MBMG
Montana Bureau of Mines and Geology

MBMG Open-File Report 719

2018 Annual Coalbed-Methane Regional Groundwater Monitoring Report: Powder River Basin, Montana

Multiple Uses of Groundwater

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2019

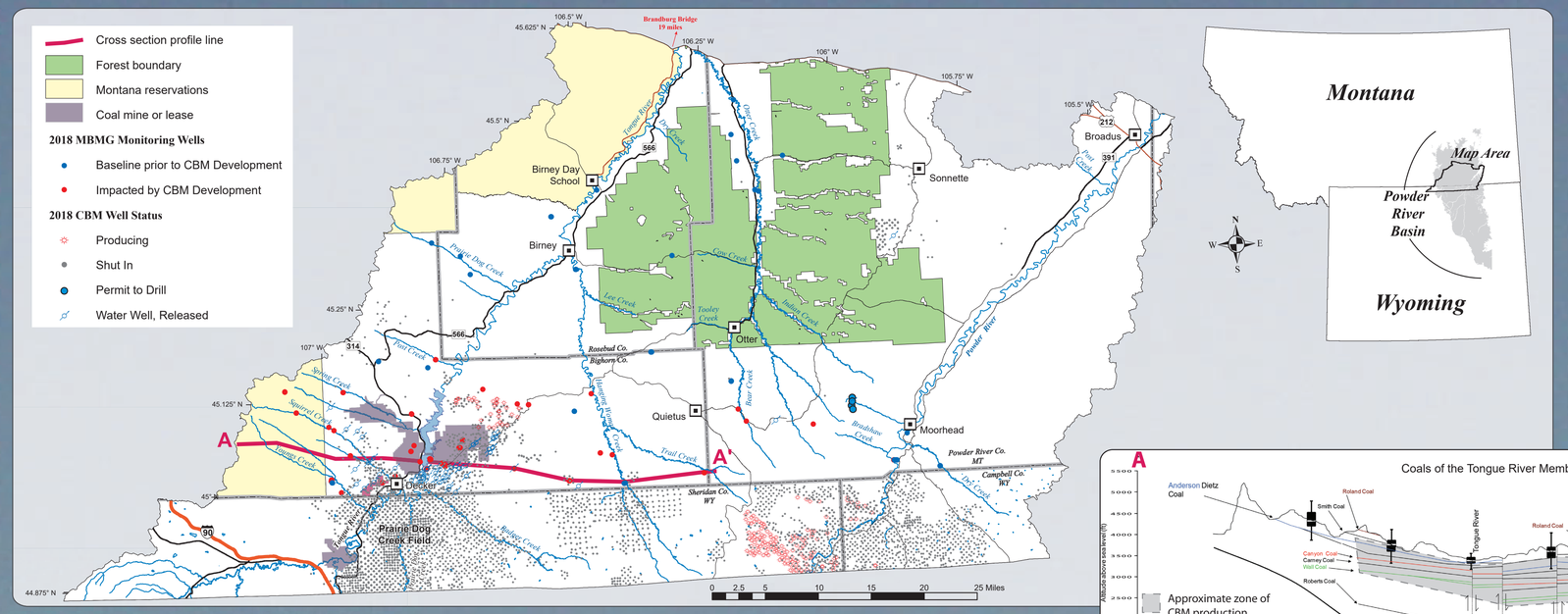
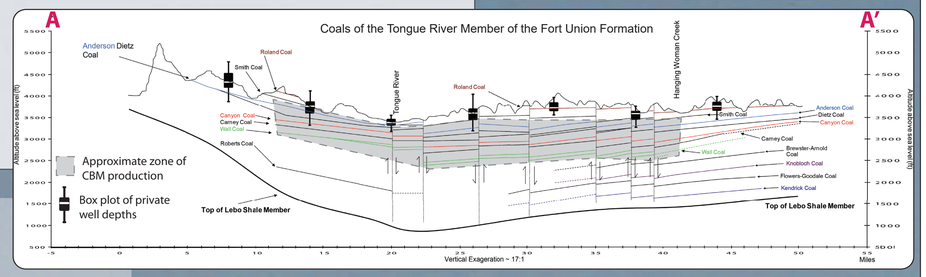


