Baseline water well testing requirements in coalbed methane development areas of Alberta

Steve Wallace
Alberta Environment, Edmonton, Alberta, Canada
Brenda Austin
Energy Resources Conservation Board, Calgary, Alberta, Canada

ABSTRACT
The Standard for Baseline Water Well Testing for Coalbed Methane Operations was implemented in 2006 in response to concerns amongst Albertans about the potential for CBM activities to adversely affect water well supplies. The Standard for Baseline Water Well Testing requires operators to test all active water wells within the vicinity of a proposed CBM well to be completed above the Base of Groundwater Protection. The testing includes a well capacity test, water quality sampling and testing for dissolved gases. The latter includes stable carbon isotopic analyses on hydrocarbon gas components. Over 6000 baseline water well tests were completed between May 2006 and May 2008. Testing of water wells as a regulatory requirement at this scale has balanced the needs of practicability with obtaining meaningful data. The development and implementation of the Standard for Baseline Water Well Testing has involved strong coordination between Alberta Environment and the Energy Resources Conservation Board and is a good example of government agencies working collaboratively to protect groundwater resources in Alberta.

RÉSUMÉ
Le "Standard for Baseline Water Well Testing for Coalbed Methane Operations" a été appliqué en 2006 pour répondre aux inquiétudes des albertains du potentiel défavorable des activités de "CBM" qui pourraient affecter les provisions d'eau. Les tests exigent que les opérateurs vérifient tous les puits d'eau actifs dans le voisinage d'un puits proposé de "CBM", qui sera complété au-dessus de la Base de Protection des Eaux Souterraines. Les tests comprennent un test de capacité du puits, des échantillons de la qualité de l'eau et un test des gaz dissous. Ce dernier inclut une analyse isotopique des composants des gaz d'hydrocarbure. Plus de 6000 tests ont été complétés depuis mai 2006. La vérification des puits, comme condition régulatrice à cette échelle, a équilibré les besoin de practibilitlé pour obtenir des données de bonne qualité. Le développement et l'implémentation du "Standard for Baseline Water Well Testing" a impliqué une forte coordination entre "Alberta Environment" et "Energy Resources Conservation Board" et est un bon exemple des agences gouvernementales travaillant en collaboration pour protéger les resources d'eau souterraine en Alberta.

1 INTRODUCTION

The significant pace of coalbed methane development in Alberta over the past five years has prompted the need to ensure that an effective regulatory framework is in place to develop the resource in an environmentally sustainable manner. Impacts to shallow groundwater resources in coalbed methane development areas are a concern for many rural Albertans and they want assurances from the government regulators that their water supplies are being protected. As a result the provincial government implemented a mandatory baseline water well testing program in 2006 in areas of coalbed methane development and is likely one of the largest scale programs of its kind in North America.

2 COALBED METHANE ACTIVITY IN ALBERTA

Coalbed Methane (CBM), also known as Natural Gas in Coal (NGC), is a relatively new source of gas production in Alberta. The methane gas is derived from the coalification process as a result of burial of organic materials over geologic time. CBM gas is regarded as an unconventional gas as the coal acts as both the source of the gas and the storage reservoir, as opposed to conventional gas where gas migrates from source rock into a different storage reservoir. CBM gas is adsorbed on to the coal surfaces and is also contained within low permeability fracture networks.

The extraction of CBM is accomplished by drilling of a well into the coal zone. Holes are cased with steel pipe cemented in place followed by perforation at the coal seam intervals. CBM wells are typically fractured stimulated with nitrogen to open up the facture networks around the well bore and enhance gas migration to the well. In some cases, lowering of the hydrostatic pressure in seams saturated with water is required to liberate the gas adsorbed onto the coal surfaces, however many coal seams in Alberta are essentially dry and do not require any dewatering.

