildlife watering, reinfiltreated, injected back into the aquifer, or treated for various uses, and can have significant impacts on water quality and quantity. CBM-produced water can contain concentrations of sodium, total dissolved solids (TDS), total suspended solids (TSS), fluoride, chloride, ammonia, and metals higher than those of the receiving waters. The sodium adsorption ratio (SAR) is the ratio of the sodium ion concentration to the combined concentrations of calcium and magnesium ions in water. Water with high SARs can cause soils to become dispersed, less permeable (resulting in reduced plant growth), and more prone to erosion; such waters may not be appropriate for irrigation. High levels of soil salinity, resulting from irrigation with some CBM-produced water can reduce crop yields. The cumulative effects of CBM-produced water on crop soils and yield and the factors that influence those effects are not completely understood. Hydrologic changes resulting from CBM operations may adversely affect fisheries; the nature and extent of those effects, however, are largely unknown. The environmental impact statement (EIS) for CBM development in the Powder River Basin states that water levels in wells completed in developed coals within 10 miles of CBM development are likely to drop and that flow rates in artesian wells and springs sourced within the area are likely to decrease (3). Until uncertainties regarding the causes, effects, and influencing factors are resolved, regulatory decisions can be driven by political arguments between those who say that care must be taken where there is a potential for degradation and those who stress the importance of resource development.

## Air Quality

Air quality impacts result from the operation of pumps and compressors and wellhead generators and diesel engines used to generate electricity. Emissions from these sources include carbon monoxide (CO), nitrogen oxides (NO<sub>x</sub>), volatile organic compounds (VOCs), sulfur dioxide (SO<sub>2</sub>), particulate matter, and toxic air pollutants. SO<sub>2</sub> and NO<sub>x</sub> contribute to the production of haze, which impairs visibility and can affect human health. Air quality and visibility can also be affected by increased wind erosion associated with the removal of vegetation, excavation, and stockpiling of soil. Toxic air pollutants can lead to health effects. The relationship between air emissions and impacts is not fully understood.

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<sup>2</sup> Other issues associated with CBM development include social, economic, cultural, recreational, and worker health; this paper, however, focuses only on environmental concerns.

## **Livestock and Wildlife**

Surface disturbances due to road construction, compressor stations, holding ponds, and pipelines can cause erosion and promote noxious weed growth, which can reduce the forage base and remove acreage from livestock and wildlife use. Storm water runoff from hard surfaces can increase sediment loads and diminish aquatic habitat. Human activities can also affect feeding, nesting, and breeding of certain species. Roads and equipment may fragment habitat and affect big game use. Human activities may also move wildlife from otherwise suitable habitats to potentially lower-quality habitats and may disturb ground nesting and prey habitats of raptors. For waterfowl, CBM development may, depending on local conditions, create new or improve existing habitats, or it can eliminate or degrade existing habitats. Elevated levels of salts and metals in produced waters may also affect wildlife and waterfowl (4).

## **Noise and Visual Impacts**

Vehicles operating on area roads, compressors, drilling, and water-pumping equipment generate noise that can be constant and at decibel levels higher than normal. The most significant sources are large compressor sites containing two or more compressors fueled by large natural gas engines. Noise can negatively affect wildlife and impair quality of life for humans. Negative visual impacts can result from areas cleared for development or eroded by CBM-produced water discharges and by CBM equipment, buildings, roads, and power lines.

# **ENVIRONMENTAL REGULATORY REQUIREMENTS**

Relatively few CBM-specific environmental regulations have been written. Typically, CBM operators must comply with regulations applicable to other oil and gas drilling and production operations. However, some states, such as Montana, where significant CBM activity is projected, have developed or are developing regulations aimed specifically at CBM. At the federal level, the U.S. Environmental Protection Agency (EPA) is developing air emission regulations that may apply to equipment used in CBM development and operations. The following paragraphs describe some of these requirements.

## **State Requirements**

Examples of state-level regulations, orders, and other environmental requirements that pertain to CBM development are summarized below.