Figure 1. The MBMG groundwater monitoring network was established to measure water levels in areas affected by coal and coalbed methane and in areas that reflect baseline conditions. The monitoring network extends from the Tongue River watershed (western boundary) to the Powder River watershed (eastern boundary). CBM development in Montana was concentrated near the Tongue River Reservoir. After ceasing gas production, many wells are repurposed into water wells for the surface owner (shown as Water Well, Released). All current production is just east of the Reservoir; however, in 2018, four new permits were approved for wells along the Powder River.

Cross section: Domestic and stock wells within 12 mi (two townships) north of the state line near the Tongue River Reservoir are completed in the shallow aquifers of the Fort Union Formation, above the Lebo Shale. The average completion depth is 175 ft. Box plots of completion depths overlying the cross section show the coal aquifers that may be targets for water wells. Portions of the box plots extend above the ground surface because of elevation variability within the area of interest. The box plots display information from private well records in GWIC (MBMG, 2019) that have total depths reported; the box plots do not include all private wells. The number of wells used to create the box plots, from west to east, are: n = 33, 38, 78, 39, 42, 34, and 42. CBM production occurs in coals above and including the Wall Coal. A small number of CBM wells were drilled to the Flowers–Goodale Coal.



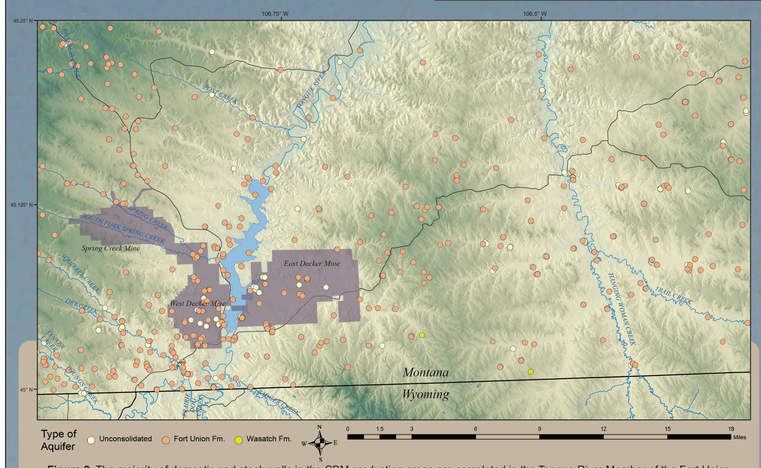


Figure 2. The majority of domestic and stock wells in the CBM production areas are completed in the Tongue River Member of the Fort Union Formation. A few wells are completed in the Wasatch Formation and the alluvial gravels of streams and rivers (MBMG, 2019).

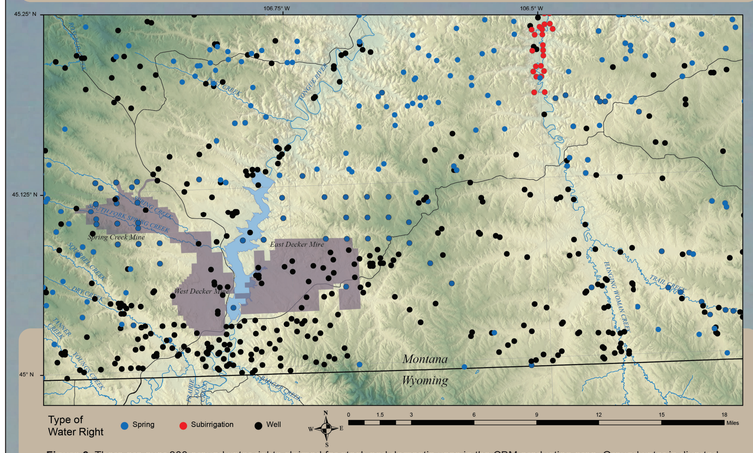


Figure 3. There are over 300 groundwater rights claimed for stock and domestic uses in the CBM production area. Groundwater is diverted through wells, springs, subirrigation, and through ponds excavated to the water table (point-of-diversion water rights from MT DNRC, 2019).