The Alberta Geological Survey has estimated up to 500 trillion cubic feet (Tcf) of natural gas to be contained within Alberta's coals, with approximately half of this amount estimated to be potentially marketable. Over 10,000 CBM wells have been drilled as of December 2006 in the province since large scale CBM production commenced several years ago (ERCB, 2005, 2006, 2007). Just under 7000 of these wells are under production as of December 2006. Unfortunately 2007

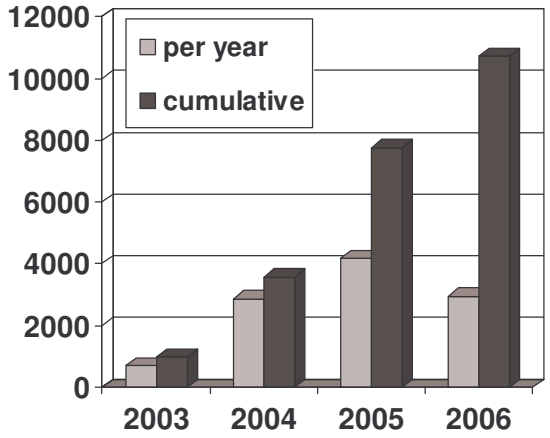

Figure 1. Number of CBM wells drilled in Alberta (source of data AEUB 2005, 2006, 2007)

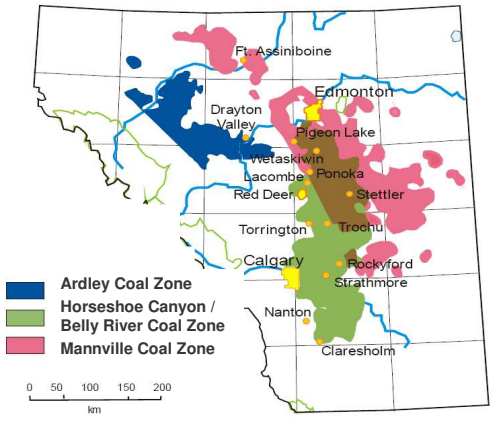

Figure 2. Prospective coal zones for CBM development (from Alberta Environment 2006)

data is not yet available. Distribution of the number of CBM wells drilled per year is shown in Figure 1. Drilling activity tends to reflect the price of natural gas, which has been on the decline in latter years.

There are three main coal zones in Alberta with CBM production potential, each possessing distinct physical characteristics. These zones are illustrated in Figure 2 while their occurrence within Alberta's geological setting is shown in Figure 3. The Horseshoe Canyon/Belly River coal zone is by far the most produced zone with over 90% of CBM wells drilled into this zone. The coals of this zone are unique in that they are essentially dry and can produce gas to a well without the need for any dewatering, although marginal amounts of water may be produced from condensation as the gas migrates up the production casing. The Horseshoe Canyon/Belly River coals vary in depth from 200m up to several hundred metres in depth depending on the location along the westerly dipping coal-bearing formations.

The Mannville coal zone is relatively deep (>1000m) and coals seams within this zone are saturated with saline water, generally in excess of 40,000 mg/l total dissolved solids (TDS). Saline water is defined in Alberta as having greater than 4000 mg/l total dissolved solids (TDS). Saline water is handled by disposal into different formations through deep disposal wells. Regulations do not permit surface impoundment of produced water, contrary to practices in the United States. Less than 10% of CBM wells drilled in Alberta to date have been in the Manville coal zone.

The Ardley coal zone occurs at relatively shallow depths compared to the other two zones and potentially contains significant quantities of non-saline water (< 4000 mg/l). To date less than 1% of CBM wells have been drilled into this zone and only a few, if any, are actively under production. However there is significant potential for increased production from the Ardely coal zone in the future.

Another source of CBM includes the Kootenay Group in the foothills region of Alberta, despite not being shown in Figure 2. Less than 0.5 % of CBM wells have been drilled into the Kootenay Group and there is currently no production from this zone. Structural features influence these CBM reservoirs to some degree as compared to the prairie deposits described above.