**Powder River Basin Controlled Groundwater Area.** The Montana Department of Natural Resources and Conservation (DNRC) has determined that coal beds are important regional aquifers in southeastern Montana, where they often provide the only practical source of freshwater for local domestic, stock, and agricultural uses.

The DNRC acknowledges that “the complexities of geology and hydrogeology and the uncertainty about the extent and precise location of future coal bed methane development do not allow an accurate assessment of conflicts with existing and future beneficial water use”(5). However, citing data showing significant effects on water levels in coal aquifers from extensive and continuous pumping of water from coal mines along the banks of the Tongue River in southern Montana, the DNRC has written an order designating the Powder River Basin Controlled Groundwater Area. This area includes all known strippable sub-bituminous coal deposits greater than 30 inches thick in southeastern Montana (6). The order applies to CBM wells only and requires that operators follow standards for drilling, completing, testing, and production of CBM wells adopted by the Board of Oil and Gas Conservation (BOGC). The BOGC considers applications for CBM production fields and, in approving specific field rules, it may add requirements and restrictions beyond those in the general operating standards. The order also requires that CBM well operators offer water mitigation agreements to owners of water wells or natural springs within one-half mile of a proposed CBM field or within one mile of the area that the operator reasonably believes may be impacted by a CBM production operation, whichever is greater. These agreements must provide for prompt replacement of water from any natural spring or water well adversely affected by the CBM project. The extent of additional restrictions and any consequent limitations in production are unknown at this time.

**Wyoming Water Discharge Permits.** Wyoming does not have numeric standards for CBM pollutants discharged to surface water. When issuing discharge permits, it sets targets for SAR levels on the basis of the Wyoming Department of Agriculture Handbook. The permits allow direct discharge if the discharge is within the range of SAR levels and no measurable changes are predicted. Such predictions may be subjective. However, to address concerns of nearby states whose waters may be affected by CBM-produced water discharges from Wyoming CBM operations, the Wyoming Department of Environmental Quality has begun discussing the development of numeric standards (7).

**Numeric Standards for CBM-Produced Water Constituent Discharges in Montana.** The State of Montana has narrative standards for SAR and electrical conductivity (EC), which is used to indicate salinity, and the Montana Department of Environmental Quality (MDEQ) is working to translate these narrative standards into numeric, site-specific standards (8). For SAR, the MDEQ is considering a formula-based approach that uses reach-specific (i.e., a portion of a stream) salinity values to determine allowable SARs and “river-reach specific” standards for salinity in which graduated levels of salinity would be allowed from the Wyoming border northward. The MDEQ says that such an approach allows for the natural, gradual increase in salinity that occurs as water flows downstream, protects beneficial uses, and equitably allocates available assimilative capacity. It notes that these components provide technical credibility and give applicants up-front knowledge regarding targets so that they can plan accordingly. Developing such regulations requires a sound understanding of the mechanisms of salinity interactions that may not be available to state regulators and thus is an important area for R&D. Numerous regulatory agencies could use the results of such R&D as they strive to develop science-based, cost-effective CBM regulations.

**Montana General Discharge Permit for CBM-Produced Water.** The MDEQ has prepared a General Discharge Permit for CBM-Produced Water, the purpose of which is to authorize discharges of CBM-produced water to specially constructed impoundments (holding ponds) for the specific beneficial use of livestock or wildlife watering. Because of the high concentrations of TDS and sodium in CBM-produced waters, irrigation of agricultural fields or rangeland with CBM-produced water is not considered a beneficial use. The permit does not authorize discharges to state surface waters (except in the event of a 25-year, 24-hour rainfall). General permit applicants must document that the adjacent landowner will use the discharged water for livestock or wildlife watering purposes and must submit a chemical analysis of more than 20 constituents in the proposed discharge. The MDEQ may deny the application if any of the constituents exceed the maximum recommended levels. The toxicity and harm of many of these constituents may depend on the site-specific conditions of the discharge area, fate and transport mechanisms, and interactions among the various constituents. The permit also requires CBM operators to monitor the produced water for TDS, oil, and grease; maximum allowable annual average concentrations are 5,000 mg/L for TDS and 10 mg/L for oil and grease. If soil salinity in the impoundment sediments, as measured by EC in a paste extract, exceeds 20 millimhos/cm, a reclamation plan must be submitted to the MDEQ and landowner to ensure that the land is returned to its previous utility and stability. Operators must also monitor the impoundment water for TDS, sodium, calcium, magnesium, SAR, EC, oil and greases, iron, barium, chloride, and sulfate and report the results to the MDEQ. If impoundment waters exceed upper bound criteria, the permittee must cease discharging and submit a plan to dispose of the water. Setting the concentration limits and monitoring frequencies may need to be refined depending on specific site conditions.