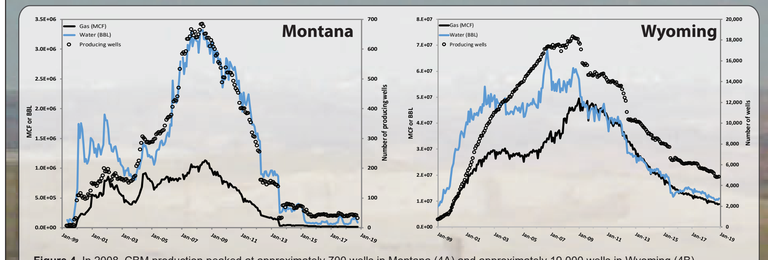


Figure 4. In 2008, CBM production peaked at approximately 700 wells in Montana (4A) and approximately 19,000 wells in Wyoming (4B). Production of gas in thousand cubic ft (MCF) and water in barrels (BBL) in Montana has stabilized at lower rates. Wyoming's production continues to decrease. Note different Y-axis scales (MBOGC, 2019).

Introduction

In Montana, coalbed methane has been commercially produced from the Fort Union Formation in the Powder River Basin since 1999. Methane is adsorbed on coal through weak bonding and water pressure. Pumping groundwater from coalbeds reduces water pressure, allowing desorption and subsequent recovery of methane (Meredith and others, 2012). Coalbed methane development occurs near two large, open-cut coal mines in Decker, Montana. Both forms of energy development require pumping groundwater, which lowers groundwater levels and can impact availability. In this rural agricultural area, groundwater is the primary water resource. Surface water is restricted to a few intermittent stream reaches and two perennial rivers, and these serve a very limited portion of the population. Domestic and stock requirements are overwhelmingly supplied by groundwater. Because of the multiple uses of Fort Union Formation groundwater, the Montana Bureau of Mines and Geology (MBMG) monitors groundwater drawdown and potential water-quality changes in these coal aquifers.

The regional Coalbed Methane (CBM) Groundwater Monitoring Program has been active in the Montana portion of the Powder River Basin since 2003. The CBM monitoring program is complementary to the Coal-Mine Monitoring Program started as a collaboration between the U.S. Bureau of Land Management (BLM) and the MBMG in 1969. These programs provide objective scientific data and interpretations for landowners, industrial and agricultural interests, and regulatory agencies so all parties have a common understanding of impacts or lack of impacts from local activities. Monitoring efforts are designed to meet the following objectives:

(1) document baseline hydrogeologic conditions in current and prospective areas of coal and CBM development in southeastern Montana;
(2) quantify changes or lack of changes in groundwater quantity and quality that occur in response to coal-energy production; and
(3) evaluate and update predictive tools used to assess magnitude of water-level drawdown and recovery time.

The MBMG CBM monitoring program continues to provide data and interpretations to the BLM, Montana Department of Natural Resources and Conservation, landowners, and others to improve understanding of impacts and recovery, to evaluate modeling predictions, and to aid environmental analyses and permitting decisions. The network of monitoring wells includes wells installed in response to actual and potential coal mining and CBM production, and "control" wells located outside zones of development (fig. 1).

Since 2016, each annual report focuses on a single topic of interest. Previous years' topics include distinguishing groundwater drawdown from coal mining and coalbed methane production (Kuzara and others, 2017) and groundwater level recovery along the state line (Meredith and others, 2018). A comprehensive dataset is available on the GWIC database (MBMG, 2019). This year's topic is multiple uses of groundwater in areas of coal and coalbed methane development.