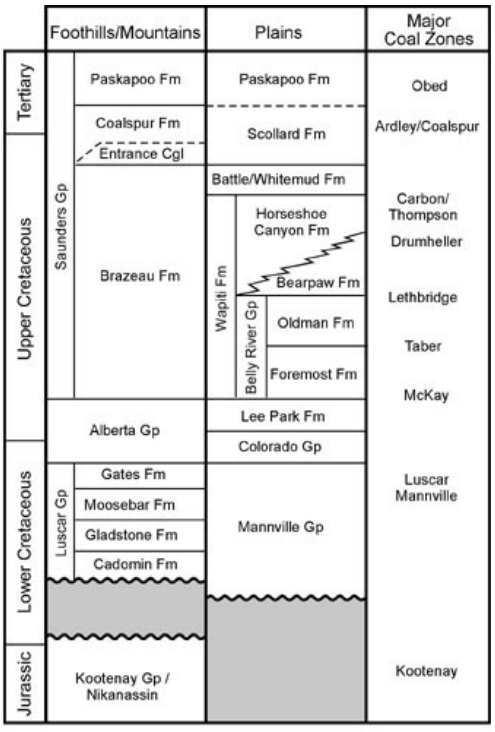

Figure 3 Stratigraphic chart showing major coal zones in Alberta (from Alberta Geological Survey)

3 REGULATION AND CONSULTATION PROCESS

The regulation of coalbed methane activity in Alberta is mainly shared between two provincial agencies, the Energy Resources Conservation Board and Alberta Environment. The Energy Resources Conservation Board (ERCB), formerly the Energy and Utilities Board (EUB), regulates the development of all of Alberta's energy resources, including CBM activity. Regulations focus on aspects such as licensing of resource extraction, drilling and completion, gas production and processing and handling of produced water. Alberta Environment's key role is to ensure that water resources are adequately protected in the vicinity of CBM operations, including the quality and availability of groundwater.

A key tool used to protect groundwater resources in Alberta is the Base of Groundwater Protection (BGP). This is the depth below which groundwater is estimated to be saline, or as described above, greater than 4000 mg/l TDS (Figure 4). Above this threshold specific requirements regarding drilling, cementing, completion and fracture stimulation have been put into place ensure protection of groundwater resources from oil & gas drilling and production activity. Completion depths for coalbed methane wells in Alberta occur both above and below the BGP.

In response to growing concerns amongst Albertans regarding CBM development, a Multi-stakeholder Advisory Committee (MAC) was put into place in 2003 to review the existing policy and regulations at the time. The MAC consisted of members representing a broad range of interests and included environmental and agricultural organizations, landowners, local governments, the energy industry and provincial government departments and agencies. The MAC released a final report in May 2006 with 44 recommendations to ensure the responsible development of CBM resources in the province. These recommendations span a broad range of topics including protection of water resources, enhancing information and knowledge, minimizing surface impacts and improving communication and consultation. A total of 13 recommendations pertain to protection of water resources and most of these focus on the protection of groundwater. One of the key recommendations was the development of a mandatory baseline water well testing program in the vicinity of proposed CBM operations, which is the focus of this paper.

4 WATER WELL TESTING

One of the first MAC recommendations to be implemented was development of the Standard for Baseline Water Well Testing for Coalbed Methane / Natural Gas in Coal Operations. The Standard, which came into effect in May 2006, was developed by Alberta Environment and is implemented and enforced by the ERCB under Directive 35: Baseline Water Well Testing Requirement for Coalbed Methane Wells Completed above the Base of Groundwater Protection.