## **EPA Requirements**

The EPA is developing requirements that are likely to apply to CBM development and operations. Some of these are described below.

**Air Quality Regulations.** EPA headquarters is developing air regulations under the Clean Air Act, which, while not targeted specifically toward CBM operations, are likely to affect them. For example, the EPA recently announced that it was going to begin developing limitations for NO<sub>x</sub>, SO<sub>2</sub>, particulate matter, and hazardous air pollutant emissions for nonroad diesel engines. It is also developing Maximum Achievable Control Technology (MACT) regulations to limit hazardous air pollutant emissions from combustion turbines, process heaters, and reciprocating internal combustion engines (among other sources), all of which may be used during CBM operations. While the EPA rules pertain to major sources and most of the equipment used in CBM operations is not considered a major source, western states are considering developing hazardous air pollution regulations to cover the minor sources as well. The EPA is also developing guidance for states to use in regulating haze-forming emissions (particularly SO<sub>2</sub> and NO<sub>x</sub>) from industrial source categories.

**National Pollutant Discharge Elimination System (NPDES) Effluent Limits.** Although the EPA has not promulgated national-level effluent limit guidelines under the Clean Water Act specifically for CBM operations, EPA Region 8 has started to develop

effluent limitations that represent Best Available Technology Economically Achievable (BAT) for CBM-produced waters. This information will help the EPA to establish NPDES permit requirements in Indian Country and could help states set or modify their own limits as appropriate.<sup>3</sup> The first step in this process is an economic analysis of disposal options. The analysis will use available information to assess the technical and economic feasibility of management and control measures available for produced water discharges; study parameters will include costs, limitations, and pollutant removal efficiencies. The EPA does not plan to conduct original research, but rather R&D to identify new, more cost-effective and efficient methods and approaches that could strengthen the EPA's evaluation.

## **Action-Specific Requirements**

In addition to state and EPA CBM regulations, individual permits and decision documents contain environmental requirements intended to mitigate potential impacts. These requirements do not apply to all CBM developments in a given state, but they indicate the types of requirements that can be expected to be developed. They may also establish precedents for future projects. Examples of such site-specific regulations are described below.

### **Decision Record for the Wyodak Drainage CBM Environmental Assessment.**

This assessment was conducted as part of the decision to allow federal leaseholders to drill up to 2,500 CBM wells in the Wyodak drainage area in Wyoming. The decision record specifies conditions of approval and required environmental mitigation measures (9). These measures, many of which could slow development or reduce the amount of production, include the following:

- Treatment or storage of CBM-produced water to ensure that pollutant constituents in the Powder and Little Powder Rivers will not be elevated beyond current baseline levels at the state line. Site-specific measures that could be required include:
  - Dispersal of CBM-produced water in the upper reaches of drainages via the installation of stock tanks.
  - Transport of CBM-produced water to distant discharge points to avoid sensitive soils, agricultural areas, or areas of potential accelerated erosion. Pipelines of “considerable length” could be required to do this.
  - Treatment of CBM-produced water going to irrigated lands if such water has SAR values not in compliance with state irrigation suitability criteria.

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<sup>3</sup> The Rocky Mountain States, where the bulk of the near-term CBM drilling activity is projected to occur, have been delegated the authority to write their own NPDES permits under the Clean Water Act.