The groundwater resource

Powder River Basin aquifers include the alluvium along streams, clinker on ridge caps, sandstones of the Wasatch Formation, and coal and sandstone units in the Tongue River Member of the Fort Union Formation. The majority of area wells are completed in the Tongue River Member (fig. 1, cross section; fig. 2). Drilling logs indicate that less than 40 percent of the Tongue River Member is made up of potential aquifer material, approximately 25 percent sandstone and 14 percent coal. The remaining 60 percent of the Tongue River Member is fine-grained siltstones and shales that do not serve as aquifers. Typical discharge rates for Tongue River Member wells are between 10 and 15 gallons per minute (gpm) but can be less than 1 gpm. The Lebo Shale Member of the Fort Union Formation is 75 to 200 ft thick and underlies the Tongue River Member (Lopez, 2006). The Lebo Shale forms an aquitard at the base of the Tongue River Member that is rarely drilled through in the study area.

Groundwater in the Tongue River Member flows generally northward, with some topographical control toward valleys (Kuzara and others, 2016). The Lebo Shale limits downward flow. The Tongue River Member aquifers discharge to wells, springs, and streams. streamflow measurements collected in the 1970s indicate that the Tongue River received 16 to 40 cubic ft per second (cfs) of groundwater discharge from the Tongue River Member along the 60-mi reach between the Tongue River Dam and the Brandenburg Bridge (Woods, 1981; Woessner and others, 1981).

There are nearly 3,000 stock and domestic wells completed in the Tongue River Member in the Powder River Basin of Montana (GWIC, 2019). The average water-well depth in the area of CBM production is 175 ft below ground surface and the maximum reported depth is 1,151 ft. Box and whisker plots of the completion depths of the 214 wells and elevations of 109 springs within 12 mi (2 townships) of the state line (fig. 1, cross section) show the geologic units most commonly used for aquifers. Coal aquifers are the most contiguous in this area and therefore are one of the primary targets for private wells (Meredith and others, 2012). The water producing depths of this set of wells partially overlaps with the depths of the CBM producing coals.

Multiple uses of groundwater

Montana's coalbed aquifers are used throughout eastern Montana as a reliable source of domestic and stock water; however, coal mining and coalbed methane production require the removal of large volumes of water from the coal. Hydraulic heads in the Dietz and Canyon coal aquifers were lowered as much as 150 and 300 ft, respectively, within areas of CBM production. The water-level drawdown of 20 ft or more extended 1.5 to 2 mi in the study area (Kuzara and others, 2016). Water levels in some monitoring wells began recovering in 2004 due to the discontinuation or reduction of nearby CBM production. Some of these wells recovered to within 80 percent of baseline levels by 2017. However, some water levels continue to decline despite the discontinuation of CBM in most locations in Montana and northern Wyoming (Meredith and others, 2018). Current CBM production only occurs to the east of the Tongue River Reservoir; however, four permits were approved in 2018 to drill CBM wells along the Powder River (fig. 1)

Groundwater use in the Upper Tongue River Watershed, based on active water rights (Basin 42B Tongue River, above and including Hanging Woman Creek; MT DNRC, 2019), is primarily for stock and domestic use (fig. 3). Groundwater use for stock accounts for 488 of the 620 water rights (79 percent). There are 97 groundwater rights for domestic use and 15 for irrigation. Additional uses include commercial, industrial, pollution abatement at the coal mines, and fisheries and recreation uses on the Tongue River Reservoir. The U.S. Bureau of Land Management has six rights for wildlife (MT DNRC, 2019). The eight townships where coalbed methane was produced overlapped with 330 groundwater right points of diversion for domestic and stock water (fig. 3)(MT DNRC, 2019).

To put the volume of CBM produced water in Montana into context of overall water use in the area, the volume of CBM produced water in Montana was summed for two calendar years. The year of peak production, 2008 (fig. 4), is compared to 2017, which is the most recent year available (figs. 5A, 5B). These totaled 4,800 and 150 acre-ft in 2008 and 2017, respectively. Figure 6 shows these volumes compared to the volume of water claimed in groundwater rights in the Tongue River watershed above Hanging Woman Creek (MT DNRC, 2019), which covers the area of CBM production.