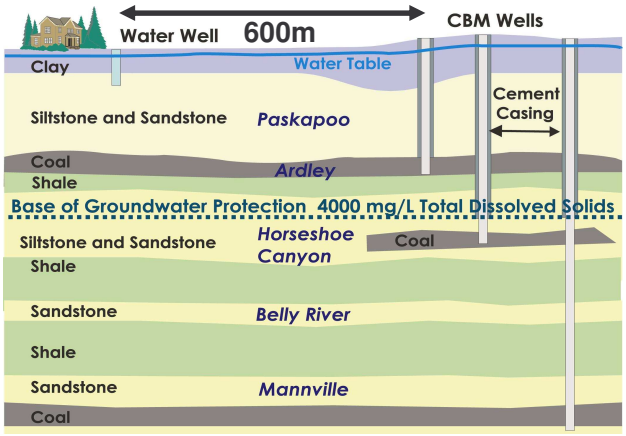

Figure 4. Base of Groundwater Protection (from Alberta Environment 2006)

The Standard requires coalbed methane operators to test all active water wells within a minimum 600m radius of a proposed CBM well completed above the Base of Groundwater Protection prior to drilling of a new CBM well or re-completion of an existing energy well for CBM production. If no water wells are found within 600m, the nearest water well within 800m must be tested. Testing is not required if the landowner refuses the test.

A well licence cannot be obtained from the ERCB until requirements under the Standard are satisfied. Well licences for CBM wells that will be completed above the Base of Groundwater Protection must be accompanied by a survey showing the location of all active water wells and observation wells, and confirmation that the offer to test these wells has occurred. Testing must occur prior to the CBM being drilled.

The main purpose of the testing is to measure and document baseline conditions for water wells which can be referred to in the event a water well is re-tested after a change in well water quality or quantity is observed by a landowner. The pre and post testing can be used to determine if any impacts have occurred due to nearby CBM activity, such as reduced yield, water quality deterioration or migration of gas.

The testing requirements comprise three main components; well capacity test, water quality sampling and gas sampling. The testing must be carried out under the direction of a professional registered with the Association of Professional Engineers, Geologists and Geophysicists of Alberta.

4.1 Well Capacity Test

A two-hour constant yield test must be performed to determine the capacity characteristics of the well. It is important to note that purpose of the test is not to determine the maximum yield of the well or aquifer parameters, rather it is to be conducted in a manner such that it can be replicated in the future for comparative purposes to assess potential impact. Testing of a well at

its full capacity is in fact discouraged by Alberta Environment to avoid over-pumping and possible damage to the well. The test can be conducted at a rate less than the maximum capacity of the well as long as sufficient drawdown is produced during the test. While testing prior to the pressure system is ideal, it has been recognized that this is not possible in most situations without significant disturbance of plumbing systems. Well capacity testing after pressure systems has been allowed provided that the test can be replicated in the future and used for comparative purposes.

4.2 Water Quality Sampling

Both routine potability and bacteriological analyses are required under the Standard. Routine potability parameters include major ions, fluoride, iron, manganese, nitrate, nitrite, TDS, total alkalinity, total hardness and pH. Bacteriological parameters include iron related bacteria (IRB), sulphate-reducing bacteria (SRB), total coliforms and fecal coliforms. The IRB and SRB tests give an indication of the presence and magnitude of nuisance bacteria, whereas the coliform analyses flag potentially harmful pathogenic bacteria in a water well supply. Recording of the exact sample location along the water distribution system is very important particularly for the bacteriological samples. All analyses must be performed by laboratories accredited for the above analyses.

4.3 Gas Sampling

The gas sampling requirements are a critical testing component under the Standard. CBM operators are required to collect gas that freely exsolves from the water supply at surface, otherwise known as free gas. Free gas samples are collected using a gas-water separator or flow-through cell. An example of such sampling apparatus is shown in Figure 5. The samples must not be heated in order to avoid unwanted isotope fractionation. The most common practice has been to collect gas samples in Tedlar bags, although other types of sample containers are also considered acceptable. The volume of gas produced per unit volume of water passed through the separator (gas/water ratio) must be recorded.

All samples collected must be submitted to an accredited laboratory for molecular compositional analysis. Gases commonly found in water well supplies in Alberta include methane and carbon dioxide, and to a lesser degree ethane, nitrogen, oxygen and hydrogen sulphide.