- Siting of compressors and compressor stations to avoid sensitive surface resources.
- Consideration of electrification of compressors.
- Soil fertility testing and soil amendments to stabilize disturbed lands.
- Effective noxious weed management.
- Timely and well-planned reclamation.
- Development of mitigation plans to address impacted wetlands;
- No water discharge within delineated or recognized wetlands or near existing wetlands, if increased discharge volumes or subsequent recharge of shallow aquifers would inundate or kill woody species.
- No construction of compressor stations or processing plants within one-half mile of known nesting areas.
- Location of compressors no less than 600 feet from sensitive receptors (residences, recreation facilities).

**Environmental Assessment for the Hanna Draw CBM Exploration Project.** In January 2002, the Bureau of Land Management published its decision record for the Hanna CBM exploration project in Wyoming (10). The record includes requirements to mitigate the potential for environmental damage that include the following:

- Denial of activities in areas with high erosion potential and or rugged topography to reduce the amount of sediment entering surface waters; and
- Limiting noise levels to a maximum of 10 dBA above background at sage grouse leks and other sensitive resource areas. The federal standard for noise at residences is 55 dBA. Limiting noise levels to 10 dBA may require the enclosure of compressor engines in buildings located at least 600 feet from sensitive receptors or sensitive resource areas.

**Montana and Wyoming Powder River Interim Water Quality Criteria Memorandum of Cooperation (MOC).** The states of Wyoming and Montana have signed a MOC aimed at helping facilitate two potentially competing goals: (1) protecting the quality of water in the Powder River Basin and (2) facilitating the development of CBM resources in both states. The MOC acknowledges that additional stream flow and water quality data need to be collected and analyzed to determine the assimilative capacities of waters in the Powder River drainage. In the interim, however, the states have agreed to work together to protect and maintain water quality conditions within Montana during the period while new CBM discharges in Wyoming are “cautiously

allowed.” During the fall of 2002, the parties expect to negotiate a final MOC. The interim agreement sets temporary threshold criteria for EC and provides that if EC exceeds these thresholds at specified monitoring stations, Wyoming will take “appropriate steps through its regulatory mechanisms to return salinity levels to conformity with this MOC (11).”

## **SUGGESTED R&D TARGET AREAS**

The environmental concerns associated with CBM development and the regulations being developed to address those concerns point to two types of R&D, the results of which can facilitate both compliance and cost-effective rule making. The first type of R&D can help CBM developers comply with existing and near-term expected requirements in a cost-effective manner, thereby minimizing impacts on CBM production. The second will provide rule-making bodies with information that will allow them to write regulations that will balance the need to protect the environment with the need to develop resources on the basis of sound science.

### **R&D to Facilitate Cost-Effective Compliance with Existing and Proposed Requirements**

R&D into the characteristics, impacts, and control technologies associated with CBM-produced water will help developers meet environmental protection goals in a cost-effective and efficient manner. R&D in the following areas can facilitate cost-effective compliance with existing regulations:

- Additions to soil or treatment of produced water or soil manipulations to reduce SAR, thereby allowing the use of produced water for irrigation;
- Techniques to increase evaporation, thereby reducing the amount of water entering ephemeral and intermittent streams that can lead to erosion;
- Injection techniques to improve aquifer recharge;
- Wetland protection techniques to mitigate effects of water discharge on or near existing wetlands;
- Man-made wetlands as a method of replacing impacted wetlands;
- Cost-effective and efficient impoundment liners/barriers to reduce the potential for infiltration of pollutants;
- Compressor design improvements to minimize air emissions, footprints, and sound and visibility impacts, including the evaluation of alternative fuels to power the compressors;

- Alternative road surfacing techniques to minimize dust generation and wildlife impacts;
- Soil amendments to stabilize disturbed lands;
- Construction equipment controls to minimize air emissions, noise, and visibility impacts;
- Soil and water treatments to minimize noxious weed growth and maximize native vegetative growth;
- Cost-effective reclamation techniques that restore land to predevelopment conditions quickly and permanently;
- Feasibility of converting gas wells to reinjection wells for produced water;
- Horizontal drilling techniques to reduce the number of wells; and
- Techniques to more precisely identify locations and quantities of CBM to reduce the number of wells drilled.