Water-level drawdown from Wyoming production also affects groundwater availability in Montana. The volume of water produced from the Wyoming CBM field closest to the Tongue River along Prairie Dog Creek was 7,200 acre-ft in 2008. The production fell to negligible volumes by 2017.

In 2008, during the peak of CBM production in Montana, the amount of groundwater produced with CBM was slightly more than the maximum claimed volume of groundwater and approximately twice the expected volume of diverted groundwater. By 2017, the amount of CBM produced water is significantly less than the volume claimed in water rights (fig. 6). This comparison does not take into account the legal or physical availability of the water.

Groundwater withdrawals for CBM production and domestic and agricultural uses are focused in the Tongue River member of the Fort Union Formation (figs. 1, 2). Quantifying volumes of CBM produced water by aquifer is difficult because half of the CBM wells are completed in multiple aquifers, with up to six coal units listed as production formations (MBOGC, 2019). However, 763 CBM wells recorded production from the Anderson–Dietz coal zone, an important local aquifer. Coal aquifers are important sources of both methane gas for energy production and agricultural and domestic water.

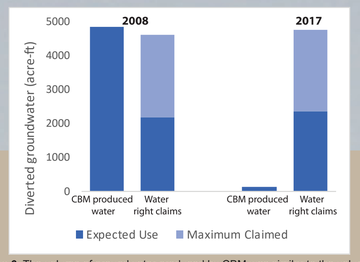


Figure 6. The volume of groundwater produced by CBM was similar to the volume of water claimed in area groundwater rights during the peak of CBM production in 2008. Current levels of CBM water production are much less than the agricultural and domestic use of groundwater.

The volume of groundwater claimed through water rights was estimated by considering rights classified as wells (462 records), springs (152 records), and subirrigation (5 records). Many water rights include a maximum volume of diverted water allowed per year; however, 309 of the records in this study area are exempt rights. Rather than a defined volume of use, these rights are limited to 10 acre-ft per year. The "maximum claimed" volume of water shown in figure 6 applies the 10 acre-ft to all exempt records and the maximum volume diverted from other records. Figure 6 also shows an "expected use" for water rights claims. This value is the sum of the rights that state a maximum volume of diverted water plus an estimated actual use for each exempt right. The estimated use for exempt rights is the average of the claimed values: 2.19 acre-ft. In calculating this average value, the four largest water rights (which are for commercial, pollution abatement, and municipal uses) were excluded from the calculation of the average value, as they range from 128 to 452 acre-ft per year. Water right records with enforceable dates from 1880 through 2008 and from 1880 to 2017 were used in the 2008 and 2017 estimates, respectively.

2019 Monitoring Plan

The monitoring network of 122 wells will be visited on a semi annual basis. There are 47 water-level data loggers installed in monitoring wells. Semiannual groundwater samples will be collected from well SL8-2Q, which is downgradient from Wyoming CBM production. All monitoring results including water levels, field measurements, and geochemical analyses will be added to the Groundwater Information Center Database (MBMG, 2019). Additional water-level dataloggers will be installed, and additional groundwater samples collected, as funding allows.

References

Kuzara, S., Bierbach, S., and Meredith, E., 2017, 2016 Annual Coalbed Methane Regional Groundwater Monitoring Report: Powder River Basin, Montana. MBMG Open-File 694.

Kuzara, S., Meredith, E., Wheaton, J., Bierbach, S., and Sasse, D., 2016, 2015 Annual coalbed methane regional groundwater monitoring report, Powder River Basin, Montana. MBMG Open-File 679.

Lopez, D.A., 2006, Structure contour map—Top of the Lebo Shale/Bearpaw Shale, Powder River Basin, southeastern Montana. MBMG Report of Investigation 16, 3 sheets, 1:250,000.

Meredith, E., Bierbach, S., Kuzara, S., Wheaton, J., and Blais, N., 2018, 2017 Annual coalbed methane regional groundwater monitoring report, Powder River Basin, Montana. MBMG Open-File Report 707.