A minimum of 20% of free gas samples collected from water wells around each CBM well must undergo stable carbon isotope ratio analysis for carbon dioxide and all hydrocarbon gases present in the gas sample. The stable isotope carbon ratios provide some insight into the origin of these gases. Shallower biogenic methane for example, typical in many aquifers and water well supplies in Alberta, tends to have lighter ratios. On the other hand deeper thermogenic methane, which may have migrated to shallower aquifers via leaky energy wells or geological pathways such as faults, tends to have heavier ratios.

Figure 5. Example of a gas-water separator (courtesy of Waterline Resources Ltd.)

4.4 Reporting

All data collected under the Standard must be submitted to landowners and Alberta Environment within two months of sampling. Data is submitted online using an electronic template and is currently stored on an internal database. Alberta Environment has committed to making this data accessible to the public and is aiming to provide web based access by the end of 2008.

5 PRELIMINARY DATA

Approximately 6240 baseline water well tests were conducted between May 2006 and May 2008. The vast majority of tests conducted to date are located within the Edmonton-Calgary corridor where most of the CBM development has taken place so far (Figure 6). Approximately 4300 tests have undergone Alberta Environment's quality control and assurance process and of these about 700 of the tests contained measurable gas, half of which have undergone isotope analysis.

Bacteriological data records show that almost all wells (99%) contained iron-related bacteria and about 80% contained sulphate-reducing bacteria present in concentrations of 1 cfu/ml or greater. While further data compilation is required to asses the distribution of concentrations, these preliminary numbers do indicate that nuisance bacteria is a very common occurrence in water well supplies across Alberta.

Even more interesting was the percentage of wells testing positive for total coliforms (22%) and fecal coliforms (3%). Some coliform detections may be false positives due to poor sampling procedures or sampling of sources exposed to contamination (eg. outside taps). However detections may be valid and a reflection of poor well management practices. Further evaluation of the data is required in this regard.

6 FUTURE STEPS

The Standard committed to a full review of the data after one year to assess the effectiveness of the program. As a result, a Science Panel was struck in 2006 to undertake the review. Science Panel members include five experts in the fields of hydrogeology and isotope geochemistry. The panel has convened on several occasions to discuss the data and are expected to provide a final report to Alberta Environment with their recommendations on the effectiveness of the Standard and suggested improvements by mid 2008.

Alberta Environment has also consulted with the consultants and laboratories performing the work to solicit feedback on the practical aspects of implementing the requirements under the Standard.

Both the Science Panel recommendations and the consultant/laboratory feedback will be taken under consideration when Alberta Environment revises the current Standard. A draft of the revised Standard is to be completed in 2008 and provided to all stakeholders for review and comment prior to its implementation.

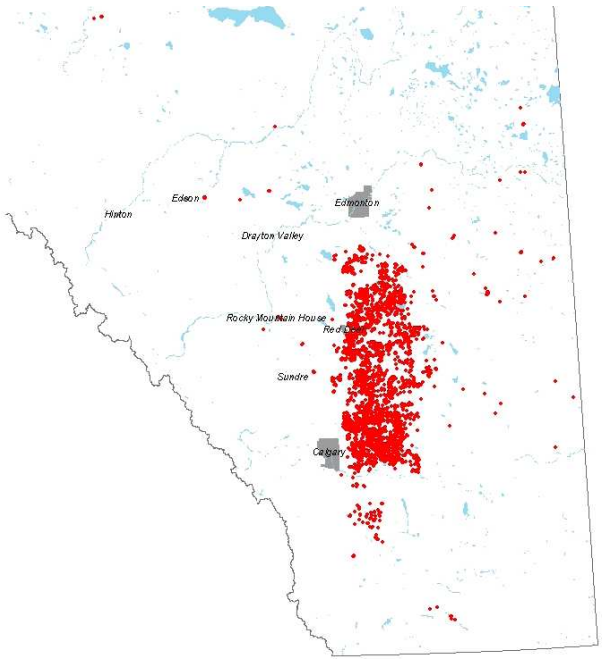

Figure 6. Distribution of baseline water wells tests

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