### **R&D Areas That Can Help with Science-Based Regulatory Development**

The following R&D areas are suggested to address uncertainties in CBM-related environmental issues and to increase the scientific input to the regulatory process:

- Fate and transport of produced water constituents in impoundments, surface waters, and groundwater;
- Effects of CBM development on groundwater systems, including target aquifers (aquifer properties, interaquifer communication, drawdown, leakage, recharge), and adjacent zones;
- Cumulative effects of CBM-produced water on crop soils and yield;
- Interaction among soil types, SAR values, salinity values, and crop species on suitability of water for irrigation;
- Effects of noise on wildlife, considering species, location, and season; and
- Air pollutant interactions and transport mechanisms.

# CONCLUSIONS

To meet the projected demand for CBM, thousands of new wells will need to be drilled in the Rocky Mountain States over the next few years. This rapid development has the potential to create significant environmental impacts. Regulatory bodies are faced with the challenge of balancing the need to meet projected energy demand with their duties to protect the environment. As they begin writing CBM regulations, it is clear that more information is needed to ensure that these rules are based on sound science and that time and money are allocated efficiently such that the environment is neither under- nor over-protected. Compliance with existing regulatory requirements can be facilitated through cost-effective mitigation approaches developed using the results of targeted R&D. At the same time, R&D aimed at resolving uncertainties can help regulators develop future requirements on the basis of sound science.

## REFERENCES CITED

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1. Energy Information Administration (EIA), *Annual Energy Outlook for 2002 with Projections to 2020*, DOE/EIA-0383(2002), Dec. 2001, available at <http://www.eia.doe.gov/oiaf/aeo/>
  2. Watson, Rebecca, Assistant Secretary, Land and Mineral Management, U.S. Department of the Interior, statement before the House Resources Subcommittee on Energy and Mineral Resources, July 16, 2002.
  3. U.S., Department of the Interior, Bureau of Land Management, Wyoming Office, Buffalo Field Office, *Draft Environmental Impact Statement and Draft Planning Amendment for the Powder River Basin Oil and Gas Project*, WY-070-02-065, Jan. 2002, available at <http://www.prb-eis.org/Documents.htm>.
  4. Ibid.
  5. *Final Order in the Matter of the Designation of the Powder River Basin Controlled Groundwater Area*, available at [http://www.dnrc.state.mt.us/wrd/final\\_order.htm](http://www.dnrc.state.mt.us/wrd/final_order.htm).
  6. Ibid.
  7. Compton, A., Montana Department of Environmental Quality, Environmental Quality Council, Coal Bed Methane Water Policy Subcommittee, Final Minutes, Dec. 10, 2001.
  8. *Development of Site-Specific Water Quality Standards for the Tongue River, Little Powder River, and Powder River*, Nov. 2000, available at [http://www.deq.state.mt.us/coal\\_bedmethane/doc/CBM-tmdl-compR.htm](http://www.deq.state.mt.us/coal_bedmethane/doc/CBM-tmdl-compR.htm).

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9. U.S. Department of the Interior, Bureau of Land Management, Wyoming State Office, Buffalo Field Office, *Decision Record for Wyoak Drainage Coal Bed Methane Environmental Assessment*, WY-070-01-034, March 2001.

10. U.S. Department of the Interior, Bureau of Land Management, Rawlins Field Office, *Environmental Assessment for the Hanna Draw Coal Bed Methane Exploration Project, Carbon County, Wyoming*, Jan. 2002, available at <http://www.wy.blm.gov/nepa/rfodocs/hannadraw.htm>.

11. *Montana and Wyoming Powder River Interim Water Quality Criteria Memorandum of Cooperation*, Sept. 2001, available at <http://deq.state.wy.us/wqd/watershed/12478-doc.pdf>.