Meredith, E., Wheaton, J., and Kuzara, S., 2012, Coalbed-Methane Basics: Ten years of lessons from the Powder River Basin, Montana. MBMG Informational Pamphlet 6.

Montana Board of Oil and Gas Conservation (MBOGC), 2019, Online Oil and Gas Information System: http://www.bogc.dnrc.mt.gov/WebApps/DataMiner/Default.aspx [accessed January 23, 2019].

Montana Bureau of Mines and Geology (MBMG), 2019, Ground-Water Information Center (GWIC) Online data: http://mbmggwic.mtech.edu [accessed January 22, 2019].

Montana Department of Natural Resource and Conservation (MT DNRC), 2019, Water Right Query System, online database: http://wrqs.dnrc.mt.gov/default.aspx [accessed Jan. 8, 2019].

Wheaton, J., and Reddish, S., 2005. Potential effects to ground water systems resulting from subsurface injection of coalbed methane production water. White paper prepared for the Montana Department of Environmental Quality.

Woessner, W.W., Osborne, T.J., Heffern, E.L., Andrews, C., Whiteman, J., Spotted Elk, W., Morales-Brink, D., 1981, Hydrologic Impacts from Potential Coal Strip Mining – Northern Cheyenne Reservation Volume 1. EPA 600/7-81-004a.

Woods, P. F., 1981, Modeled impacts of surface coal mining of dissolved solids in the Tongue River, southeastern Montana: U.S. Geological Survey Water Resources Investigations 81-64.

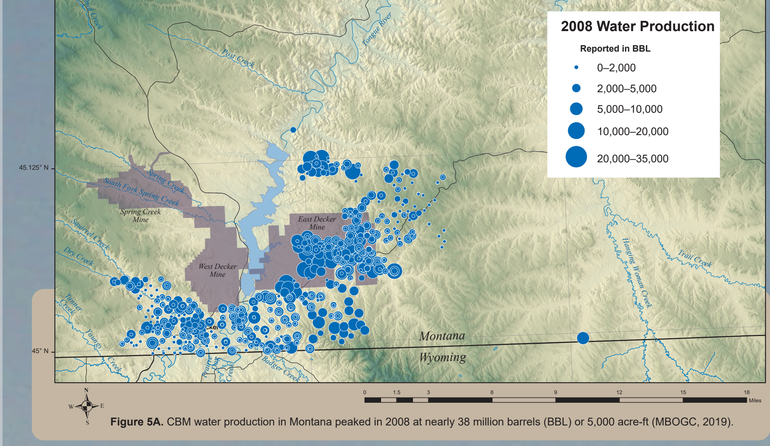


Figure 5A. CBM water production in Montana peaked in 2008 at nearly 38 million barrels (BBL) or 5,000 acre-ft (MBOGC, 2019).

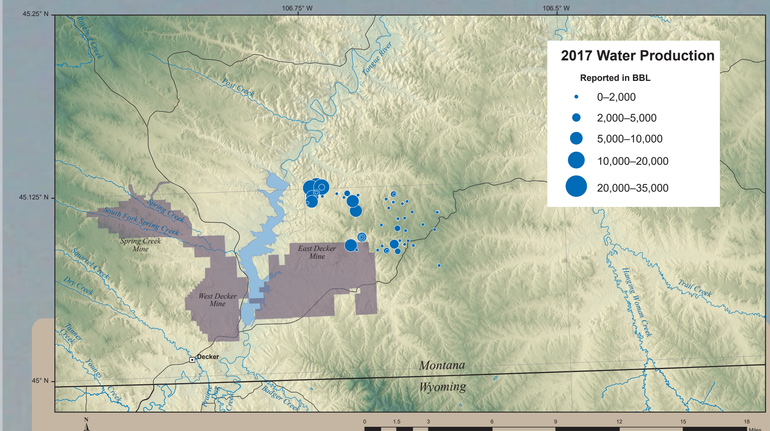


Figure 5B. CBM water production in Montana declined by 97 percent to just over 1 million barrels (BBL; 150 acre-ft) from 2008 to 2017 (MBOGC, 2019).

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